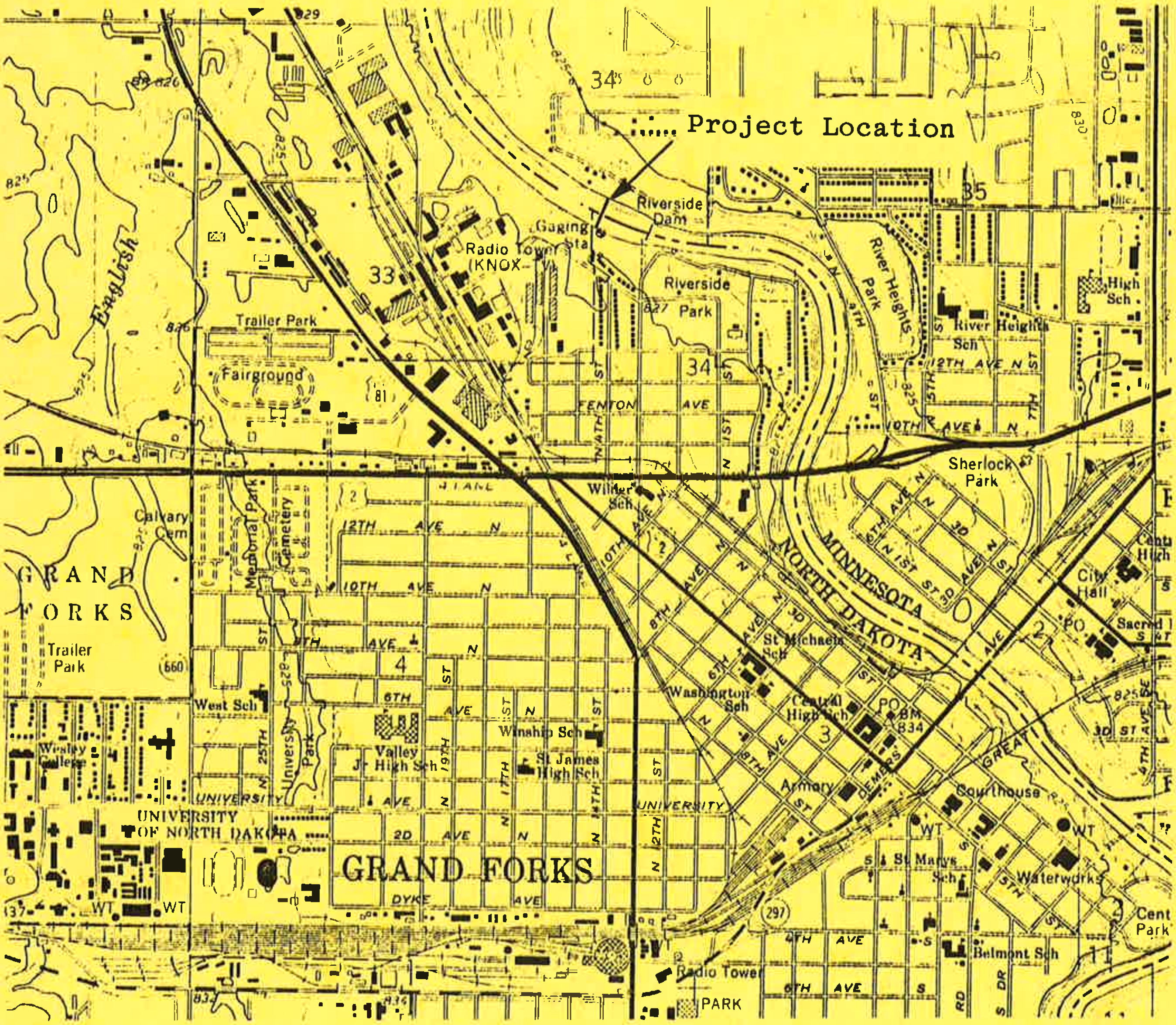
PRELIMINARY ENGINEERING REPORT

GRAND FORKS NEW RIVERSIDE PARK DAM

S.W.C. PROJECT NO. 520

GRAND FORKS COUNTY



NORTH DAKOTA
STATE WATER COMMISSION

APRIL 1984

PRELIMINARY ENGINEERING REPORT

GRAND FORKS NEW RIVERSIDE PARK DAM
SWC PROJECT #520

APRIL, 1984

North Dakota State Water Commission
State Office Building
900 E. Boulevard
Bismarck, ND 58505

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Prepared for the
City of Grand Forks

GRAND FORKS RIVERSIDE PARK DAM
SWC PROJECT #520

I. INTRODUCTION

In September of 1977, the North Dakota State Water Commission entered into an agreement with the City of Grand Forks to investigate the feasibility of constructing a new water supply dam on the Red River (See Appendix A). The purpose of the structure would be to replace the existing dam which was initially constructed in 1925 and is in an advanced state of disrepair. It has been repaired several times and is in such a condition that it could fail at any time.

The purpose of this study is to determine the feasibility of constructing a new water supply dam just downstream of the existing dam or at some other possible location. Surveys and soundings have been made of the immediate downstream area and two test holes have been drilled. The proposed dam and its features and effects will be evaluated. Conclusions and recommendations will be made regarding the possible future studies and investigations required to make the final decision as to the details of the proposed dam.

II. DESCRIPTION OF SITE

Grand Forks Riverside Park dam is an old rock filled timber crib dam located on the Red River of the North in Section 34, Township 152 North, Range 50 West, Grand Forks, North Dakota. It was constructed in 1925 at an approximate cost of $75,700, to provide partial storage for water supply for the City of Grand Forks. The rest of the City's needs are met by water from the Red Lake River in Minnesota.

The site presently under consideration is about 600 feet downstream of the existing dam and is located in Section 33, Township 152 North, Range 50 West. Figure 1 is a map showing the general location of the dam and the surficial geology of the area.

The drainage area at the dam is about 30,100 square miles. The average slope along the main channel is 0.4 feet per mile. Within the basin the land is used primarily for agriculture and the average annual precipitation is 20 inches.

Near surface sediments along the Red River in the Grand Forks area are comprised primarily of clay and silt deposited by the Red River or by glacial Lake Agassiz. Along the Red River, up to 20 feet of alluvium directly underlies land surface. The alluvium is primarily clay and silt with some fine sand, reflecting the sediments in the Red River drainage basin. The recent alluvium is underlain by approximately 80 feet of lake sediments. The lake sediments, like the alluvium, are primarily silty clay with occasional sand lenses. In places, reworked glacial till is present within the lake sediments. Approximately 100 feet of glacial till underlies the sediments deposited in glacial Lake Agassiz. The glacial till, in turn, is underlain by up to 20 feet of sand and gravel. The sand and gravel is either glacial outwash or preglacial alluvium overlying bedrock. Ordovician Winnipeg group bedrock underlies the area at approximately 200 to 220 feet below land surface.

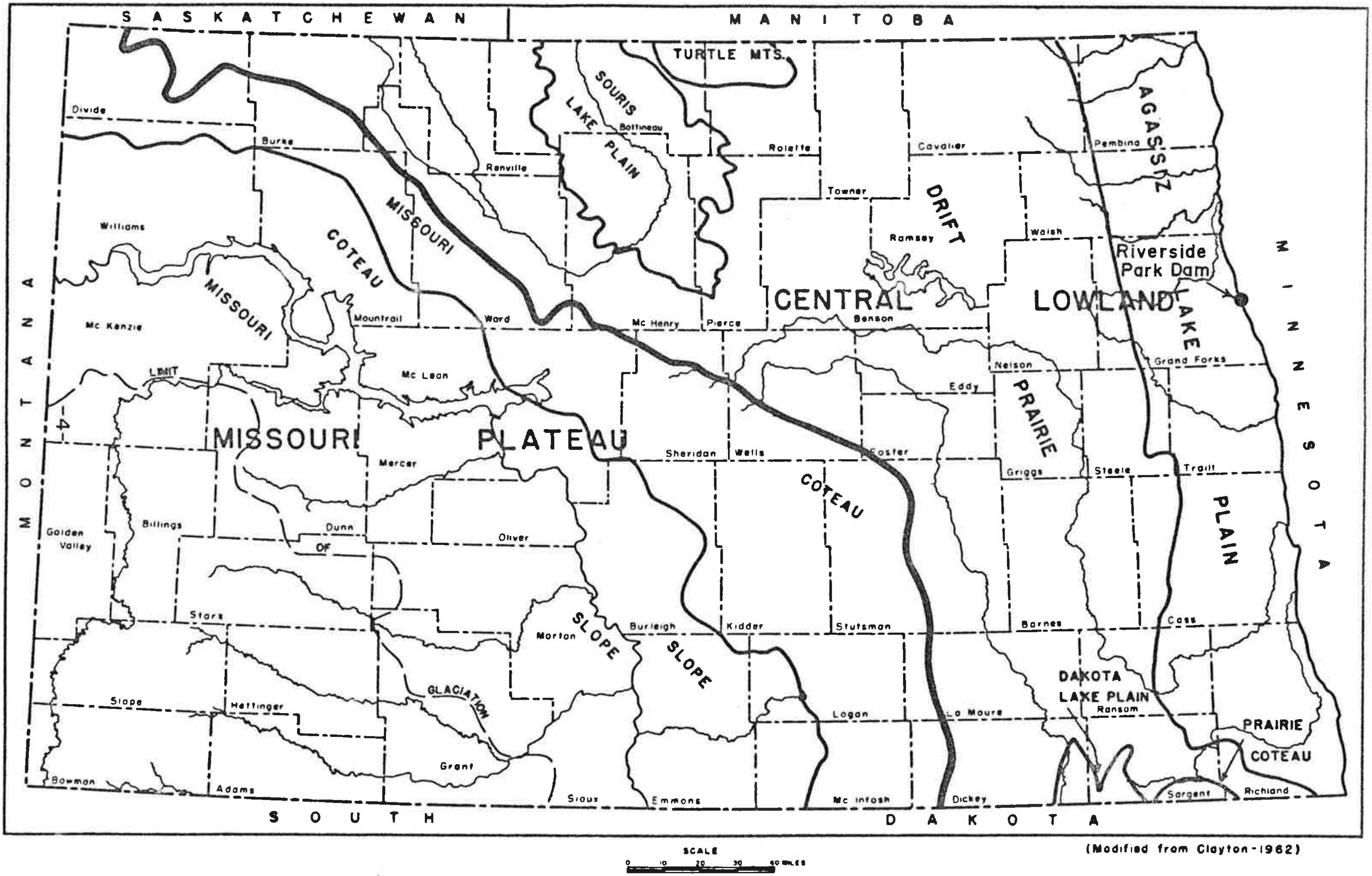


FIGURE 1 — LOCATION OF RIVERSIDE PARK DAM AND PHYSIOGRAPHIC PROVINCES OF THE AREA

III. HYDROLOGIC ANALYSIS

A hydrologic study has been sponsored by the U.S. Department of Housing and Urban Development to investigate the existence and severity of flood hazards in the City of Grand Forks, North Dakota and to aid in the administration of the Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. The results of this investigation were published in the Flood Insurance Study, dated September 1977.

The Water Resources Division of the U.S. Geological Survey furnished valuable assistance by providing basic hydraulic data pertaining to the study area. Survey data, historical flood profiles, and delineation of areas flooded for past events were obtained by contacting the U.S. Army Corps of Engineers, St. Paul District. The North Dakota State Water Commission and the City of Grand Forks, Engineering Department, furnished data and cooperated in the study. An interagency group meeting in Fargo, North Dakota, held on December 12, 1973, agreed to accept the 89,000 cubic feet per second as the 100-year flood discharge at Grand Forks.

The flow-frequency data used for the 100-year flood on the Red River of the North was coordinated by the states of Minnesota and North Dakota, U.S. Army Corps of Engineers, U.S. Geological Survey, and the Soil Conservation Service, under an interagency agreement.

The Red River flood profiles at Grand Forks are shown in Figure 2. However, as a result of the 1979 flood on the Red River, the Corps of Engineers has now revised the 100-year flood flow at Grand Forks to be about 106,000 cubic feet per second. This revision is defined in the Grand Forks - East Grand Forks Urban Water Resources Study - Flood Control Appendix - Corps of Engineers, St. Paul District, July 1981.

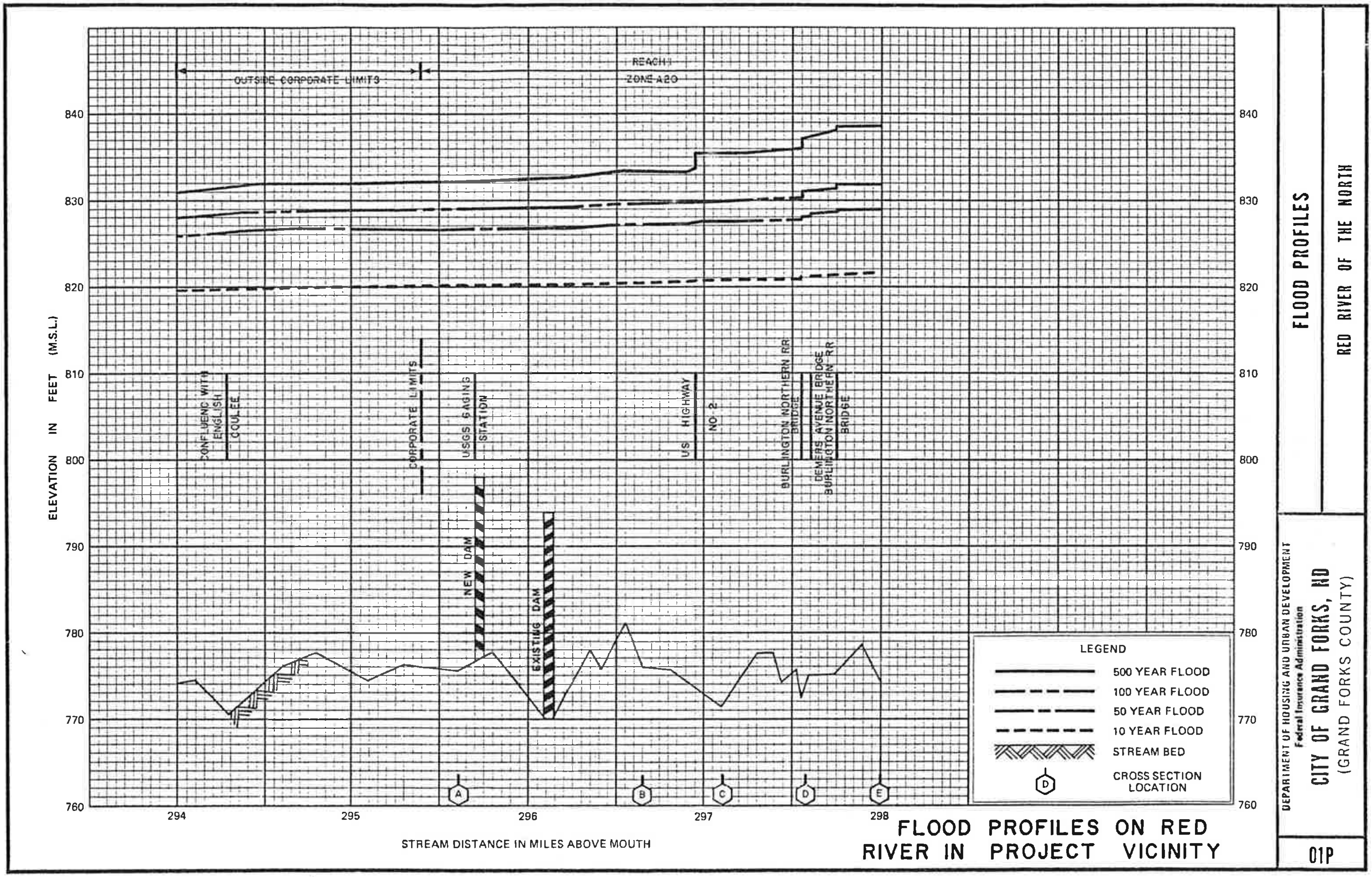

OUTSIDE CORPORATE LIMITS
REACH 1
ZONE A20
ELEVATION IN FEET (M.S.L.)
840
830
820
810
800
790
780
770
760
CONFLUENCE WITH ENGLISH COULEE
CORPORATE LIMITS
USGS GAGING STATION
NEW DAM
EXISTING DAM
US HIGHWAY NO. 2
BURLINGTON NORTHERN RR BRIDGE
DEMERS AVENUE BRIDGE
BURLINGTON NORTHERN RR BRIDGE
A
B
C
D
E
294
295
296
297
298
STREAM DISTANCE IN MILES ABOVE MOUTH
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES ON RED RIVER IN PROJECT VICINITY
FLOOD PROFILES
RED RIVER OF THE NORTH
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration
CITY OF GRAND FORKS, ND
(GRAND FORKS COUNTY)
01P

FIGURE 2

IV. HYDRAULIC ANALYSIS

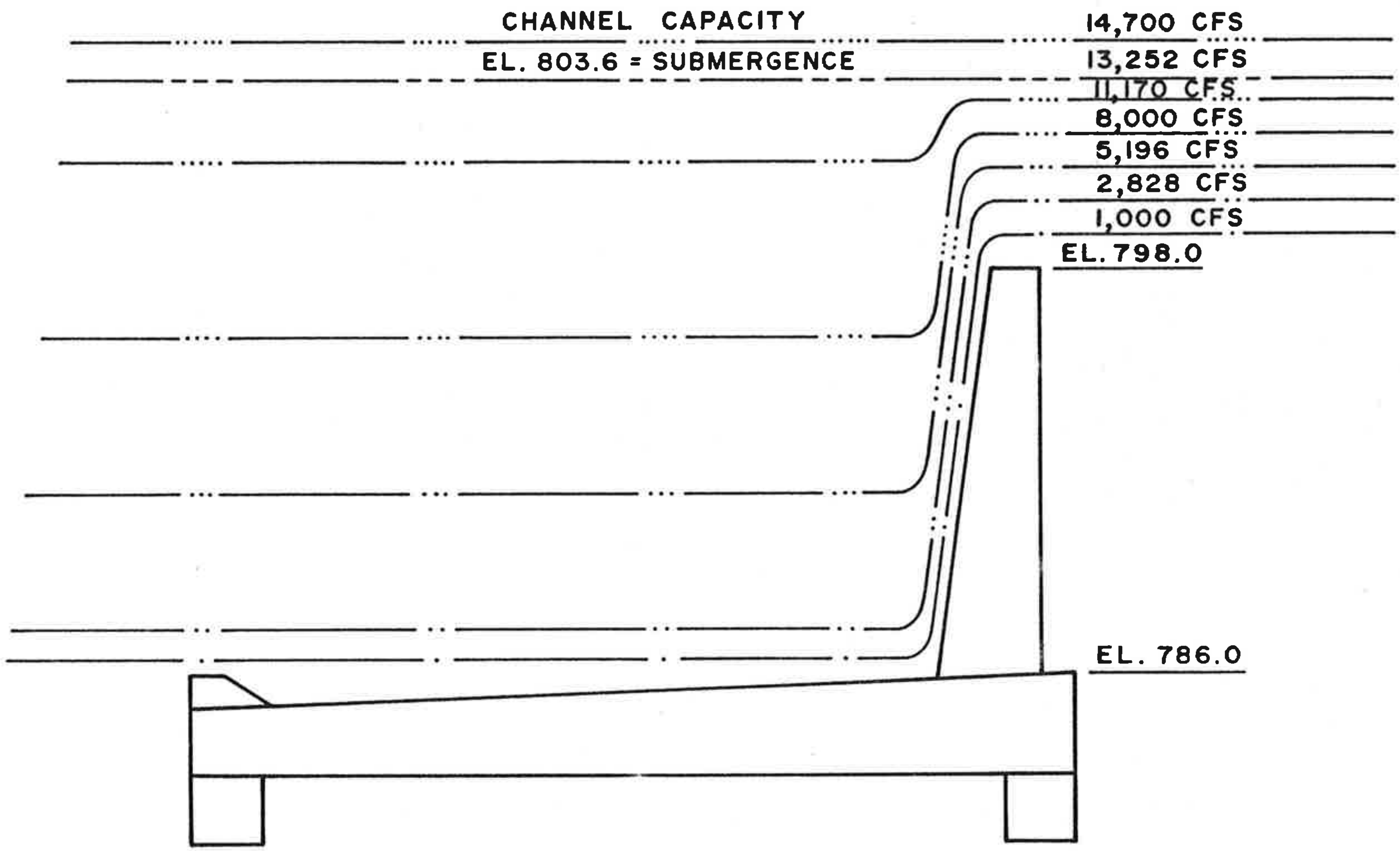
The new dam will be designed to pass the expected flows without causing any increase in any flood flows. The dam will have a 300 foot long weir set at an elevation of 798.0 msl. The side slopes will conform to the natural channel banks. In order to preserve laminar flow, the dam will operate under weir flow control until the weir submerges and the natural channel controls the flow. This occurs at an elevation of 803.6 msl and a discharge of 13,250 cfs as is shown in Figure 3, 4, and 5.

The changeover from weir control to channel control should occur within an elevation range of 1-foot with only a minor amount of turbulence. Thereafter, the flow should continue in a normal channel flow state with no turbulence or ripples indicating where the completely submerged structure is located.

Erosion and damage to the channel and river banks will be kept to a minimum with reasonable amounts of rock riprapping. Extraneous effects, caused by floating tree trunks trapped at the dam structure, may create certain turbulent and erosive currents. Tree trunks should be removed as soon as possible.

Another factor to be considered is ice jams. The size and effect of these buildups can vary considerably and are difficult to predict and evaluate.

Laboratory model studies should be made for the proposed dam before final plans are prepared. Results of the hydraulic tests serve as part of the design criteria.



GRAND FORKS NEW RIVERSIDE PARK DAM

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WEIR SUBMERGENCE STAGES

Scale: 1" = 5'

FIGURE 3

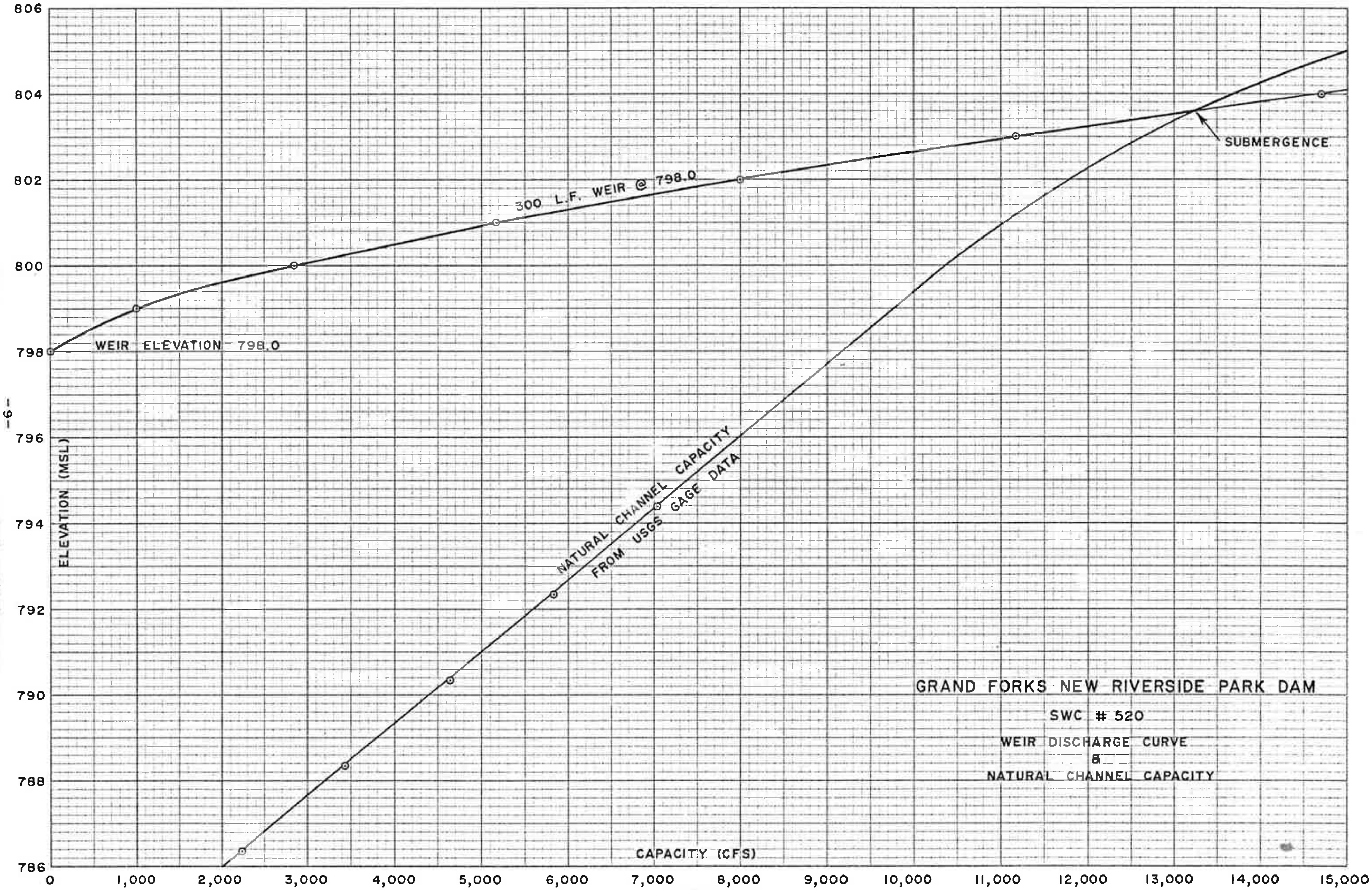

806
804
802
800
798
796
794
792
790
788
786
ELEVATION (MSL)
300 L.F. WEIR @ 798.0
WEIR ELEVATION 798.0
SUBMERGENCE
NATURAL CHANNEL CAPACITY
FROM USGS GAGE DATA
CAPACITY (CFS)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
GRAND FORKS NEW RIVERSIDE PARK DAM
SWC # 520
WEIR DISCHARGE CURVE
&
NATURAL CHANNEL CAPACITY

FIGURE 4

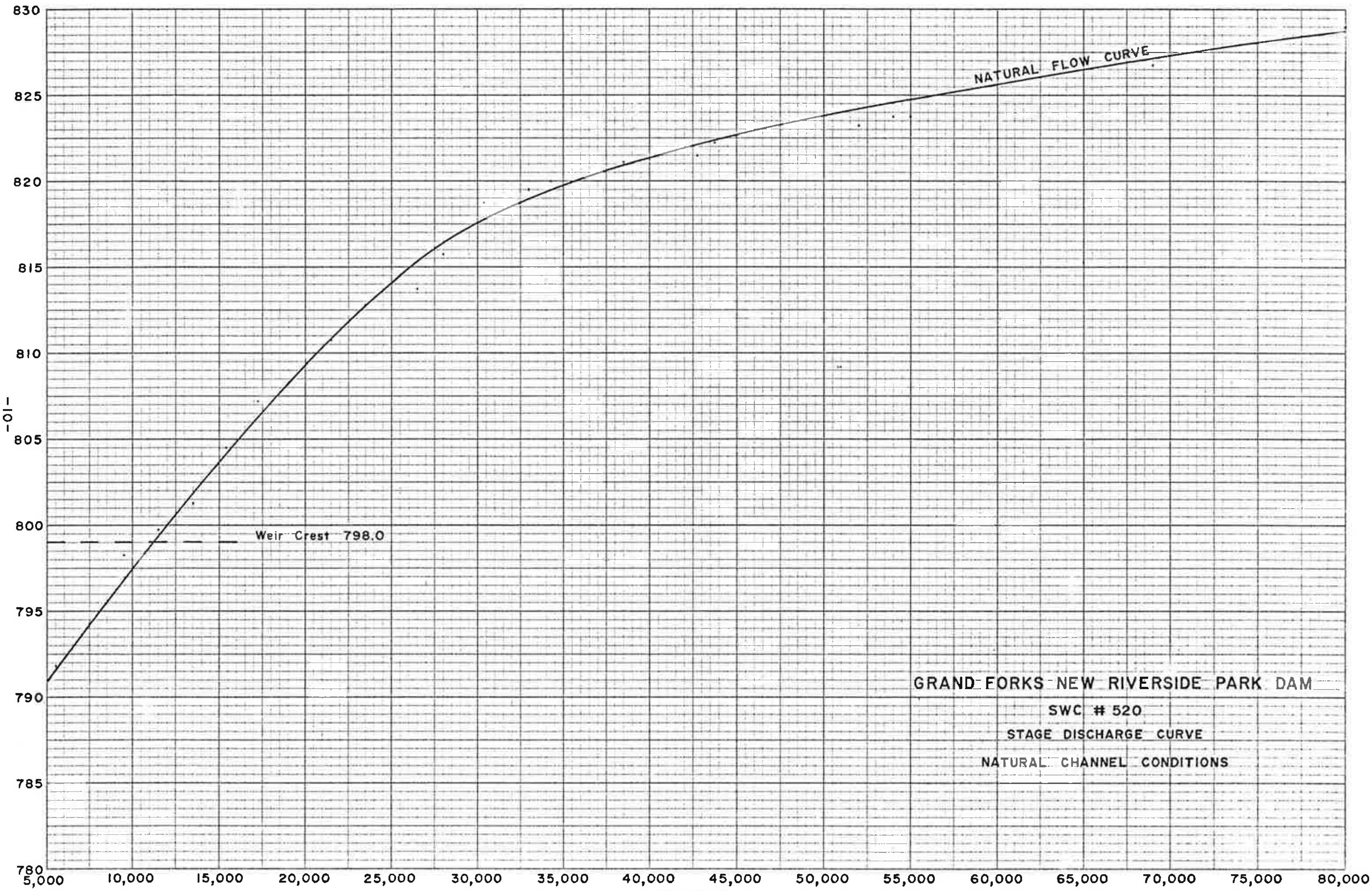

830
825
820
815
810
805
800
795
790
785
780
NATURAL FLOW CURVE
Weir Crest 798.0
GRAND FORKS NEW RIVERSIDE PARK DAM
SWC # 520
STAGE DISCHARGE CURVE
NATURAL CHANNEL CONDITIONS
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
55,000
60,000
65,000
70,000
75,000
80,000

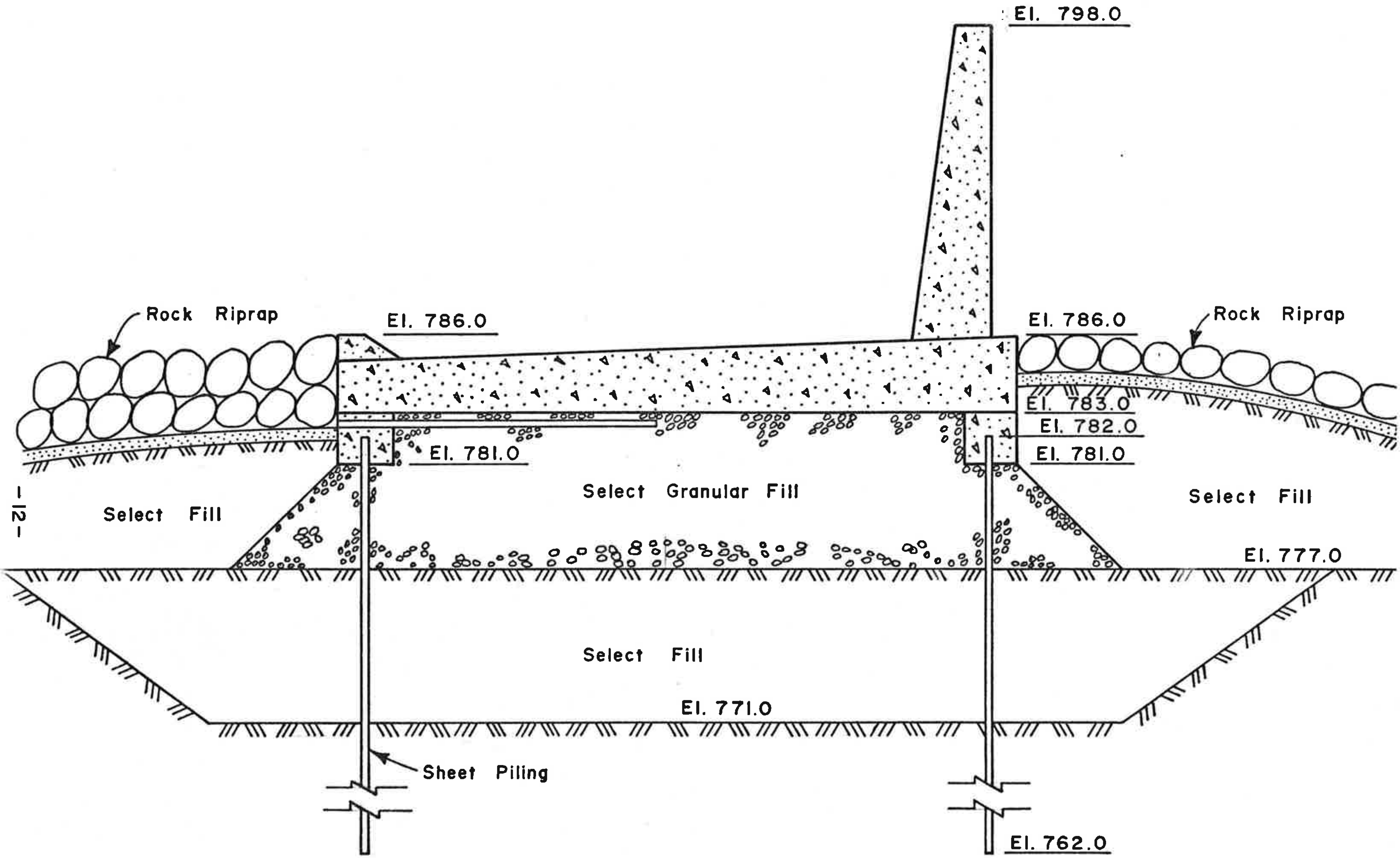
FIGURE 5

V. DAM FEATURES

The dam will be a reinforced concrete drop structure shaped to conform to the configuration of the natural channel. There will be a flat concrete slab with a vertical concrete wall at the upstream face as shown in Figure 6, 7 and 8. A row of sheet piling will be driven at the upstream face of the structure to cut off seepage under the dam. Another shorter row will be installed along the downstream face to prevent undercutting by erosive and turbulent currents. The structure will be supported by structural piling as discussed in the soils section of this report.

The slab will be placed upon a base of select granular material. To help relieve uplift pressures that may develop, 2-inch diameter tubular seeps will be installed between the granular material and the downstream face of the dam. The upstream and downstream channel and banks will be riprapped to reduce erosion. The rock riprap will be installed upon a base of filter material and geotechnical fabric to reduce undercutting. One feature that should be considered in addition is the possibility of further channel stabilization with a fly-ash portland cement admixture.

Final determination of the dam configuration will be made after an evaluation of the information developed in the proposed investigations, and model studies. These studies and investigations may establish some criteria that could significantly affect the final design of the project. Therefore, all details used in this preliminary report are subject to change and are intended to represent a starting point from which the future studies are to be expanded.



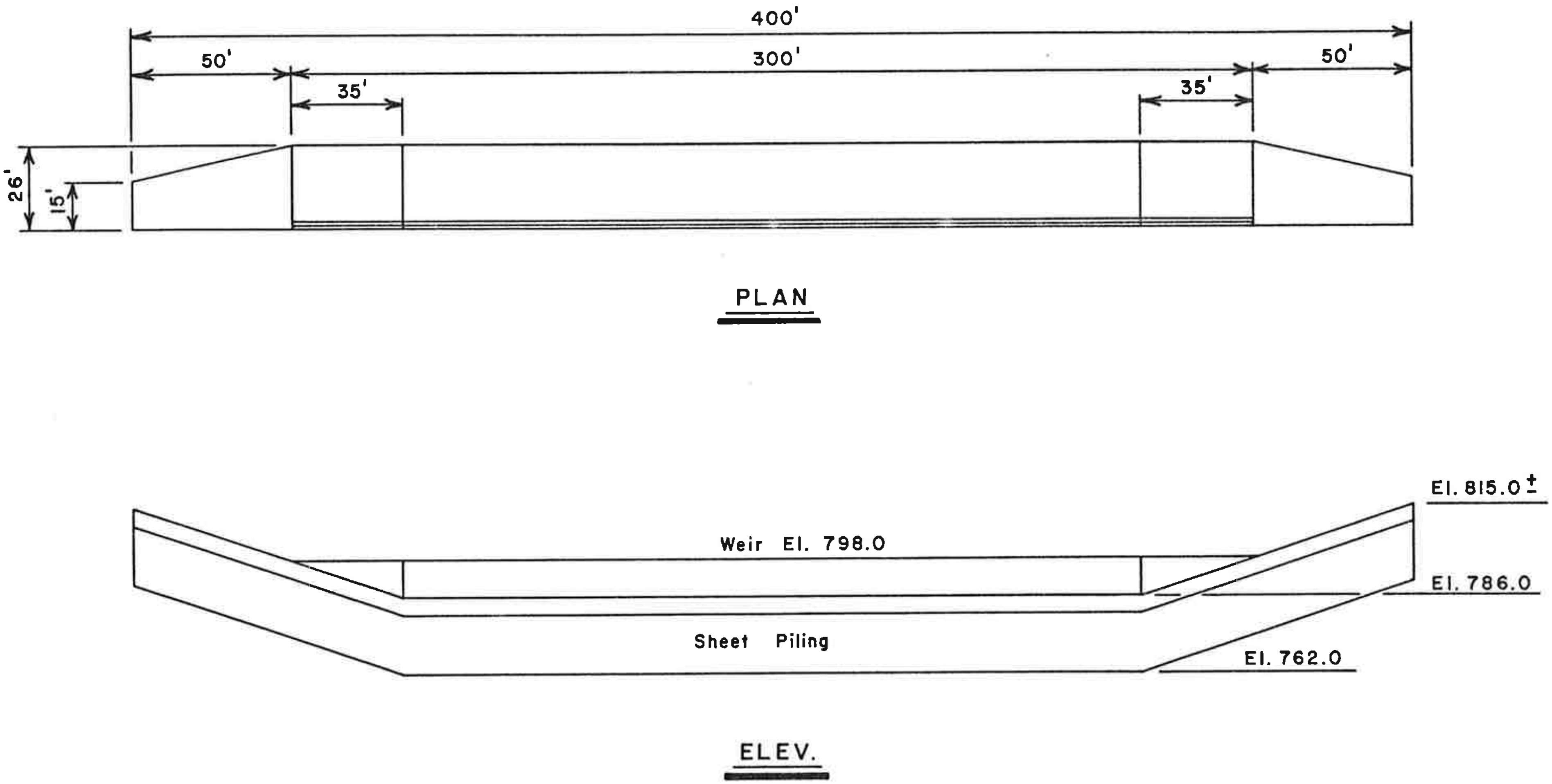
GRAND FORKS NEW RIVERSIDE PARK DAM

SWC # 520

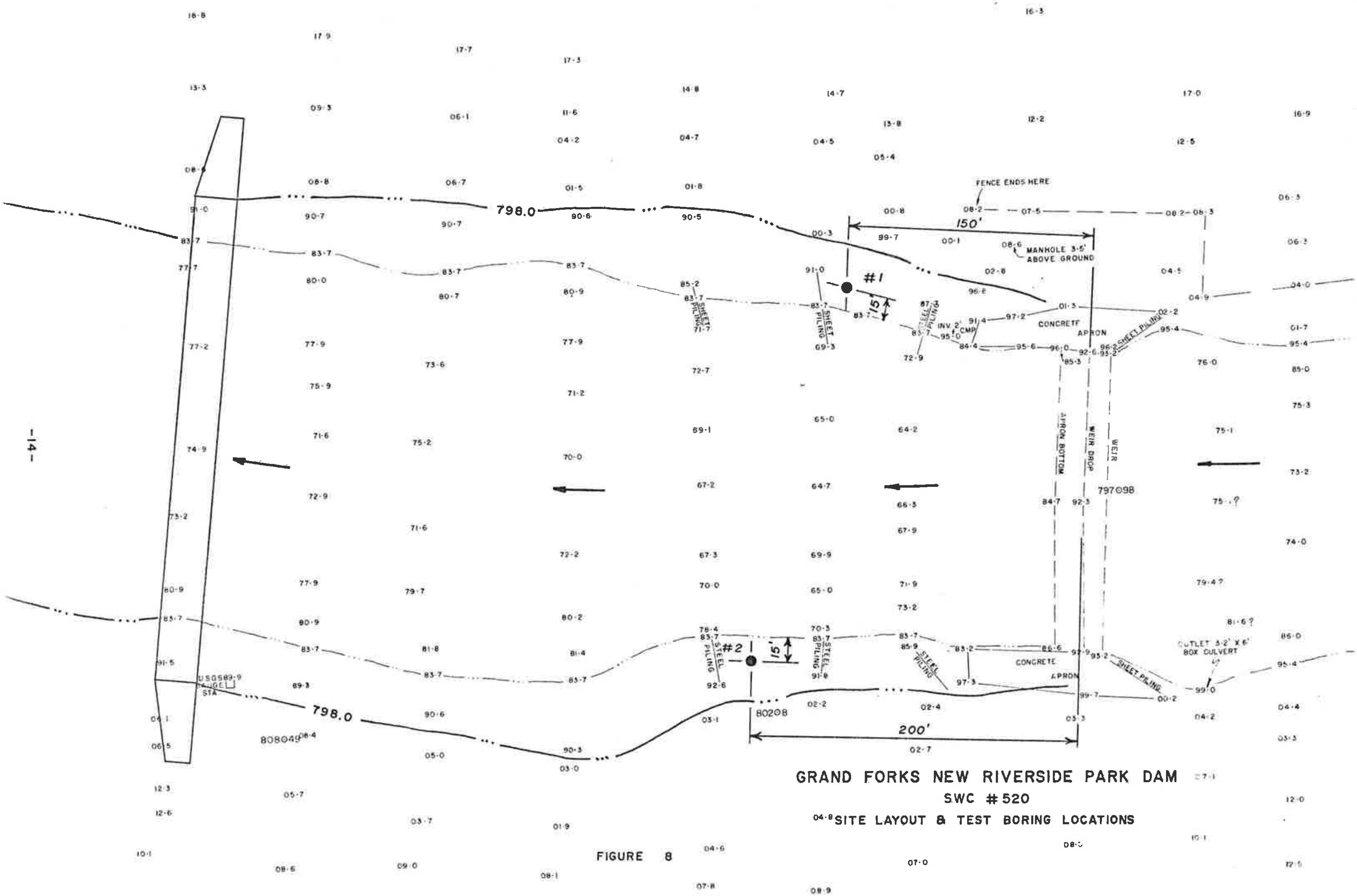
TYPICAL SECTION

Scale: 1" = 5'

FIGURE 6



GRAND FORKS NEW RIVERSIDE PARK DAM
SWC # 520
PLAN & ELEVATION VIEWS - NEW WEIR STRUCTURE
Scale: 1" = 50'
FIGURE 7



GRAND FORKS NEW RIVERSIDE PARK DAM
SWC #520
SITE LAYOUT & TEST BORING LOCATIONS

FIGURE 8

VI. CONSTRUCTION REQUIREMENTS

The reinforced concrete weir structure will be constructed in two phases. A cofferdam should be constructed out from one bank and protected with temporary riprap. The area within the cofferdam would then be dewatered. Upon completion of the dewatering, the bottom material within the coffered area would be excavated to a depth of approximately 6 feet below the existing elevation. This area would then be backfilled with a select material. The upstream and downstream rows of sheet piling and structural piling would then be driven.

A select granular material base for the slab would be installed and the reinforced concrete slab placed thereon.

The structure would be constructed in sections of about 20 feet in length. Each segment will be joined to the adjacent member with steel dowel bars. The joints will be sealed with a rubber expansion joint material. Construction joints between the slab and vertical walls would have a steel plate installed through the joint to provide a cutoff.

After completion of the structure, the adjacent area would be shaped to grade, filter material and fabric installed and rock riprap placed.

If concrete is placed during the winter, the concrete would have to be heated and protected from the elements during the curing period.

The cofferdam would require upkeep during this entire project. It is expected that each project phase will require about three months of continuous construction. With the demolition and replacement of coffer dams between phases, the project may require a total of seven months.

Assuming that the work could start in July, after the spring runoff has decreased, the project could run through January or February.

Summer storms could cause this schedule to be extended by a month or more, resulting in most of the work being accomplished during the winter months. This may be feasible but the construction costs will be proportionately higher.

VII. WATER CONTROL DURING CONSTRUCTION

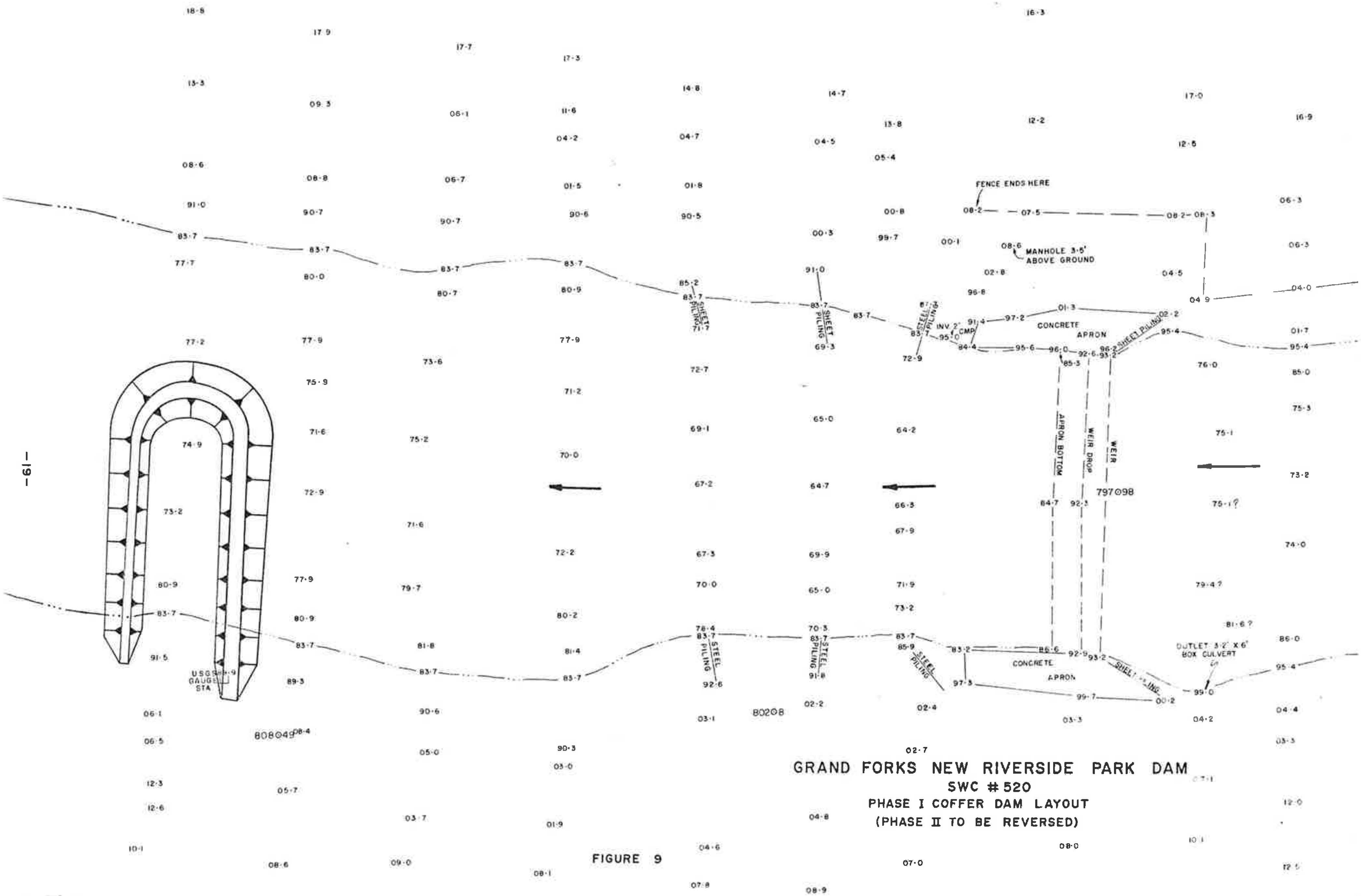
One very serious consideration in planning the dam construction program is whether the site can be protected from high flows during construction. Previous construction work has been accomplished by cofferdaming one-half of the river at a time. This has apparently proved to be adequate for a shorter duration effort and may or may not be sufficient for a project which will require considerable more time. The layout for the proposed first phase cofferdam is shown in Figure 9.

The assumption is that the horseshoe shaped cofferdam will be constructed by hauling in a fat, cohesive clay fill and dozing it into the stream in the desired configuration. The temporary earthen dike, will be protected with a riprap facing. The cofferdam will require continual upkeep and repair until the first half of the dam is completed. At that time, the first phase cofferdam will be demolished and the second phase cofferdam will be constructed. It will come out from the opposite bank in a manner similar to the first cofferdam. Since this phase will involve flow over the completed weir, instead of through a constricted open channel, the elevation of the cofferdam will have to be proportionally higher.

A design flow of 5,000 cfs was used as a trial flow rate. It was routed through the natural channel and the channel as constricted by the first phase cofferdam. The details are shown in Figure 10.

The figures show that in the natural channel situation, the flow of 5,000 cfs would result in a water surface elevation of 791.11 msl and a velocity of 1.24 ft/sec. With the cofferdam in place, the water surface would be 790.91 msl and the velocity would be 4.62 ft/sec. This indicates that the cofferdam would be a feasible proposal, but it will require rock riprap facing and considerable maintenance to survive the erosion caused by high water velocities.

The cofferdam will have to be constructed with two or three feet of freeboard to provide protection against sudden rises in river elevation due to heavy rainfalls. Assuming a three month first phase construction schedule, at least one or two of these short intense rainfalls should be anticipated and planned for in advance. This situation will pose a problem for potential contractors.



GRAND FORKS NEW RIVERSIDE PARK DAM
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PHASE I COFFER DAM LAYOUT
(PHASE II TO BE REVERSED)

FIGURE 9

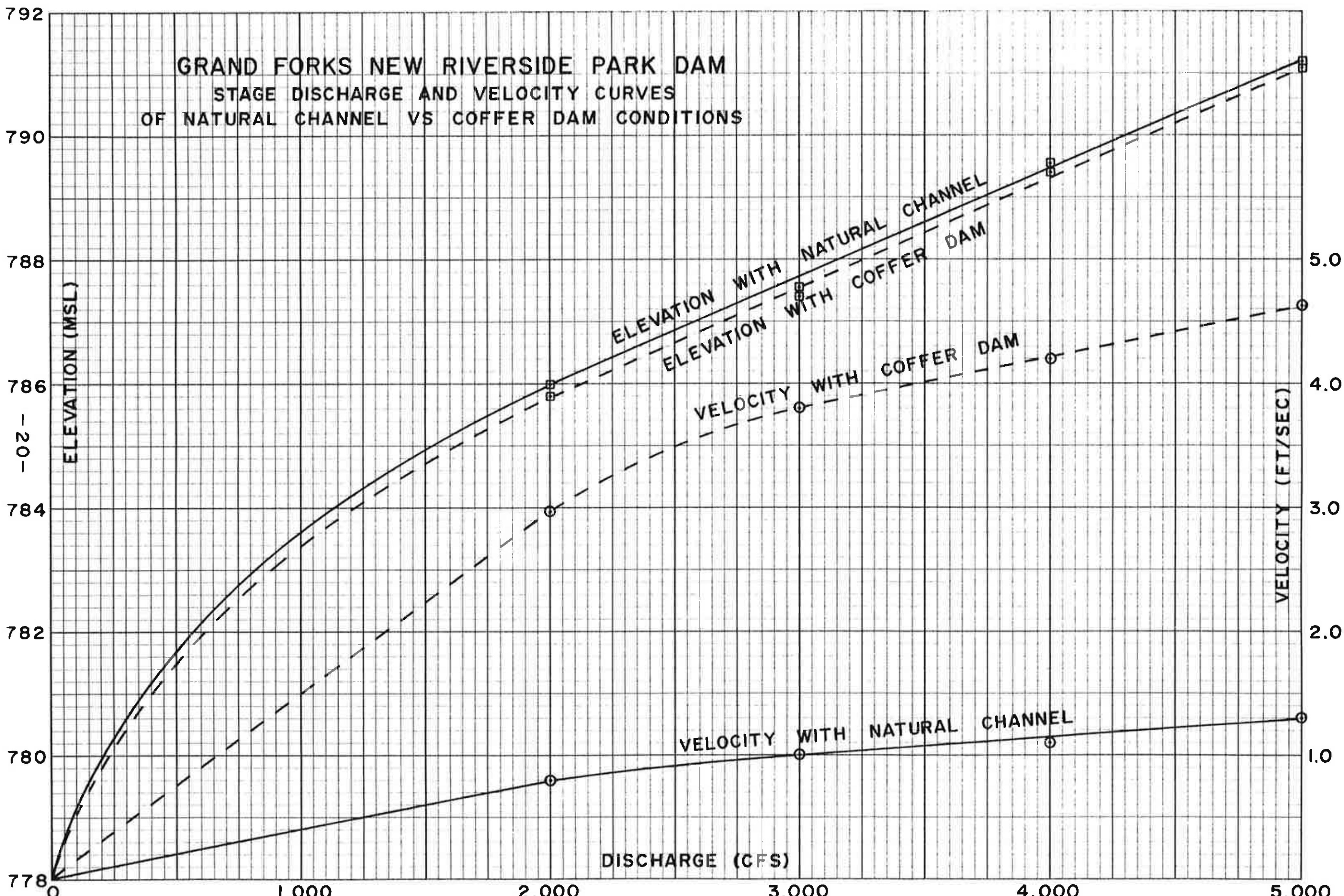

GRAND FORKS NEW RIVERSIDE PARK DAM
STAGE DISCHARGE AND VELOCITY CURVES
OF NATURAL CHANNEL VS COFFER DAM CONDITIONS
ELEVATION WITH NATURAL CHANNEL
ELEVATION WITH COFFER DAM
VELOCITY WITH COFFER DAM
VELOCITY WITH NATURAL CHANNEL
ELEVATION (MSL)
VELOCITY (FT/SEC)
DISCHARGE (CFS)
792
790
788
786
784
782
780
778
5.0
4.0
3.0
2.0
1.0
0
1,000
2,000
3,000
4,000
5,000

FIGURE 10

VIII. SOILS INVESTIGATION

A preliminary subsurface investigation was performed by a soils engineering consultant. Two drill holes were made, one on either side of the river just downstream of the existing dam as shown in Figure 8. The soils investigation report is included in Appendix B.

The limited scope of this initial investigation serves to indicate that a much more detailed investigation will be required before the final design of this project can be completed. The type and length of structural piling required was discussed, but not in detail in the soils report. A second area that will require study is the type and length of steel sheet piling that will be needed for upstream and downstream cutoff purposes. The third concern is the slope stability of the river banks. This is certainly an important factor that must be fully evaluated. A subsidiary consideration could be possible of stabilization with fly-ash and portland cement.

IX. PROJECT COSTS

Since the project is still in the preliminary investigation stage, any cost estimate for the project must be of a preliminary nature. The basic concept for the design is reasonably close to what the final design will be, therefore, the costs should be close enough for general project financial planning. As is shown in the detailed cost estimate below, all anticipated costs have been identified. The most reasonable quantities and prices (1984 construction season) have been used. If the project is delayed several years, inflation may escalate these prices.

Land acquisition costs are not included in this estimate and must be added. It is anticipated that the city will be able to acquire the land.

It may be desired to look at the feasibility of constructing the dam at a different site than the one considered. This may also change the costs.

However, it is still considered that the estimate should be close enough to cover some reasonable changes or relocations.

GRAND FORKS NEW RIVERSIDE PARK DAM

Preliminary Cost Estimate

No.	Item	Quantity	Unit Price	Total
1.	Site Preparation & Restoration	LS		$ 10,000
2.	Mobilization	LS		10,000
3.	Cofferdams and Water Control	LS		100,000
4.	Concrete (Reinforced)	1,000 CY	300.00	300,000
5.	Sheet Piling	16,500 LF	20.00	330,000
6.	Structural Piling	24,000 LF	20.00	480,000
7.	Rock Riprap	1,600 CY	25.00	40,000
8.	RRR Filter Material	500 CY	10.00	5,000
9.	Excavation	10,000 CY	2.00	20,000
10.	Fill	10,000 CY	1.00	20,000
11.	Drainage Fill	1,000 CY	12.00	12,000
12.	Misc. Materials	LS		5,000
		Subtotal		$1,332,000
		Contingencies		200,000
		Engineering		134,000
		Contract Administration		134,000
				$1,800,000

X. RECOMMENDATIONS AND CONCLUSIONS

It appears that it is possible to build the proposed new Grand Forks Riverside Park Dam. There are basically three questions to resolve in regard to the construction of the dam. These are: should a new dam be built, how will it be financed and who will share in the cost? If the project is to be pursued, the technical details, such as the location, soils investigation, piling requirements and hydrologic and hydraulic characteristics, must be fully evaluated.

This program should begin with consideration of the expected costs and the decision of the sponsoring agencies whether they wish to proceed with a more thorough investigation of the project which would enable a final design to be prepared.

Because of the apparent condition of the existing dam, a full investigation should be initiated as soon as possible. Because of the complexity of the studies and the financing difficulties, it is expected that the studies should be started this year. This will allow the project to be scheduled for construction in 1986.

APPENDIX A

Project Investigation Agreement

AGREEMENT

Preliminary Investigation
by the
North Dakota State Water Commission

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the State Engineer, Vern Fahy, and the City of Grand Forks, hereinafter referred to as the City, acting through its Mayor, C. P. O'Neill.

II. PROJECT, LOCATION AND PURPOSE

The City has requested an investigation to determine the feasibility and design for a new water supply dam on the Red River of the North. The proposed location would be in the vicinity of the existing Riverside Park Dam.

The City currently receives its municipal water supply from the Red River. The water is stored within the channel of the river by a lowhead channel dam. The existing dam is in a state of temporary repair and is structurally unsound. The repairs made are not considered adequate to meet future water supply demands.

III. PRELIMINARY INVESTIGATION

The parties agree that further information is necessary concerning the proposed project. Therefore, the Commission shall conduct preliminary investigations consisting of the following: hydrologic and field surveys, topographic mapping of the dam site, office studies, design and specifications and cost estimates.

Soil foundation investigations, laboratory testing and stability analysis shall be a responsibility of the City.

IV. DEPOSIT - REFUND

The City shall deposit $1500.00 with the Commission. Upon completion of the preliminary investigation, upon receipt of a request from the City to terminate proceeding further with the preliminary investigation, or upon a breach of this agreement by the City, the Commission shall provide the City with a statement of all expenses incurred in the preliminary investigation and shall retun any unexpended deposit funds.

V. RIGHTS OF ENTRY

The City agrees to obtain written permission from any affected landowner for surveys or subsurface investigations by the Commission (or any contractor) which are required for the preliminary investigations.

VI. INDEMNIFICATION

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

CITY OF GRAND FORKS

Mayor

September 20, 1977

Date

NORTH DAKOTA STATE WATER COMMISSION

Vern Fahy
State Engineer

September 8, 1977

Date

APPENDIX B

Twin City Testing
Subsurface Exploration Report

REPORT OF SUBSURFACE EXPLORATION PROGRAM

PROPOSED LOW HEAD DAM

RIVERSIDE PARK

GRAND FORKS, NORTH DAKOTA

#120-11173 and #54-1065

INTRODUCTION

We understand that a new reinforced concrete low head dam will be constructed a short distance downstream of the existing dam in the Riverside Park area of Grand Forks, North Dakota. We further understand that present plans call for the concrete dam to be supported on a driven pile foundation.

We have performed a subsurface exploration program and engineering review for the proposed cosntruction. The scope of our exploration program and engineering review on this project is as follows:

1. To put down two standard penetration test borings in the location of the proposed dam.
2. To perform laboratory tests on representative soil samples in order to estimate pertinent soil parameters.
3. To recommend driven pile types and estimate required pile lengths and recommended hammer energies for the proposed pile foundation.
4. To perform a preliminary review of the potential embankment stability at the site.

This report presents the results of the field and laboratory testing. Also presented are our recommendations based on a review of the field and laboratory data.

EXPLORATION PROGRAM RESULTS

Site Conditions

The site explored is approximately 150'-200' downstream of the existing weir in Riverside Park in Grand Forks, North Dakota. One boring was done on each side of the Red River.

Based on a topographic map provided to us, the river is about 200' wide at the proposed dam site. The river is approximately 20' deep. The south bank of the river is approximately 40' to 50' above the river bottom. The north bank rises to about 50' or more above the bottom of the river. The side slopes on the south bank appear to be as steep as 1 on 1.5 (vertical to horizontal) and about 1 on 2 on the north bank.

Subsurface Conditions

The subsurface conditions at the boring location on the north bank indicate soft alluvial and Lake Agassiz clay and silty clay deposits down to a depth of 35'. From 35' to 40' is found a layer of loose silty sand. Underlying the silty sand are more fat clay Lake Agassiz deposits down to a depth of 49½'. At this depth a lean clay washed till deposit is encountered and extends from 49½' down to 89'. From 89' to 103' are stiff to medium stiff fat clay deposits. Below a depth of 103' are stiff to very stiff clayey sand and sandy clay till deposits.

The soil boring performed on the south bank of the river indicates a surficial layer of fill from the surface down to a depth of 15'. This fill is a mixture of silty sand and clayey sand with some gravel and other debris. Underlying the fill are deposits similar to those encountered in boring 1. The depth to the stiff till deposits is 108'.

The attached boring logs indicate the layering of the soil deposits encountered at the two borings.

Ground water measurements were made at the times and levels as indicated on the attached boring logs. Due to the cohesive nature of the soils, the measured water levels may not be reliable indications of the true steady state water table. Normally, extended periods of time are needed to establish steady state water tables in very cohesive soils such as found on this site.

The river level undoubtedly governs the location of the water table on both sides of the river.

ENGINEERING REVIEW AND RECOMMENDATIONS

Project Information

Our understanding of the proposed construction is rather limited at this time. We understand that the structure will be a low head dam mainly constructed of reinforced concrete. We understand that it is planned to support the structure on a driven pile foundation. We have no information regarding any earthwork or other loadings to be placed on the river banks.

The scope of this report is just to address the loads, recommended depths, and hammer types for the planned pile foundation. We also will address in a preliminary way any potential embankment stability problems. Additional review and possible testing may be required to better determine the stability problems after we have a chance to review the construction plans.

Foundation Recommendations

It is our opinion that a driven pile foundation for the proposed concrete dam is the optimum foundation support system. We have no information regarding the required loads for this project; however, we feel that any piling driven would have to penetrate at least a few feet into the hard clay till deposits found at a depth of 103' in boring 1 and 108' in boring 2.

In our opinion, the most feasible pile types would be a heavy walled 7-5/8" or 9-5/8" O.D. steel pipe pile. The 7-5/8" pile can accommodate loadings of up to about 60 to 75 tons per pile. This pile would probably penetrate about 3' to 5' into the hard clay till to develop these loads. Piling of this type should be driven with a hammer having an energy rating on the order of 18,000 to 25,000 ft-lbs.

If higher loads are required, then 9-5/8" O.D. steel pipe piles with a minimum wall thickness of 0.4" is recommended. These pilings can readily develop loads of up to 100 tons and would probably penetrate about 5' to 6' into the hard glacial till. Piling of this capacity should be driven with a hammer having an energy rating on the order of 30,000 to 45,000 ft-lbs.

Steel H piling could also be considered and loads of 50 to 100 tons can be accommodated on appropriate size sections. Steel H piling would probably be substantially more expensive than the heavy walled pipe.

The above estimates are intended only for preliminary planning. The actual lengths should be predicated on a test program that would involve driving two to four test piles throughout the site. Each of the piles should be monitored with the dynamic pile analyzer. This would provide information regarding the actual required length, the efficiency of the hammer, and the required final penetration to achieve the design load with an appropriate safety factor.

Embankment Stability

A preliminary review of the slope stability of the two river banks was performed. Based on the laboratory tests and estimated soil parameters in the existing fill on the south slope, it is our opinion that the stability of the banks should definitely be reviewed. Any additional fill placed, steepening of the slopes, or seepage developed after construction of the dam, could render the banks instable.

We recommend that a more detailed analysis be performed on both banks. Once the final design of the dam is completed, we recommend that you provide plans and other information to us so that a review of the stability can be performed.

EXPLORATION PROCEDURES

Test Borings

Two standard penetration test borings were put down during the period of December 1, 1983 through December 7, 1983. The borings were located as shown on the attached sketch. Surface elevations were referenced to the benchmark also indicated on the attached sketch.

Soil Sampling

Soil sampling was performed in accordance with ASTM: D 1586-67. Using this procedure, a 2" O.D. split barrel sampler is driven into the soil by a 140 lb weight falling 30". After an initial set of 6", the number of blows required to drive the sampler an additional 12" 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. Thin wall tube samples were obtained according to ASTM: D 1587-67 where indicated by appropriate symbol on the boring logs.

Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM: D 2488-69. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification. In addition, selected samples were submitted to a program of laboratory tests. Logs of the borings indicating the depth and identification of the various strata, the N value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are attached. Charts illustrating the soil classification procedure, the descriptive terminology and symbols used on the boring logs are also attached.

LOG OF TEST BORING

JOB NO. 54-1065 VERTICAL SCALE 1" = 5' BORING NO. 2

PROJECT PROPOSED LOW HEAD DAM-RIVERSIDE PARK-GRAND FORKS, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 798.5')	GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
	FILL, mixture of SILTY SAND and CLAYEY SAND, a trace of gravel, some concrete, brick, and cinders, black and dark brown, frozen to 1½'	FILL			1	FA				
			6		2	SB				
			3		3	SB				
			4		4	SB				
			5		5	SB				
			8		6	SB				
15	SILTY CLAY, gray, soft to medium, a few lenses of silt, and wet to waterbearing sand (CL)	LAKE AGASSIZ DEPOSITS	3		7	SB				
				▼						
			4		8	SB				
					9	3T	25	98	30/15	Qc
			5		10	SB				
28	MEDIUM FAT CLAY, gray, medium to rather stiff (CH-CL)									
			8		11	SB				
					12	3T				
35										

Continue on next page

LOG OF TEST BORING

JOB NO. 54-1065 VERTICAL SCALE 1" = 5' BORING NO. 2 (Cont)

PROJECT PROPOSED LOW HEAD DAM-RIVERSIDE PARK-GRAND FORKS, NORTH DAKOTA

DEPTH IN FEET		GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
35	MEDIUM FAT CLAY, (Cont) (CH-CL)	LAKE AGASSIZ DEPOSITS (Cont)	8		13	SB				
			10		14	SB	25	101#		
			12		15	SB				
47	FAT CLAY, gray, medium (CH)									
			5		16	SB				
					17	3T	51	70	80/28	
			5		18	SB				
58	LEAN CLAY, a trace of gravel, gray, medium to rather stiff (CL)	LAKE WASHED TILL, LAKE AGASSIZ DEPOSITS								
			7		19	SB				
			7		20	SB	22	104#	37/14	
70										

Continue on next page

LOG OF TEST BORING

JOB NO. 54-1065 VERTICAL SCALE 1" = 5' BORING NO. 2 (Cont)

PROJECT PROPOSED LOW HEAD DAM-RIVERSIDE PARK-GRAND FORKS, NORTH DAKOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N	WL	SAMPLE NO.	SAMPLE TYPE	LABORATORY TESTS W	D	LL/PL	Qu
70	LEAN CLAY, (Cont) (CL)	LAKE WASHED TILL, LAKE AGASSIZ DEPOSITS (Cont)	7		21	SB				
			8		22	SB				
			10		23	SB				
			8		24	SB				
			10		25	SB	22	104#		
94	FAT CLAY, gray, rather stiff to medium to rather stiff (CH)	LAKE AGASSIZ DEPOSITS	10		26	SB				
			8		27	SB				
105										

Continue on next page

LOG OF TEST BORING

JOB NO 54-1065 VERTICAL SCALE 1" = 5' BORING NO 2 (Cont)

PROJECT PROPOSED LOW HEAD DAM-RIVERSIDE PARK-GRAND FORKS, NORTH DAKOTA

DEPTH IN FEET		GEOLOGIC ORIGIN	N	WL	SAMPLE NO	SAMPLE TYPE	W	D	LL/PL	Qu
105	FAT CLAY, (Cont)	LAKE AGASSIZ DEPOSITS (CONT.)	13		28	SB				
108	SILTY SANDY CLAY, a trace of gravel, very stiff (CL)	TILL								
			55		29	SB				
			100		30	SB	12	126#		
			98		31	SB				
121	End of Boring									
	#Calculated									

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
12-6	11:00	21'	None	19'	to	18½'
12-7	4:00	121'	24½'		to	NMR
12-7	4:30	121'	None		to	NMR
					to	

START 12-6-83 COMPLETE 12-7-83

METHOD 6FA 0-19½' @ 4:00

4DC 0-24½'

DM 19½'-119½'

CREW CHIEF Zak

SE-2 (77-B)-5

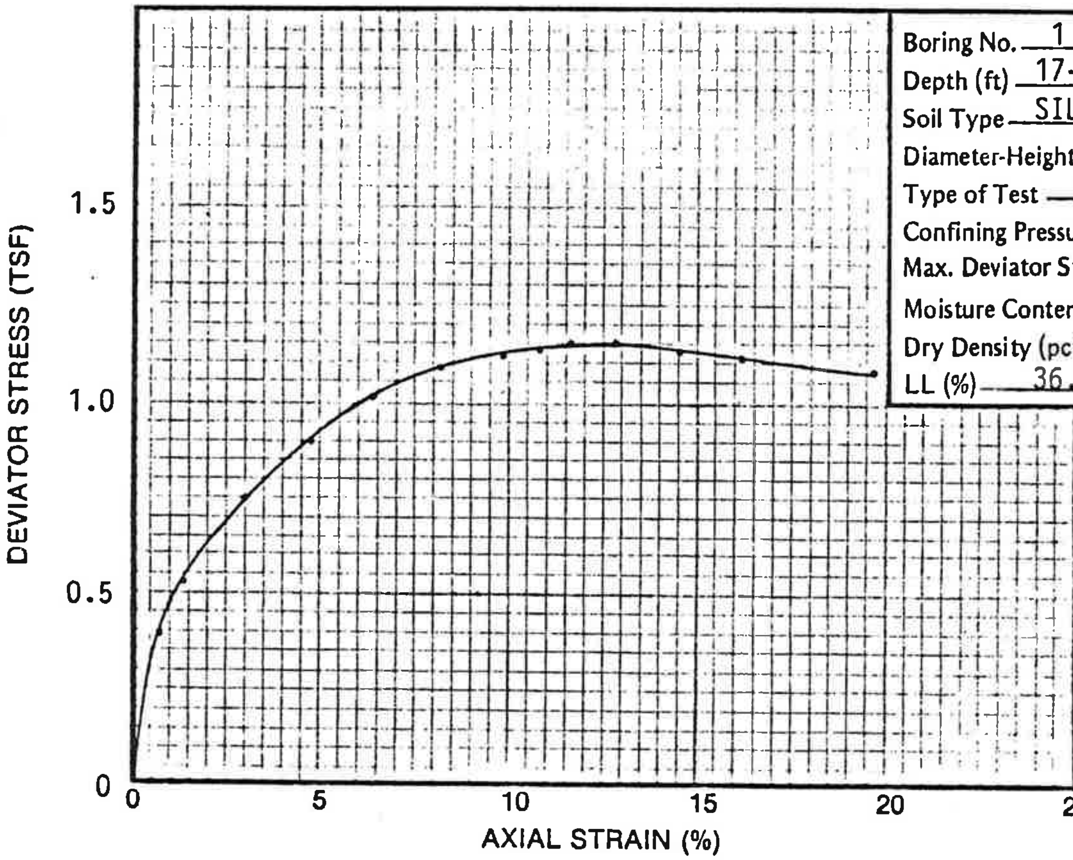
twin city testing

CONFINED — **STRESS - STRAIN CURVES** — UNCONFINED

Project: PROPOSED LOW HEAD DAM-RIVERSIDE PARK-GRAND FORKS, NORTH DAKOTA

Date: December 28, 1983

Project No. 120-11173



Boring No. 1 Sample No. 8

Depth (ft) 17-19½ (top)

Soil Type SILTY CLAY (CL)

Diameter-Height (inches) 2.80 x 5.85

Type of Test U-U

Confining Pressure 11.6 psi

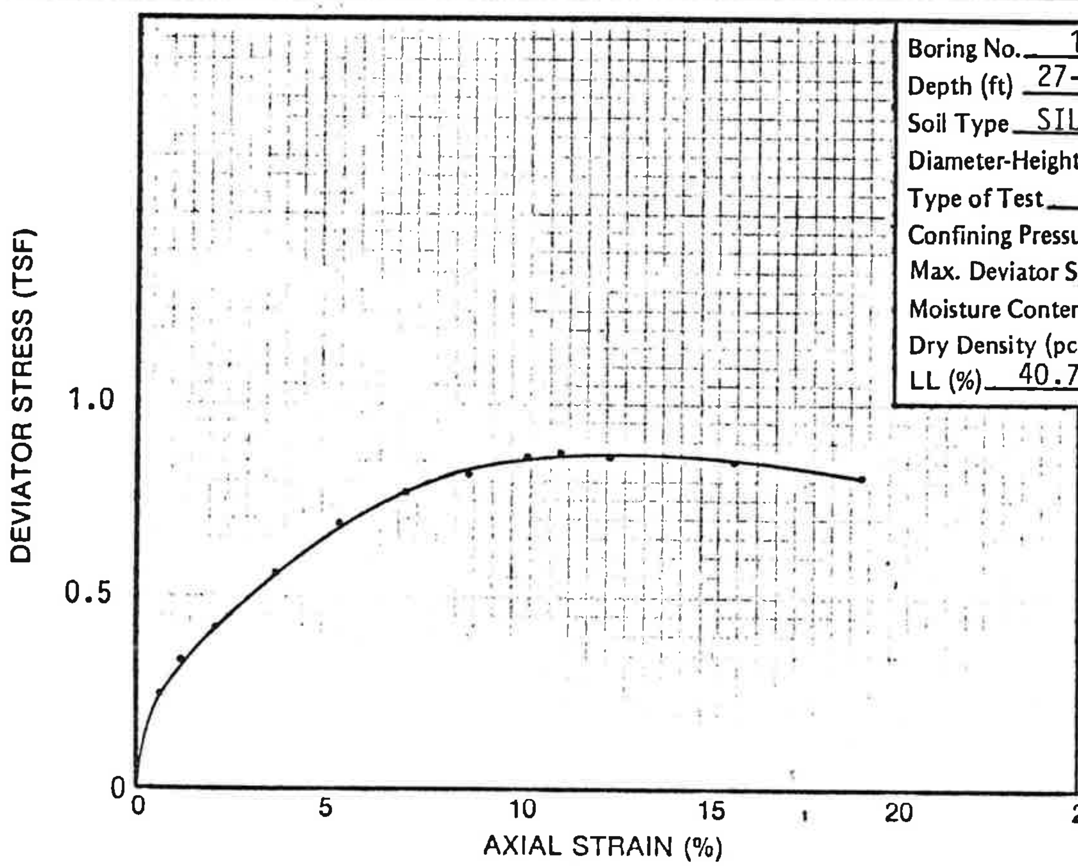
Max. Deviator Stress 1.15 tsf

Moisture Content (%) 21.4

Dry Density (pcf) 105.5

LL (%) 36.6 PL (%) 12.7

Sketch of sample after failure.



Boring No. 1 Sample No. 11

Depth (ft) 27-29½ (bot.)

Soil Type SILTY CLAY (CL)

Diameter-Height (inches) 2.85 x 5.96

Type of Test U-U

Confining Pressure 16.6 psi

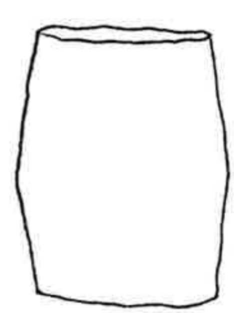
Max. Deviator Stress 0.87 tsf

Moisture Content (%) 26.3

Dry Density (pcf) 97.4

LL (%) 40.7 PL (%) 16.4

Sketch of sample after failure.



CONFINED — **STRESS - STRAIN CURVES** — UNCONFINED

Project: PROPOSED LOW HEAD DAM-RIVERSIDE PARK-GRAND FORKS, NORTH DAKOTA

Date: December 28, 1983 Project No. 120-11173

Boring No. 2 Sample No. 9

Depth (ft) 22-24½ (bot.)

Soil Type SILTY CLAY (CL)

Diameter-Height (inches) 2.87 x 5.55

Type of Test U-U

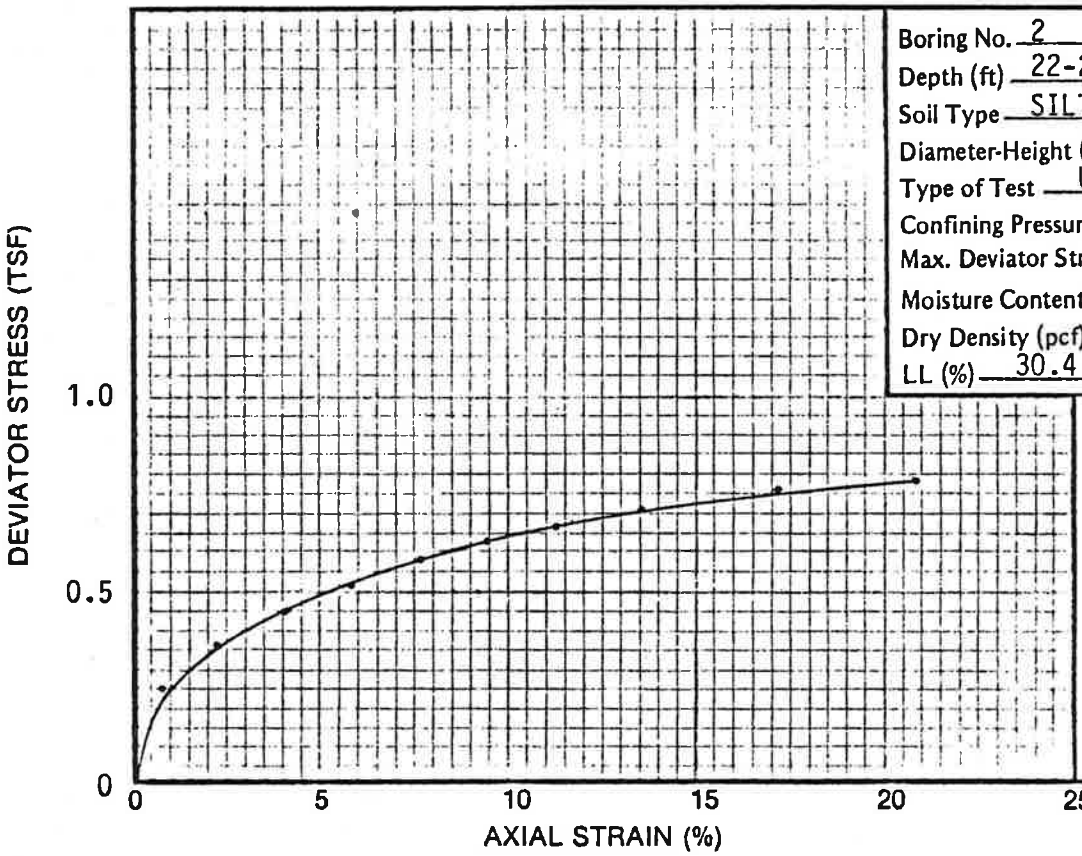
Confining Pressure 17.6 psi

Max. Deviator Stress 0.78 tsf

Moisture Content (%) 25.3

Dry Density (pcf) 98.0

LL (%) 30.4 PL (%) 15.2



Sketch of sample after failure.

Boring No. Sample No.

Depth (ft)

Soil Type

Diameter-Height (inches) x

Type of Test

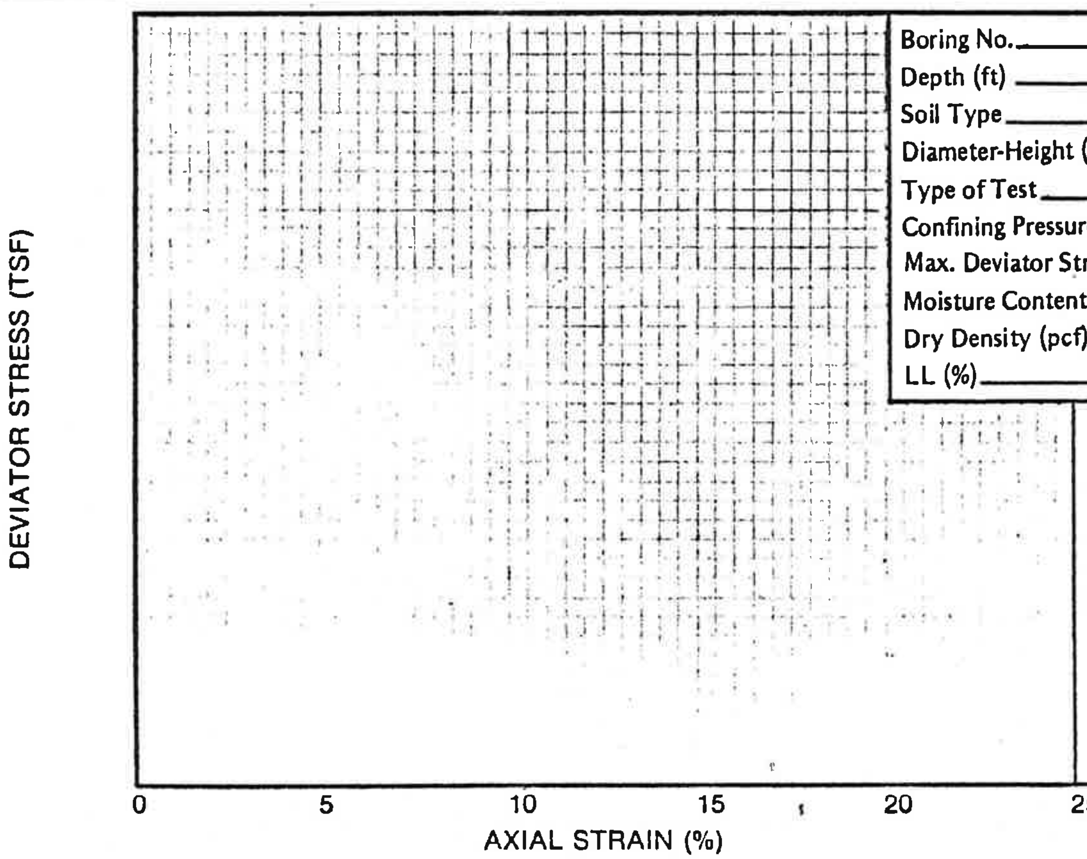
Confining Pressure

Max. Deviator Stress

Moisture Content (%)

Dry Density (pcf)

LL (%) PL (%)



Sketch of sample after failure.