Executive Summary

BLACK HAWK LAKE/HALLETT PITS FEASIBILITY STUDY

February 15, 1979

Iowa Conservation Commission

PREFACE

The following executive summary is presented to comply with the stipulations in Phases I, II, III, IV of the BLACK HAWK LAKE/HALLETT PITS FEASIBLITY STUDY which was prepared by the consultant, Hoskins - Western-Sonderegger, Inc. of Lincoln, Nebraska for the Iowa Conservation Commission.

The conclusion of this study is the specific project recommendation of the Iowa Conservation Commission. The consultant assists the Commission in selecting the most desirable option under Phase V of the study. Further project findings, as directed by the Commission, appear as separate documents.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

I. DEFINING PUBLIC ACCESS

The definition of public access precedes the discussion of Hydrologic Feasibility. The two items are very closely related, and both are centered around the physical ability to make the connection between the natural lake and the gravel pits.

Assuming the connection of the West (privately owned) Hallett Pits to Black Hawk Lake can be made, the purposes of the study are to:

1) Define possible routes of connection.

2) Determine additional public recreation benefits resulting from the project.

3) Consider possible private development opportunities that would arise from the project.

4) Discuss probable operation and maintenance factors.

The study will not attempt to:

1) Evaluate the rehabilitation or improvement of Black Hawk Lake.

2) Consider raising the level on Black Hawk Lake (by adjusting the weir).

3) Solve any water level problems on Black Hawk Lake relating to variable precipitation.

4) Solve disputes over water well development in the area.

The study is conducted to objectively develop information on project feasibility for the Iowa Conservation Commission and to coordinate both public and private interests during the study phases of the project.

Basically, the study considers connecting the privately owned West Hallett Pits with Black Hawk Lake by means of a navigation canal. Large sections of the canal would have to be excavated in order to provide the connection, since the present inlet channel is too shallow and other routes have few existing water bodies within their boundaries. Residential and recreational development around the West Hallett Pit would be an acknowledged end result of the connection project.

Route of Connection Assumptions

The connection corridor would logically follow the hydrologic connection through the ancient alluvial terraces to:

1) Keep most of the activity on state owned lands.
2) Take advantage of the excavated gravel pits already in existence.
3) Recover sand and gravel material within the corridor where possible.
4) Take advantage of the shortest distance between the larger water bodies.

Four possible routes have been studied at the request of the Iowa Conservation Commission. Route A generally parallels the Chicago - Northwestern Railroad, Route "B" follows a previously excavated canal through the central swampy areas, Route "C" follows the present inlet channel, and Route "D" passes through the Arrowhead Lakes (see Figure I-A). Each route is evaluated on the extent and magnitude of local impact, cost, the potential for possible cost recovery through the availability of commercial gravel deposits, and estimated future operations and maintenance costs. This information is found in Part IV of the report.

Public Recreation Additions

A few preconditions have to be described before a discussion of public benefits attributable to the connection can begin. First, the assumption is made that all residential development would occur around the privately-owned West Hallett Pits. Three areas of recreational deficiencies were noted in the preliminary 1978 Iowa State Comprehensive Outdoor Recreation Plan (SCORP) for Recreational Planning Region V. (See Figure 1-B) They were camping, environmental swimming, and pleasure boating. According to the Iowa Conservation Commission, their analysis of the immediate Black Hawk Lake Area discloses that the present camping facilities are not over crowded and are not projected to be overcrowded in the near future. The same is true for swimming facilities. If these types of facilities were to be built in the Hallett Pits Complex, their benefits would not be directly attributable to the lake-pits connection project. They could be built whether the connection was made or not. Any swimming or camping facilities justification would not result directly from the channel connection, but through the normal Black Hawk Lake Area master planning process. Because of the hydrologic connection of groundwater and surface water, no recreational facilities development should occur until waste water collection and treatment are provided.

Some recreation use is made of the Pits as they now exist. The connection would provide better access to the Pits, but would not increase the fisheries potential in the area. In fact, under normal conditions, Black Hawk Lake would be able to produce on the magnitude of three times as much fish poundage per acre of water as the Pits. Thus, public fishing benefits would be roughly one-third as much in

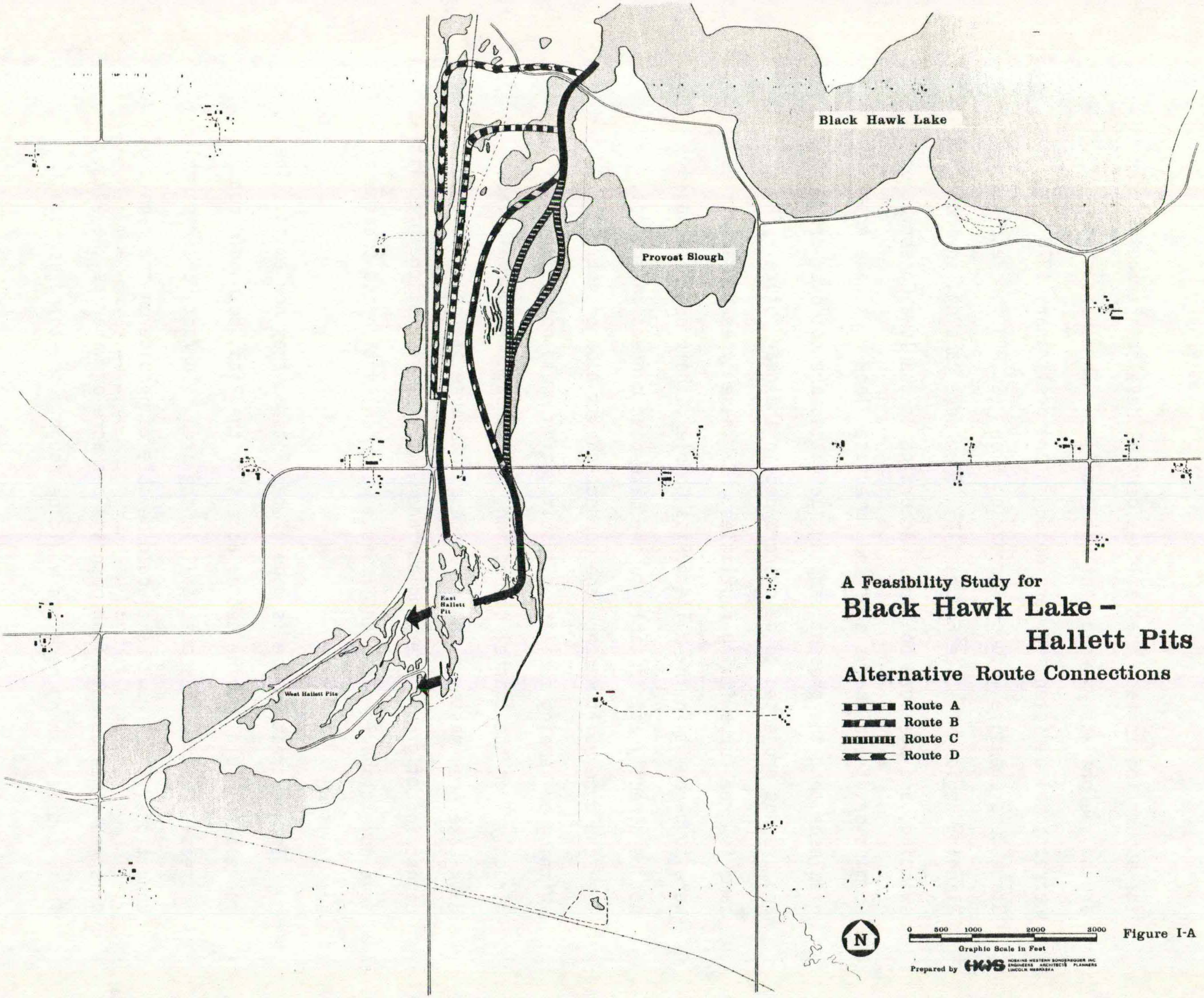

Black Hawk Lake
Provost Slough
East Hallett Pit
West Hallett Pits
A Feasibility Study for
Black Hawk Lake -
Hallett Pits
Alternative Route Connections
Route A
Route B
Route C
Route D
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by

Figure I-A

the Pits complex on an area basis.

For planning purposes, the East Hallett Pits Complex (state-owned) would not be developed as a recreation facility because of the potential conflict with wildlife habitat and present management practices. The approximate twelve acre tract adjacent to the county road in the northeast corner of the West Hallett Pits would be suitable for camping and swimming facilities at some future date when such facilities are justified.

The total water surface area in the East Hallett Pits Complex is 33 acres. Using SCORP design criteria, which converts water area to monetary benefits, and fisheries productivity information supplied by the local Iowa Conservation Commission biologist, a maximum of 1100 annual fishing visitations could result if proper access is afforded.* Present counts indicate about 300 annual visitations are already experienced. Thus, the project would net a maximum increase of 800 annual fishing visitations due to better access to the area.

Alternative Routes "A" and "D" would involve only 23 surface water acres of the East Hallett Pits Complex; thus, a total of 800 recreation days of fishing would result from the project.* After subtracting the existing 300 days, the net result would be 500 recreation days.

Pleasure boating is not considered for benefit calculation on the East Hallett Pit Complex due to the small size of the lake requirement to maintain a 300-foot restricted zone adjacent to the shore for boat fishing only. However, the increased surface area of the connection channel would result in approximately 300 additional boating recreation

*Based on a peak daily design of 2.0 water acres/Fishing party X 2.5 people/Party X 1.5 daily turnover rate X 25 peak days per season ÷ .45 (ratio of peak days to total days) ÷ 3 (comparable fishing potential factor)

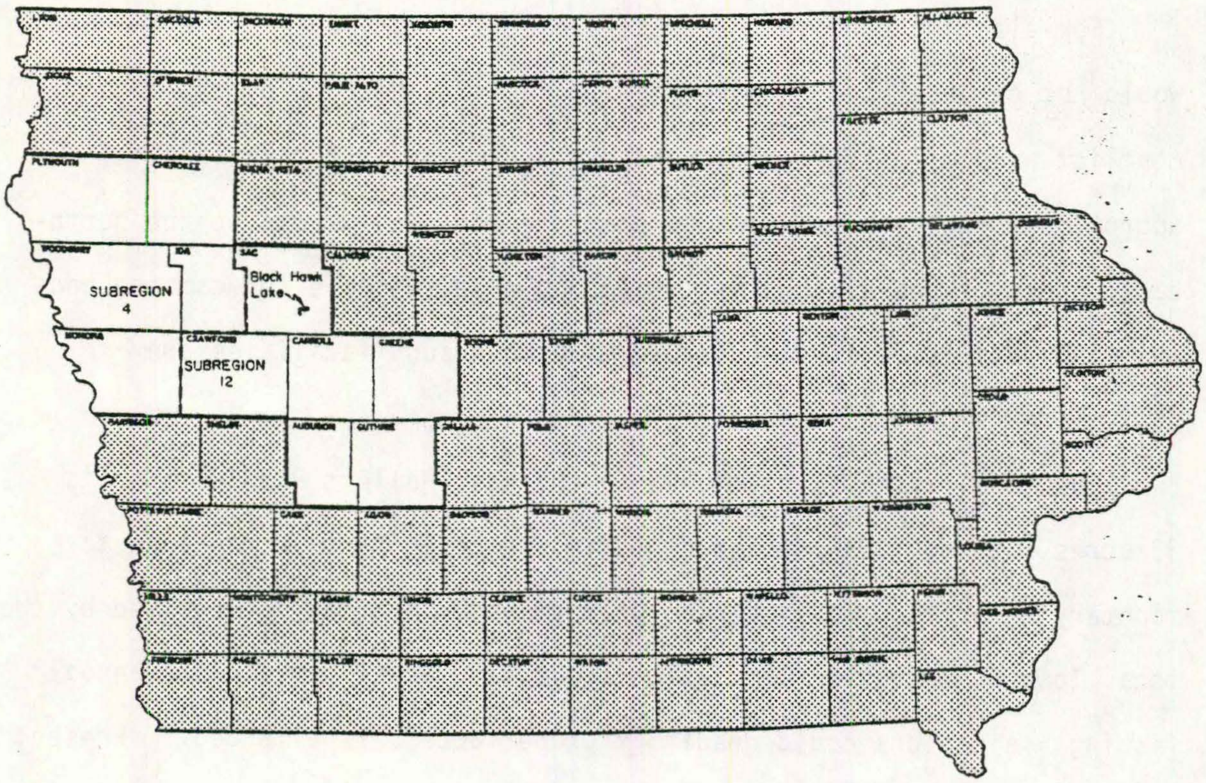


Figure I-B
RECREATION PLANNING REGION V

days annually.**

Present annual Black Hawk Lake recreation attendance figures reflect a direct relationship between the lake level and recreational visitations. Comparing the 1960 through 1973 annual attendance figures with the lake levels in Figure IIB this relationship is evident.

During the 1960 to 1973 attendance period, 3,933,700 visitations were recorded. Annual attendance ranged from 132,719 in 1961 to 372,480 in 1968 with an average annual figure of 281,000. Thus, the additional estimated project visitations resulting from project activities would be approximately 2.7 percent of the annual average lake visits.

**Based on a peak daily design of 8.5 water acres/Boating party X 2.5 people/ Party X 1.5 daily turnover rate X 25 peak days per season ÷ .45 (ratio of peak days to total days)

Private Development Opportunities

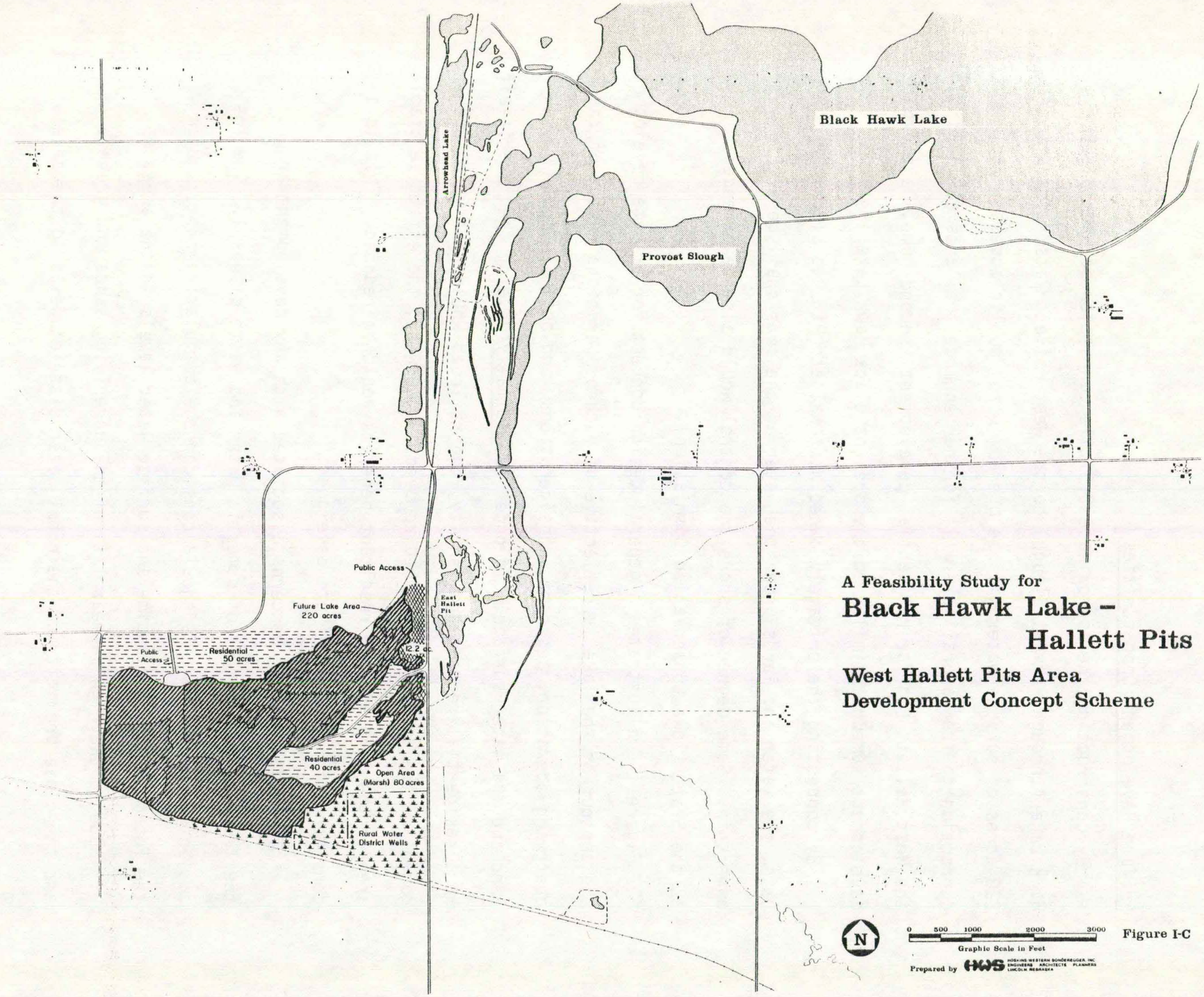
By constructing the approximate 2.3 mile connection between Black Hawk Lake (through Provost Slough) to the West Hallett Pits, approximately 220 acres of surface water will be opened up for public access. The connection to the natural lake will further enhance the lands surrounding the West Hallett Pit for residential development (second home, lake front development somewhat similar to the present Black Hawk Lake area).

By connecting the privately owned West Hallett Pits to Black Hawk Lake, the water and lands under the water of the pits shall be in State ownership. Some degree of shoreline control would also be extended to the State (Iowa Conservation Commission).

Figure I-C illustrates a general design concept for private development. The contour of the lake is reflective of future operational needs of the quarrying operation, aesthetic considerations, and optimal use of shoreland and the water surface. In order to optimally develop the lake itself as a residential/recreational entity, the railroad would have to be abandoned and the tracts and roadbed removed. Otherwise, the effective usable area of the lake and the resultant benefits would be reduced. This is a consideration for the private developer.

The most pressing concerns associated with any development around the lake are the sources of domestic water and waste disposal. The location of any water wells should consider the cummulative impacts upon the local groundwater regime and surface water levels in the area.

Due to the high permeability of the underlying sands and gravels and the close proximity of the rural water district wells to the development



A Feasibility Study for

Black Hawk Lake - Hallett Pits

West Hallett Pits Area Development Concept Scheme

Figure I-C

area, private septic tank systems would undoubtedly be unacceptable from a public health and environmental viewpoint. The nearest public disposal system is south of Wall Lake, 8000 feet to the west of the Hallett property.

Using the 300-foot shore buffer zone, 112 water acres would be allocated for potential no-wake boating benefit calculations, and 106 acres would be used for fishing benefit calculations. About 11,700 feet of shoreline also will be opened up for private fishing benefits. The West Pit is not large enough to effectively allow water skiing and large engined power boating. At least ten acres should be used for public access to the lake. Using the design criteria shown previously, the connection would support nearly 6,400 annual recreation visits in the form of pleasure boating and fishing to this area.

The projected annual recreation visitations resulting from all phases of the project are shown on the Table I-1.

Table I-1
ANNUAL RECREATION VISITATION SUMMARY

Recreation	Alternatives "A" & "D"	Alternatives "B" & "C"
Fishing (East Hallett)	500 *	800 *
Boating (East Hallett)	300 **	300 **
Subtotal - East Hallett	800	1100
Fishing (West Hallett)	3700 *	3700 *
Boating (West Hallett)	2700 **	2700 **
Subtotal - West Hallett	6400	6400
Total Directly Attributable to Project	7200	7500

*Based on a peak daily design of 2.0 water acres/fishing party X 2.5 people/party X 1.5 daily turnover rate X 25 peak days per season ÷ .45 (ratio of peak days to total days) ÷ 3 (comparable fishing potential factor)

**Based on a peak daily design of 8.5 water acres/boating party X 2.5 people/party X 1.5 daily turnover rate X 25 peak days per season ÷ .45 (ratio of peak days to total days)

Operations and Maintenance Considerations

Provost Slough which generally serves as a sediment catchment basin for Black Hawk Lake must also be dredged periodically with costs estimated to range from $6,000 to $14,500 annually depending on which route was chosen. (From a sliding scale based on $1.25 per cubic yard removed with a 400,000 cubic yard minimum and $0.05 additional for every 10,000 cubic yards under 400,000).

Some bank scour and sluffing can be expected along the boat canals, even with "no-wake" speed limitations. The use of bank vegetation, special bank grading techniques, and brush mats can minimize these problems. Average annual costs are estimated to range from $100 to $200 for streambank operations and maintenance.

Public operations and maintenance costs are estimated to be from $3,600 to $3,700 annually for the West Hallett public access and water bodies in both the East and West Hallett Complexes. These figures are based upon the additional annual recreation visitations generated by the project.

Fisheries management at Black Hawk Lake is attempting to control winter fish kill by aeration techniques. Fish stocking is programmed for the fall 1979. To do this, the present surviving species, mainly small rough fish, must be eliminated by chemical poisoning. If West Hallett Pits were connected to Black Hawk Lake prior to the fish kill program being completed, the cost of this program would be increased substantially.

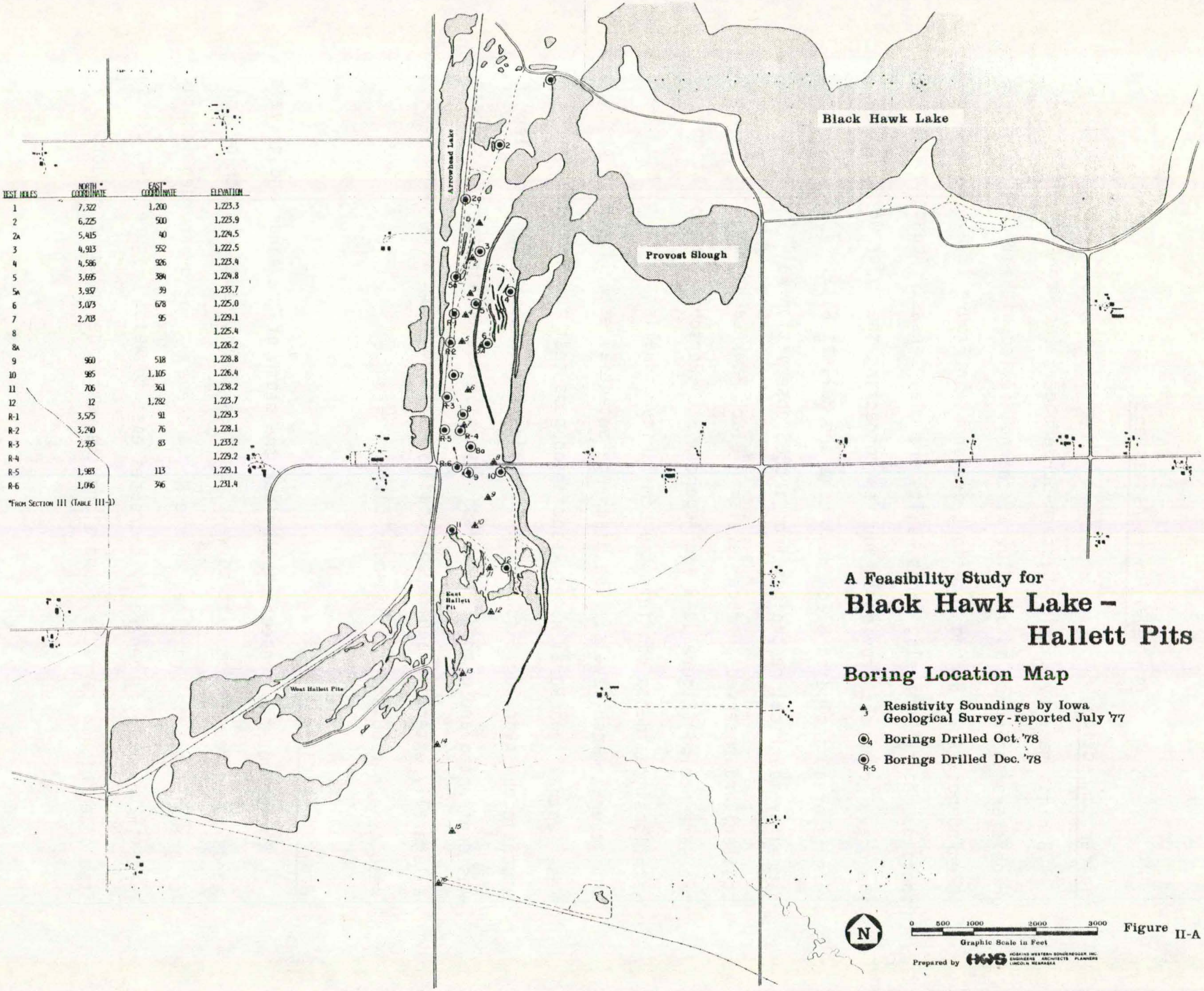
II. Hydrologic Assessment

Aquifer Connection

Borings made by Hoskins-Western-Sonderegger, Inc. confirm the topographic expression of an old fluvial channel filled with glacial outwash (See Appendix A). Boring locations are shown in Figure II-A. The outwash contains channel gravels, sands, silts and clay lenses. Abundant sand and gravel channels provide an aquifer connecting the major water bodies in this area, including Black Hawk Lake and Hallett Pits. This is confirmed by identical recordings from a USGS observation well (in the aquifer) and observed surface levels in Black Hawk Lake, measured during the same period (Figure II-B and Appendix B). Personal communication with local residents confirms the similarity of Hallett Pits to the Lake and general marsh levels. The discharge potential established in the West Central Iowa Rural Water Association pump test further supports a continuous hydrologic connection. During 24 hours, no major barrier was confronted and a good transmissivity value was obtained which suggests a laterally extensive aquifer of good hydraulic conductivity (pump test results are tabulated in Appendix C).

Aquifer Characteristics

Throughout the connection corridor the depth of the sands and gravels tends to increase from east to west, as does the percentage distribution of gravel (material retained on the No. 4 sieve). The overburden (depth of silts and clays) generally decreases east to west. Figure II-C plots the older/higher terraces found along the west side of the corridor.



TEST HOLES	NORTH* COORDINATE	EAST* COORDINATE	ELEVATION
1	7,322	1,200	1,223.3
2	6,225	500	1,223.9
2A	5,415	40	1,224.5
3	4,913	552	1,222.5
4	4,586	926	1,223.4
5	3,695	384	1,224.8
5A	3,937	39	1,233.7
6	3,073	678	1,225.0
7	2,703	95	1,229.1
8			1,225.4
8A			1,226.2
9	960	518	1,228.8
10	985	1,105	1,226.4
11	706	361	1,238.2
12	12	1,282	1,223.7
R-1	3,575	91	1,229.3
R-2	3,240	76	1,228.1
R-3	2,395	83	1,233.2
R-4			1,229.2
R-5	1,983	113	1,229.1
R-6	1,046	346	1,231.4

*From Section III (Table III-1)

A Feasibility Study for

Black Hawk Lake – Hallett Pits

Boring Location Map

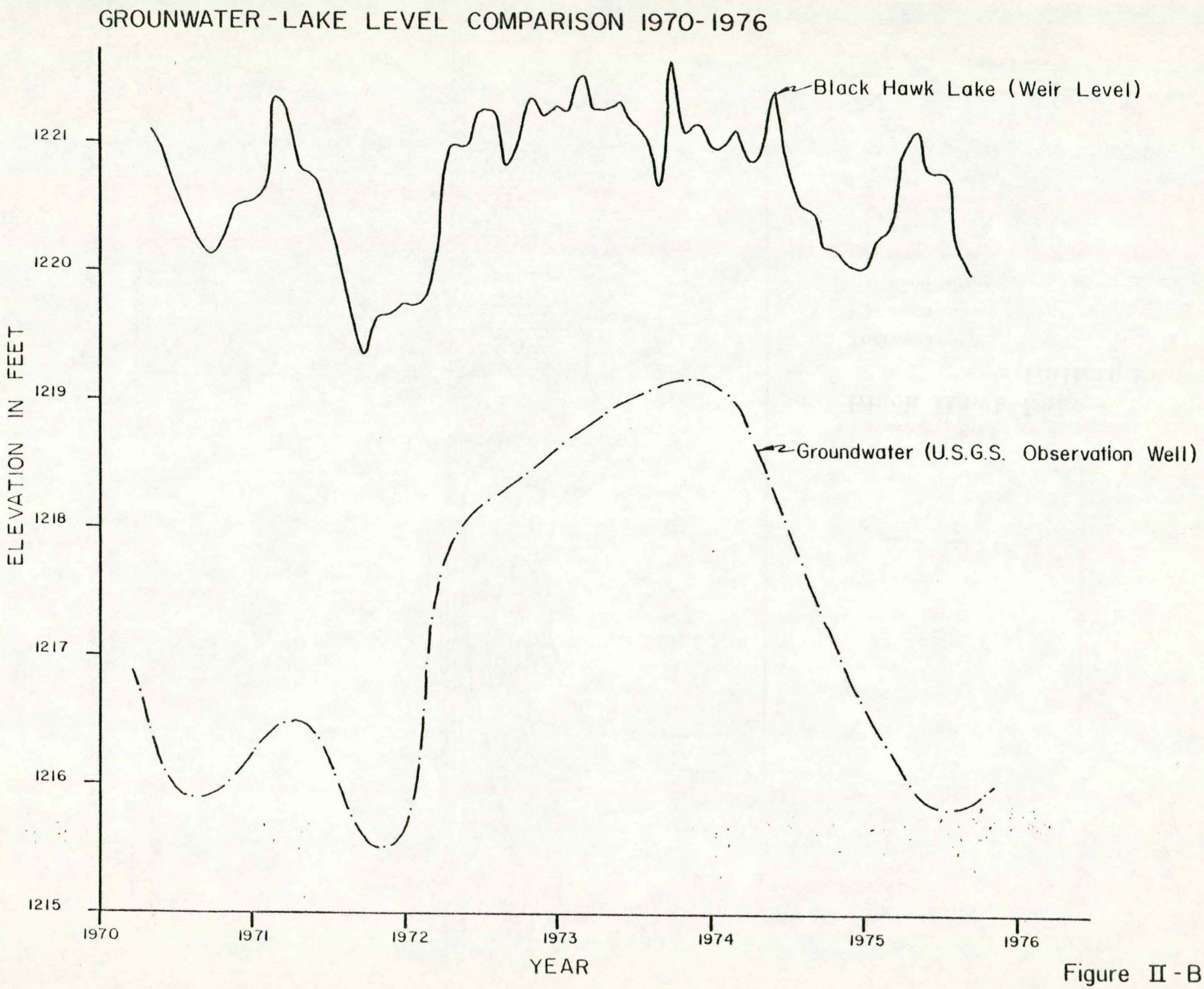
- ▲3 Resistivity Soundings by Iowa Geological Survey - reported July '77
- ◉4 Borings Drilled Oct. '78
- ◉R-5 Borings Drilled Dec. '78

N

0 500 1000 2000 3000
Graphic Scale in Feet

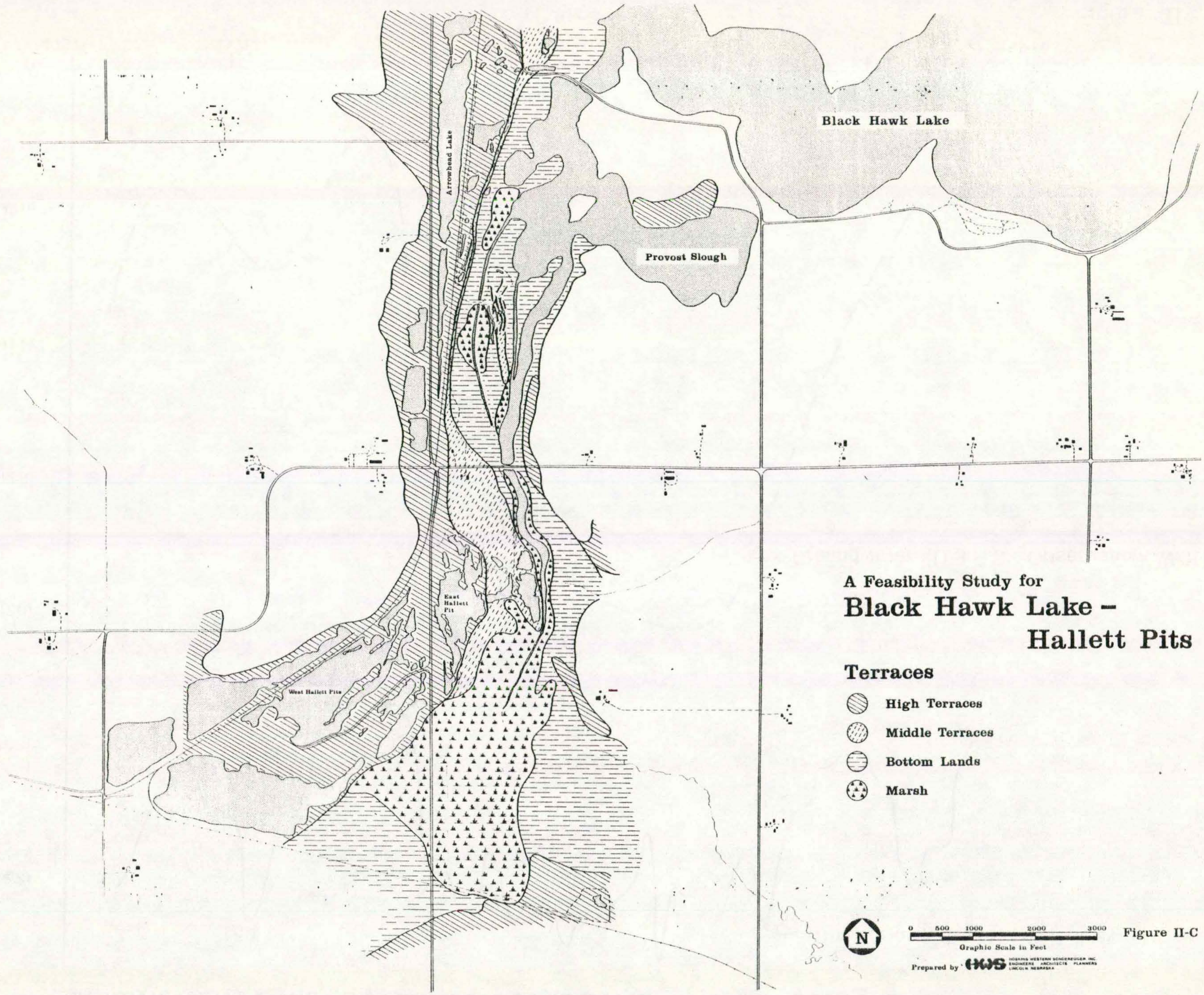
Figure II-A

Prepared by HWS Hoskins Western Sonderegger Inc. Engineers Architects Planners Lincoln Nebraska



GROUNWATER - LAKE LEVEL COMPARISON 1970-1976
Black Hawk Lake (Weir Level)
Groundwater (U.S.G.S. Observation Well)
ELEVATION IN FEET
1221
1220
1219
1218
1217
1216
1215
1970
1971
1972
1973
1974
1975
1976
YEAR

Figure II - B

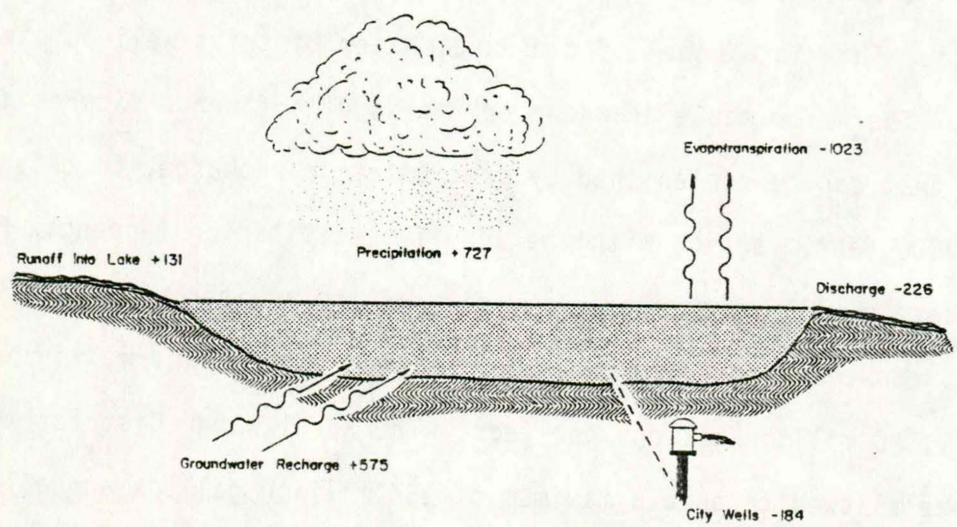

Black Hawk Lake
Provost Slough
Arrowhead Lake
East Hallett Pit
West Hallett Pits
A Feasibility Study for
Black Hawk Lake -
Hallett Pits
Terraces
High Terraces
Middle Terraces
Bottom Lands
Marsh
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by HWS
Figure II-C

Under these terraces are found the better gravel deposits with greater thicknesses.

The sand and gravel depths vary greatly, pinching out to only a few feet in depth between borings 5a, R-1 to R-6 and 11 (Figure II-A). The marshes in the central portion of the corridor are probably all that is left of the ancient river channel; overburden there will range up to ten feet in depth.

Water test well logs and HWS, Inc. borings show a similarity in the sand and gravel material throughout the corridor between Black Hawk Lake and Hallett Pits. Total transmissivity (the amount of water able to pass through a material) of all underlying material is calculated to be 66,570 gallons per day (gpd) in the Rural Water District water well pump test. Assuming the average depth of the aquifer is fifty feet, the permeability of the aquifer would be 1,300 gpd per square foot.

Black Hawk Lake Water Budget (Figure II-D)



WATER BUDGET in millions of gallons per year

Figure II-D

Black Hawk Lake receives water from surface runoff (RO) from the drainage basin at a rate of 388 million gallons per year (MG/yr.), precipitation directly on the Lake at a rate of 727 MG/yr., and by groundwater discharge at an estimated rate of 427 MG/yr. Water leaves the lake area by evapotranspiration at a rate of 1,020 MG/yr., city and local well discharge estimated at 296 MG/yr., and discharge over the weir at a rate of 226 MG/yr. (See Appendix D.)

Appendix D outlines a general basin water budget. Most of the basin's water infiltrates into the aquifer supplying the gravel pits and Black Hawk Lake. The average difference between the West Hallett Pits and Black Hawk Lake levels is 2.3 feet. Heavy withdrawals in one would soon be noticed in all the other water bodies. Likewise, changes in rainfall will affect the water table and, therefore, all lake levels. During dry years there will be drops in both Hallett Pits and Black Hawk Lake levels.

Appendix E outlines the effect on the groundwater of a continuously pumping well. This is a model of the Rural Water District well pumping at 358 gpm. The water table drawdown or radius of influence extends to a distance that can be replenished by precipitation recharge, in this case, 3,000 to 4,000 feet, varying with the annual precipitation (Appendix F.).

Increases in well discharge in any part of the aquifer will affect the lake level. However, only large discharges need cause concern, in the order of 500 to 1,000 million gallons per year. The Rural Water District wells together are allowed to pump a maximum of 188 million gallons annually.

TABLE II - 1

BLACK HAWK LAKE WEIR ANNUAL DISCHARGE SUMMARY

Year	Discharge
1970 - 71	107 MG
1971 - 72	176 MG
1972 - 73	458 MG
1973 - 74	333 MG
1974 - 75	54 MG
Total	1,128 MG

General Implications of Connecting Black Hawk Lake to the Hallett Pits

A canal connecting Hallett Pits and Black Hawk Lake would produce a single large lake. Initially, a two foot difference in elevation due to relative position in the drainage basin would produce a flow raising Black Hawk Lake about 0.1 ft. Water levels in the pits will drop a proportional amount. Subsequently, the level would reach a steady state fluctuating in response to the climate much as it does now. This would amount to a flow on the order of 0.2 cubic feet per second flow through the connection with a 2.3 foot elevation difference.

Pump discharge from the Rural Water District wells would amount to halving the difference in water elevations between the pits and the Lake. Thus, the 0.1 foot rise in Black Hawk Lake level would be even less by considering this aspect.

It must be emphasized that the connection will not cause a significant loss of groundwater. Presently a large portion of Black Hawk Lake's water budget is made up of groundwater. During wet years, some groundwater discharge will flow over the weir. However, during dry years the water will be retained in the Lake.

Based on the subsurface data, the following assumptions can be made:

1. Groundwater levels will not be significantly affected by physically connecting the West Hallett Pits to Black Hawk Lake.

2. Maximum permitted water withdrawal from wells in the immediate vicinity of the Hallett Pits and the State-owned marsh could lower the pit water levels (local groundwater elevations) as much as 0.7 feet (assuming no recharge from surface runoff). This will have the effect of lowering the hydrologic gradient between the two bodies of water, but should not materially affect the physical feasibility of the project.
3. The connection will have a very minimal effect on the Black Hawk Lake levels.
4. The concept of connecting the West Hallett Pits with Black Hawk Lake is feasible from a hydrologic standpoint under currently permitted maximum water well production rates.

III. LAND SURVEYING

Originally provisions for aerial photogrammetry were a part of the Black Hawk/Hallett Pits Feasibility Study. However, climatic conditions during the late fall of 1978 made it impossible to take aerial photographs suitable for topographic mapping.

The project need was subsequently amended to delete the aerial photography and included additional land surveying and test hole drilling. This information proved invaluable to the complete hydrologic and economic feasibility analysis. The additional test hole logs (R-1 through R-6) summaries are found in Appendix B and displayed by Figure II - A.

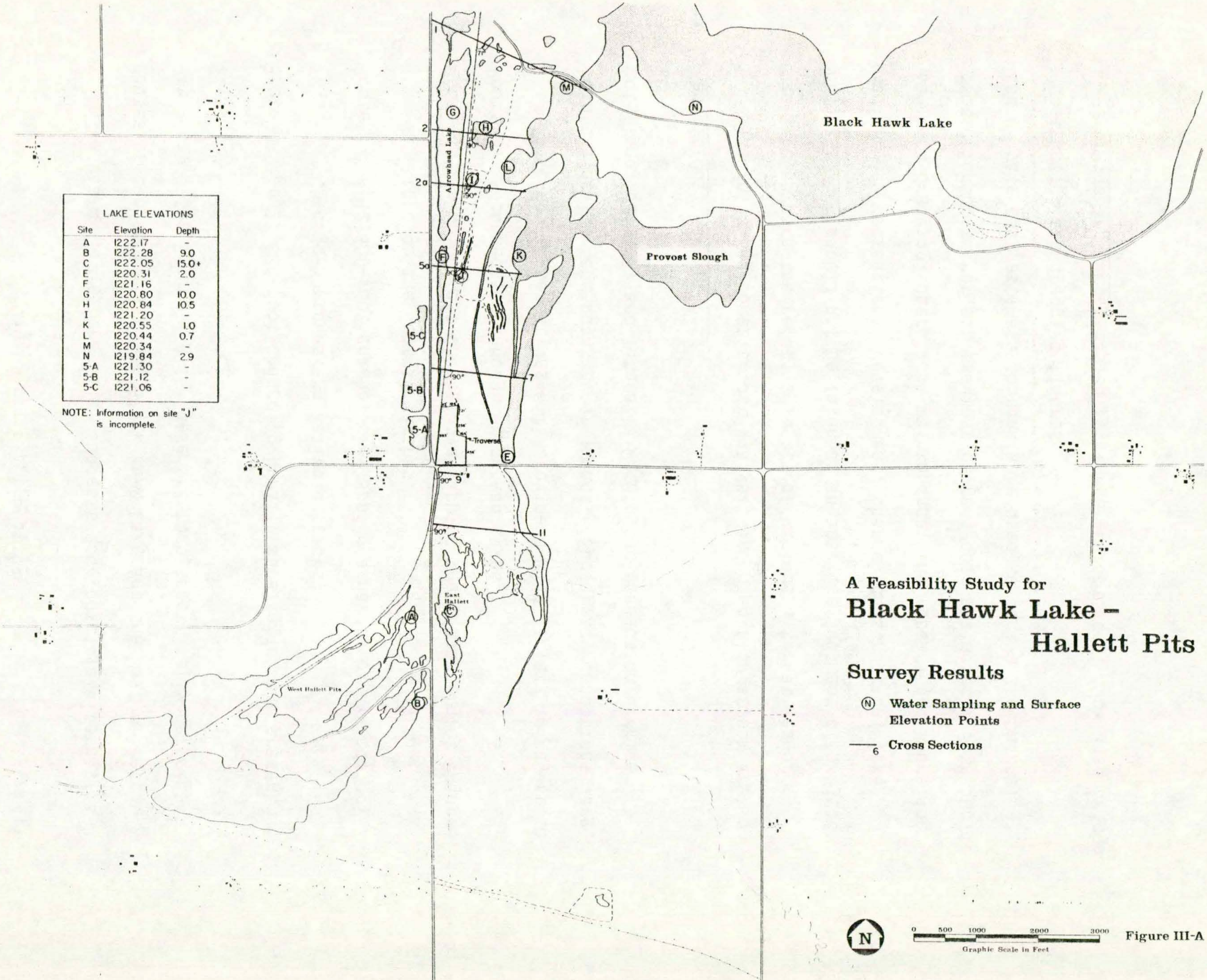
Additional land surveying determined all test hole and water elevations, which was essential for the hydrologic and environmental analysis. Water elevations taken at numerous sites are displayed in Figure III - A. The surveyed cross-sections also noted in Figure III - A document the extent of quarry operations in the corridor and were useful in the formation of the economic conclusions. Table III - 1 shows the coordinate adjustment notes.

From the surveyor's notes, a 2.3 foot water level variation was evident from Black Hawk Lake to the West Hallett Pit Complex.

TABLE III-1
COORDINATE ADJUSTMENT NOTES

@	Line	Angle	Bearing	District	+ - N/S	+ - E/W
℄ RR/Road	A B	R 84°34'30"	N 84°34'30" E	504'	+ 47.65	+ 501.74
8b	B C	R 93°51'30"	N 1°34'00" W	456'	+455.83	- 12.47
8a	C D	R103°43'30"	N 77°50'30" W	164'	+ 34.54	- 160.32
8c	D E	L104°57'30"	N 2°48'00" W	256'	+255.69	- 12.51
8	E F	R184°34'00"	N 1°46'00" E	221'	+220.89	+ 6.81
R-4	F G	R 79°25'00"	S 81°11'00" W	194'	- 29.74	- 191.71
R-5	G H	L171°02'30"	N 89°51'30" W	113'	+ .28	- 113.00
℄ RR	H A	R 90°00'00"	S 0° 8'30" W	983'	-983.00	- 2.43
				2891	+1014.88	+ 508.55
					-1012.74	- 492.44
				1908	+ 2.14	+ 16.11

	Correction N/S	Correction E/W	+ - N/S	+ - E/W	Adjusted Coordinates North	Adjusted Coordinates East	
AB	- .57	-4.90	+ 47.08	+496.84	A 1,000.00	1,000.00	℄ RR/Road
BC	- .51	-4.43	+455.32	- 16.90	B 1,047.1	1,496.8	8b
CD	- .18	-1.59	+ 34.36	-161.91	C 1,502.4	1,479.9	8a
DE	- .29	-2.49	+255.40	- 15.00	D 1,536.8	1,318.0	8c
EF	- .25	-2.15	+220.64	+ 4.66	E 1,792.2	1,303.0	8
FG	- .22	-1.89	- 29.96	-193.60	F 2,012.8	1,307.7	R-4
GH	- .13	-1.09	+ .15	-114.09	G 1,982.8	1,114.1	R-5
HA	.00	.00	-983.00	- .00	H 1,983.0	1,000.0	℄ RR
	-2.15	-16.11	+1012.95	+501.50	A 1,000.0	1,000.0	
		- 2.43	-1012.96	-501.50			
		18.54	+ .01	+ .00			



LAKE ELEVATIONS

Site	Elevation	Depth
A	1222.17	-
B	1222.28	9.0
C	1222.05	15.0+
E	1220.31	2.0
F	1221.16	-
G	1220.80	10.0
H	1220.84	10.5
I	1221.20	-
K	1220.55	1.0
L	1220.44	0.7
M	1220.34	-
N	1219.84	2.9
5-A	1221.30	-
5-B	1221.12	-
5-C	1221.06	-

NOTE: Information on site "J" is incomplete.

A Feasibility Study for

Black Hawk Lake - Hallett Pits

Survey Results

Ⓝ Water Sampling and Surface Elevation Points

—6 Cross Sections

Figure III-A

IV. DEFINE ALTERNATIVES

The basic "lay of the land" suggests four possible alternative routes of connection between Black Hawk Lake and the West Hallett Pit Area. (See Figure I-A). These are more specifically defined as follows:

Route A An 11,920-foot channel generally paralleling the present Chicago-Northwestern Railroad tracks.

Route B A 12,600-foot channel overlapping a narrow canal looping through the Central marshes.

Route C A 12,300-foot channel overlapping the present Inlet Channel.

Route D A connection through Arrowhead Lakes.

These four alternatives will provide a wide variety in regard to both the quality and quantity of impact. Subsurface conditions vary both longitudinally and laterally within the connection corridor.

Benefit/Cost Assumptions.

The following benefit/cost analysis and cash flow stream are tools to compare the relative merits of various alternatives or projects, but should not be taken as an absolute judgment of project merit. Any recreational development, channel construction, lake sediment dredging, operation, maintenance, and repair, and shoreline protection costs reflect the most current cost estimates. Both public and private cost estimate sources were used to derive the channel construction and dredging figures.

Bridge and land. Basically, three 40-foot long, two-laned bridges would be required, each with a minimum, six-foot clearance under the bridge.

Sac County is presently programming the resurfacing of the east-west county road crossing the Inlet. The in-place bridge would possibly need to be upgraded. Work is programmed for the next two to three years. If the Lake-Pit connection is to be made, this should be coordinated with other associated public works project to save on total public expenditures.

Whether the county road over the Inlet Channel is to be built to the navigation standards or not would depend on which alternative route is chosen. If either alternatives "A" or "D" are selected, then a new bridge would be required within ninety feet of the present railroad grade. This will not affect the present grade since the water level is at least seven feet below the present ground level.

Depending on which alternative route is selected, anywhere from 4.1 to 210 acres of private land will be acquired. Alternative routes "B" and "C" need greater amounts of land because a substantial portion of the Inlet Channel and Provost Slough is privately owned. Care was taken not to create inaccessible remainders and to leave a "buffer" strip between the recreational/wildlife land and the adjacent, intensive row crop agricultural uses. Figure IV - A identifies each new bridge location and additional land requirements. Figure IV-B identifies the properties affected.

A portion of the 4.1-acre tract which would be needed for either alternative routes "A" or "D" could be used as a spoil pile. However, the project cost estimates include trucking the dredge material from the site to assure that environmental damages would be minimal. The 4.1 acre

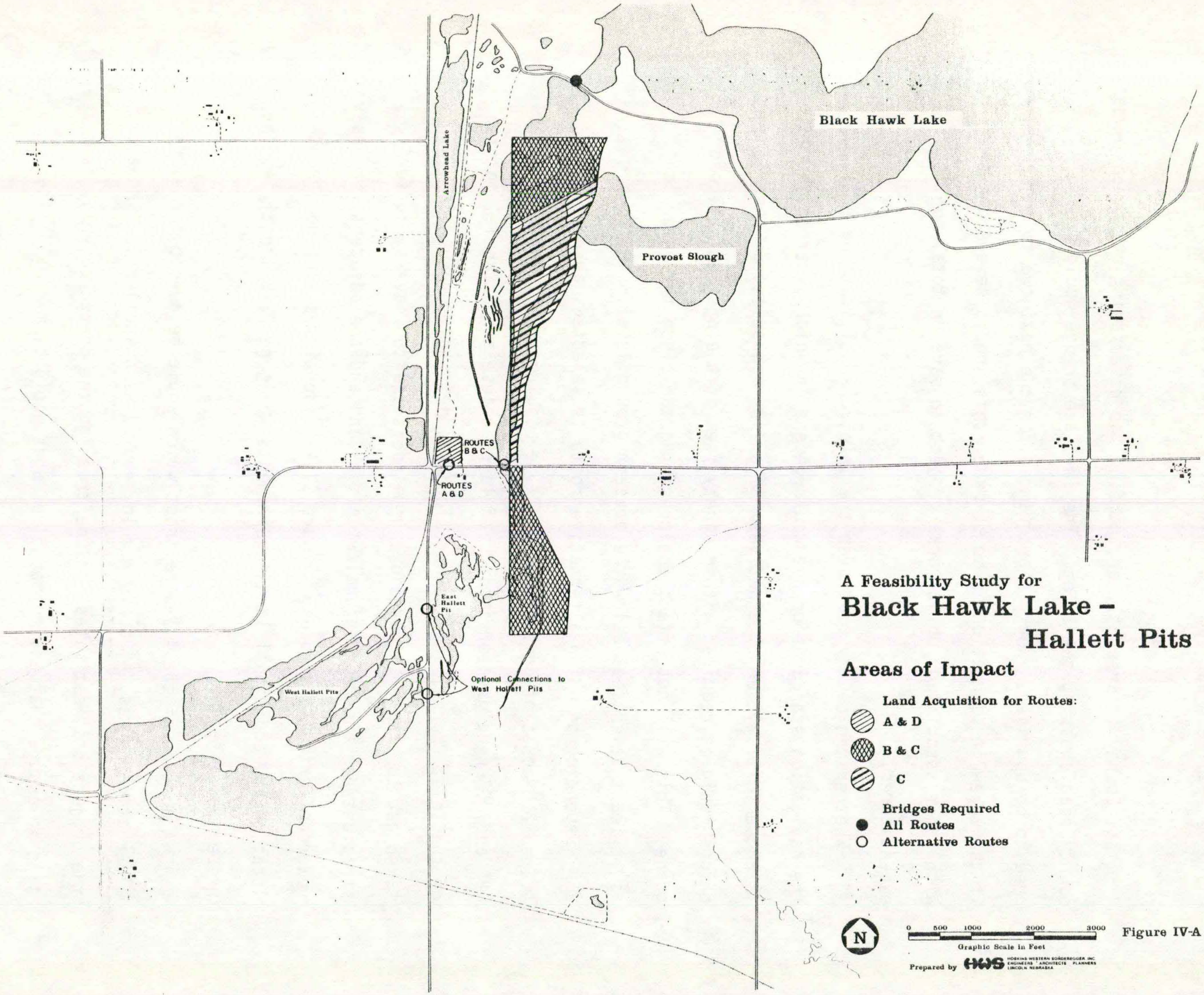

Black Hawk Lake
Arrowhead Lake
Provost Slough
ROUTES B & C
ROUTES A & D
East Hallett Pit
West Hallett Pits
Optional Connections to West Hallett Pits
A Feasibility Study for
Black Hawk Lake – Hallett Pits
Areas of Impact
Land Acquisition for Routes:
A & D
B & C
C
Bridges Required
All Routes
Alternative Routes
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by HWS

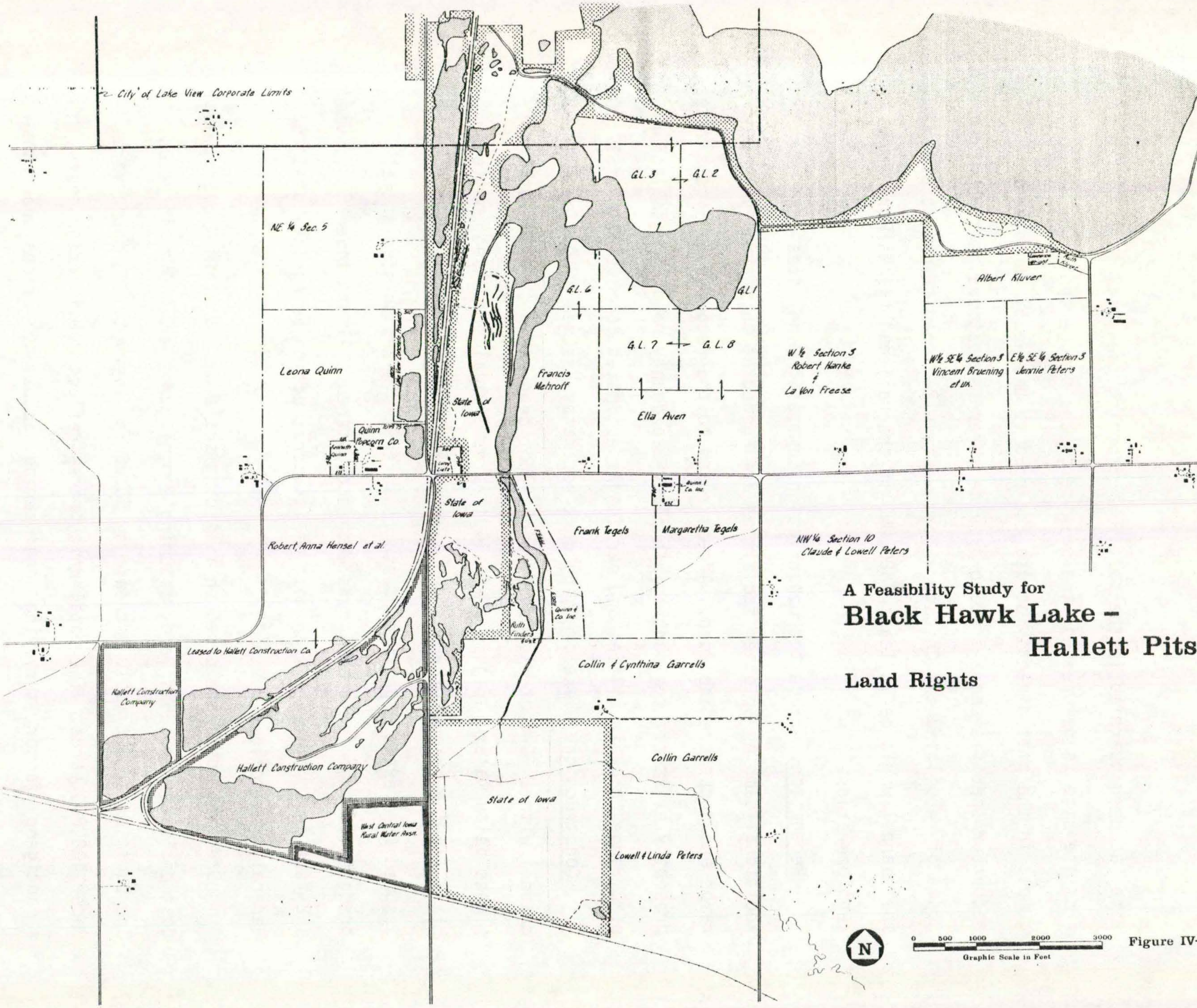
Figure IV-A

site had been quarried in the past. If trucking the spoil material from the site is not needed, the balance of the dredge spoils could be dumped in the pits directly across the road to the West, or used to recontour specific shorelines to provide safer recreational surroundings. Costs of rebuilding the Chicago - Northwestern Railroad tracks to accommodate the channel would be at least $600,000 if the railroad tracks were to be kept operational.

Recreation. Since the Conservation Commission indicates that no additional camping or other facilities are needed at this time, only boat ramps and docks are included. Access roads to the recommended access sites presently exist off the north-south black-top county road. Installation of 2 ramps, dock facilities and parking is estimated to cost nearly $17,000.

Construction. Lake dredging cost estimates assumed a 100-foot wide channel with a 60-foot wide base, eight-foot deep and with 2.5:1.0 side-slopes below water. Figure IV-C illustrates typical cross-section template for the channel through dry land. Both alternatives "A" and "D" assumed an average eight-foot depth to water table and no substantial dredging through the gravel pits each encountered. Alternative "B" assumed a 2-foot depth overland with most of its construction being lake dredging. Generally it follows route "C".

Dredging costs are based on a sliding scale with a minimum operational cost of $1.25 per cubic yard, assuming a minimum of 400,000 cubic yards. The basic unit cost would increase by $0.05 for every 10,000 cubic yards under 400,000 yards. The total unit prices reflect mobilization costs, a contigency factor, surveying, engineering, actual operations and transportation of the spoils material. Some savings can be encountered if



A Feasibility Study for

Black Hawk Lake – Hallett Pits

Land Rights

Figure IV-B

draglining or other earth-moving equipment are used. Thus, costs varied from $3.24 per cubic yard in "A" to $4.04 per cubic yard in alternative "D". Table IV-1 summarizes the volume of material for each alternative and the best 1979 cost estimate for all phases of the project.

All excavated channels will have tapered banks at the shoreline with vegetation and willow-reed mat to minimize bank erosion and sluffing. The vegetation can break wave action and help stabilize the channel bank. Costs were estimated at $5.25 a lineal foot ($2.62 per bank). Shore protection and bank revegetation would generally adhere to the typical cross section in Figure IV-C.

Operation, maintenance and replacement average annual costs were based on 0.43 per cent of the shoreline protection costs plus $0.50 per recreation day (see Table IV-1). Average annual dredging (channel) maintenance costs were based on ten inch accumulation of silt over eighteen years in the Provost Slough-Inlet Channel Area documented in the 1974 dredging study prepared for the Iowa Conservation Commission. Dredging maintenance costs range from $4.40 to $4.61 per cubic yard. Because little or no overland runoff would enter alternative routes "A", "B", and "D", the only maintenance would involve dredging the Provost Slough Area.

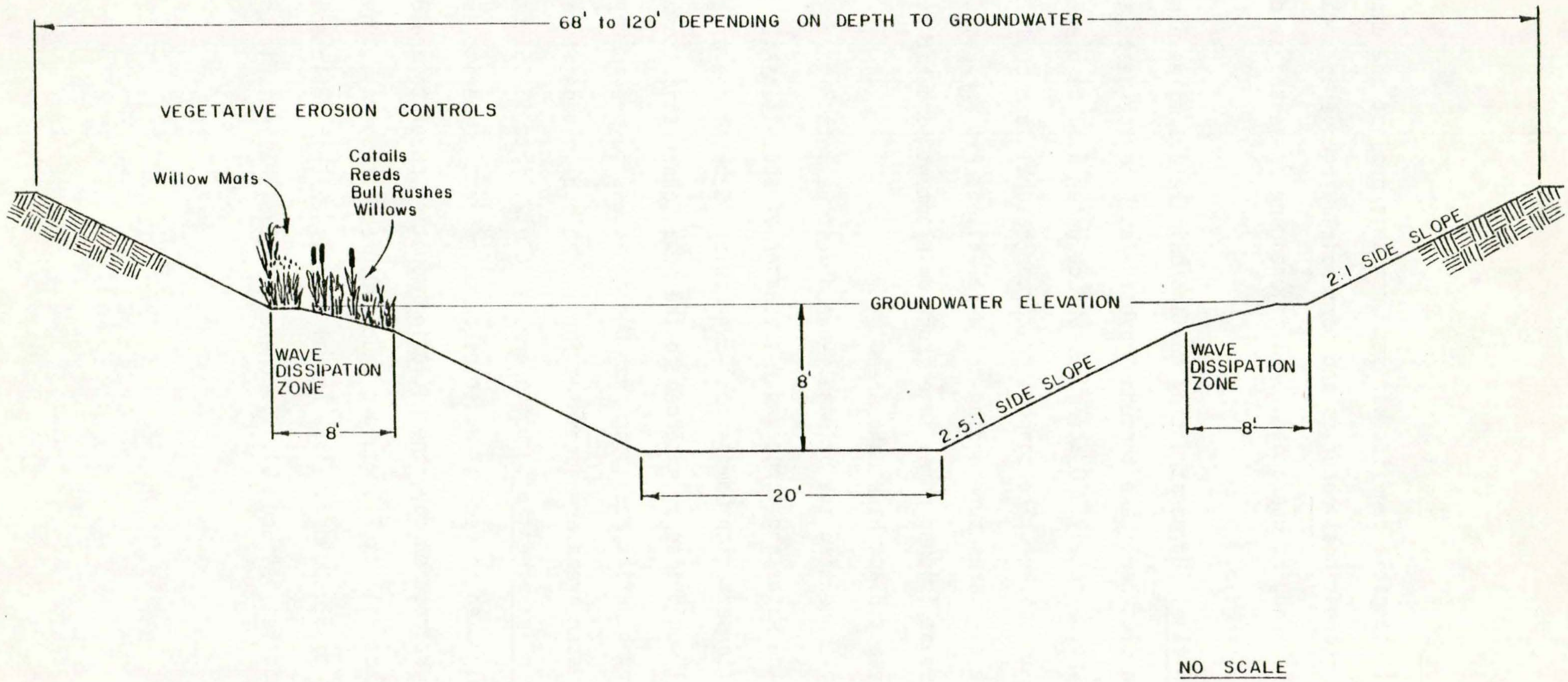
TABLE IV-1

COMPARISON OF PROJECT COSTS

Route Alternative	Road & Bridge	Private Land Acquisition	Recreational Development	Total Construction	Shoreline Protection	Total Cost	Operations, Maintenance & Replacement
	# / $	Acres / $	$	Cubic Yards / $	$	$	Average Annual Cost
A	3 / 186,000	4.1 / 1,200	17,000	234,000 / 758,200	42,500	1,004,900	9,800
B	3 / 197,000	50.0 / 15,000	17,000	200,400 / 693,400	48,800	971,200	12,300
C	3 / 197,000	210.0 / 63,000	17,000	163,300 / 609,100	51,500	937,600	18,400
D	3 / 186,000	4.1 / 1,200	17,000	124,900 / 504,600	26,200	1,335,000	9,700

*Spread over 50 years at a 6 5/8% interest rate This is the interest rate most commonly used in federal water resource project cost calculations.
**Includes $600,000 for railroad construction

Figure IV-C



CHANNEL TEMPLATE (Typical)

Benefits

All tangible benefits derived from this project are expressed as public recreational benefits and commercially recoverable material from the dredging operation. All figures are presented as dollars of average benefit.

Private. By constructing the approximate 2.3 miles connection between Blackhawk Lake through Provost Slough to the West Hallett Pits, approximately 220 acres of surface water will be opened up for public access. The connection to the natural lake could further enhance the lands surrounding the West Hallett Pit for residential development (second home, lake front development somewhat similar to the present Black Hawk Lake Area.)

By connecting the privately-owned West Hallett Pits to Black Hawk Lake, the water and lands under the water of the pits shall transfer to state (Conservation Commission) ownership. Some degree of shoreline control would also be extended to the Iowa Conservation Commission. Monetary benefits resulting from public access to previously privately-owned water areas are accounted for in the public benefit section.

Public Recreation. Using a range of \$2.25 to \$3.15 which are rates commonly used in federal water resource projects benefits estimations per annual recreation day, the following monetary benefits are derived. The main East Hallett Pit would produce 800 recreation days, yielding from \$1,800 to \$2,500 of average annual benefits. This would apply to Route Alternatives "A" and "D". If the entire East Hallett Pit complex were considered for benefits, as it would be with routes "B" and "C", 1100 recreation days would result in a $2500 - $3500 range of annual benefits.

The 6,400 additional annual recreation visitations resulting from the connection between Black Hawk Lake and the private-owned West Hallett Pits would result in a range of $14,400 to $20,200 in annual public benefits. By adding the estimated benefits for all of the Hallett Pit area, the resulting annual benefits range from $16,200 to $22,700 for Alternatives "A" and "D" and from $16,900 to $23,700 for Alternatives "B" and "C". The high range of benefits is used for benefit cost calculations later in this report.

Recoverable Benefits. Test hole boring log analyses indicate that some commercially recoverable gravels are present at the depths to which the channels would be excavated. It must be pointed out though that most of the original deposit has been previously excavated along Routes "A" and "D", and the thickness of the material and its per cent distribution are insignificant in Alternatives "B" and "C". Essentially, the extent of commercially recoverable gravels is not a significant factor in the determination of route selection and project feasibility. Total gravel tonnage is estimated to be 27,000 tons for route alternative A. At a minimum of $0.10 per ton royalty to the State of Iowa, the public benefit would be $2700.

Benefit/Cost Ratio

As Table IV-2 demonstrates, project costs for the most part outweigh benefits for all alternates. Net cost figures were derived by subtracting recoverable costs from the gross project costs. Average annual costs were derived by factoring the net project costs by the

TABLE IV-2

BENEFIT/COST COMPARISON

Route Alternative	Gross Project Costs	Recoverable Costs	Net Costs	Average Annual Costs*	Average/Annual OM/R	Total Annual Cost	Average Annual Benefit (Max)	Benefit/Cost Ratio
A	1,004,900	2,700	1,002,200	69,200	9,800	79,000	20,200	0.26/1.00
B	971,200	0	971,200	67,100	12,200	79,400	23,700	0.30/1.00
C	937,600	0	937,600	64,700	18,400	83,100	23,700	0.29/1.00
D	1,335,000	0	1,335,000	92,200	9,700	101,900	20,200	0.20/1.00

*Spread over 50 years at 6 5/8% interest This is the interest rate most commonly used in Federal Water Resources Project Cost Calculations amortization rate for a 6 5/8 per cent interest rate. This means that an average of $69,200 for route "A", for example, must be invested annually to pay off the principle and interest on the loan to obtain the funds for the project. The payments would be spread over a 50-year period. To this figure, average annual operation, maintenance, and replacement costs were added to obtain the total annual costs. Maximum expected average annual benefits were then divided by total annual costs to derive the benefit/cost ratio.

Cash Flow Analysis

The following Tables (IV-3a-d) project a cash flow for each alternative. over the 50-year life of the project. The timing and magnitude of both costs and benefits are detailed. The annual rate of return on investment which is provided was derived through a computer program that took into account the cash flow Tables (see Tables IV-3a, - 3b, -3c, -3d.). The program assumed the investment would be spread over fifty years. Because the incremental benefits (cash flow) were negative, the rate of return on investment is also negative.

TABLE IV - 3a Cash Flow Analysis

Alternative "A"		Project Costs			Total Value of Project (Gross Benefits)	Incremental Benefit (Cash Flow)
Year	Feasibility Study	Capital Items inc Eng.	O.M.& R.	Gross Costs		
0	$31,000			$31,000		-$31,000
1		$699,000		$699,000		-$699,000
2		286,200	$200	286,400	$20,200	-$266,400
3		$17,000	$200	$17,200	$20,200	+ $3,000
4 to 50			$460,600	$ 460,600	$949,400	+$488,800
Total	$31,000	$1,002,200	$461,000	$1,494,200	$989,800	-$504,400
				Average annual rate of return on investment = -2.2%		

TABLE IV - 3b Cash Flow Analysis

Alternative "B"		Project Costs			Total Value of Project (Gross Benefits)	Incremental Benefit (Cash Flow)
Year	Feasibility Study	Capital Items incl. Eng.	O.M.& R.	Gross Costs		
0	$31,000			$31,000		-$31,000
1		$699,000		$699,000		-$699,000
2		255,200	$200	$255,400	$ 23,700	-$231,700
3		$17,000	$200	$17,200	$ 23,700	+$6,500
4 to 50			$578,100	$578,100	$1,113,900	+$535,800
Total	$31,000	$971,200	$578,500	$1,580,700	$1,161,300	$419,400
				Average annual rate of return on investment =-1.9%		

TABLE IV - 3c Cash Flow Analysis

Alternative "C"		Project Costs			Total Value of Project (Gross Benefits)	Incremental Benefit (Cash Flow)
Year	Feasibility Study	Capital Items incl. Eng.	O.M.& R.	Gross Costs		
0	$31,000			$31,000		-$31,000
1		$699,000		$699,000		-$699,000
2		$221,600	$200	$221,300	$23,700	-$197,900
3		$17,000	$200	$17,200	$23,700	+ $6,500
4 to 50			$864,800	$864,300	$1,113,900	+$249,100
Total	$31,000	$937,600	$865,200	$1,333,800	$1,161,300	-$672,500
				Average annual rate of return on investment =-3.0%		

TABLE IV - 3d Cash Flow Analysis

Alternative "D"		Project Costs			Total Value of Project (Gross Benefits)	Incremental Benefit (Cash Flow)
Year	Feasibility Study	Capital Items incl. Eng.	O.M.&R.	Gross Costs		
0	$31,000			$31,000		-$31,000
1		$699,000		$699,000		-$699,000
2		$582,500	$100	$582,600	$20,200	-$562,400
3		$17,000	$100	$17,100	$20,200	+$ 3,100
4 to 50			$455,900	$455,900	$949,400	+$705,000
Total	$31,000	$1,298,500	$456,100	$1,785,600	$989,800	-$795,800
				Average annual rate of return on investment = 3.0%		

Environmental Analysis

Although the benefit/cost analysis does provide a method of evaluating the relative merits of a project on its direct monetary assets and liabilities, it does not assess the more indirect implications of the project, nor can it assess the more intangible environmental or social impacts. Thus, the following environmental assessment will consider the apparent indirect and intangible aspects of the project.

Project Purposes. As was stated in Section I, "Defining Public Access", the basic purposes of the study were to:

1) Define possible routes of connection.

2) Determine additional public recreation benefits resulting from the project.

3) Consider possible private development opportunities that would arise from the project.

4) Discuss probable operation and maintenance factors.

Further refining of the purposes were to state what the study would not accomplish, the study will not attempt to:

1) Evaluate the rehabilitation or improvement of Black Hawk Lake.

2) Consider raising the level on Black Hawk Lake (by adjusting the weir).

3) Solve any water level problems on Black Hawk Lake relating to variable precipitation.

4) Solve disputes over water well development in the area.

Project Description. The channel would begin in the southwestern arm of Black Hawk Lake in the southwest quarter of the southeast quarter of Section 33, Wall Lake Township (T87, R36) and would proceed in a southernly direction through the east half of Section 4, Viola Township

(T86, R36) to the large gravel pit in the northwest quarter of Section 9, Viola Township (T86, R36), then crossing the county road in a south-westernly direction to the large gravel pits in the southeast quarter of Section 8, Viola Township (T86, R36).

Directly affected by the project would be 226 acres of state-owned land managed for wildlife habitat. (179 acres of land and 47 acres of wetlands), 160 acres of private land in the Provost Slough Area, 504 acres of private lands in the Finders Pits Area, and 4.1 acres of private land northwest of the wildlife headquarters. The project would connect nearly 400 acres of private land west of the county road to the 975 acre Black Hawk Lake.

Four possible routes were studied. (See Figure I-A). "A" will generally parallel the Chicago-Northwestern Railroad, Route "B" will follow a previously excavated canal through the central swampy areas, Route "C" will follow the present inlet channel, and Route "D" will pass through the Arrowhead Lakes.

Each route would be a navigational canal through both open marsh and old, quarried areas. Through the marshy slough and inlet areas, a 100-foot swath would be cleared and dredged. Widths over dryland would depend upon the depth to the groundwater table. For most portions of alternatives "A" and "D", an eight foot depth was assumed to be a typical depth. Lateral construction disruption would be held to a very minimum by every means possible. Route "B" would have a 76 foot maximum corridor over dryland. About four feet on each bank would be devoted to vegetative shoreline protection, and the 20 foot plus side slope would be revegetated.

Nearly twelve acres on the east side of the West Hallett Pits complex adjacent to the county road, could be developed with camping, swimming, and fishing access facilities at some future date.

The private, residential development across the county road around the present quarry pit could begin independently of this project. If the connection is made, all water area and the lands underlying would transfer to state ownership, along with some shoreline control. Public access would also have to be provided from the county road. This would amount to about ten acres.

Environmental Description. After analyzing various sources of qualitative data, (soil surveys[1], resistivity data[2], boring logs[3], field investigation and interviews[3], and air photographs[4]) several natural phenomena become more apparent.

1) The "Wall" which formed Black Hawk Lake is an older Tazewell - Aged glacial till sitting on the west side of Lake View (See Figure V-D) and Arrowhead Lake. An ancient watershed which drained the entire Black Hawk Lake area flowed in a southwesterly direction through the Hallett Pits area into the modern day boyer river system. The last glacier left morraine deposits that probably constricted this ancient

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1 USDA, SCS Soil Survey for Sac County, Iowa, 1974.
2 Iowa Geologic Survey Analysis, by Fred Dorheim dated July 1, 1977.
3 Hoskins-Western-Sonderegger, Inc. staff, October & December 1978.
4 ASCS Air Photographs flown in 1968.

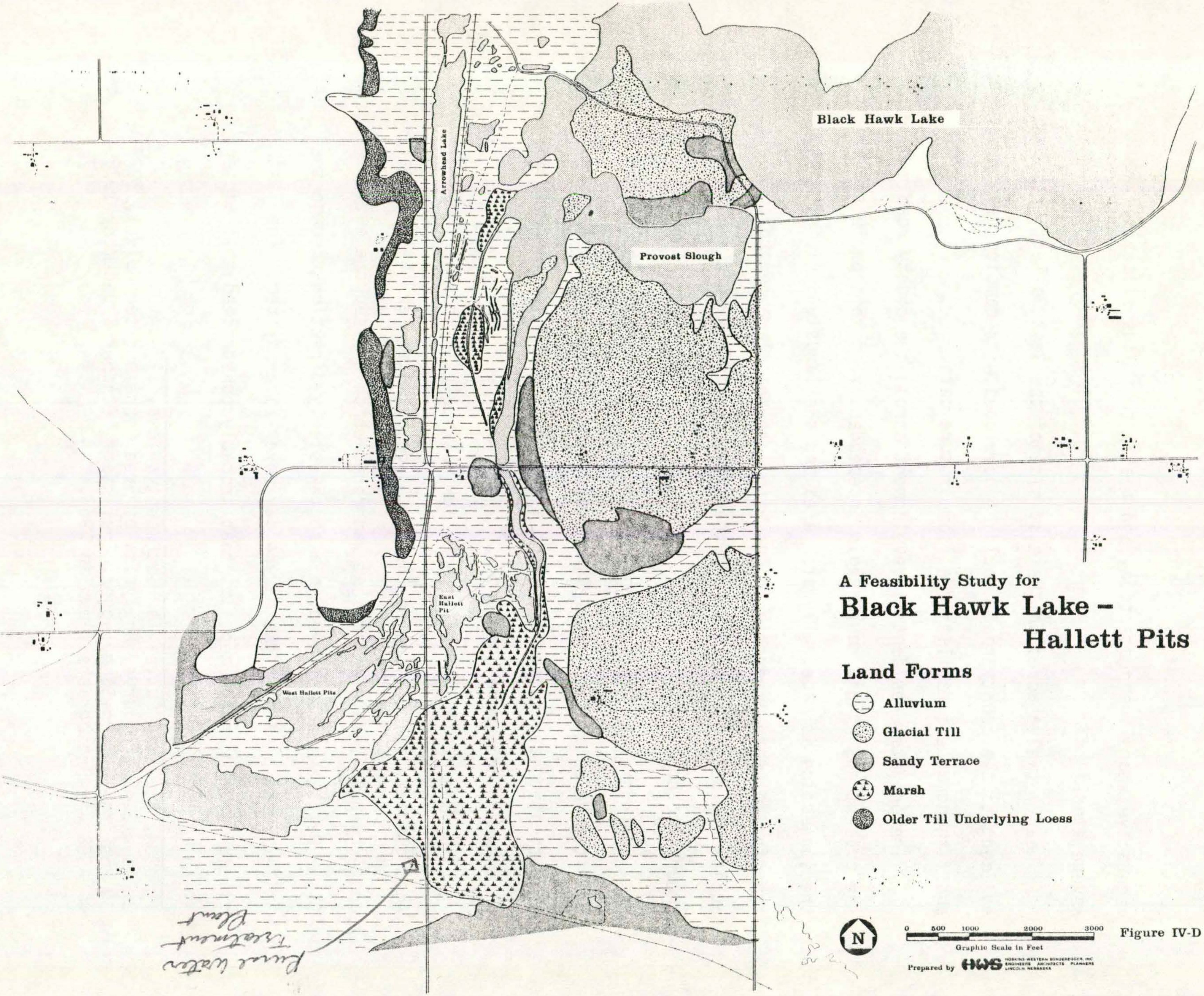

Black Hawk Lake
Arrowhead Lake
Provost Slough
East Hallett Pit
West Hallett Pits
A Feasibility Study for
Black Hawk Lake -
Hallett Pits
Land Forms
Alluvium
Glacial Till
Sandy Terrace
Marsh
Older Till Underlying Loess
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by HWS
Rural Water Treatment Plant

Figure IV-D

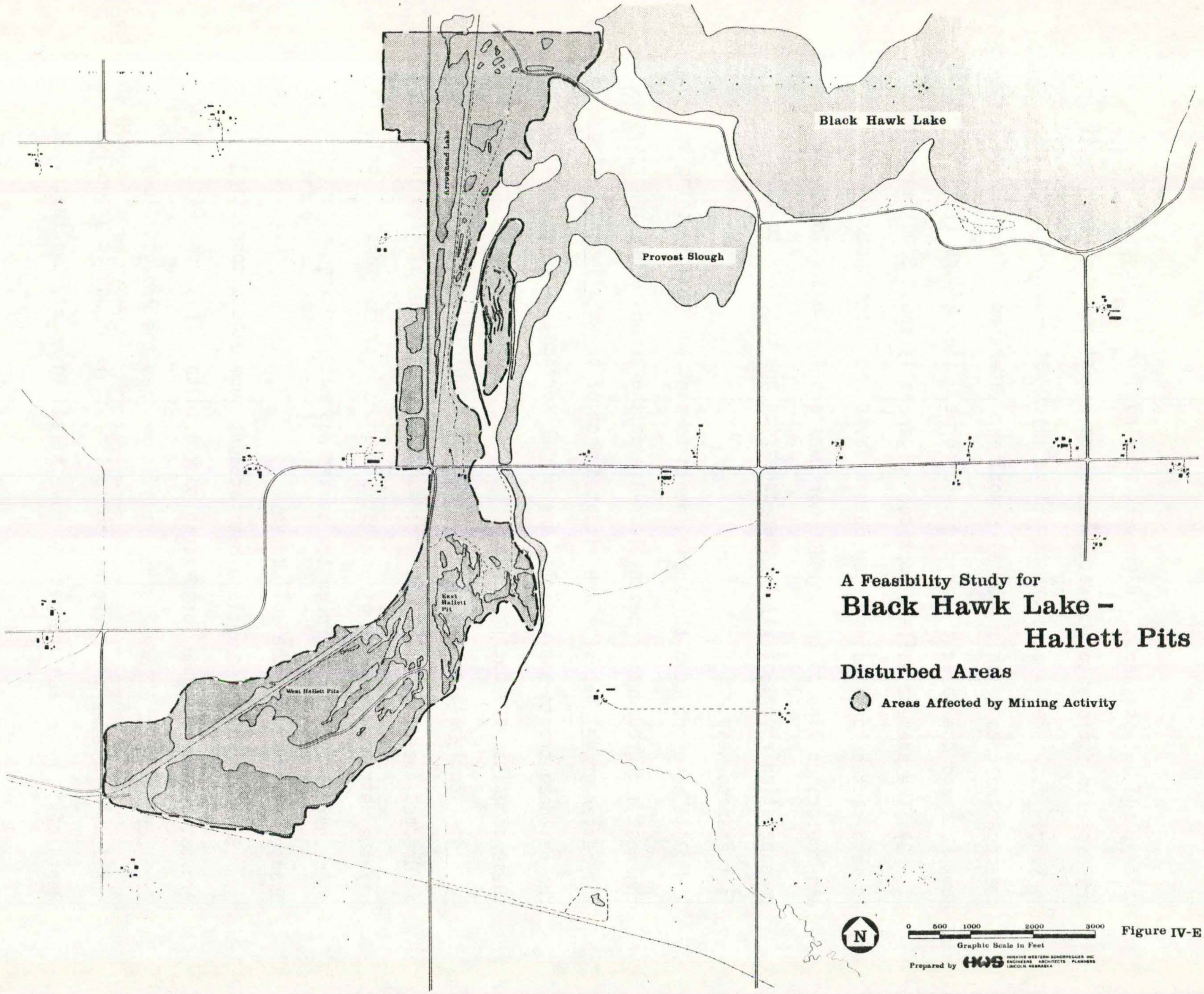
valley, and outwash sands and gravels spewing from it clogged the drainage and diminished its watershed so much that surface water could no longer flow freely through the old valley. Water backed up into the upper reaches of this glacially-modified watershed. Thus, Black Hawk Lake and the Hallett corridor were formed. (See Figure 1)

2) The present Hallett corridor is generally about 2300 feet wide. It is bisected longitudinally by both a paved Sac County Road (M-54) and the branch line of the Chicago-Northwestern Railroad. These two transporation rights-of-way further constrict the corridor to 1500 feet east to west.

3) The overburden thickness (depth to sand and gravel) thins to the west and groundwater depths increase as the ground elevation rises. The better gravel deposits are situated west of the trail paralleling the railroad tracts and underlay the higher terrace. However, most of these deposits have been removed.

4) Nearly all of the corridor has been quarried for sand and gravel or dredged (see Figure IV-E) or the surface drastically altered in some way the western shoreline of provost slough is a prime example. Only a low narrow corridor through the center has not been significantly changed according to the soil survey.

5) A significant wetland habitat continuum exists connecting Provost Slough with the large marsh to the south. This open water/marsh corridor is about 500 feet wide until it reaches the Provost Slough shallows or the marsh. However, not all of it is on public ground. Parts of it have been dredged and have silted in nearly two feet (1916


Black Hawk Lake
Provost Slough
Arrowhead Lake
East Hallett Pit
West Hallett Pits
A Feasibility Study for
Black Hawk Lake –
Hallett Pits
Disturbed Areas
Areas Affected by Mining Activity
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by HWS
Figure IV-E

depths were four feet and present depths average two feet).

6) Access to the east side of the corridor is severely limited; while the western side accords easy access.

7) Because groundwater is low in the organic nutrients needed to sustain fish and other aquatic populations, and productive littoral zones are very limited, the gravel pits in the area are not highly productive. Even though groundwater flows contribute a great deal to the volume of Black Hawk Lake water, the natural lake's productivity is higher because it receives substantial nutrient loads from overland runoff (the gravel pits receive very little, if any) and the natural lake is over 10,000 years older.

This is not to say that large fish are not commonly caught in both East and West Hallett Pits. But productivity as expressed in pounds of harvestable fish per acre is lower in the pits according to local fisheries biologists.

Black Hawk Lake has another problem which historically has adversely affected sportfishing species' populations -- winter kill. The lake is very shallow, generally not more than six (6) feet in depth. Winter ice and snow cover result in low oxygen level. The oxygen demand in the lake bottom sediments and septic leachate (most of the lakeside cottages have only recently been serviced with sanitary sewers) deplete the oxygen supply below the ice to the point that only low oxygen tolerant species such as carp, buffalo fish, and bullheads survive.

Water samples and their locations are found in the Appendix.

8) The West Hallett water level, depending on what period of the local water cycle is being described, is 2.3 feet above the Black Hawk

Lake level. When the Rural Water District Wells are placed in operation, the difference in elevation would be nearly 0.7 feet less with maximum pump discharge. The connection itself would lower the hydrologic head another 0.4 feet.

9) According to the "Five-year Development and Operation Plan" for the Lake View Game area (Hallett Corridor) there are fifty-eight (58) acres of woodland habitat. This represents about one-third of the land area in the state owned portion of the Hallett Corridor. The wooded area is generally west of the trail. Tree species are mainly cottonwood and silver maple with some box-elder, green ash, sycamore and walnut. These species are representative of Mesic Bottomland Plant Associations of the Midwest. They have established themselves on the spoil piles and disturbed areas after quarrying had stopped between thirty and forth years ago.

The understory is not thick and is typical of a late seral stage of mesic bottom land habitat. Brushy growth on the edges and less densely grown woodlands consist of sumac, dogwood species, raspberry, and mulberries.

The cottonwood and silver maple were the pioneer species in this area. They are very prolific and are able to withstand the hostile environment found on the spoil piles and disturbed areas, they were able to establish conditions conducive for other species. As this habitat evolves, cottonwood and silver maples will become less important and oak, maple, ash, and walnut will become more prominent.

Although the habitat is not pristine by any means with the previous dredging and quarrying operations, it does support a wildlife population, and receives considerable public users by hunters and non-consumptive users. As evidenced by the numbers of birdwatchers and hunters a substantial population does exist.

If animal tracks and droppings and hunter activity is a general indication of habitat productivity, then the area west of the central trail through the connection corridor (the spoils and remains of the high terrace - see Figure II-C) is not a highly productive area. Few winter signs were evident, where as to the east in the marsh and bottomlands abundant animal activity was noted. Muskrat lodges, pheasants, small rodents' and other fur bearers' tracks were evident everywhere.

10) After viewing both a 1916 field survey with general Black Hawk Lake bottom depths, and very recent lake bottom contours, very little real difference can be noted in the central and eastern bay areas. The real changes are noted in the northwestern bay where dredging and filling have altered the natural contours. In Provost Slough and the Inlet Channel, up to two feet of siltation was noted.

Thus, siltation does not seem to be a major problem in the lake proper, but only in the Inlet which acts as a large silt trap for the lake. Here the flow gradient flattens out, the channel cross-section widens considerably, and vegetation also serves to slow down flows.

This is not to say that sediments do not reach the lake; they do. However, any connection which would utilize the Inlet would be subject to high sediment rates and would increase sedimentation to the lake if proper considerations were not taken.

Environmental Impact. Depending on route selection any where from 210 acres to 4.1 acres of private land would be acquired to complete the connection. Alternatives "A" and "D" would need the 4.1-acre Leitz property east of and adjacent to the railroad right-of-way and north of and adjacent to the east-west county road. About 1.4 acres would be needed for the channel and sideslope, the remaining 2.7 acres for a spoils pile. Presently the land is occupied with a deteriorating maintenance shed and scattered rubbish. Route "B" would need nearly 90 additional acres, 40 of which are open water and marsh in upper Provost Slough and the balance is the Finder's Pits and Quinn and Company property, nearly all of which is under water or easily flooded and generally always wet. "Alternate "C" would require 210 acres of land (the 50 acres in the Finders - Quinn area and 160 acres along the Inlet through Provost Slough). Acquisition costs would vary accordingly from $63,000 in alternative "C" to $1200 for both "A" and "D".* In all cases the land is non-productive in an agricultural sense, being marshy or under water. Underlying gravel deposits have long since been tapped or are commercially sub-marginal.

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*Included in these costs are abstracting and surveying fees.

Several dry pits of about 13 acres total in area along the east line of the southeast quarter Section 5 Viola Township (T87, R36) could be used as spoils dumps. These sites would have to be purchased in fee or easements acquired.

Alternative "D" would have to pass under the Chicago-Northwestern tracks twice. This would add considerable cost to this alternative if the railroad right-of-way was not abandoned. Maximum development would provide from between 7200 and 7500 annual recreation visits. Average annual monetary benefits would range from $16,200 to $23,700 depending on which alternative is selected. Costs involved in developing the proposed recreational area are estimated to be nearly $17,000. These costs would provide mainly boating access and parking at two sites. Access roads are already present on both sides of the north/south county road. Developments for boating and fishing activity in the East Hallett Pit complex could conflict with wildlife due to the general points described in Table IV-4.

TABLE IV-4

INTERCOMPATIBILITY OF MULTIPURPOSE
WATER RELATED USES

PRIMARY USE(S)

SECONDARY USE(S)	RECREATIONAL USES	WILDLIFE
Sediment Control	Ponds for recreational use will precipitate sediment if on-channel, but this may reduce recreational value. Install small pond upstream to precipitate larger sediment and reduce drawdown.	On-channel wildlife pond will precipitate sediment, which will tend to smother bottom vegetation.
Recreational Uses		Recreational uses and wildlife are compatible if wildlife are species which tolerate disturbance. This may impose minimum size restrictions for shy species or may make quiet areas necessary.
Wildlife	Recreational ponds may have some value for tolerant wildlife species if wildlife density is kept fairly low. Water's edge treatment might present conflicts.	

By making the hydrologic connection between Black Hawk Lake and the West Hallett Pits will raise Black Hawk nearly 0.1 feet and lower the whole Hallett Pit area water level nearly 0.4 feet. An outside influence in this matter is the Rural Water District water well activity south of the pits. Once fully operational at their maximum legal pumping rate they could lower the pit water levels another 0.7 feet. Thus, the ultimate difference between water levels in the two water bodies will be halved from 2.3 feet to 1.1 feet. Water tables remote from the pit area will be affected according to the scheme detailed in Appendix E. During wet years the water levels in the marsh could be lowered as much as 0.7 foot due to well activity (infiltration from the feeder stream is not taken into account). Influence on the marsh water levels due to the connection would be insignificant. All alternatives would have the same impact magnitude.

The open marsh and wetlands of Provost Slough and along the Inlet corridor, as previously stated, are relatively highly productive. The area of channel dredging disruption is directly proportional to habitat distruction. A relative ranking of habitat impact (lowest to highest) would be "D", (2.9 acres), "A" (5.5 acres), "B" (13.9 acres), and "C" (20.1 acres). (See Figure IV - F and Table IV - 5). Alternatives "A" and "D" would pass through four to six small, abandoned gravel pits. These areas are comparatively low in fertility and diversity and therefore do not represent a high quality habitat. Furthermore, these small pits cannot support fish populations due to their susceptibility to winter kill. Alternative "B" would follow an old, shallow canal which would not sustain fish populations due to its shallowness. Thus, no permanent habitat impacts

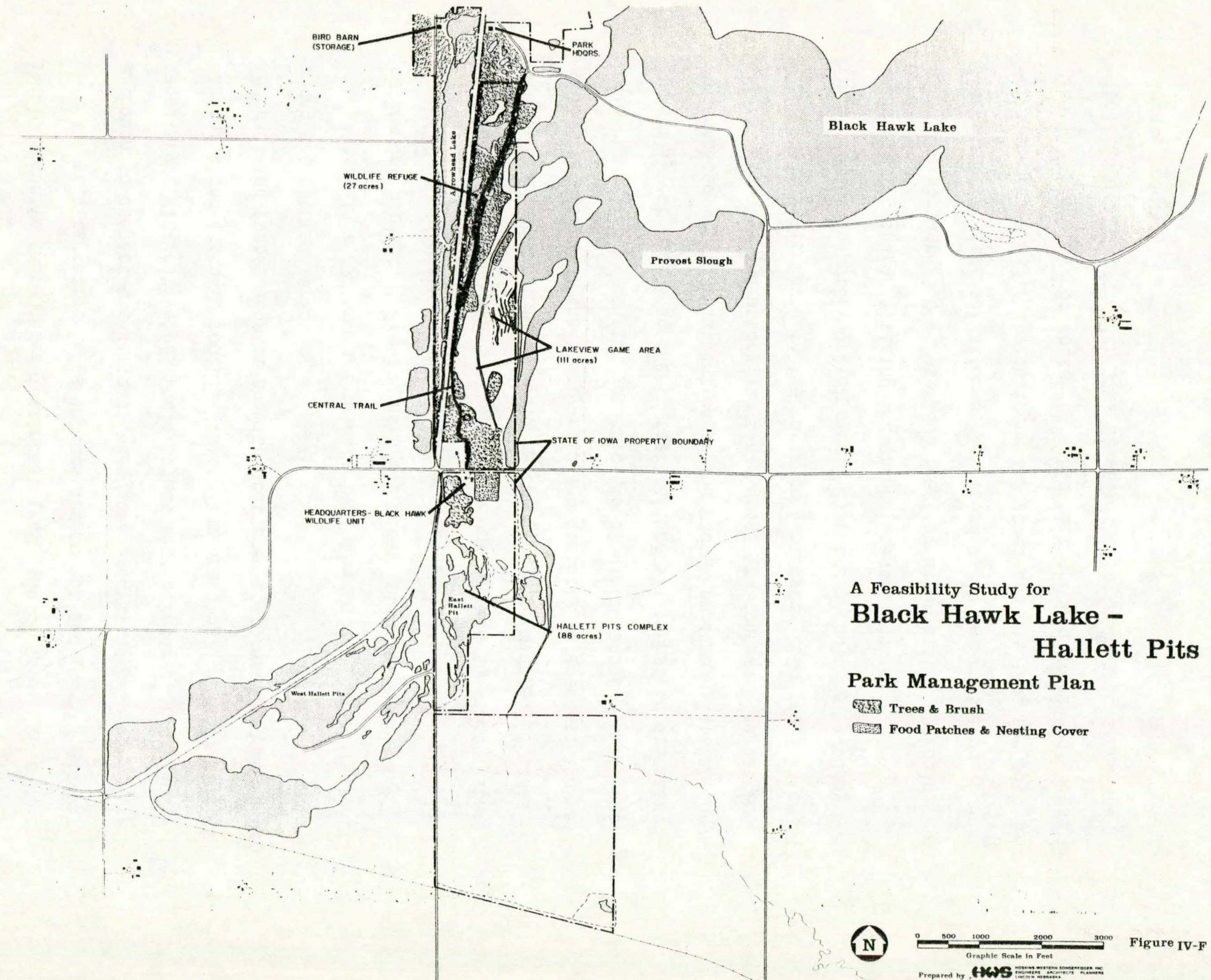

BIRD BARN (STORAGE)
PARK HDQRS.
Black Hawk Lake
Arrowhead Lake
WILDLIFE REFUGE (27 acres)
Provost Slough
LAKEVIEW GAME AREA (111 acres)
CENTRAL TRAIL
STATE OF IOWA PROPERTY BOUNDARY
HEADQUARTERS- BLACK HAWK WILDLIFE UNIT
East Hallett Pit
HALLETT PITS COMPLEX (88 acres)
West Hallett Pits
A Feasibility Study for
Black Hawk Lake – Hallett Pits
Park Management Plan
Trees & Brush
Food Patches & Nesting Cover
N
0 500 1000 2000 3000
Graphic Scale in Feet
Prepared by HWS HOSKINS-WESTERN-SONDEREGGER, INC ENGINEERS ARCHITECTS PLANNERS LINCOLN, NEBRASKA

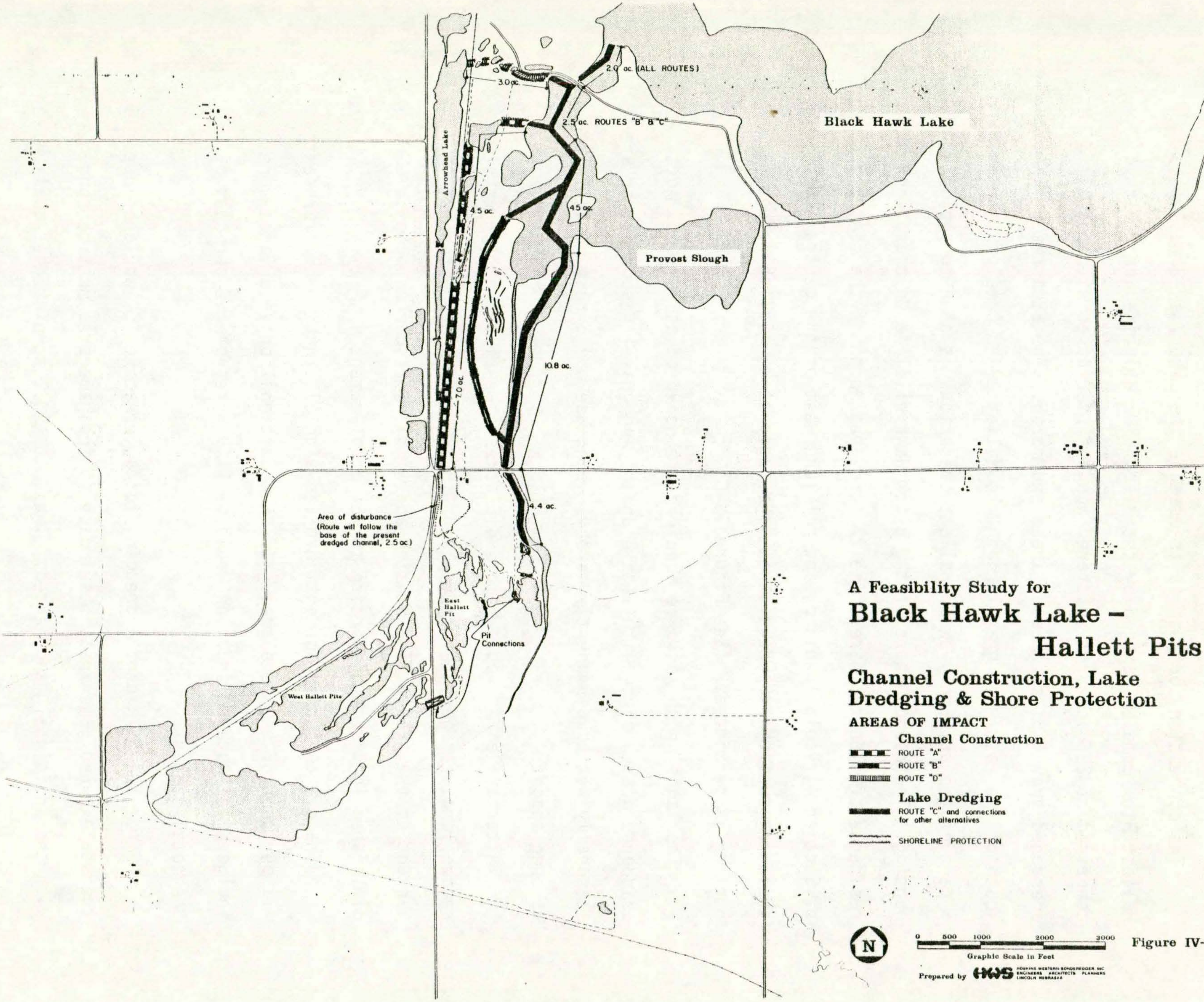
Figure IV-F

should occur in these three instances. (A,B, and D)

All of alternative "C"'s impacts are to wetland (marsh) habitat, although to connect the various lakes some excavation (7.5 acres) is necessary. Alternative "B" would affect over 8.2 acres of dryland habitat along its 6400 foot length of land dredging. Most of this is in grass and forbes vegetation with scattered cottonwood and box-elder along the channel banks.

Alternative "A" would eliminate 14.0 acres (6100 lineal feet) of bottomland habitat. The southern 2.5 acres would not remove any overstory since it would follow an existent sixty-foot channel. A few small trees and understory would be removed and the root systems of the overhead cottonwood would be damaged. The middle 7.0 acres (3000 feet north of the county road and directly adjacent to the railroad right-of-way) consist of thickets of willow and elm sapplings, generally not more than twenty feet tall or six inches in diameter. Interspaced within this portion of the route are some wildlife (sorghum) plantings. The understory is mainly grass and forbes. The better woody habitat is found in the northern 4.5 acres (2000 feet) which will interconnect the small gravel pits. Some trees could be saved by constricting and/or altering the channel centerline.

The northern 3.0 acres (1300 feet) of alternative "D" would encounter the same situation as was found along the northern 4.5 acres of alternative "A". The southern 5.3 acres are the same for both "A" and "D". The bulk of route "D" would pass through Arrowhead Lakes, an isolated gravel pit which lies between the railroad tracts and the county road.



2.0 ac. (ALL ROUTES)
3.0 ac.
2.5 ac. ROUTES "B" & "C"
Black Hawk Lake
Arrowhead Lake
4.5 ac.
4.5 ac.
Provost Slough
10.8 ac.
7.0 ac.
4.4 ac.
Area of disturbance (Route will follow the base of the present dredged channel, 2.5 ac.)
East Hallett Pit
Pit Connections
West Hallett Pits
A Feasibility Study for
Black Hawk Lake – Hallett Pits
Channel Construction, Lake Dredging & Shore Protection
AREAS OF IMPACT
Channel Construction
ROUTE "A"
ROUTE "B"
ROUTE "D"
Lake Dredging
ROUTE "C" and connections for other alternatives
SHORELINE PROTECTION
N
0
500
1000
2000
3000
Graphic Scale in Feet
Prepared by HWS
HOSKINS WESTERN SONDEREGGER INC
ENGINEERS ARCHITECTS PLANNERS
LINCOLN NEBRASKA

Figure IV-G

The connection corridor is in essense the Lake View Game Area - Hallett Pits complex managed by the Black Hawk Wildlife Unit. It is comprised of 226 acres of scattered woods, interspered with small, abandoned gravel pits, grassey areas and marsh. The 88 acres of land south of the east-west gravel road (The Hallett Pits Complex) formerly a part of the privately-owned Hallett operation, is open to public hunting. The headquarters of the Black Hawk Wildlife Unit and technician residence are located here. The 27 acre area north of the centerline of Section 4, Viola Township, and all land west of the central trail, including most of Arrowhead Lake, is managed as a wildlife refuge; no hunting is permitted. (See Figure IV-G)

The lands which would be acquired are non-productive land, mostly abandoned gravel pits, with little underlying gravel resources, or are seasonally wet to permanently marshy. Land use could best be described as open space.

Alternative "A" would remove 4.5 acres (one-sixth) of the wildlife refuge land. It would also displace 9.5 acres of hunting habitat (4.7 percent of the area). The hunting and wildlife resource would be diminished in direct proportion to the displacement.

The 8.4 acre displacement involved with alternative "B"represents 4.1 per cent of the game area. If the additional private lands were included the total disruption would be 17.9 acres or 6.2 per cent of the total area.

Since the bulk of the dredging for alternative "C" would be outside the state-owned game area, its impact to the game area must be considered with the additional land needed. Thus, its 20.1 acre dredge equals 4.9

per cent of the game area habitat resource.

Alternative "D" would require 10.8 acres (40%) of the wildlife refuge and 9.2 acres (4.6%) in the hunting area.

None of the alternatives should change the basic land management of any of the state-owned land. Some attention would have to be focused on erosion control maintenance and avoidance of recreational/wildlife interfacing impacts if more boating and fishing activities are to occur. The present fisheries management programming would be hard pressed by this project. In the near future the local fisheries biologist plans to renovate the surviving, unwanted species in Black Hawk Lake Finders Pits, the East Hallett Complex, and Provost Slough so that sport fish can be re-established. If the connection were made to the West Pits, an increase in the costs of this project would be at least 23 per cent.

No increase in fishing opportunities or resources is projected because of the connection project. Fish should not migrate from a relatively rich environment (Black Hawk Lake, Provost Slough) to the infertile surroundings of the former gravel pits. Although the channel should be deep enough to support a fish population, it too will not be as fertile as Black Hawk Lake.

With a "No-wake" boat speed policy to be in affect, (to minimize shore erosion and maximize user safety) a boat ride along the entire channel would take around twenty minutes.* Speed regulations in the channel would have to be enforced. Trash clean up efforts would have to be increased.

The project would have little effect on the two major local concerns; water well use to the south and the lack of quality pleasure boat and

*2.5 mile length $\div$ 7.5 $\frac{\text{miles}}{\text{hr}}$ = 0.33 hours (20 minutes) fishing opportunities in Black Hawk Lake. The connection would possibly drop the water elevations in the pits as much as 0.4 feet. The influence from the water well activity on the pits is greater, on the order of 0.7 foot decline.

Black Hawk Lake is a naturally shallow, glacially-induced phenomena. Due to its relationship with the surrounding watershed, it will always act as a sediment trap. In fact the area through which the connection would be made acts as the main recepticle for sediment moving toward the lake. About 2.0 inches are deposited annually in the existing Channel and Slough. Historical records indicate that little additional sediments have entered the lake proper for the last sixty years. The project will not change this relationship unless the Inlet alternates "C" or "B" are selected; under these alternatives, sediments would more easily enter the lake itself.

Lake levels are partially regulated by a weir at the east end outlet. The connection would raise the lake level about 0.1 feet which is insignificant as far as pleasure boating or land management problems are concerned. By actually creating 23 per cent more lake area, water levels fluctuating would tend to stabilize somewhat, but would still be closely tied to precipitation variations. Because the West Pits area is not large enough to support quality water skiing use, the future residents around the lake would take their boats to Black Hawk Lake (via the connection) to ski. Thus, the connection will not materially affect the present water quality and recreational opportunity difficulties the lake is now experiencing.

Except during and immediately following construction, air and water quality would not be significantly impacted.

The immediate corridor connection area is not known to have any historical or archaeological significance.

Table IV - 5 shows the absolute magnitude of impact for each alternative.

ABSOLUTE IMPACT COMPARISONS

Alternate Route	Comparative Length (Feet)	Bridge Requirements			Land Rights Acquisition (Acres)	Railroad Involvement
		#	Cost Est.	Compatibility With Present System		
A	11,920	3	$186,000	Must Build Two New Bridges & Elevate One	4.1	None
B	12,600	3	$197,000	Must Build One New Bridge & Elevate Two	210	None
C	12,300	3	$197,000	Must Build One New Bridge & Elevate Two	90	None
D	12,700	3	$186,000	Must Build Two New Bridges & Elevate One	4.1	Twice

Alternate Route	Recreation			
	Land Area Required	Development Cost	Annual Recreation Visitations Provided	Average Annual Recreational Benefits
A	2.0	$17,000	7,200	$20,200
B	2.0	$17,000	7,500	$23,700
C	2.0	$17,000	7,500	$23,700
D	2.0	$17,000	7,200	$20,200

Alternate Route	Construction		Shoreline Protection		Operation, Maintenance & Replacement*			Total $
	Total Dredging Volume (cu. yds.)	Total Cost ($)	Length (Feet)	$	Recreation $	Channel Dredge $	Shoreline $	
A	234,000	83,500	8,100	42,500	3,600	6,000	200	$ 9,800
B	200,400	80,400	9,200	48,800	3,700	8,400	200	$12,300
C	157,100	84,500	8,500	51,500	3,700	14,500	200	$18,400
D	124,900	83,300	5,000	25,200	3,600	6,000	100	9,700

*Average Annual Estimate

Alternate Route	Adverse Impacts						
	Raise Black Hawk Lake (Feet)	Lower Local Pit Levels (Feet)	Marsh Habitat Disruption (Acres)	Dry Land Disruption (Acres)	Equivalent Quality Woody Habitat (Acres)	Wildlife Refuge Acquisition and Percentage (Acres, %)	Total Habitat Removed Land and Percentage
A	0.1	0.4	5.5	14.0	3.9	4.5 (17)	9.5 (4.7)
B	0.1	0.4	13.9	8.2	2.5	0 (0)	17.9 (6.2)
C	0.1	0.4	20.1	2.5	0.8	0 (0)	20.1 (4.9)
D	0.1	0.4	2.9	3.3	2.1	10.8 (40)	9.2 (4.6)

Mitigating Measures

Specific mitigating measures are difficult to identify during the planning process but several steps have already been evaluated and general design concepts have been devised. The pre-construction measures are:

1) Evaluating several channel cross-section configurations for their impacts and feasibility.

2) Arriving on a channel design concept which should have enough depth (eight feet) to support a fish population year-around and would minimize lateral habitat disruption.

3) Devising a shoreline protection program which would minimize wave action erosion, which would also minimize the recreational/wildlife interface impact and serve as a compatible backdrop to the rest of its surroundings.

In general, several construction practices should be followed which would attempt to minimize impacts:

1) Bridge design would be coordinated with Sac County construction schedules and design.

2) Precise centerline alignment and channel width would attempt to preserve as many mature trees and woody habitat as possible.

3) The flagging of the maximum lateral extent of the channel, so that the edges could be shaped with an earth scraper to the desired slope, would minimize construction impacts outside the right-of-way.

4) Natural indigenous plant materials would be used to re-landscape the sideslope. Top soil would be stockpiled to help in re-establishing natural cover.

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BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 1
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w=Moisture Content, %	D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 10/25/78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CH	Silty clay; black; wet; high plasticity; medium stiff.			10:45
	1.5	CL	Sandy Clay; 30 to 35% fine sand; dark grayish brown; very wet; medium plasticity; soft.			Water level @ 2.0' 25 hrs. AD Water level @ 2.5' IAD
	3	SM	Silty Sand; 25 to 35% fines; fine to coarse with some gravel; saturated; slight plasticity; loose.			Filled and Capped
	5	SM	Silty Sand; 15 to 25% fine to coarse sand; saturated; loose.			Similar to Composite B-10
	46	GP	Gravel; coarse with cobbles; saturated.			
	50					

601-a

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Boring Method: 6-in. continuous flight auger	Standard Penetration Test	Boring No. 2a
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer / 30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot	Date: 10/25/78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0		Fill off of railroad slope.			Water level @ 2.0' IAD
	2	GP-GW	Gravel; fine to coarse with some sand and cobbles; saturated; medium dense.			Composite B-2a 2' to 46'
	46	CL	Sandy Clay; 25 to 30% fine sand with some gravel and cobbles; dark olive gray mottled with gray; saturated; very stiff; medium plasticity.			Same as B-7 and B-5a
	50					

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BORING LOG

PROJECT
Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 2
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer / 30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 10/25/78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL-CH	Silty Clay; black; moist to wet; medium to high plasticity; medium stiff.			
	1	CL-CH	Sandy Clay; 20-25% fine sand; dark brown; wet; medium to high plasticity; medium.			
	2	CL-CH	Same but brown.			Water level @ 3.0' IAD Water level @ 3.0' 3.0 hrs. AD
	4	SM (SC)	Silty (or Clayey) Sand; 30-40% fines; medium sand to medium gravel; saturated; slight plasticity; loose with some coarse gravel. with an occasional clay seam			Filled and capped Composite B-2 4' to 37.5'
	37.5	CL	Sandy Clay; 25 to 30% sand with some gravel and cobbles; gray (blue); saturated; stiff.			
	40	SM	Silty Sand as 4'-37.5' above.			
	41.5	CL	Sandy Clay as above. 37.5'-40'			
	45					

601-a

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BORING LOG

PROJECT
Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 3
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w=Moisture Content, % D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 10-25-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0–1	CH	Silty clay; black; very wet; high plasticity; medium.			
	1–2	CL-CH	Sandy clay; 15 to 20% fine sand; saturated; dark brown; medium to high plasticity; soft.			
	2–4	CL	Silty clay; 10 to 15% fine sand; pale brown; saturated; medium (to high); soft.			Water Level @ 2' 3 hrs. After Drilling Water Level @ 2.5' IAD Filled and Capped
	4–5	CL	Sandy clay; 30 to 40% fine sand; pale gray; saturated; low to medium plasticity; soft to medium.			
	5–6	CL	Same as 2 to 4 above but brown.			
	6–7	SM-SC	Silty (or clayey) sand-gravel; 40 to 50% fines; fine sand to fine gravel; saturated; slight plasticity; very loose.			
	7–12	SM-SC	Same but 35 to 40% fines.			
	12–17	SM	Silty sand-gravel; 15% fines; medium sand to medium gravel; saturated; loose.			Similar to Composite B-2
	17–25	CL	Sandy clay; 25% fine sand with occasional gravel; saturated; medium plasticity; medium stiff; (Blue Clay)			

601-a

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BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 4
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty clay; very dark gray; wet; medium plasticity; medium stiff.			
	1.5	CL	Silty clay; dark gray brown; 10% fine sand; wet; medium plasticity; medium stiff.			Water level @ 3' 10/25/78 Water level @ 3.5' IAD Filled and Capped
	4	SM	Silty sand; 50% fines; medium to coarse with gravel; saturated; loose.			
	5	SM	Same but 15 to 20% fines.			
	8.5	CL	Sandy clay; 15 to 20% fine sand with some gravel and cobbles; gray (blue); saturated; medium plasticity; stiff.			
	13	CL	Same as above but very stiff and 25 to 30% sand.			
	20					

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BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 5
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Fill: Silty clay; road cover.			
	1	CH	Silty clay; black; high plasticity; saturated; soft.			
	3	CH	Silty clay; light gray; saturated; high plasticity; stiff.			Water Level @ 4' 10/25/78 Filled and Capped
	5	CH	Silty clay; dark gray brown; brown; gray; saturated; high plasticity; stiff.			
	6.5	CL-CH	Sandy clay; 20 to 25% sand; saturated; gray (blue); medium to high plasticity; stiff.			
	8	SM	Silty sand; (maybe clayey sand) gray; 40 to 50% fines; saturated; loose. Fine to coarse with some gravel.			
	10	SM	Silty sand; 25 to 30% fines; fine to coarse; saturated; very loose.			Composite B-10 10' to 19'
	19	CL	Sandy clay; 20 to 25% fine sand; gray (blue); saturated; medium.			
	20	SM	Silty sand; as 10 to 19 above.			
	21.5	CL	Sandy clay; 25 to 30% fine sand with some coarse sand; gray (blue); saturated; medium to stiff.			
	25					

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BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 5a
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w = Moisture Content, % — D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 10/25/78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty Clay; with some gravel; moist; very dark grayish brown; medium to stiff.			
	3	GP-SP	Sand-Gravel; some fines; fine sand to medium gravel; moist to wet; medium dense.			
	12	GP-SP	Sand-Gravel; medium sand to coarse gravel; saturated; medium dense.			Water Level @ 12.5' IAD
	15					Composite B-2a 12' to 22'
	22	CL	Sandy Clay; 25 to 30% fine sand with some gravel; gray; saturated; medium plasticity; stiff.			
	25					

601-a

WESTERN LABORATORIES Materials Engineers 825 "J" Street Lincoln, Nebraska BORING LOG	PROJECT Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 5a
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w = Moisture Content, % D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 10/25/78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	25	CL	Same as above.			
	26	SP-SM	Sand-Silty Sand; 10 to 15% fines; fine to coarse with some fine to medium gravel; saturated; loose.			Similar to Composite B-10
	29	CL	Same as 22'-26'			
	30	SP-SM	Same as 26'-29' but also with some cobbles			
	41	CL	Sandy Clay; 25% fine sand with some gravel and cobbles; dark olive gray mottled with dark gray and yellowish brown; saturated; medium plasticity; very stiff.			
	45					

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BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 6
Undisturbed Soil Sampler: 3-in.o.d. thin-walled tube	140-lb. Hammer	30-in. Fall / 2-in.o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 10-25-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty clay; black; wet; medium plasticity; medium stiff.			
	1.5	CL	Sandy clay; 25% fine sand with some gravel; dark brown; very wet; medium plasticity; medium stiff.			
	3	CL	Sandy clay; 40% sand; gravel; saturated; brown low plasticity; soft.			Water Level @ 3.5' IAD Water Level @ 3.75' 4 hrs. AD Filled and Capped
	4	SM	Silty sand; 35 to 40% fines; brown; saturated; very slight plasticity; very loose.			
	7.5	CL	Sandy clay; 25% fine sand with occasional gravel; gray; saturated; medium stiff.			
	11.5	SM	Silty sand; 20 to 35% fines; fine to medium with some coarse sand and medium gravel with occasional cobbles; saturated; loose.			Similar To Composite B-10
	50					

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BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 7
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty clay; very dark grayish brown; moist; medium plasticity; medium stiff. (Topsoil)			
	3	CL-CH	Sandy clay; wet; 20% fine sand; wet; medium to high plasticity; stiff, brown.			
	4.5	SM	Silty sand; moist; 35 to 40% fines; brown; medium dense to loose.			
	8	GP-GW	Sand-gravel; medium sand to coarse gravel; saturated; loose to medium dense.			Water Level @ 8' IAD Water Level @ 8' 10/25/78 Filled and Capped
	30					
		CL	Sandy clay; 20 to 30% fine sand with some gravel; saturated; medium plasticity; very stiff to hard; dark olive gray mottled with dark gray (blue) and reddish brown.			
	35					

601-a

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825 "J" Street Lincoln, Nebraska

BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 8
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty clay; black; wet; medium plasticity; medium stiff. (Topsoil)			
	3	CL	Sandy clay; dark gray mottled with reddish brown; 20 to 25% fine sand with some coarse gravel; wet; medium plasticity; stiff.			Water Level @ 4' IAD Water Level @ 4.5' 10/25/78 Filled and Capped
	5	CL				
	6.5	CL	Sandy clay; dark gray brown; 25 to 30% fine sand; very wet; medium plasticity; stiff.			
			Same but 30 to 40% fine sand; saturated; medium.			
	8.5	CL	Sandy clay; 50% fine sand to coarse gravel; saturated; low plasticity; soft.			
	10	SM	Silty sand; 30 to 40% fines; fine to coarse; saturated; very loose.			Composite B-10 10′ to 18′
	18	CL	Sandy clay; 20 to 30% fine sand with some gravel and cobbles; saturated; medium plasticity; stiff; dark gray (Blue)			
	25					

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BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 8a
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w = Moisture Content, %; D = Dry Density, pcf	Penetration Resistance: N = Blows per foot			Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty clay; black; wet; medium plasticity; medium stiff. (Topsoil)			
	2	CL	Silty clay; light brown; wet; medium plasticity; medium stiff.			
	2.5	CH	Silty clay; 10% fine sand; wet; high plasticity; brown; stiff.			Water Level @ 4.5' IAD Water Level @ 5' 10/25/78 Filled and Capped
	5	CL	Sandy clay; 30% fine sand; brown; saturated; low to medium plasticity; soft.			
		CL	Gravely clay; 30 to 40% fine gravel with some sand; saturated; low to medium plasticity; soft.			
	8.5	GM-GP	Sand-Gravel; 10% fines; medium sand to medium gravel; saturated; loose.			
	11	GP	Gravel; coarse; saturated; loose.			
	14	GP-GW	Gravel; fine to coarse with some coarse sand; saturated; loose to medium dense.			Composite B-11 14′ to 25′
	20					

WESTERN LABORATORIES Materials Engineers 825 "J" Street Lincoln, Nebraska BORING LOG	PROJECT Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 8a
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer | 30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w=Moisture Content, % | D=Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	20	SP-GP	Sand-Gravel; as above but with a lot of medium sand.			
	25	CL	Sandy clay; 25% fine sand with some gravel and cobbles; saturated; medium plasticity; stiff; gray (blue).			
	25.5	SP	S-G as above.			
	25	CL	Sandy clay; as above but very stiff.			
	30					

601-a

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825 "J" Street Lincoln, Nebraska

BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 9
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer / 30-in. Fall / 2-in. o.d. Split-barrel Sampler		Sheet 1 of 2
w = Moisture Content, %	D = Dry Density, pcf	Penetration Resistance: N = Blows per foot	Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Sandy clay; very dark gray brown; wet; medium plasticity; medium to stiff. (Topsoil)			
	2.5	CH	Sandy clay; 10 to 15% fine to medium sand; brown; wet; high plasticity; stiff.			
	4.5	CL	Sandy clay; 30 to 40% sand and gravel; moist; low plasticity; loose; brown.			
	6	SM	Silty sand; 30 to 40% fines; medium sand to coarse gravel with some cobbles; wet; loose.			
	7	CP-GW	Gravel; medium sand to coarse gravel with some cobbles; saturated; loose. Occasional clay seams 3" to 6"			Cave-in at 7.5' on 10/25/78 Cave-in at 8' IAD Filled and Capped
	20					

WESTERN LABORATORIES
Materials Engineers
825 "J" Street Lincoln, Nebraska

BORING LOG

PROJECT
Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 9
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w=Moisture Content, % D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	20	GP GW	Same			Composite B-11 7' to 30'
	30	SP-SW	Sand; fine to coarse; saturated; loose to medium dense.			Composite B-9 30' to 43'
	40					
	43	SP-SM	Sand - Silty sand; fine; 10 to 15% fines; saturated; medium dense.			
	46.5	SM	Silty sand; 25% fines; fine; saturated; medium dense.			
	48	SP	Sand; fine to coarse; saturated; medium dense.			
	50					

601-a

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Materials Engineers

825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test	Boring No. 10
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer / 30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot	Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Fill: Silty clay; very dark gray brown with some gravel; wet; medium plasticity; stiff. Road Fill			Water Level @ 3.5 IAD Water Level @ 4.5 10/25/78 Filled and Capped
	6	CL	Silty clay; black; very wet to saturated; medium plasticity; soft to medium stiff.			
	10	CL	Same but with 15% fine sand.			
	11.5	SM	Silty sand; 25% fines; saturated; gray; medium dense to loose			
	12	SC-CL	Sandy clay - Clayey sand; 45 to 50% fines; saturated; dark gray; low plasticity; loose.			
	13.5	SM	Silty sand; 30% fines; fine to coarse with some fine gravel; saturated; loose.			Composite B-10 13.5′ to 22′
	20					
	22	CL	Sandy clay; 25 to 30% fine sand with some gravel and lime rocks; saturated; medium plasticity; stiff. (Glacial Till)			
	25					

WESTERN LABORATORIES Materials Engineers 825 "J" Street Lincoln, Nebraska BORING LOG	PROJECT Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. 11
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w=Moisture Content, % D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	SM & CL	Fill: Sandy Clay and Silty Sand; 50% sand and gravel; moist; low plasticity; loose to medium dense.			
	8	CL	Fill: Sandy Clay; 30% sand; dark gray mottled with reddish brown; wet; medium plasticity; stiff.			
	10	CL	Sandy clay; black; wet; medium plasticity; medium stiff.			
	11	CL	Sandy clay; 30% sand and gravel; brown; wet; medium plasticity; medium stiff to stiff.			
	13	CL	Same as above but very wet.			
	14.5	SM	Silty sand; 30% fines; fine to coarse with fine to medium gravel; very wet; medium dense to loose.			Water Level at 15.5 ft. immediately after drilling
	16.5	GP-GW	Sand-gravel; coarse sand to medium gravel; saturated; medium dense to loose.			Cave-in at 16 ft. capped and filled 10-25-78
	20					

WESTERN LABORATORIES

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825 "J" Street Lincoln, Nebraska

BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 11
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w=Moisture Content, % / D=Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	20	GP-GW	Same as above but with some coarse.			
	22	CL	Clay			Composite B-11 16.5' to 48.0'
	22.4		As 16.5' to 22'			
	40					
	48		Clay			
	48.2		As 16.5' to 22'			
	50					

WESTERN LABORATORIES
Materials Engineers
825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. 12
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer · 30-in. Fall · 2-in. o.d. Split-barrel Sampler		Sheet 1 of 1
w = Moisture Content, % · D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 10-24-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
	0	CL	Silty clay; 10% gravel; black; wet; medium plasticity; medium plasticity; stiff.			Water level @ 2.25' IAD
	1	CH	Silty clay; some sand and gravel; very dark grayish brown; very wet; high plasticity; soft to medium.			Water level @ 1.1 10/25/78
	2	CH	Silty clay; some sand and gravel; gray; saturated; high plasticity; soft to medium stiff.			
	3	CL	Sandy clay; 30% sand with some gravel and 2" lime rocks; saturated; medium plasticity; soft; gray and reddish yellow.			
	4	CL	Clayey sand; 30% fines; same color as above; with gravel and lime rocks; saturated; low plasticity; loose.			
	7	CL-CH	Sandy clay; 20% sand and gravel; dark gray mottled with reddish brown; saturated; medium plasticity; soft.			
	8	CL	Silty clay; 10 to 15% gravel and sand; gray; saturated; medium to high plasticity; soft.			
	10		Sandy clay; 30% sand with some fine gravel; dary gray (blue gray); saturated; medium plasticity; medium stiff. (Glacial)			
	15					

601-a

WESTERN LABORATORIES Materials Engineers 825 "J" Street Lincoln, Nebraska BORING LOG	PROJECT Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. R-1
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w = Moisture Content, % D = Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 12-5-76

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1229.3	0.0	CL ML	Sandy silt; dark brown to brown; 15% fine sand; moist to wet; medium to low plasticity; medium stiff. (overburden)			App. 400' south of 5a on trail; 100' east of ℄ of tracks. Water at 6.0' after drilling.
	7.0	GW	Gravel; poorly graded; some + 1"; some fines; missing 3/8 to 4.			
	9.0	SP SM	Silty sand; 15 to 20% silt; many - 4 fines.			
	12.0	CL	Silty clay; 20% fine sand; olive gray; some brown; saturated; medium plasticity; stiff.			
	15.5	CL SC	Sandy clay; 25% + fines; occasional + 3/8; saturated; medium plasticity fines; soft; loose.			
	20.0					

WESTERN LABORATORIES

Materials Engineers

825 "J" Street Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. R-1
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w=Moisture Content, %	D=Dry Density, pcf	Penetration Resistance: N=Blows per foot		Date: 12-5-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1209.3	20.0	SC CL	Same as above.			
	25.0	GM SM	Silty sand gravel; 15% silt; nothing + 3/4"; medium dense.			
	40.0	GW GP	Gravel; poorly graded; lot + 3/8; 15% + 3/4. Dense			

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825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. R-2
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer / 30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 12-5-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1228.1		CL ML	Sandy silt; very dark brown to brown; 15% fine sand; moist to wet; low plasticity; medium stiff.			
	5.0	SP	Sand; some gravel.			Water at 7.0' after drilling.
	10.0	CL	Silty clay; 15 to 20% fine sand; olive gray; saturated; medium plasticity; stiff.			
	12.0	SP SM	Silty sand; 15% silt; many - 4 fines.			
	15.0	CL	Silty clay; 15 to 20% fine sand; olive gray to bluish gray; saturated; medium plasticity; stiff.			
	17.0	SC	Sandy clay; 25% + fines. Similar to R-1 at 15+.			
	20.0					

WESTERN LABORATORIES

Materials Engineers

825 "J" Street Lincoln, Nebraska

BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. R-2
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 12-5-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1208.1	20.0		Same as above.			
	25.0	GM SM	Silty sand gravel; 15% silt; occasional + 3/4"; medium dense.			
			See R-1 at same depth.			
	40.0					Broke Hydraulic Hose

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Materials Engineers

825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. R-3
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w=Moisture Content, % D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 12-6-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1233.2	0.0	CL ML	Silty clay; very dark brown; wet; medium to low plasticity; medium stiff.			
	1.0	SM	Silty sand; some + 4.			Water at 8.0' after drilling.
	5.5	GM	Silty gravel; some fine sand; 15 to 20%; silt.			
	14.0	SM GM	Silty sand with some gravel.			
	16.0	CL	Sandy clay; olive gray; saturated; medium plasticity; 15 to 20% sand; stiff.			
	20.0					

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825 "J" Street   Lincoln, Nebraska

BORING LOG

PROJECT

Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger		Standard Penetration Test	Boring No. R-3
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 2 of 2
w=Moisture Content, %	D=Dry Density, pcf	Penetration Resistance: N=Blows per foot	Date: 12-6-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1213.2	20.0		Same as above.			
	21.0	SM SG	Silty sand and gravel; 20% fines; 10% + 4.			
	40.0	GW	Gravel			
	50.0					

601-a

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Materials Engineers

825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test	Boring No. R-4
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer / 30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot	Date: 12-6-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1229.2	0.0	CL	Silty clay; very dark brown to brown; 10 to 15% fine sand.			
	1.0	SM	Silty sand; 15 to 20% silt; some + 4'.			
	7.0	CL ML	Sandy silt; brown to yellowish brown; saturated; 15 to 20% fine sand; low plasticity; medium stiff.			Cave-in at 7.0' after drilling.
	11.0	CL	Sandy clay; blue gray with some olive gray; saturated; medium plasticity; stiff; 10 to 20% sand.			
	20.0	SM	Silty sand; 20 to 25% silt; nothing over + 4.			
	25.0					

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825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test			Boring No. R-6
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall	2-in. o.d. Split-barrel Sampler	Sheet 1 of 1
w=Moisture Content, % D=Dry Density, pcf	Penetration Resistance: N=Blows per foot			Date: 12-6-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1231.4		CL	Fill; silty clay; very dark brown to brown; wet; medium plasticity; stiff.			
		SM	Silty sand; 20% silt.			No Water
		GM	Silty gravel; 20% silt; some fine sand; 20%.			
	12.0	CL	Sandy clay; very dark gray with blue and olive; wet; very medium plasticity; very stiff.			
	15.0					

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Materials Engineers

825 "J" Street — Lincoln, Nebraska

BORING LOG

PROJECT: Black Hawk Lake, Iowa

Boring Method: 6-in. continuous flight auger	Standard Penetration Test		Boring No. R-5
Undisturbed Soil Sampler: 3-in. o.d. thin-walled tube	140-lb. Hammer	30-in. Fall / 2-in. o.d. Split-barrel Sampler	Sheet 1 of 2
w = Moisture Content, % / D = Dry Density, pcf	Penetration Resistance: N = Blows per foot		Date: 12-6-78

Elevation	Depth	Group Symbol	Description of Materials	Sample No.	Blows	Remarks
1229.1		CL	Silty clay; very dark brown; wet; medium plasticity; medium stiff.			
	2.5	SM GM	Sand; silty gravel.			Water at 7.5' after drilling.
	7.0	JM	Silty sand.			
	8.0	CL	Sandy clay; brown to yellowish brown; wet to very wet; medium plasticity; stiff. (Glacial)			
		CL	Sandy clay; blue gray with some olive; 15% fine sand.			
	20.0					

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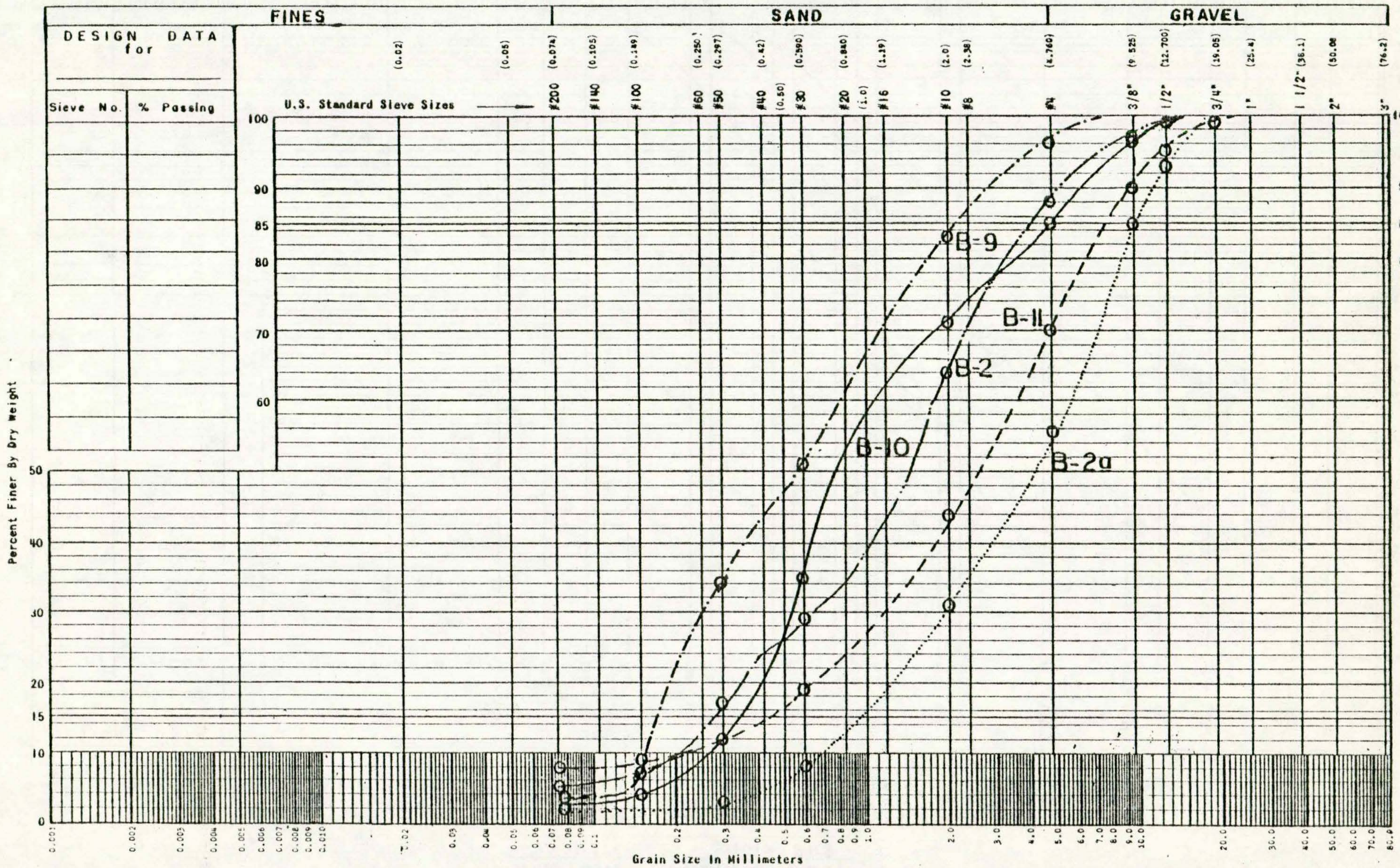
GRAIN SIZE DISTRIBUTION GRAPH

Project ________________ Location ________________



B-4 Composite Sample Number

Sheet No. ____ of ____

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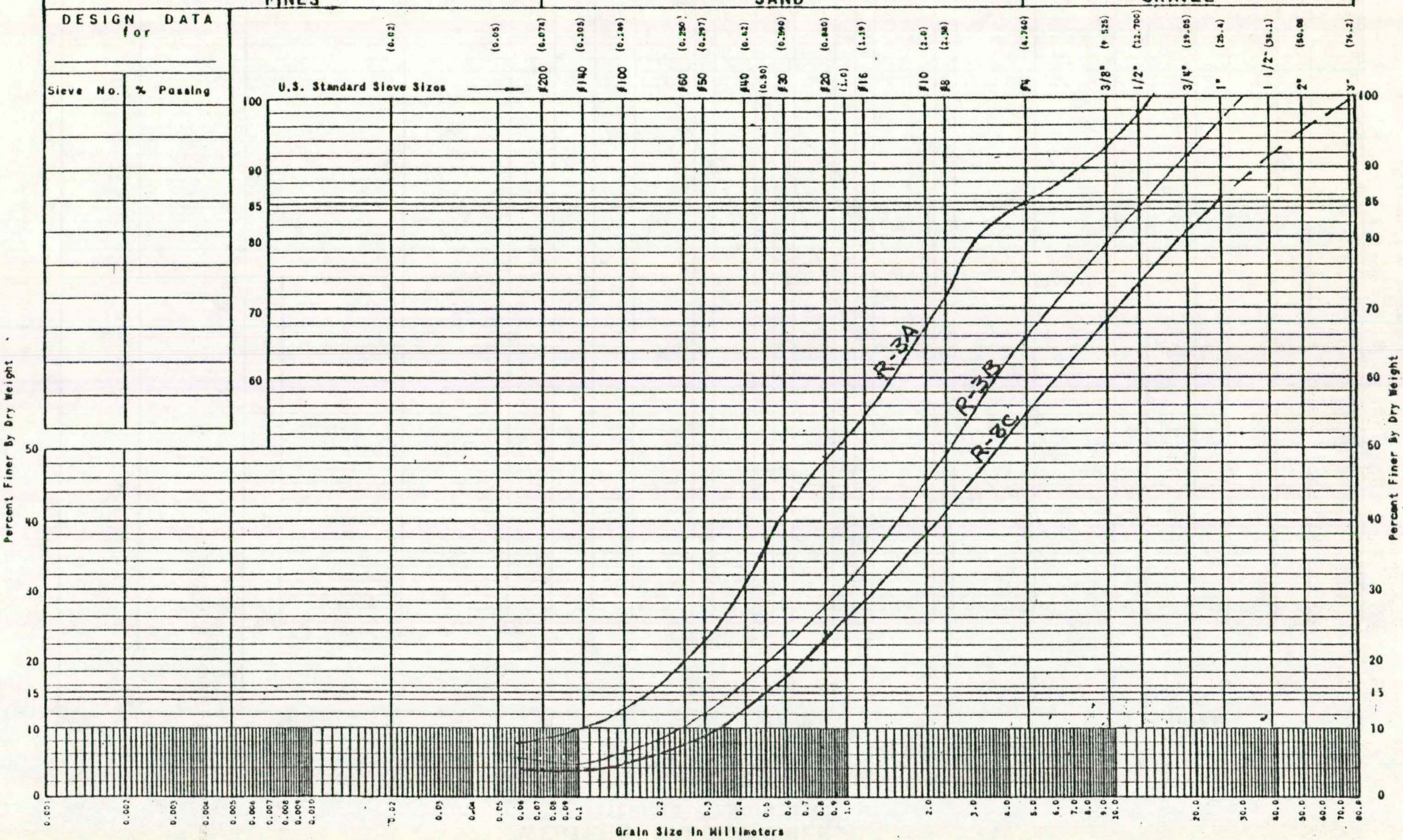
GRAIN SIZE DISTRIBUTION GRAPH

Project BLACK HAWK LAKE 78/3135(2) Location BORE HOLE R-3

DESIGN DATA for	
Sieve No.	% Passing



Sheet No. ___ of ___

Report on Gravel Investigation Along West Side of Sections 4 and 9, T.86N., R.36 W. Sac County.

The interpretations in this report are based on earth-resistivity data obtained on April 14th, 1977. Fred H. Dorheim, Iowa Geological Survey, made the survey and the interpretations. He was assisted by personnel from the Iowa State Conservation Commission.

On the attached aerial photo the numbers circled in red show the location of the E-R stations.

Sta. No.	Overburden	Sand or gravel	
1	0-15'	15-35'	
2	0- 5'	5-20'	
		20-40'	Dirty gravel
3	0-10'	10-35'	
4	0- 4'	4-50'	
5	0- 5'	5-35'	
5A	0-10'	10-40'	
6	0-10'	10-32'	
		32-50'	Dirty gravel
7	0-10'	10-32'	
8	Sandy clay to 50 ft.		
9	0- 5'	5-30'	
10	0- 5'	5-11'	
11	0- 2'	2-20'	
12	0-13'	13-30'	Dirty sand clay from 18 to 20'
13	0- 5'	5-30'	
14	0-10'	10-40'	
15	0-10' Peat and loam	10-30'	
		30-35'	Clay
		35-50'	Sand and gravel
16 Ran this on Dike	0-13' Dike.	13-42'	Sand and gravel.

Stations 2-7 inclusive average 8 feet of overburden and 27 feet of gravel. This works out to be about 13000 yds^3 of overburden and 43,560 yds^3 of sand and gravel per acre. This is a ratio of sand and gravel to overburden of about 3 to 1.

Station 8 does not look good.

Stations 9-15 inclusive average 7 feet of overburden and 20 feet of sand and gravel. This works out to be about 11000 yds^3 of overburden and 32,000 yds^3 of gravel per acre. The ratio of sand and gravel to overburden is about 3 to 1.

I talked with Mr. James Myers at DOT about quality of the material in the area. During the period 1971-1976 their tests on material from Halle H's pit (the nearest pit) show that the material was accepted for asphaltic concrete. The gradation showed 25 to 30% plus 4 (gravel) and 70-75% sand.

Fred H. Dorheim
Chief Geologist, IGS

APPENDIX B

SAMPLE LIST

Sample Number	Where Sampled	
Composite B-2	B-2	4' - 37.5'
Composite B-2A	B-2a	2' - 46'
	B-5a	12' - 22'
Composite B-9	B-9	30' - 43'
Composite B-10	B-10	3.5' - 22'
	B-8	10' - 18'
	B-5	10' - 19'
Composite B-11	B-11	16.5' - 48'
	B-9	7' - 30'
	B-7	8' - 31'
	B-8a	14' - 25'

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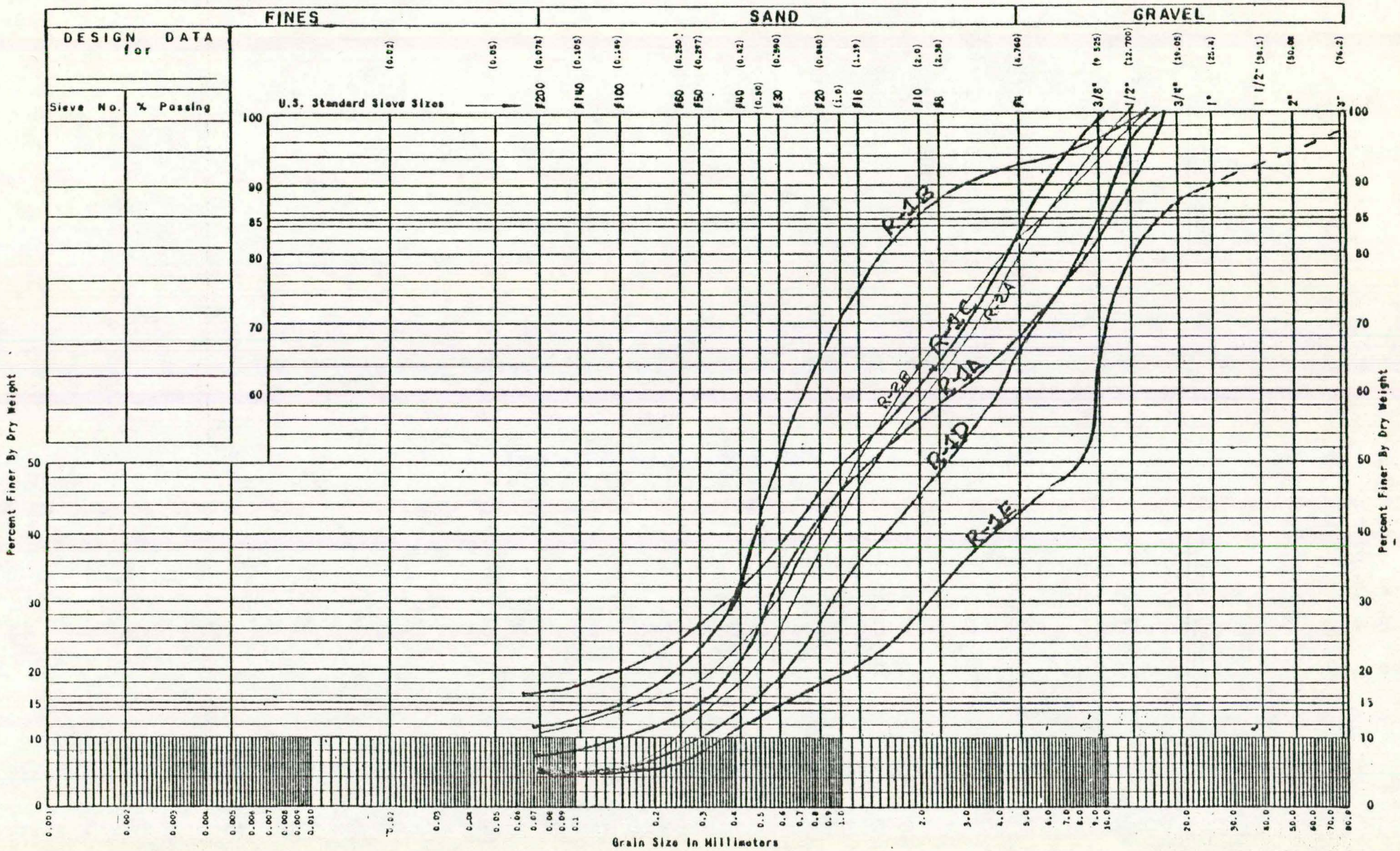
GRAIN SIZE DISTRIBUTION GRAPH

Project BLACK HAWK LAKE 78/3135(2) Location BORE HOLES R-1 & R-2

DESIGN DATA for

Sieve No.	% Passing



Sheet No. ___ of ___

DES MOINES RIVER BASIN

05482315 BLACKHAWK LAKE AT LAKE VIEW, IOWA

LOCATION.--Lat 42°18'15", long 95°02'30", in NW1/4 SE1/4 sec.33, T.87 N., R.36 W., Sac County, on south shore across from swimming beach at Lake View and 2 mi (3.2 km) upstream from lake outlet.

DRAINAGE AREA.--23.3 mi² (60.3 km²).

PERIOD OF RECORD.--April 1970 to September 1975 (discontinued).

GAGE.--Water-stage recorder. Datum of gage is 1,218.50 ft (371.40 m) above mean sea level and 2.00 ft (0.61 m) below crest of spillway of dam at outlet. Prior to June 25, 1970, nonrecording gage at lake outlet.

EXTREMES.--Current year: Maximum gage height, 2.67 ft (0.814 m) Apr. 27; minimum, 1.30 ft (0.396 m) Sept. 30.
Period of record: Maximum gage height, 3.45 ft (1.052 m) Feb. 20, 1971; minimum, 0.59 ft (0.180 m) Oct. 27, 1971.

REMARKS.--Lake is formed by concrete dam with ungated overflow spillway at elevation 1,220.50 ft (372.008 m) above mean sea level. Lake is used for conservation and recreation. Area of lake is approximately 957 acres (390 hm²).

GAGE HEIGHT, IN FEET, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.69	1.61	1.57	1.59	1.75	1.80	2.46	2.55	2.27	2.27	1.76	1.58
2	1.69	1.60	1.57	1.61	1.75	1.80	2.45	2.53	2.26	2.25	1.77	1.58
3	1.69	1.59	1.57	1.63	1.75	1.80	2.43	2.51	2.25	2.23	1.75	1.55
4	1.68	1.59	1.56	1.63	1.78	1.79	2.44	2.49	2.25	2.22	1.74	1.56
5	1.65	1.59	1.56	1.63	1.80	1.80	2.43	2.46	2.22	2.20	1.72	1.59
6	1.64	1.58	1.56	1.63	1.80	1.81	2.44	2.48	2.20	2.18	1.70	1.59
7	1.65	1.58	1.56	1.63	1.79	1.84	2.44	2.47	2.20	2.16	1.68	1.56
8	1.64	1.59	1.55	1.64	1.80	1.84	2.46	2.47	2.21	2.14	1.63	1.55
9	1.64	1.60	1.55	1.64	1.80	1.84	2.48	2.45	2.24	2.12	1.62	1.55
10	1.64	1.60	1.55	1.67	1.80	1.85	2.49	2.44	2.23	2.10	1.63	1.53
11	1.64	1.58	1.55	1.75	1.80	1.85	2.48	2.46	2.29	2.07	1.66	1.55
12	1.63	1.57	1.55	1.74	1.80	1.86	2.47	2.46	2.30	2.05	1.58	1.54
13	1.64	1.58	1.54	1.73	1.80	1.86	2.45	2.44	2.30	2.03	1.65	1.54
14	1.60	1.58	1.55	1.73	1.79	1.87	2.45	2.39	2.31	2.02	1.65	1.53
15	1.61	1.60	1.59	1.74	1.79	1.86	2.44	2.37	2.30	2.01	1.63	1.52
16	1.60	1.60	1.59	1.75	1.79	1.86	2.45	2.38	2.32	1.99	1.62	1.51
17	1.60	1.60	1.58	1.75	1.80	1.86	2.42	2.34	2.30	1.96	1.60	1.52
18	1.59	1.60	1.58	1.74	1.81	1.87	2.41	2.32	2.36	1.92	1.60	1.48
19	1.58	1.58	1.58	1.75	1.81	1.88	2.39	2.32	2.40	1.92	1.60	1.43
20	1.59	1.57	1.58	1.74	1.81	1.93	2.38	2.31	2.39	1.91	1.59	1.42
21	1.59	1.60	1.59	1.76	1.81	2.12	2.42	2.28	2.39	1.89	1.57	1.43
22	1.55	1.59	1.60	1.75	1.81	2.29	2.42	2.29	2.39	1.89	1.57	1.43
23	1.55	1.56	1.59	1.75	1.81	2.39	2.44	2.27	2.37	1.89	1.52	1.42
24	1.55	1.55	1.59	1.75	1.81	2.46	2.45	2.24	2.38	1.87	1.54	1.41
25	1.54	1.57	1.59	1.75	1.80	2.45	2.45	2.23	2.38	1.86	1.49	1.40
26	1.53	1.57	1.59	1.75	1.80	2.45	2.49	2.24	2.37	1.85	1.48	1.39
27	1.54	1.54	1.60	1.75	1.80	2.50	2.49	2.22	2.35	1.83	1.54	1.39
28	1.55	1.55	1.60	1.75	1.80	2.51	2.60	2.28	2.34	1.83	1.57	1.39
29	1.56	1.55	1.59	1.76	------	2.50	2.60	2.29	2.32	1.79	1.60	1.38
30	1.57	1.57	1.59	1.75	------	2.49	2.58	2.28	2.30	1.78	1.60	1.36
31	1.60	------	1.59	1.75	------	2.48	------	2.27	------	1.75	1.60	------
MEAN	1.61	1.58	1.57	1.71	1.80	2.05	2.46	2.37	2.31	2.00	1.62	1.49
MAX	1.69	1.61	1.60	1.76	1.81	2.51	2.60	2.55	2.40	2.27	1.77	1.59
MIN	1.53	1.54	1.54	1.59	1.75	1.79	2.38	2.22	2.20	1.75	1.48	1.36

WTR YR 1975 MEAN 1.88 MAX 2.60 MIN 1.36

05482315 BLACKHAWK LAKE AT LAKE VIEW, IOWA

LOCATION.--Lat 42°18'15", long 95°02'30", in NW1/4 SE1/4 sec.33, T.87 N., R.36 W., Sac County, on south shore across from swimming beach at Lake View and 2 miles upstream from lake outlet.
DRAINAGE AREA.--23.3 sq mi.
PERIOD OF RECORD.--April 1970 to current year.
GAGE.--Water-stage recorder. Datum of gage is 1,218.50 ft above mean sea level and 2.00 ft below crest of spillway of dam at outlet. Prior to June 25, 1970, nonrecording gage at lake outlet.

GAGE HEIGHT, IN FEET, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.51	2.86	2.71	2.78	2.75	3.03	2.76	2.77	2.81	2.65	2.56	2.16
2	2.50	2.93	2.71	2.79	2.73	3.30	2.76	2.85	2.80	2.81	2.53	2.14
3	2.49	2.97	2.69	2.82	2.70	3.36	2.76	2.90	2.77	3.02	2.50	2.12
4	2.48	3.00	2.68	2.80	2.68	3.35	2.73	2.92	2.78	3.08	2.49	2.10
5	2.48	3.04	2.67	2.76	2.68	3.30	2.70	2.90	2.78	3.07	2.47	2.07
6	2.46	3.03	2.67	2.73	2.68	3.26	2.69	2.89	2.75	3.00	2.42	2.06
7	2.44	3.03	2.66	2.69	2.68	3.24	2.65	2.90	2.72	2.92	2.41	2.05
8	2.43	3.06	2.65	2.67	2.66	3.20	2.65	2.98	2.67	2.85	2.39	2.06
9	2.44	3.09	2.64	2.65	2.65	3.17	2.62	3.01	2.65	2.81	2.37	2.07
10	2.44	3.12	2.63	2.63	2.64	3.15	2.62	2.99	2.60	2.75	2.35	2.07
11	2.41	3.15	2.62	2.62	2.63	3.24	2.61	2.94	2.56	2.70	2.34	2.07
12	2.40	3.16	2.64	2.60	2.62	3.28	2.63	2.88	2.57	2.64	2.32	2.07
13	2.39	3.17	2.64	2.58	2.63	3.27	2.68	2.85	2.59	2.60	2.32	2.07
14	2.38	3.19	2.62	2.57	2.64	3.34	2.70	2.81	2.60	2.55	2.31	2.05
15	2.38	3.10	2.61	2.57	2.63	3.30	2.73	2.78	2.63	2.52	2.30	2.07
16	2.35	3.00	2.60	2.58	2.60	3.24	2.84	2.72	2.60	2.49	2.30	2.11
17	2.35	2.93	2.59	2.70	2.59	3.17	2.89	2.71	2.57	2.47	2.31	2.12
18	2.34	2.89	2.58	2.95	2.58	3.13	2.88	2.67	2.62	2.43	2.29	2.13
19	2.33	2.85	2.57	3.00	2.57	3.07	2.90	2.66	2.71	2.43	2.27	2.12
20	2.37	2.82	2.57	2.97	2.57	3.01	2.84	2.65	2.76	2.45	2.25	2.12
21	2.40	2.79	2.56	2.96	2.56	2.96	2.76	2.63	2.76	2.49	2.25	2.12
22	2.45	2.77	2.56	2.95	2.56	2.93	2.70	2.60	2.74	2.50	2.23	2.11
23	2.58	2.76	2.55	2.90	2.57	2.90	2.69	2.58	2.70	2.51	2.26	2.12
24	2.66	2.75	2.55	2.87	2.58	2.94	2.68	2.53	2.70	2.55	2.25	2.14
25	2.70	2.71	2.54	2.83	2.65	2.98	2.78	2.51	2.64	2.56	2.25	2.16
26	2.73	2.71	2.53	2.81	2.74	2.96	2.82	2.58	2.63	2.54	2.23	2.67
27	2.73	2.70	2.52	2.80	2.78	2.93	2.81	2.68	2.57	2.52	2.21	3.06
28	2.74	2.71	2.50	2.79	2.80	2.87	2.81	2.77	2.55	2.50	2.21	3.21
29	2.75	2.72	2.55	2.77	------	2.83	2.78	2.83	2.52	2.56	2.19	3.25
30	2.77	2.72	2.68	2.75	------	2.80	2.77	2.84	2.51	2.61	2.18	3.22
31	2.81	------	2.76	2.73	------	2.78	------	2.82	------	2.59	2.18	------
MEAN	2.51	2.92	2.61	2.76	2.65	3.11	2.74	2.78	2.66	2.65	2.32	2.26
MAX	2.81	3.19	2.76	3.00	2.80	3.36	2.90	3.01	2.81	3.08	2.56	3.25
MIN	2.33	2.70	2.50	2.57	2.56	2.78	2.61	2.51	2.51	2.43	2.18	2.05

WTR YR 1973 MEAN 2.67 MAX 3.36 MIN 2.05

GAGE HEIGHT, IN FEET, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.16	2.58	2.67	2.48	2.48	2.60	2.36	2.42	2.90	2.37		1.98
2	3.11	2.55	2.65	2.47	2.49	2.60	2.40	2.38	2.85	2.35		1.98
3	3.05	2.55	2.63	2.46	2.48	2.65	2.42	2.35	2.82	2.35		1.98
4	2.99	2.55	2.60	2.45	2.48	2.67	2.46	2.35	2.76	2.35		1.97
5	2.94	2.53	2.60	2.44	2.46	2.68	2.51	2.33	2.74	2.35		1.97
6	2.90	2.54	2.60	2.45	2.46	2.67	2.53	2.33	2.70	2.34		1.96
7	2.89	2.52	2.59	2.45	2.45	2.65	2.53	2.35	2.69	2.32		1.94
8	2.86	2.50	2.58	2.44	2.44	2.65	2.52	2.35	2.70	2.30	2.00	1.94
9	2.85	2.50	2.57	2.44	2.44	2.65	2.52	2.36	2.69	2.27	2.01	1.93
10	2.87	2.49	2.55	2.43	2.43	2.65	2.54	2.40	2.63	2.30	2.02	1.93
11	3.03	2.48	2.54	2.43	2.42	2.66	2.55	2.44	2.60	2.30	2.01	1.91
12	3.18	2.49	2.54	2.43	2.43	2.65	2.54	2.44	2.59	2.30	2.00	1.93
13	3.20	2.47	2.54	2.42	2.44	2.65	2.52	2.56	2.57	2.26	2.01	1.93
14	3.18	2.51	2.54	2.42	2.46	2.64	2.53	2.54	2.55	2.25	2.03	1.91
15	3.13	2.54	2.53	2.41	2.48	2.58	2.55	2.56	2.50		2.03	1.91
16	3.08	2.55	2.53	2.40	2.48	2.55	2.56	2.57	2.47		2.05	1.91
17	3.02	2.55	2.52	2.41	2.50	2.55	2.55	2.60	2.45		2.07	1.88
18	2.97	2.52	2.51	2.41	2.55	2.52	2.55	2.82	2.45		2.10	1.88
19	2.92	2.54	2.50	2.42	2.60	2.50	2.56	3.16	2.44		2.11	1.87
20	2.90	2.64	2.49	2.42	2.62	2.50	2.57	3.27	2.44		2.10	1.86
21	2.86	2.70	2.48	2.44	2.62	2.48	2.49	3.25	2.42		2.09	1.83
22	2.82	2.75	2.48	2.45	2.64	2.46	2.46	3.22	2.50		2.08	1.83
23	2.80	2.77	2.47	2.45	2.62	2.47	2.45	3.15	2.51		2.07	1.83
24	2.75	2.77	2.50	2.45	2.60	2.45	2.46	3.09	2.50		2.07	1.79
25	2.70	2.77	2.54	2.45	2.59	2.44	2.44	3.05	2.50		2.05	1.78
26	2.68	2.76	2.54	2.45	2.58	2.43	2.45	3.05	2.49		2.04	1.77
27	2.65	2.73	2.54	2.45	2.57	2.43	2.45	3.02	2.46		2.05	1.76
28	2.62	2.71	2.53	2.45	2.60	2.42	2.45	2.96	2.45		2.04	1.74
29	2.61	2.70	2.52	2.45	------	2.40	2.43	3.04	2.45		2.03	1.71
30	2.60	2.68	2.51	2.45	------	2.40	2.41	3.00	2.42		2.01	1.70
31	2.58	------	2.49	2.46	------	2.42	------	2.94	------		1.99	------
MEAN	2.90	2.60	2.54	2.44	2.51	2.55	2.49	2.72	2.57			1.88
MAX	3.20	2.77	2.67	2.48	2.64	2.68	2.57	3.27	2.90			1.98
MIN	2.58	2.47	2.47	2.40	2.42	2.40	2.36	2.33	2.39			1.70

DES MOINES RIVER BASIN

05482315 BLACKHAWK LAKE AT LAKE VIEW, IOWA

LOCATION.--Lat 42°18'15", long 95°02'30", in NW1/4 SE1/4 sec.33, T.87 N., R.36 W., Sac County, on south shore across from swimming beach at Lake View and 2 miles upstream from lake outlet.
DRAINAGE AREA.--23.3 sq mi.
PERIOD OF RECORD.--April 1970 to current year.
GAGE.--Water-stage recorder. Datum of gage is 1,218.50 ft above mean sea level and 2.00 ft below crest of spillway of dam at outlet. Prior to June 25, 1970, nonrecording gage at lake outlet.

GAGE HEIGHT, IN FEET, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.63	1.79	2.01	2.04	2.06	2.86	2.76	2.25	2.23	1.97	1.55	1.12
2	1.59	1.80	2.02	2.03	2.06	2.81	2.72	2.24	2.23	1.95	1.54	1.10
3	1.58	1.83	1.96	2.08	2.05	2.76	2.71	2.25	2.23	1.94	1.53	1.09
4	1.58	1.81	2.01	2.11	2.07	2.72	2.68	2.23	2.23	1.93	1.52	1.08
5	1.58	1.82	1.98	2.10	2.09	2.68	2.65	2.26	2.23	1.93	1.49	1.04
6	1.58	1.80	2.00	2.09	2.08	2.66	2.63	2.25	2.26	1.93	1.48	1.02
7	1.60	1.82	2.00	2.09	2.08	2.64	2.61	2.24	2.29	1.94	1.47	1.02
8	1.70	1.84	2.00	2.10	2.08	2.62	2.58	2.23	2.30	1.93	1.45	.99
9	1.79	1.87	2.00	2.09	2.08	2.60	2.55	2.23	2.31	1.93	1.44	.97
10	1.84	1.88	2.03	2.09	2.07	2.59	2.55	2.24	2.31	1.95	1.42	.95
11	1.84	1.88	2.06	2.08	2.07	2.60	2.49	2.23	2.29	1.96	1.40	.94
12	1.84	1.89	2.06	2.08	2.07	2.75	2.47	2.21	2.28	1.95	1.38	.92
13	1.84	1.89	2.06	2.08	2.08	3.01	2.43	2.19	2.27	1.92	1.37	.91
14	1.83	1.88	2.06	2.08	2.08	3.16	2.42	2.18	2.25	1.91	1.36	.87
15	1.83	1.88	2.06	2.08	2.08	3.15	2.43	2.17	2.25	1.88	1.35	.85
16	1.83	1.88	2.07	2.08	2.08	3.07	2.38	2.16	2.24	1.86	1.33	.83
17	1.81	1.88	2.07	2.08	2.08	3.00	2.40	2.15	2.23	1.85	1.32	.82
18	1.81	1.89	2.07	2.08	2.25	2.97	2.40	2.19	2.20	1.82	1.29	.81
19	1.82	1.96	2.07	2.08	3.10	2.97	2.38	2.24	2.19	1.78	1.30	.81
20	1.82	1.96	2.07	2.08	3.44	2.92	2.38	2.27	2.15	1.77	1.30	.80
21	1.82	1.98	2.06	2.08	3.37	2.89	2.41	2.29	2.14	1.74	1.28	.78
22	1.82	1.90	2.06	2.07	3.33	2.86	2.38	2.31	2.12	1.72	1.25	.79
23	1.82	1.97	2.06	2.07	3.23	2.84	2.33	2.29	2.10	1.72	1.24	.81
24	1.82	1.97	2.05	2.07	3.13	2.81	2.33	2.25	2.08	1.69	1.23	.82
25	1.83	1.96	2.05	2.07	3.06	2.79	2.32	2.24	2.05	1.67	1.21	.85
26	1.82	1.96	2.05	2.07	3.00	2.77	2.32	2.24	2.04	1.64	1.19	.86
27	1.82	1.96	2.04	2.07	2.96	2.76	2.30	2.23	2.00	1.63	1.17	.86
28	1.81	1.98	2.04	2.07	2.91	2.79	2.26	2.23	1.96	1.62	1.16	.84
29	1.81	1.99	2.04	2.07	------	2.82	2.28	2.22	1.95	1.61	1.14	.87
30	1.80	2.00	2.04	2.07	------	2.83	2.26	2.23	1.98	1.58	1.13	.88
31	1.80	------	2.04	2.07	------	2.82	------	2.24	------	1.57	1.12	------

GAGE HEIGHT, IN FEET, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.85	1.15	1.16	1.24	1.24	1.36	2.18	2.50	2.48	2.75	2.74	2.31
2	.84	1.14	1.16	1.24	1.25	1.48	2.20	2.52	2.46	2.75	2.76	2.31
3	.80	1.12	1.16	1.23	1.25	1.59	2.17	2.57	2.47	2.73	2.74	2.30
4	.80	1.14	1.16	1.23	1.25	1.63	2.19	2.59	2.47	2.69	2.71	2.29
5	.75	1.10	1.17	1.23	1.25	1.64	2.20	2.61	2.49	2.67	2.68	2.28
6	.75	1.05	1.17	1.23	1.25	1.66	2.20	2.66	2.51	2.66	2.66	2.28
7	.75	1.10	1.17	1.23	1.25	1.78	2.21	2.69	2.58	2.65	2.65	2.27
8	.70	1.10	1.18	1.23	1.26	1.87	2.20	2.71	2.68	2.64	2.61	2.26
9	.70	1.09	1.19	1.23	1.27	1.92	2.18	2.71	2.72	2.63	2.59	2.26
10	.70	1.08	1.19	1.23	1.30	1.96	2.18	2.71	2.73	2.60	2.58	2.32
11	.68	1.08	1.19	1.22	1.30	1.98	2.19	2.71	2.68	2.59	2.55	2.54
12	.68	1.08	1.19	1.22	1.30	2.01	2.18	2.70	2.66	2.59	2.54	2.67
13	.66	1.12	1.18	1.21	1.30	2.04	2.16	2.71	2.73	2.58	2.52	2.74
14	.65	1.05	1.18	1.21	1.30	2.06	2.17	2.69	2.80	2.56	2.50	2.78
15	.65	1.09	1.19	1.21	1.30	2.07	2.17	2.68	2.82	2.55	2.48	2.78
16	.67	1.09	1.19	1.20	1.30	2.09	2.17	2.66	2.82	2.53	2.45	2.77
17	.67	1.14	1.20	1.20	1.31	2.11	2.18	2.64	2.86	2.90	2.42	2.75
18	.73	1.12	1.20	1.20	1.30	2.12	2.16	2.61	2.91	3.31	2.40	2.74
19	.69	1.12	1.20	1.20	1.30	2.13	2.17	2.59	2.94	3.41	2.38	2.74
20	.70	1.10	1.20	1.20	1.30	2.13	2.19	2.56	2.89	3.39	2.36	2.71
21	.72	1.12	1.20	1.20	1.29	2.13	2.22	2.54	2.85	3.27	2.34	2.67
22	.71	1.14	1.20	1.19	1.29	2.15	2.22	2.52	2.80	3.12	2.30	2.64
23	.71	1.13	1.19	1.22	1.29	2.17	2.19	2.54	2.76	3.00	2.29	2.62
24	.72	1.13	1.19	1.23	1.29	2.17	2.21	2.54	2.72	2.98	2.28	2.59
25	.72	1.13	1.19	1.23	1.31	2.17	2.22	2.52	2.69	2.92	2.32	2.59
26	.71	1.13	1.19	1.23	1.31	2.20	2.22	2.51	2.67	2.89	2.33	2.58
27	.77	1.14	1.18	1.24	1.31	2.20	2.25	2.53	2.67	2.83	2.33	2.58
28	.80	1.16	1.18	1.24	1.31	2.20	2.36	2.54	2.75	2.78	2.32	2.56
29	.91	1.16	1.19	1.24	1.31	2.18	2.41	2.52	2.78	2.73	2.32	2.54
30	1.07	1.16	1.23	1.24	------	2.20	2.47	2.51	2.78	2.69	2.32	2.52
31	1.12	------	1.24	1.24	------	2.18	------	2.49	------	2.65	2.32	------
MEAN	.75	1.12	1.19	1.22	1.29	1.99	2.21	2.60	2.71	2.81	2.48	2.53
MAX	1.12	1.16	1.24	1.24	1.31	2.20	2.47	2.71	2.94	3.41	2.76	2.78
MIN	.65	1.05	1.16	1.19	1.24	1.36	2.16	2.49	2.46	2.53	2.28	2.26

WTR YR 1972 MEAN 1.91 MAX 3.41 MIN .65

APPENDIX D

BASIN WATER BUDGET

		Inflow Gallons/year	Outflow Gallons/year
(B.A.)	Basin 23.3 $Mi.^2 = 6.50 \times 10^8 ft.^2$		
(L.A.)	Black Hawk Lake 957 acres = $0.417 \times 10^8 ft.^2$		
(D.A.)	Drainage Area BA-LA = $6.08 \times 10^8 ft.^2$		
(Ppt.)	Annual Precipitation = 28"/year or 2.33 feet/year		
	Volume of Precipitation over Basin = (Ppt.) x (BA) x 7.48 gallons per cubic foot $(g/ft.^3)$* =	$+1.13 \times 10^{10}$	
(R.)	Recharge=0.25 ft./yr.		
	0.25 ft./yr. x (B.A.) x $(7.48g/ft.^3)$*	0.12×10^{10}	
(ET)	Evapotranspiration = 2.0 ft/yr.		
	2.0 ft./yr. x (B.A.) x $(7.48g/ft.^3)$*		-9.72×10^9
(RU)	Runoff=(Volppt) - (R) - (ET) = RU		-0.39×10^9
(QL)	Basin Surface Discharge at Lake Weir		-0.23×10^9
(C.W.)	City Wells 350 gpm x 1440 Min/day x 365 days		-0.18 x 10
(Sub.)	Leakage of Groundwater out of Basin approximately 1,400 gal/day		
		1.25×10^{10}	1.13×10^{10}

Unknown 2300 gal/min. perhaps local domestic and livestock use.

Difference = 12×10^8 gallons per year

*A constant equating gallons of water to cubic feet of water

APPENDIX D (Cont'd.)

BLACK HAWK WATER BUDGET

	Inflow Gallons/year	Outflow Gallons/year
Runoff	3.88×10^8	
Precipitation directly on Lake 2.33 ft. x L.A. x 7.48 gal/ft.	7.27×10^8	
Groundwater Infiltration (150' x 6') x 1300 feet/day x 365 days	4.27×10^8	
Lake Evapotranspiration = 3.28 ft/yr. x (L.A.) x 7.48g/ft.^{3}		1.02×10^9
Lake Discharge		2.26×10^8
	1.54×10^9	1.25×10^9

2.96×10^8 Gallons/year

Difference which is equivalent to 563 gallons per minute. Possible sources of this difference could be groundwater seepage or municipal and private well discharge

APPENDIX C
PUMP TESTS SUMMARY

Drawdown (Radius of Influence)

West Central Iowa Rural Water Association

Q Max.: 188,000,000 gallons per year

Max. Rate: 6,000 gpm

(Two Wells) one used, the other in backup Q = 358 gpm

Single Well Radius of Influence

$s = \frac{114.6}{T} Wu$ (drawdown in feet at any point in discharging well vicinity)

Q = 358 gpm (pumping rate)

T = 66,600 gpd/ft. (coefficient of aquifer transmissibility)

S = .25 (a dimensionless coefficient of storage)

r = distance in feet from center of pumped well to point where drawdown is measured

t = Time since pumping began in days

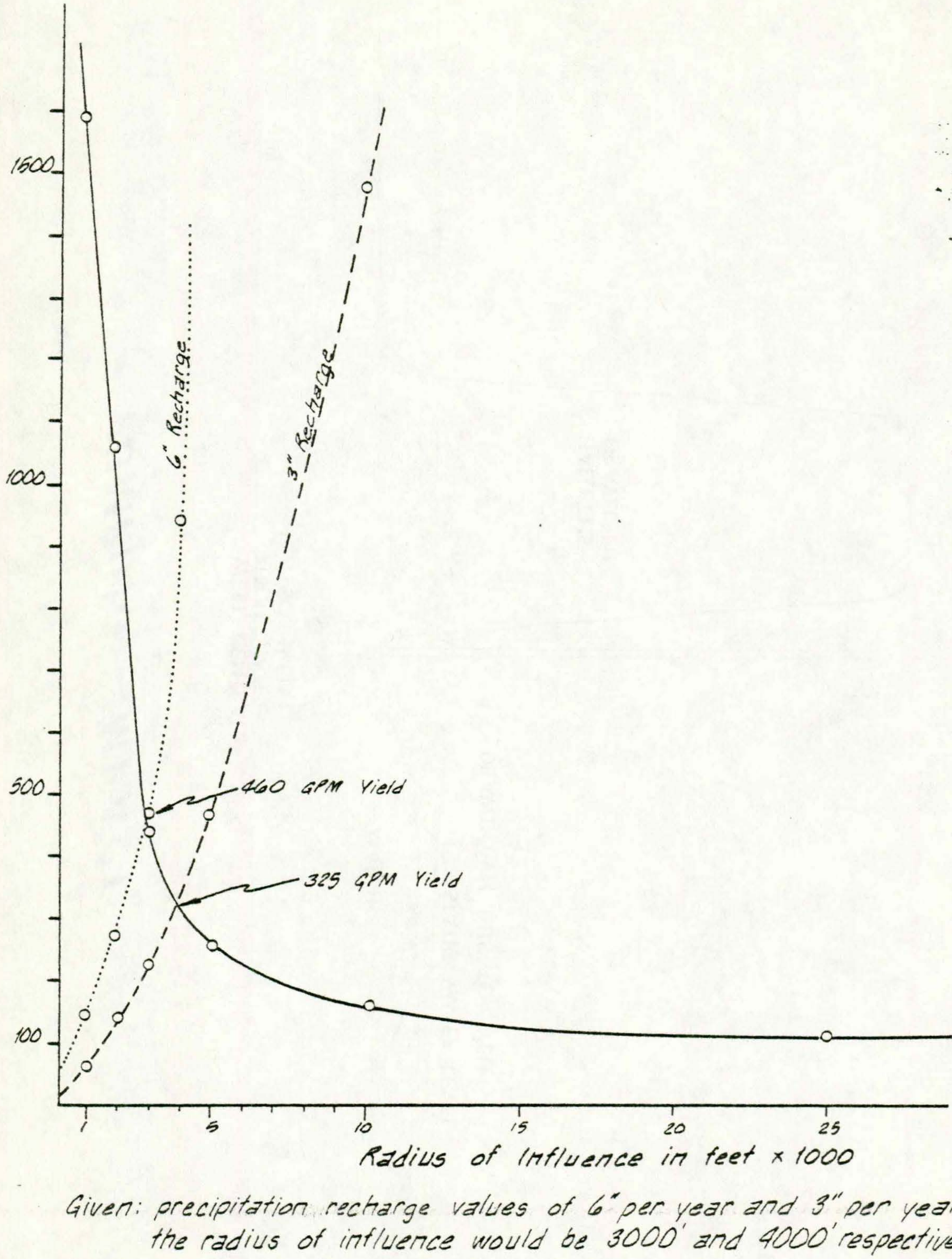
$u = \frac{1.87\ r^2 S}{Tt}$ $Wu = \frac{.sT}{114.6}$

(Values of u) Radius

Days	100 Ft.	225 Ft.	3225	5000
10	7×10^{-3}	3.5×10^{-2}	7.3	17.5
100	7×10^{-4}	3.5×10^{-3}	0.73	1.75
365	1.9×10^{-4}	9.7×10^{-4}	0.20	4.8×10^{-1}
1000	7×10^{-5}	3.5×10^{-4}	7.3×10^{-2}	1.7×10^{-1}

(Values of Wu)

10	4.3916	2.8099	.00008239	
100	6.6879	5.0813	.3532	.07465
365	7.9915	6.3620	1.22227	.5848
1000	8.9899	7.3807	2.1118	1.35278

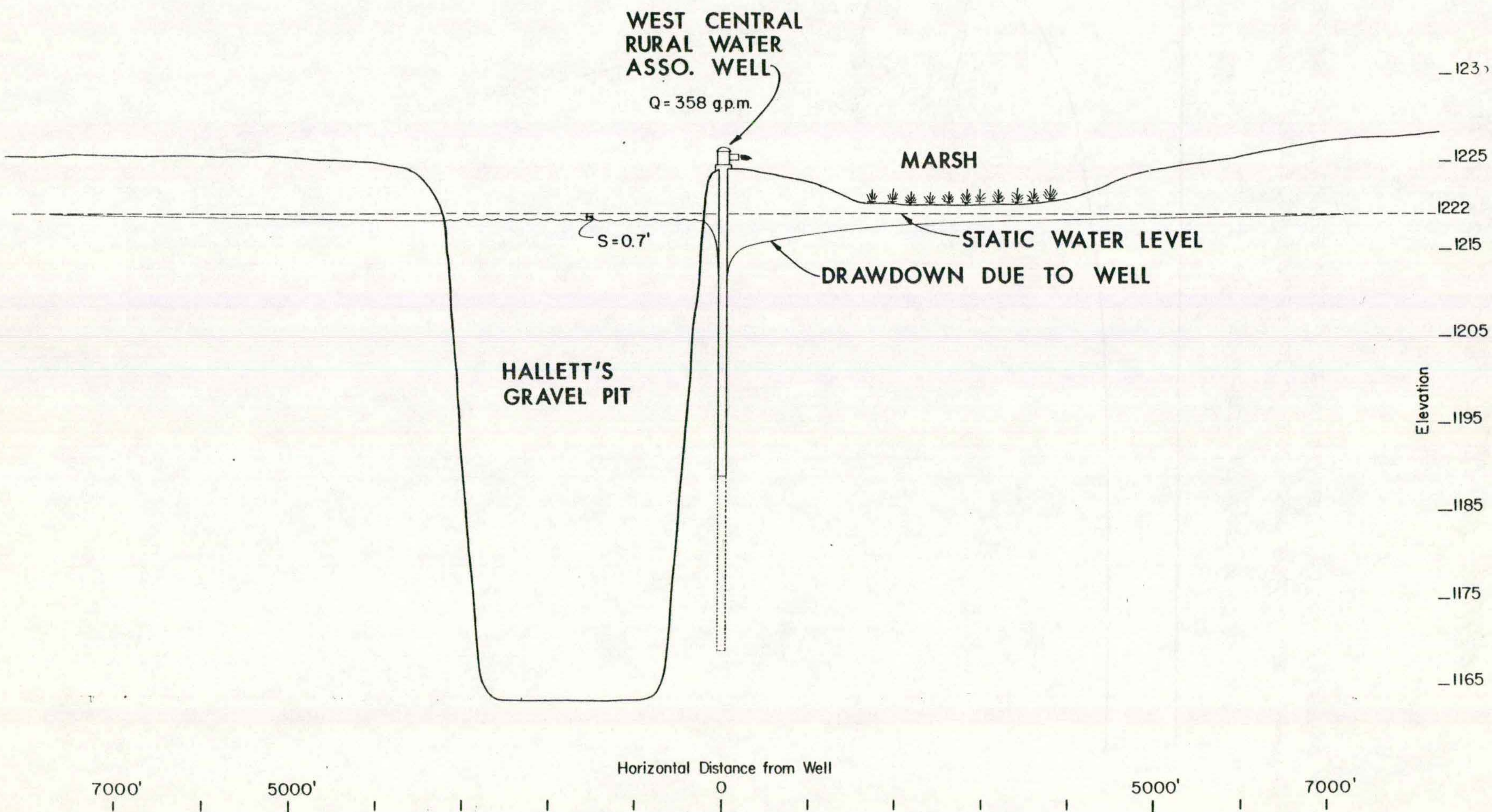


Given: precipitation recharge values of 6" per year and 3" per year - the radius of influence would be 3000' and 4000' respectively.

RADIUS OF INFLUENCE AS A FUNCTION OF PUMP DISCHARGE AND PRECIPITATION RECHARGE

Appendix F

PUMPING IMPACT



Appendix E

(After 365 Days)

(Land Side) Radius (r)	Drawdown(s)	(Pit Side) (r)	(s)
100 ft.	4.9'		
225 ft.	3.9'	225'	0.7'
3,225	0.7'	3,225'	0.7'
5,000	0.4'	5,000'	0.4'
6,000	0.2'	6,000'	0.2'
7,000	0.15'		

WESTERN LABORATORIES
Analytical Services
P. O. BOX 80358
LINCOLN, NEBRASKA 68501

Date: February 20, 1979

For: Blackhawk Lake
Job #78/3025-2

Date Received: 1/79
Date Tested: 1/79
Sample of: Water
Laboratory Identification No.
Field Identification No.

	Total Dissolved Solids	Total Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Total Iron as Fe
Sample B	395 mg/l	205 mg/l	305 mg/l	0.2 mg/l
Sample C	315 mg/l	136 mg/l	242 mg/l	1.7 mg/l
Sample E	620 mg/l	370 mg/l	492 mg/l	0.5 mg/l
Sample G	290 mg/l	160 mg/l	221 mg/l	0.8 mg/l
Sample H	230 mg/l	182 mg/l	211 mg/l	0.4 mg/l
Sample J	295 mg/l	204 mg/l	263 mg/l	0.6 mg/l
Sample K	650 mg/l	387 mg/l	492 mg/l	7.2 mg/l
Sample L	760 mg/l	362 mg/l	563 mg/l	7.2 mg/l
Sample N	380 mg/l	227 mg/l	273 mg/l	0.3 mg/l

By Gary C. Brandt

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Date Tested: 1/79
Sample of: Water
Laboratory Identification No.
Field Identification No.

	Total Manganese as Mn	Nitrate Nitrogen as N
Sample B	0.04 mg/l	<0.10 mg/l
Sample C	0.20 mg/l	0.30 mg/l
Sample E	0.29 mg/l	3.24 mg/l
Sample G	0.05 mg/l	< 0.10 mg/l
Sample H	0.10 mg/l	< 0.10 mg/l
Sample J	0.76 mg/l	≤ 0.10 mg/l
Sample K	3.08 mg/l	2.10 mg/l
Sample L	2.43 mg/l	0.76 mg/l
Sample N	0.05 mg/l	0.24 mg/l

By Gary C. Brandt