Economics Research Associates

A PRELIMINARY STUDY OF DREDGING PROGRAMS, BENEFITS, COSTS, AN EFFECTS FOR EIGHT IOWA LAKES

PREPARED FOR

IOWA STATE CONSERVATION COMMISSION

DECEMBER 1974

BRABHAM

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San Francisco, California
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

Section I

INTRODUCTION

Economics Research Associates (ERA) and Engineering Consultants, Inc., (ECI) were retained in early August by the Iowa Conservation Commission to perform a study of costs, benefits, and impacts of dredging programs for eight Iowa lakes. This study was commissioned by the Iowa General Assembly to assist in determining public policy with respect to the dredging of the subject lakes.

ECI, as a subcontractor to ERA, undertook to perform the environmental and engineering analyses. Working with ECI, and as an extension of their work, ERA evaluated the economic impacts of lake dredging in terms of costs and benefits.

The Iowa Lakes Study was conducted over a four month period and represents a purely independent, professional analysis of the costs, benefits, and impacts of dredging the eight subject lakes. The ECI work was conducted under the direction of Max K. Kuehl, Chief Engineer. Dr. Louis E. Haley assumed primary responsibility for the engineering analysis, assisted by Mr. Harry Cole. Dr. Howard W. Dennis was responsible for environmental analyses. The ERA staff was directed by Mr. J. Richard McElyea, Senior Vice President who served as project manager. As project leader, Mr. Carlyle MacHarg III, Senior Associate, directed the field work and analysis. Miss Mary Carol Emerson and Mr. Peter T. Shaw, Associates, conducted most of the field work and contributed significantly to the analysis and report preparation. Frequent project team meetings and conference calls assured coordination throughout the study, and all members of the project team functioned regularly as working participants.

The report is organized in six sections as described in the table of contents. Environmental and engineering analyses are presented first, followed by the economics.

Section II

SUMMARY AND CONCLUSIONS

This section of the report presents the major conclusions of the Iowa Lakes Study. The findings presented herein are the result of a preliminary analysis of the feasibility of dredging eight Iowa lakes and, as such, are intended to be used as guidelines for public policy decisions. The environmental, engineering, and economic factors relevant to determining whether or not a lake should be dredged are reviewed in general. Following this discussion, the specific dredging programs proposed for each of the study lakes are summarized in terms of cost/benefit analysis. Costs include adverse effects of dredging which are not quantifiable, as well as those which can be expressed in monetary terms. Similarly, both quantitative and qualitative benefits are identified as decision-making considerations, though the latter defy precise economic analysis. Methodology and background data employed in formulating these conclusions are presented in subsequent sections of this report.

ENVIRONMENTAL CONSIDERATIONS

Lakes are sensitive to any changes that affect their water, energy, and nutrient budgets as such shifts can induce progressive changes in the biota. In addition to the natural rate of eutrophication, that is, nutrient and mineral loads imposed on a lake due to natural conditions, man's activities both in the watershed and the lake itself can effect radical changes in the interrelationship of lakes' components. The following paragraphs summarize environmental costs and benefits which are considerations in determining dredging's feasibility.

Turbidity

The constant wave action, both natural and boat-stimulated, to which shallow lakes such as the eight study lakes are subjected, eliminates oxygen and temperature gradients and brings sediments into suspension. The resultant turbidity in the euphotic zone affects light penetration, photosynthesis, and in turn dissolved oxygen concentrations, producing a negative impact on bottom-dwelling fauna and fish reproduction and feeding.

The short term effect of dredging would be to increase turbidity, particularly in aqueous disposal operations, with concomitant aesthetic displeasure, reduction of light penetration, flocculation of planktonic algae, and reduction of dissolved oxygen and of available food for fish and fowl. Further, by its tendency to raise surface-water temperatures, increased turbidity could synergize the effects of pesticides, heavy metals, dissolved gases, detergents, and other toxic or debilitating pollutants.

Related to increased turbidity, resulting from disturbance of bottom sediments, is an increase in the amount of organic material in solution, and thereby a change in the chemical content of the water. The resultant increased demand for oxygen could create dangerously low oxygen levels. A sufficiently high water level should be maintained during dredging to ensure that the dilution factor for turbidity and nutrients reintroduced into the system by dredging would not be reduced to levels fatal to the fish population.

Runoff and Sediment

Eutrophication of a body of water includes the accumulation of sediments. It is an evolutionary process to which all lakes are subject to a greater or lesser extent, depending on the watershed-reservoir ratio, topography, soils, and climatic conditions. The deposition of silt reduces depth and produces a closer association between the zones of photosynthesis and decay.

Each of the three man-made lakes in this study (Backbone, Mill Creek, and Rock Creek) is so situated that its watershed is many times larger than its reservoir area. The resultant potential for high sediment yield is compounded by topography and soils conducive to erosion.

The five natural lakes have fairly small watersheds; the two oxbows (Blue and Manawa) have no effective watershed, and Five Island's watershed is principally confined to tile drainage. Reports indicate conservation measures are being implemented to control the larger watersheds of Silver and Black Hawk lakes.

Pollution

The primary sources of pollution for the study lakes, with the exception of the oxbow lakes, are agricultural runoff, including fertilizers, pesticides, and herbicides applied to crop lands in the watershed, and feedlot runoff. The latter is prevalent in the drainage area of Silver and Five Island lakes. Additional nutrients could be contributed to Manawa and Five Island lakes via runoff from heavily fertilized golf courses adjacent to the lakes.

A pollution source equally hazardous to water quality and demanding investigation and improvement is infiltration of sewage effluent into ground water and lake. This problem emerges from housing developments situated around all study lakes, except Backbone and Mill Creek, and must be solved before any positive effects of dredging on water quality could be realized.

Bankcaving represents another potential source of pollution by sediment which exists at all lakes. It is due, primarily, to storm conditions, high water, and wave action. As with other sources of pollution by sedimentation, effective controls are needed to prevent bank erosion. First, the equilibrium position (point at which insufficient material has been eroded to provide a protective reach which greatly reduces erosion potential) should not be disturbed in locations where it has been reached. And secondly, shoreline protection can be extended.

Spoil Disposal

Environmental factors associated with spoil disposal vary depending on whether it is an aqueous disposal or land disposal operation. However, the effects of both operations are contingent upon the components of the spoil deposited. The presence in sediments of constituents other than rock debris and soil, such as biostimulants and toxins, can result in release of noxious materials in either operation.

Aqueous disposal has the short-term effect of increasing turbidity, amassing sediment, and depleting oxygen, and thereby destroying spawning areas, smothering organisms, and reducing bottom habitat diversity, food supplies and vegetation.

Land spoil disposal involves land use change and ecological disruption, as well as potential release of toxic pollutants, odor, mosquitos, and high bacteria content in the area of containment.

Visual Impact

The most obvious environmental effect of dredging is the introduction of the dredge into the lake. The physical presence of the dredge and spoil pipelines will create an aesthetic change and block boating during the life of the project. Motors and pumps will create higher noise levels disturbing to wildlife and, possibly, to lake residents. Lowered water levels will affect fish and wildlife habitats and will expose littoral areas and emergent vegetation. A positive effect of the latter will be to allow maintenance of banks and permit control of unwanted vegetation.

Long-Term Environmental Effects

Indications are that the adverse effects of dredging on the environment are primarily short term, lasting only as long as the dredge operates. Adverse effects of spoil disposal can endure throughout the period required to rehabilitate the site, four to five years, though they become less objectionable as the spoil is dewatered.

On a long-term basis it appears that water chemistry will improve, bottom fauna will recolonize in greater numbers, and overall fishing potential will be enhanced. Motorboating and water-skiing will definitely be improved, though lake management becomes necessary to reduce conflicts between these enhanced recreation activities. Further, watershed management and sewer and septic facility controls are essential to the realization of improved water quality expected through dredging of the lakes.

Dredging should not be considered a panacea for declining lake quality, nor should it be undertaken without understanding the operations and their negative as well as positive consequences.

<u>Life of Lakes Assuming No Dredging</u>

Predictions concerning lake longevity are difficult to make even under the most informed circumstances and thus should be considered only in a broad time frame.

Assuming continuation of present conditions, the subject lakes with the largest and least controlled watersheds are apt to infill and decline in terms of recreational quality at the most rapid rates. Such is the case at Backbone, Mill Creek, and Rock Creek lakes whose lives are roughly estimated at 25, 20 and 100 years, respectively. The main body of Rock Creek Lake is protected, temporarily, from the bulk of the sediment load by a highway bridge across the north end of the lake.

Though the lives of Lake Manawa and Silver Lake are not threatened by sedimentation, water quality is a significant problem in both cases. Nutrient input is high and unless corrective measures are initiated Manawa could become an urbanized backwater swamp of the Missouri River in the next 20 years. In the same period of time, Lake Park, located on the lee side of Silver Lake, could lose its water supply and experience increasing odor problems.

Bank erosion could reduce the maximum depth of Five Island Lake and promote a decline in more active recreational activities in the next 20-25 years. Sudden demise is not foreseen for either Black Hawk or Blue Lake, as Provost Bay traps sediment for the former and the water level is artificially maintained at the latter. However, activity curtailment could become necessary as these lakes age.

ENGINEERING CONSIDERATIONS

Engineering considerations associated with dredging involve identifying variables which determine how much sediment should be removed and how best to remove and deposit it, and secondly, quantifying costs of pre-construction investigation, construction of dikes and weirs, and operation of the dredge itself. Frequently, environmental and engineering considerations overlap. For example, physical characteristics of lake sediment must be delineated in order to determine the most feasible method of removing the material and the total volume to be withdrawn, as well as to gauge the impact of spoil disposal on the environment. The following paragraphs summarize the variables to be identified from an engineering standpoint, and the costs associated therewith.

Spoil Disposal Sites

The scarcity of spoil disposal sites, and the problems attending various site conditions, are highly significant engineering considerations. Locations suitable for confined land disposal if available within reasonable distances from the lakes may be difficult to acquire or lease. Aqueous deposition sites rarely can accommodate sufficiently large volumes of spoil, and negative environmental effects such as destruction of wildlife habitat might result. The nonavailability of spoil disposal sites, coupled with rapid resedimentation rates resulting from watershed-reservoir imbalance, eliminates the three man-made lakes in this study from further consideration of dredging's feasibility.

Spoil disposal site procurement costs can be calculated on the basis of preliminary estimates of the volume of dredged material. A per acre allowance for use of site ($400 is the figure used for the purposes of this study) is then applied to acreage required to contain the spoil at an average depth of four feet. The range of estimated spoil site procurement costs is shown below:

Lake	Estimated Spoil Site Procurement Cost
Black Hawk	$138,000
Blue	$ 8,800
Five Island	$104,000
Manawa	$130,000
Silver	$138,000

Spoil Disposal Construction

Some of the feasible containment areas for the dredged spoil of the subject lakes will be small, artificially closed, natural depressions and others will be wholly artificially diked facilities on rather flat agricultural land. Nearly every containment area should have a spillway or overflow weir and perhaps settling basins, as careful control of water quality and dewatering rate of the return flow must be maintained.

Spoil site construction should be preceded by adequate soil exploration to ensure the specific dikes' designs are the most appropriate for soil and subsurface conditions particular to each site. Further, spoil sites should be surveyed on a scale of 1:100 with contour intervals not greater than one foot to allow calculation of containable volumes and amount of diking required. Spoil site survey costs are estimated at $50 per acre and field investigations, a part of which is the aforementioned soil exploration, are assumed to equal 5% of construction costs for each lake.

Pre-construction field investigations will identify the nature of variables upon which spoil site construction costs are based. However, preliminary estimates can be made with the understanding that the costs will vary pending further investigations. Thus, for the purposes of this study, spoil disposal construction costs were estimated as an allowance per cubic yard of spoil for sites of varying engineering difficulty. The range of difficulty as estimated is shown in the following allowances:

Lake	Spoil Site Construction Allowance per Cubic Yard of Spoil
Black Hawk	$0.75
Blue	1.00
Five Island	0.85
Manawa	1.00
Silver	0.75

Dredging

How much dredged material should be withdrawn and from which areas of the lake are questions for which precise answers must be based on current bottom samples, lake surveys, and hydrographic maps. Project engineers have estimated $250 per acre for the cost of lake surveying and mapping.

The payment for removal of sediment is usually based on the quantity of material actually removed. Inaccurate quantity computations, due to insufficient or unreliable data, can result in grossly inaccurate preliminary cost estimates. For the purposes of this preliminary feasibility study, however, volumes of spoil, and costs of dredging and shore-line protection necessary to ensure benefits of dredging have been estimated for the five lakes where dredging is deemed feasible. They are shown below:

Lake	Volume of Spoil (million cubic yards)	Estimated Cost of Dredging (thousands of dollars)	Estimated Cost of Shore-line Protection (thousands of dollars)
Black Hawk	3.02	$4,250	$200
Blue	0.14	300	40
Five Island	1.67	2,500	260
Manawa	2.10	3,700	150
Silver	2.20	3,000	37

In addition to the preliminary nature of the cost estimates outlined in this study, the exclusion of costs for improving and maintaining lake environs other than spoil deposition areas should be noted. It is likely that improvements to adjacent sewer and septic facilities and control of lake watersheds could improve water quality prior to dredging; it is certain that benefits to water quality from dredging cannot be sustained or even realized until such improvements and controls are in effect.

ECONOMIC CONSIDERATIONS

Economic considerations involved in determining the feasibility of dredging the subject lakes are, primarily, the impacts of recreational quality enhancement on supply and demand of recreational opportunities measured in terms of user benefits, and secondly, monetary benefits which may accrue to lake shore property owners and to regional economies. These considerations are summarized in the following paragraphs.

Supply of Recreational Opportunities

A review of the supply of recreation opportunities entails two aspects; first, activities and facilities, attendance and market areas of the subject lakes, and second, development of competitive recreation areas which would increase the supply of recreation opportunities and thereby reduce the demand for recreation at the subject lakes.

Activities and Facilities

According to the Iowa State Conservation Commission classification system the eight study lakes and their associated state parks are general outdoor recreation areas, that is, areas not designed for high density use, though they provide a variety of facilities. Without exception, the subject lakes offer boat access, camping facilities, picnicking facilities, shelter, and the opportunity to fish and swim. The quality of the recreation experience may vary with each activity from lake to lake. Further, some of the lakes offer hunting, hiking trails, showers, and concessions. State-owned rental accommodations are available at some lakes; cabins at Backbone, and enclosed shelters at Blue and Mill Creek lakes.

A relationship between facilities and activities pursued by recreationists at the subject lakes was clearly indicated by findings of the ERA survey of lake users. Fishing ranked among the five most often pursued and preferred activities at every lake, but it attracted fewer participants at Backbone Lake, where fishermen indicate it is becoming a less rewarding pastime. Swimming, camping, picnicking, hiking, nature walks, and passive enjoyment of the outdoors were the other activities most frequently selected by lake visitors. As in the case of fishing, these were pursued and preferred in varying degrees, lake to lake, contingent upon the facilities available and the quality of the recreational experience. For example, more recreationists hiked where trail systems are developed and scenery is particularly attractive (i.e., Backbone and Blue lakes), and more sailors are found at Manawa where there is a sailing club on the lake shore.

Attendance and Market Areas

Lake size and facility development, location in relation to population concentrations, and competing recreation areas are factors which affect attendance at the study lakes and the ability of each lake to penetrate its respective market areas. Park officer reports show daily attendance at all the study lakes/state parks (though reporting is incomplete for Silver and Mill Creek, and reports are not available for Five Island).

These statistics reflect higher attendance levels on weekends and holidays versus weekdays, and in summer months versus other seasons. Annual attendance figures for the thirteen year period investigated in this study (1960-1973) do not reflect steady patterns of attendance decline or growth for most lakes, with possible exceptions of steady growth at Blue and Rock Creek lakes.

ERA survey findings indicate very small percentages of out-of-state visitors to all study lakes, except Lake Manawa and Blue Lake where proximity to Nebraska population centers produces more out-of-state visitors. Further, the survey showed visitor origins were generally distributed in primary (within 25 miles of lake in question), secondary (25-50 miles) and tertiary (50-100 miles) market areas, with the most visits originating from the shortest distances. This was particularly the case at Lake Manawa (93 percent from primary market area), Mill Creek Lake (94 percent) and Five Island Lake (67 percent).

Market area penetration rates are functions of market area visitation distributions and population totals. As such, they vary widely from lake to lake and from zone to zone for each lake. Naturally, the larger attendance totals from less populated market areas yield the highest penetration rates; and conversely, the smaller attendance totals from the larger market areas produce the lowest penetration rates.

Competitive Recreation Areas

Future attendance at the study lakes could be redirected to newly developed recreation areas, provided that the new areas offer recreation experiences of comparable or better quality and are as accessible to potential visitors. A review of competitive developments whose impact would be felt within the next decade reveals several which would affect attendance at Rock Creek and Black Hawk lakes, and others which could have a moderate effect on attendance at Manawa and Blue Lakes. Silver Lake will continue to be subject to the strong competitive influence of the Spirit and Okoboji lakes area.

Demand for Recreation Opportunities

Significant findings of the National Recreation Survey conducted in 1972 are that participation in outdoor recreation will grow one-third faster than U. S. population between now and 1978; swimming will continue to draw the most participation; boating, outdoor pool swimming, and water-skiing will be third, fourth, and fifth fastest growing activities, and the proportion of outdoor recreation taking place on vacations and overnight trips will increase. Forecasts of increases or decreases in various activity participations, when applied to activity patterns at the individual study lakes (per ERA survey findings), yield a weighted average annual per capita recreation growth rate. These are shown below for each lake:

Lake	Average Annual Per Capita Recreation Growth Rate
Backbone	0.45%
Black Hawk	0.45
Blue	0.48
Five Island	0.43
Manawa	0.57
Mill Creek	0.32
Rock Creek	0.55
Silver	0.38

Recreational Quality Enhancement

The effects of the proposed dredging programs on recreation activities at the five lakes where dredging is feasible will be partly qualitative, partly quantitative. Improvements to water quality, water skiing, fishing and swimming will encourage greater recreational use of the lakes. However, assessment of the magnitude of increased use remains largely a subjective matter.

A quantitative aspect can be added to this assessment if impacts are rated on a scale of 10 ranging from negligible impact to substantial, thus permitting comparison among the lakes of the effectiveness of dredging. It might be that a costly program at one lake would have little impact, while a moderate effort at another would dramatically enhance its quality and recreational appeal. The study lakes' ratings on this scale are shown below:

Lake	Recreational Quality Enhancement Rating (scale of ten)
Black Hawk	7
Blue	4
Five Island	5
Manawa	9
Silver	5

User Benefits

The basic unit of user benefit is the recreation day, defined as the participation of one person in one or more activities during all or part of a 12-hour period. From the range of values per general recreation day, suggested by government standards ($0.75 to 2.25), a factor of $2.00 was selected for Blue, Black Hawk, Five Island and Silver lakes. Lake Manawa was assigned a value of $2.25 per recreation day due to its location, unique among the study lakes, in urban Council Bluffs where competition for recreation or amusement expenditures is a more significant factor.

Attendance projections for the subject lakes under dredge and no dredge conditions, based on consideration of recreational quality enhancement, population trends, general recreation demand trends and competition, show the impact of dredging in terms of recreation days. User benefits, then, offer a monetary unit of measurement for the incremental difference between dredging and not dredging the subject lakes; that is, a monetary measure of the benefit of dredging. These benefit values are shown below for the five lakes where dredging is deemed feasible from an engineering standpoint:

Lakes	Average Annual Benefit (thousands of dollars) To 1990	After 1990
Black Hawk	$ 82.7	$1,100.0
Blue	25.4	32.6
Five Island	54.1	67.6
Manawa	964.0	1,508.9
Silver	30.3	37.0

Appreciation Potential of Lake Shore Property

One possible economic benefit which was examined in this benefit/cost analysis of dredging is the potential increase in values of residential and commercial real property adjacent to lakes under study. Four of the study lakes were eliminated from the analysis of property value appreciation; Rock Creek, Mill Creek, and Backbone because dredging is not recommended from an engineering standpoint, and Blue Lake due to paucity of private property to be considered.

Dredging of the remaining four lakes--Manawa, Black Hawk, Silver, and Five Island--could benefit real property values. The conclusion of these four individual investigations of property value trends is that the effect of dredging would be to prevent depreciation of property values as the lakes decline in quality rather than to encourage more rapid appreciation than presently prevails.

Benefits to Regional Economies

To the extent that commercial enterprises attract recreationists from outside their accustomed market area they are expecting goods and services, that is, introducing new dollars into local economies. This new income, itself a significant benefit, then becomes available for re-spending in the local economy or outside it. The ratio which describes the amount of each new dollar which is respent in the local economy is a multiplier.

For most of the study lakes the impact of the multiplier effect will be minimal as they have few commercial enterprises geared to recreation purchases. Further, survey findings showed a substantial portion of visitors coming from within a 50-mile radius of the lake. The only lake with both significant long-distance visitation patterns and a degree of local commercial activity able to absorb extra-regional dollars is Black Hawk Lake.

LAKE BY LAKE COST/BENEFIT ANALYSIS

Environmental, engineering, and economic considerations summarized in the preceding paragraphs enabled the study team to assess costs, benefits and impacts of dredging the eight subject lakes. A rating of these considerations on a scale of one to ten (seven categories were considered quantifiable) for each lake is shown in Summary Table 1. The rating totals for the lakes provide an index of the desirability of dredging the lakes; high ratings corresponding to high desirability in terms of the categories considered. Total estimated costs of dredging and years to recover these costs based on incremental benefit values

Summary Table 1

SUMMARY RATING OF DREDGING EFFECTS OR CONSIDERATIONS FOR THE EIGHT IOWA STUDY LAKES1/

		Lake							
	Category of Effect or Consideration	Backbone	Black Hawk	Blue	Five Island	Manawa	Mill Creek	Rock Creek	Silver
1.	Availability of Spoil Area	1	9	8	8	9	0	0	6
2.	Rate of Siltation	0	10	10	9	10	0	0	9
3.	Need for Shore Protection	0	3	8	1	4	0	0	6
4.	Recreational Quality Enhancement	0	7	4	5	9	0	0	5
5.	Impact on Property Values	0	7	1	3	10	0	0	3
6.	Regional Economic Impact	0	4	1	1	1	0	0	2
7.	Environmental Effects	0	6	1	5	10	0	0	5
	Rating Totals	0	46	33	32	53	0	0	36
	Total Dredging Costs (millions of dollars)	0	$9.9	$0.7	$6.2	$8.7	0	0	$7.0
	Years Required to Recover Costs	0	101.4	25.9	93.8	9.1	0	0	191.4

1/ Note: For each category of effect lakes are rated on a scale from 1 to 10 with 10 representing the maximum positive (or minimum negative) effect. A rating of 0 in Category 1-3 was considered so seriously low as to preclude the lake from subsequent rating or consideration as a dredging candidate.

Source: Engineering Consultants, Inc., and Economics Research Associates.

derived from dredging are also shown. Again, it must be emphasized that the costs shown do not include certain costs which must be incurred for improving and maintaining lake environs. The following paragraphs summarize costs and benefits of dredging lake by lake.

Backbone Lake

Backbone Lake has been described as a mature lake that has progressed in the past 34 years from a man-made reservoir to a habitat comparable to a marsh or a shallow farm pond. Siltation has been so heavy that the microhabitat for game fish has been destroyed and upstream deposition is degrading the trout fishing and trout habitat. Boating with motors is difficult, if not impossible, in many parts of the lake, and even canoers often scrape into sediment.

The watershed is large, 78,250 acres, uncontrolled, and of sufficient gradient to bring silts and sands of the upland down to the lake in great quantities. The majority of the soils are well drained but are subject to frost action. This plus steep slopes contribute to the siltation problem.

Spoil from dredging is another difficult problem. Spoil disposal areas are limited and lie below the dam. Runoff from the spoil would probably enter the Maquoketa River; depending upon the analysis of the sediments and bottom water, downstream pollution problems could occur. The only likely spoil area could accommodate so little spoil that the positive effects of dredging would be very short-lived. Dredging at Backbone Lake is not recommended from an engineering and environmental standpoint.

Black Hawk Lake

The study team concludes that dredging of Black Hawk Lake would be desirable from a lake quality and environmental standpoint, and is feasible from an engineering standpoint if combined with the plan formulated by a local citizen group to use Hallett's Pit as a sedimentation basin. Black Hawk received a total desirability rating of 46 (out of a possible 70) which reflects the availability of adequate spoil sites and the fact that the watershed is reported to be largely under soil conservation measures. It is estimated that recreational quality will be significantly enhanced, and substantial monetary benefits could accrue to lake shore property values and the local economy.

The total cost of dredging Black Hawk is estimated at 9.9 million dollars. Certainly no such program should be started until the septic and sewer facilities for the many homes about the lake have been checked and their proper functioning verified. Point source discharges into tributaries of the lake should be surveyed and proper action taken to prevent discharge of contaminants. The spoil will fill Hallet's Pit to its premining level, so if any of the woody growth has economic value, it should be cut prior to filling. Spoil could pollute groundwater supplies in the area, though the sides and bottom of the pit seem to be comprised of fairly impermeable materials.

Though the desirability of dredging Black Hawk is high, second only to Lake Manawa, the proposed dredging is not feasible from an economic perspective. The years required to recover the costs of dredging (101.4) are probably in excess of the life of the lake. This is the result of the substantial cost of the proposed dredging program (highest of all study lakes), and the heavy impact on attendance anticipated from competitive recreation areas.

Blue Lake

A modest dredging program is proposed for Blue Lake at a total estimated cost of $745,000. There is some question as to the advisability of extensive dredging in the southern part of Blue Lake as planned, and before dredging, the value of this wildlife habitat should be determined and compared with the benefits of dredging.

The spoil disposal areas are so situated that problems can be expected. The biggest problem could be groundwater recharge through the loose sandy soils of the likely disposal area east of the lake. Secondly, an excess of groundwater could flood the septic systems and/or cesspools used in the trailer park situated east of the lake. The problem of seepage from these septic systems and cesspools is very real now and dredging should not be initiated until a groundwater survey is made of the east bank to ascertain the extent of pollution and corrective measures effectuated.

Recreational quality is expected to be least enhanced at Blue Lake, and negligible impact is expected on property values and the local economy. Further, the water quality at Blue is better than at most others, so little improvement in this aspect is foreseen. Thus, Blue Lake received a low total desirability rating (second only to Five Island).

The utility of dredging Blue Lake is marginal. Competition is expected to have a moderate impact on future attendance and the number of years required to recover the costs of a modest dredging program are substantial (25.9).

Five Island Lake

At the present time, a local citizens group is formulating plans for development of a tourist attraction using Five Island Lake as a focal point. The full development of their plans is dependent upon the dredging of the lake and the use of spoil to develop wildlife habitat in the northern third of the lake. If this is in fact a viable plan, it is suggested that cooperation with wildlife officials be sought prior to implementation. Without also planning for the proper types of cover and food, any such scheme as this is doomed to failure and may shorten the dredged life of the lake.

The dredging program proposed for Five Island Lake, at a total estimated cost of 6.2 million dollars, envisions use of some aqueous spoil disposal areas and extension of six miles of shoreline protection to preserve dredging's benefits in light of the ongoing problem of bank erosion. Runoff from the urban areas adjacent to the south end of the lake and feedlot drainage on the west side of the lake should be investigated as contributors of nutrients to the lake.

Five Island Lake received the lowest total desirability rating, primarily due to the extensive shore protection required. Recreational quality is estimated to be moderately enhanced by dredging and some impact on property values is expected. Yet, the lake draws a high percentage of its visitors from a small, sparsely populated market area which it has already penetrated at a high rate. On the economic scale of "years to recover" the feasibility of dredging Five Island becomes negative as it is estimated that 93.8 years would be required.

Lake Manawa

A substantial dredging program is proposed for Lake Manawa, second only to that proposed for Black Hawk in terms of volume and costs. The total cost is estimated at 8.7 million dollars. This cost does not include the cost of corrections which must be made in septic and sewer facilities around the lake prior to the initiation of a dredging program.

Water quality at Manawa appears to be the poorest among the study lakes. On the north shore a fish and game club, second-home developments, a private golf course and lake-associated businesses provide a wide area of impervious surface for runoff and present a very real pollution potential. A two-fold problem is presented by the housing developments situated around the lake--septic and sewer facilities and fertilization of lawns and landscaping plants. It is clear that water quality benefits from dredging could not be realized until these sources of pollution are investigated and controlled.

With so much room for improvement, Lake Manawa received the highest total desirability rating among the study lakes. The effect of dredging on water quality and recreation activities is expected to be very positive, and property values could benefit from dredging, particularly vis-a-vis the no dredge alternative.

The feasibility of dredging Lake Manawa is positive from an economic standpoint as well. The years required to recover the costs of a substantial dredging program are estimated at 9.1, considerably lower than any other study lake.

Mill Creek Lake

The watershed of Mill Creek Lake is so large and uncontrolled that sediment would be replaced about as fast as it is removed. The in-filling of the upper end of the lake and subsequent vegetation growth have provided a rather good bird habitat. Dredging could adversely affect this by reducing the water level and causing sloughing of material from upper areas into the dredged area.

Spoil disposal is also a problem. To deposit spoil in the north-east part of the lake would only serve to reduce the already small area of water as well as to infringe upon the bird habitat with attendant nega-tive consequences. Other spoil areas are inadequate to contain the amount of dredged material suggested for removal.

In view of the rapid resiltation likely and the limited spoil sites available, it is not recommended that Mill Creek Lake be dredged.

Rock Creek Lake

As in the case of Backbone and Mill Creek lakes the sedimentation rate at Rock Creek Lake is high. Dredging could be an extremely short-term improvement and would have minimal effect on water quality be-cause of continued nutrient intrusion from agricultural runoff.

Spoil disposal areas are at a minimum. The two arms of the lake in the south end are already heavily silted in, particularly in their upper reaches. These areas, in which the water is about two feet deep, are essentially lost to users of the lake and could be used for aqueous disposal. However, the wildlife habitat that has been established there would be destroyed and sediment problems in the lake might be compounded.

Therefore, because of both excessive erosion in the watershed and the nonavailability of spoil disposal sites, the study team recommends dredging of Rock Creek Lake not be considered further.

Silver Lake

Silver Lake has been dredged previously, but high silt and nutrient loads from agricultural runoff rapidly negated the beneficial effects of dredging. Since that time it has been reported by the Silver Lake Improvement Committee that 95 percent of the watershed is under conservation measures. Presumably, dredging would now have some lasting benefits, though it should not be undertaken until septic systems and sewer systems for the houses and cabins around the lake have been surveyed, the cost of which would be additional to the total estimated cost of the proposed dredging program.

From an engineering standpoint it is recommended that Silver Lake be dredged, with the extent of dredging dependent on acquisition of adequate spoil disposal sites. Some of the sites identified as possible disposal areas may become unusable if further investigations identify them as habitat for migratory birds. Should the proposed dredging program be limited as a consequence, priority should be given to deepening the eastern portion of the lake around the city water intake pipe.

The non-economic inventives to dredge Silver Lake are not high; it received a total desirability rating considerably lower than Manawa or Black Hawk. It is likely dredging would benefit the city water supply to a greater degree than the quality of recreation activities. The economic measure of dredging's desirability points to a negative conclusion; the years required to recover the costs of the proposed 7 million dollar dredging program are estimated at 191.4.

Section III

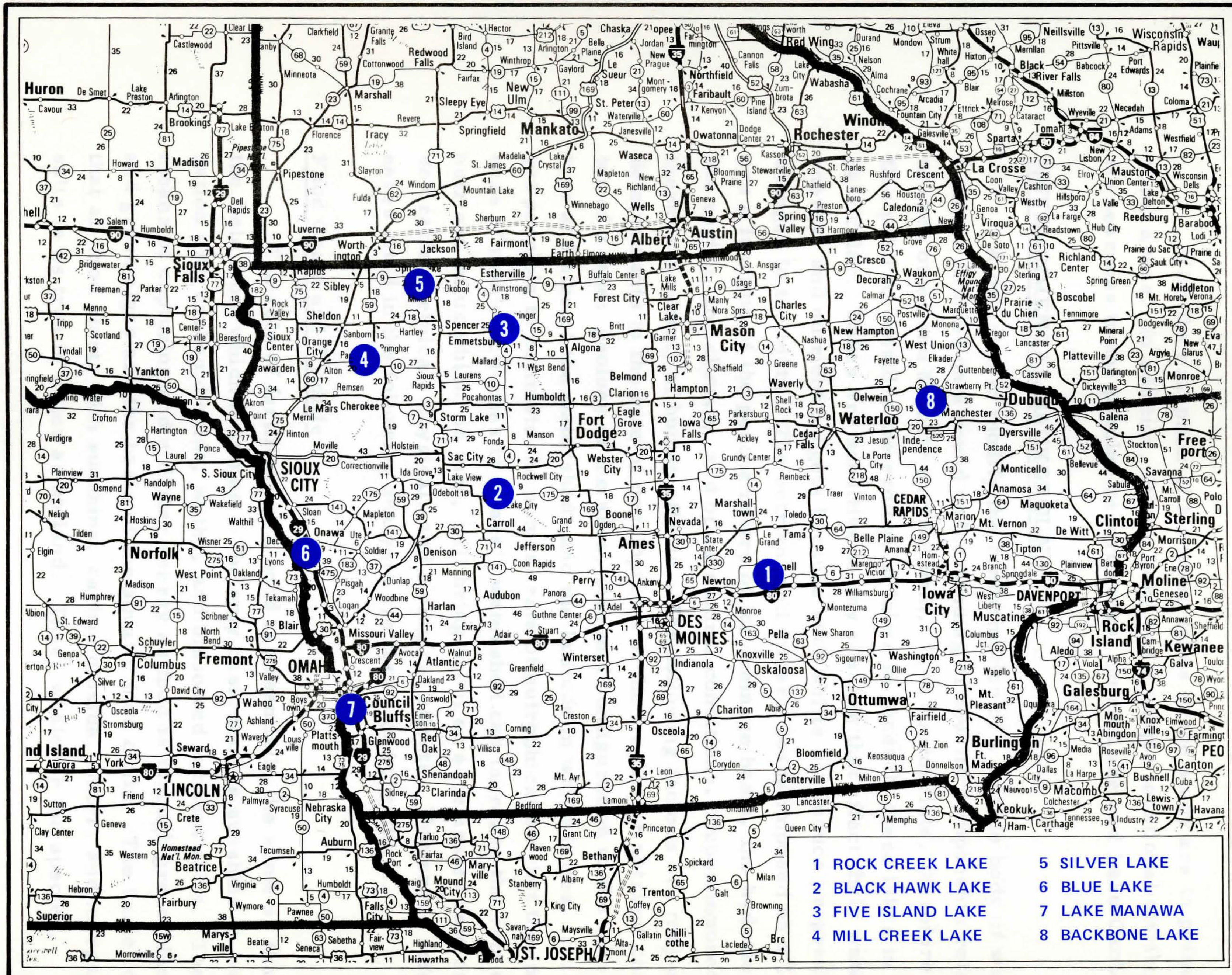
PROPOSED DREDGING PROGRAMS

Early field work by study team engineers and environmental specialists suggested that physical and environmental constraints might limit the amount of dredging feasible at some of the lakes, regardless of the desirability of an extensive dredging program aimed at improving lake quality. Accordingly, the engineering effort was conditioned by two considerations: first, what improvements do local residents and other lake users desire as indicated by community contact committees or by existing plans for lake development; and second, what physical constraints such as siltation rates, spoil site availability, shore line erosion, and the like might limit the degree to which dredging could meet recreationists' wishes. This section details the results and recommendations of engineering and environmental analyses.

LOCATION OF LAKES IN THE STUDY

Figure 1 shows the locations of each of the eight subject lakes. As can be seen, they are dispersed geographically across the state of Iowa, except that none is in the southeastern part of the state. Rock Creek and Backbone lakes are in the eastern half of the state, the former being little more than an hour's drive from Des Moines while Backbone, farther north, is approximately halfway between Waterloo and Dubuque.

Two lakes, Manawa in Council Bluffs and Blue near Onawa, are oxbow lakes formed by bends in the Missouri River along the Iowa-Nebraska border. The remaining four lie in the northwest quarter of the state: Black Hawk at Lake View in Sac County, Mill Creek near Paullina in O'Brien County, Five Island at Emmetsburg in Palo Alto County, and Silver Lake near the Minnesota border at Lake Park in Dickinson County.



Source: Economics Research Associates.

Figure 1

LOCATION OF STUDY LAKES

With the exception of Manawa, lakes in the study are in primarily rural areas. In addition, Silver Lake has a unique locational attribute in its nearness to the popular resort areas, Spirit Lake and Lake Okoboji.

ENVIRONMENTAL BACKGROUND

A decision to modify the conformation of a sizable body of water must be founded on a sound understanding of how its components relate to each other and to their environment. It is appropriate, therefore, at this point to consider the ecology of lakes in general, these lakes in particular. Lakes are sensitive to any changes that affect their water, energy, and nutrient budgets because such shifts can induce progressive changes in the biota. The nutrient and mineral loads imposed on a lake are a function of the geochemistry of its drainage basin, the hydrology of the region, the climate, and other natural conditions. Superimposed on these is a variety of human effects. The following factors are major determinants in the rate of development of the trophic or nutrient character of a lake: geology of the area, size and configuration of the lake basin, type and size of the watershed, and the latitude in which it lies. It is not yet possible to estimate the natural rate of eutrophication, but the influence of man'e activities in a lake's watershed can increase the rate of nutrient influx which, in turn, will bring about an accelerated rate of undesirable chemical, physical, and biological effects. Numerous references cited in the following analysis are listed in Appendix A.

Food Chain and Wildlife

The role of fertilizer in a pond is essentially the same as that in the field from which it comes. The only basic food is sunshine in combination with carbon dioxide, water, and dissolved nutrient salts. The sole means of capturing and utilizing energy as food is through green plants, and green algae are the basis of the aquatic food chain. The basic idea that all food starts with sunshine, carbon dioxide, water, and inorganic salts is as true in water as on land. Thus, whatever the species, whether predatory bass or bottom-dwelling sucker, the cycle of events that leads to fish on the line starts with the photosynthetic activity of green plants. In water the fundamental food unit is the noncolonial green alga plant. Other simple algae, such as the blue-green algae, the diatom, and the filamentous green algae, may also enter the food chain. Green algae are in a few instances consumed directly by fish, usually forage species like the blunt-nose minnow, stone roller, and gizzard shad. In a typical pattern the algae are eaten either by plankton organisms such as daphina (the water flea) or a related crustacean, or by aquatic insects. There may be interposed at this point a varying number of steps from green algae directly to small fish, or from algae to crustacean to insect to fish, or an even more complex pattern.

Shallow ponds and marshes are the most productive of all types of aquatic habitat. They are most attractive to waterfowl, especially the dippers or paddlers such as mallards, pintails, and teal who, with muskrats and their hay-mound huts are an integral part of this kind of environment. Crayfish for the raccoon and seeds for the mice, which in turn are food for the mink and fox, can be found here while the periphery of a marsh contains grasses and plant communities that provide food and cover for pheasants, rabbits, skunks, and a host of others.

Decline in Wildlife

Since the natural lakes of the study can be classified as Type 5, "inland open fresh water," with some lakes associated with Type 4, "inland deep fresh marsh," wildlife becomes an important consideration when contemplating any change in the lakes' status. Type 5 areas are used extensively as breeding grounds in the North Central States. The borders of such areas serve as nesting sites throughout the Northern states and wherever vegetation is plentiful; they are used in all areas as feeding and resting places by migratory waterfowl. In some of the Midwestern states a decrease in certain bird populations has been noted in the past 15 years. An extensive study by the Natural History Division (Mills, et al, 1966) of the state of Illinois showed a decrease in waterfowl including mallards, the lesser scaup, ring-necked duck, and other diving ducks. Other bird populations that have dwindled significantly are the cormorants and herons. Egrets showed an increase until 1962, but have declined since that time. It is suggested that the drop in the number of these birds is related to water pollution with subsequent loss of food supply. Excessive sedimentation and toxic wastes destroyed fingernail clams and other bottom fauna, creating a drastic reduction in the food supply of the diving ducks. In addition, changes in water level have had a serious effect on emergent shore vegetation and on the insect population that it sustains. The loss of this food source also has affected waterfowl populations.

While the decrease in most species was attributed to pollution and loss of food supplies, the lower mallard population resulted from the drought in the middle 1950s. It is interesting to note that residents of Emmetsburg, Iowa, remember the many waterfowl that made use of Five Island Lake prior to the drought in 1954-1955. Neither the habitat nor the wildlife populations have returned to predrought conditions.

There are all types of water habitats and many different patterns of plant and animal successions. The ecology of marshes and shallow ponds is a science in itself, as is the ecology of lakes and streams. Most people concerned with the water resource problem cannot be aware of all the details of the various professional areas, and they should realize that fish and game production is fraught with problems directly related to the fields of pollution control, watershed management, water rights, economics, and other disciplines designed to improve human welfare. The degree to which any particular wetland area can be made more productive for wildlife depends largely on local factors.

LAKES OF THE STUDY AREA

Chemical Analysis

Table 1 gives the chemical analysis for the water of five of the study lakes. The chemistry of the average water for all lakes is quite similar to that of river water in Iowa. In general, the Iowa lakes are typical hard-water bodies of the bicarbonate type. However, analysis of water samples taken from Silver Lake in 1956-1957 (Coble, 1969) show a much higher reading for dissolved solids (696 mg/l) and sulfate (290 mg/l) than do the other lakes. These sulfate concentrations were 10 times those obtained from samples in West Okoboji.

Bachmann's data (shown in Table 1) do not indicate this range. In fact, his data show the sulfate content in West Okoboji to be 3 ppm greater than that at Silver Lake. Volker (1962) reporting on a study at East Okoboji found sulfate, chloride, and total hardness concentrations in line with those reported by Bachmann. This confirmation conflicts with Coble's data of 1969 and highlights the need for current information on the lakes involved in this study.

General Characteristics

Studies involving Iowa lakes (Volker, 1962; Owen, 1958; Mitzuer and McDonald, 1969) and lakes in Minnesota (Manson, et al, 1968) present information that may give a general insight into the characteristics of the lakes being examined here.

Shallow lakes such as those under scrutiny are subject to constant wave action. As shown in the above-referenced studies, this motion eliminates oxygen and temperature gradients. Because of the elimination of the temperature gradient, no thermocline was established and consequently no epilimnion or hypolimnion were differentiated. The natural churning of the water and those waves caused by motorboating had a significant effect on lake bottom sediments, bringing much debris into suspension. The

Table 1

CHEMICAL ANALYSIS OF WATER OF FIVE IOWA LAKES
July-August, 1964

Lake	Specific Conductance	Alkalinity ppm $CaCO_3$	Total Hardness ppm $CaCO_3$	Ca ppm	Mg ppm	Cl ppm	Sulfate ppm
Backbone	358	153	181	42	19	55.0	33
Black Hawk	430	153	206	37	27	1.9	61
Five Island	327	136	151	28	20	14.9	14
Rock Creek	289	125	140	36	12	4.0	26
Silver	588	114	276	46	39	6.9	26
Average for Lakes Within Wisconsin Glacial Drift	409	160	199	35	27	5.9	46
Average for Lakes Outside Wisconsin Glacial Drift	261	102	116	30	10	5.8	24

Source: Bachmann, 1965.

resulting turbidity in the euphotic zone affected light penetration, photosynthesis, and in turn dissolved oxygen concentrations. Although not reported, this constant shifting of bottom sediments must certainly have had a great impact on bottom-dwelling fauna, not to mention the effects on fish reproduction and feeding. In addition to these problems, Bartleson (1971) reported a doubling of the phosphorus concentration in the water when bottom sediments were agitated.

Runoff and Sediment

Of the eight lakes considered in this study, five are natural lakes (two oxbow lakes and three shallow lakes in the glacial drift) and three are man-made impoundments. Each of the man-made lakes is so situated that its watershed is many times larger than the reservoir area; as a result of this imbalance, each is seriously threatened by sedimentation. Adding to the imbalance of the watershed-reservoir ratio is the fact that within each watershed the topography and the soils are such that the erosion potential is high. The midcontinent climatic conditions add a further dimension to sediment yield problems in the uncontrolled watersheds.

Table 2 shows surface and watershed acreage for each of the subject lakes. The natural lakes have fairly small watersheds. In fact, the two oxbow lakes, Manawa and Blue, can be considered to have no effective watershed, and the watershed for Five Island Lake is principally confined to tile drainage. Silver Lake with the largest watershed of the natural lakes, a watershed-reservoir ratio of 15.5 to 1, is reported to be 90 to 95 percent controlled by conservation measures. The watershed for Black Hawk is slightly smaller with a watershed-reservoir ratio of 14.1 to 1, and conservation measures are being implemented. Approximately 50 percent of the watershed is presently covered by conservation measures.

The lakes have high nitrate and phosphate levels, most likely because of the intensive agricultural activities within their respective watersheds. In addition, organic matter and sediment are contributed to the

Table 2

SURFACE AND WATERSHED AREAS
FOR THE SUBJECT LAKES

Lake	County	Surface Area (acres)	Watershed Area (acres)
Backbone	Delaware	125	78,250
Black Hawk	Sac	957	13,500
Blue	Onawa	918	1,361
Five Island	Palo Alto	945	7,440
Manawa	Pottawattamie	660	negligible
Mill Creek	O'Brien	25	3,500
Rock Creek	Jasper	640	27,260
Silver	Dickinson	1,068	16,550

Source: Iowa Conservation Commission.

lake's regularly by runoff from the agricultural lands in their basins. These substances, together with the shallow nature of the lakes, make them eutrophic, with high biological activity. Extensive blooms of blue-green algae have been reported on all the lakes, and complaints have been made regarding the unsightly conditions and frequent unpleasant odors.

Eutrophication of a body of water includes the accumulation of sediments. Such a process is evolutionary, and all lakes are affected by it to a greater or lesser extent. It is difficult to separate the effects of sedimentation from those of other factors on the limnology and fishery of a lake. The cultural introduction of nitrates, phosphates, and other inorganic substances, as well as the buildup of organic sediments from the life processes within the lake itself result in an increased supply of nutrients for plankton and then higher forms of aquatic life. The deposition of silt reduces depth and produces a closer association between the zones of photosynthesis and decay.

Runoff, with the resultant sediment and nutrient load, will continue as long as an area receives precipitation. Effective controls are needed to prevent erosion, to short-circuit feedlot runoff, to reduce introduction of nutrients into lake waters. Over the past 83 years, Iowa climatic data show a tendency toward "wetter than average years." This means greater than average runoff and hence accelerated erosion. Such a condition is important, particularly in agricultural areas, as it has been found empirically that 18.2 percent of the precipitation on land planted to corn is lost as runoff. This compares with only a 1.2 percent loss from land growing continuous bluegrass.

Schuab (1956) estimates the minimum yield from an average Iowa watershed to be 2.1 inches of run-off per year. By using this figure with data provided by Livesey (1972), estimates of sediment production can be obtained for the watersheds of the study lakes. These estimates are shown in Table 3.

Table 3

ESTIMATED SEDIMENT YIELD FROM IOWA STUDY LAKES' WATERSHEDS

Lake	Sediment (acre-feet)	Production (tons per square mile)	Lake Size (acres)
Backbone	244.4	250	125
Black Hawk	42.5	350	957
Blue	negligible	negligible	918
Five Island	23.3	375	945
Manawa	negligible	negligible	660
Mill Creek	47.0	350	25
Rock Creek	85.2	900	640
Silver	51.7	340	1,068

Source: Schuab (1956) and Livesey (1972).

If this procedure correctly estimates the sediment yield from the various watersheds, it can be seen that about 2 feet of silt can be expected to accumulate in Backbone Lake every year. The rate of filling can be calculated for all the lakes; however, this sediment yield figure presupposes an uncontrolled watershed.

One thing that increases the sediment problem is the recent tendency to increase cultivated acreages in Iowa as farmers are putting into production the steeper, more easily eroded lands. Also there has been a trend from maintaining pasture and hay meadow to cultivating row crops with the concomitant increase in erosion.

The lakes are all fairly shallow. The natural lakes are inherently shallow, although siltation may take up as much as one-half of the pool area in the cases of Manawa, Five Island, and Black Hawk. In the man-made lakes the percentage is probably higher, but despite this Rock Creek Lake has areas along the old channel where water depths range up to 12, even 16 feet.

For several of the lakes, the inlet or some man-made structure plays an important role in controlling sedimentation in the lake proper. In Rock Creek the highway bridge across the northern part of the lake constricts the general flow of water into the southern part and, as a consequence, much of the silt is deposited above the bridge or just below it in a subaqueous delta. A similar situation exists with Five Island Lake, where a railroad bridge separates the lake's northern four-fifths from its southern fifth. Inlet bays are important for this same reason: at Silver Lake, Trappers Bay; at Black Hawk, Prospect Bay. The net result in each case is an excess of sediment and fairly rapid filling above the structure or within the bay, with concomitant growth of vegetation and algal blooms.

Mill Creek and Backbone lakes do not have these controls and, as a result, the full effect of the movement of the silt is felt by the main body of the reservoir. Blue Lake and Lake Manawa, with no effective watersheds, used to be subject to siltation by floodwaters of the Missouri; but with the development of levee systems and other controls, this source of sediment is now fairly remote.

Sources of Pollution

All the lakes are subject to pollution from various sources, although these may vary from lake to lake. Except for the oxbow lakes, the principal source of pollution is agricultural runoff; this includes fertilizers, pesticides, and herbicides applied to crop lands in the watershed, as well as feedlot runoff. Potential for feedlot runoff is particularly noticeable in the drainage area of Silver Lake and Five Island Lake. Inasmuch as recharge for Lake Manawa is supplied via conduit from Mosquito Creek, any nutrient or other pollutant present in this creek would be introduced into the lake.

A major potential for pollution present at Five Island, Black Hawk, and Manawa is runoff from urban areas. Since runoff from the golf course at Manawa could enter the lake, any excess fertilization of the fairways or greens could contribute unwanted nutrients to the lake.

One source of pollutants that needs an in-depth study because of its potential hazard to human health is the effluent from housing developments, cottages, and farmhouses situated about every lake. This is a very real problem at all lakes except Backbone and Mill Creek. It has been assumed in the areas not serviced by sewers that septic systems are in use, but this is not necessarily the case. The effluent from some dwellings is direct to drainage ways leading to the water body. Even in the areas using septic systems, nothing is known about the efficiency of the systems, the capacity of the drainage fields, or the transmissibility of sediments into which the septic systems drain. Certainly in those areas where development is particularly dense or ill-planned this must be a major problem. Examples of such development can be found at Silver, Black Hawk, Blue, and Manawa lakes. Unfortunately, little concern is expressed for this potential health hazard. The high nutrient level of Lake Manawa for example is very suspicious inasmuch as this lake's watershed is limited.

Also along these same lines, nothing is known about the leakage from the sewers where sewer systems are present and infiltration of the effluent into the ground water and hence into the water body is a possibility. How old and efficient are the sewer systems? What is the line loss? These are other questions which cannot be answered with available information.

Regarding possible groundwater pollution, it is interesting that at Blue Lake, where supplemental water is provided by a shallow well, filamentous algae were observed only around the outlet of the well to the lake. This could imply a high nutrient content in the well water. However, algae have been reported in other parts of the lake as well.

One area of potential pollution by sediment that has not been considered is bankcaving. Bankcaving can be brought about during high water and storm conditions such as occurred this spring at Rock Creek. It can result from wave action due to the prevailing winds or from excessive use of motorboats. This later point has been disputed; however, a study in Illinois (Roberts, 1971) indicated that a speeding boat pulling a skier at 20 miles per hour at a distance of 20 yards from shore can send waves shoreward that exert pressures between 500 and 1,000 pounds per square inch on the bank materials. Obviously this potential for erosion exists at all lakes where such activities are allowed. One aspect of bank erosion not considered is the equilibrium position. For example, depending upon the types of sediments, a certain point is reached when sufficient bank material has been eroded to provide a protective reach which greatly reduces potential for further erosion. These areas can be found at most lakes, and nothing should be done to upset the equilibrium conditions.

The lakes have been broken down into two general categories, natural and man-made, and two subclasses of natural lakes, oxbow and glacial.

Although generalities can be expressed about a class or subclass, each lake has its own personality based on its site and situation. Effects of dredging are best judged according to local conditions.

GENERAL ENVIRONMENTAL EFFECTS OF DREDGING

Short-Term Effects

The water, energy, and nutrient budgets are critical to a lake's existence and each of these could be affected by dredging. Few analyses of these changes have been undertaken until recently, when the Corps of Engineers initiated a study of dredging and its effects. Physical alterations induced by dredging include changes in bottom geometry, creation of deeper water areas, changes in bottom substrata and habitat, modification of future sediment distribution patterns, alteration in the sediment-water interface with subsequent release of biostimulatory or toxic chemicals, and creation of turbidity clouds.

To date, the Corps' studies have documented few short-term effects. The short-term effects associated with aqueous disposal operations can usually be detected during the disposal operation or shortly thereafter. The most common of these effects reported are:

1. Turbidity: aesthetically displeasing, reduces light penetration, flocculates planktonic algae, decreases availability of food.

2. Sediment buildup: destroys spawning areas, smothers benthic organisms, reduces bottom habitat diversity, reduces food supplies, reduces vegetation covering.

3. Oxygen depletion: suffocates organisms in the area, releases noxious materials such as methane, sulfides, and metals.

The possibility of long-term effects are usually attributed to the presence in sediments of constituents other than rock debris and soil, such as biostimulants (phosphates and nitrates) and toxins (heavy metals, pesticides). Both of these types of components--biostimulants and toxins--are often chemically or physically absorbed within the sediment matrix. The full impact of the release of these materials is not known because the chemistry and nutrient uptake of the various forms of aquatic life is not understood.

Silting

As opposed to the dearth of studies related to the effects of lake dredging, there is extensive literature on the effect of silt on aquatic organisms (Langlois 1941; Buck 1956), especially estuarine species. Effects on phytoplankton and light attenuation have been reported by Ragotzhie (1957), Jones and Willis (1956), and Williams (1966). The effects of silt and dissolved solids on fish eggs, larvae, and adult fishes were reported by Langlois (1941), Buck (1956), and Jones (1956), while Wilson (1956) and Aldrich (1961) detailed the effect of sedimentation on the benthic community. Most of these are related to estuarine and riverine studies. While none of the studies pertains to lakes, the results are of interest in any scrutiny of a water environment. No gross effect from disposal of fine material was observed in microscopic plants and animals, in eggs and larvae, or in adult fish. Some species of bottom animals survived deposition, and several began repopulation soon after deposition. This general information in view of the report by Owen (1957) suggests that few long-term effects will be experienced by bottom-dwelling organisms. In fact, if one is concerned about the effect on fishing, Owen's study indicates that dredging may actually benefit certain forage fauna such as Chaoborus larvae and Chironomidae larvae. Both species were found to be more abundant in the dredged zone of North Twin Lake, Iowa, than in the undredged portion. Owen's results indicated an annual crop of both species of 33.1 pounds per acre in the dredged portion of the lake compared to 16.1 pounds per acre in the undredged zone.

What makes this meaningful is that Kutkuhn (1955, 1958) found that fish in North Twin Lake were not necessarily selective as to food class but readily ate what was most available. More to the point, he found that adults of all species sampled seemed to have a preference for the Chaoborus larvae and pupae, and these were found in large numbers only in the dredged zone of North Twin Lake.

At the time of his investigation, some 15 years after dredging, he also found that higher aquatic vegetation, both submersed and emergent, was noticeably sparse and spotty. However, he did not relate this lack of aquatic vegetation in any way with dredging.

Turbidity

One very noticeable effect of dredging is an increase in turbidity from the disturbance of the bottom sediments. Primarily, productivity and abundance of phytoplankton and the amount of dissolved oxygen are related to turbidity. Turbidity, by confining insolation to the surface layer, has a tendency to raise surface-water temperatures. An increase in temperature by itself is bad but it also can synergize the effects of pesticides, heavy metals, dissolved gases, detergents, and other toxic or debilitating pollutants. Higher temperature can decrease the oxygen content and, under certain circumstances, may also accentuate development of algal blooms, particularly the blue-green species.

Chemical Changes

In addition to increasing the turbidity, disturbance of bottom sediments can increase the amount of organic material in solution and change the chemical content of the water. When there is an increase in organic material there is a concomitant increase in oxygen demand, a change that can contribute to dangerously low oxygen levels.

Chemical changes in the water of dredged lakes have been reported by Bartleson (1971), Churchill and Brasher (1972), and Brasher et al (1973). Reporting on a lake-dredging project in South Dakota, the latter two investigators recorded changes in alkalinity, silica, and manganese, which showed a general increase, and in calcium and total hardness, which decreased. The most dramatic change was in phosphate levels, both orthophosphate and total phosphate. Specifically, beginning in the summer of 1972, within a few days of the commencement of dredging operations, phosphate levels at all monitoring sites exhibited a sharp rise. A 300 percent increase in orthophosphate was recorded. A concomitant increase in vegetation was not recorded.

In this same study the chemical characteristics of the spoil area were also monitored. It was found that water from the dredge spoil underwent chemical changes also. Monitoring indicated a decrease in pH and in orthophosphate levels and a 10 percent increase in conductivity. Records pointed to a reaction toward the neutral--sometimes lower by 2 pH units. Four months after dredging operations ceased, the silt deposits had a lower orthophosphate level (0.19 mg PO_4/liter) than the lake water had before dredging began (approximately 0.35 mg PO_4/liter).

Problems of Spoil Disposal

Three basic problems are associated with land disposal of spoil: (1) environmental impact of disposal, not at all understood at this time; (2) problems of site availability; and (3) technical problems related to design, construction, operation, and utilization of land disposal sites. There have been very few studies concerning the effect of land disposal. Diversity of environmental situations creates problems since no one dredging procedure will be satisfactory everywhere.

Problems exist with disposal because spoil can contain other solids such as rock, wood, broken glass, pieces of metal, and other debris. Grain size, moisture content, and plasticity--all important properties about which little is known--affect dredging rates, types of equipment, and methods of disposal. Grain size also determines the amount of turbidity associated with dredging and disposal and the rate at which solids settle. Spoils with high water retention cause land disposal problems as excessive moisture is frequently associated with objectionable odors and high organic content. As a result there are potential health problems associated with disposal. Containment areas can become mosquito breeding grounds and high bacteria counts have been observed at disposal sites following periods of heavy precipitation.

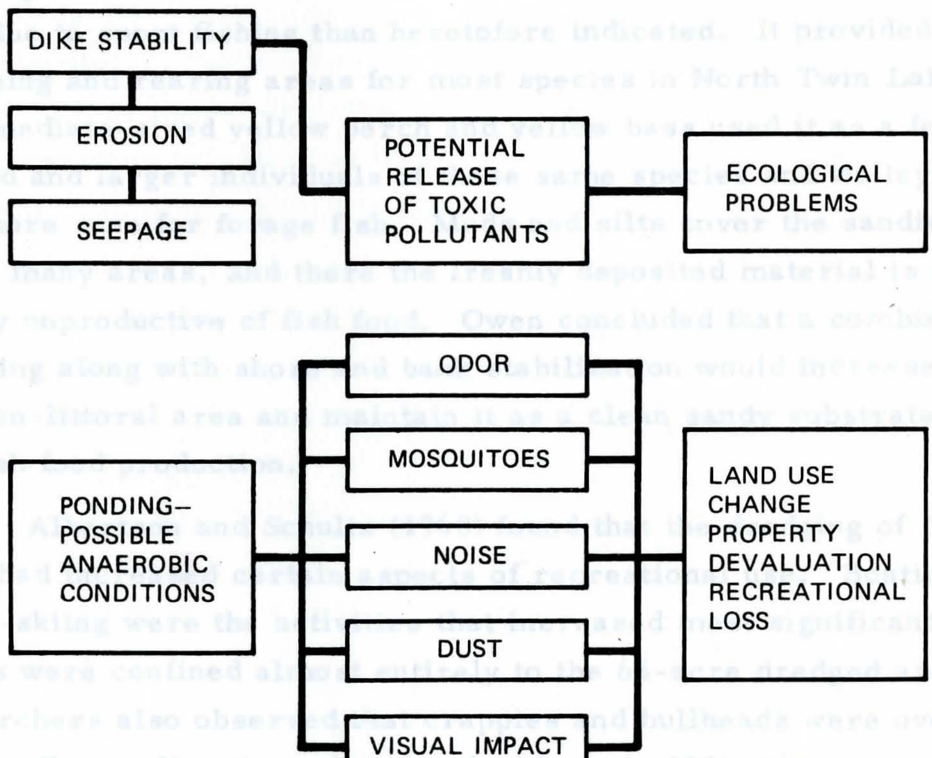
Objectionable conditions fall into three categories: (1) those associated with disposal area effectiveness, for example, dike failure; (2) those associated with biological, chemical, and physical changes caused by the disposal area; and (3) those arising from site selection, such as ecological disruption and land-use changes. Figure 2 portrays the various impacts of dredging and dike stability.

Rehandling of polluted dredged materials is an alternative. Solids and liquids could be separated and, if necessary, the liquid portion treated. Solids could be conditioned and separated and marketable materials sold. Highly polluted materials would be minimized in the process. Such a course of action would, however, be expensive.

Lake Dredging in Iowa

To a limited degree some investigators have studied the effects of lake dredging in Iowa. North Twin Lake has been studied by Owen (1957, 1958), and Kutkuhn (1955, 1958). Little Wall Lake in Hamilton County, Iowa, was studied by Albertson and Schultz (1968). Additional limited data are available from a study of lakes in South Dakota (Brashier, et al, 1973).

During the past 35 years several lakes in Iowa have been dredged. The one receiving the most scientific attention has been North Twin Lake in Calhoun County, which was partially deepened by dredging in 1939 and



Source: Engineering Consultants, Inc.

Figure 2

IMPACT OF DREDGING AND DIKE STABILITY

and 1940. Owen (1958) noticed that the erosion-littoral area (the wave-washed shore zone) at North Twin Lake was substantially wider in the southern end where dredging had been performed. The erosion-littoral zone was 77 feet in the southern area compared to 57 feet in the northern undredged end. Owen also found that this wider littoral zone was of greater value to sport fishing than heretofore indicated. It provided essential spawning and rearing areas for most species in North Twin Lake. Intermediate-sized yellow perch and yellow bass used it as a feeding ground and larger individuals of these same species and walleye visited the shore zone for forage fish. Muds and silts cover the sandier materials in many areas, and there the freshly deposited material is almost totally unproductive of fish food. Owen concluded that a combination of dredging along with shore and bank stabilization would increase the erosion-littoral area and maintain it as a clean sandy substrata suitable for fish food production.

Albertson and Schultz (1968) found that the dredging of Little Wall Lake had increased certain aspects of recreational use. Boating and water-skiing were the activities that increased most significantly but these sports were confined almost entirely to the 65-acre dredged areas. The researchers also observed that crappies and bullheads were over-abundant and small, smaller than what they had been in 1956, three years after dredging. The game fish were larger, with large mouth bass and pike doing quite well, but boating activity was so extensive that bass fishermen were discouraged from trying to fish. From a recreational standpoint one activity was enhanced at the expense of another. From such studies one gains an insight into the importance of planning and establishing priorities before undertaking any project.

All lakes do not react to dredging in the same way; morphometric characteristics of lakes are not the same-small volume and shallow depth may facilitate greater nutrient retention. Chemical characteristics are different and vary with sediment rate and flushing rate. Windom (1972), reporting on effects of dredging in estuaries, states that in natural and relatively unpolluted areas dredging has no significant adverse effect on water quality, and in polluted areas water quality improvement does not necessarily bear any simple relation to the composition of sediment dredged.

Unfortunately, this study does not perforce relate to lakes in general or lakes in Iowa in particular. No criteria can be set up for environmental effects at the present time because of the lack of information. Dredging and the resultant disposal of spoil are increasingly complex problems.

The most obvious effect of dredging is the introduction of the dredge into the lake. Its physical presence and the spoil pipelines will create an aesthetic change during the life of the project. The pipeline carrying the spoil will block transportation and boating on one side of the barge. Higher noise levels will prevail as the motors and pumps on the barge remove the spoil to the disposal areas. These surface phenomena will last through completion of the project. Other surface phenomena will be the effects on the emergent vegetation and the littoral zone as the water level falls during dredging. Inasmuch as 80 percent of the material dredged from each lake will be water, a significant reduction in lake level is a distinct possibility.

This projected reduction in water level will also affect the wildlife and fish habitats, with the degree of impact depending upon the rates of dredging and of dewatering the sludge. Care should be taken not to reduce the water level too much; the dilution factor for turbidity and nutrients reintroduced into the system by dredging could be reduced to levels fatal to the fish population.

Positive effects will arise from lowering the water level during dredging. This lowering will allow maintenance of the littoral areas and banks as well as permit control of unwanted vegetation.

Summary and Conclusions

Few studies have been made regarding the effects of dredging and the placement of dredge spoil. Only recently has the federal government, through the research efforts of the Corps of Engineers, Waterways Experiment Station, begun an intensive examination of dredging problems. Most of their activities to date have centered around channel dredging, harbor dredging, and coastal operations. Their efforts are too recent to have produced practical results and data for use in analyzing lake dredging.

Outside of the immediate effect of the dredge itself, the short-term adverse effects may be summarized as follows:

1. Temporary destruction of bottom fauna
2. Disruption of fisheries
3. Disturbance of wildlife, particularly by noise
4. Eradication of some aquatic vegetation
5. Increase in turbidity
6. Lower water levels
7. Increase in nutrient loads.

Indications are that the effects will be short-lived, lasting only as long as the dredge operates. On a long-term basis, assuming proper lake management techniques are followed, it appears that water chemistry will improve, bottom fauna will recolonize in greater numbers, and overall fishing potential will be enhanced. Motorboating and water-skiing will definitely be improved, but management is necessary to prevent the activities of one group from disrupting those of others.

Based on available information, it appears that nutrient release in summer would be more likely to produce bloom conditions than it would in fall or winter. In late fall dredging would have the least effect on the benthos; natural population levels of most species are at their lowest level in November and December. During February, March, September, and October one can expect the least damage to fish eggs, larvae, post-larvae organisms, and the young. From this it might be suggested that dredging, if adopted as a viable plan, should be conducted in the fall to mitigate the effects of the resultant disturbance to the system.

The public is becoming more aware of the effects of water pollution and is demanding lake rehabilitation. The general attitude seems to be that dredging is the panacea. Care should be taken to explain that dredging is not a cure-all, that it should not be undertaken without understanding the operations and their consequences, and that no action should be taken without the prior development of a plan and the setting forth of the purposes and results sought.

Limnology is a fairly new science and present scientific and technical knowledge of lakes and their environment has been applied only to a very limited extent. Stumm and Morgan in 1970 gave this succinct statement of the problem:

> How can we restore the ecological balance between photosynthetic and respiratory activity in a nutritionally enriched (polluted) lake? We have to develop the ability to modify and to manipulate our aquatic environment in order to improve its quality. Despite significant developments these problems cannot be solved by technology alone as long as we lack the necessary understanding of the aquatic environment. Man masters nature not by force but by understanding.

GENERAL ENGINEERING ANALYSIS

An extensive review of the literature on lakes and ponds reveals that there is no finished lake dredging project in the upper Midwest for which there are complete and reliable data. Basic information relating to the effects of dredging on the ecosystem of a lake is difficult to find. The literature indicates that there appears to be little concern about how dredging can improve lake environment or about the possible damage that it may cause.

There have been many minor lake dredging projects in the Midwestern United States that were primarily concerned with the improvement of the littoral zone. Many of these included only several hundred feet of the lake shoreline and have not contributed to the scientific knowledge of lakes.

Land Disposal

A significant problem faced in dredging programs is the scarcity of sites available for confined land disposal. Locations suitable for receiving spoil from the lakes to be dredged will be difficult to acquire or lease. If new uses for spoil can be found, they will help to alleviate the problem. In addition, ways must be found to reduce the environmental impact of land disposal, revising or modifying disposal areas so as to make them more attractive and less objectionable.

In most of the terrain around the eight lakes, available land within reasonable distances of the proposed dredging areas is scarce, and is usually in the form of scattered tracts. While foundation conditions are generally good, at most locations, because of geographical conditions, spoil cannot be massed to considerable heights.

Disposal Site Conditions and Dike Construction

The range in variation in size of containment areas is so great as almost to preclude generalization. Sizes range from a possible maximum of about 300 acres to some parcels of less than 10 acres. All of the likely containment areas around a lake will probably be developed for a single dredging operation. At this stage it is impossible to estimate the construction costs. Some of the feasible containment areas will be small, artificially closed, natural depressions and others are wholly artificial diked facilities on rather flat agricultural ground. At only one lake is it proposed to use a paludal location. For the containment areas a dike, levee, or bulkhead will be the characteristic feature. It appears that the dikes can be constructed of local materials such as rock, rubble, industrial refuse, or related materials. Undoubtedly the earthen dikes will have to be reinforced, bolstered, or augmented with lumber, railroad ties, plywood sheeting, plastic sheeting, or the like. Nearly every containment area should have a spillway or overflow weir and maybe settling basins. To accommodate varying filling rates and ponding time requirements, most of the weirs should be either stoplog or height adjustable types. It is anticipated that dike construction problems will vary with location, especially from the ground moraine to the Missouri River Valley. Most dikes will be 4 to 10 feet in height.

Dike design should always be preceded by adequate soil exploration involving boring, sampling, and testing. Such a program is needed to inform the designer about physical properties of the subsurface and alert him to any unusual conditions which may affect the structure. Stability analyses are needed to determine the factor of safety of the fill with respect to its base. Proper design and construction will ensure that the dike is safe and stable during all phases of construction and operation of the containment area. Since foundation soils can vary widely, there probably should be a variety of dike designs. Each dike should be designed specifically for its site. However, there are certain design procedures that can be used as guidelines for all of the likely containment or disposal areas.

Normally, construction methods and techniques are left to the discretion of the contractor. However, the construction companies are usually only interested in satisfying the requirements of their contracts. Special design consideration must be specified in the contract and attention given to soils known to cause dike failure. For example, dikes on very soft or marshy ground or on thick strata of relatively homogeneous soft clay are susceptible to failure by sinking; dikes on stratified ground containing layers of soft clay or clay containing sand and silt are apt to fail by spreading.

A containment area should be considered as a settling pond whose waters will probably need protection from the wind. The detention time is a function of the inlet flow rate and storage volume. It is necessary when planning a containment area to estimate the rate of fill as well as the settling and dewatering time. As filling continues, settled solids will decrease the volume and the detention time will be decreased. Therefore, settleable solids tests should be run on the materials that will be dredged so that removal efficiencies can be estimated in relation to, or as a function of, detention time. One of the main functions of containment areas is to remove suspended solids from the return flow and consideration must be given to outlet structures and return ditches. In other words, the outlet structure should be such that there will be no short-circuiting of the flow from the inlet. The structures should be adjustable weirs or rectangular outlets with stop logs and should always be vertically raised or lowered in a manner that provides adequate retention time and return water quality control. It may become necessary to line the return ditches to prevent scouring and permit turbidity control.

Obstructions

The presence of tree stumps, large boulders, and refuse creates problems in lake dredging. These slow the dredging process, resulting in increased costs. The usual procedure is to excavate around these obstructions or to remove them with cranes or draglines operated from shores or on a floating barge.

Sedimentation

In attempting to define the conditions contributing to the existing status of lake sedimentation, an assessment of erosion in the watershed must be made. Erosion control of developed riparian land and lake banks is a must as shore line erosion can cause significant sedimentation.

Generally, in Midwestern lakes, the materials at the sediment-water interface are highly flocculent and may consist of 80 percent or more water. At increased depths in the sediment profile, densities generally become greater down to hard lake bottom. The flocculent materials can cause major handling problems.

Accurate delineations of physical characteristics which define the depth, classification, type, and location of the sediments are needed. These measurements are necessary in determining the most feasible method of removing the material and the total volume to be withdrawn. Other physical factors which need to be determined and studied in detail before dredging is done are: temperature of the water, lake area and volume, turbidity, hydrology of the lake basin, lake depth, and the relationship between the physical-chemical and biological factors.

Hydrology

Before developing dredging plans, the hydrology of the lake watershed should be analyzed. This study should include both surface water and groundwater and the effect of lake dredging on both. Under certain conditions a lake could possibly be ruined by removal of the bottom seal.

By utilizing a hydraulic dredge to remove lake sediments, it is possible to lower the lake level to such an extent that the dredge cannot operate. This problem is fairly common in dredging small lakes when the dredge water is not returned to the lake.

Lake Mapping

A hydrographic map of the lake bottom is necessary to determine project feasibility and estimated project costs. Sounding data to discover depth of sediment and a determination of the depth of flocculent materials are needed to decide on the type of dredging equipment and estimate the cost of excavation of spoil. Preliminary sounding stations should be properly spaced so that general relief of the present lake bottom can be obtained to determine the final spacing which is necessary for quantity computations. The payment for removal of sediment is usually based on the quantity of material actually removed. Inaccurate quantity computations, because of insufficient or unreliable data, can result in grossly inaccurate preliminary cost estimates.

Bottom Sampling

The required amount of bottom sampling data will vary from lake to lake. The extent of bottom sampling is dependent upon the variation of lake bottom soil conditions. Generally, the type of sediment present will not vary markedly throughout the lake, but the widest variation will occur between samples taken near the shore line. Bottom samples are required to assess the effect of their removal on the lake environment and for determining the preliminary estimate of dredging costs.

Precedence Diagram

Figure 3 is a detailed diagram showing the precedence attached to each of the numerous considerations involved in lake dredging.

INDIVIDUAL ENGINEERING AND ENVIRONMENTAL ANALYSES

Following are reports of environmental and engineering analyses of each of the eight lakes in this study, together with discussions of community plans for lake improvement and recommendations for dredging which address these plans, are physically feasible from an engineering standpoint, and are environmentally acceptable.

Backbone State Park

Located in the northwestern portion of Delaware County in northeastern Iowa, Backbone State Park lies in the highly dissected loess and "Iowa till" covering the Silurian dolomites. The lake, formed by an artificial impoundment on the Maquoketa River, lies in a sharp valley cut into upper Silurian Niagrian Series exposing the Silurian Alexandrian Series at the base of the valley. One major stream, the Maquoketa River and one minor stream, Lamont Creek, have eroded sufficiently into the dolomites, carving walls nearly vertical in places, to present a jagged interfluve which has been named The Backbone. Local relief is 100 feet and relief in the watershed draining to Backbone Lake is 190 feet, certainly a sufficient gradient to bring the silts and sands of the upland down to the lake in great quantities. The majority of the soils are well drained but are subject to frost action. This plus steep slopes contribute to the siltation problem.

Nestled as it is in the highly dissected upland of northwestern Delaware County, Backbone Lake is a surprise, to the unwary traveler who finds this setting in relatively "flat" Iowa. The immediate area of the park and the canyon leading to the lake resemble an alpine setting. Thus, one is not surprised to see the many campers and picnickers enjoying the aesthetics of this anomaly in the prairie, playing in park areas in the southern, broader area hospitable to water-oriented recreation, enjoying a solitary assess the effect of their removal on the lake environment and for determining the preliminary estimate of dredging costs.

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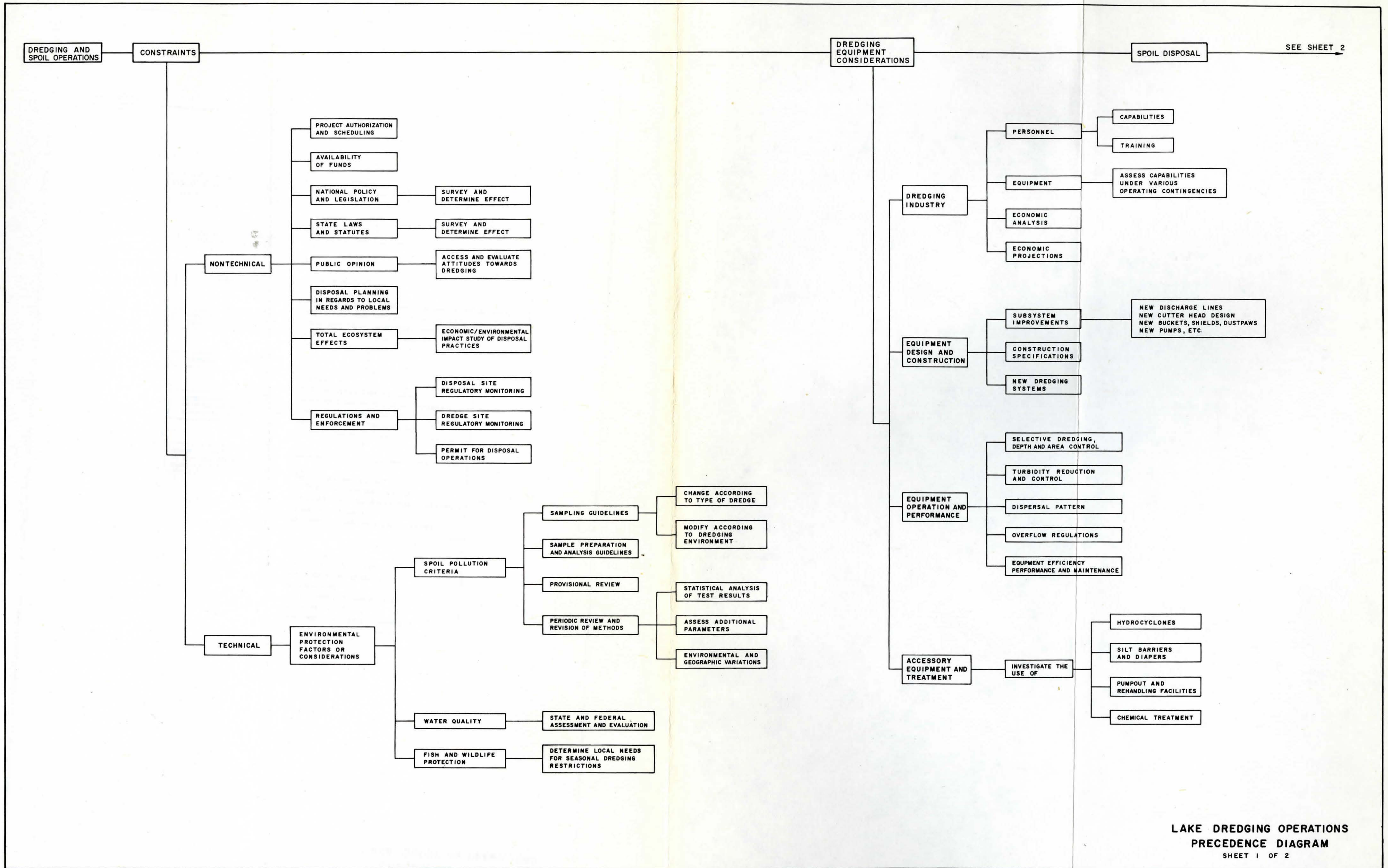

Figure 3

LAKE DREDGING OPERATIONS
PRECEDENCE DIAGRAM

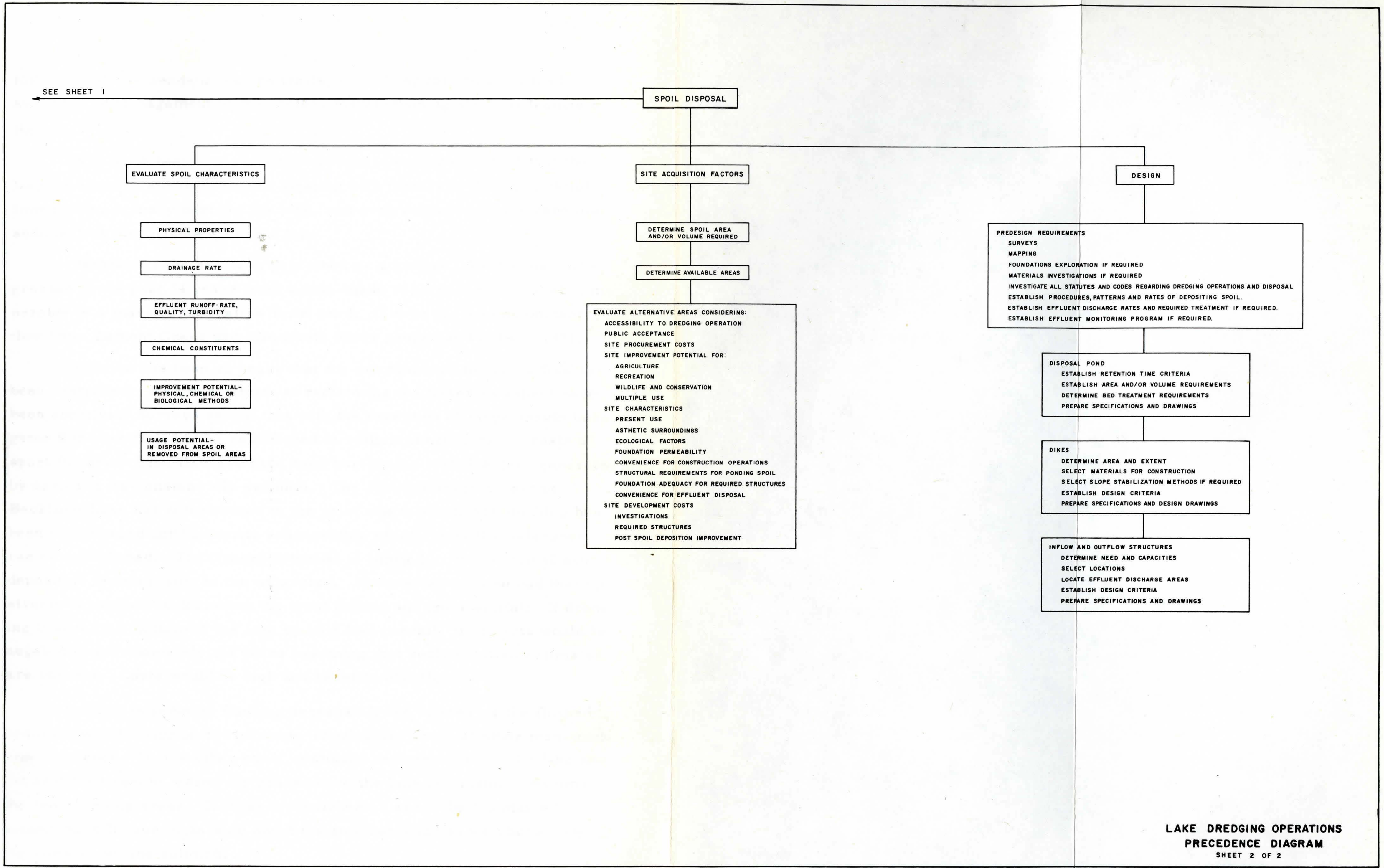

Figure 3
(Continued)

hike through the woods on nature trails, or casting for the trout made available by management of the cooler, faster-running streams leading to the lake.

With such beautiful surroundings one is saddened to find that the lake holds more silt than water. Boating with motors is difficult, if not impossible, in many parts of the lake, and even canoers often scrape into sediment as they paddle about the lake.

Backbone Lake has been described as a mature lake that has progressed in the past 34 years from a man-made reservoir to a habitat comparable to a marsh or a shallow farm pond. It does possess a constant flow from Lamont Creek and Maquoketa River gauged at 44 cfs in 1971.

Siltation has been so heavy that the microhabitat for game fish has been destroyed. Recent attempts at reclaiming the fisheries aspect have been abortive. Surveys reveal that with the exception of large-mouth bass, game fish have failed to be established in sufficient numbers to create a sport fishery. Even the bass have been hurt by the turbid waters generated by carp and the constant silt problem. The sports fishery aspect of Backbone Lake has deteriorated to the point where additional stocking has been discouraged until adequate conservation practices in the watershed can be established. The fishery potential is limited by the continual sand deposition from erosion in the watershed. Sedimentation is so bad that upstream deposition is degrading the trout fishing and trout habitat. If dredging lowered the bottom of the lake by nine feet overall, its effects would be negated in approximately six years assuming that sedimentation estimates are correct. Costs would be high and benefits doubtful.

Neither is periodic flushing necessarily the answer as the flushed sediment would continue downstream, causing problems at other man-made impoundments. On the other hand, continued sedimentation in the lake and the sedimentation to lessen the grade above the lake is causing problems in the trout-fishing areas. If these trout fisheries are to be maintained, something will have to be done about the sedimentation at Backbone. Dredging alone is not the solution.

Spoil from dredging is another difficult problem. Spoil disposal areas are limited and lie below the dam. Runoff from the spoil would probably enter the Maquoketa River; depending upon the analysis of the sediments and bottom water, downstream pollution problems could occur.

The total watershed area of Backbone Lake is 78,250 acres, 30 percent of which contributes 12 or more tons of sediment per acre per year. Total sedimentation from the entire watershed averages 3.6 tons per acre per year, or 281,700 tons per year.

There is only one likely spoil disposal area within reasonable distance of the lake, and it can only accommodate 203,000 cubic yards. Estimates of spoil created by dredging alternatives in which a 15-foot depth is created progressively upstream from the spillway are:

Dredging Alternative	Distance from Southeast Spillway (feet)	Spoil Volume (cubic yards)
A	10,000	1,000,000
B	2,000	287,000
C	1,100	155,000

If the 1,100-foot program is undertaken, dredging will cost upwards of $425,000 and will require about 130 days for completion. However, the effect of dredging will be short-lived as the sedimented bottom above the dredged area shifts toward the spillway and erosion from the watershed continues. Dredging at Backbone Lake is not recommended.

Black Hawk Lake

Black Hawk Lake, formerly Wall Lake, has been noted as an outing place since the turn of the century, when steamers traversed its water. Once supporting two resort hotels and approximately 100 cottages, this 957-acre lake now has a more residential aspect with most of the cottages and houses being primary or secondary homes. Recreational activities are swimming, boating, water-skiing, and fishing. Although much of the housing is for private use, public facilities, such as boat ramps and electrified campgrounds, are available for the many tourists who visit the lake each year. The marsh area south of the lake is a wildlife and game refuge.

The lake and its 13,500-acre watershed lie in the level- to gently-undulating upland on the edge of the Cary-Mankato drift plain. Draining to the east into Indian Creek, a tributary of the Raccoon River, the lake lies on the principal interfluve between the Mississippi and Missouri rivers drainage. Gravel deposits on this upland are probably kame terraces and outwash deposits associated with the glacial ice front. The majority of the soils in the watershed are well drained but have a tendency to expand when wet.

The banks of the lake are from 2 to 15 feet high except for the outlet on the east side and a portion in the extreme southwest where the inlet meanders through the low, poorly drained Black Hawk Marsh into Provost Bay. It is possible that the lake once drained to the west through Goose Pond into the Boyer River.

The banks have been badly eroded by wind and ice. Recent action by homeowners, who have placed riprap and concrete blocks along the shore line, has served to mitigate some of the erosional problems.

The watershed lies principally to the south between the towns of Lake View located on the western shore of the lake and Breda approximately 10 miles to the south-southeast. Until this past year the sewer effluent from Breda ran directly into the main tributary of the lake. Much of the nutrient problem and resulting emergent vegetation and algae problems have been attributed to this source.

Other bodies of water lie to the south and south-southwest of the lake. Except for Black Hawk Marsh, these are abandoned gravel mining operations--Lake Arrowhead and Hallet's Pits.

A group of local citizens, interested in preserving and protecting the lake, have formulated plans which in part would increase the available boating area by a series of channels connecting the major water bodies. Their preliminary plans call for dredging areas in Black Hawk Lake and rerouting the lake's tributary through Hallet's Pits and thence to the lake. The 60-foot-deep Hallet's Pits area would serve as a desilting basin, thus preserving the dredged depth of the lake for years to come.

Although it has been dredged previously, Black Hawk Lake today displays its natural tendency toward shallowness. In 1956, maintenance work was performed and the inlet was straightened. Since that time 10 inches of silt have accumulated in the new channel, and the deeper parts of the lake have filled in since the last dredging.

The shallowness of the lake and the sometimes low water levels lead to periodic winter fish kills. The last winter kill was in the winter of 1970-1971. In 1968, a survey of the lake showed a rather extensive list of game fish and pan fish.

Erosion and siltation from the county watershed are a diminishing problem. Current trends indicate that within a few years 75 percent of agricultural lands will be benefiting from soil conservation measures. Dredging proposals initiated by the community plan can be accomplished at 12 spots including the main inlet channel, with some 400 acres of bottom involved and yielding an estimated 3.0 million cubic yards of spoil. Dredging, utilizing a "Mud Cat" and a 12-inch hydraulic dredge with booster pump, will require an estimated three dredging seasons and will cost approximately $4.25 million. In addition, shore-line protection is needed on approximately four miles at an estimated cost of $200,000. Figure 4 offers a visual representation of the proposed dredging program for Black Hawk.

Spoil areas sufficient to accommodate approximately 2.8 million cubic yards have been identified subject to 1) appropriate dewatering of the benthic deposits and 2) refined topographic maps. Land preparation

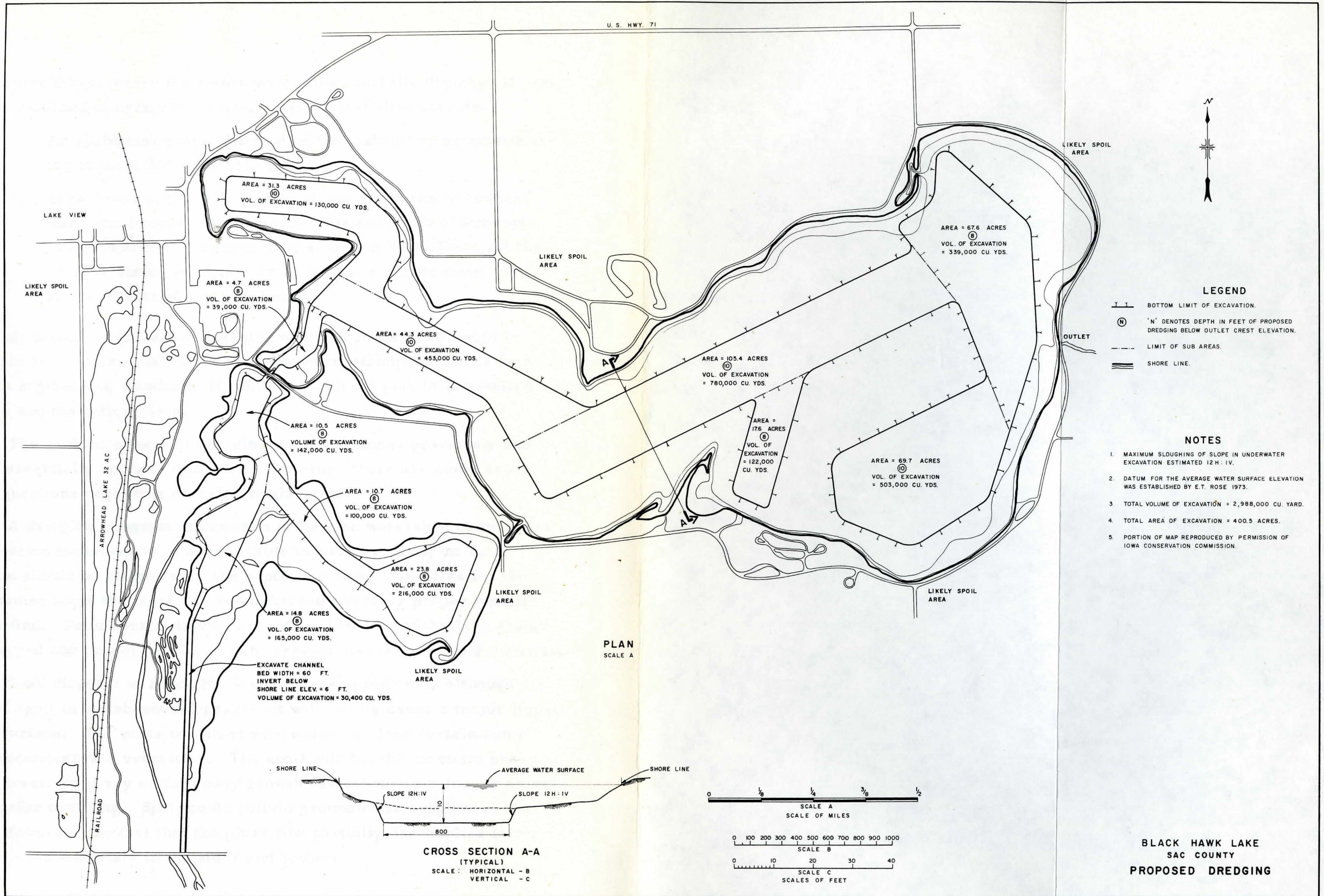

Figure 4

PROPOSED DREDGING FOR BLACK HAWK LAKE

will require dikes, weirs for return water flow, and tile drainage if land is to be returned to agricultural use. Likely spoil sites include:

1. An abandoned gravel pit west of the main lake, accommodating at least 800,000 cubic yards.

2. Land areas at the following locations: between Arrowhead Lake and Provost Slough; to the east and south of Provost Slough; north of the main lake; at Cotton Wood Point, at the 30-acre state recreation area; southeast of the main lake; and northeast of Sac City Beach.

The study team concludes that dredging of Black Hawk Lake would be desirable from a lake quality and environmental standpoint and is feasible from an engineering standpoint if combined with the plan to use Hallett's Pit as a sedimentation basin.

The general effects of dredging were mentioned previously and should essentially apply to this lake. However, there are some areas where questions regarding dredging might arise.

A dredging program undertaken before the watershed came under conservation measures is of questionable value. Certainly no such program should be started until the septic and sewer facilities for the many homes about the lake have been checked and their proper functioning verified. Point source discharges into tributaries of the lake should be surveyed and proper action taken to prevent discharge of contaminants.

Spoil disposal at Black Hawk could cause problems, although disposal of spoil in the abandoned gravel pit will hardly cause a major impact on the surface. The pit is not filled with water but does contain some small second-growth vegetation. The spoil will fill the pit to its premining level, so if any of the woody growth has economic value, it should be cut prior to filling. Spoil could pollute groundwater supplies in the area. However, the fact that the pit is now partially dry implies fairly impermeable materials in the sides and bottom.

In other spoil disposal areas, the haphazard filling of depressions and marshes should be discouraged as such actions could be most detrimental to wildlife.

Blue Lake

Blue Lake is situated on the flood plain of the Missouri River and is an old cutoff, an oxbow lake with a very small watershed and a distinct reliance on groundwater for recharge. Often this groundwater recharge is insufficient to maintain a stable level and the inflow is supplemented by well water. Local residents maintain that silt has covered the springs, thus requiring the supplemental water.

It was reported that Blue Lake was dredged prior to 1950; however, the 1952 Missouri River flood backfilled the lake with up to five feet of silt. The west half of the lake, more shallow than the east half, is a good wildlife area, thickly grown with large quantities of water plants and rushes.

The east half of the lake is used for water-oriented recreation and has well-maintained picnicking and camping facilities in Lewis and Clark Park. Both east and west banks of the south end of the east lake are choked with reeds and rushes. Except for some filamentous algae around the supplemental well outlet into the lake, no algae was observed although reports indicate it has occurred in other locations of the lake.

Until recently, development around the eastern side of the lake was limited to a church camp and farmhouses. In the past two years, however, lots have been sold or leased to mobile home owners on the east side of the lake. At the present time, there is no county planning or zoning to prevent this type of development. Sanitation and disposal of wastes from these homes provide a real threat to the water quality of the lake.

An informal community plan envisions dredging as a means to improving boating, fishing, and water-skiing. However, increased water-skiing activity might induce more rapid shore erosion by motorboat wakes.

Available spoil sites east of the trailer complex and on farmland south of the park can accommodate perhaps 160,000 cubic yards of spoil. Accordingly, as shown in Figure 5, a spot-dredging program has been prepared for four sites which will achieve 10-foot soundings over 57.7 acres. Channelizing the lake bed would create 630,000 cubic yards of spoil and is not feasible from a disposal standpoint.

A 10-inch hydraulic dredge could accomplish the project in about 70 days at a cost of $450,000. Alternatively, a portable dredge and booster pump would require approximately 295 days, but would cost only $300,000. Because of anticipated wave action, creep, sluff, and the sandy shore line in this narrow lake, it is recommended that the bottom line distance from the shore line be 150 feet. Additionally, some 4,000 feet of shore line require protection at an estimated cost of $40,000.

Extensive dredging in the southern part of Blue Lake as planned would not remove the reedy vegetation now growing there, as dredging will occur approximately 150 feet from the shoreline. The swimming area, found to the north almost at the bend of the lake, is essentially free of vegetation. However, before dredging in the southern area, the value of this wildlife habitat relative to that found on the western arm of the oxbow should be determined and compared with the benefits of dredging. At this time the southern vegetated area serves, or can serve, as cover for the animal population in the east arm of the oxbow lake; and since it does not interfere with swimming, it is suggested that it be maintained as is.

The spoil disposal areas are so situated that problems can be expected. The biggest problem could be groundwater recharge through the loose sandy soils of the likely disposal area east of the lake. Secondly, an excess of groundwater could flood the septic systems and/or cesspools used in the trailer park situated east of the lake. The water skiing activity only induce more rapid shore erosion by motor-boat wakes.

Available spoil sites east of the trailer complex and on farmland could accommodate perhaps 100,000 cubic yards of spoil. Accordingly, as shown in Figure 3, a spot-dredging program has been prepared for four areas which will achieve 10-foot soundings over 51.7 acres. Channelizing the area [illegible] would create 530,000 cubic yards of spoil and [illegible] spoil standpoint.

A 10-inch hydraulic dredge could accomplish the project in about 70 days at a cost of $250,000. Alternatively, a portable dredge and booster pump would require approximately 295 days, and would cost only $300,000. Because of anticipated wave action, erosion, silt, and the sandy shore line in this narrow band, it is recommended that the bottom [illegible] distance from the shore line be 150 feet. Additionally, some 4,000 feet of shore line [illegible] protection at an estimated cost of $40,000.

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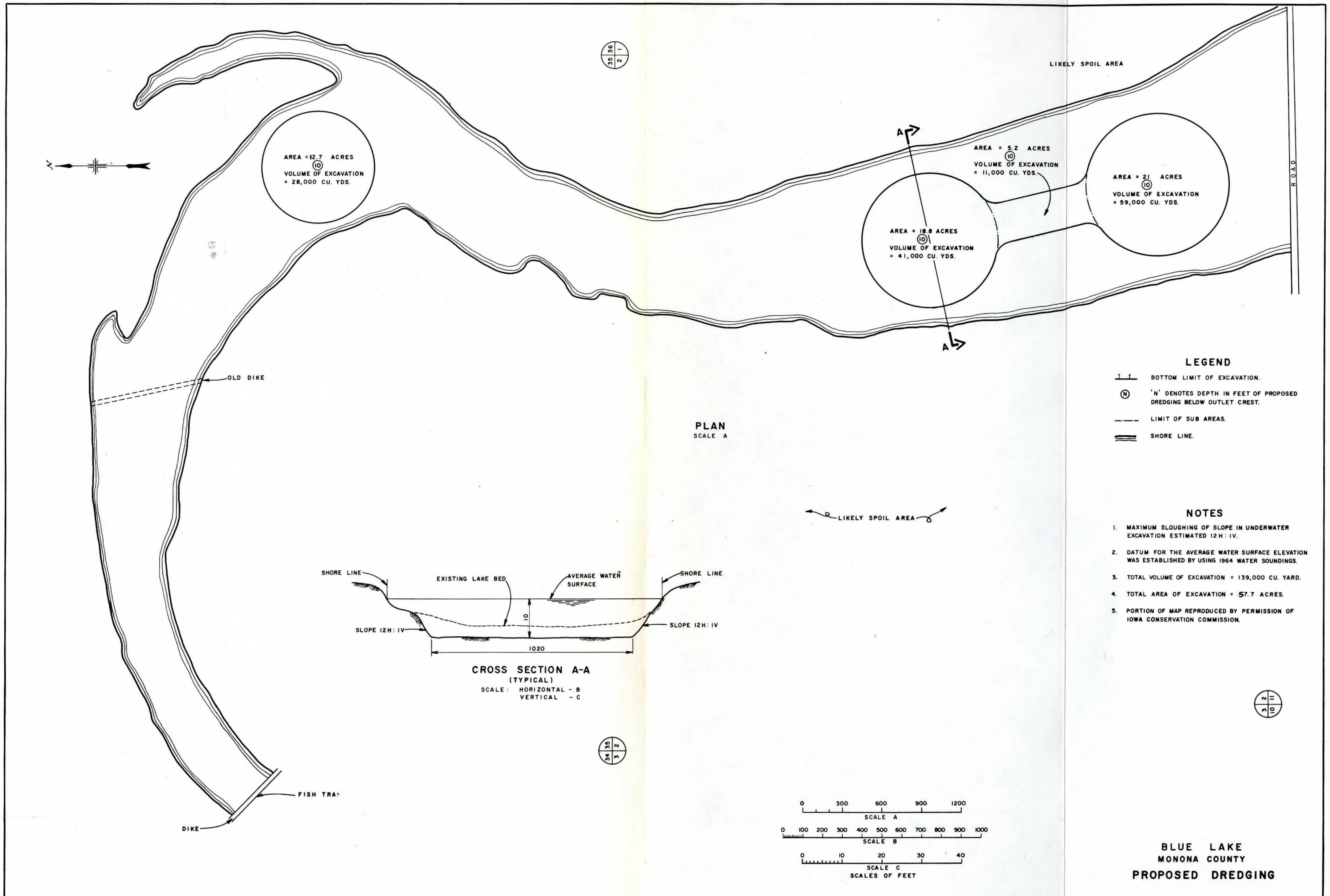


Figure 5

PROPOSED DREDGING FOR BLUE LAKE

problem of seepage from these septic systems and cesspools is very real now. A considerable amount of nitrates and other pollutants most probably are entering the lake from this source at the present time and raising the water table could add to the hazard.

Dredging should not be initiated until a groundwater survey is made on the east bank to ascertain the extent of pollution emanating from the trailer village. Land-use planning and zoning could prevent extension of this problem.

Five Island Lake

If it hadn't been for community action 60 years ago, this 945-acre lake lying on the north edge of Emmetsburg, Iowa, might today be a cornfield. In 1910, in accordance with state law, a petition was filed with the state to drain the lake (known then as Medium Lake). The citizens of Emmetsburg, concerned that they might lose this valuable resource, formed the Medium Lake Improvement Company and began a program of dredging and bank stabilization that became the first attempt at lake improvement undertaken in the state of Iowa by any group, governmental or private. This community spirit is still alive in a local group seeking to improve the lake and preparing plans for an attraction suitable to draw tourists.

The lake is deeper now than it was in 1916, but two separate periods of dredging have occurred since then. Spoil from the dredging was used to build new islands or enlarge existing ones. At a public celebration July 4, 1944, the lake was renamed Five Island Lake to correspond with the five wooded islands found therein.

The lake has a small watershed (7,443 acres), relying mainly upon tile drainage from the poorly drained Webster soils which are found on the gently rolling drift-covered plain. The east bank has been eroded at a rather constant rate, losing as much as 15 feet of bank in some places over the past 30 years. Several areas can be found where willow trees lean toward the lake at a rather steep angle, the soil having been scoured from around their roots. The silt derived from the erosion of the banks has been swept down into the old dredged areas.

Since the principal tributary to the lake contains for the most part tile drainage, sheet wash-off of agricultural lands adjacent to the lake and bank erosion dominate as sources of sediment. This sediment has filled the north end of the lake to approximately the predredged levels. Runoff from the urban areas adjacent to the south end of the lake certainly contributes materials to this part of the lake.

The shallowness of the lake and the small size of its drainage area are contributing factors in low-water problems during periods of drought and winter-kill potential in the cold weather. To mitigate the effects of thick or prolonged ice cover, the citizens of Emmetsburg pump lake water over the ice to aid in recharging the oxygen level; this action has reduced the winter fish kill problems.

On the west side, a feed lot is adjacent to drainage leading directly to the lake, and runoff from this source could be a principal source of nutrients.

Rooted and nonrooted vegetation is abundant in the north end and often is thick enough to hamper summer fishing. The shallowness of the lake causes fish to congregate in the deeper parts--principally in the southern end--during winter. As a result, ice fishing for walleye is particularly good.

The lake, particularly at its north end, was reported to have been at one time an excellent duck-hunting area. The loss of reeds and rushes after the dry period in the mid-fifties, when the lake level was particularly low, has lead to a reduction of the migratory waterfowl and has, for the most part, eliminated duck nesting.

At the present time, a local citizens group is formulating plans for the development of a tourist attraction using the lake as a focal point.

The full development of their plans is dependent upon the dredging of the lake and the use of spoil to develop wildlife habitat.

Spot-dredging of 220 acres is proposed and will create an estimated 1.7 million cubic yards of spoil, based on 1970 soundings and a 1935 lake bed survey. Two locations in the vicinities of Kearny State Park and Emmetsburg are to be excavated to a depth of 10 feet, with other areas dredged to a depth of eight feet. Equipment needed includes both a mud cat for 300 days and a 12-inch hydraulic dredge with booster pump for 260 days. Total cost of dredging is estimated at $2.5 million. Figure 6 shows this proposed dredging program.

Because of wave action, narrowness of the lake, shore-line erosion, sluff, and creep, it is suggested that the dredging bottom line not be closer than 150 feet to the shore.

Preliminary estimates of spoil site capacities, made in the absence of maps with one-foot contour intervals, indicate that approximately 1.5 million cubic yards of spoil can be accommodated. Suitable spoil sites include:

1. North and west sides of Island V.
2. North side of Island IV.
3. East lake shore between lake and highway, requiring considerable diking.
4. Agricultural land north of park and west of railroad, requiring diking.
5. East of railroad bridge and north of railroad.
6. North of Emmetsburg and east of railroad.
7. Agricultural land east of Island V between lake and road.
8. North of Emmetsburg between diked shore line and road.

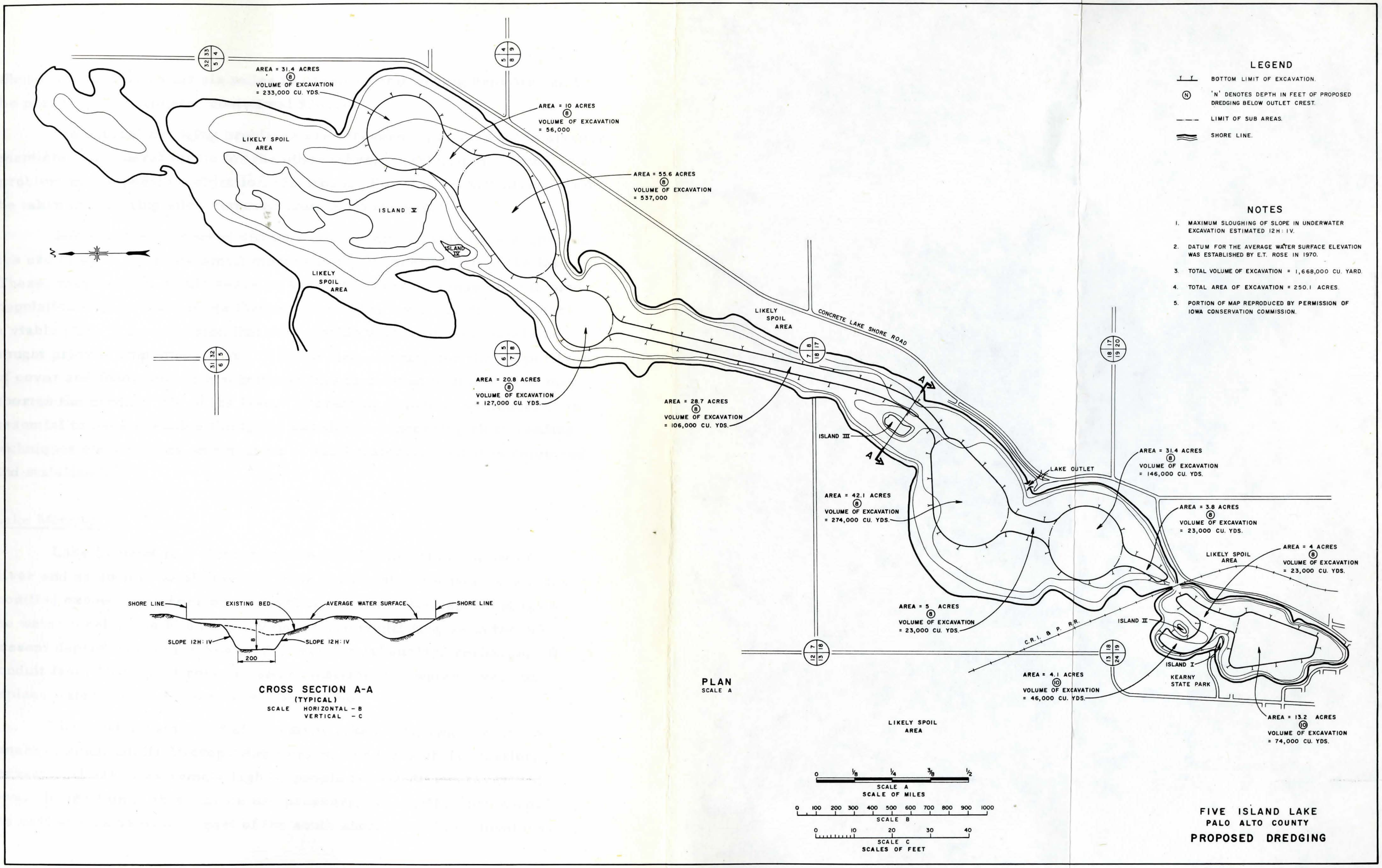


Figure 6

PROPOSED DREDGING FOR FIVE ISLAND LAKE

Shore line protection for six miles is essential if dredging benefits are to be preserved. Estimated costs total $260,000.

No unusual dredging problems are foreseen other than those already mentioned in general terms for the other lakes. Spoil disposal could be a problem due to possible objectionable odors. For this reason care should be taken in selecting sites removed from Emmetsburg.

Some of the concerned citizens in Palo Alto County have suggested the use of spoil to create small mounds in the northern third of the lake. These, they reason, would serve as waterfowl nesting areas and the bird population would return to its former (pre-1954) level. If this is in fact a viable plan, it is suggested that cooperation with wildlife officials be sought prior to implementation. Without also planning for the proper types of cover and food, any such scheme as this is doomed to failure and may shorten the dredged life of the lake. In creating artificial wetlands, it is essential to have available the latest knowledge concerning plant seeding techniques and concepts on retention of spoil material until it is colonized and stabilized.

Lake Manawa

Lake Manawa is a remnant of the old channel of the Missouri River and as such is located on the flood plain. Manawa is a very much modified oxbow lake whose water level at one time was dependent upon the water level of the Missouri. Reports are conflicting as to the lake's present dependency on the Missouri River for subsurface recharge. A conduit from Mosquito Creek is used to maintain the water level and replace water lost to seepage and evaporation.

The most urbanized of all the study lakes, Manawa lies in the Omaha-Council Bluffs Metropolitan Region. Because of its location, recreational use is extremely high by people from both Nebraska and Iowa. In addition to this outside use pressure, the north, northwest, and east shores as well as part of the south shore have been developed for clubs, marinas, and private homes. State-owned land is principally located along the south shore and to the south of the lake, although the state also owns a strip of land around part of the lake providing access to the water, and a spit running south from the bow of the oxbow containing recreational facilities and a swimming beach.

Topographically the area is flat. Natural undulations in the surface probably represent levees flanking old abandoned channels. Access roads on the east and west sides and on the south probably follow, and owe much of their height to, the natural levee, although some of the height is from dredge spoil.

On the north shore a fish and game club, second-home developments, a private golf course, marinas, and lake-associated businesses provide a wide area of impervious surface for runoff and present a very real pollution potential. Another pollution problem is presented by the housing developments situated around the lake. Problems are twofold--septic and sewer facilities and fertilization of lawns and landscaping plants. There is no sewer system along the south, west, and northwest sides of the lake, the houses in these areas relying on septic systems.

It is reported that a city sewer is available from the swimming cove on the north side to the southeast corner of the lake. However, it is not known how many businesses and residences in the area are actually hooked up to it. Furthermore, no data are available on the infiltration rate from the sewer line.

The water quality at Manawa is not good. It appears to be a highly fertile lake with much vegetative growth. Particularly noticeable are the American lotus, a rooted aquatic, and blue-green algae. With the amount of vegetation generated in the lake and the fertilization from runoff and carelessness, BOD (biochemical oxygen demand) must be extremely high. There are no data available on water quality; however, on July 18, 1972, Moeller and Erickson of the Iowa Conservation Commission spot-sampled the lake for dissolved oxygen and reported only 5 ppm at 10 feet; a secchi disc reading at this time was 12 inches.

In spite of the low dissolved-oxygen reading and the obviously high BOD, there have been no winter fish kills reported since the 1950s. This may be partly because the Fish and Game Club installs lines in several places in front of its dock facilities and bubbles air through them in the winter to provide open areas for ice fishermen.

The lake is shallow (averaging five feet), highly vegetated, and nutrient rich. The bottom sediments are thick and probably high in organics and nutrients. Much lake bank erosion has taken place in the past few years and is particularly noticeable on the northeast and east shores. The depth of the sediments, the shallowness of the lake, and the constant maintenance of the water level are additional problems.

Property owners who have homes on the lake and others with a vested interest in the survival of the lake have formed a citizens' action group and with the aid of the Council Bluffs' planning office have devised a use plan and modifications for the lake. The functions of this plan are based on dredging the lake.

As shown in Figure 7, it is proposed that spot dredging be carried out over 405 of the lake's 660 acres. Proposed depths vary from 6 to 12 feet, depending on the use planned for different areas of the lake. Estimated volume of spoil is 2.1 million cubic yards. A 12-inch hydraulic dredge operating 320 days could accomplish the project at an estimated cost of $3.7 million. A small mud cat dredge can be used as part of a lake management program for close-in dredging and cleaning up of the littoral area. Extensive shore-line erosion indicates approximately 3.5 miles of shore need either additional, improved, or new protection at an estimated cost of $150,000. Deep excavation (the bottom line) should not be closer than 150 feet to the shore line.

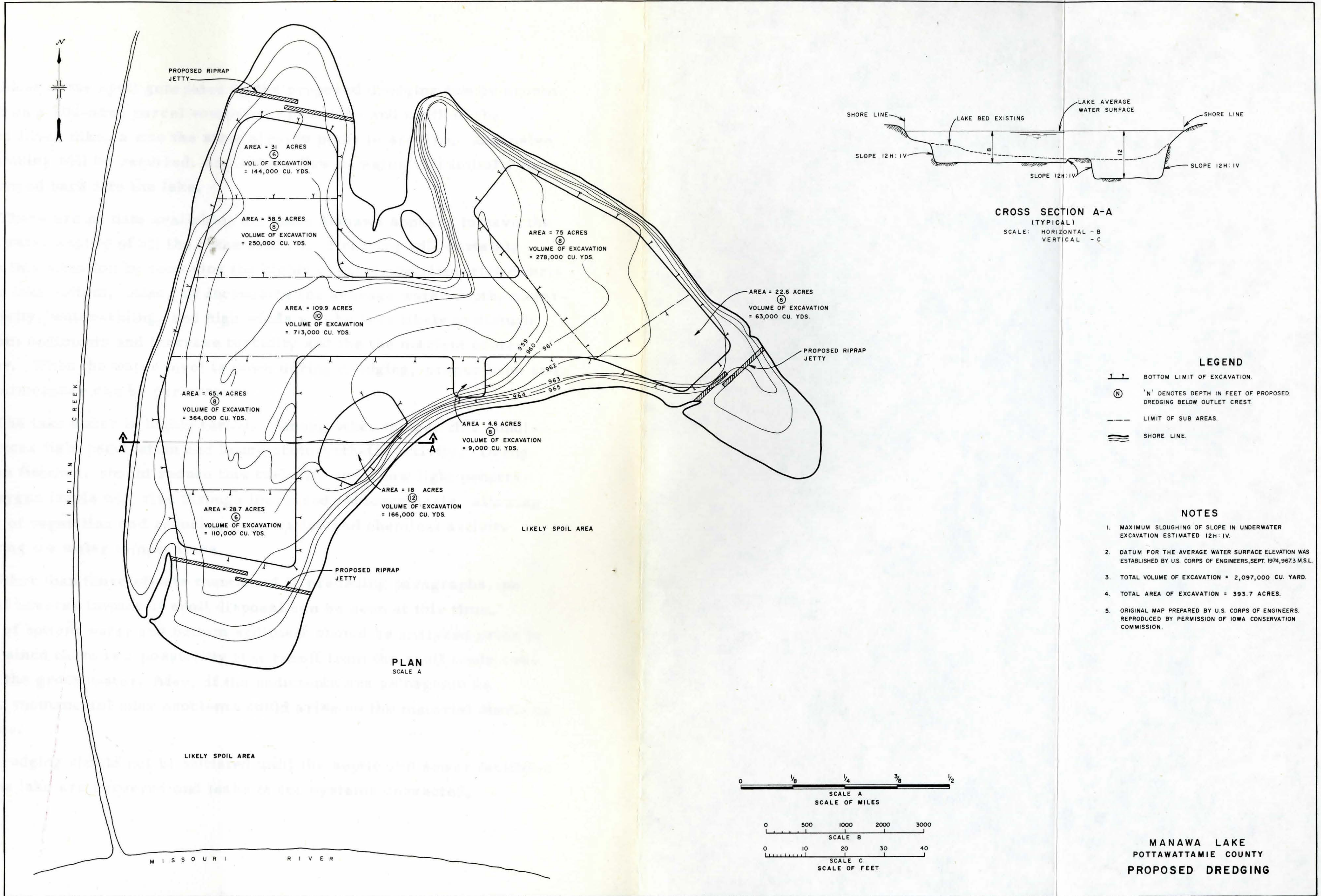


Figure 7

PROPOSED DREDGING FOR LAKE MANAWA

Most of the spoil generated by the proposed dredging can be accommodated on a 300-acre parcel southwest of the lake and north of the Missouri River dike, a site the state already plans to acquire. Extensive spoil pumping will be required, and return flow of water will initially have to be pumped back into the lake.

There are no data available, but Lake Manawa appears to have the poorest water quality of all the lakes studied. Dredging will certainly improve this situation by removing the highly organic, nutrient-rich debris from the lake bottom. Also, by increasing the average water depth, motorboat activity, water-skiing, and high winds will be less likely to disturb the bottom sediments and increase turbidity and the the nutrient content of the water. When the water level is down during dredging, proper bank and shore maintenance can be performed.

The lake water is highly turbid. Among other things, this condition reduces light penetration and hence photosynthetic activity. Dredging, when finished, should reduce this turbidity and allow light penetration. Oxygen levels will rise through increased photosynthesis, allowing a change of vegetation and reducing evaporation and chemical activity by lowering the water temperature.

Other than those effects mentioned in preceding paragraphs, no additional adverse impact of spoil disposal can be seen at this time. Samples of bottom water and bottom sediment should be analyzed prior to dredging since there is a possibility that runoff from the spoil could contaminate the groundwater. Also, if the sediments are as organic as assumed, monumental odor problems could arise as the material starts to decompose.

Dredging should not be initiated until the septic and sewer facilities around the lake are surveyed and leaks in the systems corrected.

Mill Creek

The lake at Mill Creek State Park is a small impoundment on Cole Creek, a tributary to Mill Creek. The watershed of the lake is more than 100 times the size of the lake (25 acres), runoff from which carries such a large sediment load that the upper end of the lake is heavily silted. The lake is found on the level-to-undulating loessial upland of O'Brien County. The uplands are well drained by Mill Creek and its tributaries, and few conservation measures are in effect within the watershed. Most of the soils are well drained and are located on 2 to 4 percent slopes. The susceptibility to frost action, however, leads to erosion problems.

The park grounds on the south and southwest sides are well maintained and offer opportunities for picnicking, swimming, general outings, and access to the lake for fishing. In general, the pan fish are stunted. The west and north ends of the lake are in natural cover, offering opportunities for those who desire to take nature walks and observe the plentiful bird life.

In the shallower areas rooted vegetation is dense and must present problems in fishing and fish management. Algae are quite thick, extending in mats 10 to 15 feet out from the west and north banks of the lake.

The flow through the lake is of such volume that winter kill is not a problem and much of the debris that gets into the mainstream is swept over the dam.

The area of the watershed compared with that of the lake at Mill Creek is so large that sediment would be replaced about as fast as it is removed. The infilling of the upper end of the lake with subsequent growth of vegetation has provided a rather good bird habitat. Dredging could adversely affect this by (1) reducing the water level, and (2) causing sloughing of material from the upper areas into the dredged area, that is, in effect the upstream migration of the knick-point created by the dredge.

Spoil disposal is also a problem. To deposit spoil in the northeast part of the lake would only serve to reduce the already small area of water as well as to infringe upon the bird habitat with attendant harm. The spoil area east of the airport is inadequate to contain the amount of dredged material suggested to be removed.

Various methods of controlling the aquatic vegetation and algal blooms should be investigated before proceeding with any dredging plan. Certainly dredging should not be initiated except as a last resort and then not until the watershed is controlled by conservation measures.

A spot-dredging program covering 6.6 acres will yield an estimated 52,000 cubic yards of spoil, which can be removed by either dragline or small mud cat. If a dragline is used, the spoil will have to be moved by land transport. Estimated dredging costs range from $90,000 to $150,000. Protection of about 1,500 feet of shore line is needed and would cost roughly $15,000.

There are two likely spoil areas, one in water. The northeast thumb of the lake, with the installation of a silt screen, can accommodate approximately 25 percent of the estimated spoil. The likely on-land spoil area, between the municipal airstrip and the county highway east of the lake, is small and has erosion and drainage problems. However, it can accommodate perhaps 15 percent of the spoil.

In view of the rapid resiltation likely and the limited spoil sites available, it is not recommended that Mill Creek Lake be dredged.

<u>Rock Creek Lake</u>

Situated in park-like surroundings, the lake is within the rolling-to-strongly-rolling, broken topography of the Kansan Drift area. Drainages are well integrated and valley sides pronounced, and a number of drainages appear entrenched. The majority of the soils are well drained, with some indications of plasticity.

Many of the well-tended, mowed, natural grass slopes fall to within a few feet of the water. In other areas, particularly the arms leading east and west from the main body of the lake, the banks are 6 to 10 feet above the lake surface. In places bank height is as much as 15 feet above lake level. In these arm areas the vegetation is second-growth woodland. Each arm is a former tributary to Rock Creek and as such brings high silt loads to the lake, particularly during spring rains. About one-fourth of the surface has been lost to the lake in recent years because of siltation. The subaerial portions of the silt deposits are being rapidly vegetated by willows and sedges, while the water portions harbor cattails and pondweeds.

The upland exhibits sufficient dissection so that many farm ponds can be seen in the drainage area to the south and east of the lake. There is a possibility that side slopes have not yet reached equilibrium with the new base line provided by the lake. Certainly this is true of Rock Creek itself, as can be seen from the massive loads of silt that have obliterated the old inlet in the northern part of the lake.

To the west of the lake, several areas of slumping can be observed along the grassed side-slopes of its tributaries. This is certainly not an equilibrium feature and it is suspected that the heavy spring rains contributed to this mass wasting phenomenon. Here the bare soil has been exposed along the scarplets, allowing rain and sheetwash to release additional sediment to the lake. This sedimentation will continue until the scarplets are healed and revegetated.

Bank slumping, particularly along the east bank of the lake, both north and south of the bridge, gives evidence of the high surface runoff and sediment load flowing to the lake during the spring rains. In many places on the east side, the surface area of the lake was extended as the shore line was eroded by as much as six feet.

The erosive potential of the spring rains in the uplands and farm lands of the contributing watershed are particularly noticeable in the area north of the bridge, where it is estimated that as much as two feet of silt were deposited in approximately two days, extending marsh areas well down the lake toward the bridge. Former marsh and wildlife areas in the north were heavily silted and new vegetation is rapidly covering these freshly formed depositional landforms.

Grinnell Study

Rock Creek Lake was previously studied intensively by students at Grinnell College. Their conclusion was to do nothing. Dredging is not feasible unless watershed conservation measures are initiated and completed. They suggested several short-range programs that could be implemented to correct some of the imbalances causing eutrophication. However, on the basis of their cost-benefit analysis, they felt it was "obvious that the benefits accrued from taking any of the proposed measures would not begin to be equal to their cost."

Assuming dredging is undertaken, spoil disposal areas are at a minimum. The two arms of the lake in the south end are already heavily silted in, particularly in their upper reaches. These areas, in which the water is about two feet deep, are essentially lost to the users of the lake and could be used for disposal areas. However, the wildlife habitat that has been established there would be destroyed and sediment problems in the lake might be compounded. As in the case of Backbone and Mill Creek, the sedimentation rate is high. Any beneficial effects of dredging would be short-lived.

Rock Creek Lake encompasses 640 surface acres of water in a 12.7-mile shore line. Water depths range typically from 8.5 to 12 feet at lake center. The watershed, at 27,260 acres, is substantial. Further, 8,084 acres of the watershed contribute two to five tons of silt per year and 6,067 acres contribute 11 or more tons per year. Dredging, thus, could be an extremely short-term improvement and would have minimal effect on water quality because of continued nutrient intrusion from agricultural runoff. Deepening the lake might prevent fish winter kill but, typically, two years are required after dredging for fish populations to regenerate, during which time siltation would likely reclaim dredged areas.

Analysis of lake depths indicates an adequate dredging program would cover 13 spots and produce an estimated 1.8 million cubic yards of spoil and would require 300 days of dredging at a cost of $2.5 million-$3.0 million. However, there are virtually no spoil sites available that are not in the fingers of the lake. Therefore, because of both excessive erosion in the watershed and the nonavailability of spoil disposal sites, the study team recommends dredging of Rock Creek Lake not be considered further.

<u>Silver Lake</u>

Silver Lake is located in western Dickinson County, west of the "Great Lakes" of Iowa, in the rolling kettle and kame topography on the western edge of the Makato-Cary glacial till. The 1,068 acres of the lake are adjacent to the west boundary of the community of Lake Park; in fact, the town relies on the lake for its municipal water supply. The lake's north, west, and east banks are high and, for the most part, tree lined. On the east bank, the Lake Park side, the city has built a park with camping and recreational facilities. While a large part of the south shore is devoted to primary and secondary home sites, it also offers much to interest the naturalist. This shore is low and swampy in parts with several springs and a flowing well. In addition, Silver Lake Fen is located on the southwest side. The fen, which is in the state preserve system, is an unusual and interesting ecotone with rare and exotic vegetation.

The watershed lies primarily to the west and northwest and has two main tributaries. One enters Trappers Bay on the north; the other enters the west side from the overflow from a newly constructed sedimentation dam. The entrance from Trappers Bay into Silver Lake has recently been reworked so that the bay also serves as a good siltation pond--perhaps too good since it is rapidly being filled. It was reported that approximately 95 percent of the watershed is now subject to conservation practices, a situation that should appreciably reduce the sediment yield.

Various reports on lake chemistry differ. It is not known where the samples were taken. It is possible that the high sulfate readings were obtained from samples taken near Silver Lake Fen. Eickstaedt (1964) reported extremely high sulfate readings from the fen pools (840-1520 ppm), lake marsh area (550 ppm), and the pool associated with the fen (280 ppm). An interesting analysis was made by a local high school student. In specimens taken during the winter of 1968, 0.08 ppm of chromium was found. This concentration is 0.03 ppm greater than the mandatory limits set by the U.S. Public Health Service, and if this concentration remained at this level or increased, the water supply should be condemned for drinking purposes.

There are some unique features about Silver Lake that should be protected and preserved. The most prominent is the above-mentioned fen at the southwest corner of the lake. Under no circumstance should dredging or spoil disposal be allowed to affect this area.

Lying as the watershed does in rolling, kettle-hole topography, many depressions contain water, at least part of the year, and are classified as good duck habitat. South of the lake are several low-lying swales and swamps. Ducks find these to be a good habitat and nesting has been reported in the area. Prior to finalizing any plans for spoil disposal, the suitability of the proposed disposal area for waterfowl habitat should be ascertained.

The water at Silver Lake is quite turbid and contains much algae, though it does not appear to be as bad as the water at Lake Manawa. The algae, particularly the blue-green variety, are very abundant throughout the summer. Sparse stands of submergents, principally narrow leaf pondweed, have been noted. Emergents are principally round stem bulrush.

The town of Lake Park uses Silver Lake as its water supply. Excessive algae in drinking water can clog sand filters, increase chlorine demand, and contribute undesirable color, tastes, and odors to the finished water. Lake Park has had these problems in the past and will have them in the future unless something is done to remove the algae problem.

This lake has been dredged previously, but high silt and nutrient loads from agricultural runoff rapidly negated the beneficial effects of dredging. Since that time it has been reported by the Silver Lake Improvement Committee that 95 percent of the watershed at Silver Lake has been placed under conservation measures. Presumably, dredging would now have some lasting benefits. A community plan urges dredging of the lake to improve domestic water supply and recreation potentials.

Dredging should not be undertaken until the septic systems and sewer systems for the houses and cabins around the lake have been surveyed. Also, attempts should be made to ascertain the limiting nutrients for the algae population, particularly the blue-green varieties and the source of these nutrients. The organic content of the sediments should be ascertained, since oxidation of highly organic materials can cause odor problems. If the spoil material will be highly organic, steps can be taken to mitigate the odor problem.

At the present time Trappers Bay acts as a sediment and nutrient trap, and dredging will not affect the bay's productivity. Algal blooms that initiate in the bay will be able to enter into the main part of the lake unless some screening measures are initiated.

A suggested spot-dredging program, based on environmental and engineering considerations, will produce approximately 2.2 million cubic yards of spoil at a cost of $3.0 million, using a 12-inch hydraulic dredge and booster pump operating 370 days. Additional lake-management dredging and maintenance around the littoral zone by mud cat is urged, and shore line protection for approximately 5,000 feet and costing $37,000 is required. Figure 8 depicts the suggested dredging program.

In the absence of detailed topographic surveys, it is estimated that probable spoil sites can receive roughly 1.8 million cubic yards. The likely spoil areas will all require some pumping and are:

1. East of the John Deere property and in the vicinity of the sewage treatment ponds. Pumping will be needed and the return flow to the lake is not practical from this area. The water will go into the West Branch of the Little Sioux River; however, if necessary, the water from the spoil area could be returned to the lake by pumping. Diking of the area will be required.
2. Northeast of Trappers Bay, across the railroad tracks.
3. Farmland southeast of the lake and north of the state highway; will require diking.
4. Pasture land, south of the state highway and about 500 feet east of the east entrance to the golf course.
5. Marginal cropland and grassland, north of the state highway, east of the west entrance to the golf course and west of the golf course. Minimal diking will be required.
6. Farmland, north of the state highway, west of the west entrance to the golf course and south of the western part of the lake.

From an engineering standpoint it is recommended that Silver Lake be dredged, with the extent of dredging dependent on acquisition of adequate spoil disposal sites. Priority should be given to deepening the eastern portion of the lake around the city water intake pipe.

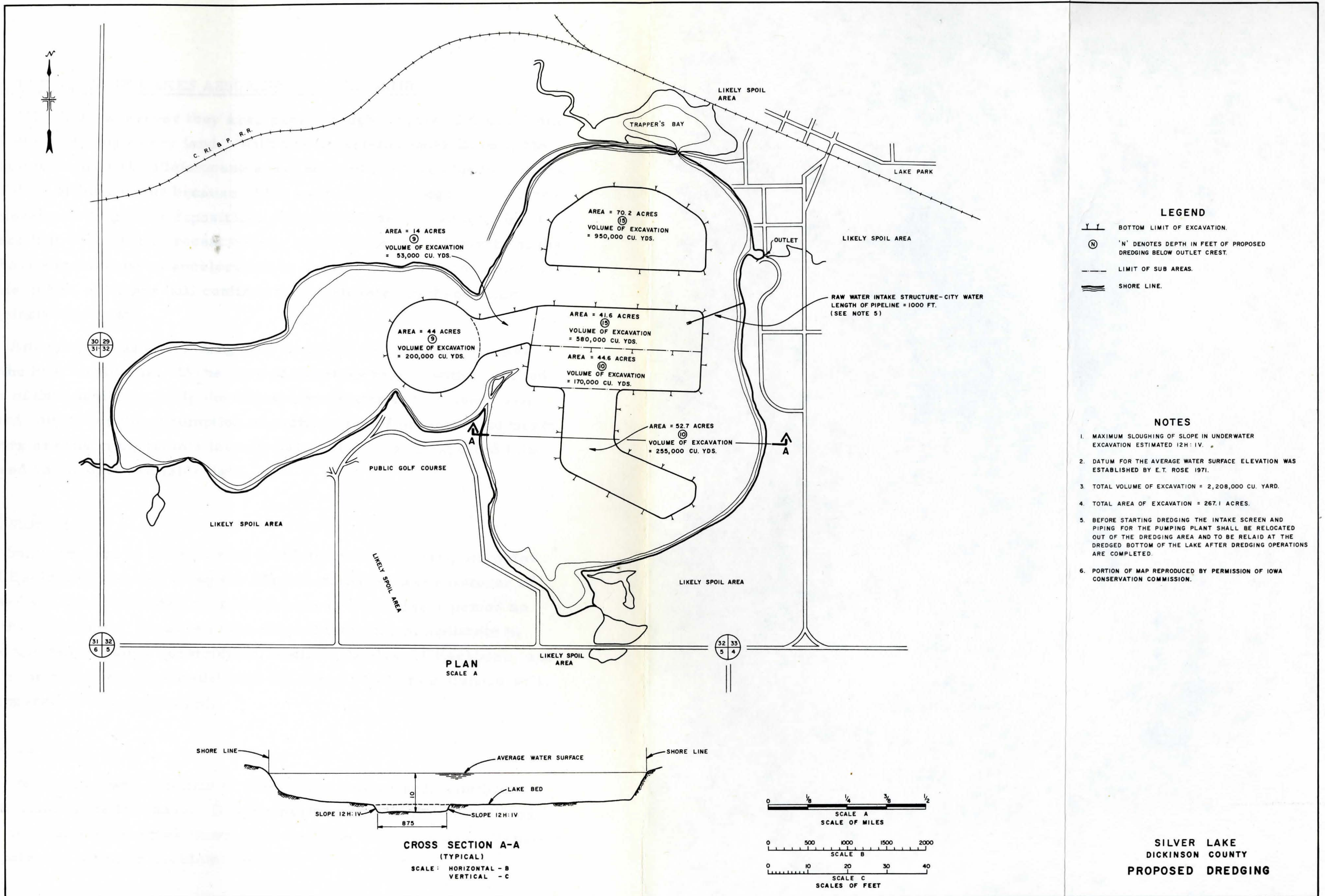


Figure 8

PROPOSED DREDGING FOR SILVER LAKE

EXPECTED LIFE OF LAKES ASSUMING NO DREDGING

All lakes, wherever they are, pass through a cycle of decay from lake to marsh to bog to dry land. With few exceptions most lakes came into existence since the Pleistocene era. Most of the lakes located on the glacial drift of Iowa occur because of the existence of topographic expressions developed by glacial deposition. These have been gradually infilling since that time, but in recent times, since European colonization, the lakes have experienced an acceleration in decay. Unless proper measures are undertaken, all lakes will continue to deteriorate, perhaps at an increasingly rapid rate.

Any predictions concerning lake longevity are difficult to make under the best conditions. In the case of the study lakes, with a limited amount of data available, only the widest time frame can be used, and this used only under the assumption of continuation of present conditions. Following are the study team's lake-by-lake estimates of expected lake life based on the best available data.

Backbone Lake

Sedimentation is such a great problem in the uncontrolled watershed of Backbone Lake and along the Maquoketa River that existence of this lake as a water-oriented recreation area is limited to a period no longer than 25 years. Because of the natural tendency of sediment to migrate upstream from a constriction, such as the dam at Backbone, not only will the reservoir be silted-in but the clear, cool trout fishery will be endangered, if not eliminated.

Black Hawk Lake

Provost Bay will continue to relieve the bulk of sediment brought to Black Hawk by its tributary. In spite of this some sediment will continue to be deposited in Black Hawk Lake itself by lake currents. Removal of the upstream pollution problems will help reduce nutrient input but nothing is known of the nutrients received from urban runoff and the septic-sewer systems. If these sources are controlled, there is no reason to predict the sudden demise of Black Hawk Lake within the foreseeable future. However, certain activities will be curtailed, that is, motorboating and water-skiing. The fishing potential will decrease and fisheries management will present an increasing problem as the aging process of the lake continues.

Blue Lake

As long as the water level at Blue Lake can be maintained artificially, this lake should continue to offer certain water-oriented recreation. However, motorboating and water-skiing will have to be curtailed as the lake ages. It is quite possible that the reported lowering of the water level of the Missouri River has had a significantly deleterious effect on Blue Lake, a particular aspect that should be studied. The pollution potential that exists because of the development of the trailer village on the east shore, unless corrected, could cause rapid deterioration of the lake's waters and foster noxious algal blooms that would detract from the aesthetic appearance of the lake.

Five Island Lake

Without protective measures it is assumed that bank erosion and caving will continue at Five Island. Inasmuch as this material must go somewhere within the lake, the life of Five Island might be measured as a function of shore line erosion. If one assumes that the reported 20-25 feet of shore line erosion on the east bank in the past 20 years is correct, then some 32,000 cubic yards of shore material could be added to the lake bottom over the next two decades. This would raise the entire bottom more than seven inches. Since the material would not be distributed evenly over the bottom, but would be deposited, for the most part, in the deeper areas, one could expect a rapid decrease in maximum water depth with a general decline in the more active lake-oriented recreational activities.

Continued sedimentation and general aging of the lake will lead to more definite eutrophic conditions. Emmetsburg, situated on the south end of the lake, could be plagued by unsightly algal blooms and odor problems.

Lake Manawa

The organic content, the nutrient content, and questionable water quality of Lake Manawa are problems that will all be compounded greatly by the passage of time. Eutropic growth varies from lake to lake and rates of growth certainly cannot be predicted. However, it is difficult to see how Manawa can exist more than another generation. Not only will recreational activities cease but unless some sort of corrective measures are undertaken, Manawa will not be a very agreeable place near which to live. One also must remember that the water level here, as at Blue Lake, is artificially maintained. At the present time there are only rudimentary controls over the sediment content of this water supply and no controls over the nutrient content. It is very conceivable that in the next 20 years Lake Manawa, without any action taken, could become an urbanized backwater swamp of the Missouri River.

Mill Creek

The sedimentation rate at Mill Creek is rapid and the nutrient input from agricultural sources is high. As a consequence, lake filling and algal blooms are ongoing phenomena. Without some sort of program established either for the lake or its watershed, Mill Creek could be expected to fill in within the next 20 years and become a marsh area--an artificial wetland.

Rock Creek Lake

Rock Creek Lake, as at Backbone and Mill Creek, is subjected to heavy sedimentation. However, certain physical conditions exist at Rock Creek that serve to protect the main body of the lake from such rapid filling. The highway bridge across the north end of the lake is a constriction that reduces the velocity of the main water supply so that the bulk of the sediment load is dropped north of the span. At the present rate of sedimentation, the area of the lake north of the bridge will become a marsh within the next 10-15 years. After that, the main body of Rock Creek will commence to fill more rapidly. Without any action its life may be estimated to be 100 years.

Silver Lake

With its watershed reported to be 90-95 percent controlled by conservation measures and Trappers Bay serving as a fairly effective sediment trap, there is no reason to expect additional sedimentation within Silver Lake such that the life of lake is threatened if certain bank erosion measures are implemented. However, nutrient input is high and water quality a problem. Seasonally, Silver Lake experiences rather severe algal blooms and resulting aesthetic problems as these blooms die off and decompose. Unless some action is initiated to correct the nutrient and water quality problems, Lake Park will lose its water supply and, being located on the lee side of the lake, will experience continued increasing odor problems in the next 10-15 years.

SUMMARY

Dredging at the three man-made lakes--Rock Creek, Backbone, and Mill Creek--is deemed not feasible because of the combination of rapid siltation rates from surrounding watersheds and the nonavailability of adequate spoil disposal sites. Dredging at the other five lakes is physically and environmentally feasible, depending on successful acquisition of identified spoil disposal sites and assuming sewer problems and nutrient problems are first resolved. Subsequent sections of this report analyze potential benefits arising from the suggested dredging projects. And, in the final section, costs of dredging are reviewed and compared against potential benefits.

Section IV

RECREATIONAL USE ANALYSIS

RECREATION FACILITIES AT THE SUBJECT LAKES

Table 4 outlines recreation facilities available at the eight study lakes and their associated state parks. All eight lakes are state owned and have adjacent state parks, although the state park on Five Island Lake, Kearney Reserve, is under municipal management. Permanent full-time state park officers reside at Backbone, Black Hawk, Blue, Manawa, and Rock Creek lakes. The facilities listed in Table 4 include any and all that draw outdoor recreationists to the specified lake, its state park, and its peripheral area.

The State Conservation Commission classifies recreation areas by their primary use. According to this classification system, the eight study lakes and their state parks are general outdoor recreation areas and natural environment areas, as opposed to high-density recreation areas or unique, natural, primitive, historic, or undeveloped lands. General outdoor recreation areas are intended for less intensive use, though they provide a variety of facilities. They are more "resource-oriented" in design and location than the urban center location of "use-oriented" areas. Natural environment areas limit man-made developments to those necessary for access and sanitation and encourage scattered use.

The following paragraphs describe the existing facilities and attractions at each of the eight study lakes.

Backbone Lake

Backbone Lake, State Park, and Forest are located four miles south of the town of Strawberry Point, population 1,281, which recently opened a public outdoor swimming pool. The Upper Backbone area, entered from the north is heavily forested and traversed throughout by

Table 4

LAKE/STATE PARK RECREATION FACILITIES

	Boating					Camping						Picnicking						Other
Lake	Boat Access	No Size Limit	6 Horsepower Unit	Electric Motor	Cabins	Modern	Non-Modern	Undeveloped	Concession	Fishing	Hunting	Enclosed Shelter	Developed	Undeveloped	Shelters	Showers	Swimming	Hiking Trails	
Backbone	*		*		*	*			*	*	*		*		*	*	*	*	Golf
Black Hawk	*	*				*				*			*		*	*	*	*	
Blue/Lewis & Clark	*	*				*			*	*	*	*	*		*	*	*	*	Historic Interest
Five Island/Kearney Reserve	*	*						*		*	*		*		*		*		Golf, Historic Interest, Swimming Pool
Manawa	*	*				*				*	*		*		*	*	*	*	Golf
Mill Creek	*			*			*			*		*	*		*		*		Golf
Rock Creek	*		*			*			*	*	*		*		*	*	*		
Silver/Trappers Bay	*	*					*	*		*	*		*		*		*		Golf, Swimming Pool

Source: Iowa Conservation Commission and Economics Research Associates.

approximately three miles of winding paved road. Provision is made for numerous accesses to the Maquoketa River, which flows through the area and feeds the lake. The state fish hatchery, located in the Upper Backbone park area, and the golf course adjacent to the park are open to the public. Their attractiveness to lake visitors was demonstrated in the ERA survey findings.

Extensive trail systems for hiking and snowmobiles, as well as campgrounds, shelters, and picnicking facilities, penetrate the park area and surround Backbone Lake. A swimming beach is located at the south shore of the lake, where rental cabins, paddleboats, and canoes are also available.

Black Hawk Lake

Black Hawk Lake, State Park, and natural wildlife area are located adjacent to Lake View, a town of 1,249 residents. The lake is encircled by paved road which provides public access for camping, picnicking, fishing, and swimming, as well as scenic driving at all points, excluding the stretches of private property (approximately 20 percent of total waterfront area) developed as permanent residences and second homes.

In addition to facilities listed in Table 4, private rental cabins, a boat marina, swimming beaches, and city parks are located on the lake shore. The statue of Chief Black Hawk and a restored log cabin are points of interest visited by lake users. The adjacent Arrowhead Lake, Provost Slough vicinity, is a wildlife refuge attracting migratory species and providing additional picnicking and fishing.

Blue Lake

Blue Lake and its associated Lewis and Clark State Park are situated between the Missouri River and the town of Onawa, population 3,154, and are easily accessible from a major interstate freeway.

The oxbow shape of the lake encloses a wooded area of nature trails, campgrounds, and picnicking facilities, and an enclosed shelter, rentable by the day for large groups. The east half of the lake is most suitable for fishing, swimming and boating, whereas the west half, shallow and overgrown, attracts a wide variety of game and fowl.

Five Island Lake

Situated at the north end of the town of Emmetsburg, population 4,150, this long, narrow lake covers 945 acres, bordered by both residential and agricultural property, and provides numerous secluded shore fishing spots. Other water-oriented recreation activities generally center around the southern end of the lake, where boat ramps, private boat docks, swimming beach, and picnic facilities are located.

Soper Park, a city park on the south lake shore, contains a playground and swimming pool, and Kearney Reserve campground and the golf course are located nearby on the southwest lake shore.

Manawa Lake

Lake Manawa is the exception to the study lakes generally, because of its nearness to an urban population center (that is, Council Bluffs, Omaha, population 545,273) though it is not classified as a high-density recreation area and does not have facilities to accommodate the intensive use implied by that classification. Various well-developed recreation facilities are provided for lake and state park visitors, and most of the lake shore is accessible by paved road.

A significant portion of the lake shore is residentially and commercially developed for private use and offers a sailing club, country club, (golf and tennis), boat livery, and fish and game association.

Mill Creek Lake

Mill Creek is located one mile east of Paullina, population 1,257, and is considerably smaller in water and land acreage than the other study lakes. The park area and recreation facilities are concentrated in one area and access to the lake is limited to one road intersecting the main highway. Access to the nearby golf course is by another road intersecting the highway.

Rock Creek Lake

Though Rock Creek Lake and State Park are not adjoined to a town, they are located near the towns of Kellogg and Grinnell, home of Grinnell College. Newton, the county seat with a population of 15,619 residents, is approximately 15 miles away.

The lake is divided north-south by a highway bridge. The northern portion is maintained as a hunting and fishing area, while the southern portion is developed for other water-oriented recreation activities. Rental boats and motorboats are available though motor size is limited to six horsepower. Most of the lake shore is accessible to the public by paved road, except for a small section that is residentially developed.

Silver Lake

The northeastern shore of Silver Lake and Trappers Bay State Park adjoins Lake Park, a town of 976 residents, some of whom have homes on the lake shore. Residential sites have been developed along the southwestern shore near the golf course in recent years, and an additional portion of the lake shore is private agricultural land.

Public access to the lake is accomplished through Trappers Bay Park, several isolated unpaved roads on the west shore, a campground on the south shore, and a city park complete with swimming pool, picnicking facilities, and fishing dock, on the east shore.

IOWA LAKES SURVEY

A review of available literature pertaining to recreation uses of Iowa lakes produced information on a regional and subregional basis, but did not provide data on recreation use for individual lakes. Therefore, ERA undertook a recreation-use survey of each of the eight lakes included in this study.

Scope and Method of Approach

The survey period was defined and limited by the timing and scope of the Iowa Lakes Study, and took 10 days--from Saturday, August 24 through Labor Day, September 2. Respondents were contacted at the lakes during the eight most heavily attended hours of the day, those hours varying from lake to lake as determined by interviewer experience.

The study team developed a 12-item questionnaire[1/] to obtain data regarding activities pursued at the lakes, user age composition, duration and frequency of visits, and distances travelled to visit the lakes. User opinions were solicited. Specifically, respondents were asked to comment on their perception of dredging's potential effect on their use and enjoyment of the lake, and to identify facilities they believed could be added or improved to enhance the lake's recreation potential.

The survey was conducted by lake community residents who administered the questionnaire and recorded information regarding party size and composition. The interviewers contacted lake users in beach, park, and concession areas, parking lots, campgrounds, and fishing sites along the lake shore. They were instructed to select respondents from people engaged in a variety of activities so that a representative sampling of visitors and their activities would be obtained. A one hundred percent sampling of lake users was neither expected nor considered useful for the purposes of the survey.

1/ Questionnaire is contained in Appendix B.

Because of the fact that the ERA/ECI benefit-cost study was not awarded and initiated until early August, it was not physically possible to commence interviewing for the survey until August 24. This date represented the latest possible chance to obtain a representative and sizable sample of recreation users at the lakes during this season. Thus, there was no opportunity for a pilot study, that is, a period of questionnaire testing.

Other disadvantages of the survey timing were unseasonably cold and wet weather and, in some lake areas, resumption of school sessions during the week of the survey, and in others during the week following Labor Day weekend. These factors were expected to affect attendance and use of the lakes.

Survey Findings

Respondents were found to be generally interested and cooperative, and capable of answering all questionnaire items. A total of 3,934 questionnaires were completed. The distribution of responses by lake is shown in Table 5.

Location of Residence and Distance Driven to Visit Lake

Table 6 shows for each lake the location of residence for respondents. As shown, responses indicate a very small percentage of out-of-state visitors to the lakes in question. Although the study team believes that more out-of-state visitors attend the lakes during peak vacation travel season, it is doubtful that the percentage, relative to lake-using Iowans, would be much higher. When compared with Table 7, which reflects the number of miles driven to visit the lakes, it appears that even in instances where out-of-state attendance is relatively high, that is, at Lake Manawa and Blue Lake, the driving distance remains low.

Table 5

SURVEY RESPONSES

Lake	Number of Completed Questionnaires
Backbone	775
Black Hawk	430
Blue	611
Five Island	616
Manawa	510
Mill Creek	166
Rock Creek	642
Silver	184

Source: Economics Research Associates.

Table 6

LOCATION OF RESIDENCE
(Percent)

Lake	Iowa	Out of State
Backbone	94%	6%
Black Hawk	89	11
Blue	71	29
Five Island	92	8
Manawa	61	39
Mill Creek	98	2
Rock Creek	93	7
Silver	91	9

Source: Economics Research Associates.

Table 7

DRIVING DISTANCE TO LAKE
(Percent)

Lake	Miles 0-25	26-50	51-75	76-100	101-200	Above 200
Backbone	16%	24%	27%	10%	19%	4%
Black Hawk	20	15	18	24	20	3
Blue	35	23	29	6	4	3
Five Island	67	12	6	1	11	3
Manawa	93	3	2	1	1	0
Mill Creek	94	0	1	0	3	2
Rock Creek	38	34	16	7	3	2
Silver	17	18	20	25	12	9

Source: Economics Research Associates.

Generally, Tables 6 and 7 reflect the local, regional nature of the eight lakes' market areas, with Mill Creek showing the most distinct community orientation. The higher percentage of out-of-state visitors to Manawa and Blue lakes are clearly the result of their locations near Nebraska. In the case of Manawa, the short distance driven to the lake reflects a heavy attendance draw from nearby population centers, that is, Council Bluffs, Iowa and Omaha, Nebraska.

In contrast to these two lakes, which are situated near the state border and draw heavily from out-of-state, Silver Lake, lying approximately five miles from the Iowa-Minnesota border, draws visitors primarily from northwestern Iowa. This may be because of the abundance of lakes in southern Minnesota and the predominant attraction of the Spirit and Okoboji lakes area, located a short distance east of Silver Lake.

Age Composition of Lake Visitors

Table 8 reflects the age groups distribution of survey respondents. Significantly higher percentages for certain age groups might be indicative of activities pursued at the lakes where they are reflected. For example, the highest percentage in the 12-18 age group was reflected at Mill Creek Lake, to which many youths ride bicycles from nearby Paullina to swim (note the high percentage of swimmers at Mill Creek in Table 11). Fishing, by a large margin, is the most preferred and pursued activity at Five Island and Silver lakes, where exceptionally high percentage were reflected in the 51-65 and above 65 age groups.

Length of Visit

Table 9 indicates respondents' length of stay at the study lakes and reflects an unexpectedly high percentage of visits exceeding one day for Backbone, Black Hawk, Blue, Silver, and Rock Creek lakes. Presumably, visitors spending one or more days at the lakes are campers or, possibly, cabin renters. The number of campers would be reflected in camping

Table 8

AGE OF RESPONDENTS
(Percent)

Lake	Age Group 12-18	19-26	27-36	37-50	51-65	Above 65
Backbone	10%	20%	23%	27%	10%	4%
Black Hawk	13	20	22	27	12	6
Blue	16	21	26	20	13	4
Five Island	23	12	14	19	20	12
Manawa	7	19	29	26	14	5
Mill Creek	39	13	11	17	9	11
Rock Creek	15	14	22	24	19	6
Silver	11	11	14	19	25	20

Source: Economics Research Associates.

Table 9

LENGTH OF VISIT
(Percent)

Lake	Hours			Days			
	1 to 4	5 to 8	9 to 12	1	2	3	4 or More
Backbone	20%	17%	3%	4%	30%	13%	13%
Black Hawk	11	10	1	8	33	21	16
Blue	28	21	1	4	14	23	9
Five Island	69	19	0	4	5	1	2
Manawa	52	35	1	1	4	5	2
Mill Creek	84	8	2	2	3	1	0
Rock Creek	21	22	2	6	25	17	7
Silver	20	18	2	23	20	11	6

Source: Economics Research Associates.

participation percentages which, in fact, are higher for the five lakes in question (reference Table 11).

High percentages for visits of one day or longer, and correspondingly high percentages for camping participation, however, conflict with camping attendance statistics, available for the lakes at which state parks are located through monthly reports of the state park officer. As shown in Table 10, camping attendance does not generally exceed 10 percent of total attendance, and in most cases is significantly less. State-owned rental cabins and privately-owned rental cabins are available on the lake shores of Backbone and Black Hawk lakes, respectively. However, they are not numerous and could not account for the high percentage of lengthy visits.

It is possible that Labor Day weekend was an exceptionally popular period for camping and, further, that campers represented the most easily approached group of respondents for the interviewers. Allowing for respondents who may have included their driving times to and from the lakes, the fact remains that the high percentage of visitors staying one day or longer shown for five of the eight lakes is unrealistic and should not be considered reliable as an index for periods other than the period of the survey.

Recreation Activities

Table 11 outlines the questionnaire responses indicating which activities are pursued at each lake. Percentages shown are the number of times an activity was indicated at each lake relative to the total number of respondents for that lake. As most respondents engaged in more than one activity during their visit to the lake, activity totals for each lake exceed 100 percent. The availability of activities and the number of activities engaged in per respondent vary from one lake to another; thus, one must be careful when comparing the percentages among lakes. The average number of activities indicated per person are as shown on page IV-17.

Table 10

CAMPING ATTENDANCE

Lake	1972 Attendance	Percent of Total Attendance	1973 Attendance	Percent of Total Attendance
Backbone	20,739	5.0%	26,073	9.7%
Black Hawk	12,564	4.2	12,551	4.3
Blue	13,718	6.1	12,076	3.8
Manawa	614	0.2	5,472	.9
Mill Creek	817	4.0	532	5.9
Rock Creek	25,080	3.9	25,872	5.4

Source: Iowa Conservation Commission.

Table 11

PARTICIPATION IN SELECTED ACTIVITIES[1/]
(Percent)

	A. Fishing	B. Fowl Hunting	C. Game Hunting	D. Swimming	E. Water Skiing	F. Motor Boating	G. Sailing	H. Camping	I. Picnicking	J. Hiking	K. Bird Watching	L. Snowmobiling	M. Ice Skating	N. Ice Fishing	O. Sled Coasting	P. Ice Boating	Q. Nature Walking	R. Other[2/]
Backbone	43	1	2	40	1	4	3	47	44	40	9	2	.5	1	1	0	45	11
Black Hawk	72	3	2	67	35	45	4	75	55	26	8	2	1	4	.2	.2	40	5
Blue	62	6	6	63	28	39	4	58	70	46	14	6	9	4	2	1	53	7
Five Island	88	12	11	31	18	39	7	26	53	18	15	18	20	23	9	2	31	5
Manawa	68	7	1	51	26	36	15	22	60	14	10	8	14	13	3	1	36	10
Mill Creek	66	1	0	71	0	4	4	29	64	34	14	12	30	10	4	0	38	14
Rock Creek	75	5	4	37	0	34	5	52	51	21	6	3	4	5	2	.3	29	5
Silver	86	5	3	14	3	27	1	30	38	6	5	2	1	9	1	1	14	2

1/ Number of times an activity was indicated as a percent of total respondents.
2/ Examples of "other" activities listed include kite flying, bicycling, canoeing.

Source: Economics Research Associates.

Visitor Activity Participation

Lake	Average Number of Activities per Person
Backbone	2.9
Black Hawk	4.4
Blue	4.8
Five Island	4.3
Manawa	4.0
Mill Creek	3.7
Rock Creek	3.4
Silver	2.5

The most frequently pursued activities at each lake generally coincide with the most preferred activities as indicated by a question which asks respondents to rank the selected activities preferentially. In general for all eight lakes, fishing, picnicking, swimming, and camping (in that order) were the four most often pursued and preferred activities. Motorboating, nature walks, hiking, and water-skiing were mentioned significantly less often, but were included in the top five activities pursued and preferred at the eight lakes.

Significant exceptions to prevalent activity patterns are usually related to the existence or lack of particular lake facilities. For example, the high percentage of sailors at Lake Manawa is the result of the presence of a sailing club at the lake shore. Hiking and nature walks draw more participants at Backbone Lake, where trail systems are more developed and scenery is particularly attractive. Conversely, camping participation is relatively low at Mill Creek and Five Island, where camping facilities are lacking.

In some cases variations in activity patterns occur where lake facilities do not appear to be the cause and other factors should be considered. For instance, Lake Manawa reported relatively few campers despite its ample supply of modern camping facilities. Assuming other variables involved, such as weather, were as conducive to camping as the activities pursued by more people, the explanation may be found in the average distance travelled and length of stay. Clearly, the largest percentage of visitors to Lake Manawa are day trippers from within twenty-five miles of the lake.

It is interesting to note the seasonality of the recreation activities displaying the highest level of participation, as they tend to be exclusively or primarily summer activities. As the questionnaire listed activity choices for all seasons, the low percentages for fall and winter activities suggest several possibilities: that fall and winter sports enthusiasts were not surveyed as they do not participate in summer activities as well; also, that respondents may have interpreted the question as pertaining only to activities engaged in during the survey period. However, it is reasonable to conclude that fall and winter activities, especially water- and ice-oriented activities draw relatively few visitors to the lakes. These survey findings are confirmed by monthly attendance statistics which will be presented subsequently and which show a high concentration of attendance in summer months.

Lake User Opinions

Tables 12, 13, and 14 represent the findings of questionnaire items that solicit opinions of lake users regarding the impact of dredging the lakes. Table 12 measures the effect of dredging on use and enjoyment of the lake; Table 13 measures the effect on length of stay, and Table 14 measures intended frequency of visits. As respondents were given minimal information about dredging--what parts of the lake would be dredged, what depth would be attained, what the visible consequences would be, etcetera--it was expected that most respondents would be unable to give an educated opinion as to its effect. Yet the survey indicates that most respondents had strong perceptions and feelings regarding dredging's effect.

Table 12

EFFECT OF DREDGING ON USE
AND ENJOYMENT OF THE LAKE
(Percent)

Lake	Positive	Negative	No Effect
Backbone	54%	6%	40%
Black Hawk	65	7	28
Blue	85	2	13
Five Island	94	2	4
Manawa	90	1	9
Mill Creek	99	0	1
Rock Creek	45	10	45
Silver	75	4	21

Source: Economics Research Associates.

Table 13

IF DREDGING OCCURRED, WOULD YOU STAY LONGER AT THE LAKE?
(Percent)

Lake	Yes	No
Backbone	43%	57%
Black Hawk	63	37
Blue	78	22
Five Island	89	11
Manawa	85	15
Mill Creek	87	13
Rock Creek	35	65
Silver	64	36

Source: Economics Research Associates.

Table 14

IF DREDGING OCCURRED, WOULD YOU VISIT THE LAKE MORE OFTEN?
(Percent)

	Yes	No
Backbone	45%	55%
Black Hawk	61	39
Blue	84	16
Five Island	91	9
Manawa	87	13
Mill Creek	91	9
Rock Creek	41	59
Silver	70	30

Source: Economics Research Associates.

Not only did most respondents have opinions about dredging, but these opinions were predominantly positive. Lake users anticipated that dredging would provide better swimming and fishing, more beaches, improved water quality, and would reduce hazards associated with boating and water-skiing. There is a rough correlation between positive attitudes toward dredging and shorter length of visit and distances travelled. That is, persons who lived closest to the lake tended to be more favorably inclined toward dredging. At lakes where fewer respondents indicated dredging would cause them to stay longer or visit more often, visitors surveyed had stayed longer and driven further to the lake than visitors in general to the other lakes.

Conclusions

Caution is indicated in expanding 10-day survey findings, obtained during the waning vacation travel and water-oriented recreation season, to year-round use patterns. However, the study lakes were well-attended during the survey period, as state park office statistics shown in the text table below indicate,[1/] and the sampling obtained provides valuable indications of where lake visitors come from, what they do at the lakes and how they feel about dredging.

Lake	Visitor Attendance (August 24-September 2)
Backbone	22,000
Black Hawk	20,165
Blue	8,750
Manawa	23,057
Rock Creek	23,100
Silver	1,355

1/ Data not currently available for Five Island Lake or Mill Creek Lake.

Where Lake Visitors Come From

Generally, the study lakes are visited by Iowans who travel less than 100 miles to participate in available recreation activities. Significant out-of-state attendance was noted at Lake Manawa and Blue Lake, which are located near Iowa's western border and attract visitors from nearby Nebraska population centers.

Lake size and facility development, location in relation to population concentrations, and competing recreation areas can be considered factors which affect how far people travel to visit the lakes. Mill Creek, the smallest of the study lakes, attracts 94 percent of its attendance from within a 25-mile radius lacking any large population centers. Lake Manawa draws an equally high percentage from within an equivalent radius, but is larger, offers a wider variety of developed facilities, and is located within 25 miles of the densely populated Omaha-Council Bluffs area.

Certain lakes feel the impact of competing recreation areas, as reflected in driving distances for Silver, Black Hawk and Rock Creek lakes. The lower percentage of visitors travelling less than 25 miles to Silver Lake indicates many potential visitors within that radius gravitate to the Spirit and Okoboji lakes area. Attendance at Black Hawk may be similarly affected by competition from Storm Lake, and potential visitors to Rock Creek, from a distance of more than 50 miles to the south or west, apparently prefer to attend any of the numerous reservoirs or lakes in that vicinity.

Finally, the survey indications of where people come from to visit the study lakes provided the basis for definition of market areas for the lakes (see Market Area Delineation and Demographics).

What Lake Visitors Do

Survey results reflected wide participation in various water-oriented and other recreation activities at all the study lakes. The average respondent participated in summer activities; fall and winter activities were selected infrequently.

Fishing was indicated as the most pursued and preferred activity at four of the lakes, especially at Five Island and Silver lakes, where it enjoyed twice the participation of any other activity. Although fishing ranked among the five most often pursued and preferred activities at every lake, it attracted fewer participants at Backbone, where fishermen indicated it was becoming a less rewarding pastime.

Swimming, camping, picnicking, hiking, nature walks, and passive enjoyment of the outdoors were the other activities most frequently selected by lake visitors. As in the case of fishing, these were pursued and preferred in varying degrees, lake to lake, contingent upon the availability of facilities and the quality of the recreational experience provided by the activity at each lake.

A relationship between facilities and activities pursued was clearly indicated by survey findings. As previously mentioned, more recreationists hiked where trail systems are developed and scenery is particularly attractive (that is, Backbone and Blue lakes); more sailors are found at Manawa, where there is a sailing club. It was noted, however, that the activity percentages do not always indicate facility availability or quality of recreational experience. A case in point is Lake Manawa, where fewer campers may indicate prevalent day usage pattern, unaffected by the ample supply of modern camping facilities.

Survey results regarding recreation pursuits at the study lakes provided a basis for more detailed analysis of recreation demand. As a result of the findings, average growth rates were weighted for different types of activities at each individual lake (see Section V, Demand Analysis - Use Potentials).

<u>How Lake Visitors Feel About Dredging</u>

The survey findings are conclusive with respect to lake visitors' perceptions of how dredging might affect their use and enjoyment of the lakes. Presumably these opinions are, for the most part, uneducated as respondents were not provided factual information regarding dredging programs and their impacts. Most respondents felt dredging would have a positive effect on most lakes, and, concurrently, would be conducive to longer and more frequent visits. It is interesting to note that those surveyed demonstrated less enthusiasm for dredging at Backbone and Rock Creek lakes, both of which in fact were found to be the least feasible to dredge from an engineering standpoint.

MARKET ANALYSIS

Attendance Histories

Statistics reflecting visitor attendance at the eight study lakes are furnished by monthly reports of the state park officers. Daily attendance estimates are based on an average of periodic car counts, taken at intervals during peak visitor hours, to which a multiplier, indicating average persons per car, and a turnover factor are applied.

These statistics are available for all months at lakes where a permanent full-time park officer resides; that is Backbone, Black Hawk, Blue, Manawa, and Rock Creek. Park officers are maintained only part-time, generally during peak visitor season, at Mill Creek and Silver Lake (Trappers Bay). Thus, attendance figures for those lakes are limited to April or May through September for most years in the period 1960-1973, reviewed herein. Trappers Bay did not report attendance until 1973, except for two months in 1969. Five Island Lake/Kearney Reserve was not included in this reporting system and, unfortunately, other sources of attendance statistics are not available.

Attendance estimates available in officer reports may not be consistently accurate, though if attained by the park service formula should yield reasonably accurate figures. Statistics reported for the study lakes during a 13-year period (1960-1973) exhibit fluctuations in visitation totals for some lakes which do not follow reasonable expectations and cannot be explained by general social and economic conditions or by particular lake circumstances. Further, ERA attendance estimates for the 10-day survey period deviate in varying increments from park officer estimates for the same period at each study lake. However, as the only available indicators of recreation visitation at the study lakes they are more useful than estimates which would emerge from general sources such as state or national averages, and thus have been accepted for use in this study.

Annual Attendance

Table 15 delineates annual attendance for the period 1960-1973 at the study lakes/state parks where figures are available. Instances of incomplete reporting resulting in partial annual attendance figures are footnoted where they occur.

The patterns yielded by these statistics for each lake are graphically represented in Figures 9 through 14. It becomes apparent that no two lakes experienced a similar pattern of growth and/or decline during this 14-year period. The lack of correlation, in any one year, of attendance growth or decline at some or all lakes indicates that attendance fluctuations are less contingent upon general climatic or economic conditions common to all lakes than upon circumstances unique to each. Such circumstances might include road closures, extended power shutoffs in campgrounds, winter fish kill, or heavy algae bloom. Attendance statistics do reflect high sensitivity of visitor attendance to factors which are not always measurable.

Although lake attendance does not seem to peak at some or all study lakes in the same years during this period, several of the study lakes experienced relatively steady patterns of attendance growth. Figure 10 shows such growth at Black Hawk, Figure 11 at Blue, and Figure 14 at Rock Creek.

Attendance at Backbone peaked in 1964 and has failed to attain that level subsequently. Fluctuations in the last few years have been slight. Similarly, Mill Creek attendance has dropped from the levels achieved

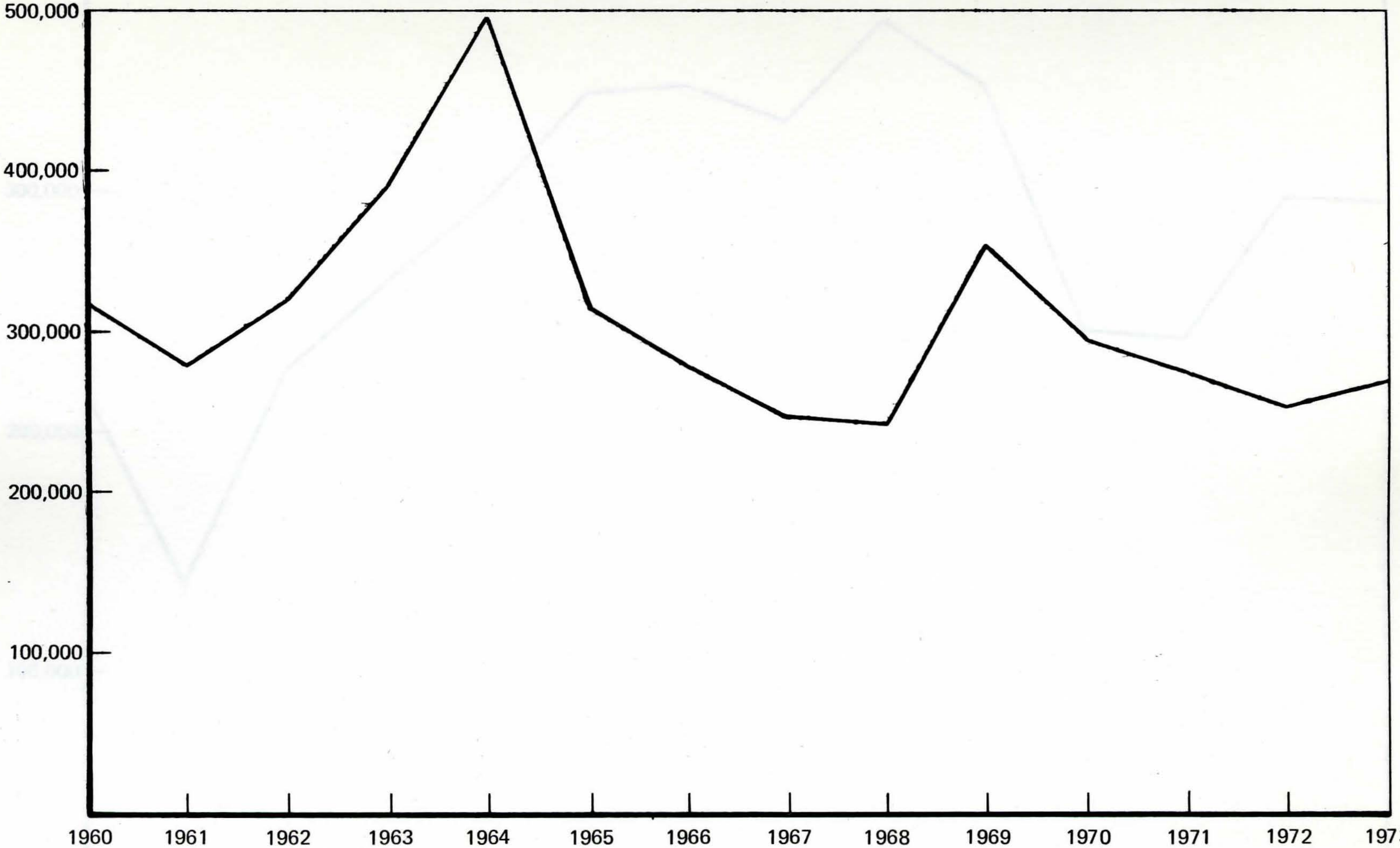
Table 15

ANNUAL ATTENDANCE BY LAKE
1960-1973

Lake	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Backbone	317,052	276,175	322,870	389,706	494,920	319,946	278,104	248,678	245,101	354,305	294,359	275,563	258,759	269,371
Black Hawk	216,820	132,719	225,150	264,045	291,694	341,625	344,520	332,380	372,480	344,407	239,775	237,605	297,970	292,510
Blue	121,935	172,500	190,020	195,110	193,020	198,090	199,920	165,910	197,175	224,300	215,725	218,140	223,960	315,053
Manawa	489,422	686,920	432,750	710,755	363,595	601,205	437,910	617,180	450,263	853,359	623,843	705,248	315,600	594,580
Mill Creek	55,732	54,534	44,869	46,507	51,199	47,136	54,655	36,808 1/	22,680 1/	18,130 1/	34,750 1/	37,375	20,284	8,913 1/
Rock Creek	274,416	338,510	262,426	325,701	334,988	397,055	462,129	464,580	504,529	378,450	446,163	521,098	709,220	476,275
Silver	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	2,145 2/	n. a.	n. a.	n. a.	33,120 3/

n. a. means not available.
1/ Six months attendance.
2/ Two months attendance.
3/ Nine months attendance.

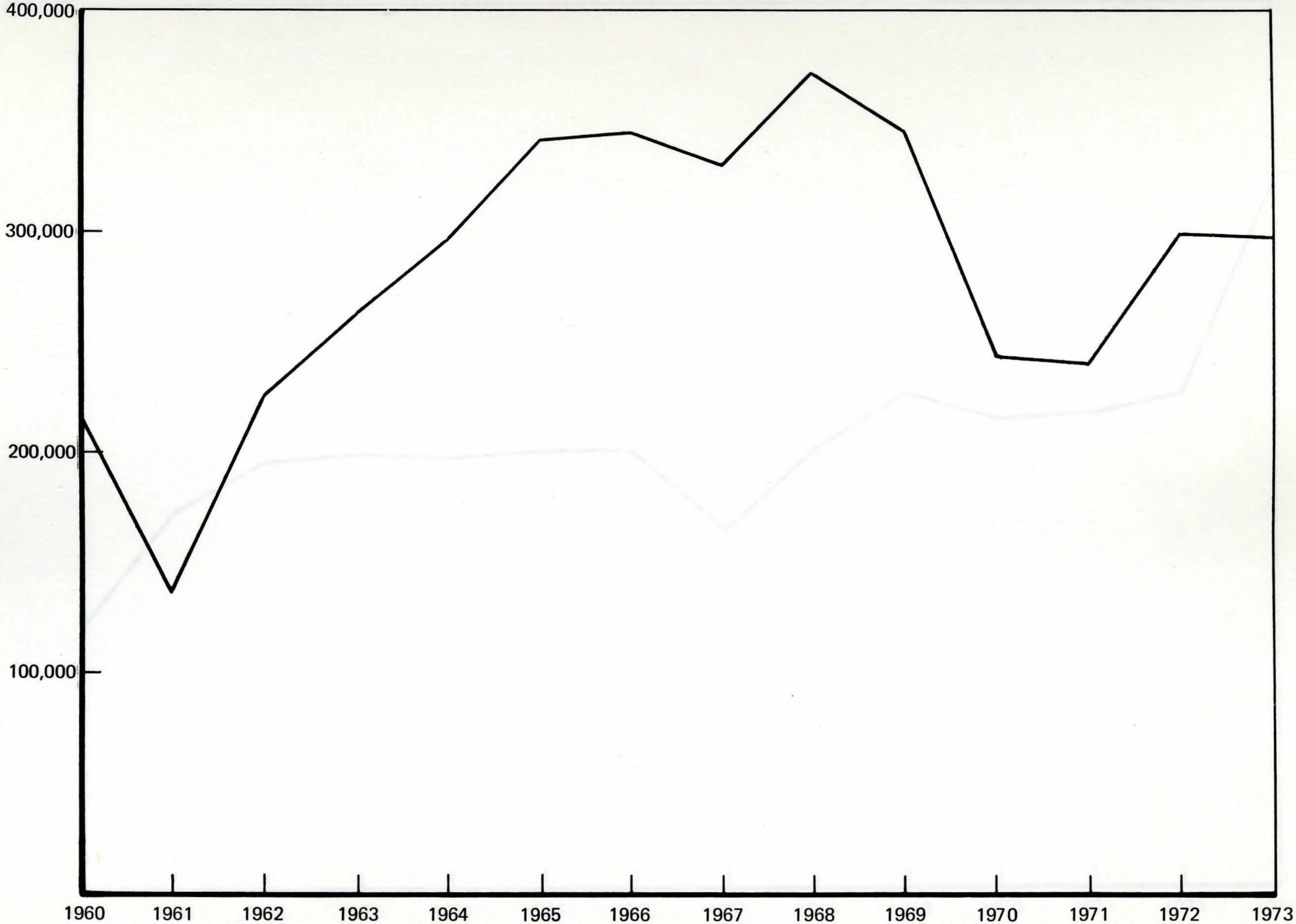
Source: Iowa Conservation Commission.



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 9

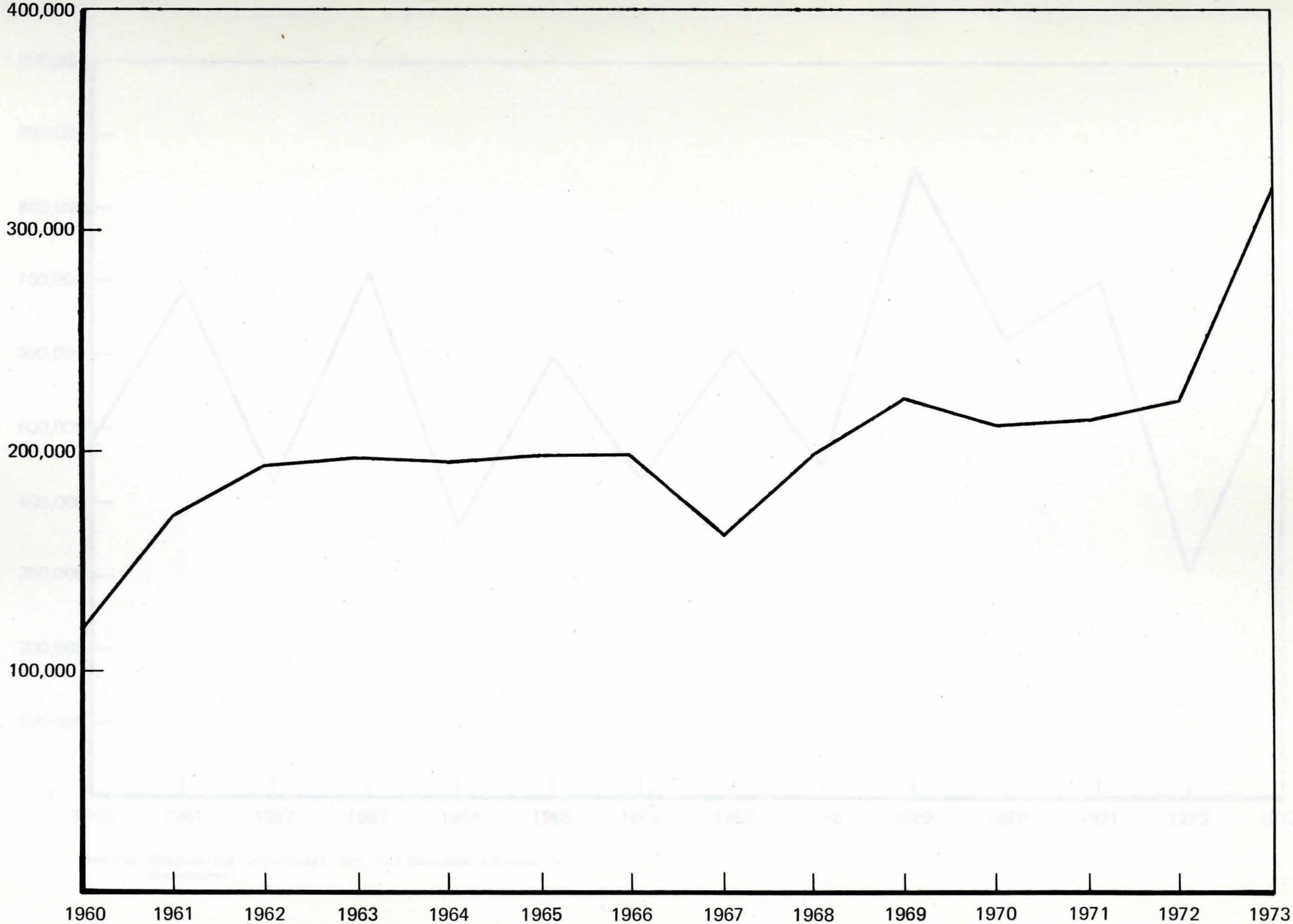
ANNUAL ATTENDANCE
BACKBONE LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 10

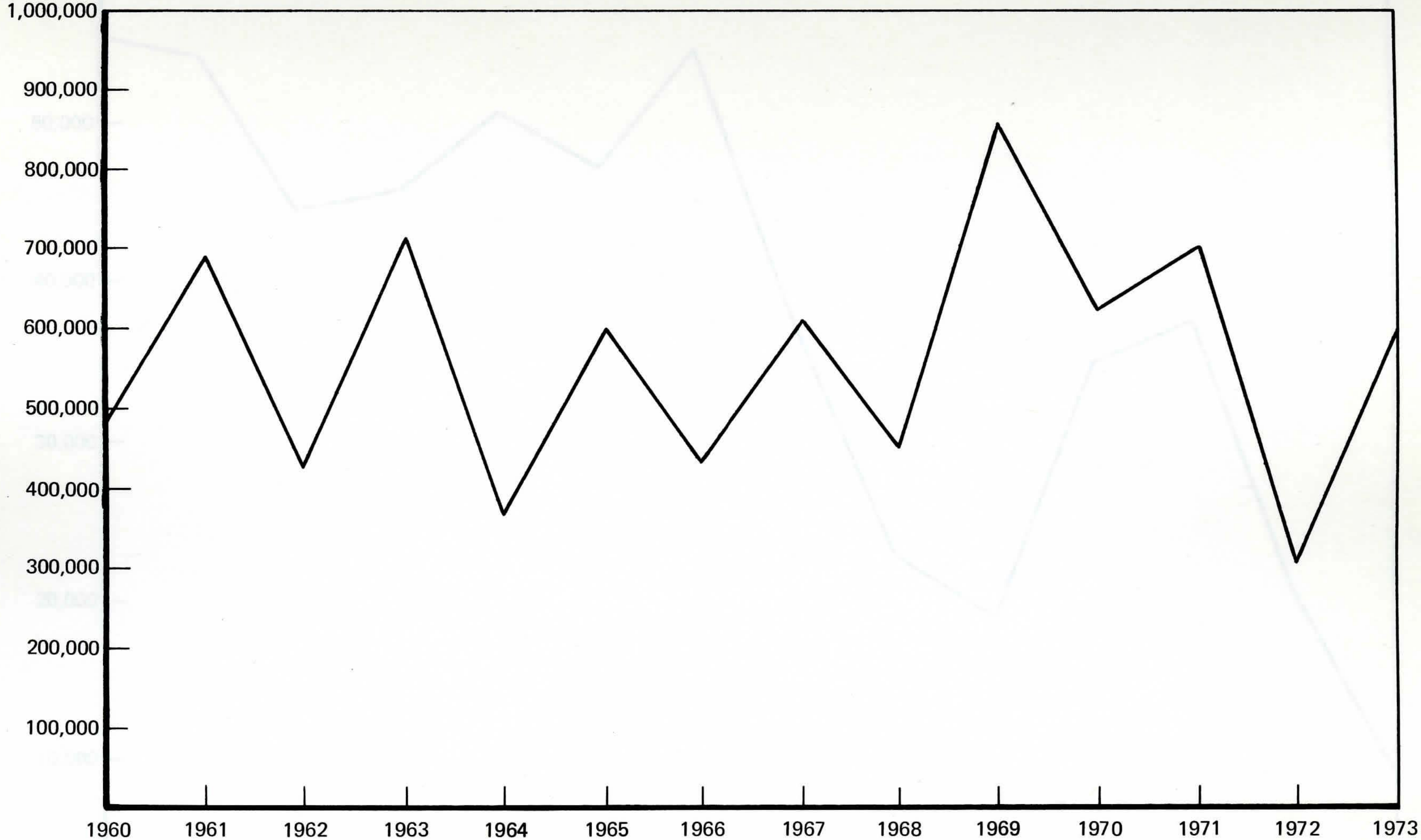
ANNUAL ATTENDANCE
BLACK HAWK LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 11

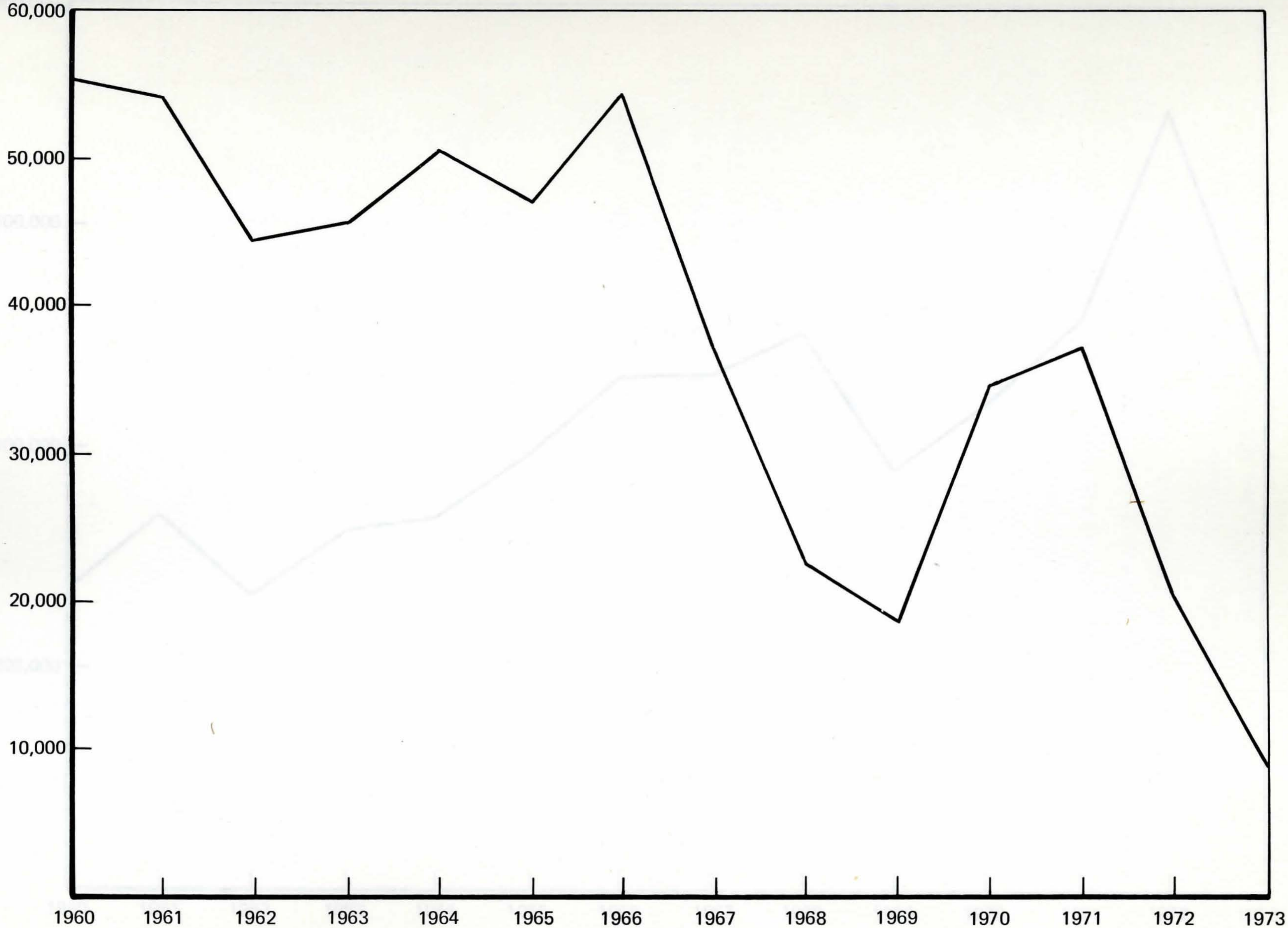
ANNUAL ATTENDANCE
BLUE LAKE



Source: Engineering Consultants, Inc. and Economics Research Associates.

Figure 12

ANNUAL ATTENDANCE
LAKE MANAWA

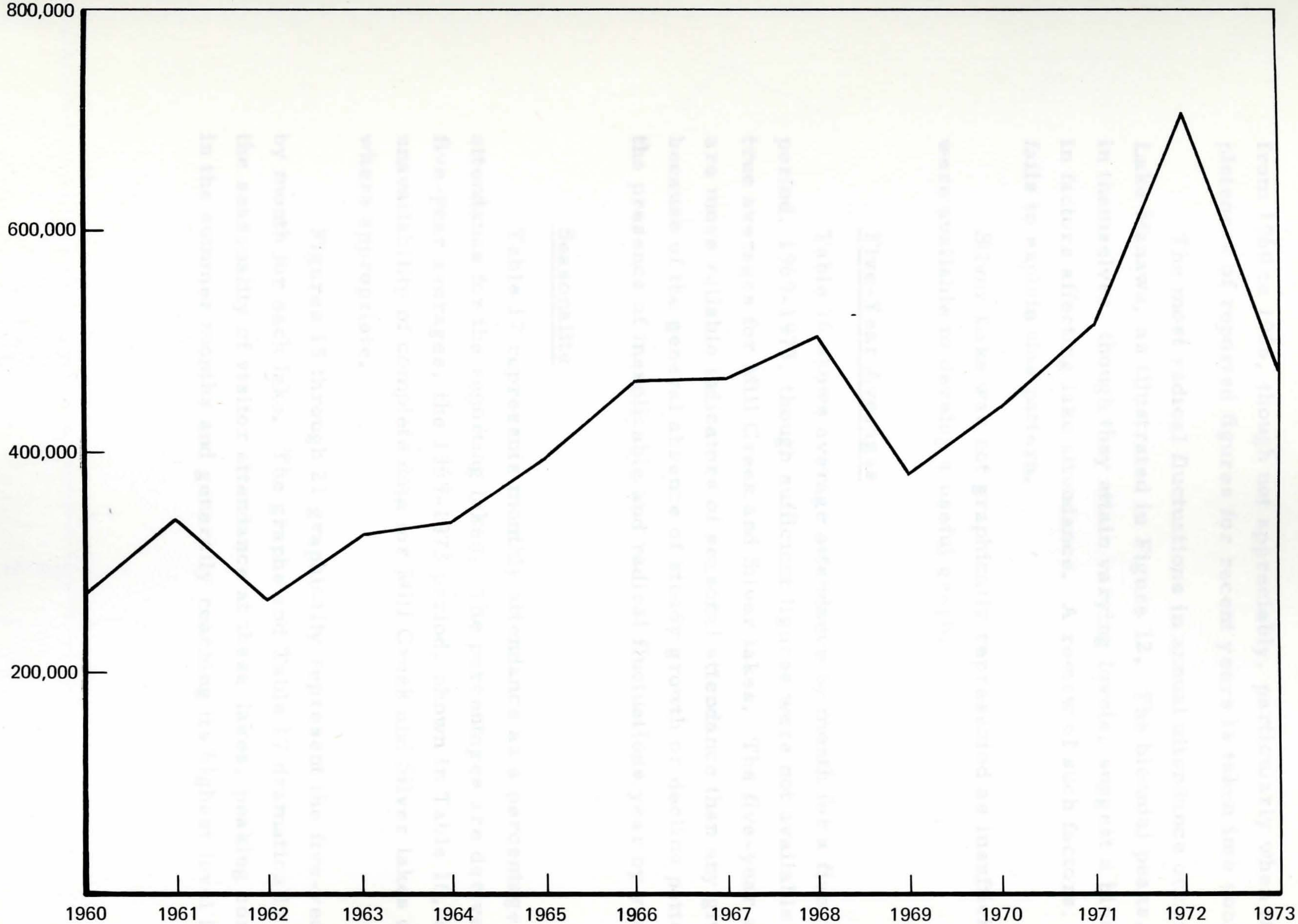


Source: Iowa Conservation Commission and Economics Research Associates.

Figure 13

ANNUAL ATTENDANCE
MILL CREEK LAKE

Note: Annual figures for 1967-1970 and 1973 based on six-months attendance.



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 14

ANNUAL ATTENDANCE
ROCK CREEK LAKE

from 1960 to 1966, though not appreciably, particularly when the incompleteness of reported figures for recent years is taken into consideration.

The most radical fluctuations in annual attendance occurred at Lake Manawa, as illustrated in Figure 12. The biennial peaks, a pattern in themselves, though they attain varying levels, suggest a biennial change in factors affecting lake attendance. A review of such factors, however, fails to explain this pattern.

Silver Lake was not graphically represented as insufficient data were available to develop a useful graph.

Five-Year Averages

Table 16 shows average attendance by month for a five-year period, 1969-1973, though sufficient figures were not available to compile true averages for Mill Creek and Silver lakes. The five-year averages are more reliable indicators of seasonal attendance than any given year, because of the general absence of steady growth or decline patterns and the presence of inexplicable and radical fluctuations year by year.

Seasonality

Table 17 represents monthly attendance as a percentage of annual attendance for the reporting lakes. The percentages are derived from five-year averages, the 1969-1973 period, shown in Table 16, and the unavailability of complete data for Mill Creek and Silver lakes are noted where appropriate.

Figures 15 through 21 graphically represent the five-year averages by month for each lake. The graphs and Table 17 dramatically evidence the seasonality of visitor attendance at these lakes, peaking consistently in the summer months and generally reaching its highest level in July.

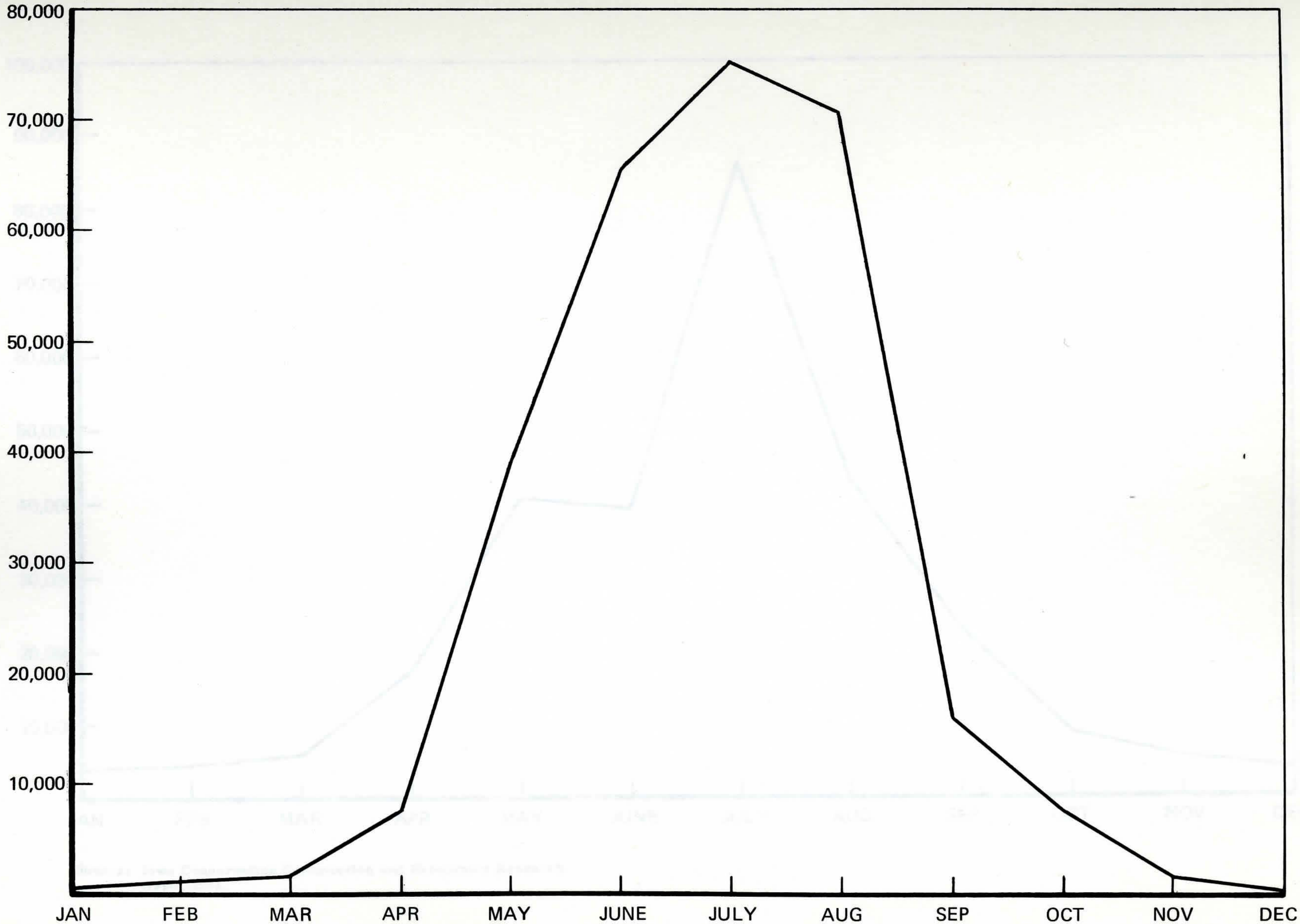
Table 16

MONTHLY ATTENDANCE BY LAKE
FIVE-YEAR AVERAGE
1969-1973

Lake	January	February	March	April	May	June	July	August	September	October	November	December	Total
Backbone	940	1,318	1,670	7,667	39,611	66,220	75,244	71,427	16,616	7,548	1,587	671	290,519
Black Hawk	4,014	4,337	5,519	17,360	41,040	39,480	85,440	43,405	22,482	9,341	5,885	4,150	282,453
Blue	4,520	6,487	9,009	15,574	27,317	36,118	68,268	33,561	17,194	9,938	6,683	4,767	239,436
Manawa	6,175	5,622	10,483	46,385	89,814	114,312	118,601	133,346	56,628	15,532	12,283	9,345	618,526
Mill Creek	n. a.	n. a.	n.a.	2,266 1/	3,937	4,943	6,681	4,477	2,436	454 1/	n. a.	n. a.	25,194 2/
Rock Creek	8,339	6,857	9,885	28,822	66,783	82,777	102,892	105,465	55,779	22,688	8,525	7,430	506,242
Silver	n. a.	n. a.	n. a.	2,460 1/	3,975 1/	8,850 1/	5,673 1/	1,171 1/	1,875 1/	775 1/	600 1/	750 1/	26,079 2/

n. a. means not available.
1/ Data not available for five-year average.
2/ Data not available for full year attendance averages.

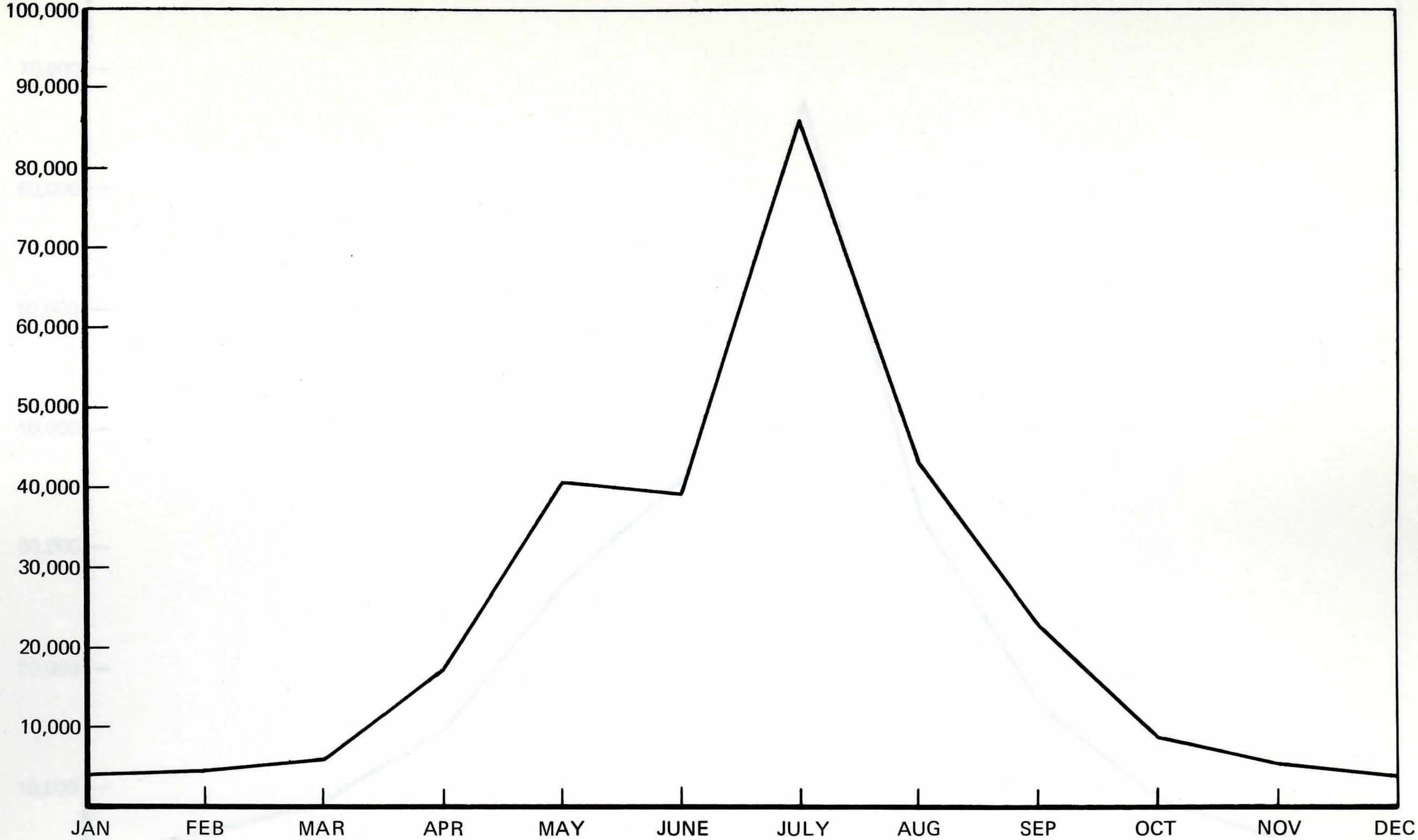
Source: Iowa Conservation Commission and Economics Research Associates.



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 15

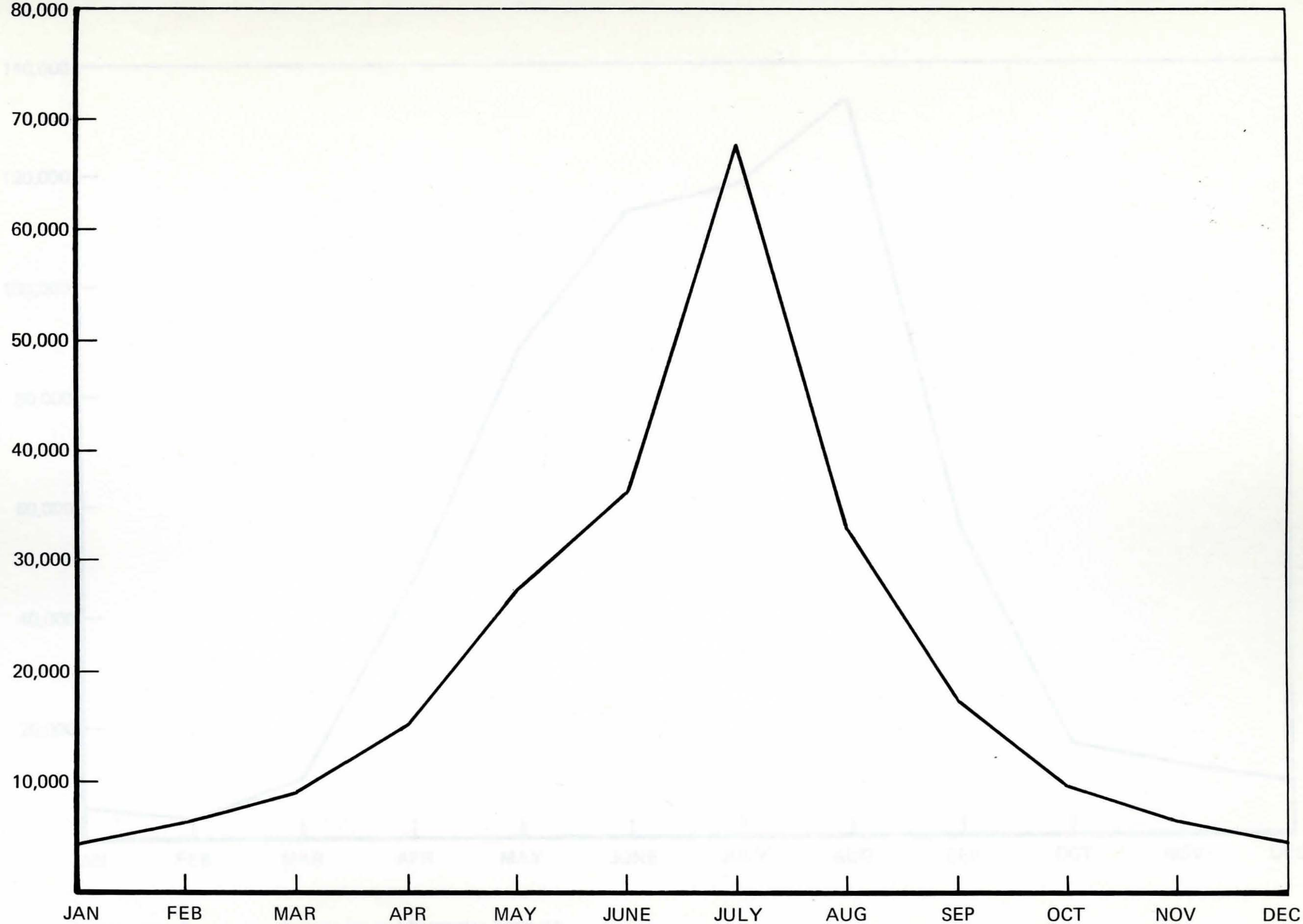
MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
BACKBONE LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 16

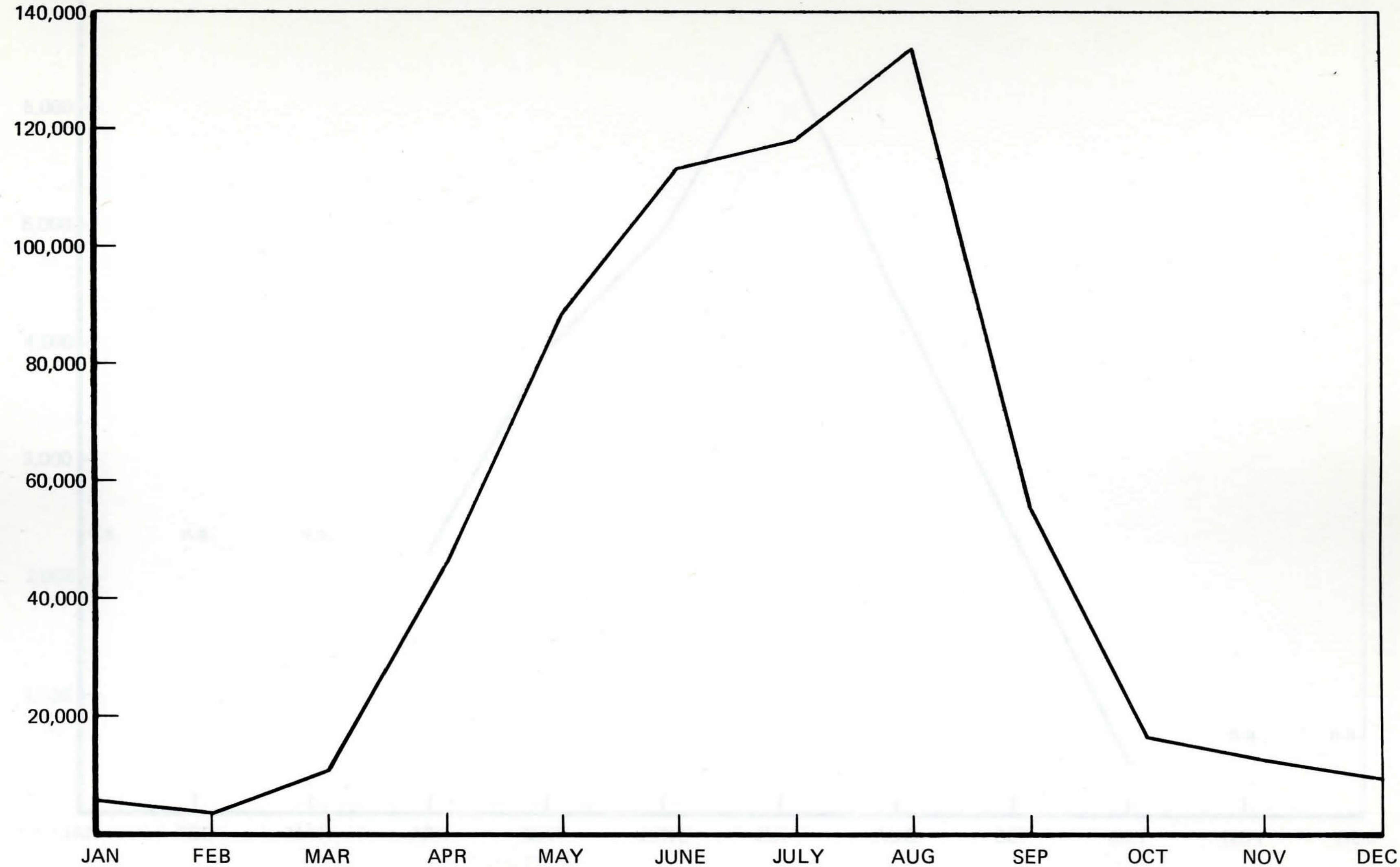
MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
BLACK HAWK LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 17

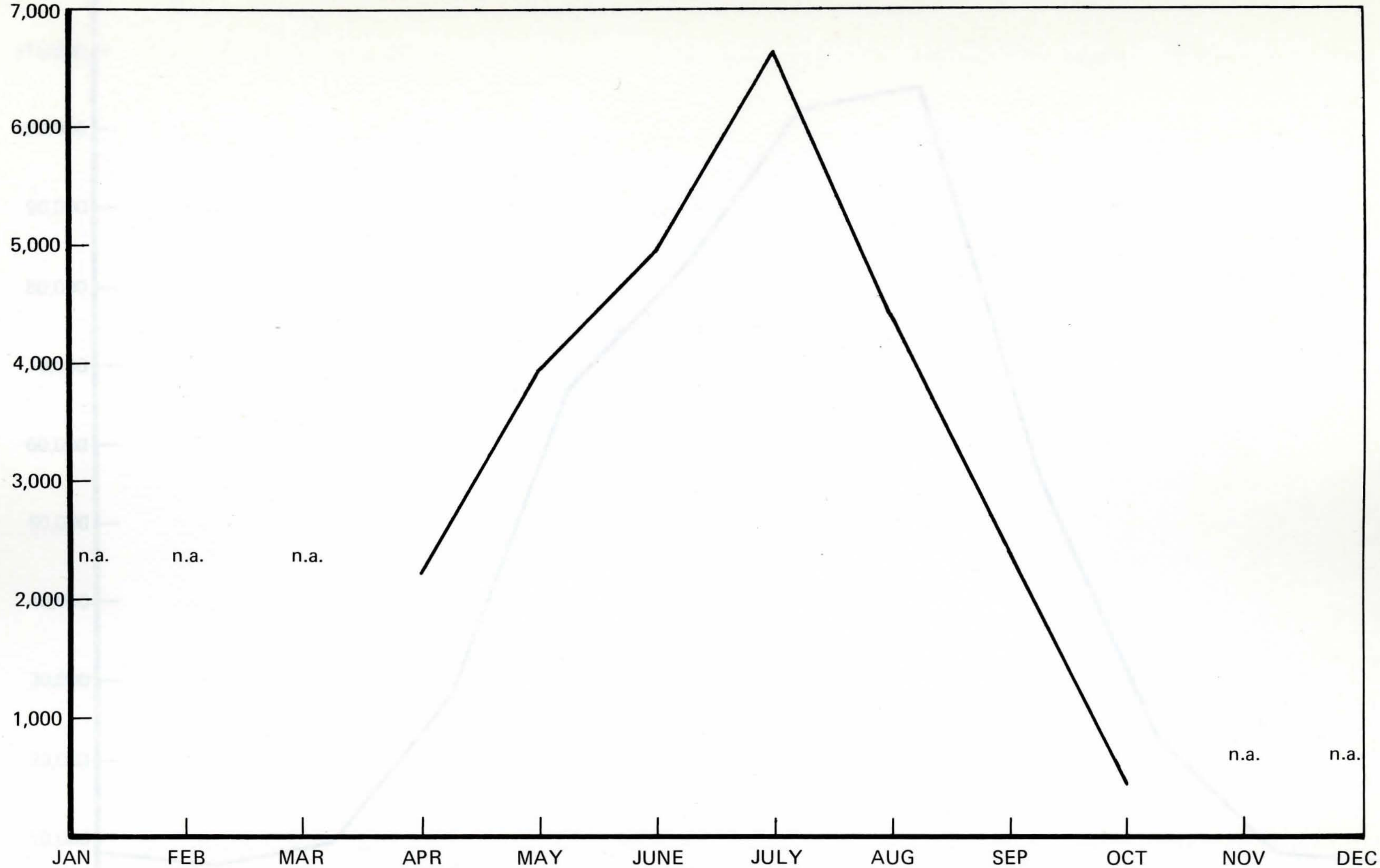
MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
BLUE LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 18

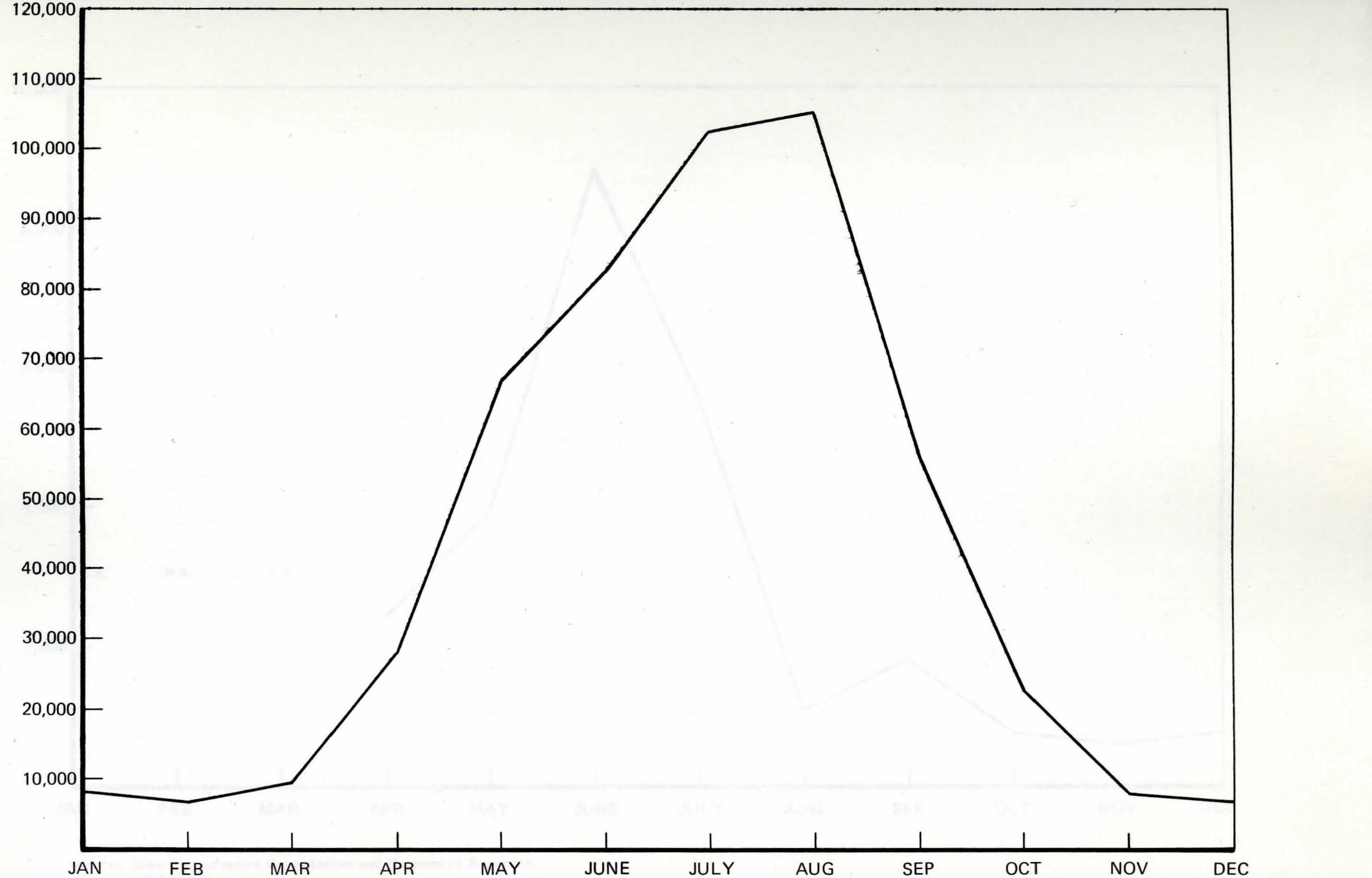
MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
LAKE MANAWA



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 19

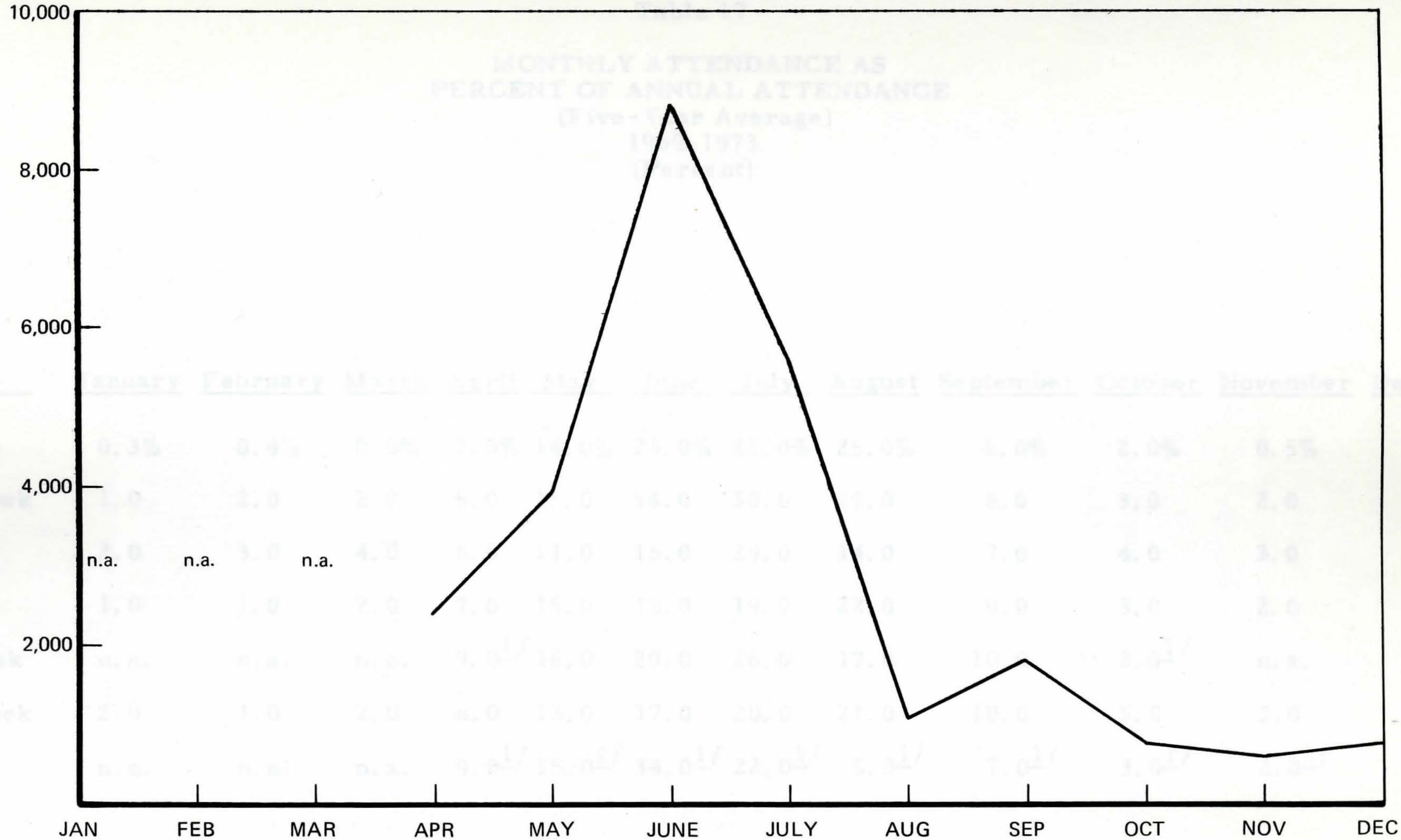
MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
MILL CREEK LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 20

MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
ROCK CREEK LAKE



Source: Iowa Conservation Commission and Economics Research Associates.

Figure 21

MONTHLY ATTENDANCE
(FIVE-YEAR AVERAGE, 1969-1973)
SILVER LAKE

Table 17

MONTHLY ATTENDANCE AS
PERCENT OF ANNUAL ATTENDANCE
(Five-Year Average)
1969-1973
(Percent)

Lake	January	February	March	April	May	June	July	August	September	October	November	December
Backbone	0.3%	0.4%	0.6%	2.0%	14.0%	23.0%	26.0%	25.0%	6.0%	2.0%	0.5%	0.2%
Black Hawk	1.0	2.0	2.0	6.0	15.0	14.0	30.0	15.0	8.0	3.0	2.0	2.0
Blue	2.0	3.0	4.0	6.0	11.0	15.0	29.0	14.0	7.0	4.0	3.0	2.0
Manawa	1.0	1.0	2.0	7.0	15.0	18.0	19.0	22.0	9.0	3.0	2.0	1.0
Mill Creek	n.a.	n.a.	n.a.	9.0 1/	16.0	20.0	26.0	17.0	10.0	2.0 1/	n.a.	n.a.
Rock Creek	2.0	1.0	2.0	6.0	13.0	17.0	20.0	21.0	10.0	5.0	2.0	1.0
Silver	n.a.	n.a.	n.a.	9.0 1/	15.0 1/	34.0 1/	22.0 1/	5.0 1/	7.0 1/	3.0 1/	2.0 1/	3.0 1/

n.a. means not available.
1/ Average of less than five years.

Source: Iowa Conservation Commission and Economics Research Associates.

Weekday versus Peak-Day

Table 18 reflects the percentage of weekday versus weekend attendance by lake for the most heavily attended months of the year. As in the seasonality table, and graphs, the percentages are based on five-year averages for the 1969-1973 period.

Generally the figures demonstrate a predictable relationship between weekends and holidays and recreation activity participation. Backbone, Black Hawk, Manawa, and Rock Creek consistently attracted a significantly higher percentage of visitors on weekends and holidays, with Rock Creek evidencing the most distinct orientation to weekend use. The pattern appears reversed for Mill Creek, where weekday attendance equals or exceeds weekend and holiday attendance during these months.

Market Area Delineation

Figures 22 through 25 physically locate three market areas for each study lake. Based on ERA survey results regarding distances respondents traveled to visit the lakes, the primary, secondary, and tertiary market areas were defined as within 25-, 50-, and 100-mile driving distances of the lakes, respectively. The areas were then drawn to scale with radii extending 20, 40, and 80 miles, straight-line distances, as it was determined a 20 percent reduction applied to driving distances would approximate straight-line distances.

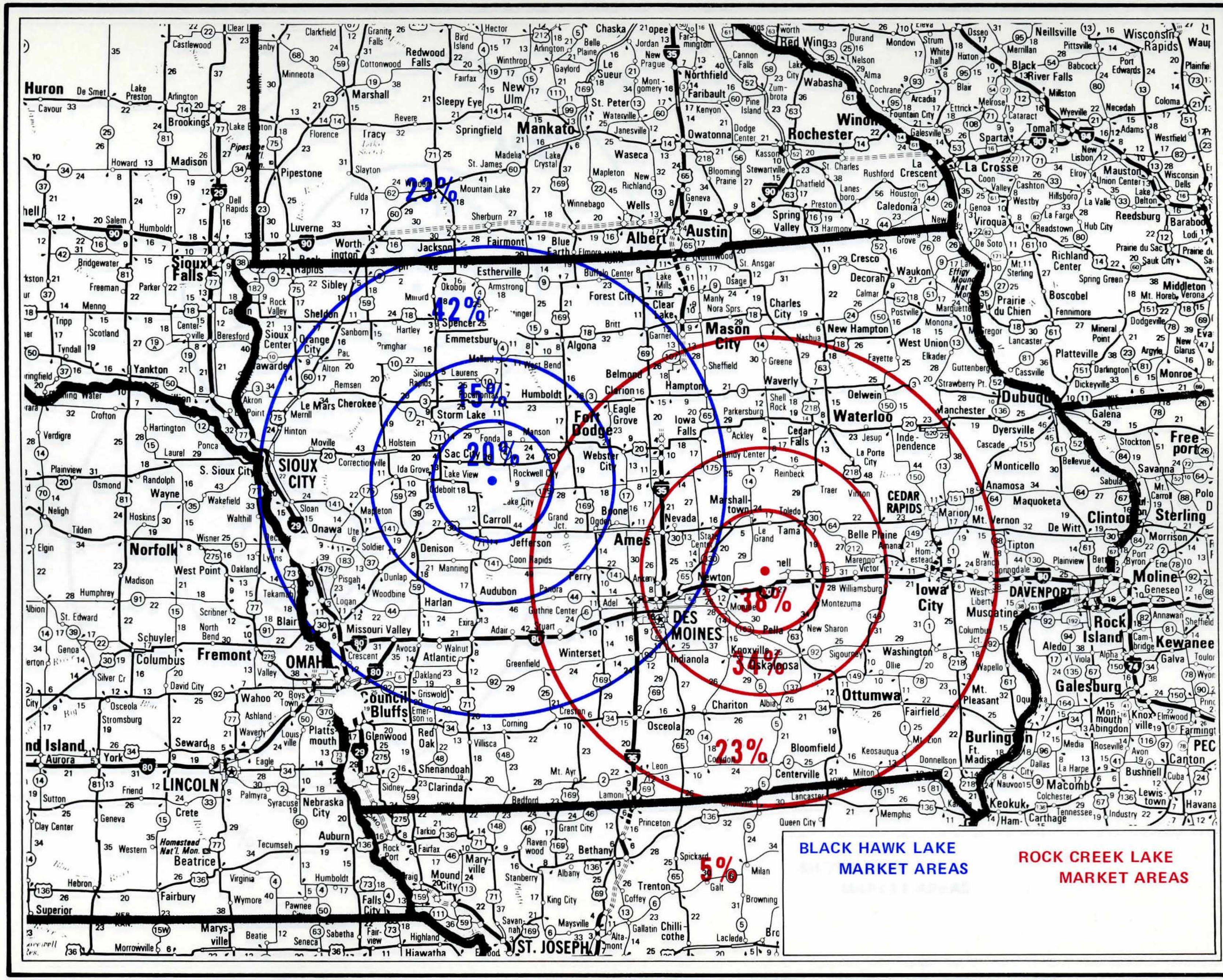
Percentage distribution of visitors, as indicated by the ERA survey, is shown for each market area and for areas outside the specifically described market areas, lake by lake. The primary, secondary, and tertiary market areas encompass the majority of the populations served by the study lakes, as indicated by the survey. However, significant percentages of surveyed recreationists traveled farther than 100 miles to attend several of the lakes examined; 23 percent at Backbone and Black Hawk, and 21 percent at Silver Lake. Delineating a fourth market area with, for example, a 160-mile straight-line radius (representing

Table 18

WEEKDAY VERSUS WEEKEND/PEAK DAY ATTENDANCE
(Percent)

Lake	April		May		June		July		August		September	
	Weekday	Weekend and Peak Day	Weekday	Weekend and Peak Day	Weekday	Weekend and Peak Day	Weekday	Weekend and Peak Day	Weekday	Weekend and Peak Day	Weekday	Weekend and Peak Day
Backbone	26%	74%	29%	71%	26%	74%	25%	75%	33%	67%	23%	77%
Black Hawk	30	70	24	76	33	67	17	83	28	72	25	75
Manawa	28	72	35	65	44	56	34	66	40	60	29	71
Blue	55	45	46	54	53	47	55	45	53	47	46	54
Mill Creek	55	45	56	44	71	29	46	54	67	33	66	34
Rock Creek	21	79	12	88	14	86	13	87	14	86	17	83
Silver	44	56	51	49	34	66	35	65	42	58	51	49

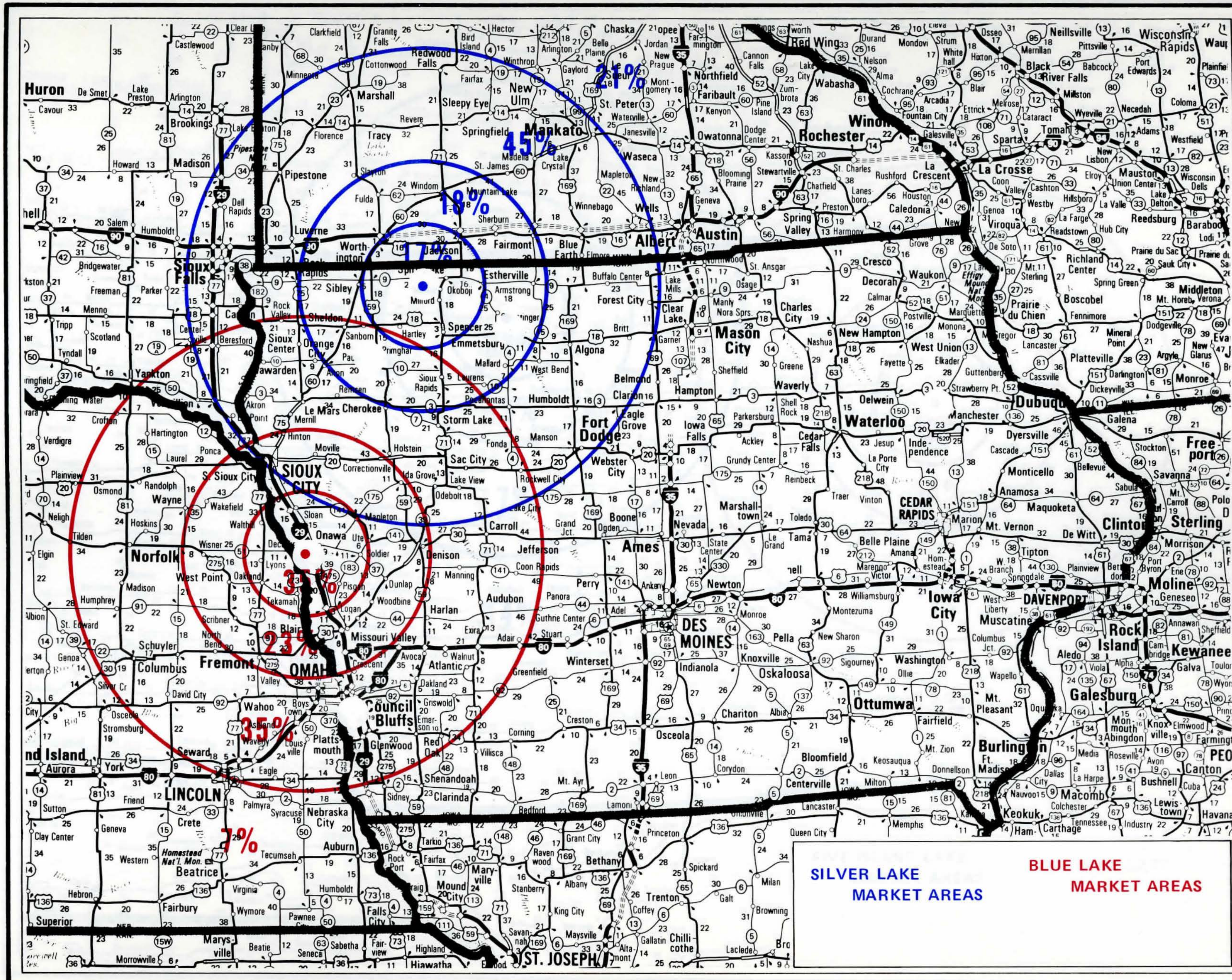
Source: Iowa Conservation Commission and Economics Research Associates.



Source: Economics Research Associates.

Figure 22

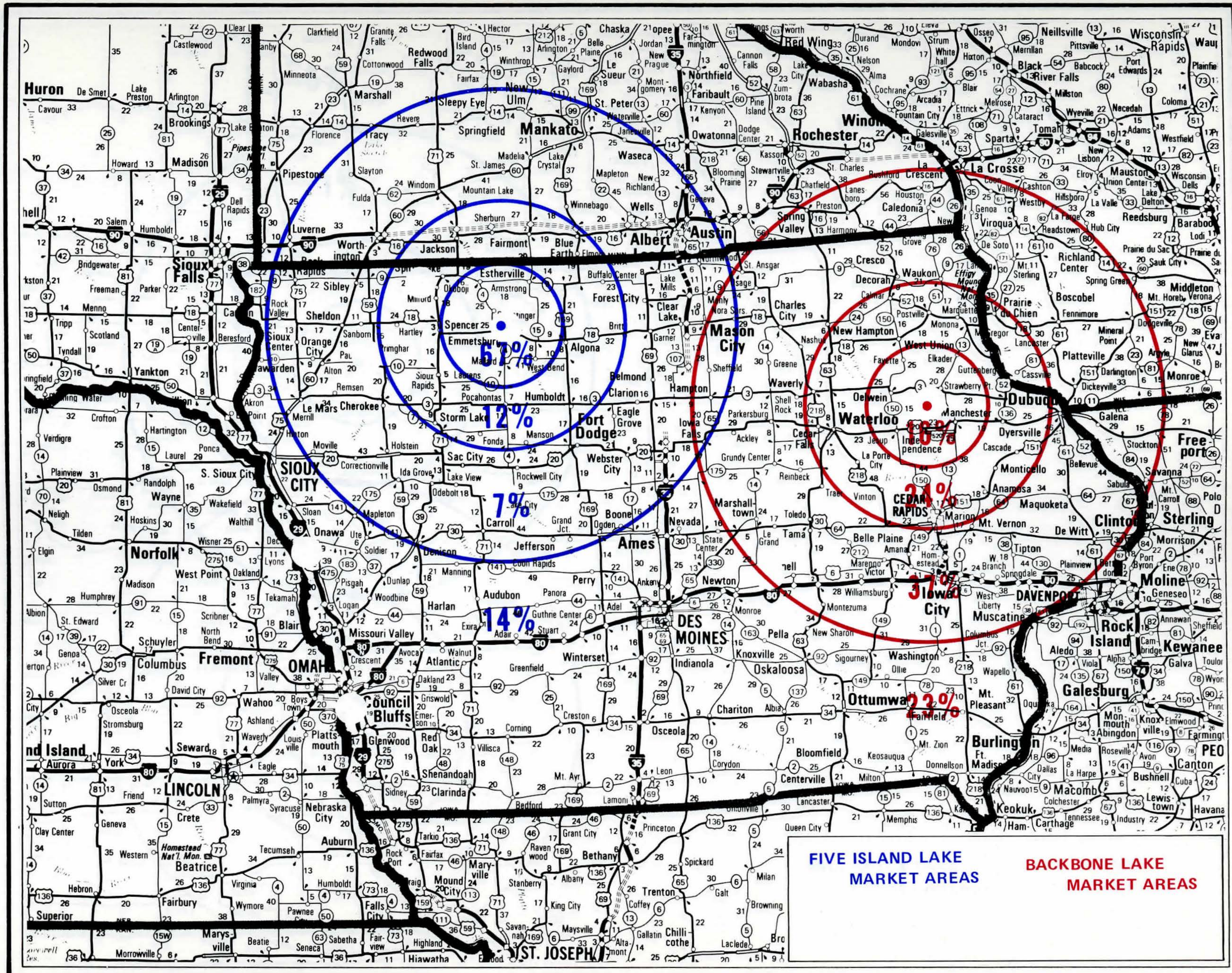
MARKET AREAS FOR
ROCK CREEK AND BLACK HAWK LAKES



Source: Economics Research Associates.

Figure 23

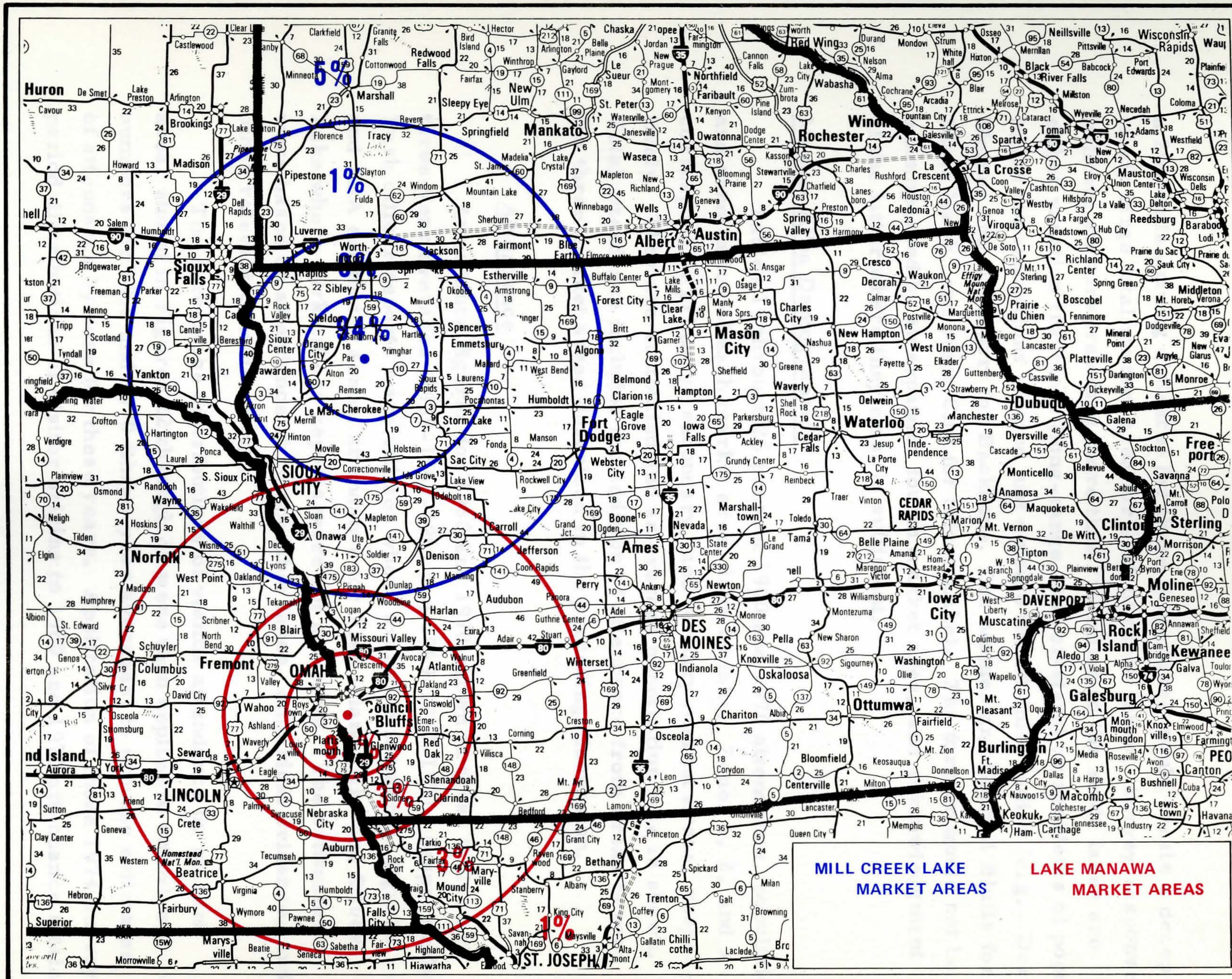
MARKET AREAS FOR
SILVER AND BLUE LAKES



Source: Economics Research Associates.

Figure 24

MARKET AREAS FOR
BACKBONE AND FIVE ISLAND LAKES



Source: Economics Research Associates.

Figure 25

MARKET AREAS FOR
MILL CREEK LAKE AND LAKE MANAWA

a 200-mile driving distance) for these three lakes would create a deceptively large total market area for each of these lakes. Survey responses indicate visitors traveling more than 100 miles to the study lakes are either vacation travelers (long-range, out-of-state) or residents of population concentrations located just outside the 80-mile radius (e.g., Des Moines and Davenport for Backbone, Des Moines and Council Bluffs for Black Hawk, and Sioux City for Silver Lake). The former would not be encompassed by an expanded fourth market area, and acknowledgment of the latter where they exist is sufficient.

Market Area Demographics

Tables 19 through 26 present 1960 and 1970 attendance, population, and penetration of each market area, lake by lake. Zones 1, 2, and 3 correspond to primary, secondary, and tertiary market areas, respectively. They are subtotaled and an average penetration rate is shown. Total attendance includes the addition of attendance from areas beyond the three market areas described in the preceding discussion.

Attendance

Attendance figures for 1960 and 1970 shown in these tables are three-year averages (1959-1960-1961 and 1969-1970-1971, respectively). Park officer reports were utilized where available for annual figures, and ERA estimated annual attendance for Five Island Lake and Silver Lake where park officer reports were not available. The estimates were based on attendance at comparable lakes, empirical evidence, and other relevant considerations.

The percentage distributions of visitor attendance by market area, shown in Figures 22 through 25 were then applied to attendance numbers for 1960 and 1970 (three-year averages) to provide estimates of attendance by zone for these years. Application of these 1974 survey period distributions of visitor origins to 1960 and 1970 attendance totals

Table 19

HISTORICAL ATTENDANCE AT BACKBONE LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	40,687	49,292
Population	52,667	51,166
Penetration	77%	96%
Zone 2 (25-50 miles)		
Attendance	61,030	73,938
Population	152,700	164,779
Penetration	40%	45%
Zone 3 (50-100 miles)		
Attendance	94,088	113,988
Population	631,794	687,265
Penetration	14.9%	16.6%
Subtotal (0-100 miles)		
Attendance	195,805	237,218
Population	837,161	903,210
Penetration	23%	26%
Other Areas (more than 100 miles)		
Attendance	58,487	70,857
Total Attendance	254,292	308,075

Source: Economics Research Associates.

Table 20

HISTORICAL ATTENDANCE AT BLACK HAWK LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	36,646	54,786
Population	34,826	32,772
Penetration	105%	167%
Zone 2 (25-50 miles)		
Attendance	27,485	41,089
Population	110,038	104,327
Penetration	25%	39%
Zone 3 (50-100 miles)		
Attendance	76,957	115,050
Population	595,781	582,078
Penetration	12.9%	1 .8%
Subtotal (0-100 miles)		
Attendance	141,088	210,925
Population	740,645	719,177
Penetration	19%	29%
Other Areas (more than 100 miles)		
Attendance	42,143	63,003
Total Attendance	183,231	273,929

Source: Economics Research Associates.

Table 21

HISTORICAL ATTENDANCE AT BLUE LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	46,693	76,786
Population	24,412	21,175
Penetration	191%	353%
Zone 2 (25-50 miles)		
Attendance	30,684	50,459
Population	181,282	178,724
Penetration	17%	28%
Zone 3 (50-100 miles)		
Attendance	46,693	76,786
Population	850,007	933,988
Penetration	5.5%	8.2%
Subtotal (0-100 miles)		
Attendance	124,070	204,031
Population	1,055,701	1,143,463
Penetration	12%	18%
Other Areas (more than 100 miles)		
Attendance	9,339	15,357
Total Attendance	133,409	219,388

Source: Economics Research Associates.

Table 22

HISTORICAL ATTENDANCE
AT FIVE ISLAND LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	79,023	100,500
Population	27,342	25,647
Penetration	289%	392%
Zone 2 (25-50 miles)		
Attendance	14,153	18,000
Population	119,560	111,956
Penetration	12%	16%
Zone 3 (50-100 miles)		
Attendance	8,256	10,500
Population	539,364	522,913
Penetration	1.5%	2.0%
Subtotal (0-100 miles)		
Attendance	101,432	129,000
Population	686,266	660,516
Penetration	15.0%	20.0%
Other Areas (more than 100 miles)		
Attendance	16,512	21,000
Total Attendance	117,944	150,000

Source: Economics Research Associates.

Table 23
HISTORICAL ATTENDANCE
AT LAKE MANAWA
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	667,500	676,559
Population	455,906	535,963
Penetration	146%	126%
Zone 2 (25-50 miles)		
Attendance	21,532	21,825
Population	128,974	125,324
Penetration	17%	17%
Zone 3 (50-100 miles)		
Attendance	21,532	21,825
Population	492,916	489,318
Penetration	4.4%	4.5%
Subtotal (0-100 miles)		
Attendance	710,564	720,209
Population	1,077,796	1,150,605
Penetration	66%	63%
Other Areas (more than 100 miles)		
Attendance	7,177	7,275
Total Attendance	717,741	727,484

Source: Economics Research Associates.

Table 24

HISTORICAL ATTENDANCE AT MILL CREEK LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	41,980	31,107
Population	39,424	37,796
Penetration	107%	82%
Zone 2 (25-50 miles)		
Attendance	0	0
Population	113,102	114,188
Penetration	0	0
Zone 3 (50-100 miles		
Attendance	447	331
Population	575,505	557,779
Penetration	.08%	.06%
Subtotal (0-100 miles)		
Attendance	42,427	31,438
Population	728,031	709,763
Penetration	5.8%	4.4%
Other Areas (more than 100 miles)		
Attendance	2,233	1,655
Total Attendance	44,660	33,093

Source: Economics Research Associates.

Table 25

HISTORICAL ATTENDANCE AT ROCK CREEK LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	119,343	170,457
Population	76,582	78,244
Penetration	156%	218%
Zone 2 (25-50 miles)		
Attendance	106,781	152,514
Population	154,386	161,657
Penetration	69%	94%
Zone 3 (50-100 miles)		
Attendance	72,234	103,171
Population	952,288	1,057,519
Penetration	7.5%	9.8%
Subtotal (0-100 miles)		
Attendance	298,358	426,142
Population	1,190,256	1,297,420
Penetration	25%	33%
Other Areas (more than 100 miles)		
Attendance	15,703	22,429
Total Attendance	314,061	448,571

Source: Economics Research Associates.

Table 26

HISTORICAL ATTENDANCE
AT SILVER LAKE
BY ZONE
1960 and 1970

	1960	1970
Zone 1 (0-25 miles)		
Attendance	12,900	11,824
Population	43,694	41,011
Penetration	30%	29%
Zone 2 (25-50 miles)		
Attendance	13,600	12,520
Population	101,725	196,924
Penetration	13.4%	13%
Zone 3 (50-100 miles)		
Attendance	34,000	31,298
Population	502,374	490,468
Penetration	6.8%	6.4%
Subtotal (0-100 miles)		
Attendance	60,500	55,642
Population	647,793	628,403
Penetration	9.3%	8.9%
Other Areas (more than 100 miles)		
Attendance	15,100	13,910
Total Attendance	75,600	69,552

Source: Economics Research Associates.

permits limited comparative analysis, as it is acknowledged that different distributions might have been operative in 1960 and 1970 visitation patterns.

Population

Population statistics for the lakes' zones were provided by computer programs which identified and totaled populations of census tracts and enumeration districts within the 20-, 40-, and 80-mile radii, according to 1970 census data. These population totals by zone were then used to identify counties, partial and/or total, in Iowa and in contiguous states (where zones overlapped state borders) comprising the various market areas. Such identification of market area counties facilitiated more precise estimates of market area populations for 1960 from data available by county (U.S. Department of Commerce, Bureau of Census). Market area counties also provided a basis for population projections for 1980 and 1990 presented in Section V.

Penetration Rates

Penetration percentages indicate the rates at which visitors were drawn from market area populations. As they are functions of varying populations and visitation totals, they vary widely from lake to lake and from zone to zone for each lake. Naturally, the larger attendance totals from less populated market areas yielded the highest penetration rates; and, conversely, the smaller number of visitors from the larger market areas produced the lowest penetration rates. The range of 1970 penetration rates is shown below for each zone:

Zone 1	29% - 392%
Zone 2	0% - 94%
Zone 3	.06% - 19.80%

Section V

DEMAND ANALYSIS

The preceding section established base line data for recreational use of the lakes being studied. This section, taking the base line data as a starting point, analyzes trends in national and regional recreation patterns as well as local factors that might affect future use of the lakes. Then, the probable impact of the dredging recommendations detailed in Section III on recreation use of the lakes is assessed, leading to a forecast of attendance levels under both the dredging and the do-nothing options.

USE POTENTIALS

A National Recreation Survey (NRS) conducted by the U.S. Department of the Interior's Bureau of Outdoor Recreation in 1972 established current levels of recreation participation in 29 activities throughout the coterminous United States (that is, excluding Alaska and Hawaii). Then, using socioeconomic relationships observed during the survey, the study developed a forecasting model which utilized projections of population, income, and other demographic characteristics to estimate future levels of recreation activity demand. These projections were performed for each of 171 BEA (U.S. Department of Commerce Bureau of Economic Analysis) areas. Seven of the BEA areas encompass most of the state of Iowa and parts of adjacent Illinois, Wisconsin, Nebraska, and South Dakota--the region which ERA's survey at the study area lakes revealed contributed the most participants to recreation activities. That is, the seven BEA areas are approximately equivalent to the general market area of demand for the eight lakes. Forecasts cover the period 1972 to 1978 and, since the projection population change is the most significant variable in the forecasting model, the output format has been so designed that the percentage change in population can be subtracted from the percentage change in recreation to obtain the net change in recreation resulting from all other factors combined. Thus, if population in fact changes at a different rate from that used in the study, it is a simple matter to adjust recreation forecasts to reflect more reliable population information.

Significant findings of the study taken at the national level are as follows:1/

- Participation in outdoor recreation will grow one-third faster than the United States population between now and 1978.
- Swimming will continue as the activity drawing the most participation.
- Boating (excluding sailing and canoeing), outdoor pool swimming, and water-skiing will be the third, fourth, and fifth fastest growing activities.
- The proportion of outdoor recreation taking place on vacations and overnight trips (as opposed to that occurring on day trips) will increase.

Implications for Iowa Lakes

Table 27 shows activity forecasts for the seven BEA regions in the Iowa lakes market areas. The numbers indicate the total percentage increase or decrease in activities over a six-year period ending in 1978. The last column shows the expected population change for the same period, again as a percentage above the 1972 base level. As an example, the number of camping activity days in the Omaha BEA area is forecast to increase 10 percent from 1972 to 1978. At the same time the population will increase 7.0 percent, so that the per capita increase in camping equals 3.0 percent, or approximately 0.5 percent per year.

1/ Outdoor Recreation, A Legacy for America: Appendix A, an Economic Analysis. United States Department of the Interior, Bureau of Outdoor Recreation, December 1973.

Table 27

PERCENTAGE CHANGE IN QUANTITIES OF OUTDOOR RECREATION ACTIVITIES DEMANDED IN IOWA AND ADJACENT BEA[1/] ECONOMIC AREAS

Between 1972 and 1978

	BEA Area	Camping	Fishing	Motorcycling	Nature Walks	Walking	Bicycling	Water Skiing	Other Boating	Outdoor Pool Swimming	Other Outdoor Swimming	Golf	Other Outdoor Sports	Outdoor Concerts and Plays	Outdoor Spectator Sports	Zoos, Fairs, Parks	Sightseeing	Picnicking	Projected Population Change
80	Cedar Rapids, Iowa	13	11	12	15	12	12	15	18	14	14	19	5	13	19	11	12	12	9
81	Dubuque, Iowa[2/]	4	3	3	5	4	1	4	8	4	4	10	-3	4	9	2	4	3	2
103	Sioux City, Iowa[3/]	2	1	1	4	2	-1	3	7	2	3	9	-6	2	8	0	2	1	0
104	Fort Dodge, Iowa	4	3	3	6	4	2	6	8	5	5	11	-4	4	11	2	4	3	2
105	Waterloo, Iowa	5	4	4	7	5	4	7	9	7	6	11	-2	5	11	3	4	4	2
106	Des Moines, Iowa	9	8	8	10	8	7	10	13	10	9	14	1	9	5	7	8	8	6
107	Omaha, Nebraska	10	8	9	12	9	8	12	15	11	11	16	2	10	16	7	9	9	7

1/ U.S. Department of Commerce, Bureau of Economic Analysis.
2/ Includes parts of Wisconsin and Illinois.
3/ Includes parts of Nebraska and South Dakota.
4/ Includes parts of Nebraska.

Source: United States Department of the Interior, Bureau of Outdoor Recreation, 1973.

From the list of 17 activities, Table 28 presents a matrix showing which activities contribute to attendance at each of the eight lakes. Water-skiing is not a factor at Backbone, Mill Creek, or Rock Creek.

Further, the average annual per capita increase for each activity has been computed by first subtracting population growth from activity growth and second by identifying the annual growth rate which, if compounded for six years, would yield the accumulated growth rate.

Summing the projected growth rates of all appropriate activities at a given lake and then dividing by the number of activities yields an unweighted average growth rate for all recreation at that lake through 1978. For the growth rates at each lake to reflect more closely the types of activities most likely to occur, a weighted average growth rate has been computed. For example, at Manawa Lake, camping activity will increase more rapidly than picnicking, but picnicking is roughly three times more popular than camping (refer to discussions of survey findings in Section IV) so that the absolute increase in picnickers will be greater than that for campers. Table 29 presents the results of these weighted computations for each lake along with weighted population growth rates for those market areas comprised of more than one BEA area. Total projected rate of growth in demand for recreational activities in each of the eight market areas is the sum of the respective population growth rates and per capita recreation growth rates, shown in the last column. Note that Silver Lake, despite having the same market area as Mill Creek Lake, has a slightly larger growth rate, a result of the impact of water-skiing potential on the weighted per capita recreation growth rate.

COMPETITIVE ENVIRONMENT

While the demand for water-oriented recreation will increase as discussed above, it does not necessarily follow that attendance at the eight lakes under study will increase at the same rate. Continued deterioration of the lakes plus development of competing facilities can affect the supply of recreation opportunities among which market area residents may choose.

Table 28

AVERAGE ANNUAL GROWTH RATES
IN PER CAPITA RECREATION ACTIVITIES
AT EIGHT IOWA LAKES
(Percent)

	Backbone	Black Hawk	Blue	Five Island	Manawa	Mill Creek	Rock Creek	Silver
Camping	0.5%	0.4%	0.4%	0.3%	0.5%	0.3%	0.5%	0.3%
Fishing	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.2
Motorcycling								
Nature Walks	0.8	0.6	0.7	0.7	0.8	0.7	0.8	0.7
Walking	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.3
Bicycling								
Water Skiing		0.6	0.7	0.7	0.8			0.6
Other Boating	1.2	1.1	1.2	1.0	1.3	1.1	1.2	1.1
Outdoor Pool Swimming								
Other Outdoor Swimming	0.6	0.5	0.6	0.5	0.7	0.5	0.7	0.5
Golf								
Other Outdoor Sports	-1.1	-0.9	-0.9	-1.0	-0.8	-1.0	-0.7	-1.0
Picnicking	0.3	0.2	0.2	0.2	0.3	0.2	0.4	0.2

Note: Growth rates are net of population growth.

Source: Economics Research Associates.

Table 29

AVERAGE ANNUAL GROWTH IN
POPULATION AND RECREATION ACTIVITIES
FOR EIGHT LAKE MARKET AREAS

Lake	BEA Areas Included	Average Annual Population Growth	Average Annual Per Capita Recreation Growth	Average Annual Recreation Demand Growth Rate
Backbone	80, 81, 105	0.4%	0.45%	0.85%
Black Hawk	103, 104, 106	0.6	0.45	1.05
Blue	103, 107	0.7	0.48	1.18
Five Island	104	0.3	0.43	0.73
Manawa	107	1.1	0.57	1.67
Mill Creek	103, 104	1.2	0.32	1.52
Rock Creek	80, 105, 106	0.9	0.55	1.45
Silver	103, 104	1.2	0.38	1.58

Source: 1972 National Recreation Survey and Economics Research Associates.

Other Lakes

Opening of new lands and improved facilities in Iowa will redirect attendance from declining lakes. Most new development activity is centering in southeast and south central Iowa, so that lakes which in the past have penetrated the Des Moines and southern market areas will lose some support. For example, realtors in the Rock Creek area are aware that power-boat enthusiasts are shifting to Red Rock Reservoir and Rathbun Reservoir, where there is room for water-skiing and no horsepower restrictions.

At Big Creek Lake just north of Des Moines, approximately $1.1 million is earmarked for general development by the Iowa Conservation Commission over the 1974-1977 period. The 960-acre reservoir is complete and additional shore facilities are planned. In addition, the Saylorville Reservoir nine miles north of Des Moines will open some 5,500 acres to the public by 1977.

Pleasant Creek, a stream in east central Iowa (Region II, Subregion 10), will be dammed at a cost of $750,000 plus $1.5 million for recreation development, with completion set for 1979. In Region III, Subregion 16, dam construction costing $500,000 is planned for Franklin Township Lake by 1975. Recreation development costing $850,000 are scheduled for Perry Creek Reservoir in Region V, Subregion 4, due in 1977; and in Region VI, Subregion 5, long-range plans call for $2.0 million in general development at Brushy Creek.

North of Backbone Lake at Fayette, land has been acquired on the Volga River for impoundment of a 530-acre reservoir. At present, there are doubts about the performance of the bottom seal and projected costs of $6.5 million plus $2 million for recreation facilities may deter development, so the project's future is uncertain.

Finally, several developments are planned for areas on or near the Missouri River. South of Sioux City, the Snyder-Winnebago area is slated for an 800 acre oxbow lake, pending completion of an environmental impact study. Farther south, near Decatur, Nebraska, four oxbows are being improved for recreation use. They are located on the Iowa side of the river and range in size from 200 acres (Louisville Bend) to 500 acres (Upper Decatur Lake), representing 1,400 total surface acres of water. Though these are not new lakes, they could not have been considered a competitive factor previously as water levels were sporadic and generally low, and access by land was difficult or impossible. Lastly, the Papillion Creek Watershed Project, in west Omaha, recently undertaken for flood and erosion control, will create as many as twenty impoundments for recreation use. These lakes will vary widely in size and depth, but will offer a total of 42,000 surface acres of water, possibly by 1980. The most distant of these lakes will be located no more than thirty miles from Omaha.

Table 30 lists the probable additions to the Iowa lake inventory and summarizes the impact they may have on attendance at the eight lakes in the present study. Determination of which study lakes will be affected is based on whether a new lake is located within the primary or secondary market area of a study lake. Assessment of the significance of impact of a new lake is based primarily on the level of development expenditures proposed, or on the size of the new lake where that information is known. For example, the 960-acre reservoir at Big Creek is roughly the size of Black Hawk Lake. If the two lakes are equally attractive to recreationists, the new lake will have moderate impact on attendance at the existing lake being studied. Saylorville Reservoir, on the other hand, offering some 5,500 acres, will have a high impact on attendance among persons for whom black Hawk is not more easily accessible.

Table 30

NEW LAKES IN IOWA AND PROBABLE IMPACT
ON EIGHT STUDY LAKES

New Lake	Affected Lakes	Date of Impact	Significance
Red Rock Reservoir	Rock Creek, Black Hawk	current	high
Rathbun Reservoir	Rock Creek, Black Hawk	current	high
Big Creek	Rock Creek, Black Hawk	1974-1977	moderate
Saylorville Reservoir	Rock Creek, Black Hawk	1977	high
Papillion Creek Watershed Project	Manawa	1975-1980	moderate
Blackbird Bend	Blue	1975-1980	moderate
Louisville Bend	Blue	1975-1980	moderate
Upper Decatur Lake	Blue	1975-1980	moderate
Middle Decatur Bend	Blue	1975-1980	moderate
Franklin Township Lake	Rock Creek	1975	moderate
Badger Creek	Rock Creek, Black Hawk	1977-1979	low
Perry Creek Reservoir	Blue Lake, Mill Creek	1977	moderate
Pleasant Creek	Rock Creek, Backbone	1979	moderate
Brushy Creek	Black Hawk, Five Islands	1980	moderate
Volga River	Backbone	n. a.	low
Snyder-Winnebago	Blue Lake, Mill Creek	n. a.	moderate

n. a. means not available.

Source: Economics Research Associates.

IMPACT OF DREDGING ON RECREATION

The effects of the proposed dredging programs on recreation activities at the five lakes where dredging is feasible will be partly qualitative, partly quantitative. The user survey conducted at the lakes and described in Section IV of this report found nearly unanimous belief that dredging would enhance the quality of recreation experiences. Respondents felt fishing, water-skiing, and swimming would all be improved. Further, at most lakes more than half those questioned indicated they would visit the lake more frequently and for longer periods. However, these opinions were offered before any definitive dredging plans were made so that they are little more than conjecture. Further, the responses do not lend themselves to quantitative analysis that might pinpoint the increase in attendance anticipated as the result of dredging.

Some quantitative judgments, however, are warranted. In programs of extensive dredging, water-skiing and sailing will be improved as greater areas are freed of shallows and submerged obstacles. Water quality may improve as a result of the removal of nutrient-rich sediments. Fishing may benefit even from limited spot-dredging programs where deeper water eliminates winter kill caused by low oxygen levels. Cleaner water will foster proliferation of sight-feeding species. Reduction of emergent vegetation will open up shore areas to beach swimming and picnicking. Each of these improvements will encourage greater recreational use of the impacted lakes. Thus the effect of dredging is quantitative. However, the assessment of the magnitude of increased use remains largely a subjective matter; the number of user-days generated by greater fish populations, for example, is impossible to determine precisely. Similarly, the opening up of new surface acreage to water-skiing may release substantial pent-up demand for this sport by persons who did not previously participate, or it may simply encourage more frequent use by current enthusiasts. Such assessments are necessarily subjective.

A quantitative aspect can be added to this assessment if impacts are rated on a scale of 10 ranging from negligible impact to substantial.

That is, if it is apparent that dredging will significantly improve the appeal of a lake, extend its useful life considerably, and create important additional capacity, a high rating is justified. On the other hand, if dredging fails to correct other factors detracting from recreation appeal such as water pollution, or if the dredging program is severely limited by the lack of spoil sites so that minimal enhancement results, a low rating would be appropriate. An advantage of the rating system, in addition to its obvious usefulness in describing any given lake, is that it permits comparison among the lakes of the effectiveness of dredging. It might be that a costly program at one lake would have little impact, while a moderate effort at another would dramatically enhance its quality and recreational appeal.

Man-Made Lakes

As discussed in Section III of this report, dredging is not recommended at Backbone, Mill Creek, and Rock Creek lakes due to both the nonavailability of spoil disposal sites and the continuing high rates of siltation which would negate the dredging efforts in a short time. Discussion of recreational appeal enhancement is moot for these lakes.

Black Hawk

The spot-dredging program proposed at Black Hawk Lake will promote safer, more extensive water-skiing by providing turnaround areas and removing debris and other submerged obstacles. Greater bottom depths will mitigate against winter fish kill and enhance both winter and summer fishing. Channelization of inlets and interconnecting bodies of water will enlarge the area accessible to boaters.

On a scale of 10, Black Hawk has been rated seven. This is not to say that recreation opportunities will not be excellent, but rather that the improvement over existing conditions is above average but not outstanding. Recreation at Black Hawk is pleasant now so that the improvement after dredging will be noticeable but not dramatic.

Blue Lake

Spot-dredging at Blue Lake, limited by the small spoil disposal area available to 140,000 cubic yards instead of the 630,000 cubic yards which full channelizing would create, will have a modest impact on recreation potential. Water-skiing is limited as much by the narrowness of the lake as by its current water depth. Similarly, water quality at Blue Lake is better than at most others, so little improvement in this aspect if foreseen. Likewise, swimming and fishing will be enhanced only slightly by dredging. The study team has given this lake a rating of four, indicating that enhancement of recreational quality will be roughly half that expected at Black Hawk Lake.

Five Island Lake

Dredging efforts at Five Island Lake will be of a volume more than 12 times that at Blue Lake but about half that proposed at Black Hawk. Depositing of spoil on some of the islands may enhance wildlife habitats, while dredging will improve boating, water-skiing, and fishing in the middle lake and swimming and shore activities in the bottom lake. Although the dredging program is not as extensive as at Black Hawk, the potential gain for recreationists is slightly greater in view of present shallowness. Weighing the restrictions on dredging against room for enhancement of lake quality, the study team has rated Five Island Lake at five.

Manawa Lake

Dredging efforts at Manawa Lake will be substantial, second only to those at Black Hawk in terms of volume and costs. As described in Section III, the effect of dredging on water quality and recreational activities is expected to be very positive. Removal of organic and nutrient-rich sediments should reduce water pollution, while deepening of the lake will permit safer, more extensive water-skiing and sailing. Emergent vegetation, which currently chokes much of the lake, will be removed, and spawning areas and wildlike habitat will be created behind the proposed jetties.

With so much room for improvement, the effects of dredging have been rated nine. Preventing a perfect score of 10 are considerations of pollution from sewer and septic systems, landscaping, and water supply all of which will remain unaffected by dredging.

Silver Lake

Dredging at Silver Lake is limited by less than adequate spoil disposal areas. Some of the places identified as possible sites may become unusable if they prove to be habitat for migratory birds. Further, water entering the main body of the lake through Trappers Bay may continue to introduce algal blooms and other water quality problems regardless of dredging.

Much of the proposed dredging is designed to deepen the lake at the intake point for city water. This will have less impact on recreation potentials than a more general deepening program. Fishing may be improved, but water-skiing and swimming probably will gain little, while pollution from septic systems and agricultural uses around the lake will continue. Still, the recreational conditions at the lake are presently so unappealing that a little improvement could go a long way. Thus, the impact of dredging at Silver Lake has been rated five on the scale of 10.

Table 31 summarizes the rated impacts of proposed dredging programs on the enhancement of recreation potentials at the five lakes.

FORECAST OF STUDY LAKE ATTENDANCE

The process of projecting attendance for the various lakes under the alternatives of dredging involved the participation of the entire project staff and individual personal observations of the lakes and activities at them, interviews with local representatives and park rangers, and the use of statistical data. The project team had anticipated that more data would be available from case studies to use in projecting attendance for the subject lakes. However, detailed review of the

Table 31

IMPACT OF DREDGING ON ENHANCEMENT OF RECREATION POTENTIALS AT FIVE IOWA LAKES
(Rated on Scale of Ten)

Lake	Rating
Black Hawk	7
Blue	4
Five Island	5
Manawa	9
Silver	5

Source: Economics Research Associates.

literature (covered in Section III) revealed that there were no truly comparable situations where water quality, dredging, and historical attendance (before and after dredging) data was available. This type of information, when available, is a useful tool in testing the reasonableness of projections.

Factors Considered

A number of factors were carefully selected by the project team to be used as the basis for forecasting attendance. These included the following:

- Trends in attendance between 1960 and 1970 as compared with trends in population in the market area.
- Trends in penetration of the market area.
- Estimates of the impact that dredging will have on various types of recreation at the individual lakes.
- Future competition which will result from the creation of new lakes.
- Increase in the overall demand for outdoor recreation.
- Information on the sources of attendance by market zones, based on the results of surveys of attendees.

Population

The factors utilized for projections vary substantially in terms of the range from concrete data to judgmental data. For example, historical population data by market zone are "hard" figures based on census data. Market area counties, identified by computer-produced population totals (see discussion in Section IV), provided the basis for projections of population (1980 and 1990) by zone. These projections of population have been incorporated into Tables 32 through 39 in the discussion of attendance forecasts which follows below.

Population projections for 1980 and 1990 were available by county for Iowa[1/] and, by application of projected growth rates, by state for out-of-state counties involved.[2/] It should be noted that the population projections for zones which overlap Iowa state borders become less precise where they encompass more out-of-state counties for which projected state growth rates for 1980 and 1990 were applied to 1970 census data, in lieu of unavailable projections by county.

Attendance

Statistics on attendance at the lakes are compiled by the rangers according to a formula established by the Parks Division of the Iowa Conservation Commission. Although we have encountered skepticism regarding the validity of these figures, it was not possible within the timing of this study to conduct a survey which could either prove or disprove the validity of attendance figures for each individual lake. If the formula is actually adhered to by the rangers and their staff, it should yield a reasonably accurate attendance figure.

With regard to sources of attendance by zone, we believe that our survey information is accurate, at least for the peak summer attendance period.

Other

Finally, in evaluating the impact that dredging will have on attendance, we have relied partly on engineering data and partly on judgment, taking into consideration the existing condition of the lake, activities on the lake now and those that could be added through dredging and other factors relating to the lake's attractiveness before and after dredging. The

1/ Population Projections by Age and Sex for State and Counties of Iowa, Iowa State University, June 1973.

2/ U.S. Department of Commerce Population Estimates and Projections, Series P-25, No. 477, March 1972.

impact of dredging was discussed previously in Section V. At each of the study lakes it was found that an inverse relationship exists between effects of dredging on penetration levels and distance from the lake. The analysis of competition required an assessment of the impact of proposed new reservoirs (also discussed in Section V) on the specific lake under study. It was found that competition serves to exaggerate the impacts of dredging on attendance. When alternatives are not available, residents are inclined to visit a lake in spite of declining lake quality. However, as alternatives become available, residents are inclined to shift their patronage to the new lakes if a dredging program is not undertaken and recreation quality declines significantly.

Lake by Lake Attendance Analysis

The following discussion provides forecasts of attendance for each of the lakes under the two alternatives--dredging and no dredging. Since for three of the lakes--Backbone, Rock Creek, and Mill Creek--we recommended that dredging not take place, we have forecast attendance for these lakes only under the no dredge alternative. In the discussion of attendance forecasts for each lake, a summary table lists historical data on attendance by zone as well as projections under the dredge, no dredge alternatives. The reader may also wish to refer back to Figures 22 through 25, which are maps showing the location of each lake and the areas contained within each of the three market zones.

Backbone Lake

As indicated above, dredging is not recommended for Backbone Lake, Rock Creek Lake, and Mill Creek Lake for the reasons cited in Section III. However, to complete this section of the study, we have developed projections of attendance for the three lakes assuming that dredging will not occur (see Table 32).

Table 32

HISTORICAL AND FORECAST ATTENDANCE
AT BACKBONE LAKE BY ZONE
1960-1990

	Historical		Forecast (no dredge)	
	1960	1970	1980	1990
Zone 1 (0-25 miles)				
Attendance	40,687	49,292	54,800	55,000
Population	52,667	51,166	51,700	51,900
Penetration	77%	96%	106%	106%
Zone 2 (25-50 miles)				
Attendance	61,030	73,938	92,100	109,600
Population	152,700	164,779	204,600	254,800
Penetration	40%	45%	45%	43%
Zone 3 (50-100 miles)				
Attendance	94,088	113,988	139,200	147,100
Population	631,794	687,265	818,900	980,400
Penetration	14.9%	16.6%	17.0%	15.0%
Subtotal (0-100 miles)				
Attendance	195,805	237,218	286,100	311,700
Population	837,161	903,210	1,075,200	1,227,100
Penetration	23%	26%	27%	24%
Other Areas (more than 100 miles)				
Attendance	58,487	70,857	85,500	93,100
Total Attendance	254,292	308,075	371,600	404,800

Source: Economics Research Associates.

Even without dredging and the prospects for siltation described earlier, we have projected an increase in attendance for Backbone amounting to slightly under 100,000 persons over the projection period to 1990, a percentage increase of 31 percent. The rationale for projecting this magnitude of increase without dredging is as follows:

- Backbone is a unique type of attraction for the Iowa recreationist and is not used solely as a water recreation resource. Our surveys showed a high interest in hiking, picnicking, and general recreation in addition to water-related activities. In our opinion, Backbone will continue to be an important attraction even if it reverts to its original condition as a river instead of a reservoir.

- We anticipate that recreation demand for Backbone will increase at approximately the overall rate for recreation described earlier in this section in the initial projection period, and then decline slightly in the later period. We have adjusted our penetration rates to reflect this projection. This is described in more detail by zone below.

- Of substantial importance is the fact that Backbone is located in a market area which is expected to show significant population increases in all three zones over the projection period (a percentage increase of 42.5 percent). Thus, even a decrease in penetration rates can result in a significant overall attendance increase.

- Competition is not expected to be an important factor in attendance at Backbone.

In examining the projections for Backbone on a zone-by-zone basis for the two time periods, we used the following factors for forecasting:

Zone 1 A 10-percent increase in market penetration up to 1980 and no increase in penetration between 1980 and 1990.

Zone 2 No increase in penetration up to 1980 and a slight decline from 45 percent to 43 percent during the next 10 years.

Zone 3 No increase in market penetration up to 1980 and a 2-percent decline during the next 10 years.

The two offsetting factors in these penetration rates are (1) the overall increase in the demand for recreation and (2) the gradual deterioration of the water usage component of the lake.

Black Hawk Lake

Attendance at Black Hawk Lake increased substantially during the period from 1960 to 1970 despite the fact that population in its three market zones decreased slightly indicating its popularity for repeat visits. Black Hawk has been most successful among the lakes in penetrating its Zone 3 market area, with 42 percent of attendance from this source and a penetration rate of 20 percent.

Black Hawk will be more affected by future competition than any of the other lakes, and the competition will most severely impact Zone 3, the area which has been the major source of attendance. The three major competitive lakes which are expected to divert attendance from Black Hawk are Big Creek, just north of Des Moines, planned to open in the 1974-1977 period; the Saylorville Reservoir (5,500 acres), 9 miles north of Des Moines, due to open in 1977; and Brushy Creek, slated for development in the period between 1980 and 1990.

As a result of this strong competition, total attendance at Black Hawk Lake is expected to decrease by 1980 even if dredging is carried out. Referring to Table 33, it may be noted that we have forecast a drop in

Table 33

HISTORICAL AND FORECAST ATTENDANCE
AT BLACK HAWK LAKE BY ZONE
1960-1990

	Historical		Forecast			
			1980		1990	
	1960	1970	Dredge	No Dredge	Dredge	No Dredge
Zone 1 (0-25 miles)						
Attendance	36,646	54,786	85,100	63,900	88,800	59,200
Population	34,826	32,772	31,300	31,300	29,000	29,600
Penetration	105%	167%	272%	204%	300%	200%
Zone 2 (25-50 miles)						
Attendance	27,485	41,089	34,200	30,200	33,600	24,700
Population	110,038	104,327	97,400	97,400	91,500	91,500
Penetration	25%	39%	35%	31%	37%	27%
Zone 3 (50-100 miles)						
Attendance	76,957	115,050	25,000	25,000	26,400	26,400
Population	595,781	582,078	581,900	581,900	586,800	586,800
Penetration	12.9%	19.8%	4.3%	4.3%	4.5%	4.5%
Subtotal (0-100 miles)						
Attendance	141,088	210,925	144,300	119,100	148,800	110,300
Population	740,645	719,177	710,600	710,600	707,900	707,900
Penetration	19%	29%	20%	17%	21%	16%
Other Areas (more than 100 miles)						
Attendance	42,143	63,003	43,100	35,600	44,400	32,900
Total Attendance	183,231	273,929	187,400	154,700	193,200	143,200

Source: Economics Research Associates.

penetration of the Zone 3 market from almost 20 percent to just under 5 percent; this would have the impact of reducing attendance from this source from a present level of 115,000 to approximately 25,000 persons, with or without dredging. The new competition is also expected to affect Zone 2, although much less significantly than Zone 3 because of the geographic relationship of the new reservoirs to the three zones.

Future competition is not expected to be a factor in Zone 1, which has shown a steady increase in attendance in the past. In forecasting the attendance in Zone 1, with and without dredging, we gave particular weight to the fact that the impact of dredging on recreation is expected to be very significant (a rating of 7 on a scale of 1 to 10) due to the nature of the dredging. Using 1970 attendance of 55,000 as a base, we have forecast that Black Hawk will increase its attendance both with and without dredging, but that the increase under the dredging alternative will be more dramatic--89,000 by 1990 versus 59,000 without dredging.

In summary, we have forecast an overall drop in attendance at Black Hawk Lake, even if it is dredged, due to the anticipated severe competition from Big Creek and Saylorville Reservoirs, both of which are expected to heavily impact the Zone 3 market area attendance.

Blue Lake

Although the figures in Table 34 indicate a sharp increase in attendance at Blue Lake between 1960 and 1970, actually the attendance has been fairly stable (around 200,000) between 1961 and 1970 (see Figure 11). In developing projections for Blue Lake, the assumption was made that Lake Manawa would be dredged and that an improved Manawa would provide some competition for Blue Lake in Zone 3. Though we did not assume that the Perry Creek or Snyder Winnebago Reservoirs would be competitive factors, the development of four Missouri River oxbows, namely, Blackbird Bend, Upper Decatur Lake, Middle Decatur Bend, and Louisville Bend, was considered a substantial competitive factor.

Table 34

HISTORICAL AND FORECAST ATTENDANCE
AT BLUE LAKE BY ZONE
1960-1990

	Historical		Forecast			
			1980		1990	
	1960	1970	Dredge	No Dredge	Dredge	No Dredge
Zone 1 (0-25 miles)						
Attendance	46,693	76,786	54,800	50,100	55,400	45,800
Population	24,412	21,175	20,300	20,300	19,100	19,100
Penetration	191%	353%	270%	247%	290%	240%
Zone 2 (25-50 miles)						
Attendance	30,684	50,459	46,500	42,700	51,000	45,400
Population	181,282	178,724	185,900	185,900	189,000	189,000
Penetration	17%	28%	25%	23%	27%	24%
Zone 3 (50-100 miles)						
Attendance	46,693	76,786	54,300	54,300	59,700	59,700
Population	850,007	933,988	987,500	987,500	1,029,300	1,029,300
Penetration	5.5%	8.2%	5.5%	5.5%	5.8%	5.8%
Subtotal (0-100 miles)						
Attendance	124,070	204,031	155,600	147,100	166,100	150,900
Population	1,055,701	1,143,463	1,193,700	1,193,700	1,237,400	1,237,400
Penetration	12%	18%	13%	12%	13%	12%
Other Areas (more than 100 miles)						
Attendance	9,339	15,357	11,700	11,100	12,500	11,400
Total Attendance	133,409	219,388	167,300	158,200	178,600	162,300

Source: Economics Research Associates.

The analysis presented earlier in Section V indicated that dredging would have a modest impact on the recreation potential of Blue Lake as compared with other lakes such as Black Hawk and Manawa. Also, the quality of the water at Blue Lake is better now than at most other lakes so that the improvement will not be as noticeable. The impact of dredging was given a rating of 4, indicating that the enhancement of recreational quality will be roughly half of that expected at Black Hawk Lake.

Blue Lake has traditionally achieved an extremely high penetration of its local (Zone 1) market of 353 percent, equivalent to every person in the local area visiting Blue Lake approximately 3.5 times per year. As suggested above, the most significant impact on Blue Lake's future attendance will be the on-going improvement of the Blackbird-Decatur-Louisville Bend oxbows, located within 11 miles of Onawa. All factors considered, in projecting future attendance for Zone 1, we have forecast a decrease under both the dredging and no dredging alternatives. Penetration has been reduced to 270 percent under the dredging alternative for 1980, and to 247 percent for the no dredging alternative. Attendance for 1990 assumes moderate increases in the penetration rates, over the 1980 levels, for both dredging and no dredging which are estimated at 290 percent and 240 percent, respectively.

In Zone 2, a similar type of projection has been made for the dredge and no dredge alternatives. The 1980 penetration rates are estimated at 25 percent for dredge and 23 percent for no dredge. In 1990, moderate increases result in a 27 percent penetration for dredge and 24 percent for no dredge.

For Zone 3, additional competition from the dredging of Lake Manawa was taken into consideration. Under both alternatives Blue Lake's penetration of that zone was dropped from a present 8 percent to 5.5 percent in 1980 and increased slightly thereafter. At Blue Lake, as with all the study lakes, it is believed that the effects of dredging on penetration levels are inversely related to distance from the lake. In 1990, for example, it is projected that visitation from Zone 1 will be 21 percent greater if Blue Lake is dredged. The difference narrows for Zone 2, to 12 percent, and is nullified for Zone 3 from which the same number of visitors are projected regardless of whether or not the lake is dredged.

In summary, we have forecast an overall attendance at Blue Lake considerably lower than present levels under both dredging and no dredging alternatives, primarily because of significant negative impact of competition and limited positive effects of dredging.

Five Island Lake

Five Island Lake derives approximately two-thirds of its attendance from a strong repeat business (high penetration) of its rather small local market. The estimated attendance from Zone 1 of approximately 100,000 persons indicates that the lake attracts residents from this local market on the average of four times per year; this is the highest Zone 1 penetration of any of the lakes studied. Attendance has increased gradually over the past 10 years despite a decreasing population in all three of its market zones.

In discussing the impact of dredging on Five Island Lake, it was noted that dredging will improve boating, water skiing and fishing in the middle lake and swimming and shore activities in the bottom lake. In addition, the depositing of spoil on some of the islands may enhance wildlife habitats. Although the proposed dredging program is not as extensive as that for Black Hawk, the potential gain for recreationists is considerable in view of present shallowness. Our rating on dredging impact was 5 on a scale of 1 to 10.

Competition from new lakes is not considered an important factor for Five Island Lake, because of its strong local appeal and the absence of proposed new lakes in the area. Dredging improvements at Black Hawk, Silver, and Blue Lake could affect Zone 3 attendance, but this zone is only a minor source of attendees.

Taking all of the forecasting factors into consideration we have projected a slight drop in attendance under the no dredging alternative and a significant increase in the period from 1975 to 1980 under the dredging alternative.

For the no dredging alternative, in Zone 1, our assumption was that the slight decline in the quality of the lake without dredging would be offset by the overall increase in water-oriented recreation during the projection period. Thus, the penetration rate of the declining local market was increased to 440 percent in 1980 and decreased to 420 percent by 1990. Under the dredging alternative, we have projected in Table 35 that the penetration rate of the Zone 1 market would increase to 500 percent by 1980 and then increase at a slower rate to 535 percent by 1990, just enough to hold attendance level.

In Zone 2, for the no dredging alternative, we utilized the same assumptions in regard to the penetration rate increase exceeding the reduction in water quality, resulting in an increased penetration rate and, consequently, a moderate increase in total attendance. For the dredging alternative, we have projected an increase in penetration due to the impact of dredging by 1980 and a leveling out after that point.

In Zone 3, for the no dredging alternative, the same assumptions were used as in Zones 1 and 2; however, because Zone 3 market is projected to increase rather than decrease in population, attendance is forecast to increase slightly over the projection period, the result of a constant penetration rate of an increasing market. Under the dredging alternative, we have projected an increase in the penetration rate resulting in a 40 percent increase in attendance from the Zone 3 market over the projection period.

Table 35

HISTORICAL AND FORECAST ATTENDANCE
AT FIVE ISLAND LAKE
BY ZONE
1960-1990

	Historical		Forecast			
			1980		1990	
	1960	1970	Dredge	No Dredge	Dredge	No Dredge
Zone 1 (0-25 miles)						
Attendance	79,023	100,500	122,500	107,800	123,000	96,000
Population	27,342	25,647	24,500	24,500	23,000	23,000
Penetration	289%	392%	500%	440%	535%	420%
Zone 2 (25-50 miles)						
Attendance	14,153	18,000	24,400	22,200	25,200	21,900
Population	119,560	111,956	111,000	111,000	109,700	109,700
Penetration	12%	16%	22%	20%	23%	20%
Zone 3 (50-100 miles)						
Attendance	8,256	10,500	13,500	12,900	14,000	13,400
Population	539,364	522,913	538,000	538,000	556,700	556,700
Penetration	1.5%	2.0%	2.5%	2.4%	2.5%	2.4%
Subtotal (0-100 miles)						
Attendance	101,432	129,000	160,400	142,900	154,200	132,000
Population	686,266	660,516	673,500	673,500	689,400	689,400
Penetration	15.0%	20.0%	24%	21%	22%	19%
Other Areas (more than 100 miles)						
Attendance	16,512	21,000	26,100	23,300	25,100	21,500
Total Attendance	117,944	150,000	186,500	166,200	187,300	153,500

Source: Economics Research Associates.

In summary, we have forecast an increase in attendance of almost 25 percent due to dredging up to 1980 and a leveling off at that point. Without dredging, we have forecast an increase in attendance to 1980 and subsequent decline to a level slightly above the present attendance level by 1990.

Lake Manawa

Lake Manawa is by far the most heavily attended of the eight lakes studied. Attendance overall has not varied much over the past 10 years, but it has followed an inexplicable up and down pattern year by year (see Figure 12). Attempts to explain this alternating phenomenon were not conclusive.

As discussed earlier, the impact of dredging on Manawa is expected to be the greatest of any lake (rated 9 on a scale of 1 to 10). Removal of organic and nutrient rich sediments should reduce water pollution and deepening of the lake will permit safer, more extensive water skiing and sailing.

Lake Manawa is expected to be impacted by competition from the Papillion Creek Watershed Project in West Omaha, discussed earlier in Section V. Presumably the project will intensify the disparity between dredge and no dredge projected penetration rates and attendance levels, particularly in Zone 1. Since it presently draws 93 percent of its attendance from the local area (Zone 1), any new lakes near other population centers are expected to have little if any impact.

The differences between the dredging and no dredging projections are more pronounced for Lake Manawa for the reasons explained above. In Zone 1, for both alternatives we have projected in Table 36 that the lake will reduce its penetration of a growing market area. The severe reduction under the no dredge alternative is due to the short life predicted for the lake provided a dredging program is not initiated. Under the dredging alternative, we project that the lake will reduce its penetration of an increasing market to 110 percent in 1980 and 1990, though the attendance level will be slightly increased over present levels by 1990.

In Zone 2, a similar pattern is forecast; however, the numbers involved are much smaller. Without dredging we forecast a severe drop in penetration and attendance by 1990; the penetration rate will decline from the present level of 17 percent to 4 percent in 1990. With dredging we project a continuation of the present penetration level, assuming general recreation growth will be offset by the competition discussed above, and a consequent slight decline in attendance by 1990. A similar rationale was applied to the attendance potentials for Zone 3.

In summary, total attendance at Lake Manawa is expected to drop severely without dredging, primarily due to the deterioration of water quality. Dredging is expected to result in a slight increase in attendance by 1990 over the 1970 figure in Table 36. It should be noted that this figure represents the high side of Lake Manawa's yearly fluctuations in attendance levels.

<u>Mill Creek Lake</u>

Mill Creek Lake presents a situation quite different from that at Backbone and Rock Creek or any of the other lakes studied. The lake is so small and so shallow that, without dredging, it will cease to be a water recreation resource of any significant value. It is this factor, rather than competition or any of the other factors taken into consideration in forecasting attendance at other lakes, which has led us to the conclusion that, without dredging, attendance at Mill Creek Lake will decline by approximately one-third by 1980 (all attendance will come from its local market) and further decline to an insignificant number by 1980 (see Table 37).

The substantiation for this conclusion is found in the discussions on dredging potentials and the expected life of the lakes in Section III.

Table 36

HISTORICAL AND FORECAST ATTENDANCE
AT LAKE MANAWA
BY ZONE
1960-1990

	Historical		Forecast			
			1980		1990	
	1960	1970	Dredge	No Dredge	Dredge	No Dredge
Zone 1 (0-25 miles)						
Attendance	667,500	676,559	644,900	469,000	697,800	63,400
Population	455,906	535,963	586,300	586,300	634,400	634,400
Penetration	146%	126%	110%	80%	110%	10%
Zone 2 (25-50 miles)						
Attendance	21,532	21,825	20,900	16,000	20,700	4,900
Population	128,974	125,324	122,800	122,800	121,500	121,500
Penetration	17%	17%	17%	13%	17%	4%
Zone 3 (50-100 miles)						
Attendance	21,532	21,825	21,100	17,400	21,400	7,700
Population	492,916	489,318	498,000	498,000	510,500	510,500
Penetration	4.4%	4.5%	4.2%	3.5%	4.2%	1.5%
Subtotal (0-100 miles)						
Attendance	710,564	720,209	686,900	502,400	741,100	76,000
Population	1,077,796	1,150,605	1,207,100	1,207,100	1,266,400	1,266,400
Penetration	66%	63%	57%	42%	58%	6%
Other Areas (more than 100 miles)						
Attendance	7,177	7,275	6,900	5,100	7,500	800
Total Attendance	717,741	727,484	693,800	507,500	747,400	76,800

Source: Economics Research Associates.

Table 37

HISTORICAL AND FORECAST ATTENDANCE
AT MILL CREEK LAKE BY ZONE
1960-1990

	Historical		Forecast (no dredge)	
	1960	1970	1980	1990
Zone 1 (0-25 miles)				
Attendance	41,980	31,107	21,600	Negligible
Population	39,424	37,796	36,000	34,400
Penetration	107%	82%	60%	Negligible
Zone 2 (25-50 miles)				
Attendance	Negligible	Negligible	Negligible	Negligible
Population	113,102	114,188	106,600	102,800
Penetration	Negligible	Negligible	Negligible	Negligible
Zone 3 (50-100 miles)				
Attendance	447	331	Negligible	Negligible
Population	575,505	557,779	569,300	579,600
Penetration	.08%	.06%	Negligible	Negligible
Subtotal (0-100 miles)				
Attendance	42,427	31,438	21,600	Negligible
Population	728,031	709,763	711,900	716,800
Penetration	6%	4%	3.0%	Negligible
Other Areas (more than 100 miles)				
Attendance	2,233	1,655	1,100	Negligible
Total Attendance	44,660	33,093	22,700	Negligible

Source: Economics Research Associates.

Rock Creek Lake

Rock Creek Lake showed a fairly steady upward pattern in attendance from 1960 through 1973, with dips in 1969 and 1973. At present, Rock Creek Lake's attendance is fairly well distributed between its three zones with 38 percent coming from Zone 1, 34 percent from Zone 2, and 23 percent from Zone 3.

In addition to problems of siltation, the major factor affecting future attendance at Rock Creek Lake is the number of new reservoirs which will provide very strong competition, particularly in Zones 2 and 3. As shown in Table 38, in forecasting attendance by zone we have indicated an increasing penetration of the local area (Zone 1) amounting to about 10 percent over the projection period. We have forecast a sharp decrease (approximately 30 percent) in Zone 2 from a present penetration of 94 percent (the highest Zone 2 penetration for any lake studied) to 65 percent in 1980 and 1990. This drop in penetration will occur because of the competition of Big Creek Reservoir and Saylorville Reservoir. In Zone 3 we estimate that the decline in market penetration will be even greater, from 9.8 percent down to 4 percent, a drop of 60 percent. Major competition for this market consists of the recently opened Rathbun and Red Rock Reservoirs and the longer range Brushy Creek Reservoir.

The area within 100 miles of Rock Creek Lake is expected to show more than a 33-percent increase in population between 1970 and 1990. Thus, the drop in penetration will be partly offset by the increase in population. Our forecast indicates a decrease in attendance for Rock Creek Lake from approximately 450,000 at present to a level of 364,000 by 1980 and increasing to 394,000 by 1990.

Silver Lake

Silver Lake is limited in its attendance potentials because of its proximity to the large resort and recreation complex at Spirit Lake and Lake Okoboji. No matter what types of dredging activities are carried out,

Table 38

HISTORICAL AND FORECAST ATTENDANCE
AT ROCK CREEK LAKE BY ZONE
1960-1990

	Historical 1960	Historical 1970	Forecast (no dredge) 1980	Forecast (no dredge) 1990
Zone 1 (0-25 miles)				
Attendance	119,343	170,457	180,900	192,400
Population	76,582	78,244	79,000	80,200
Penetration	156%	218%	229%	240%
Zone 2 (25-50 miles)				
Attendance	106,781	152,514	114,100	123,300
Population	154,386	161,657	175,500	189,700
Penetration	69%	94%	65%	65%
Zone 3 (50-100 miles)				
Attendance	72,234	103,171	50,800	59,000
Population	952,288	1,057,519	1,269,800	1,475,200
Penetration	7.5%	9.8%	4.0%	4.0%
Subtotal (0-100 miles)				
Attendance	298,358	426,142	345,800	374,700
Population	1,190,256	1,297,420	1,524,300	1,745,100
Penetration	25%	33%	23%	22%
Other Areas (more than 100 miles)				
Attendance	15,703	22,429	78,200	19,700
Total Attendance	314,061	448,571	364,000	394,400

Source: Economics Research Associates.

Silver Lake will not be able to make major inroads into the water recreation market given the quality and size of existing competition. A dredging program should, however, encourage higher participation from local sources. We have adjusted the attendance figures for Silver Lake substantially (doubling them) to account for the fact that the state park occupies a rather small portion of the lake and that there are many other recreation sites on the lake.

In discussing the impact of dredging on Silver Lake, it was pointed out that dredging was limited by less than adequate spoil areas so that some of the dredging projects originally under investigation were found not to be feasible. Also, it was noted that water entering the main body of the lake through Trappers Bay may continue to introduce water quality problems regardless of dredging. Much of the proposed dredging is designed to deepen the lake at the intake point for city water. This was necessary because of the limitation of adequate spoil areas for further dredging, but it will impact recreation potentials less than a more general deepening program. Fishing should be improved, but water skiing and swimming will probably not improve appreciably. In spite of these limitations, we have rated the impact of dredging at Silver Lake as 5 on a scale of 1 to 10, primarily because the present recreational conditions are so unappealing that any improvements will have an important psychological effect.

Competition from new lakes is not a consideration in the future attendance of Silver Lake, but dredging of Black Hawk and Five Island Lake could impact its attendance in Zone 3.

As with Five Island Lake, we have projected in Table 39 a slight decrease in attendance under the no dredge alternative and a reasonably significant increase in attendance if dredging takes place. The explanations of projections by zone are given below.

Under the no dredge alternative in Zone 1, we have projected a decline in penetration from nearly 30 percent of the market at present to 27 percent by 1980 and 23 percent by 1990. Since the population in the market area is expected to increase, this results in an absolute drop of

Table 39

HISTORICAL AND FORECAST ATTENDANCE
AT SILVER LAKE
BY ZONE
1960-1990

	Historical		Forecast			
			1980		1990	
	1960	1970	Dredge	No Dredge	Dredge	No Dredge
Zone 1 (0-25 miles)						
Attendance	12,900	11,824	14,500	11,400	14,300	10,000
Population	43,694	41,011	42,300	42,300	43,400	43,400
Penetration	30%	29%	33%	27%	33%	23%
Zone 2 (25-50 miles)						
Attendance	13,600	12,520	15,200	13,200	15,700	12,600
Population	101,725	96,924	101,300	101,300	104,800	104,800
Penetration	13%	13%	15%	13%	15%	12%
Zone 3 (50-100 miles)						
Attendance	34,000	31,298	37,400	31,900	40,700	32,600
Population	502,374	490,468	498,400	498,400	543,100	543,100
Penetration	6.8%	6.4%	7.5%	6.4%	7.5%	6.0%
Subtotal (0-100 miles)						
Attendance	60,500	55,642	66,600	56,500	70,700	55,200
Population	647,793	628,403	642,000	642,000	691,300	691,300
Penetration	9%	9%	10%	9%	10%	8%
Other Areas (more than 100 miles)						
Attendance	15,100	13,910	16,700	15,000	17,700	14,700
Total Attendance	75,600	69,552	83,300	71,500	88,400	69,900

Source: Economics Research Associates.

only approximately 2,000 persons over the period. If dredging takes place, we project a near-term increase to a 33-percent penetration of the market and then a leveling out after the initial impact.

In Zone 2, we have forecast a slight drop of penetration for the no dredge alternative from 13 percent down to 12 percent by 1990, while under the dredging alternative, we project a slight increase in penetration of from 13 percent to 15 percent. A similar approach was taken for Zone 3 projections, conforming to the inverse relationship between dredging's impact on penetration levels and distance from the lake.

In summary, we have forecast an approximate 20 percent increase in attendance due to dredging up to 1980 and a leveling off past that point. Without dredging, attendance is projected to remain at approximately the same level. This projection results from market area population growth which offsets the penetration rate declines which could be expected under these circumstances.

Section VI

BENEFIT COST ANALYSIS

After a brief review of probable costs expected under dredging programs proposed earlier in this report, this section describes benefits that might offset these costs and, in an economic sense, might be considered the return on investment. Benefits consist of increased recreational activity discussed in the preceding section, increased commercial activity catering to recreationists, and higher property values for the owners of real estate in the vicinity of the improved lakes. These benefits are stated in monetary terms and presented in current values, assuming that any effect which would derive from discounting future benefits would be offset by inflating recreation-day benefit values.

COSTS

As detailed in Section III, dredging is feasible at only five of the eight lakes considered in this study because of the lack of likely spoil disposal sites and/or the possibility of only short-range benefits resulting from rapid sedimentation rates. Project engineers have estimated dredging costs based on lake depth contours mapped by various sources. The accuracy of these estimates is therefore dependent on the accuracy and currency of the maps. Bottom samples were not adequate to determine precisely the types of sediment that will be dredged, so that cost estimates are preliminary. The estimated volume of spoil and costs of dredging and shore-line protection are summarized below for each of the five lakes where dredging is feasible.

Lake	Volume of Spoil (million cu. yd.)	Estimated Cost of Dredging (thousands of dollars)	Estimated Cost of Shore-line Protection (thousands of dollars)
Black Hawk	3.02	$4,250	$200
Blue	0.14	300	40
Five Island	1.67	2,500	260
Manawa	2.10	3,700	150
Silver	2.20	3,000	37

Additional cost components of dredging are estimated in Table 40 for each of the five lakes where dredging is deemed feasible from an engineering standpoint. The following costs are included here:

- Spoil disposal construction costs, including diking, drainage provisions and site rehabilitation.
- Spoil disposal site procurement, based on a per acre allowance for use of a site which would accommodate a four foot depth of spoil deposition over the required period of time.
- Lake surveying and mapping (where dredging is proposed for only a small portion of the lake the total lake area is not surveyed).
- Spoil site surveys to determine containable volumes and amount of diking required.
- Field investigations, including lake bottom and water quality sampling and testing, spoil site foundations explorations, hydrologic measurements and compilation of environmental data.
- Engineering and administration services, including predesign reports, specifications, final designs and construction drawings. Administrative services include supervision and inspection of construction, and procurement of required goods and services.
- An allowance for contingencies to compensate for unknown site conditions and adjustments to quantities and prices for construction.

Clearly, the costs associated with dredging, enumerated in Table 40, represent a substantial additional increment to the estimated dredging and shore-line protection costs. The following text table thus

Table 40

ESTIMATED COSTS ASSOCIATED WITH DREDGING
(Thousands of Dollars)

	Lake				
	Black Hawk	Blue	Five Island	Manawa	Silver
Spoil Disposal Construction	2,264	139.0	1,418	2,097	1,656
Spoil Disposal Site Procurement	138	8.8	104	130	138
Lake Surveying and Mapping	240	50.0	120	165	175
Spoil Site Surveying and Mapping	17	1.3	13	17	18
Field Investigations	336	24.0	209	297	235
Engineering and Administration	806	57.5	502	714	563
Contingencies	1,650	124.4	1,025	1,454	1,164
Total--Estimated Associated Costs	5,451	405.0	3,391	4,874	3,949

Source: Engineering Consultants, Inc.

indicates our best current estimate of total dredging and off site costs for each of the lakes under consideration:

Lake	Total Cost (thousands of dollars)
Black Hawk	$9,901
Blue	745
Five Island	6,151
Manawa	8,724
Silver	6,986

It should be emphasized these costs do not include any allowances for improvements to the lakes' environs other than spoil deposition areas. Improvements to sewage systems and surrounding drainage areas are assumed to be preconditions to dredging and not a part of the dredging process itself. Further, these costs are preliminary and, as such, will probably vary as more detailed data from in-depth investigations become available.

USER BENEFITS

Despite many scholarly efforts over at least the past decade, placing a hard economic value on a recreational experience remains an elusive, if desirable, goal. Since much outdoor recreation can be pursued largely free of monetary cost by the recreationist, there is little market data available to suggest a given activity's relative worth, whether compared with another outdoor activity or with some other leisure-time pursuit. For example, the value of bowling and golfing to consumers can be measured and compared largely by the charges per game or for greens fees and membership charges in golf clubs; but comparing these activities with hunting, swimming, boating, or camping is difficult since admission or participation fees either are not charged or vary widely.

Nonetheless, the necessity of estimating the value of a recreation project so that it can be measured against development costs and ranked against other projects has produced several methods of calculating surrogate market values for outdoor activities. Following is a brief description of some of these methods.

Cost of Outing

Even though the outdoor facility used by recreationists may not charge user fees, participants still must devote some of their discretionary income to the activity. Costs of food, transportation, lodging, and equipment above the normal at-home expenditures may be totaled to give a measure of a family's perception of the value of a recreational experience. For example the costs of guns, trained dogs, and special clothing make hunting an expensive sport. The National Park Service reports a figure commonly used in this type of calculation as $14 per family per day.

Income Foregone

Another method values the recreation experience in terms of the income a person or family could have earned if leisure time had been spent at additional work. A head of household working at a second job might expect to take home $20 a day after taxes, so that the user benefit per family day equals $20.

Some difficulties arise out of this method, however. First, much outdoor recreation, such as hunting, fishing, and camping, is enjoyed by retired persons for whom foregone income is not a viable alternative. Second, children and spouses not employed outside the home may still take advantage of recreation opportunities even though the head of household takes a second job. Third, employment opportunities may be too limited to permit finding a second job, in which case leisure time has no money-earning alternative.

Commercial Costs Comparisons

A minimum benefit to users can be based on the costs facing a recreationist were he to pay commercial rates for equivalent opportunities. Fees at private swimming pools, camp sites, and fish ponds can be used to establish market values. Similarly, the market price of fish, fowl, and meat can be used to estimate the value of game taken by anglers and hunters. The last concept again avoids the question of how to measure the recreational enjoyment of an activity.

Maintenance Costs

Some proponents of public recreation facilities argue that while development costs may properly be funded from the public coffer, maintenance costs should be borne by the actual users. The theory seems to be that recreation is good for society and should be generally available as part of the social infrastructure, but that persons availing themselves of such capital improvements should pay for their operation and maintenance. As an example, the current maintenance costs per recreation day (see definition below under Government Standards) at Army Corps of Engineer lakes ranges from \$0.15 to \$1.00 depending on the intensity of use. The mean value is about \$0.25 per recreation day.

Government Standards

In the face of this confusing and inconclusive array of methods for assessing potential user benefits for recreation projects, government agencies and planners have nonetheless found it necessary to establish some uniform criteria, however arbitrary, to aid in determining development priorities among potential projects. It is desirable to express these benefits in monetary terms so that they may be compared directly to development costs. In most cases, no attempt is made to give relative values to one activity over another; (e.g., picnicking versus swimming or fishing). Studies of activity demand will determine what mix of facilities is optimal, but user benefits among activities are treated as equal.

The basic unit of user benefit, then, is the recreation day, defined as the participation of one person in one or more activities during all or part of a 12-hour period. The Corps of Engineers currently values recreation days at its projects at \$2.70 to \$2.80. The Fish and Wildlife Service uses a \$6.00 daily figure. Standards established in 1973 by the Water Resources Council in accordance with the Water Resources Planning Act of 1965 (Public Law 89-80) propose a two-level valuation for general and specialized recreation days. A general recreation day is one "involving primarily those activities attractive to the majority of outdoor recreationists and which generally require the development and maintenance of convenient access and adequate facilities." Included activities are swimming, picnicking, boating, and most warm-water fishing. The specialized recreation day involves "primarily those activities for which opportunities, in general, are limited; intensity of use is low, and often may involve a large personal expense by the user." Trout fishing and hunting are examples. The suggested range of values per general recreation day is \$0.75 to \$2.25; for specialized recreation days, \$3.00 to \$9.00. It is expected that most of the use at the eight lakes being studied will be general. In deciding what value in the \$0.75 to \$2.25 range is appropriate for a given lake, "the applicable rule to follow, taking cognizance of the unique circumstances of a particular setting, including the availability of actual market data and experience, is to use that procedure which appears to provide the best measure or expression of willingness to pay by the actual consumer of the recreation good or service provided by the plan."1/

Given the variety of activities possible at each lake (a visitor may combine fishing, camping, and picnicking in one user day) ERA proposes to use a \$2.00 factor for valuing incremental use at the lakes resulting from dredging. This valuation near the high end of the range seems justified by the relative paucity of other recreational resources and

1/ Water Resources Council, 1973.

alternatives in rural Iowa and by the variety of activities possible at most lakes. An exception is in urban Council Bluffs, where recreationists may have other choices provided by commercial competitors for their amusement dollars. It is proposed, therefore, that a value of \$2.25 per user day be assigned to incremental attendance resulting from dredging of Lake Manawa.

THE MULTIPLIER EFFECT

To the extent that commercial enterprises attract recreationists from outside their accustomed market area, they are exporting goods and services. That is, new dollars are introduced into local economies. This new income, itself a significant benefit, then becomes available for respending in the local economy or outside it. The ratio which describes the amount of each new dollar which is respent in the local economy before being "leaked" to the outside in subsequent purchases is a multiplier.

In rural locations with few commercial outlets, first-round spending by recreationists is limited and second-round spending by businesses is minimal. Recreationists bring much of their food, equipment, and even lodging (campers) with them. Businesses catering to recreationist purchase most of their goods from outside sources, so that leakage is substantial.

In more urban locations, the greater variety of goods and services available capture more of the recreationists' expenditures. Gas, food, lodging, and equipment for recreational purposes can all be obtained near the recreation site. Further, wholesale suppliers of retail items are more likely to operate in the local economy so that fewer of the new recreation dollars are leaked to the outside in second-round spending.

For most of the lakes being considered here, the impact of the multiplier effect will be minimal. Backbone Lake, Rock Creek Lake, Mill Creek Lake, Silver Lake, and Blue Lake have few commercial enterprises geared to recreation purchases. Further, findings of the on-site survey conducted by ERA show that a substantial proportion of visitors came from within a 50-mile radius of the lake, as can be seen below:

Lake	Visitation by Distance Traveled 0-25 Miles	26-50 Miles	Total
Back Bone	16%	24%	40%
Black Hawk	20	15	35
Blue	35	23	58
Five Island	67	12	79
Manawa	93	3	96
Mill Creek	94	0	94
Rock Creek	38	34	72
Silver	17	18	35

For all practical purposes, then, the only lake with both significant long-distance visitation patterns and a degree of local commercial activity able to absorb extra-regional dollars is Black Hawk Lake.

As stated previously, no generally applicable multiplier is available. Rather, in-depth studies of specific economic regions show a range of multipliers sensitive to local conditions. A study of fishing expenditures in New Mexico showed the following percentages of sales which resulted in value added to the state economy; that is, the amount of expenditure not leaked to suppliers outside the state and therefore available for a second round of purchases.

Vehicles	12.0%
Boats and Motors	25.0
Camping Equipment	28.4
Transportation	18.3
Food	45.9
Lodging	69.0
Tackle	28.4
Special Clothing	24.5
Horses, etc.	31.5
Fees	122.2

Thus, the first-round multiplier for vehicles was 1.12 and for fees 2.00. The second and subsequent rounds were not calculated, so that the composite multiplier was not determined.

A study in Sullivan County, Pennsylvania, revealed the following multiplier in a rural recreation economy:

Expenditure Category	Multiplier
Hunters and Anglers	1.56
Tourists	1.58
Second-home Owners	1.62

The U.S. Area Redevelopment Administration espouses a multiplier of 1.5 on that part of recreation expenditures which goes to payment of local wages. Finally, a study of Norris Lake in rural Tennessee revealed a 1962 multiplier of 1.53 but a multiplier of 1.74 on incremental income between 1962 and 1967. Apparently, as recreational expenditures increased, the local economy expanded and was able to capture and retain a progressively greater share of first- and second-round expenditures.

The studies discussed above indicate a multiplier of 1.5 can reasonably be expected to operate in the Black Hawk area. Further, it is possible that greater recreational activity which might result from dredging could induce a multiplier near 1.75 on the increment of expenditures above current levels. Again, the other lakes under study either are set in a limited local economy or are utilized to such an extent by local residents that outside expenditures by new recreationists would be insignificant.

APPRECIATION POTENTIAL OF LAKE SHORE PROPERTY

One possible economic benefit which was examined in this benefit/cost analysis of dredging is the potential increase in values of residential and commercial real property adjacent to the lakes under study. Generally, lake view and lake front properties command higher market values than nearby landlocked parcels and increase in value at a faster rate than the latter.

However, many factors in addition to water orientation affect rates of appreciation and may increase or decrease the disparity with other properties. Basically, these factors act on the supply and demand levels for such properties. For example, proximity to an urban population center will normally create greater demand pressure for lake-oriented primary or secondary residences. Conversely, remote lakes in agricultural areas will normally experience lower demand levels.

On the supply side, physical constraints may affect property values. A lake whose shores are largely reserved for public parks may offer a limited supply of private parcels whose values might then appreciate more rapidly than at a similar lake with an abundance of private parcels. Similarly, zoning practices such as requirements for sewage treatment rather than septic tanks can affect the density, quality, supply, and price of lake properties.

Other factors affecting property values have to do with lake quality and appeal. Dredging is only one method of enhancing lake quality and might be insufficient to protect property values in the absence of other lake management practices. For example, adjacent agricultural uses may introduce animal waste, nutrient runoff, and silt into lake waters, impairing the enjoyment and even the health of recreationists. Similarly, erosion of unprotected banks by wave action or unsightly draw down during droughts can adversely affect use and property values.

With so many factors influencing trends in property values, it is not possible to establish a universally applicable factor defining the impact of dredging on property values at the lakes in question. Rather, ERA has approached each lake separately to determine the relative influences of supply, demand, and lake quality factors on property values and their appreciation rates. The potential impact of dredging is considered as one of the lake quality controls. As an aid in this analysis, ERA recorded the circumstances of property values at Storm Lake in Buena Vista County, since it has been dredged in the past and may illustrate appreciation trends applicable to lakes in the present study.

Storm Lake

The city of Storm Lake, with a 1970 population just under 8,600, is the Buena Vista County Seat and maintains a local economy not dependent on Storm Lake as a recreation attraction. The lake offers 3,060 surface acres of water and both public and private ownership of shore properties. There appears to be a sufficient supply of lake-oriented properties, many of them vacant parcels, to ensure the willing buyer/willing seller market relationship.

Storm Lake was dredged from 1936 to 1948, 1949 to 1952, and again from 1960 to 1970. Reports on the amount of dredging are unfortunately not sufficiently precise to assess impacts on lake quality. For purposes of a conservative analysis, ERA assumes lake quality was maintained but not improved. Table 41 lists property values as determined by the Buena Vista County Assessor for selected waterfront properties, for the city of Storm Lake, and for all towns in Buena Vista County. Two parcels from each of the waterfront neighborhoods revealed a range of average annual rates of price appreciation of 6.8 percent to 14.2 percent between 1970 and 1974. During the same period, total assessed valuation of residential properties in the city of Storm Lake rose 7.8 percent annually, and in all towns in the county, 7.2 percent. While the results are not conclusive, it appears that water orientation alone is not sufficient to cause property values to appreciate more rapidly than adjacent properties not at the water's edge. The two Casino Beach properties in the sample which had the highest rate of appreciation were set behind a sidewalk easement for public access to the shore, indicating that private riparian rights are not necessarily critical to property value appreciation.

Project Lakes

Four of the lakes in the current study can be eliminated from the analysis of property value appreciation. Rock Creek Lake, Mill Creek Lake, and Backbone Lake are man-made bodies where dredging either would not help due to rapid resedimentation or is not feasible because of the lack of spoil deposit sites. Lake management and soil conservation practices in the surrounding watersheds are prerequisites to improved recreational appeal. In addition to these three, Blue Lake is bordered by very little private property to be considered. It consists primarily of a trailer park with no zoning and utilizing septic tanks so that densities and quality of development are uncontrolled.

Dredging of the remaining four lakes--Manawa, Black Hawk, Silver, and Five Island--could benefit real property values. Recreation on Manawa Lake would improve with the clearing away of emergent vegetation and algal bloom. Access to the water would be improved for properties now choked with floating lotus plants. Manawa Lake, located in Council Bluffs and

Table 41
LAND VALUE APPRECIATION
STORM LAKE
1966-1974

	1966	1970	1974	Average Annual Percent Change 1970-1974
Waterfront Parcels				
Casino Beach	$1,708	$ 2,336	$ 3,975	14.2%
	801	1,226	1,999	13.0
Belaire		11,756	15,290	6.8
	86	86	2,568	1/
Lakeside	4,541	4,667	6,801	6.8
	2,461	2,587	3,510	7.9
Towns				
Storm Lake	7,909,622	8,995,093	12,166,506	7.8
All Towns	12,080,658	13,465,282	17,752,722	7.2

1/ This parcel was discarded from the analysis as it must reflect some extraneous input such as property improvements between 1970 and 1974.

Source: Buena Vista County Assessor.

across the Missouri River from Omaha, serves an urban economy which prompts use of lake properties for primary residences, so that improvements and public facilities are more substantial than at rural lakes. The combination of recreational and residential pressures make properties near the lake quite desirable. While dredging may or may not add to the demand for such properties, it certainly will maintain demand by preventing further deterioration of the lake.

The Pottawattamie County Assessor in Council Bluffs maintains records of sales of properties as an aid in monitoring value appreciation. ERA searched these records for properties which had been sold twice since 1970 and for which comparable sales prices were provided. That is, improvements added to the property between sales or non-monetary considerations such as trades disqualified a property from consideration by ERA. Twenty-two properties located in Westlake Village, Lakeview Acres, Lakoma Addition, Lakoma Annex, Manawa Park, and Lakewood Villas experienced an average annual rate of value appreciation of 33 percent from 1970 to 1974. In 1973, these residential areas had a combined market value of approximately \$4.6 million.[1/]

Clearly Lake Manawa is one of the prime residential areas in Council Bluffs. Local realtors report a scarcity of lake properties for sale, and virtually no new properties remain to be developed. Further, in Council Bluffs generally there exists a shortage of new housing units, so that older houses appreciate more rapidly. Until recently, public bonding programs for utility, sewer, and water districts were not statutorily possible, so that developers faced staggering infrastructure costs before houses could be built and sold. In addition, FHA financing was not allowed for houses using wells and septic tanks. The result of these two factors has been a lack of new housing developments, creating a sellers' market for existing units in Council Bluffs. Reflecting this, the estimated

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1/ Based on 1973 assessed values of \$1,006,917 which is pegged at 27 percent of market value by law but which, according to the assessor, in fact equals 22 percent of market value because of time lag of reassessments behind market sales.

1974 assessment for residential and commercial properties in Council Bluffs is 11.5 percent above the 1973 assessment. At 33 percent, appreciation of lake properties is nearly three times the current rate of increase in city assessments.

While declining lake quality does not seem to have seriously affected the rather remarkable market performance of properties at Lake Manawa, it is possible that the further decline and eventual death of the lake would undercut such high values and rates of price appreciation. If the new law permitting public financing of utility districts in new subdivisions combine with availability of mortgage money, the desirability of lake property enhanced by scarcity will diminish. Again, it appears that improving lake quality by dredging or other means will protect current property values and, at least in the near term, enable them to appreciate more rapidly than other Council Bluffs neighborhoods.

Black Hawk Lake, in Sac County, supports many resort and residential properties, as well as a few primary residences in Lake View City. Total assessed valuation for Lake View City and lake-oriented residential properties in Wall Lake Township and Viola approximates \$10.223 million. Reassessment, carried out every four years, will occur in 1975 and will indicate an increase in the range of 25 percent, or 5.7 percent on an average annual basis. "Resort" property, however, will be reassessed 40 to 50 percent higher, or by 8.8 to 10.7 percent per year. And, waterfront property, currently assessed at \$150 per front foot, is expected to be revalued by the assessor at \$325, representing an average annual appreciation of 22 percent.

Table 42 shows recent resales of lake-oriented properties previously marketed by a Lake View City realtor. The range of appreciation is 5 to 14 percent. The realtor further reports that he has a waiting list of potential buyers but no properties are for sale.

In such a sellers' market, it is difficult to estimate the effect of dredging on property values. Nonavailability of land and inflation are the

Table 42

LAND VALUE APPRECIATION
BLACK HAWK LAKE
1964-1974

Parcel	1964	1966	1968	1973	1974	Average Annual Appreciation (percent)
A		$ 9,000			$20,000	10.5%
B			$12,000		18,000	7.0
C		15,000			22,000	4.9
D	$11,000			$36,000		14.1

Source: Vernon Wickes, Realtor and Economics Research Associates.

dominant pressures on prices. However, the Sac County Assessor estimates that if the lake were not at least maintained, waterfront lots currently valued at $10,000 would depreciate to $1,500 as compared with new urban lots in Lake View City valued at $3,000. The expected life of the lake without dredging thus becomes more important than anticipated improvements in lake quality that might result.

Silver Lake and Five Island Lake are in similar circumstances with regard to property appreciation potentials. Recreation opportunities could be improved on both as the result of dredging. While Silver Lake has a smaller resident population than Five Island (976 as against 4,150), it is nearer to the popular Spirit and Okoboji lakes and could absorb spill-over pressure. Both have waterfront property currently in agricultural use so that if zoning and engineering considerations permit, new water-oriented residential properties could be developed to meet expanded demand. In this case, appreciation of existing properties would be influenced by inflated costs of new construction rather than by scarcity of land. Again, it appears that the effect of dredging would be to prevent depreciation of property values as the lakes decline in quality rather than to encourage more rapid appreciation than presently prevails.

At Five Island Lake, research efforts failed to establish rates of appreciation for lake-oriented properties. Realtors report sales are so infrequent that no reliable data are available. One parcel, sold in 1968 and resold in 1974, increased in value only 1.0 percent per year. Another property resold in just two months at a 12.5 percent profit, while a third sold in two years with a 5.0 percent average annual appreciation indicated.

With the exception of one 10-acre parcel, which may be subdivided, there seems little interest among holders of lake front agricultural acreage in developing residential lots. Demand seems to exceed supply for existing residences, so price appreciation at present is more a function of scarcity than lake quality. If new lots are opened up, the pent-up demand might be satisfied without further price appreciation.

Current market values of properties around the lake, including parcels up to two blocks from the water, total approximately $3.8 million, based on tax rate assessments. Of this $2.6 million is residential or commercial; the rest, agricultural. By comparison, total value of residential properties in Emmetsburg is nearly $9 million.

At Silver Lake, appreciation of lake-oriented properties appears to be substantial despite poor lake quality and relatively greater availability of lots. A local realtor reports approximately 17 lots are on the market at present and estimates 200 more, half of them on the waterfront, could be developed from remaining large landholdings. Still, he indicates parcels which sold three years ago for $3,000 are now selling for $7,000, pointing to a 33.0 percent average annual rate of price appreciation.

Market value of properties around the lake, including agricultural acreage, totals approximately $2.1 million, as derived from county assessor's rates. Within Lake Park's incorporated limits, total market value of residential properties is $6.8 million. Thus the lake is a significant contributor to local tax rolls, and in fact most new development in Lake Park centers in the south near the lake.

In view of the availability of lots and developable properties and the current high rate of value appreciation (equal to the rate at Lake Manawa), it is hard to conclude that the limited dredging considered in this study will affect property values substantially. No amount of dredging could improve Silver Lake to the level of Lake Okoboji, where waterfront values of $250 per front foot are seven to ten times the $25 to $35 range found at Silver Lake. And, on the other hand, property values have been increasing even in the absence of dredging. Again, it appears that dredging, if it prevents further significant declines in lake quality, will allow property values to continue their accustomed appreciation and permit the continued development of new lots.

BENEFITS VERSUS COSTS

Having previously established 1) forecasts of lake attendance with and without dredging; 2) approximate costs of dredging; and 3) dollar value of recreation use and attendance at the lakes, it is now possible to compare in monetary terms the costs and benefits of dredging. Table 43 shows dredging costs, average annual benefit values, and the number of benefit years required to recover costs. Average annual benefit values are shown for the 14-year period, 1977-1990 and for after 1990. Values shown for the first period are based on the average difference in attendance under dredge and no-dredge conditions between 1980 and 1990. Values shown for the period after 1990 assume that the 1990 difference will remain constant. As discussed previously in this section, the value of each recreation-day is estimated to be \$2.00 at each lake except for Manawa which is \$2.25.

It should be emphasized that annual benefits derived from dredging are defined as the difference between the recreation value assuming dredging and assuming no-dredging. This is as opposed to comparing the value if dredged with the existing value.

Since the benefits derived from dredging will extend for many years into the future, it is not feasible to compare a single cost of dredging with a single value of dredging. For this reason it is useful to consider the number of years which would be required to recover the dredging costs based on incremental benefit values derived from dredging. Years to recover, therefore, becomes one measure of dredging feasibility based on the standard of economic benefit/cost. As shown in Table 43, the years to recover vary from a maximum of 191.4 for Silver Lake to a minimum of 9.1 years at Manawa Lake.

CONCLUSION

It is beyond the authority and responsibility of the study team to determine whether or not the subject lakes should be dredged. Rather,

Table 43

COMPARISON OF BENEFITS AND COSTS OF DREDGING

Lake	Total Cost (thousands of dollars)	Average Annual Benefit (thousands of dollars) 1/ To 1990 2/	After 1990	Years Required to Recover Costs
Black Hawk	$9,901	$ 82.7	$1 100.0	101.4
Blue	745	25.4	32.6	25.9
Five Island	6,151	54.1	67.6	93.8
Manawa	8,724	964.0	1,508.9	9.1
Silver	6,986	30.3	37.0	191.4

1/ Assumes $2.00 per incremental recreation day for all lakes except Manawa which is calculated at $2.25 per recreation day. Benefit values are in constant dollars. It is assumed that increases in annual benefits are offset by the discount factor applying to future values.

2/ From 1977 through 1990 is 14 years.

Source: Economics Research Associates.

we have attempted to provide the Iowa General Assembly guidance in reaching a public policy decision regarding the future of the lakes. In this regard, the study team concluded that based on environmental and engineering considerations it would definitely not be in the public interest to dredge three of the lakes: Backbone, Mill Creek, and Rock Creek.

As shown above, in terms of economic cost/benefit analysis the merits of dredging vary dramatically for the five remaining lakes. For these lakes dredging programs were proposed and are feasible from an environmental and engineering standpoint. From an economic perspective it appears that Lake Manawa should definitely be dredged, providing sewer and nutrient problems are first resolved. The utility of dredging Blue Lake is marginal, given the substantial number of years (25.9) required to recover costs of a modest dredging program. The advisability of dredging Black Hawk, Five Island, or Silver is doubtful, since the number of years required to recover the costs probably exceeds the lives of the lakes.

However, in most public policy decisions of this nature, the benefit/cost analysis is only one element in the overall decision process, although an important one. For example, the state may decide that in order to provide sufficient water recreation resources in certain areas of the state, it may be justified in making an expenditure for dredging, even though the payback period is longer than conventional rules of thumb for recapture of capital expenditures would warrant. For instance, Lake Park's dependence on Silver Lake for its fresh water supply may be deemed by the State to be a compelling reason to dredge the lake, overriding strictly economic considerations.

SUMMARY

Table 44 offers a summary review in matrix form of specific dredging effects or considerations for each of the eight study lakes. This should assist the reader in bringing into perspective the various findings of this benefit-cost study. As shown in the table, each of the

Table 44

SUMMARY RATING OF DREDGING EFFECTS OR CONSIDERATIONS FOR THE EIGHT IOWA STUDY LAKES1/

	Category of Effect or Consideration	Lake							
		Backbone	Black Hawk	Blue	Five Island	Manawa	Mill Creek	Rock Creek	Silver
1.	Availability of Spoil Area	1	9	8	8	9	0	0	6
2.	Rate of Siltation	0	10	10	9	10	0	0	9
3.	Need for Shore Protection	0	3	8	1	4	0	0	6
4.	Recreational Quality Enhancement	0	7	4	5	9	0	0	5
5.	Impact on Property Values	0	7	1	3	10	0	0	3
6.	Regional Economic Impact	0	4	1	1	1	0	0	2
7.	Environmental Effects	0	6	1	5	10	0	0	5
	Rating Totals	0	46	33	32	53	0	0	36
	Total Dredging Costs (millions of dollars)	0	$9.9	$0.7	$6.2	$8.7	0	0	$7.0
	Years Required to Recover Costs	0	101.4	25.9	93.8	9.1	0	0	191.4

1/ Note: For each category of effect lakes are rated on a scale from 1 to 10 with 10 representing the maximum positive (or minimum negative) effect. A rating of 0 in Category 1-3 was considered so seriously low as to preclude the lake from subsequent rating or consideration as a dredging candidate.

Source: Engineering Consultants, Inc., and Economics Research Associates.

eight study lakes is rated on a scale of 1 to 10 for each of seven categories of dredging effects or considerations. A rating of 10 represents a maximum positive or minimum negative effect. For example, a rating of 9 for spoil area availability at Manawa indicates little or no problem in finding adequate area for spoil deposit within the proposed dredging program. A rating of 1 at Blue Lake for impact on property values indicates very little effect on property values at Blue Lake as a result of dredging. A rating of 0 indicates that the problem is so serious as to preclude a lake from further consideration as a candidate for dredging This, of course, was the case for Backbone, Mill Creek, and Rock Creek.

The rating totals for the lakes provide an index of the desirability of dredging the lakes, although cost of dredging and economic value of dredging have not been directly considered in this index. A high total rating for a lake suggests the relative desirability of dredging that lake. As shown in the table, Manawa achieves the highest index score (53), followed by Black Hawk (46). The remaining three lakes are relatively close behind in the following order: Silver (36), Blue (33), and Five Island (32). It should be pointed out that a maximum score would have been 70, a minimum score, 7. It is reasonable to conclude that on the basis of this index each of the five lakes surviving the critical tests scored fairly well.

Following the rating totals, the table shows estimated total dredging costs (including associated off-lake costs and shoreline protection costs as well as dredging costs) based on the dredging programs proposed in Section III. With the exception of Blue Lake for which dredging costs are only \$745, 000, costs range from \$6. 2 million at Five Island to \$9. 9 million at Black Hawk.

The years required to recover costs based on economic recreation benefits from dredging, as discussed previously, are reiterated on the last line of the table. It is interesting to compare the rating totals, which are essentially non-economic indicators of dredging desirability, with the "years to recover" figures, which represent the economic (benefit/cost) measure of dredging desirability. Only in the case of Lake Manawa do we find a high non-economic incentive to dredge as well as a strong economic motivation. Manawa achieved the highest total rating (53) and also required the fewest years (9. 1) to recover dredging costs from recreation benefit values generated. Black Hawk, on the other hand, achieved the second highest total rating (46) and yet required 101. 4 years to recover dredging costs. The explanation for this apparent anomaly lies in the fact that while environmentally dredging is very desirable at Black Hawk the strong impact of competition from new reservoirs will severely reduce the attendance potentials for the lake in the important Zone 3 whether or not the lake is dredged. Also in conflict is Blue Lake which achieved a total rating of only 33 (second lowest) yet which required 25. 9 years to recover dredging costs. The explanation here is mainly that the rather modest dredging program proposed for Blue Lake requires a total expenditure of only $745, 000.

Appendix A

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Appendix B

QUESTIONNAIRE

The Iowa Conservation Commission is evaluating the potential benefits and costs which would result from dredging various lakes in the state. This lake is one of those lakes being evaluated. We would sincerely appreciate your taking a few moments at this time to answer the following questions.

1. Location of Residence:

   a.________________(state)

   b.________________(city)

   c.________________(foreign country)

2. Age of Respondent:

   a.____12-18 d.____37-50

   b.____19-26 e.____51-65

   c.____27-36 f.____over 65

3. How many times do you visit this lake annually?

   a.________________(number of times)

   b.________________(This is our first visit to the lake).

4. How long do you usually stay at this lake?

   a.________________Hours OR ________________Days

5. How far do you drive to visit this lake?

   a.________________Miles

6. Which of the following activities do you engage in during your visits to this lake? (Please check all appropriate activities).

a._____Fishing	h._____Camping	o._____Sled Coasting
b._____Fowl Hunting	i._____Picnicking	p._____Ice Boating
c._____Game Hunting	j._____Hiking	q._____Nature walks and passive enjoyment of the outdoors
d._____Swimming	k._____Bird Watching	r._____Other (specify)
e._____Water Skiing	l._____Snowmobiling	
f._____Motor Boating	m._____Ice Skating	
g._____Sailing	n._____Ice Fishing	

7. Please rank in order of their importance to you (from 1 to 3) the following activities. Also, in the adjacent box indicate the number of hours you devoted to each of those activities during a typical day at the lake.

Rating	Hours							
a.____	☐	Fishing	h.____	☐	Camping	o.____	☐	Sled Coasting
b.____	☐	Fowl Hunting	i.____	☐	Picnicking	p.____	☐	Ice Boating
c.____	☐	Game Hunting	j.____	☐	Hiking	q.____	☐	Nature walks and passive enjoyment of the outdoors
d.____	☐	Swimming	k.____	☐	Bird Watching			
e.____	☐	Water Skiing	l.____	☐	Snowmobiling	r.____	☐	Other (specify)
f.____	☐	Motor Boating	m.____	☐	Ice Skating			
g.____	☐	Sailing	n.____	☐	Ice Fishing			

8. Assuming that this lake were to be partially dredged, the quality of some recreation activities might be improved; some might be unchanged; and some could be negatively affected. For instance, if the lake were deepened about 2-4 feet in certain spots, fishing and swimming could be improved. On the other hand, if marshes were dredged or spoils deposited in marshes, waterfowl hunting might be negatively affected.

   What effect do you believe this partial dredging might have upon your enjoyment and utilization of the lake?

   a.________ Positive b.________ Negative c.________ No effect

9. If this lake were deepened in places as described above, what (if any) additional activities would you expect to enjoy? (If none, write none.)

a.____________ c.____________ e.____________

b.____________ d.____________ f.____________

10. Would selective dredging of the lake likely cause you to stay longer at the lake?

a.________Yes b.________No

11. Would selective dredging of the lake likely cause you to increase the frequency of your visits?

a.________Yes b.________No

12. What, if any facilities do you believe should be added at the lake?

a.____________ c.____________ e.____________

b.____________ d.____________ f.____________

Thank you!

Car Number:________________