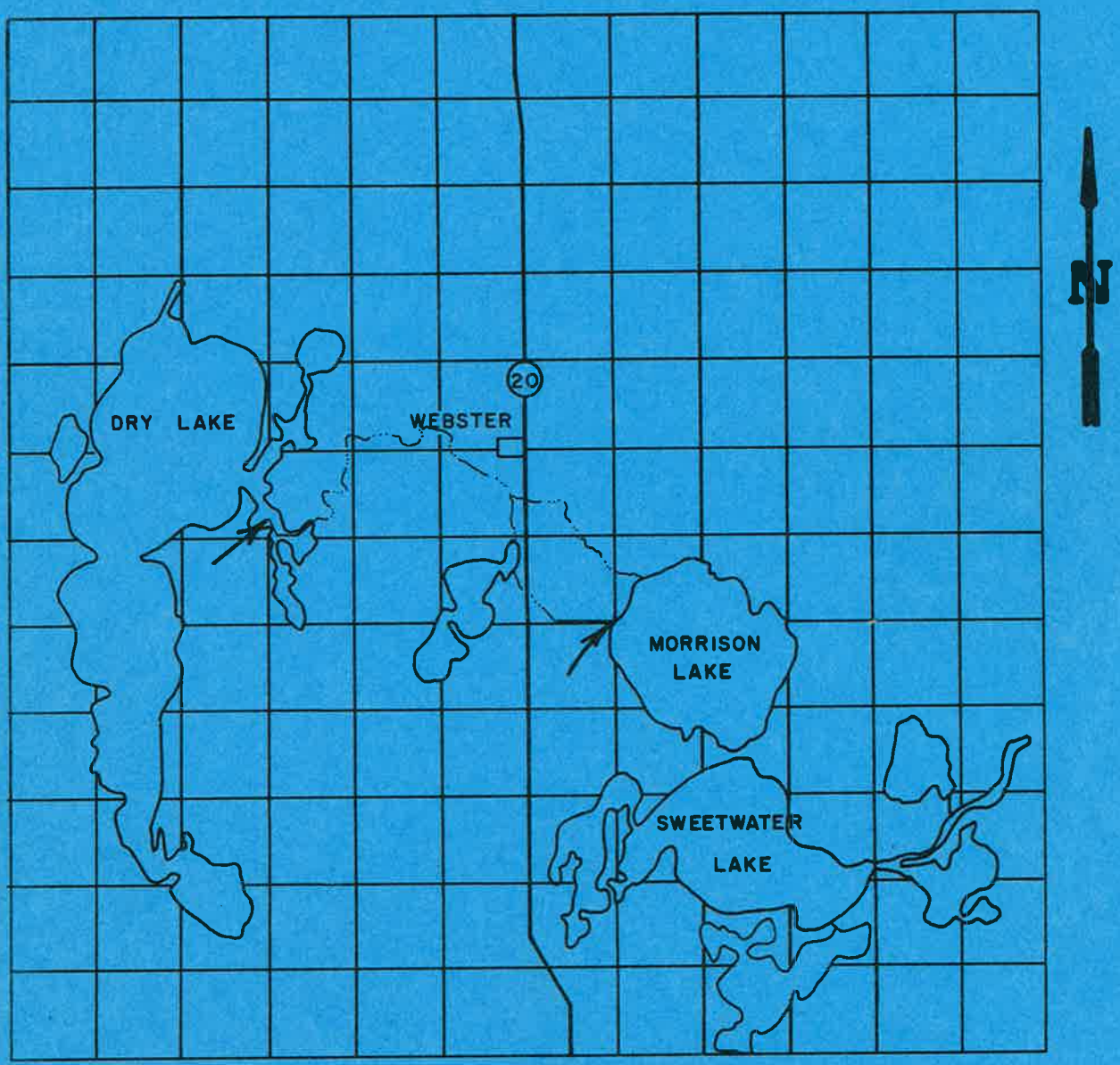
PRELIMINARY ENGINEERING REPORT
MORRISON LAKE OUTLET

WATER SURFACE PROFILE STUDY

SWC PROJECT NO. 1746



← DENOTES STUDY AREA

NORTH DAKOTA
STATE WATER COMMISSION
JULY 1982

PRELIMINARY ENGINEERING REPORT

MORRISON LAKE OUTLET
WATER SURFACE PROFILE STUDY
SWC PROJECT #1746
JULY, 1982

NORTH DAKOTA STATE WATER COMMISSION
900 EAST BOULEVARD
BISMARCK, NORTH DAKOTA 58505

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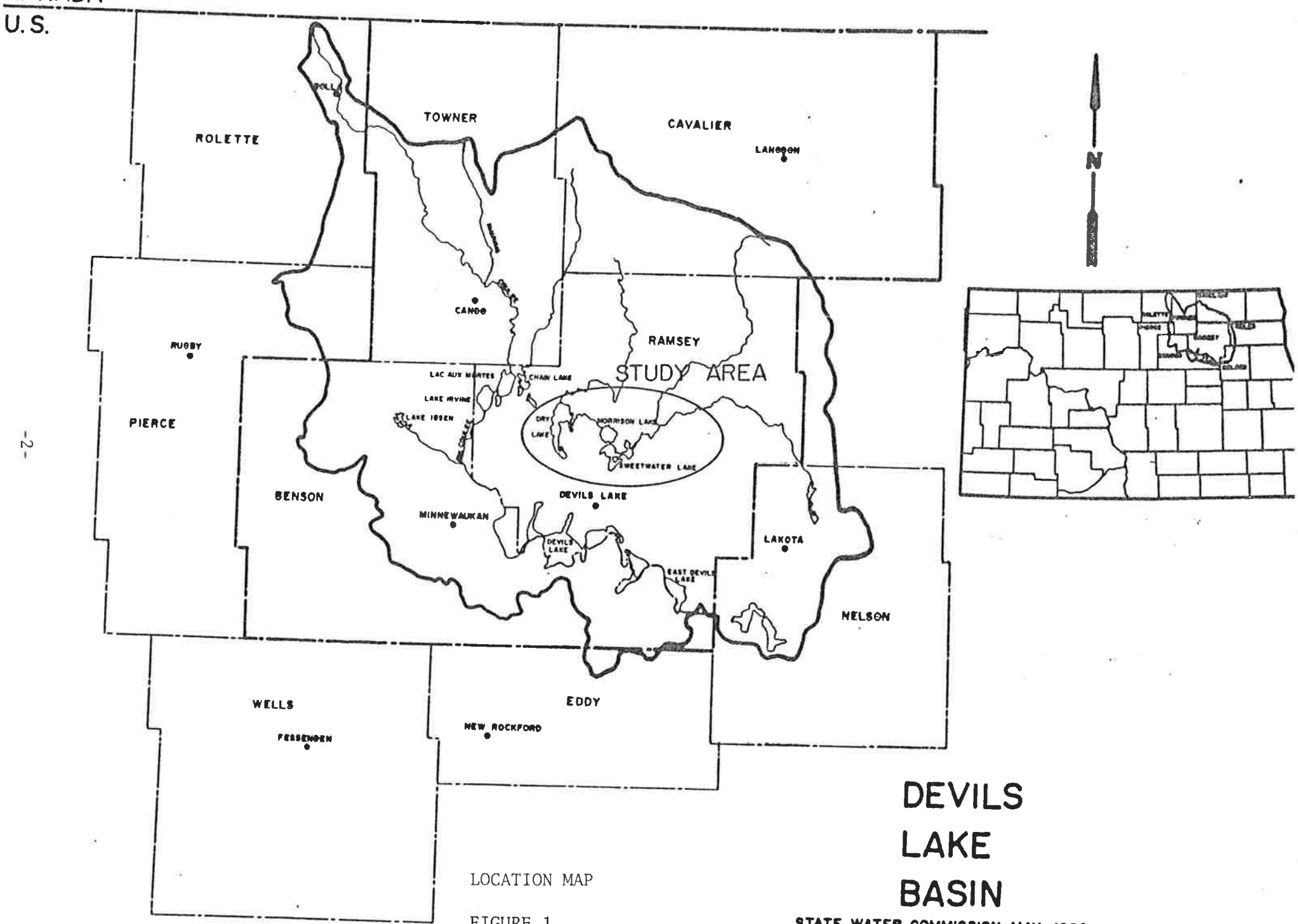
I. INTRODUCTION

This report discusses the results of a study of the effects of improving an outlet from Morrison Lake. A preliminary investigation agreement was made between the North Dakota State Water Commission and the Ramsey County Water Resource Board, on August 6, 1981. A copy of the agreement may be found in Appendix A. Figure 1 shows the general location of the study. The study area includes Morrison Lake, Dry Lake, and the channel that runs between them. The study's main objective was to improve an outlet on Morrison Lake, along with making any needed channel improvements. An analysis of the existing channel structures and problem areas in the channel was conducted. Recommendations as to what could be done to improve the outlet and channel were also made. An estimated cost for their implementation was completed.

A hydrologic study was used to do the engineering analysis. Water surface elevations were calculated from that study and a water surface profile developed. These elevations were used to determine effects on existing channel conditions and the structures.



LOCATION MAP

FIGURE 1

II. DESCRIPTION OF STUDY AREA

Morrison and Dry Lakes are located in Ramsey County in the Devils Lake Basin. The channel between the lakes is approximately 9.4 miles along the centerline. Figure 2 shows the study area. Morrison Lake has two outlets, with the southwest outlet located in the W½ of Section 14, Township 155 North, Range 64 West. The northwest outlet is located in the SW¼ of Section 11, Township 155 North, Range 64 West. The two outlet channels join near Highway 20 and flow into Dry Lake in the SW¼ of Section 6, Township 155 North, Range 64 West.

Significant flooding occurs around Sweetwater and Morrison Lakes. Table 1 shows the water area of Sweetwater-Morrison Lake at selected elevations. The majority of the land above 1459 MSL is farmed, if possible.

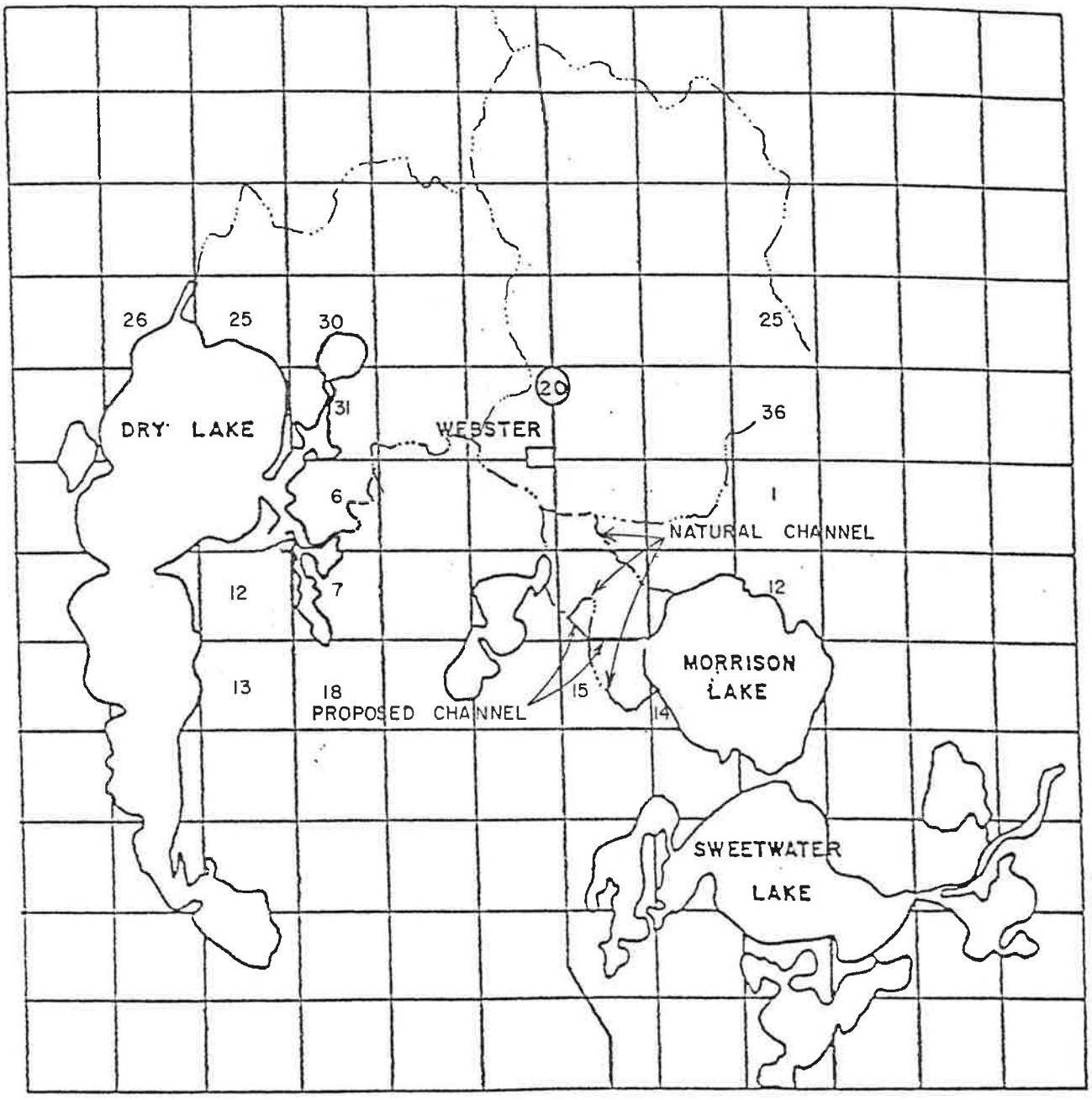
TABLE 1

Water Surface Acreages

Description	Elevations (MSL)	Acreage (Acres)
Natural Control Level	1459.0	6300
Meandered Level	1460.6	7500
Peak Flood Level - 1979	1461.4	8300

The first mile of the channel below the southwest outlet of Morrison Lake is obstructed by heavy slough grasses and cattails. This results in long duration flooding around Sweetwater-Morrison Lakes.

The discharge level of the northwest outlet from Morrison Lake is approximately two feet higher than the southwest outlet. Therefore, the



STUDY AREA MAP
FIGURE 2

northwest outlet is only used during high flood periods. The channel below the northwest outlet is poorly defined and extremely flat, resulting in significant flooding whenever the northwest channel is used.

The two channels from Morrison Lake join on the west side of Highway 20. The channel below Highway 20 is generally well defined but the channel has a very low capacity in certain areas before overbank flooding occurs.

In 1979, approximately 1,000 acres were flooded along the channels between Morrison and Dry Lakes.

III. ENGINEERING ANALYSIS

Study Procedures

The study includes an estimate of flood flow frequencies, an analysis of current channel conditions, and an analysis of improved channel conditions. The costs of the improvements were also estimated.

The Corps of Engineer's Water Surface Profile Program, HEC-2, was used to analyze the various structures and channels. The program has options to use different flows, change channel characteristics and analyze many factors that influence water levels. Topographic ground surveys of the channel and structures were completed and used for input to the HEC-2 program.

Basin Hydrology and Flood Flow Frequencies

Very little historical streamflow data exists on Sweetwater-Morrison Lakes or along the outlet channel to Dry Lake. Although no official records exists, the information gathered during or soon after the 1979 flood is considered reasonably accurate.

In 1979, Sweetwater-Morrison Lakes reached an estimated peak elevation of 1461.4 mean sea level. The outflow from these lakes overtopped Highway #20 south of Webster by approximately six inches and the east-west rural gravel road north of Lake Cavanaugh by 2.5 feet. In 1979, Dry Lake reached a peak elevation of 1451.0 MSL.

It was estimated that the total 1979 inflow to Sweetwater-Morrison Lakes exceeded 40,000 acre-feet. The peak discharge from the lakes was estimated at 1,200 cfs. The northwest outlet carried approximately 1,000 cfs and the southwest outlet about 200 cfs. The 1979 runoff into Sweetwater-Morrison Lakes was estimated to be about a 50 year frequency. Reports from farmers around the lakes indicate the 1979 flood exceeded

all floods of this century. The 1950 flood, however, was thought to be only slightly lower in magnitude. The structures and channel improvements in this study were analyzed for a 10 year flood. State Water Commission design criteria does not allow for the design of flood protection for agricultural areas for more than a 10 year event. The costs for constructing projects for large magnitude floods cannot be justified. The discharge of 400 cfs from Morrison Lake was determined to provide 10 year protection in Sweetwater-Morrison Lakes. A discharge of 400 cfs would keep Sweetwater-Morrison Lakes below the estimated meandered elevation of 1460.6 MSL during a 10 year flood assuming the control elevation is set at elevation 1459.0 MSL.

Water Surface Profile Analysis

Topographic surveys consisting of cross-sections and structure details were taken along the channels between Morrison Lake and Dry Lake. Seven structures (bridge or culvert crossings) and a machinery crossing were surveyed. Plate 1 shows the location and Table 2 contains details of the structures.

The capacity of the channel and structures were evaluated with the HEC-2 computer model. The computer results for the 1200 cfs (1979) flow were compared to 1979 high water marks and aerial photographs taken in May, 1979. The comparison showed that the computer program adequately predicted water elevations.

After the model was calibrated for a 1,200 cfs flow, the adequacy of the natural channel and structures was evaluated for a 400 cfs flow. The southwest outlet, although lower than the northwest outlet, was not adequate to pass a 400 cfs flow. The water level of Sweetwater-Morrison Lakes from a 10 year inflow, increased from 1459 msl to 1460.8 msl. Plates 2, 3, and 4 show the water surface profiles of the channel.

TABLE 2

STRUCTURE DESCRIPTIONS

Structure Number	Legal Description S-T-R	Description H-W-L	Roadway Elevation (msl)	Invert (msl)
1.	10-155-64	Conc. Box Cul. 5.0'x8.2'x22.6' L.C. 1457.7	1461.4	1452.7
2.	9,10-155-64	Conc. Bridge 6'x38'x45' L.C. 1460.5	1463.6	1454.5
3.	4, 9-155-64	3-36"x41' RCP Cul. 2-3'x4'x41' Elip. CMP Cul. L.C. 1455.4	1457.5	1452.4
4.	4, 3-155-64	4-BBL Conc. Box Cul. 4.2'x3.2'x58' 3 Div. @ 0.7' Wide L.C. 1455.5	1460.1	1451.3
5.	33,4-156,155-64	Conc. Bridge 7.4'x46'x26' 2 Conc. Div. @ 1.5' Wide, L.C. 1456.8	1459.4	1449.4
6.	32,5-156,155-64	CMP Cul. 36"x52' L.C. 1453.3	1459.2	1450.3
7.	31,32-156-64	Bridge w/con. Deck & Wood TR. Walls 11.4'x59'x30.5' L.C. 1459.0	1461.3	1447.6
X-Sec.	4,15-155-64	Machinery Crossing	1459.8	

L.C. Low Chord

The proposed new channel from Morrison Lake would have an 80 foot bottom width and an average channel gradient of 0.0004. Approximately 5,200 feet of new channel would be constructed. The new channel would join the existing channel approximately 800 feet east of Highway 20. The 800 feet of existing channel would also be widened to an 80 foot bottom width. The inside slope of the new channel will be 2:1 and the outside slopes will be approximately 10:1, or a slope that is farmable.

No improvements are proposed in Section 9, Township 155 North, Range 64 West. The existing channel through Cavanaugh Lake is adequate for a flow of 400 cfs. Structure #3 is a gravel road located between Sections 4 and 9, which is on the north side of Cavanaugh Lake. The road would be able to pass 400 cfs without being overtopped. The water level on the culverts would be approximately the low chord elevation. Since there is a small difference in the water levels on the two sides, there would be backwater occurring on the south side in Cavanaugh Lake.

Channel improvements in Section 4, Township 155, Range 64, will consist of an 80 foot bottom width, a slope of 0.0004, and inside side slopes of 2:1. The improved channel will require approximately 22 acres that will not be able to be cultivated. Some of that acreage is the existing channel which is not cultivated now. The dike should be placed along the confluence of the northwest outlet. It would connect the channel and the Highway #20 bridge. The channel used would have a 30 foot bottom width and taking up less than one acre of land, with some of that being the existing channel. Flapgates could be installed to keep water from backing up and flooding in Section 3, although only minimal flooding would occur with flows less than 400 cfs.

IV. ANALYSIS OF IMPROVEMENTS

General

The main objectives of the various improvements analyzed were: (1) to pass a 10 year flood without raising Sweetwater-Morrison Lakes higher than 1460.6 msl, and (2) to keep the discharges from Morrison Lake within the channel banks. The project improvements selected to accomplish these objectives consist of a new outlet on Morrison Lake, a new channel from Morrison Lake to Highway 20 to replace the southwest channel, and modifications to the channel between Highway 20 and Dry Lake. The existing culvert and bridge structures will be generally adequate if the downstream channels are improved. Plate 1 shows the location of the improvements.

The new channel and outlet structure were selected over modifications to the existing channel for several reasons: (1) the new outlet structure would be less costly to construct at the proposed site than at the existing discharge location, (2) the existing channel meanders through several wetland areas. Modifications in the wetland areas would be costly and the permits necessary to do the modification may be difficult to obtain, and (3) the proposed channel would be shorter than the existing channel and generally follow the section line between Sections 10 and 15. This will cause less disruption to agricultural operations. The new channel between Morrison Lake and Highway #20 will require approximately 18 acres of farmland. Some of that acreage is the existing section line.

Table 3 compares the existing and improved channel water levels for both a 400 cfs (ten year flood) and 1200 cfs discharge (a 1979 equivalent flood).

The 10 year flood level of Sweetwater-Morrison Lakes would be

reduced approximately 6-inches and the discharges from Morrison Lake would be confined to the new channel. The northwest outlet would not be used for a 10 year flood.

TABLE 3

Existing and Improved Water Levels

Event	Morrison Lake Elev. (MSL) Existing	Improved	N. Hwy. 20 Bridge #4 Elev. (MSL) Existing	Improved	Structure #5 Elev. (MSL) Existing	Improved
10 Year	1461.0	1460.6	1457.5	1455.2	1456.3	1454.5
1979	1461.4	1461.0	1460.5	- 1459.0 -	1458.9	1457.2

For a 1979 equivalent flood, both the new channel and the northwest channel would be used. However, Sweetwater-Morrison Lakes would raise to 1461.0 msl or 0.4 feet lower than in 1979. The channel from the northwest outlet would be cut in half and Highway #20 south of Webster would not be overtopped as in 1979. Although a 1979 level flood would still cause considerable flooding of agricultural land, the number of acres flooded and the duration of the flooding would be significantly reduced.

Summary of Improvements

The new Morrison Lake outlet structure at the southwest outlet would consist of a 70 foot sheet piling weir with a control elevation at 1459 msl (Figure 3). The weir will have a capacity of 400 cfs when Morrison Lake reaches 1460.6 msl. Once Morrison Lake exceeds 1460.75 msl the existing northwest outlet would discharge. The 1459 msl control elevation for Morrison Lake was used because it is very close to the existing control elevation. Morrison Lake has frozen at 1459 msl during most years when records were available.

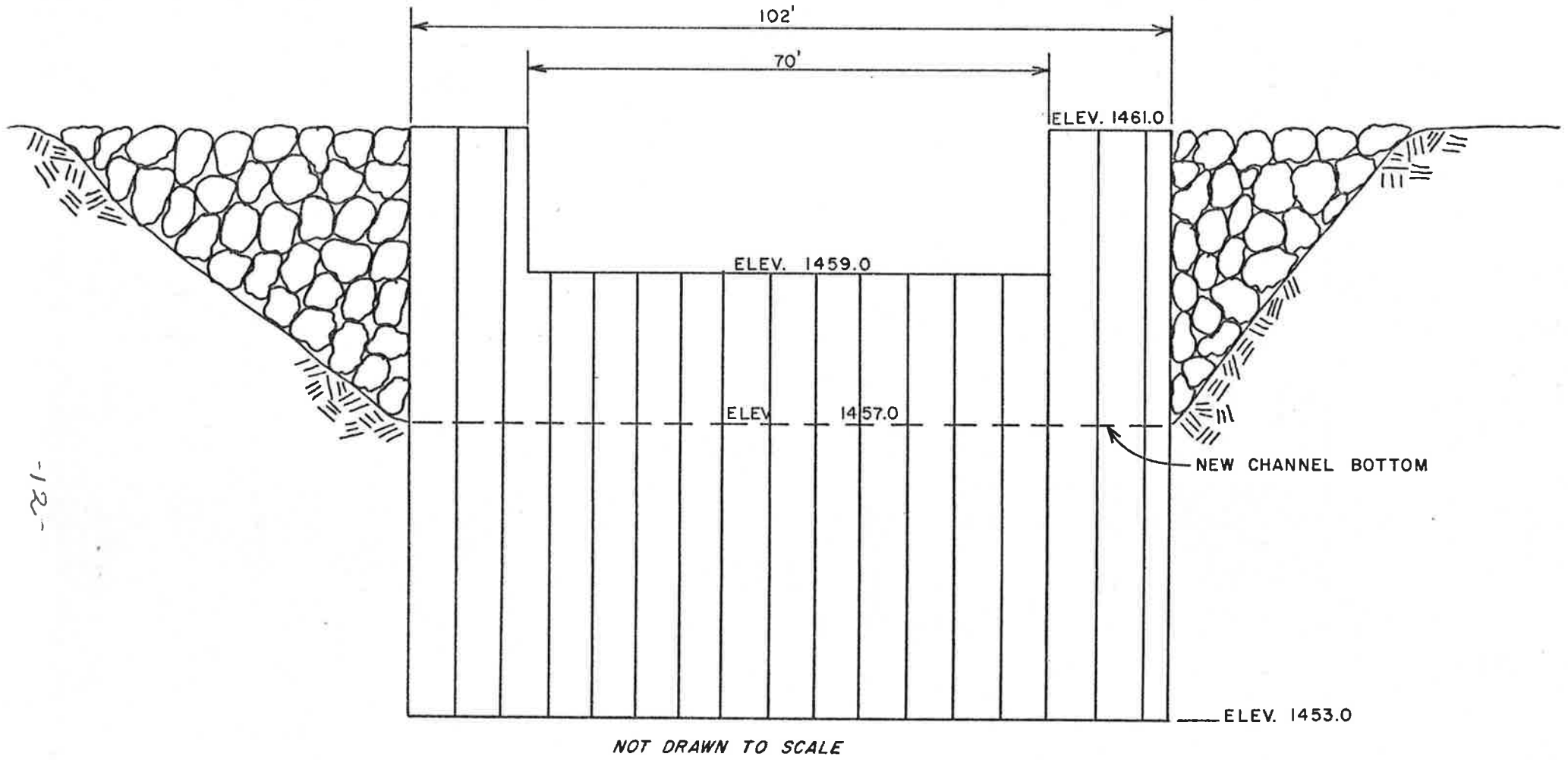

102'
70'
ELEV. 1461.0
ELEV. 1459.0
ELEV 1457.0
NEW CHANNEL BOTTOM
ELEV. 1453.0
NOT DRAWN TO SCALE

FIGURE 3

The channel area between Dry Lake and Structure #5 is well defined. A bottom width of 50 feet will be used along with a slope of 0.0002 for the improvement. The earthwork from the channel will be placed along the channel to build small dikes. Some of the dredging by Dry Lake may be hard to complete in a wet year.

Earthwork details from Morrison Lake to Dry Lake are shown in Table 4. The distance starts at zero at Dry Lake and is cumulative to Morrison Lake.

Field inlets will be needed along the channel to ensure that local runoff will continue to drain off into the channel. Two culverts, a 24" and 36", should be placed where the new channel crosses the old channel in Sections 10 and 15, west of Morrison Lake. The water in the slough could pass through Section 15 and into the channel. At the confluence of the northwest outlet, a dike would be built west from Highway 20 to the main channel. A bottom width of 30 feet, inside side slopes of 2:1, and a gradeline sloping toward the main channel would be used. Two culverts would be located in the N½ of Section 4, one on each side of the dikes for local runoff. In Section 33, north of Structure #5, a culvert would be installed in the dike. This would allow the channel coming from the north an outlet. Culverts would be placed in other areas to allow natural runoff from the ditches. The existing southwest outlet from Morrison Lake would be blocked. During years of large runoff water would still discharge through the northwest outlet.

TABLE 4

EARTHWORK ESTIMATION

Locations S-T-R	Channel Distance Between Locations (Feet)	Improved Channel Bottom Width (Feet)	Earthwork Cubic Yards Excava.	Dike	Cost Dollars
Dry Lake	14,334	50	31,454	2,889	47,181
Structure #7 31,32-156-64	24,615	50	8,242	Make Berm	6,594
Structure #5 33,4-156,155-64	33,065	80	75,120	56,340	93,900
Structure #3 4,9-155-64	37,368	Natural	No Earthwork		
Structure #2 Highway 20 9,10-155-64	43,405	80	115,556	94,444	144,445
Morrison Lake New Outlet 11-155-64		New Channel			
TOTAL			230,372	153,673	292,120

1.25 per cubic yard for excavation, hauling, and compaction.
1.50 per cubic yard for dredging.
.80 per cubic yard for excavation only.

Excavated material will be used on the dikes, therefore, some of the costs of diking will be accounted for in excavation.

Summary of Structures

Generally, few improvements or changes are proposed for the existing road crossings and structures. The proposed channel improvements were made in such a manner as to not affect the existing structure. The following is a brief description of each structure.

1. A concrete box culvert is located in Section 10. It crosses the northwest channel at a low spot between the upstream and downstream sides. The bridge has adequate capacity, but due to the flat land surrounding it, flooding occurs. No improvements would benefit the area, except to dike off the lake to an elevation of 1460.75.

2. This is the Highway 20 bridge that crosses the west outlet channel 9100 feet south of Webster. It is a concrete bridge and has adequate capacity for the improved conditions. A railroad bridge is located just upstream, but should not cause any problems if improvements are not made to it. Vegetation in the two bridge areas could be removed to help the flow. A water elevation for 400 cfs was more than two feet below the chord of the highway bridge.

3. A gravel road is located on the north end of Cavanaugh Lake, west of Highway 20. There are three 36" RCP culverts and two 36"x48" eliptical culverts in the roadway. A water elevation for 400 cfs was within 0.2 feet of the low chord. There will be no improvements made to the structure due to the cost vs. the benefits received. The upstream channel will not be changed through Cavanaugh Lake but improvements will be made on the downstream channel, in Section 4.

4. This is the Highway 20 bridge that crosses the northwest outlet channel 3200 feet south of Webster. It is a 4 barrel concrete box culvert. A railroad bridge is located just upstream but should not cause any problems if improvements are not made to it. A water elevation for 400 cfs would come within 0.2 feet of the low chord. No channel improvements will be made upstream on the northwest outlet. A 30 foot wide channel will be diked and connected from Highway 20 to the main improved channel.

5. This concrete bridge is located west of Webster, between Sections 33 and 4, with two dividers each 1.5 feet wide. A water elevation for 400 cfs was over a foot lower than the low chord. Approximately, one foot of dredging may be needed in the invert of the bridge. The bridge supports are deep enough not to have problems with that excavation.

6. A culvert passes through the roadway between Sections 5 and 32. The channel used to pass water south through the road and then back through to the north, then a channel was placed on the north side, which diverted the main flow of water from passing through the road. Now the culvert in place has no significant effect on the channel flow. It provides an outlet for a small slough on the south side of the road.

7. This structure is located between Sections 31 and 32. It has a concrete deck and wood training walls. A water elevation for 400 cfs was several feet below the low chord. This bridge has adequate capacity for expected flows. Vegetation in this area should not be of any significance.

V. COST EVALUATION FOR IMPROVEMENTS

Weir Structure on Morrison Lake

A weir structure would be used for the control on Morrison Lake. It will have a control elevation of 1459.0 msl with a 70 foot opening. Approximate costs for the weir are listed below:

TABLE 5

Weir Cost Estimation

	Quantity	Cost
Sheet Piling and Installation $24 a linear foot	510	$12,240
Rock Riprap up and Downstream $20 a cubic yard	68	1,360
Site Preparation		2,000
Filter Blanket Riprap $10 a cubic yard	34	340
TOTAL		$15,940

Listed in Table 3 are the quantities of earthwork for the dikes and channel excavation. Also included is a cost for the earthwork. Total cost on the earthwork is approximately $292,120. Cost will vary depending on conditions. Conditions would be how much excavation material will be suitable for dike work, how wet the soil will be in that year during construction, and if soil would have to be hauled in or away. Most of the excavation from the channel will be used for the dikes. The earthwork for the excavation and dikes will have a pretty good balance due to shrinkage during compaction.

Placement of culverts along the channel will provide an outlet for local runoff. There will be flapgates placed on the culverts to

prevent flooding from the channel onto adjacent areas. An estimated cost for the culverts would be $9,000 installed, and $1,200 for flapgates.

Some work would be needed on the northwest and old west outlets of Morrison Lake. Blocks would be needed with an approximate cost of $6,500. To obtain a project estimate, costs for earthwork, weir structure, culverts, outlet blocks, and contingencies were totaled. The project cost summary is shown in Table 6.

TABLE 6

Project Cost Summary

ITEM	COST
Earthwork	$ 292,120
Weir Structure	15,940
Culverts and Flapgates	10,200
Outlet Blocks	6,500
Engineering, Contract Administration and Contingencies	97,428
TOTAL	$ 422,188

VI. SUMMARY AND RECOMMENDATIONS

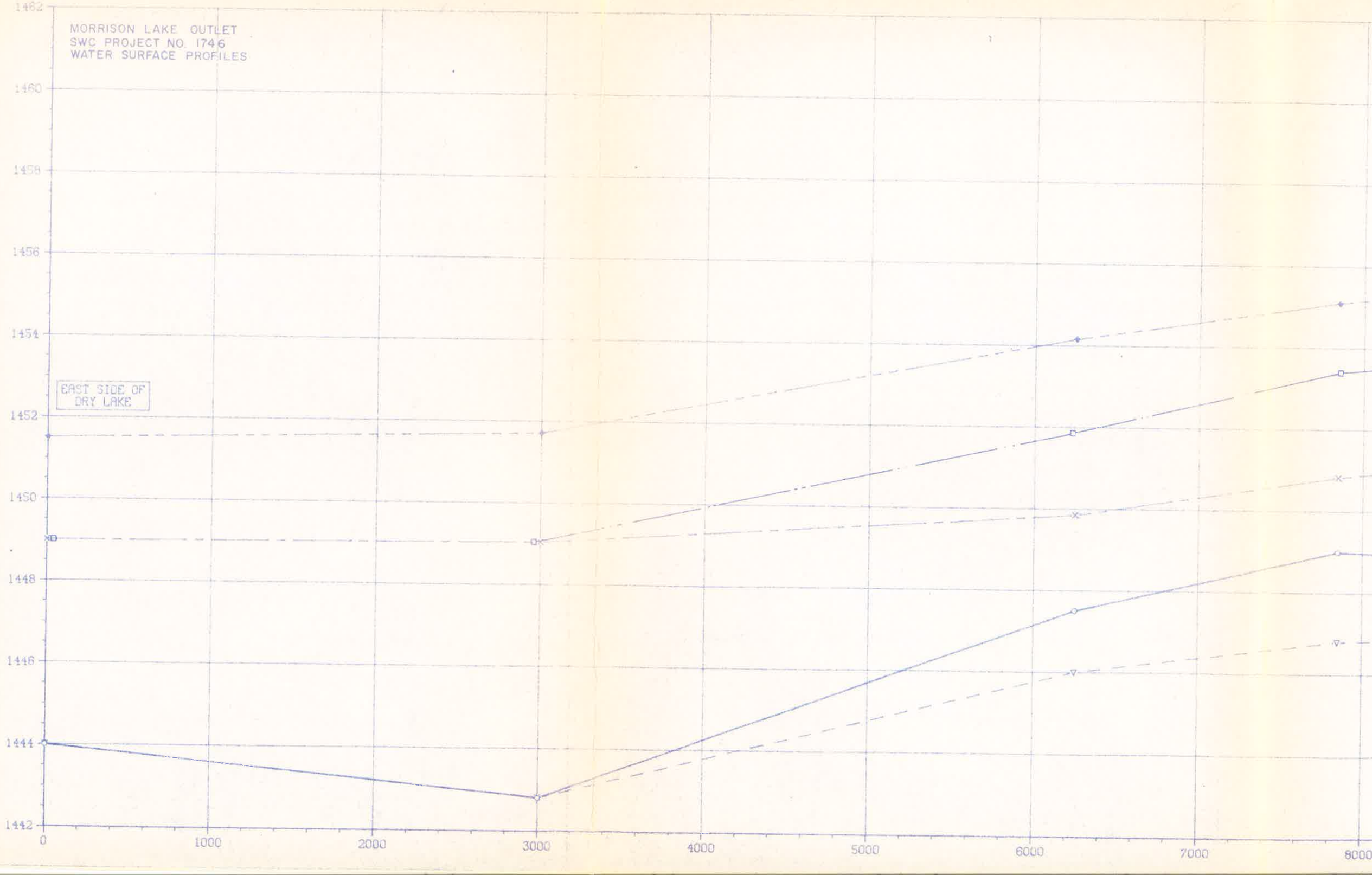
A new outlet control for Morrison Lake was studied. Also, channel and structure capacities were analyzed between Morrison Lake and Dry Lake. The HEC-2 computer program was used to determine surface water elevations along the channel and at the structures. Elevations were found for flows of 400 and 1200 cfs. The 1200 cfs flow was used to calibrate a working model reflecting natural conditions in the area. A 400 cfs flow was run with natural conditions and the problem areas were located. Then 400 cfs was run with improved conditions with the costs and effects being analyzed. The flow used would be that of a 10 year event.

Starting at Morrison Lake, a new west outlet would be constructed using a sheet piling weir for the control. Morrison Lake should discharge 400 cfs at approximately 1460.6, using a 70 foot opening on the weir. The weir crest would be at 1459.0. In Sections 10, 11, and 15 the bottom width of the new channel from Morrison Lake to Highway 20 would be 80 feet. Excavation material from the channel will be placed on the sides resulting in a farmable slope. The channel area in Section 9 by Cavanaugh Lake will be left in its natural condition since it is too wet in most years for construction. The channel that runs parallel to Highway 20 in Section 4 would have a bottom width of 80 feet. The excavation material would be placed along the sides as small dikes, farmable on the outside slopes. From Structure #5 to Dry Lake a bottom width of 50 feet should be cut. The soil would be placed on the outside, using a farmable slope.

The channel improvements, new weir outlet, and the new channel should bring relief from flooding. The benefits would be to the channel and the surrounding area. These reductions are to the average year flood. The total cost recommendation would be $422,188.


STRUCTURE NO. 7
STRUCTURE NO. 5
STRUCTURE NO. 6
EXISTING CHANNEL TO BE IMPROVED
STRUCTURE NO. 3
STRUCTURE NO. 4
STRUCTURE NO. 1
STUCTURE NO. 2
NATURAL NORTHWEST OUTLET
PROPOSED NEW CHANNEL AND OUTLET
NATURAL SOUTHWEST OUTLET
HIGHWAY 20
DEGROAT
WEBSTER
HARDI
DRY LAKE
FRESHWATER
MORRISON LAKE
Stone Lake
Cavanaugh Lake
Webster Cem
Webster
St Peter and Paul Ch
School No 1
School No 2

MORRISON LAKE OUTLET
SWC PROJECT NO. 1746
WATER SURFACE PROFILES



ROADWAY

STRUCTURE NO. 7

1462
1460
1458
1456
1454
1452
1450
1448
1446
1444
1442

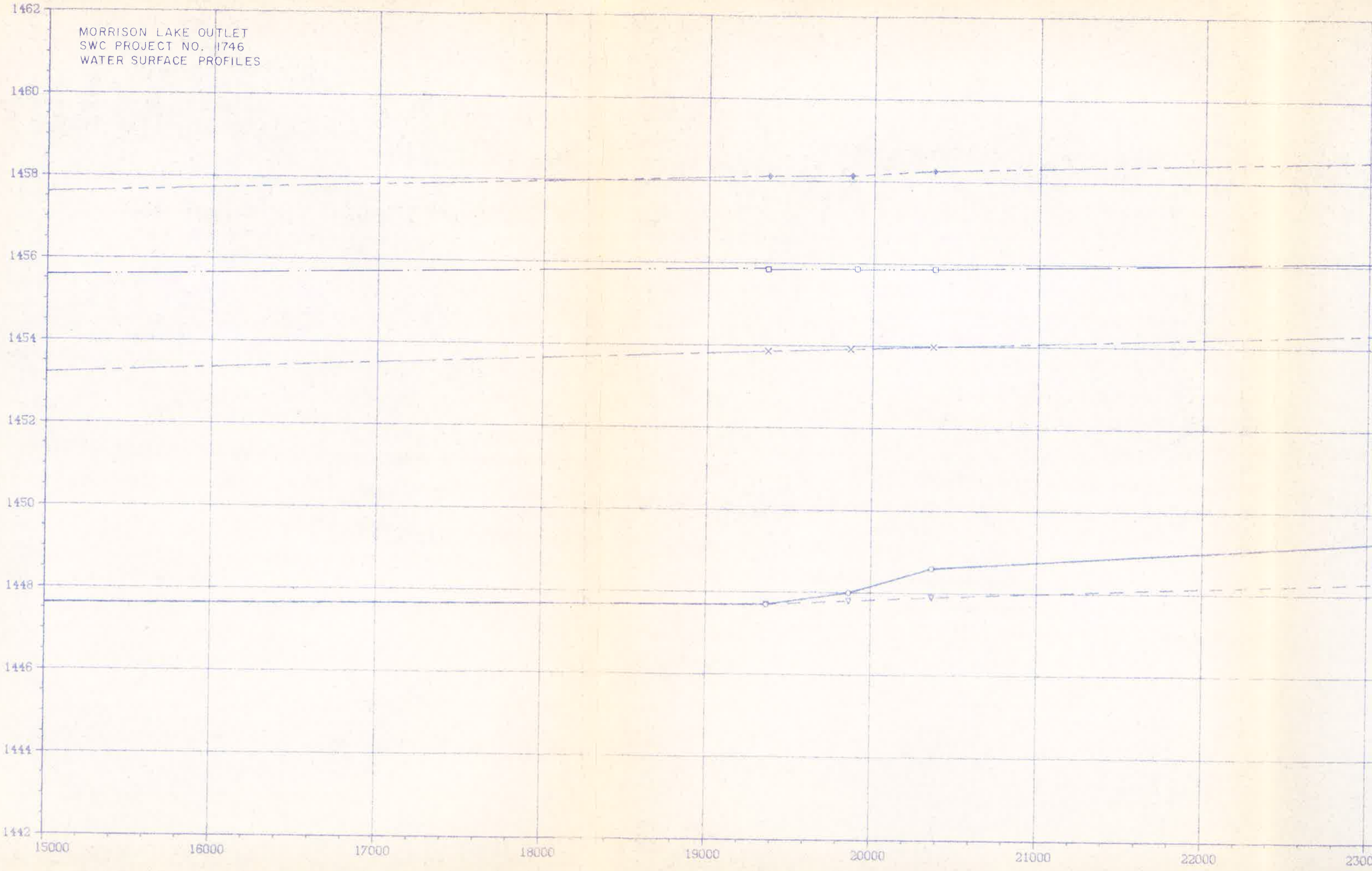
7000
8000
9000
10000
11000
12000
13000
14000
15000

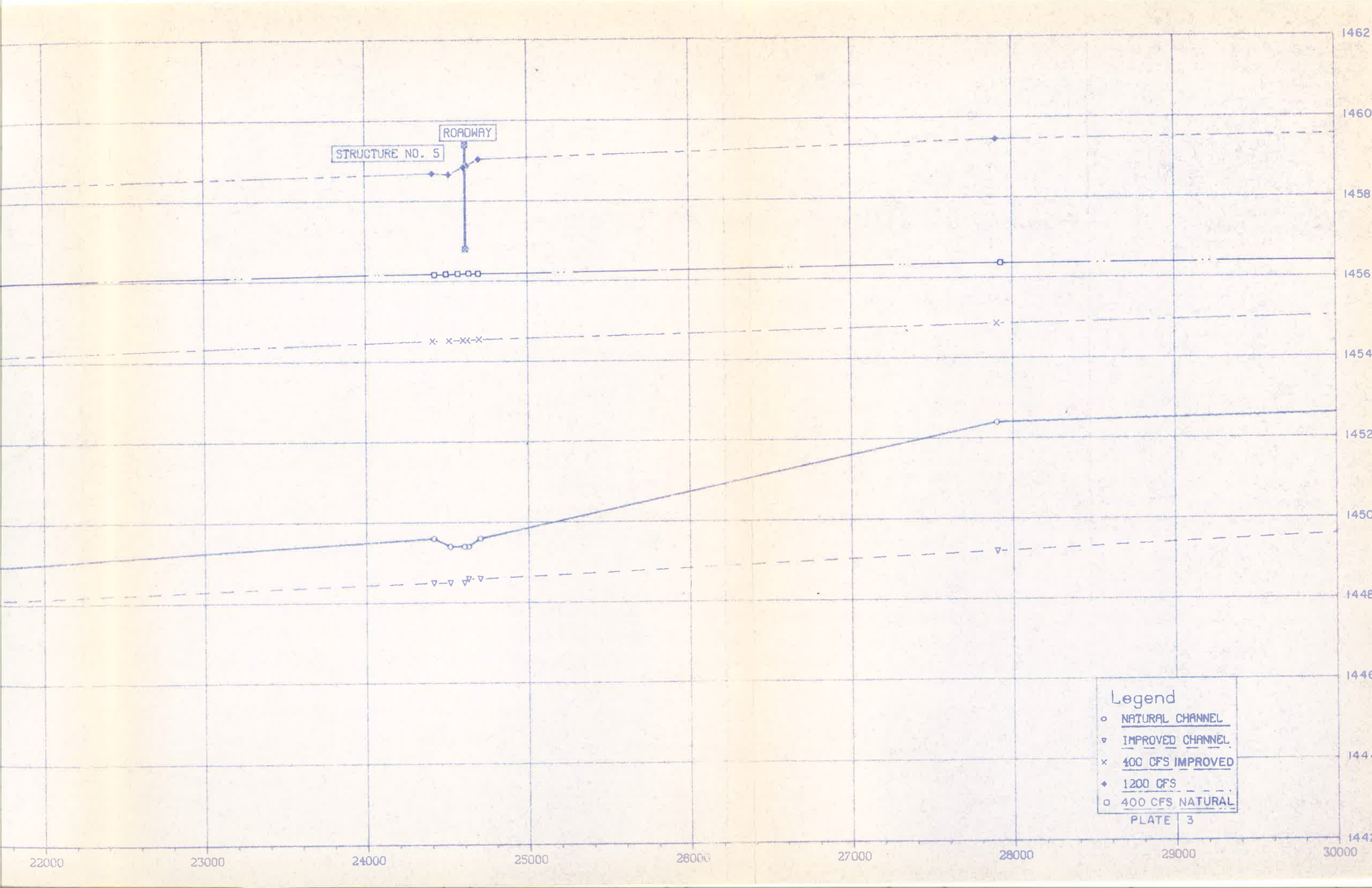
Legend

- NATURAL CHANNEL
- IMPROVED CHANNEL
- 400 CFS IMPROVED
- 1200 CFS
- 400 CFS NATURAL

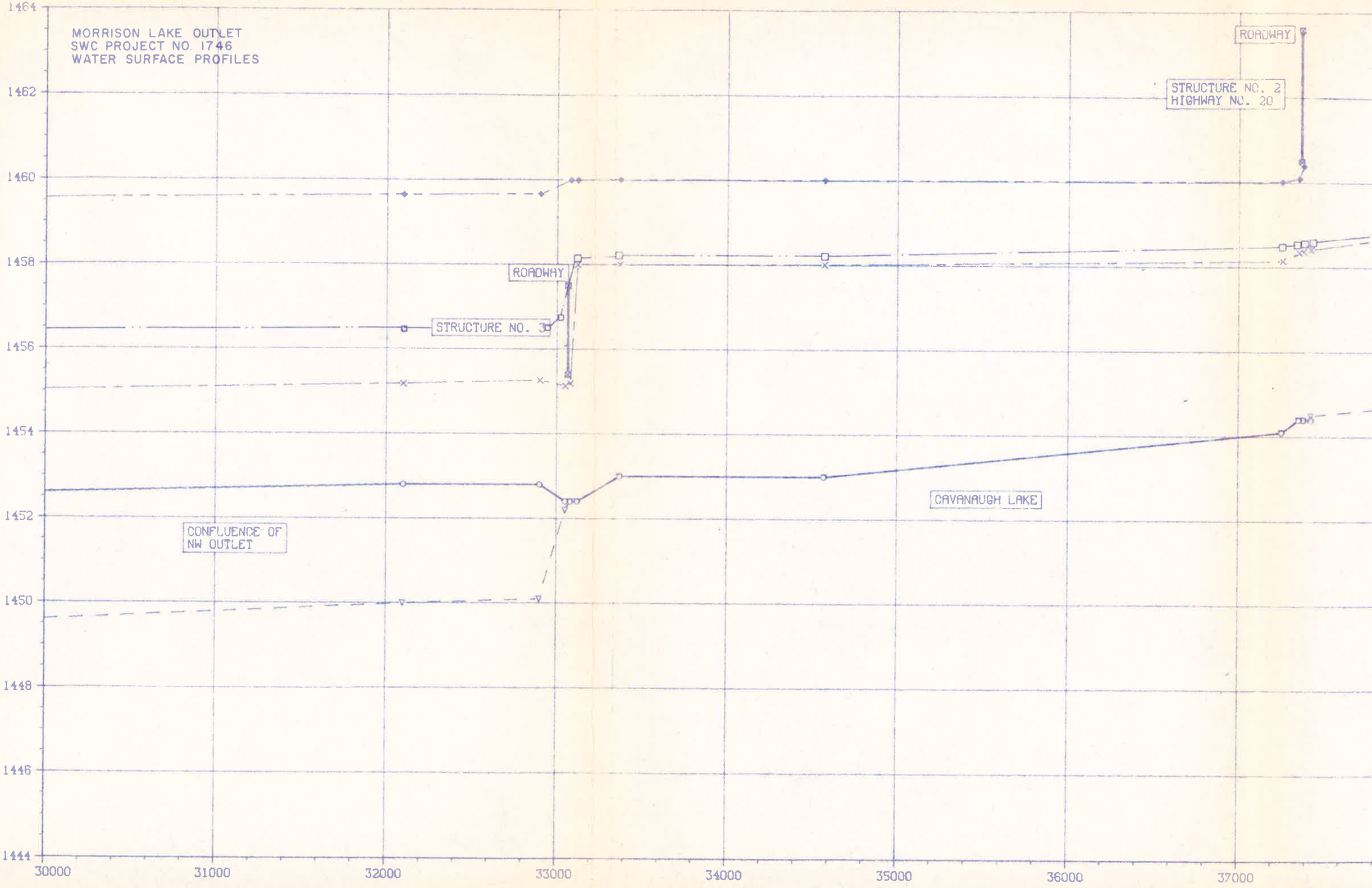
PLATE 2

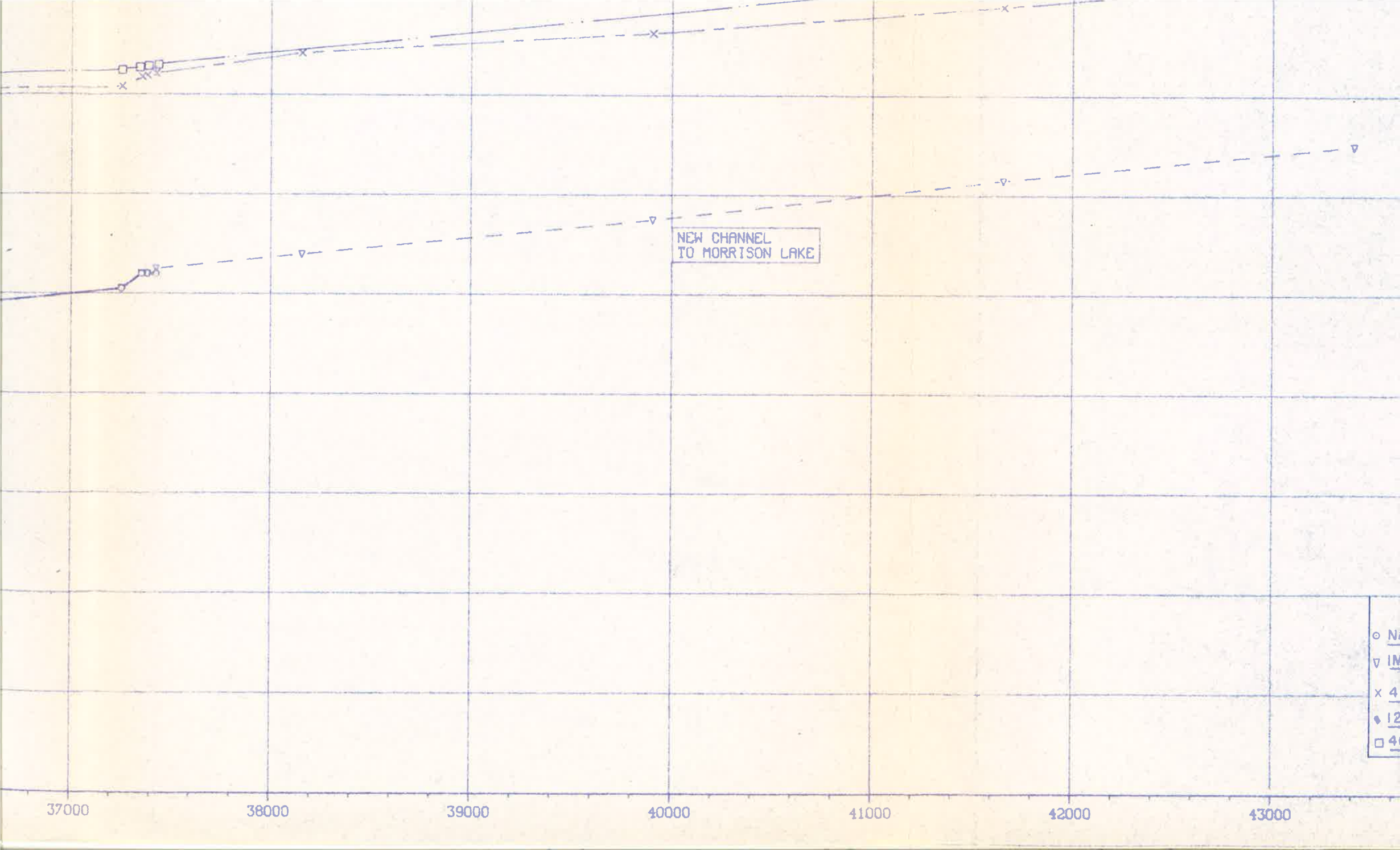
MORRISON LAKE OUTLET
SWC PROJECT NO. 1746
WATER SURFACE PROFILES




ROADWAY
STRUCTURE NO. 5
1462
1460
1458
1456
1454
1452
1450
1448
1446
1444
1442
22000
23000
24000
25000
26000
27000
28000
29000
30000
Legend
NATURAL CHANNEL
IMPROVED CHANNEL
400 CFS IMPROVED
1200 CFS
400 CFS NATURAL
PLATE 3

MORRISON LAKE OUTLET
SWC PROJECT NO. 1746
WATER SURFACE PROFILES




NEW CHANNEL
TO MORRISON LAKE
37000
38000
39000
40000
41000
42000
43000

APPENDIX A

Preliminary Investigation Agreement

S.W.C. Project # 1746
August 6, 1981

A G R E E M E N T

Preliminary Investigation by the
North Dakota State Water Commission
for Morrison Lake Outlet

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 Ramsey County Water Resource Board, hereinafter referred to as the Board, acting through its Chairman, Robert Garsky.

II. PROJECT, LOCATION AND PURPOSE

The Board has requested the Commission to investigate the improvement of the outlet to Morrison Lake. This would include the channel running between Morrison Lake and Dry Lake. The investigation shall begin at the outlet to Morrison Lake, located in the west half of Section 14, Township 155 North, Range 64 West, and extend to the point where the channel flows into Dry Lake, located in the southwest quarter of Section 31, Township 156 North, Range 64 West. The purpose of this investigation is to study the effects of increased flows from Morrison Lake on the channel between the improved outlet and Dry Lake.

III. PRELIMINARY INVESTIGATION

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

1. Obtain field data for a hydrologic analysis of the study area and a water surface profile study. Some hydrologic information will be obtained from the drainage area above Morrison Lake.
2. Complete a hydrologic analysis of the area to determine expected flows to evaluate channel and crossing capacities.
3. Determine the water surface profiles along the study area to show effects of increased flows and identify areas causing problems.
4. Present a report discussing the results of the water surface profile and hydrology studies. The report will identify any problem areas and present recommended improvements and their estimated costs.

IV. DEPOSIT - REFUND

The Board shall deposit a total of $2,500 with the Commission to partially pay for 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 landowner for field investigations by the Commission which are required for the preliminary investigation.

VI. CHANGES TO AGREEMENT

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

Robert Garsky

ROBERT GARSKY, CHAIRMAN
Ramsey County Water Resource Board

8-24-81
DATE

Vernon Fahy

VERNON FAHY
State Engineer

8-25-81
DATE

WITNESS

Mark Emerson
WITNESS