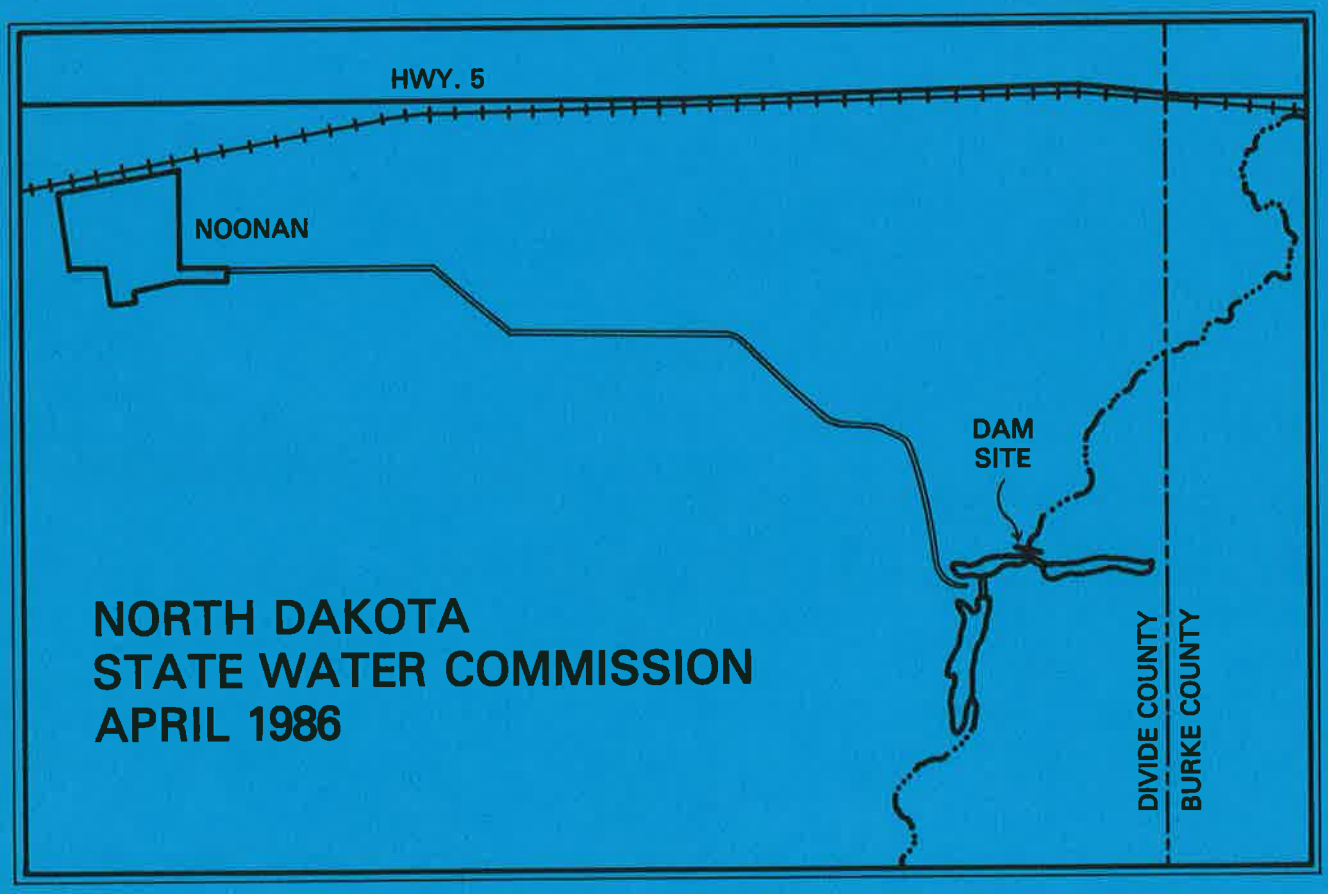
PRELIMINARY ENGINEERING REPORT

BAUKOL-NOONAN DAM

DIVIDE COUNTY, NORTH DAKOTA

SWC PROJECT NO. 1696



NORTH DAKOTA
STATE WATER COMMISSION
APRIL 1986

PRELIMINARY ENGINEERING REPORT

BAUKOL-NOONAN DAM

SWC PROJECT 1696

APRIL 1986

North Dakota State Water Commission
900 East Boulevard
Bismarck, North Dakota 58505-0187

Prepared By:

Dennis Reep
Water Resource Engineer

Submitted By:

David A. Sprynczynatyk, P.E.
Director of Engineering

Approved By:

Vernon Fahy, P.E.
State Engineer

Table of Contents

Tables

Figures

Appendices

I. INTRODUCTION

A. Background

In 1929, Harris M. Baukol started the Baukol-Noonan Coal Mine southeast of Noonan in Divide County. At that time, leveling and reclaiming the mined area were not requirements of the law. Mining operations ceased in the late 1950s, leaving several deep cuts sided by piles of overburden spoil material. Narrow, deep ponds were created when these cuts filled with water, most likely from a combination of ground water infiltration and surface water runoff.

On June 8, 1983, the North Dakota Game and Fish Department was deeded 1,380 acres of this abandoned mine land for use as a wildlife management area. Several of these ponds were stocked with fish in 1983, and most seem to support fish life quite well. Three of these ponds are of particular interest as they are in the path of an intermittent surface runoff stream. The stream is a tributary to West Branch Short Creek. The purpose of this study is to determine the feasibility of a dam on this tributary which would connect the three ponds.

B. Study Objectives

On July 17, 1985, the North Dakota State Water Commission entered into an agreement with the Divide County Water Resource Board to conduct a preliminary engineering study of the proposed Baukol-Noonan Dam. The State Water Commission was to complete the following requirements:

1. A study of the hydrology of the watershed.
2. Field surveys necessary to establish control for baselines, centerlines, and elevations of bench marks.

3. A borrow investigation to determine the amount and location of any suitable material.

4. A subsurface investigation to determine the engineering properties of the soils below the surface at the site.

5. Soils laboratory tests on the soil samples taken in the borrow and subsurface investigations.

6. A preliminary design of the dam.

7. A preliminary cost estimate.

8. A preliminary engineering report that will present the results of this study.

II. DESCRIPTION OF BASIN

A. Location and Size

The drainage basin for Baukol-Noonan Dam is located approximately three miles southeast of Noonan, North Dakota, in Divide County. The basin, with an area of 6.1 square miles, has its design point located in Section 12, Township 162 North, Range 95 West. From there it encompasses an area roughly one mile wide by six miles long to the south with the upper reach located in Section 1, Township 161 North, Range 95 West (See Figure 1).

B. Geology and Topography

The upper 2/3 reach of the Baukol-Noonan Drainage Basin is geologically classified as dead-ice moraine. It is described as a hummocky accumulation of drift, chiefly till, lacking linear trends, generally high local relief that exceeds 30 feet, numerous kettles, non-integrated drainage, ice-disintegration features, deposited by a stagnant glacier. The lower 1/3 is a combination of ground moraine and outwash plain and channel fill. Ground moraine is a gently undulating accumulation of drift, chiefly till, low local relief generally not exceeding 10 feet. Outwash plain and channel fill is described as an accumulation of drift, chiefly glaciofluvial, generally stratified, that is a plain or a shallow and narrow valley, chiefly ice marginal.

A drop of 400 feet is encountered when traveling from the upper reach of the basin to the design point. This results in an average slope of about 1.4 percent. The slope along the flow channel is fairly uniform throughout the entire reach.

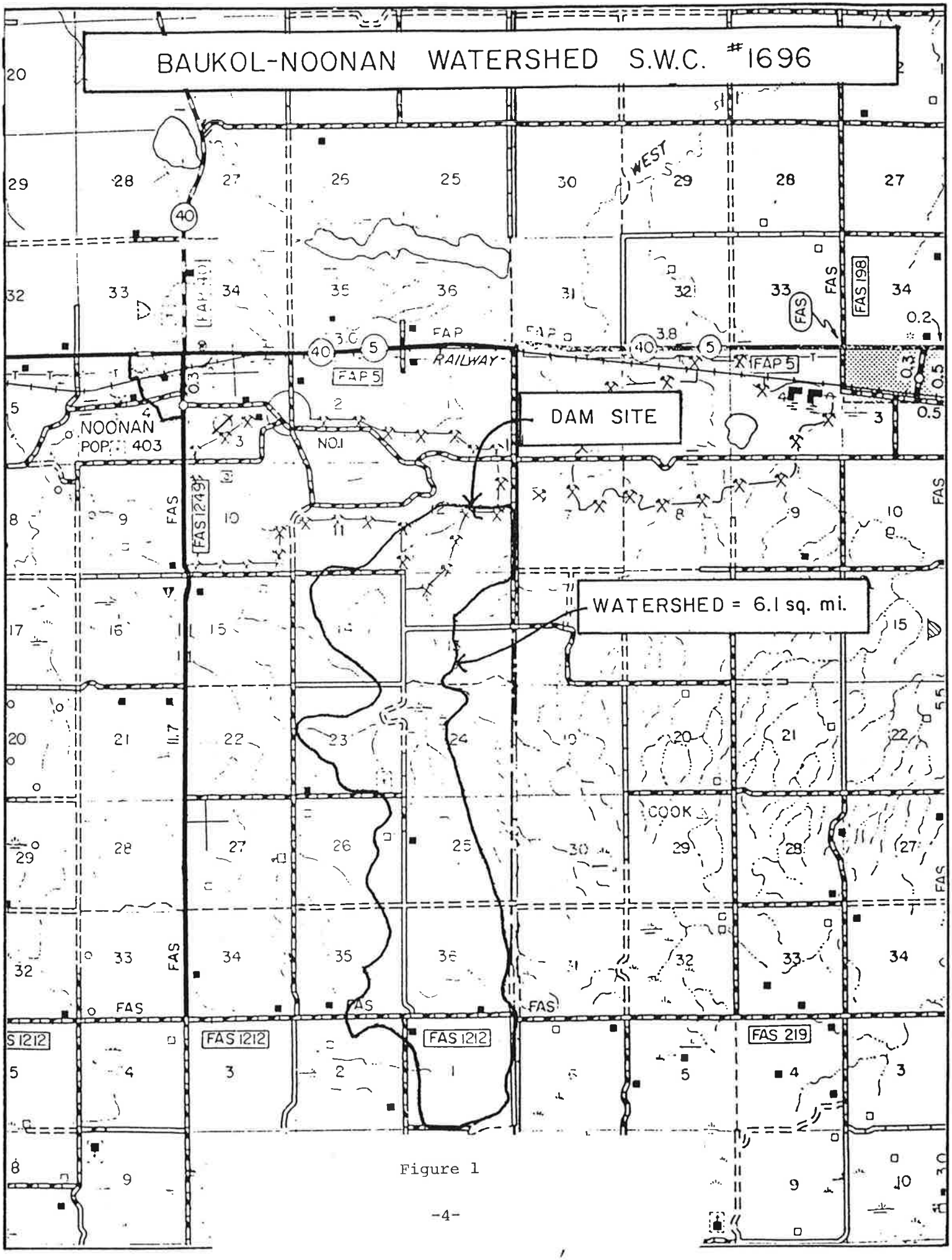

BAUKOL-NOONAN WATERSHED S.W.C. #1696
DAM SITE
WATERSHED = 6.1 sq. mi.
NOONAN
POP: 403
RAILWAY
FAP 5
FAS 1212
FAS 198
FAS 219
COOK
WEST

Figure 1

C. Climate

The climate for the basin can best be labeled as middle latitude steppe. In the steppe climate, temperature variations are relatively rapid day to day, the winters are relatively cold, streams are intermittent, and the greater part of the precipitation falls during the summer.

Records of temperature and precipitation have been kept at Crosby for more than 50 years. Temperature extremes during one year have been as great as $-47^{\circ}F$ to $111^{\circ}F$. The average January temperature is $3.6^{\circ}F$ and the July average $67.7^{\circ}F$. Annual precipitation averages 14.09 inches with most of it in the form of rain during the months of May, June, July, and August.

III. STUDY APPROACH

A. General

The main objective of the proposed project is to connect the three ponds, and to help produce a higher quality fish production area. In order to determine feasibility of such a project, several different facets of the site and drainage basin had to be investigated. They include:

1. Field Survey - A topographic survey was required to help locate the most feasible dam site, to determine earthwork quantities, and to determine pond capacities.

2. Hydrology - The hydrology of the basin was investigated to determine the expected annual yield and the magnitude of the different frequency events.

3. Ground Water - The question of whether the ponds were just "windows of the aquifer" was studied.

4. Soils Testing - Soils along the selected dam site along with those in potential borrow areas were tested for suitability.

5. Preliminary Design - As a result of the above mentioned investigations, a preliminary dam design was created.

B. Surveys

In 1975, the North Dakota State Water Commission conducted a topographic survey of the three ponds and the surrounding spoil piles. Soundings were performed on the ponds themselves to determine contours beneath the water surface. In 1985, the survey crew returned to extend the existing survey up to the 1992.0 msl contour and to provide greater detail on possible dam sites.

After the location of the dam was narrowed down to one site, the crew staked the location of test holes for the soil exploration. The

test holes were located along the centerline of the dam, under the inlet and outlet works, and in the vicinity of the potential borrow area.

C. Hydrology

The Baukol-Noonan Drainage basin is relatively small. Therefore, it was necessary to examine the expected yield from the drainage basin and the evaporation from the ponds. Unit values were taken from isometric graphs found in the Soil Conservation Service's "Hydrology Manual for North Dakota", and then used to calculate the yield and evaporation for the basin.

In order to size the dam and its outlet works, the magnitude and duration of runoff from hydrologic events with a range of frequencies were required. Different types of events were analyzed to find the one which produced the highest stage in the reservoir. Included in these were the 10-day rainfall, 24-hour rainfall, 4-hour rainfall, and 10-day runoff from snowmelt. The 10-day rainfall gave the highest stages for the different frequencies and was used for design purposes. The events used for sizing were determined by the class of dam. Baukol-Noonan is classified as a class III dam. Class III dams range in height from 10 to 24 feet and are categorized as medium hazard.

The magnitude and duration of runoff were obtained using the program HEC-1, Flood Hydrology Package, developed by the Hydrologic Engineering Center of the Corps of Engineers. This modular program supports a variety of methods for each component of the hydrologic process. The methods used in this study are as follows:

1. Precipitation - A standard design table was used. The amount of precipitation was reduced to take ponding into account.

2. Infiltration - The Soil Conservation Service method was used. This method used an empirical "Curve Number" based on soil type, land use, and other factors, to compute infiltration losses.

3. Unit Hydrograph - The Soil Conservation Service unit hydrograph was used. This is a one parameter unit hydrograph based on the subbasin time of concentration, which can be determined with a good degree of confidence. (The SCS Curve Numbers and unit hydrograph techniques are used extensively in North Dakota.)

4. Storage Routing - The modified puls method was used to route the hydrographs through the ponds.

Information gained from this model included: (1) inflow hydrographs; (2) reservoir stage hydrographs; (3) outflow hydrographs.

IV. STUDY RESULTS

A. Dam Classification

In order to design the outlet works for a dam, that dam must be classified. Dams are classified according to the potential hazard to property or loss of life, should the dam suddenly fail. The following hazard categories of dams and a brief description was described in the "North Dakota Dam Design Handbook."

Low - Dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails.

Medium - Dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for a loss of a few lives may be expected if the dam fails.

High - Dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is potential for the loss of more than a few lives if the dam fails.

Baukol-Noonan Dam is classified as a medium hazard dam due to the Burlington Northern Railroad and State Highway 5, both of which are approximately two miles downstream.

After a dam has been given a hazard category, it can be classified according to its height. The following table was listed in the "North Dakota Dam Design Handbook":

Dam Design Classifications

Dam Heights (Feet Above Streambed)	Hazard Categories Low	Medium	High
Less than 10	I	II	IV
10 to 24	II	III	IV
25 to 39	III	III	IV
40 to 55	III	IV	V
Over 55	III	IV	V

The dam height for Baukol-Noonan is 23 feet. Therefore, it will be designed as a class III dam.

B. Groundwater

One of the major questions regarding the feasibility of this project is whether or not it will hold water. In a strip mine such as Baukol-Noonan, it is generally not feasible to harvest the entire coal field. Hence, there is always some unmined coal, called outcrop, left in place on the outer edges of the mine. Since coal is relatively permeable, it was feared that damming the intermittent stream would only raise water levels to the extent the surrounding water table could be raised. This is what is meant by the term "window of the aquifer".

In an attempt to address this concern, a pump test was performed during the spring of 1985. The idea behind this test was to draw down pond #3 (See Figure 2) while monitoring surrounding piezometers, and then to monitor the water level in pond #3 after pumping. During the first 12 to 14 hours of pumping, a small drop of water levels was recorded in the surrounding piezometers which indicates some interconnection with the pond. For the rest of the test however, the piezometer

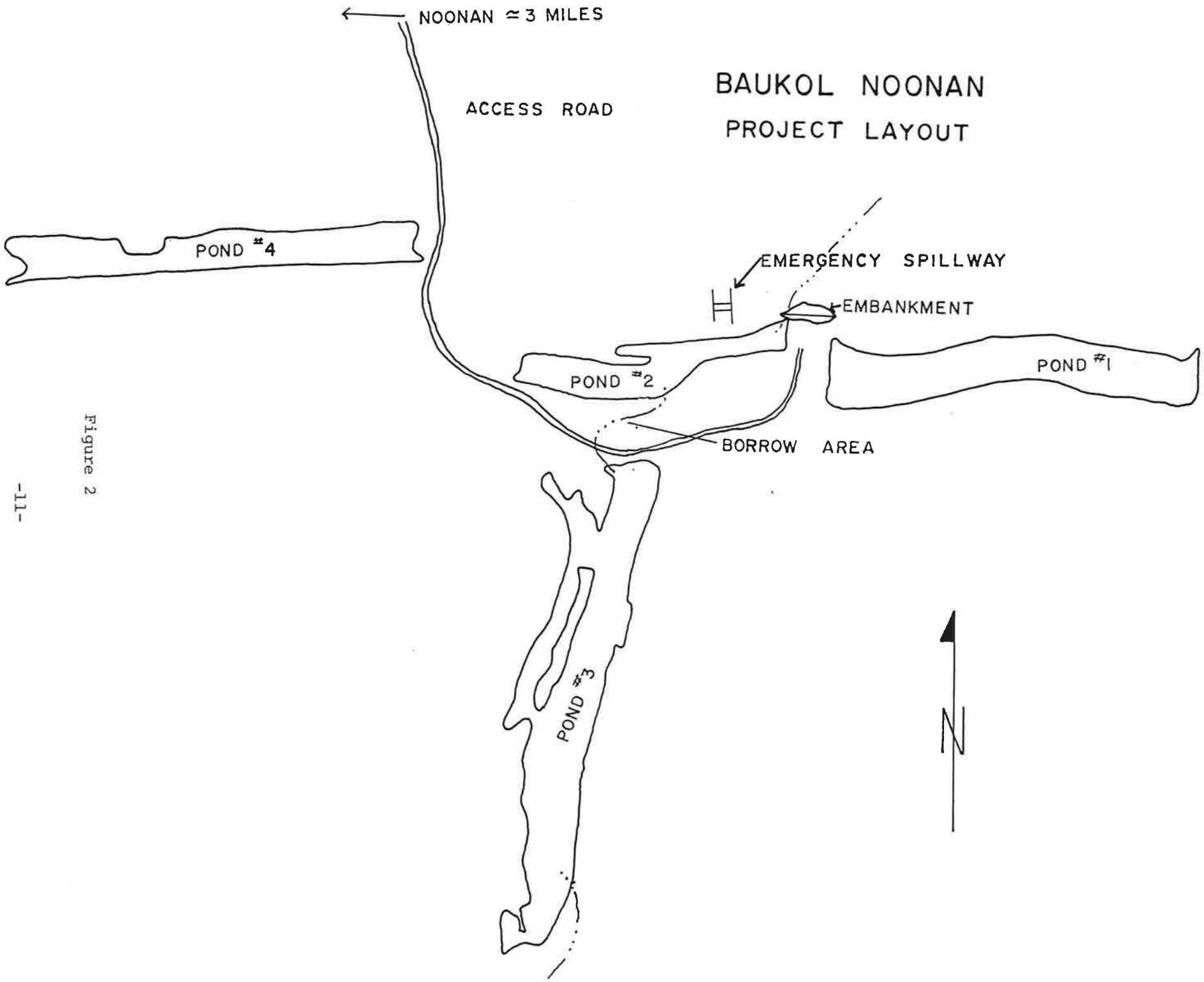

NOONAN ≃ 3 MILES
ACCESS ROAD
BAUKOL NOONAN
PROJECT LAYOUT
POND #4
EMERGENCY SPILLWAY
EMBANKMENT
POND #2
POND #1
BORROW AREA
POND #3
N

Figure 2

water levels remained stationary. The pond was drawn down 1.75 feet. Readings for two weeks following the completion of pumping showed no change in the water level. This data suggests the ponds are independent of the groundwater system, but the test results still are not considered conclusive.

Another method used in trying to find an answer to the above question was to look at the water surface elevations of the different ponds. On September 23, 1985, water surface elevations for the ponds were as follows: Pond #1 - 1967.6; Pond #2 - 1969.3; Pond #3 - 1980.0; Pond #4 - 1979.1 (See Figure 2). In the fall of 1975, when the first survey was performed, the water levels were: Pond #1 - 1979.4; Pond #2 - 1968.6; Pond #3 - 1972.4. An assessment of the impermeability of each pond based on water surface elevations follows:

> Pond #1 - Based on the difference between Ponds 1 and 2, it is safe to say Pond #1 is tight on the west side. However, the south side of Pond #1 is still a question mark.
>
> Pond #2 - Due to the differences in water surface elevation between Pond #2, and Ponds 1, 3, and 4, it is safe to say Pond #2 is watertight on the south, west, and east sides.
>
> Pond #3 - Is of no concern since it generally is at or near the design elevation.

The last way to view this question was to look at the groundwater elevations compared to the pond elevations. Ed Murphy of the State Geological Survey was consulted for this part of the study. Mr. Murphy has extensive experience in the groundwater studies of this part of North Dakota. His analysis consists of three possible relationships between the groundwater table and pond levels which have occurred over

the past five years. They are described below and shown graphically in Figure 3.

Alternative 1 - If the water table is below the base of the pond, the infiltration will increase beneath the ponds due to the higher head created by the pond level increase, but the pond level should be maintainable.

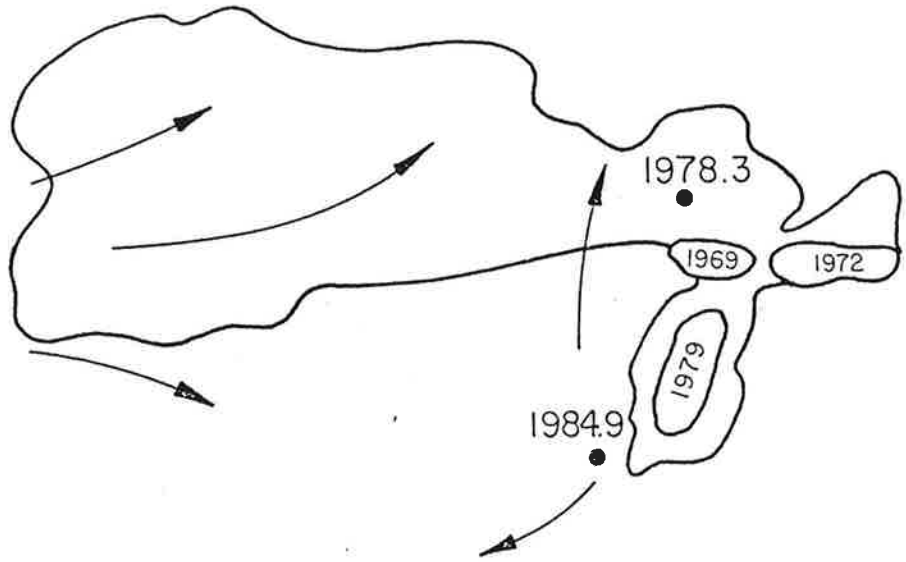
Alternative 2 - If the water table and the pond levels coincide, the raising of the pond level will result in the raising of the water table and water will flow out of the pond at a faster rate to obtain equilibrium.

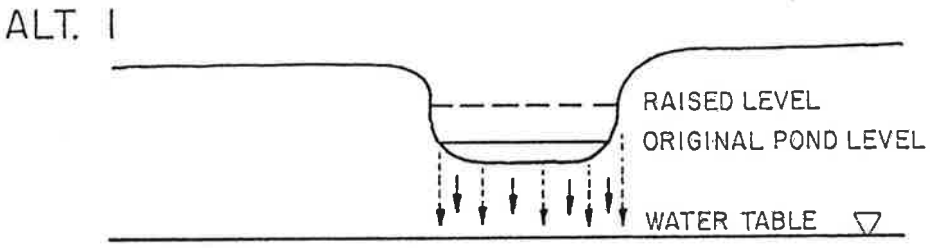
Alternative 3 - In this alternative, the water table is above the present level of the ponds. Measurements from 1982-1984 have shown the water level in the piezometers to be somewhat constant. Measurements in 1975 and again in 1985, have also had the ponds at a somewhat constant elevation. The levels in the piezometers have been approximately five feet higher than those in the ponds. This means the ponds are discharge areas for groundwater. Apparently, these ponds have reached equilibrium below the level of the groundwater table due to the low hydraulic conductivity of the surrounding sediments and the loss of water to evaporation. If the pond levels are not raised above the groundwater table, there should be no significant flow out of the pond.

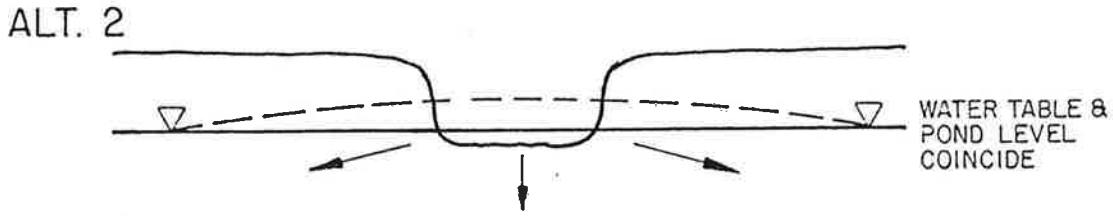
If the ponds were at the same elevation as measured in 1985, during the period 1982-1984, Alternative 3 is most likely the relationship. Local input has suggested that there has been no significant change in the pond levels in recent history. Therefore, it is likely that the ponds will hold water.

C. Soils Exploration

A subsurface investigation of the site and borrow area soils was initiated by the State Water Commission in order to determine the feasibility of using these soils in the construction of an earthen-fill dam. Twin City Testing and Engineering Laboratories, Inc., was contracted to perform the drilling and testing. The number and location of the test holes were selected and staked by the State Water Commission.


1978.3
1969
1972
1979
1984.9


ALT. 1
RAISED LEVEL
ORIGINAL POND LEVEL
WATER TABLE


ALT. 2
WATER TABLE &
POND LEVEL
COINCIDE

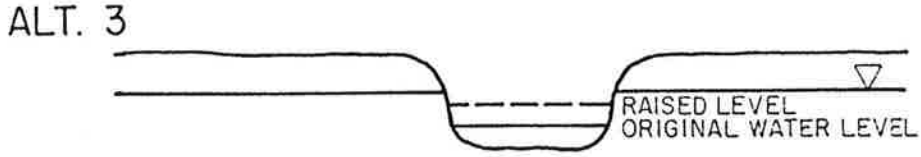

ALT. 3
RAISED LEVEL
ORIGINAL WATER LEVEL

Figure 3

Drilling commenced October 1, 1985 and was completed October 18, 1985. A total of 13 borings were performed: five along the centerline of dam; two under the principle spillway, and six from the borrow area.

Borings along the centerline of the dam and outlet works were generally advanced 30 to 35 feet with the exception of borings 4 and 4A which were advanced 40 to 50 feet. Depths advanced in borings in borrow area #1 were all 15 feet. The total footage drilled was 345 feet.

Standard penetration sampling was done on all the borings along the dam centerline and outlet works. In the procedure, a 2-inch outside diameter split barrel sampler is driven into the soil by dropping a 140 pound hammer a distance of 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as the penetration resistance or "N" value. The "N" value is an index of the relative density of cohesionless soils and the consistency of cohesive soils.

A 6-inch auger was used to sample the soils in borrow area #1. Because of this method, the determination of the depth and extent of the various layers of soil and the consistency of cohesive soils are only approximate.

As the samples were obtained in the field, they were classified visually and manually by the crew chief. Portions of these samples were then brought into the laboratory for further study and verification of the classification. Logs of the borings from representative locations

indicating the depth and identification of the various strata, the "N" value, laboratory test data, water level information, and pertinent information regarding the method of maintaining and advancing the holes are attached as Appendix B. Boring #2 is located on the centerline of the dam and principal spillway, and Boring #7 is located in borrow area 1.

Selected samples were tested for moisture content, density, liquid limit, plastic limit, grain size distribution, unconfined compressive strength, triaxial shear strength, moisture-density relationship using the standard proctor method, dispersion analysis using the pinhole test, and soil resistivity using a Miller Soil Box Method.

The Miller Soil Box Method mentioned above was used to test the borrow area soils for potential corrosivity. Results of this test showed the soils to be highly corrosive to metal. The resistivity of the soil at optimum moisture content is equal to 475 OHM-CM, which indicates that cathodic protection would be required for a metal outlet.

D. Hydrology

1. Basin Yield

As mentioned earlier in this report, the drainage basin for Baukol-Noonan Dam is relatively small. Therefore, it was necessary to investigate the yield potential of the basin to determine if it would keep the reservoir full.

The area encompassed by the basin is 6.1 square miles. The Soil Conservation Service's "Hydrology Manual For North Dakota" gives a 80 percent yield of 11 acre-feet per square mile and a 50 percent yield of 20 acre-feet per square mile. This means a runoff of 67 acre-feet and 122 acre-feet can be expected every 1.25 and 2 years, respectively.

After the expected yield was calculated, the evaporation losses were examined. again the "Hydrology Manual for North Dakota" was consulted to obtain an annual evaporation rate. A value of 34.3 inches of evaporation per year was calculated. Starting at the control elevation of 1980.0 msl, the annual evaporation losses would be about 100 acre-feet. Figures 4, 5, and 6, show area-capacity curves for Ponds 1, 2, and 3. Figure 7 shows all area-capacity curves for the combination of the three ponds.

Based on expected yield and evaporation, the reservoir will gain more water than it will lose once every 1.7 years. In other words, the reservoir will have approximately a 60 percent chance having a net increase in volume each year.

2. Design Events

Outlet works of a dam are required to have flow capacities such that they pass the runoff from precipitation events as suggested by its classification. The "North Dakota Dam Design Handbook" gives the following table as a guideline for precipitation criteria:

BAUKOL–NOONAN DAM POND #1

AREA–CAPACITY

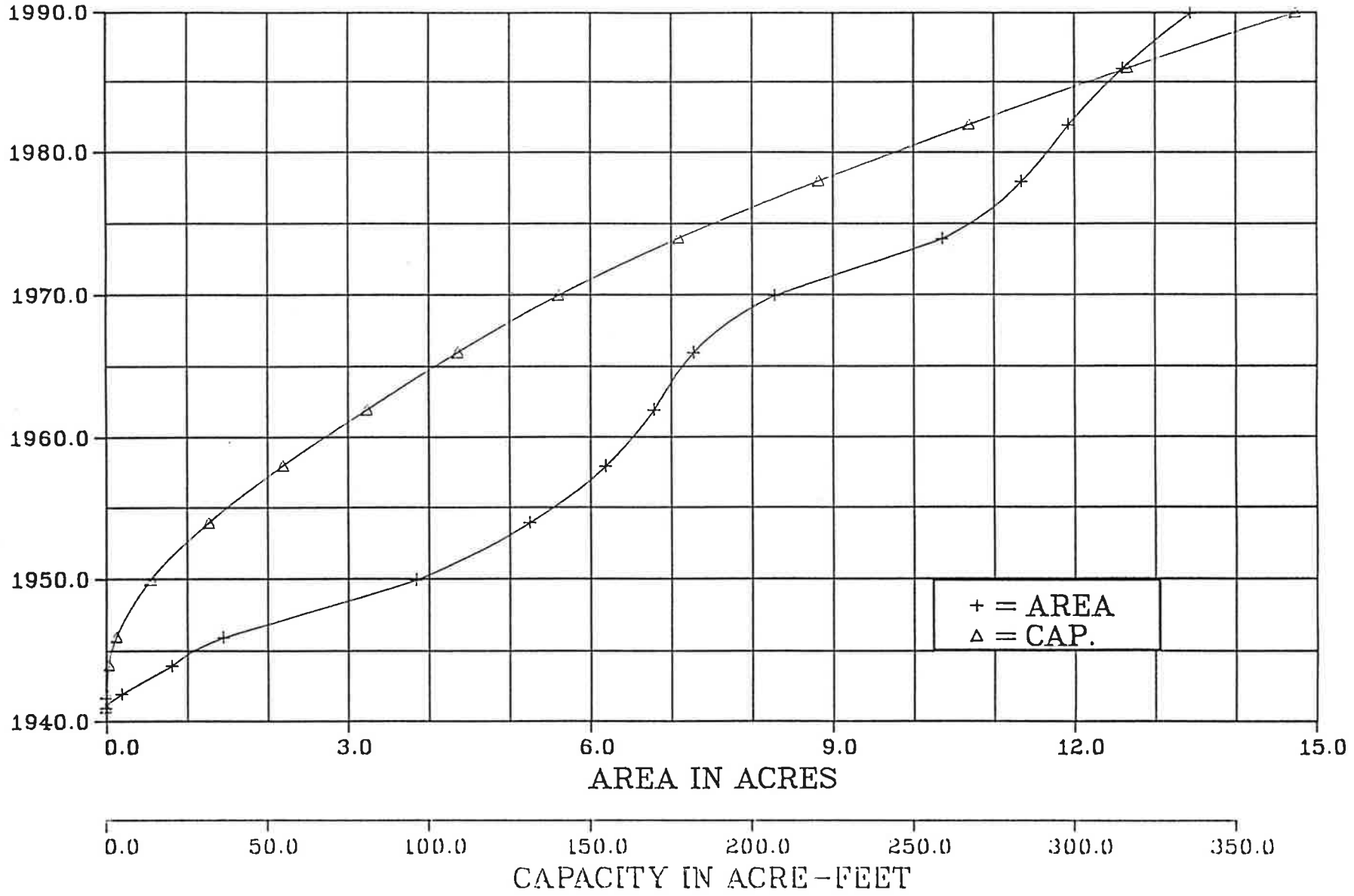


Figure 4

BAUKOL–NOONAN DAM POND #2

AREA–CAPACITY

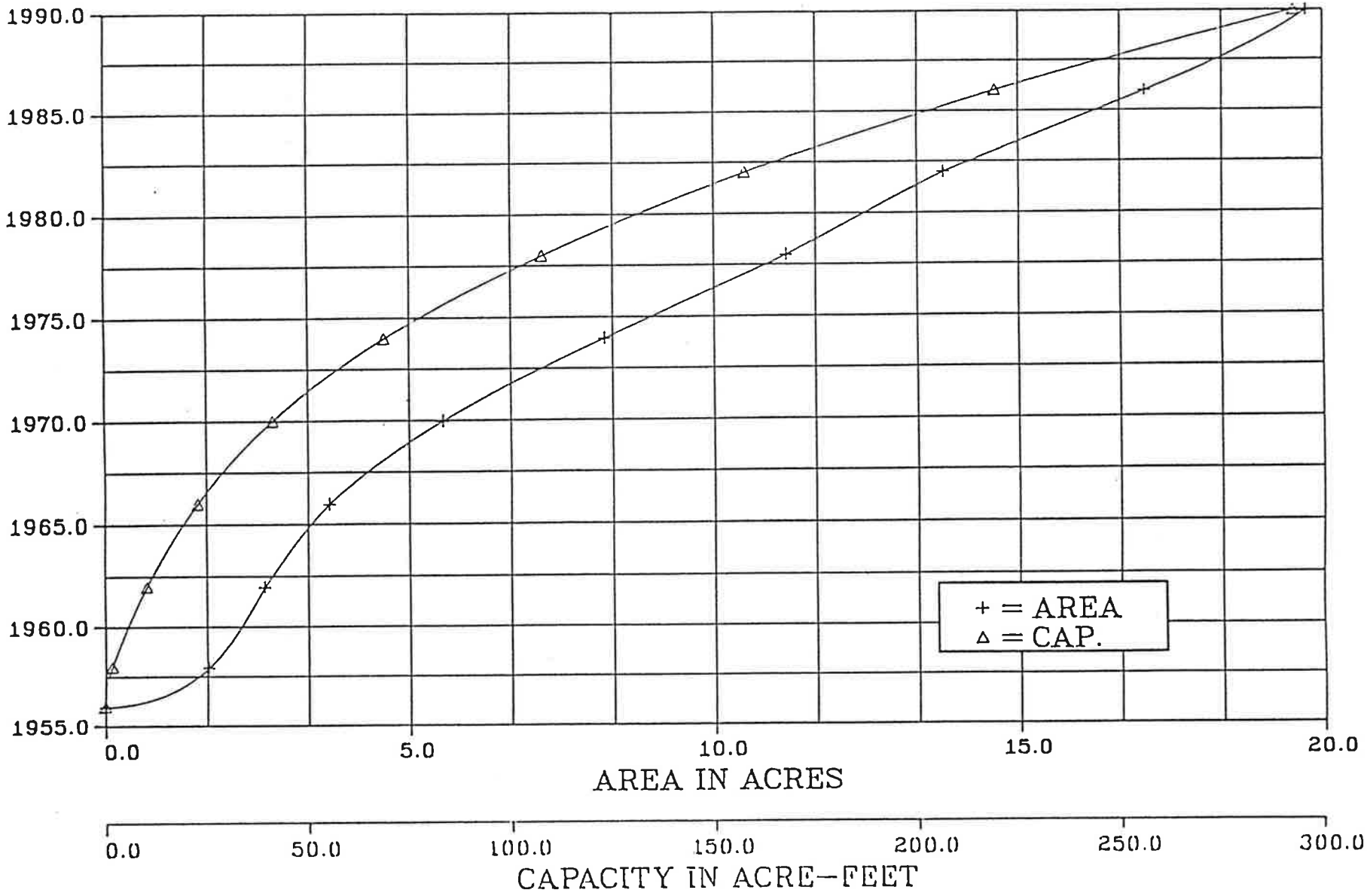


Figure 5

BAUKOL–NOONAN DAM POND #3

AREA–CAPACITY

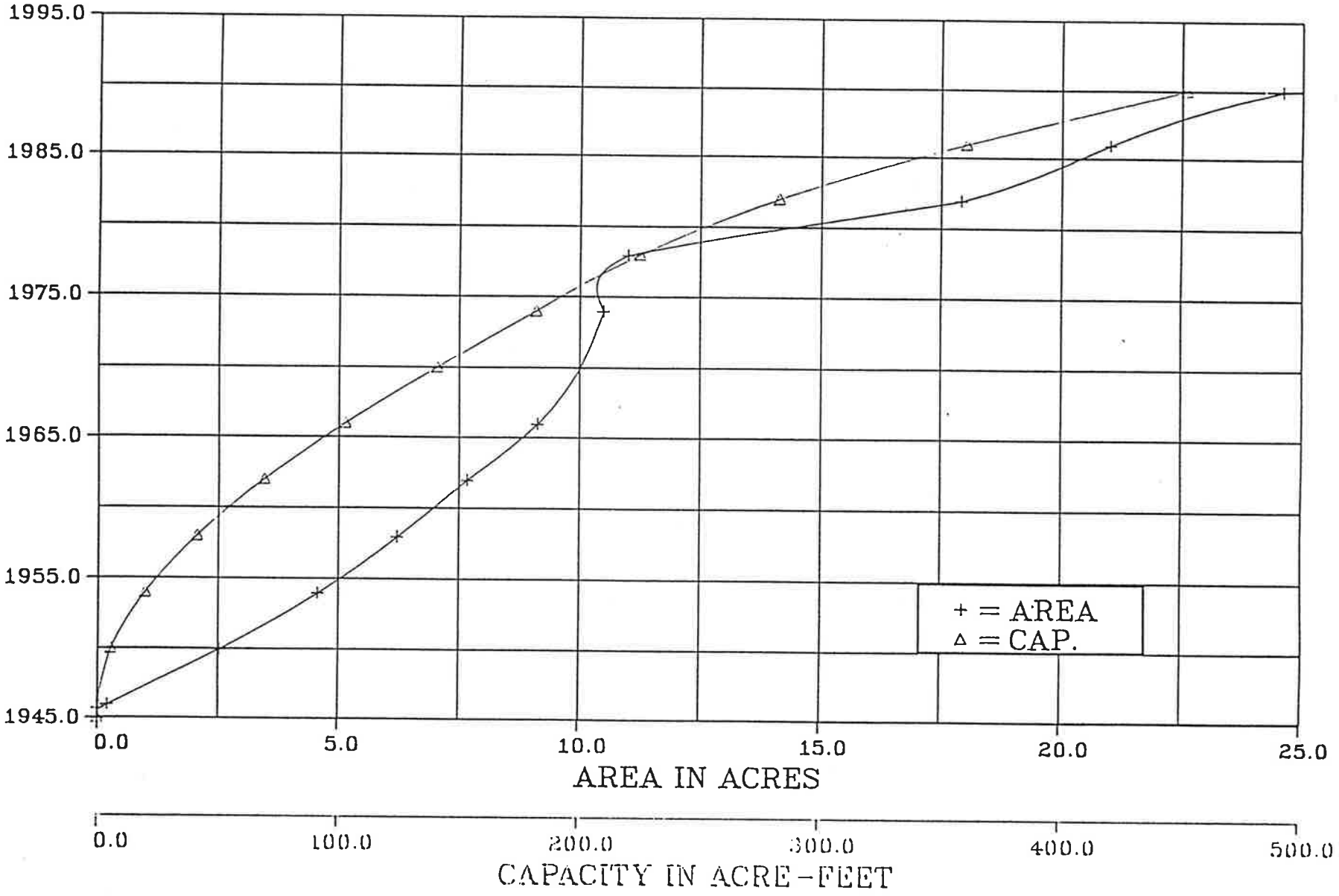


Figure 6

BAUKOL–NOONAN DAM PONDS 1,2, AND 3

AREA–CAPACITY

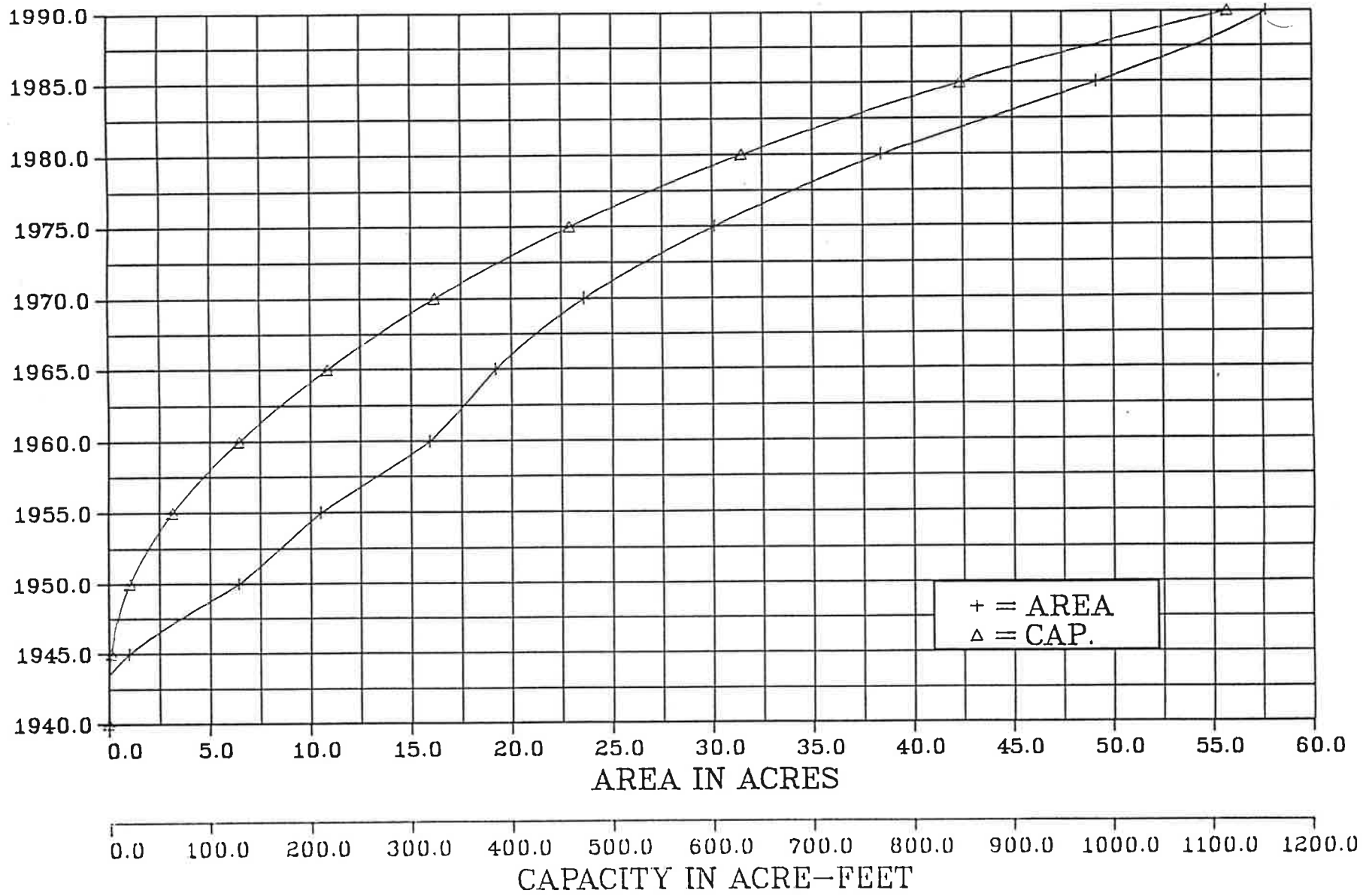


Figure 7

Return Period, Years

Dam Classification	Principal Spillway	Emergency Spillway Criteria Velocity	Freeboard
I	-	10	25
II	-	25	50
III	25	100	0.3 PMP*
IV	50	0.3 PMP*	0.5 PMP*
V	100	0.4 PMP*	PMP*

*PMP = Probable Maximum Precipitation

Therefore, it was necessary to evaluate the 25-year, 100-year, and 0.3 PMP precipitation events. A ten-day rainfall precipitation table was used for the 25- and 100-year events and a six hour table for the 0.3 PMP event. Table 1 shows the resulting peak flows and total volumes for these events and Figures 8 and 9 show the inflow hydrographs.

TABLE 1

Event	Peak Inflow (cfs)	Total Inflow Volume (acre-feet)
25 Year	800	790
100 Year	1,300	1,260
.3 PMP	2,450	620

E. Preliminary Design

1. Hydraulic Design

According to the criteria for outlet works on class III dams, the principal spillway must pass a 25-year event without any flow going through the emergency spillway. The emergency spillway must pass a 100-year event without creating excessive velocities in the spillway. Together they must pass a .3 PMP without overtopping the dam.

In planning the management of the reservoir, it was decided that the control elevation would be at 1980.0 msl and the top of dam at

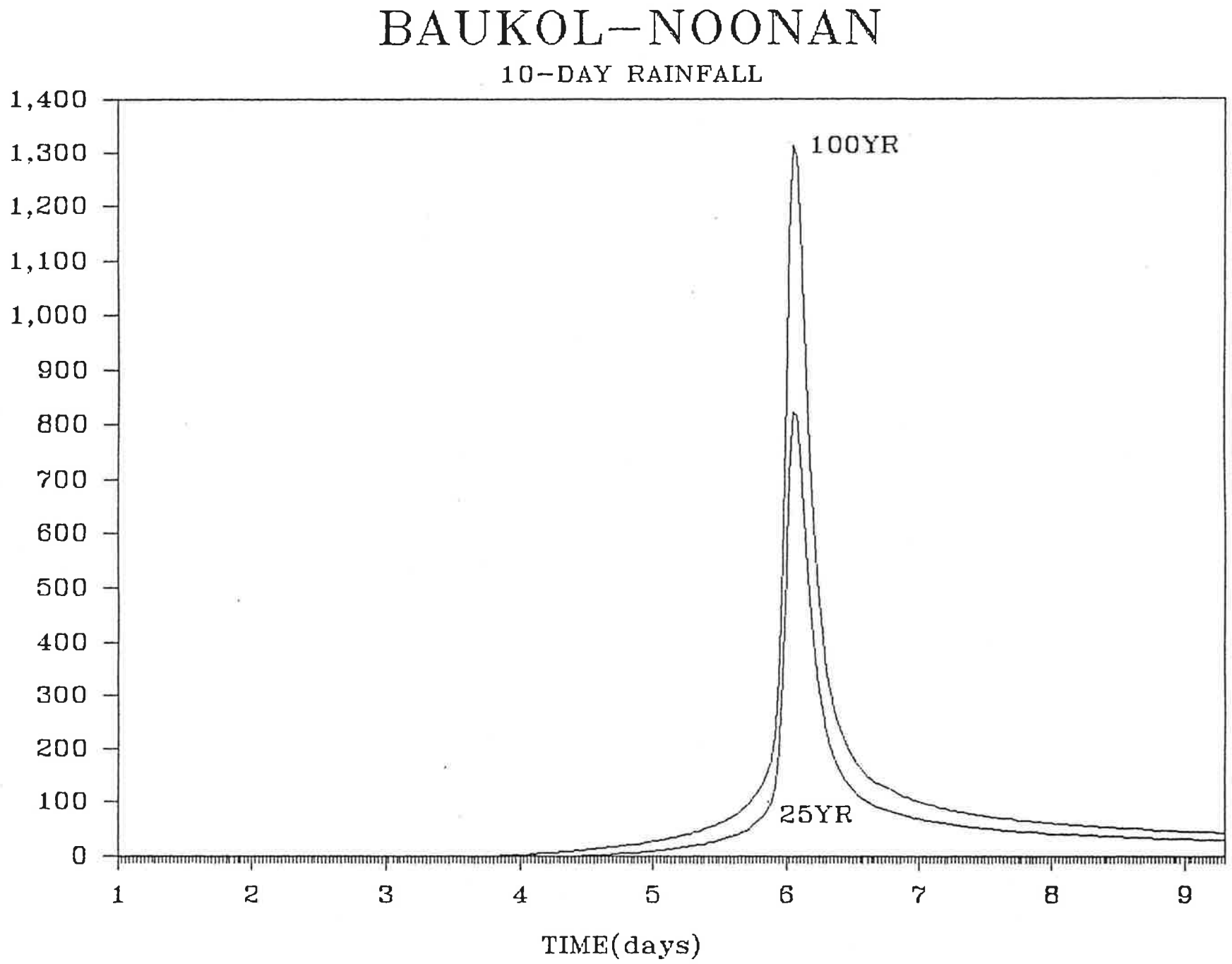

BAUKOL–NOONAN
10–DAY RAINFALL
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
INFLOW(cfs)
100YR
25YR
1
2
3
4
5
6
7
8
9
TIME(days)

Figure 8

BAUKOL–NOONAN DAM

.3 PMP

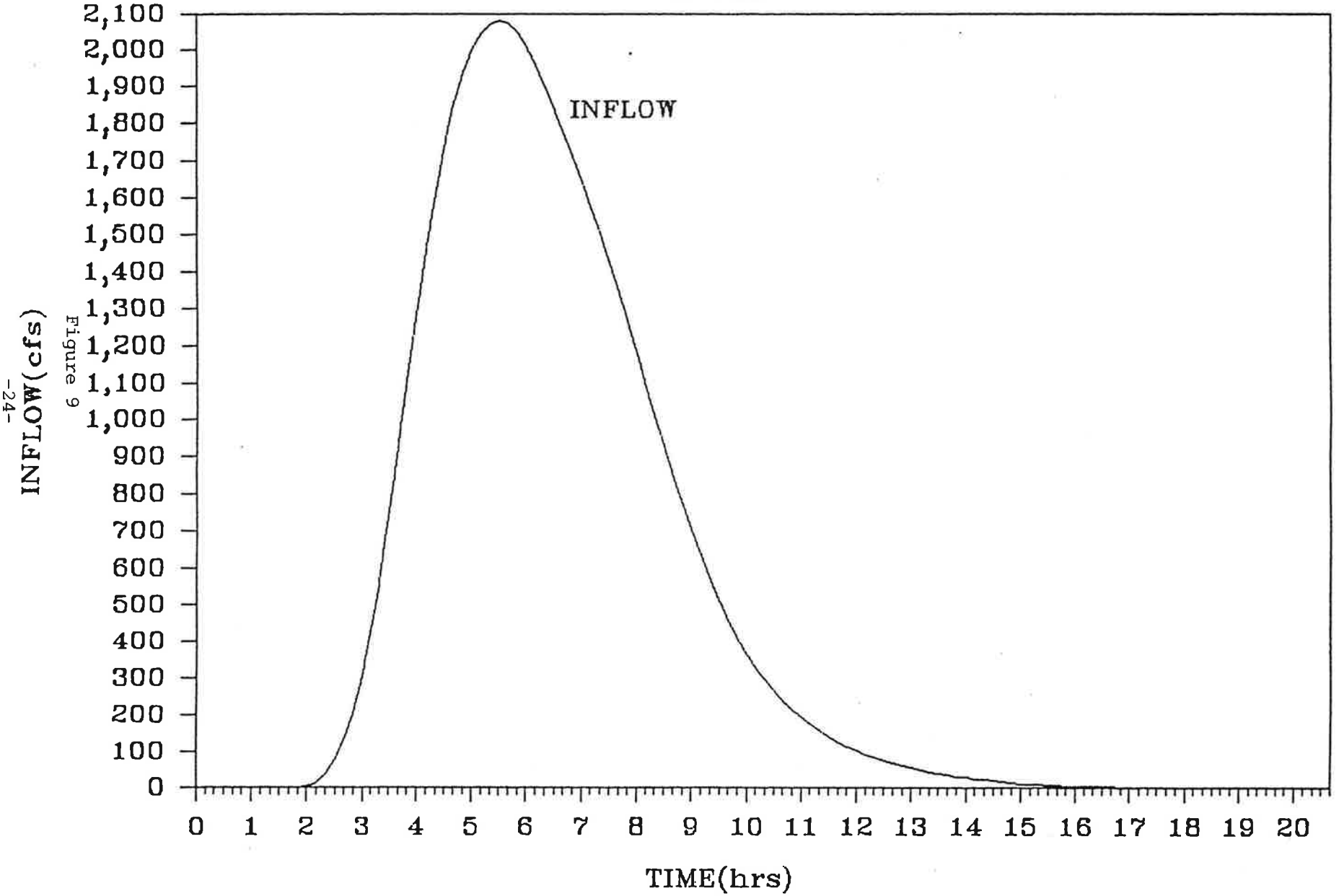


Figure 9

1990.0 msl. Using a 5-foot CMP riser with a 4-foot barrel through the dam as the principal spillway, the 25-year event resulted in a peak water surface elevation of 1986.2 msl. Therefore, the emergency spillway elevation was set at 1986.0 msl. After the elevation of the emergency spillway was determined, the channel cross-section and slope had to be designed to satisfy the velocity and freeboard criteria.

Normally, channel slopes are limited to the 1-2% range. However, due to limited space available, slopes in the 3-4% range were investigated. A minimum bottom width of 75 feet is required to pass the .3 PMP without overtopping the dam. With those two limiting factors, different bottom widths and slopes were tried and checked for velocity for the 100-year event. Table 2 shows the velocities and duration of the combinations tried (all calculations are for 1:1 side slopes).

TABLE 2

Duration of Velocity Greater than, Hours

Velocity FT/S	BW-75' S=4%	BW=100' S=4%	BW=120' S=4%	BW=75' S=3%	BW=100' S=3%	BW=120' S=3%
7	1.4	-	-	-	-	-
6	3.9	2.8	1.5	2.6	1.3	-
5	6.2	5.0	4.2	5.0	4.0	3.2
4	8.6	7.3	6.7	7.7	6.5	5.7
3	11.5	10.4	10.0	11.0	9.6	8.9
2	14.0	13.0	12.0	13.7	12.4	12.0

Using the above table and comparing the amount of excavation required, it was decided to use the 100-foot bottom width with a slope of 4 percent. Figures 10, 11 and 12, show the inflow-outflow relationships for the 25-year, 100-year and .3 PMP events. Table 3

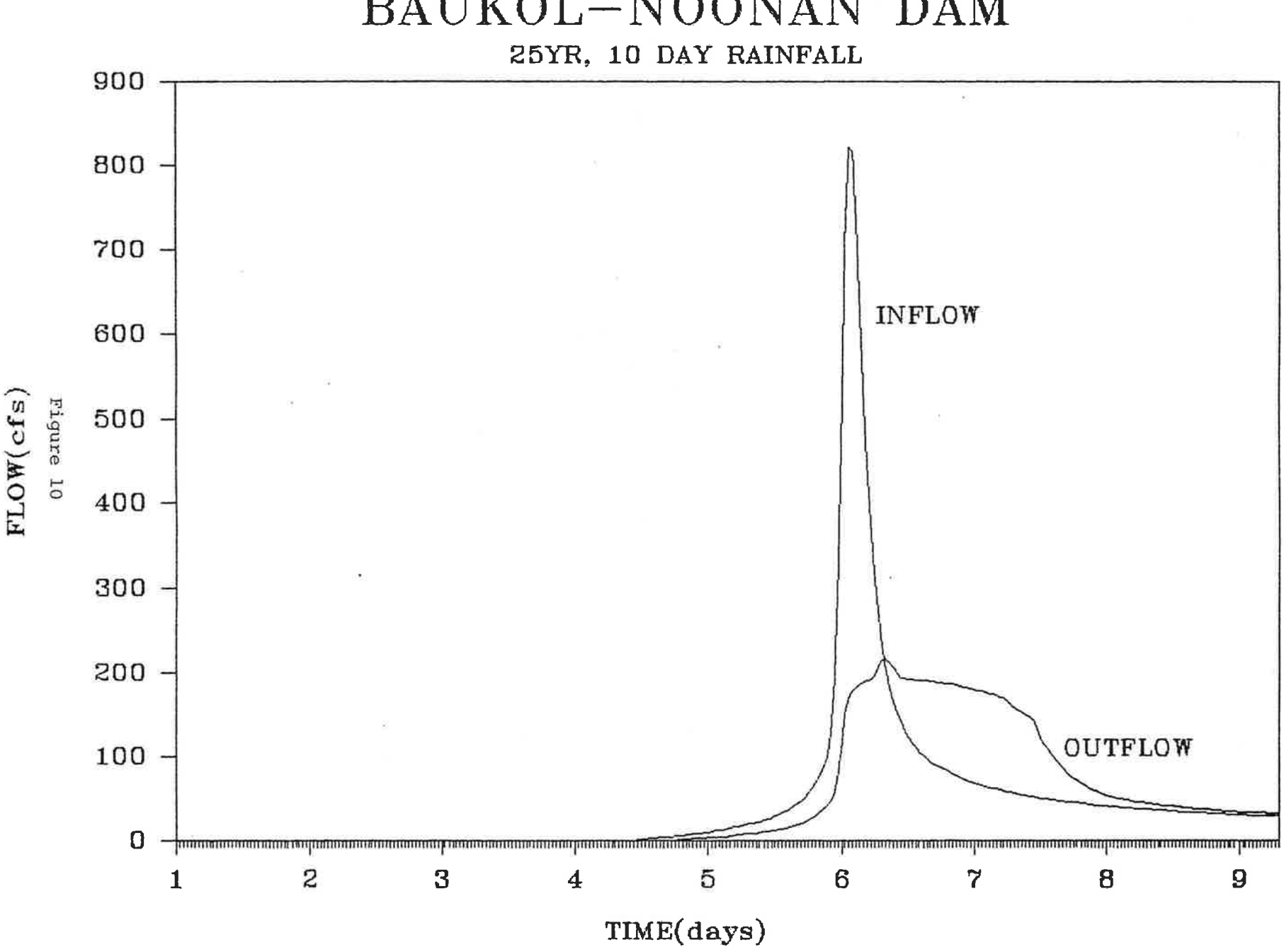

BAUKOL–NOONAN DAM
25YR, 10 DAY RAINFALL
900
800
700
600
500
400
300
200
100
0
FLOW(cfs)
INFLOW
OUTFLOW
1
2
3
4
5
6
7
8
9
TIME(days)

Figure 10

BAUKOL–NOONAN DAM

100YR, 10 DAY RAINFALL

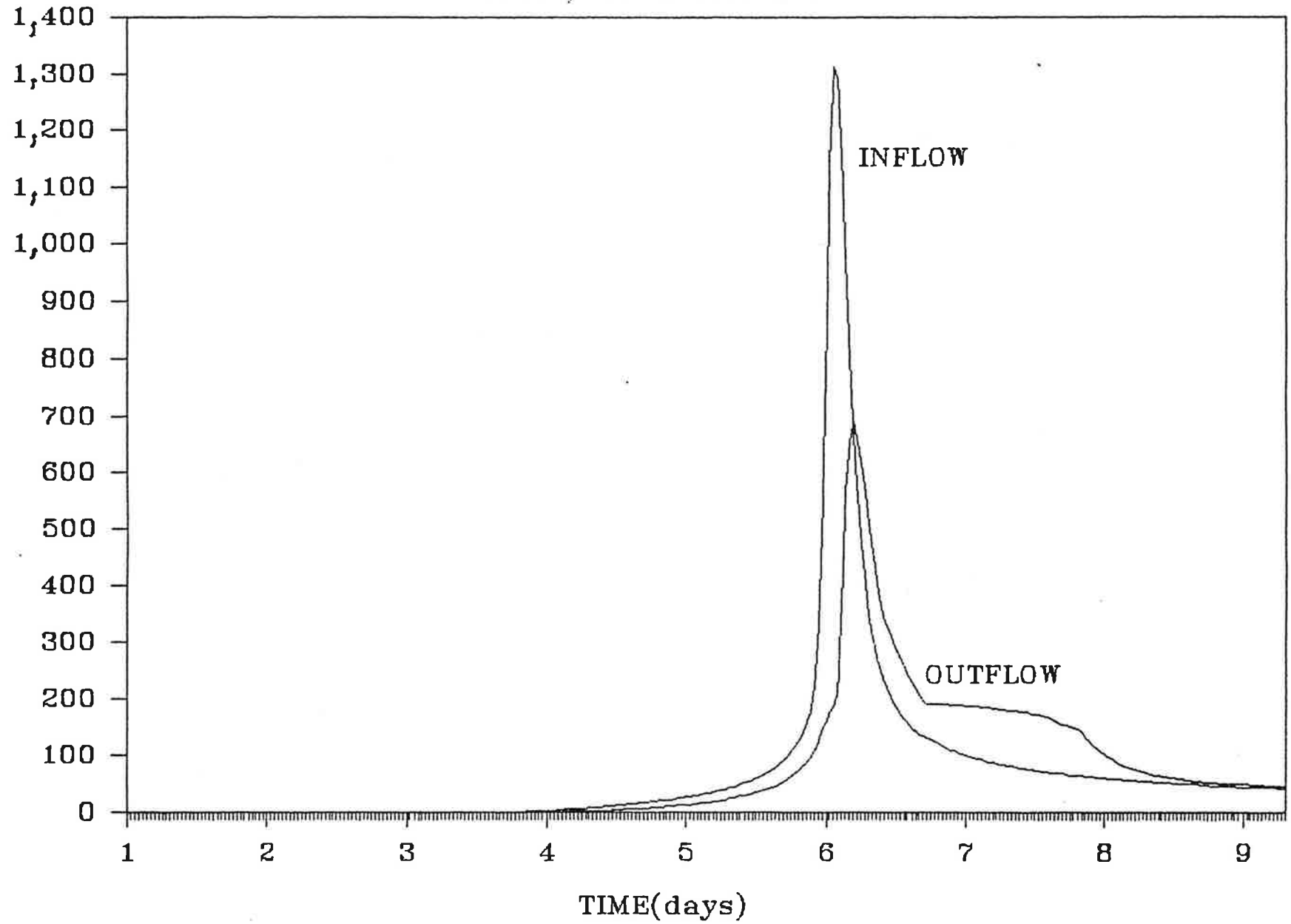


Figure 11

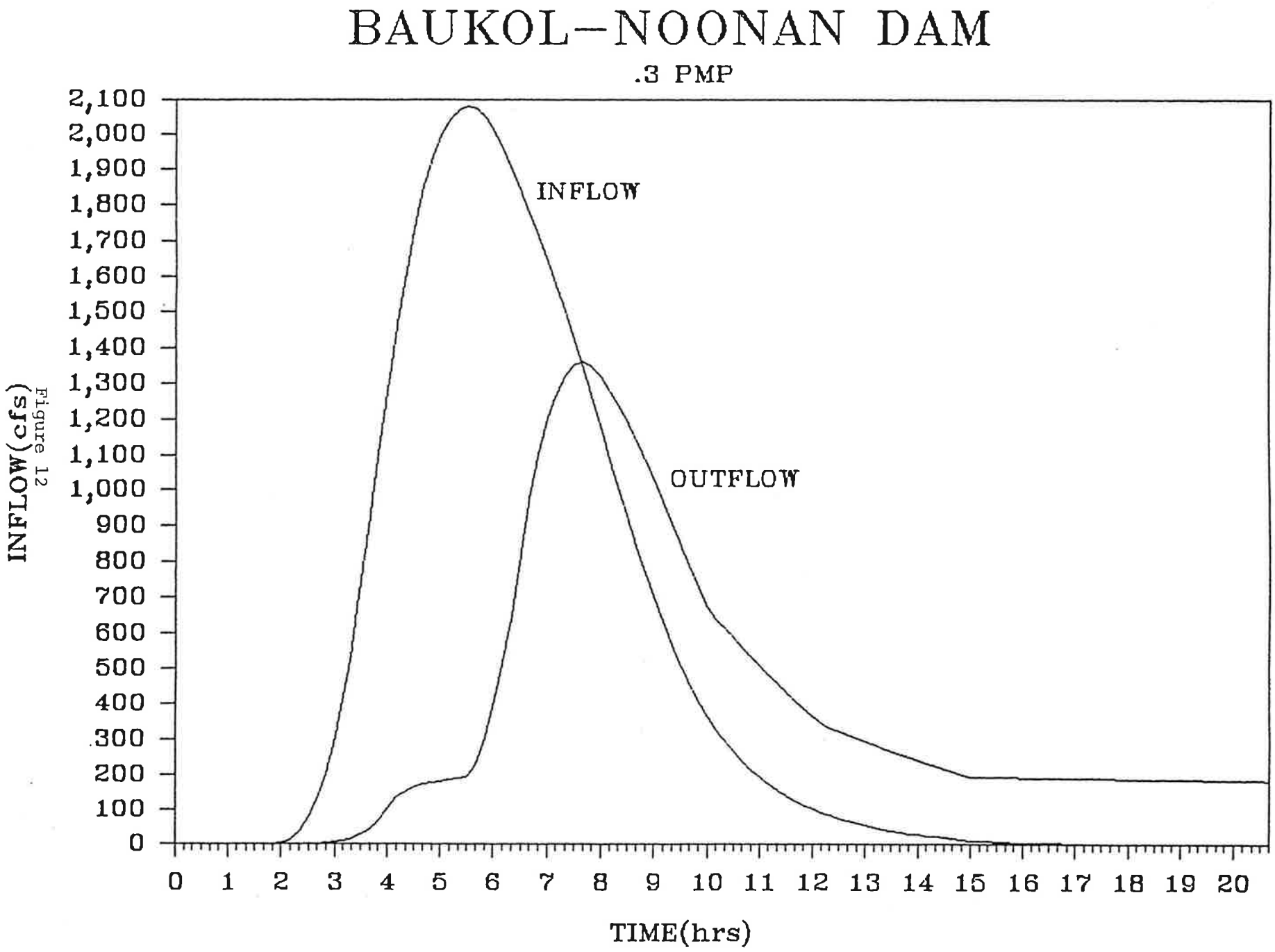

BAUKOL–NOONAN DAM
.3 PMP
INFLOW
OUTFLOW
INFLOW(cfs)
TIME(hrs)
2,100
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Figure 12

summarizes the peak inflow, outflow, water surface elevation, and storage.

TABLE 3

Peak Values

Event	Inflow	Outflow, cfs	W.S.E., msl	Storage, Ac-Ft
25-year	800	220	1986.2	910
100-year	1,300	700	1988.0	1,000
.3 PMP	2,100	1,350	1989.1	1,060

2. Foundation and Embankment Design

Excavation of existing soft clays under the proposed embankment is recommended to help reduce excessive settlements. Stripping the top one-foot of clay should sufficiently satisfy this requirement.

Along the centerline, a cut-off trench will be excavated down to shale (elevation 1963.0 msl). The trench will be 12 feet wide with 1:1 side slopes. It will then be dewatered and filled with compacted clays to provide a deterrent to seepage under the dam. A trench will also be excavated and refilled just as the centerline trench to protect against differential settlements along the spillway.

Both the left and right abutments are spoil piles from the mining operation. Seepage could conceivably take place due to loose zones in these piles. The soils which comprise the spoil piles are high in plasticity and non-dispersive, thereby suggesting the chance of seepage occurring is small. However, to increase the safety of the structure, it is recommended the surface of the abutments be compacted. This would

consist of compacting the outer two feet of clay up to the control elevation of 1980.0 msl. The compaction should extend a distance of about 50 feet from the abutment-dam interface.

For an embankment height of 23 feet, a top width of 12 feet is recommended. Side slopes of 3:1 are suggested to achieve stability. A cross-section of the dam through the emergency spillway is shown in Figure 13.

The emergency spillway is to be cut out of an existing ridge about 300 feet to the west of the left abutment. This location is the most economical while being a safe distance from the dam itself. Figure 14 shows the relative positioning of the structures.

3. Connecting Channels

Two connecting channels will be constructed to enhance the accessibility to all three ponds by boat. One channel will connect Ponds 1 and 2, and the other will connect Ponds 2 and 3. They will be a trapezoidal cross-section 20 feet wide with 4:1 side slopes. The bottom elevation will be 1973.0 msl. The seven foot depth should prohibit cattail growth and allow sufficient navigation for the types of boats to be allowed on the reservoir.

BAUKOL NOONAN DAM

CROSS-SECTION OF EMBANKMENT THROUGH PRINCIPAL SPILLWAY

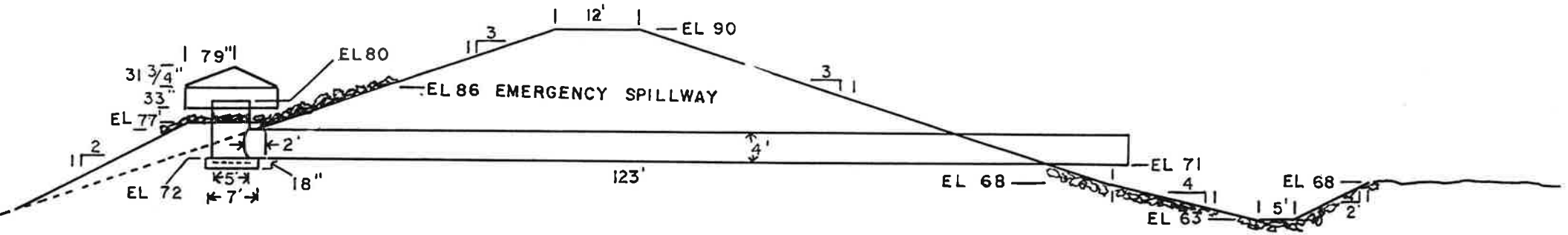
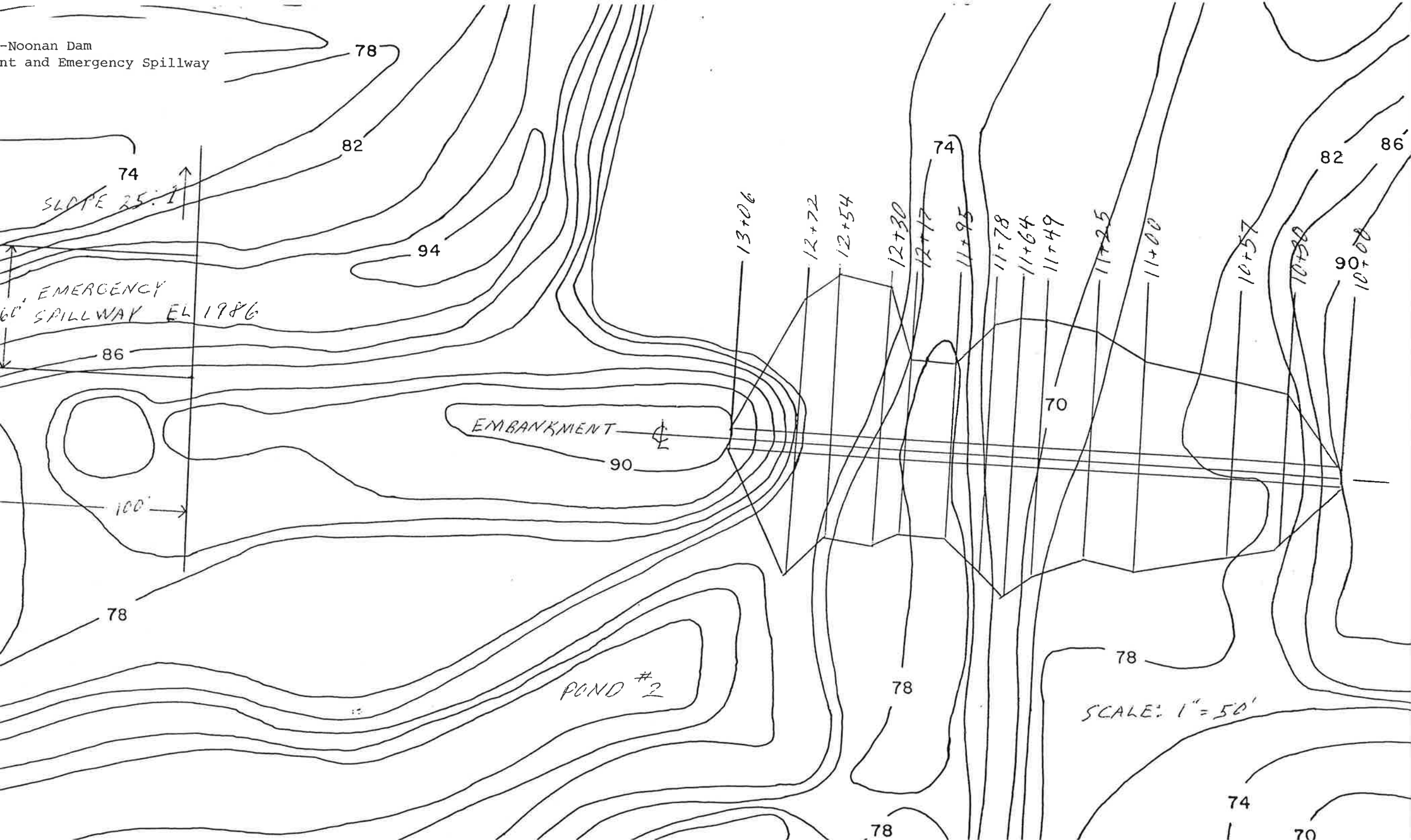


Figure 13

-Noonan Dam
nt and Emergency Spillway



F. Preliminary Cost Estimate

Table 4

Project Features	Quantity	Unit	Unit Cost	Cost
Mobilization	1	LS	$ 5,000.00	$ 5,000
Stripping	1,200	CY	1.00	1,200
Core Trench - Centerline Dam	5,000	CY	2.00	10,000
Principal Spillway Core Trench	200	CY	2.00	400
Principal Spillway - CMP	1	LS	20,000.00	20,000
Emergency Spillway	4,000	CY	1.50	6,000
Cathodic Protection	1	LS	3,000.00	3,000
Fill For Dam	16,000	CY	1.00	16,000
Gravel	175	CY	10.00	1,750
Riprap	450	CY	12.00	5,400
Channel Between Ponds 1 & 2	1,250	CY	2.00	2,500
Channel Between Ponds 2 & 3	4,800	CY	2.00	9,600
Water Control	1	LS	5,000.00	5,000
	Subtotal			$ 85,850
	Administration, Engineering and Contingencies 30%			$ 26,150
	Total			$112,000

V. SUMMARY

The feasibility of constructing a dam in the spoils of the abandoned Baukol-Noonan strip mine has been investigated. Located in Section 12, Township 162 North, Range 95 West, the dam site has a drainage area of 6.1 square miles. Baukol-Noonan Dam is classified as a medium hazard, class III dam.

Based on average yield and evaporation estimates, the reservoir can be expected to have a net gain in water six out of every ten years. Design events for the various hydraulic structure were as follows: principal spillway - ten-day rainfall 25-year event; emergency spillway - ten-day rainfall 100-year event and; top of dam - .3 PMP. The resulting hydraulic structures can be described as follows: principal spillway - 5-foot CMP riser with 4-foot CMP barrel 123 feet in length; emergency spillway - 100 feet wide with 1:1 side slopes and a 4 percent bottom slope. The embankment will have a top width of 12 feet, a height of 23 feet, and side slopes of 3:1 with the top of dam at 1990.0 msl.

The soils survey indicated the presence of suitable embankment material. The borrow area soils predominately consisted of fat clays which should provide the needed impervious wall in the dam. However, the fat clays are highly corrosive and cathodic protection will be required to prolong the life of the metal principal spillway. Foundation soils were also found to be adequate.

Enough evidence has been collected to support the theory that the ponds will hold water. The belief now is the ponds are discharge areas for the ground water system.

The estimated construction cost for the project is $112,000. It is now up to the Divide County Water Resource Board to decide if they wish to proceed with the project.

APPENDIX A

Agreement for investigation of a dam on a tributary to West Branch Short Creek near Noonan

SWC Project #1696
July, 1985

A G R E E M E N T

Investigation of a Dam on a
Tributary to West Branch Short Creek
Near Noonan

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the State Engineer, Vernon Fahy; and the Divide County Water Resource Board, hereinafter referred to as the Board, acting through its Chairman, Robert Priebe.

II. PROJECT, LOCATION, AND PURPOSE

The Board wishes to investigate the feasibility of constructing a dam on a tributary to West Branch Short Creek for the purpose of recreation. The proposed dam site is located south and east of the City of Noonan, in the NE quarter of Section 12, Township 162 North, Range 95 West.

III. PRELIMINARY INVESTIGATION

The parties agree that further information is necessary concerning the proposed project. Therefore, the Commission shall conduct the following:

1. Conduct a study of the hydrology of the watershed.
2. Field surveys necessary to establish control for baselines, centerlines and elevations of bench marks.
3. A borrow investigation to determine the amount and location of any suitable material.
4. A subsurface investigation to determine the engineering properties of the soils below the surface at the site.

5. Soils laboratory tests on the soil samples taken in the borrow and subsurface investigations.

6. A preliminary design of the dam.

7. A preliminary cost estimate.

8. Prepare a preliminary engineering report that will present the results of this study.

IV. DEPOSIT - REFUND

The Board shall deposit a total of $4,000.00 with the Commission to partially defray the costs of the investigation. Upon receipt of a request from the Board to terminate proceeding further with the preliminary investigation or upon a breach of this agreement by any of the parties, the Commission shall provide the Board with a statement of all expenses incurred in the investigation and shall refund to the Board any unexpended funds.

V. RIGHTS-OF-ENTRY

The Board agrees to obtain written permission from any affected landowners for field investigations by the Commission which are required for the preliminary investigation.

VI. INDEMNIFICATION

The Board hereby accepts responsibility for and holds the Commission free from all claims and damages to all public and private properties, rights or persons arising out of this investigation. In the event a suit is initiated or judgment rendered against the Commission, the Board shall indemnify it for any judgment arrived at or judgment satisfied.

VII. CHANGES TO THE AGREEMENT

Changes to any contractual provisions herein will not be effective or binding unless such changes are made in writing, signed by both parties and attached hereto.

NORTH DAKOTA STATE WATER COMMISSION
By:

VERNON FAHY
State Engineer

DATE: July 9, 1985

WITNESS:

DIVIDE COUNTY WATER RESOURCE BOARD
By:

ROBERT PRIEBE
Chairman

DATE: July 17, 1985

WITNESS:

APPENDIX B

Log of Borings*
Baukol-Noonan Dam
SWC #1696

*Taken from Twin City Testing and Engineering Laboratories, Inc.
TCT #120 86-1023, December 16, 1985

LOG OF TEST BORING

JOB NO 120 86-1032 VERTICAL SCALE 1" = 4' BORING NO 2

PROJECT PROPOSED DAM - HARRIS M. BAUKOL MINE - NOONAN, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1972.4')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LAB TESTS W	D	LL/PL	Qu
	FILL, MOSTLY FAT CLAY, brown				1	FA				
4	FAT CLAY, grayish brown, soft to medium (CH)		2		2	SB				
			6		3	SB				
9	SHALE, brown, rather stiff (Textural Classification: Fat Clay (CH))		10		4	SB	25		63/20	
11½	SHALE, gray, very stiff, with lenses of silt (Textural Classification: Fat Clay (CH))		34		5	SB				
			56		6	2L				
			33		7	SB				
22½	Lignite		100/0.4		8	SB				
30½	End of Boring		100/0.6		9	SB				

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
10-2	4:10	30½'	None	29'	to	3'
					to	
					to	
					to	

START 10-2-85 COMPLETE 10-2-85

METHOD 6 FA 0-8' @ 4:00

4 C 0-10, JW 8-29½'

CREW CHIEF Jacabson

SE-2 (77-B) 4

twin city testing corporation

LOG OF TEST BORING

JOB NO 120 86-1032 VERTICAL SCALE 1" = 4' BORING NO 7

PROJECT PROPOSED DAM - HARRIS M. BAUKOL MINE - NOONAN, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 1986.0')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	LAB TESTS W	LAB TESTS D	LAB TESTS LL/PL	LAB TESTS Qu
	FAT CLAY, brown (CH)				1	B				
5	FAT CLAY, brownish gray (CH)				2	3T	31	92		Proctor
					3	B			89/15	MA Qu Qc D R
12	FAT CLAY, dark brown (CH)				4	B			56/17	Proctor
15	End of Boring									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
					to	NMR
					to	
					to	
					to	

START 10-18-85 COMPLETE 10-18-85

METHOD 6 FA 0-15' @ 4:14

CREW CHIEF Jacobson

twin city testing corporation

SE-2 (77-B) 4