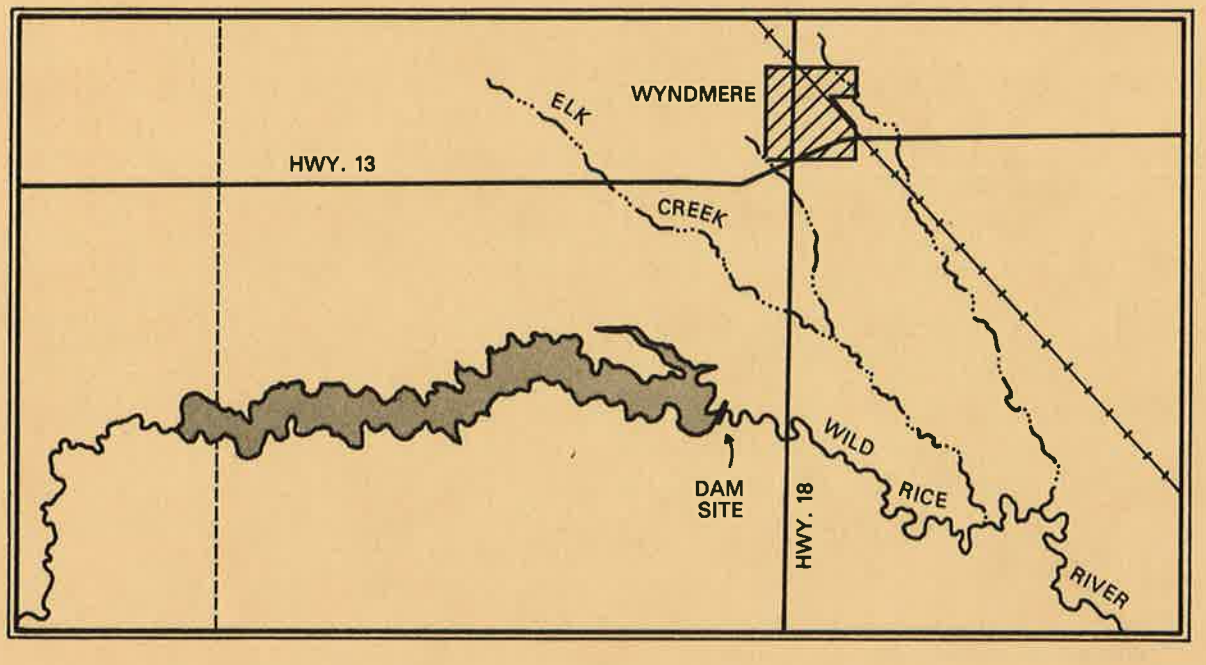
PRELIMINARY ENGINEERING REPORT

WR-190 DAM

RICHLAND COUNTY, NORTH DAKOTA

SWC PROJECT NO. 1792



NORTH DAKOTA
STATE WATER COMMISSION

MARCH 1986

PRELIMINARY ENGINEERING REPORT

WR-190 DAM

SWC Project #1792

North Dakota State Water Commission
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WR-190

State Water Commission Project #1792

Technical assistance in the preparation of this report was received from Mark Ziemer of the Corps of Engineers and the Corps' Technical Research Center.

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I. Introduction

Background:

In June of 1984, the North Dakota State Water Commission entered into an agreement (Appendix A) with the Richland County Water Resource Board to investigate the feasibility of constructing a dry dam on the Wild Rice River for the purpose of flood control. The proposed dam site is located in the NW 1/4 Section 25, Township 132 North, Range 52 West, in Richland County. The dam site is located approximately three miles south of Wyndmere, North Dakota. The basin area at the site is 1,160 square miles. Moore Engineering conducted a study of the proposed site and completed the "Wild Rice River Watershed Hydrology Analysis and Flood Retention Study" in November 1982. In this study, the site was identified as WR-190.

Study Objectives:

This report describes the geology, subsurface conditions, and the soil characteristics at the proposed WR-190 site. It also contains a description of the basin's hydrology and a summary of the project's preliminary design, cost estimate, and a discussion of the overall feasibility of the project.

II. Description of the Study Area

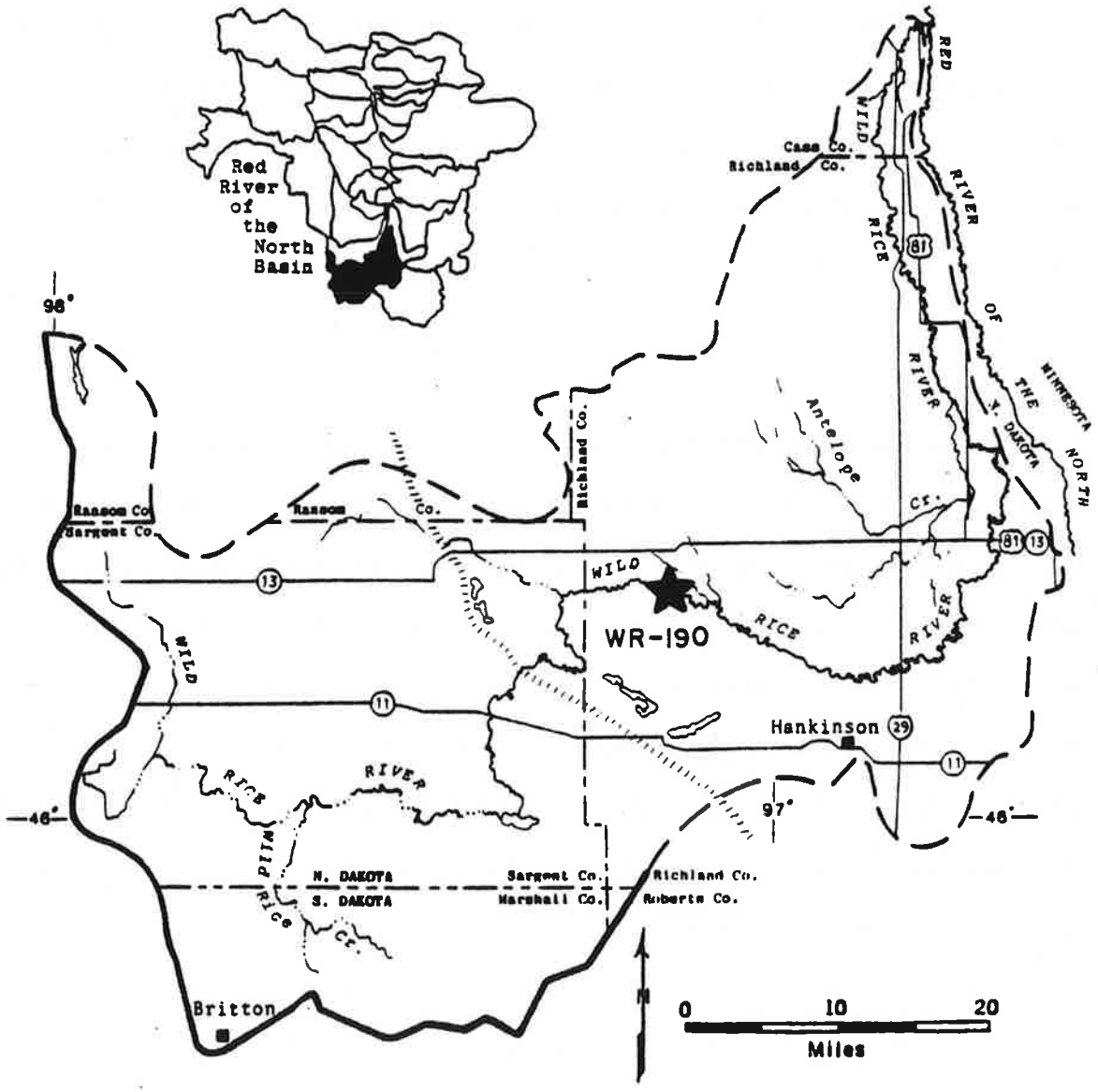
Location and Topography:

The Wild Rice River Basin occupies 2,240 square miles of the southwest portion of the Red River Watershed (Figure 1). The Basin is comprised of a portion of six counties including Sargent, Ransom, Richland, and Cass Counties in North Dakota; and Marshall and Roberts County in South Dakota. The Wild Rice River traverses 243 miles through varied landscape before its confluence with the Red River, 18 miles south of Fargo, North Dakota. Upstream (west) of the proposed dam site, the topography is characterized by morainic hills, large swamps, lakes, low swales and potholes. The average gradient of the Wild Rice River is approximately 1.7 feet/mile.

The proposed WR-190 site is located in the southwestern portion of the Red River Valley physiographic division and is part of the Lake Agassiz plain. The Lake Agassiz plain ranges from approximately elevation 1,065 msl to 1,060 msl in the vicinity of the site. The Wild Rice River Valley is entrenched approximately 40 feet into the lake plain and ranges from approximately 500 to 3,000 feet wide in the vicinity of the site. The stream channel flows a winding course within the flood plain. The valley sides are moderately sloped, ranging from 5:1 to 10:1.

The south abutment of the proposed dam site is a grass and scrub brush covered knoll. The slope on the west side of the south abutment is rather steep at 3:1. The slope along the centerline of the south abutment is 10:1 and slightly steeper at the toe. The north abutment has several knolls and a slope of less than 10:1.

WILD RICE RIVER BASIN



Taken from Corps of Engineers December 1980
"Red River of the North Reconnaissance Report".

FIG. 1

Just downstream of the site the north riverbank has caved to a slope of 2.5:1. Wetland vegetation occurs well above the normal water level indicating seepage occurs from this slope. The area between this steep portion and the centerline has a slope of approximately 4:1.

Approximately 900 feet downstream of the proposed dam's centerline, an old road embankment crosses the valley. An abandoned bridge connects the road embankments at the Wild Rice River. The road embankment is several feet higher than the valley floor, therefore, it could affect the tailwater elevation at the dam.

Geology:

The proposed WR-190 dam site is located in an alluvial stream valley of recent origin. Bordering the valley and extending about one mile southwest and northeast of the site is lake-washed till of the Lake Agassiz Plain. Bordering the lake-washed till to the south is the Herman Beach, the highest stage of the pro-glacial Lake Agassiz. South of the Herman Beach is ground moraine deposited by the most recent ice sheet (Mankato) of the late Wisconsin glaciation. North of the proposed site are the Sheyenne River delta sand and silt deposits. Some of the sand has been blown into dunes.

The interpretation of the bedrock geology from North Dakota Geological Survey Bulletin 46 indicates that the Greenhorn Shale Formation will be the first bedrock encountered. The bedrock would be encountered between elevations 850 and 800 msl or approximately 200 feet below the stream bed at the dam site.

The subsurface geology inferred from soil borings at the dam site is shown in Figure 2 and summarized in Table 1. The borings ST-3 through ST-7, drilled in the flood plain, encountered a blanket of about four to eight feet of soft clay and silt over loose alluvial silt and sand down to about elevation 1,000 msl. Boring ST-7 encountered silt and clay to a depth of 17 feet which is thought to be a "plug" in an old channel. Beneath the alluvium these borings encountered lacustrine silt and sand over fat lacustrine clay at approximately elevation 956. These lacustrine deposits correlate to the buried lake deposits postulated in Bulletin 46.

Borings ST-2 and ST-8, on the side slopes of the abutments, also encountered lacustrine silt and sand. In boring ST-8, the top 7 feet of silt was loose, possibly indicating slippage or erosion in the abutment. Borings ST-1 and ST-9 near the tops of the abutments and borings B-10 through B-28 encountered lake-washed till. At boring ST-1, the till extended to a depth of at least 31 feet. Two borings in the emergency spillway area, ST-11 and ST-13, encountered less than 11 feet of till over lacustrine deposits.

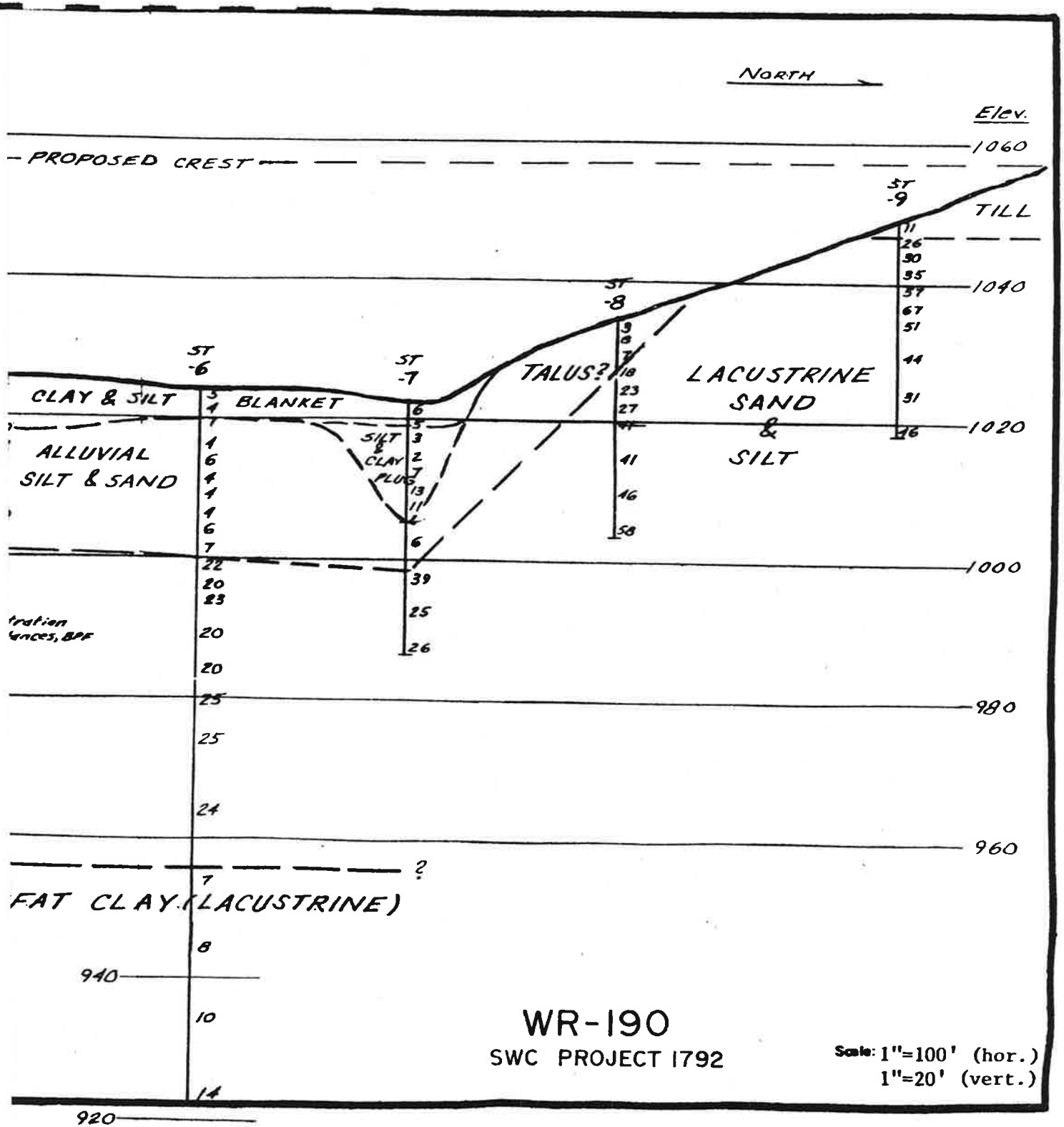

NORTH
Elev.
PROPOSED CREST
1060
1040
1020
1000
980
960
940
920
ST -6
ST -7
ST -8
ST -9
CLAY & SILT BLANKET
ALLUVIAL SILT & SAND
SILT & CLAY PLUG
TALUS?
LACUSTRINE SAND & SILT
TILL
FAT CLAY (LACUSTRINE)
?
WR-190
SWC PROJECT 1792
Scale: 1"=100' (hor.)
1"=20' (vert.)

TABLE 1: GEOLOGICAL SUMMARY

WR-190 SWC PROJECT 1792

Boring	Topsoil	Silt & Clay Blanket	Sand & Silt Alluvium	Lacustrine Sand	Lacustrine Silt	Lacustrine Clay	Till
ST-1	0- ½'	---	½-4 '	---	---	---	4 -31'
ST-2	0-1½'	---	---	1½-31'	---	---	---
ST-3	0-1 '	1 -4 '	4 - 24'	24-46'	---	---	---
ST-4	0-1½'	1½-7 '	7 -21'	---	---	---	---
ST-5	0- ½'	½-8 '	8 -19'	19-21'	---	---	---
ST-6	0-1½'	1½-4 '	4 -24'	---	24-68'	68-101'	---
ST-7	0-1½'	1½-17'	17 -24'	---	24-36'	---	---
ST-8	0-1½'	---	1½-7 '	---	7-31'	---	---
ST-9	---	---	---	4-25'	25-31'	---	0 - 4'
ST-11	0-1½'	---	1½-4 '	8½-11'	---	---	4 -8½'
ST-13	0-1½'	---	1½-6½'	9-11'	---	---	6½-9 '
ST-15	0-1½'	---	---	---	---	---	1½-11'
ST-17	0-1½'	---	1½-3½'	---	---	---	3½-11'
ST-19	0-2 '	---	---	---	---	---	2 -11'
ST-21	0-1½'	---	1½-6½'	---	---	---	6½-11'
ST-23	0- ½'	---	---	---	---	---	½-11'
ST-25	0-2 '	---	---	---	---	---	2 -11'
ST-27	0.8	---	---	---	---	---	0.8-11'

* Taken from Braun Engineering & Testing report BND 84-062:

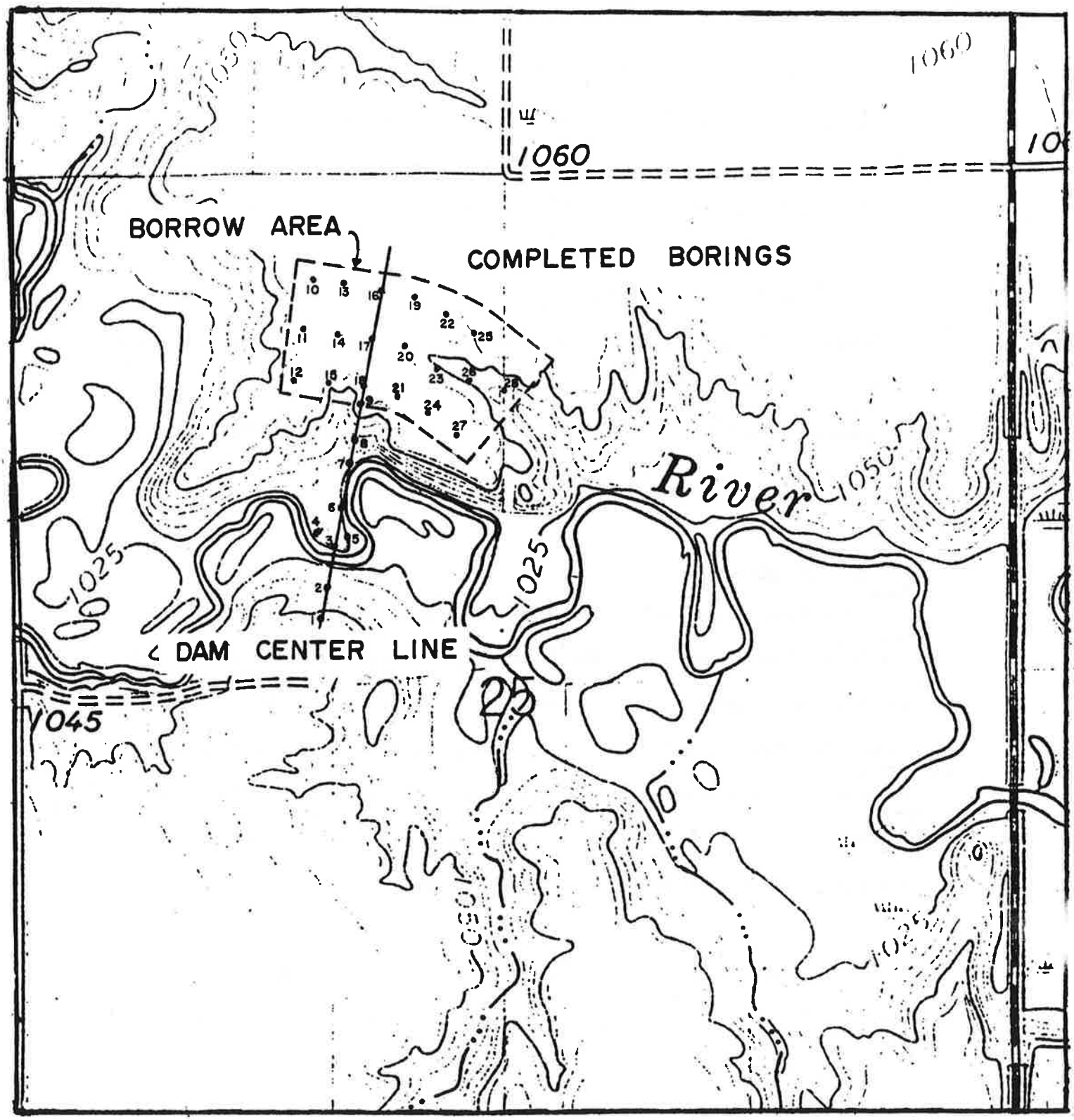
III. Soils Analysis

Subsurface Exploration:

A subsurface exploration program was initiated by the State Water Commission to determine the feasibility of an earthfill flood detention dry dam at the WR-190 site. Drilling and testing was performed by Braun Engineering Testing of North Dakota, Inc. The topography of the dam site, showing locations and elevations of all centerline test borings and borrow area test holes, was surveyed by the State Water Commission. The location for all borings were chosen and staked by the State Water Commission.

The subsurface exploration began November 8, 1984, and was completed on November 23, 1984. The entire program consisted of 28 borings: 9 test borings along the proposed centerline of the dam and 19 in the proposed spillway and borrow area. A topography map of the dam site showing the boring locations, dam centerline and borrow area is shown in Figure 3. The logs of the borings are in Appendix B.

Borings 1 through 9 and the odd-numbered borings from 11 through 27 were penetration test borings and are designated by the prefix "ST" (split-tube). Borings ST-1 through ST-9 were generally advanced to depths of 21 to 46 feet, except boring ST-6 which was advanced to a depth of 101 feet. Borings ST-11 through ST-27 were advanced to a depth of 11 feet. The penetration test borings were drilled with a 3 1/4-inch hollow-stem auger except for boring St-6 which was advanced below 20 feet with bentonite drilling mud by the rotary method. The total footage of the penetration test borings was 446 feet.



BORING LOCATION

WR-190 DAM SITE

SWC PROJECT 1792

FIG 3

Even-numbered borings 10 through 28 were auger borings and are designated by the prefix B. They were advanced with a 5 1/2-inch diameter solid-stem auger. The strata and soils were classified in the field by the driller. The total footage of auger borings was 100 feet.

Occasional 3-inch diameter thin-walled tubes (Shelby tubes) were obtained in the penetration test borings. Intervals sampled with tubes were noted "TW" on the logs. In addition, holes were drilled alongside borings ST-5 and ST-6 to a depth of 10 feet and tube samples were obtained.

Laboratory Testing:

The laboratory testing program was determined at a meeting between the State Water Commission and Braun Engineering and Testing representatives on January 15, 1985. The laboratory tests included: twenty sieve-hydrometer analysis, 4 sieve analyses, 7 Atterberg limit tests, 3 moisture-density relationships, 3 permeability tests, 3 dispersion tests, 7 moisture content and 2 organic content tests. The results of the tests are summarized in Table 2.

The visual classification of the topsoil and blanket soil ranged from silty sand to slightly plastic silt to silty clay and organic silty clay. These soils form the upper 4 to 8 feet in boring ST-3 through ST-6. Liquid limits of the clay samples were relatively low. Moisture contents were high and organic contents were moderate.

TABLE 2: SUMMARY LABORATORY TEST

WR-190 SWC PROJECT 1792

Boring	Depth, feet	Geology	Description	Symbol	%C	%$	%FS	%M &CS	%G	MC	OC	LL	PI
ST-2	2½-3½	Lacustrine	Sandy Silt	ML-CL	21	40	32	7	--	--	--	--	--
ST-2	7½-8½	Lacustrine	Silty Sand	SM	6	34	59	1	--	--	--	--	--
ST-2	10-11	Lacustrine	Silt	ML	8	90	2	--	--	--	--	--	--
ST-3	½-1½	Topsoil	Organic Clay	OL	--	--	--	--	--	33	3.4	34	8
ST-3	2½-3½	Blanket	Sandy Silt	ML-CL	18	38	43	1	--	--	--	--	--
ST-3	7½-8½	Alluvium	Silty Sand	SM	8	23	46	13	--	--	--	--	--
ST-3	17½-18½	Alluvium	Silty Sand	SM	--	24	75	1	--	--	--	--	--
ST-3	22½-23½	Alluvium	Silty Sand	SM	--	14	62	20	4	--	--	--	--
ST-3	32½-33½	Lacustrine	Silt	ML	6	76	25	3	--	--	--	--	--
ST-4	½-1½	Topsoil	Organic Clay	OL	--	--	--	--	--	30	3.8	37	10
ST-4	2½-3½	Blanket	Silty Clay	CL	--	--	—	--	--	37	--	39	15
ST-4	10-11'	Alluvium	Sandy Silt	ML-CL	12	43	45	--	--	--	--	--	--
ST-4	15-16'	Alluvium	Silty Sand	SM	--	15	41	41	3	--	--	--	--
ST-5	12½-13½	Alluvium	Silty Sand	SM	8	28	66	--	--	--	--	--	--
ST-5	20-21	Lacustrine	Silty Sand	SM	6	15	79	--	--	--	--	--	--
ST-6	12½-13½	Alluvium	Silty Sand	SM	--	27	62	1	--	--	--	--	--
ST-6	20-21	Alluvium	Silty Sand	SM	5	32	63	--	--	--	--	--	--
ST-6	25-26	Lacustrine	Silt	ML	8	90	2	--	--	--	--	--	--
ST-6	70-71	Lacustrine	Fat Clay	CH	--	--	--	--	--	41	--	54	22
ST-6	80-81	Lacustrine	Fat Clay	CH	--	--	--	--	--	40	--	54	27
ST-6	90-91	Lacustrine	Fat Clay	CH	--	--	--	--	--	41	--	52	21
ST-6	100-101	Lacustrine	Fat Clay	CH	--	--	--	--	--	41	--	55	23
ST-8	5-6'	Alluvium	Sandy Silt	ML	7	56	37	--	--	--	--	--	--
ST-8	10-11'	Lacustrine	Silt	ML	6	85	9	--	--	--	--	--	--
ST-8	15-16'	Lacustrine	Silt	ML	5	93	2	--	--	--	--	--	--
ST-9	5-6'	Lacustrine	Silty Sand	SM	5	10	84	1	--	--	--	--	--
ST-9	15-16'	Lacustrine	Silty Sand	SM	3	30	67	--	--	--	--	--	--
ST-9	20-21'	Lacustrine	Silt	ML	4	90	6	--	--	--	--	--	--
B-12	1½-10	Till	Sandy Clay	CL	24	48	17	10	1	Permeability = 4.5×10^{-9}			
B-20	1½-10	Till	Sandy Clay	CL	26	50	15	9	--	Permeability = 1.2×10^{-7}			
B-28	1-10	Till	Sandy Clay	CL	24	48	17	11	--	Permeability = 1.2×10^{-8}			

Abbreviations: C=clay (finer than 0.002 mm), $=silt, FS=fine sand (#40 to 200), M & CS=medium and coarse sand, G=gravel (plus #4), MC=moisture content, OC=organic content, LL=liquid limit, PI=plastic index.

* Taken from Braun Engineering & Testing report BND 84-062:

Alluvium (river deposited) soils were encountered below the blanket soils down to approximately elevation 1,000 msl. Visual classifications ranged from silty sand to sandy silt to slightly plastic sandy silt. The sand was predominately fine-grained with only a trace of gravel. An exception was a courser grained deposit from 22 to 24 feet in boring ST-3.

Lacustrine sand and silt was encountered beneath the alluvium and part way up the abutments. Visual classifications ranged from silty sand to sandy silt to silt to slightly plastic silt. The samples generally had a narrow range of grain sizes. The sand was nearly all fine-grained.

Lacustrine (lake deposited) fat clays were encountered below elevation 956 msl in boring ST-6. The liquid limit, plastic limit, and moisture content value of these samples indicate that overall the clay is quite uniform even though lenses and seams of silty clay and fatter clay were evident.

Samples of till were taken from borings B-12, B-20, and B-28. The grain sizes were well distributed. The dispersion tests indicate the clay till was non-dispersive.

Foundation:

The term "foundation" as used herein includes the valley floor and not the abutments.

Borings ST-3 through St-6 encountered 4 to 8 feet of soft topsoil consisting of a clay and silt blanket. Boring ST-7 encountered 17 feet of soft to medium clay, silt, and clayey sand. It is likely these soils have a low quick or unconsolidated undrained strength. During construction, the quick strength of clay layers often controls stability.

Long-term stability is controlled by the slow or consolidated drained strength of soils. The soils at the site appeared to be of typical strength. If the dam has 3:1 side slopes, the factor of safety for the drained condition will still be nearly 1.5, even if the clay blanket soils are left in place.

The clay blanket soils are soft and compressible. However, their thickness is limited, therefore, it is expected that consolidation of the blanket soils will be only several inches after placement of the embankment and most of the consolidation will be complete in one year. The clay "plug" encountered by boring St-7 is considerably thicker. At this location a settlement in the range of 1/2 to 1 foot occurring over a period of several years after construction is expected.

The potential for consolidation of the fat clay below 68 feet is less predictable. The existing effective verticle stress is in the range of 4,000 to 6,000 psf. The proposed embankment will add about 2,500 psf. Depending upon the pre-consolidation pressure, consolidation could be substantial and occur over a very long period of time.

Corps of Engineers studies have shown that the vertical permeability of a clay, silt, and slightly plastic sandy silt top blanket are approximately .0001 cm/sec. The horizontal permeability of nonplastic sandy silt would be .00013 cm/sec and a silty sand would be .0005 cm/sec.

Based upon permeability-grain size relationships, the foundation horizontal permeability can be estimated as .006 cm/sec. This is a relatively low permeability in a pervious foundation.

Medium dense to dense lacustrine silt and silty sand were encountered at about elevation 1,000 msl. These deposits appear to be substantially less permeable than the alluvial silts and sands. It appears that 20 feet may be used as the depth of the pervious foundation.

Abutments:

Medium dense to dense lacustrine sands and silts or very stiff to hard clay till were generally encountered in the abutments. Boring ST-8, however, encountered loose alluvial sandy silt to a depth of 7 feet. Stability problems in the silt during construction are not anticipated, however, seepage under and around the abutments during a flood could cause stability problems in the silt.

The borings encountered strata of uniformly graded nonplastic silty sand and silt. Significant horizontal seepage is anticipated in the more permeable layers and strata under and around the abutments.

Embankment:

If the clay till, found within the borrow area, is used as embankment material and is compacted to at least 95 percent of the standard Proctor maximum dry density, it is anticipated that it will be stable, relatively incompressible, and impermeable. Laboratory test indicate the permeability was about $1X10^{-7}$ cm/sec and less.

IV. Hydrology Analysis

Introduction:

At the request of the North Dakota State Water Commission, the St. Paul District, Corps of Engineers, analyzed the hydrologic effects of the proposed WR-190 dam on the Wild Rice River main stem. Specific data used to complete their study was acquired from Moore Engineering, the State Water Commission, and other sources as needed. The results of the Corps' study are incorporated into their February 17, 1986 report, entitled "Wild Rice River, North Dakota WR-190 Dam Site Analysis." The report is included in Appendix C.

Two methods of analysis were used by the Corps to determine the downstream effects of the proposed WR-190 dam. The first method was based on specific flood events and the second was based on a synthetic model using frequency curves. In addition, frequency curves were developed at selected points within the Wild Rice River basin. The synthetic analysis is based on the developed frequency curves.

The two methods of analysis used by the Corps employed the HEC-1 computer model. The HEC-1 model was developed by the Hydrologic Engineering Center of the Corps of Engineers and is used to compute peak discharges and flow volumes of various frequency storms. The model formulates a mathematical hydrologic model of the watershed based on the following components of the hydrologic process: The amount of rainfall, rainfall distribution, soil type, land use, and the hydraulic characteristics of the stream channels and drainage area. The model can be used

to compare flood flows before a structure is built to the flows after its construction.

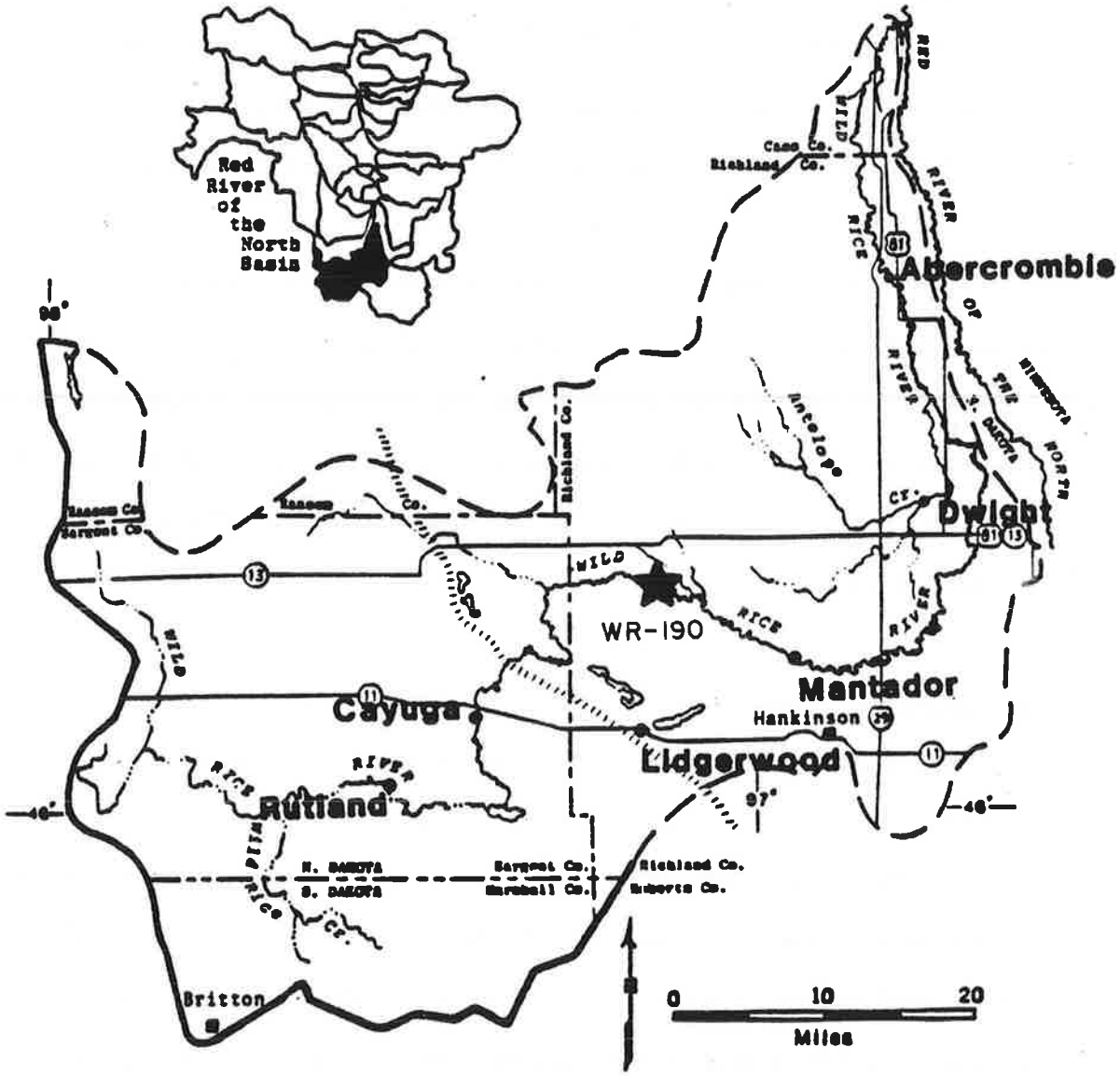
Frequency Analysis:

A frequency analysis for the following Wild Rice River gaging stations was included in the Corps' February 17, 1986 report: Rutland (Wild Rice main stem), Cayuga (Wild Rice main stem), Lidgerwood (Grass Lake Tributary), Mantador (Wild Rice main stem), Dwight (Antelope Creek), and Abercrombie (Wild Rice main stem). The location of the sites are shown in Figure 4. The frequency analysis was completed following the guidelines of the Water Resource Council Bulletin #17B and data obtained from WATSTOR. Appendix C contains tables of the output from the frequency analysis. The results for various flood events are summarized in Table 3.

Synthetic Analysis:

Synthetic hydrographs for the WR-190 site were developed by the Corps for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood events. The inflow hydrographs were determined by routing the Cayuga hydrographs to the dam site. Local flows were determined similar to the method used for the historic event analysis. The inflow peaks at the dam site are not significantly higher than the flows above Cayuga. Local flows run off before the flow from upstream of Cayuga arrives at the WR-190 site. Appendix C contains the synthetic inflow hydrographs for WR-190. Table 4 shows the existing peak flows at the dam site.

GAGING STATIONS WILD RICE RIVER



Taken from Corps of Engineers February 17, 1986
"WR-190 Damsite Analysis".

WR-190 SWC PROJECT 1792

FIG 4

TABLE 3. ADOPTED FREQUENCY DATA FOR WILD RICE RIVER, ND.

WR-190 SWC PROJECT #1792

LOCATION	COMPUTED DISCHARGE IN CFS EXCEEDENCE FREQUENCY IN PERCENT (RETURN PERIOD IN YEARS) 10 (10)	4 (25)	2 (50)	1 (100)	0.2 (500)
WILD RICE RIVER NEAR RUTLAND	602	1080	1560	2130	3930
WILD RICE RIVER NEAR CAYUGA	785	1280	1740	2300	4000
GRASS LAKE TRIB NEAR LIDGERWOOD	31	51	69	90	150
WRR TRIB. NEAR MANTADOR	54	123	212	346	946
WILD RICE RIVER NEAR MANTADOR	986	1640	2270	3050	5540
ANTELOPE CREEK NEAR DWIGHT	2520	4660	6810	9480	17900
WILD RICE RIVER NEAR ABERCROMBIE	4020	6510	8730	11200	18100

TABLE 4
Existing Peak Flows at WR-190

Event	Inflow
300-year	4,060 cfs
200-year	3,235 cfs
100-year	2,542 cfs
50-year	1,937 cfs
25-year	1,424 cfs
10-year	877 cfs
5-year	546 cfs
2-year	212 cfs

V. Preliminary Design

Dam Design Classification:

Dams are classified according to their potential hazard to property and potential for loss of life if the dam should suddenly fail. Existing conditions, future downstream development, and the dam height are considered when classifying a dam.

The WR-190 dam site is located in a rural area where there is little probability of future residential development. Failure of this dam could result in damage to agricultural land, State Highway 18 and township roads. No loss of life is expected if the dam would fail. Therefore, the proposed WR-190 dam is categorized as a low hazard dam. The dam height is approximately 38 feet, therefore, the dam design classification for the proposed WR-190 dam is classification III, according to the North Dakota Dam Design Handbook. The hydrologic criteria for a class III dam are that it pass a 100-year event without excessive velocities in the emergency spillway and that it pass a 30 percent PMP event without overtopping.

Hydraulic Design:

An elevation-capacity curve (Figure 5) for the WR-190 site was developed using a USGS topographic map of the reservoir area. The elevation-capacity curve and the inflow hydrographs were then used to determine outflow hydrographs by routing the inflows through the reservoir using the HEC-1 model. A revised spillway rating was determined using the following design criteria: A 250-foot long, 42-inch diameter low level pipe at elevation 1,024 msl. A principal spillway consisting

WR-190 SWC PROJ #1792

AREA-CAPACITY

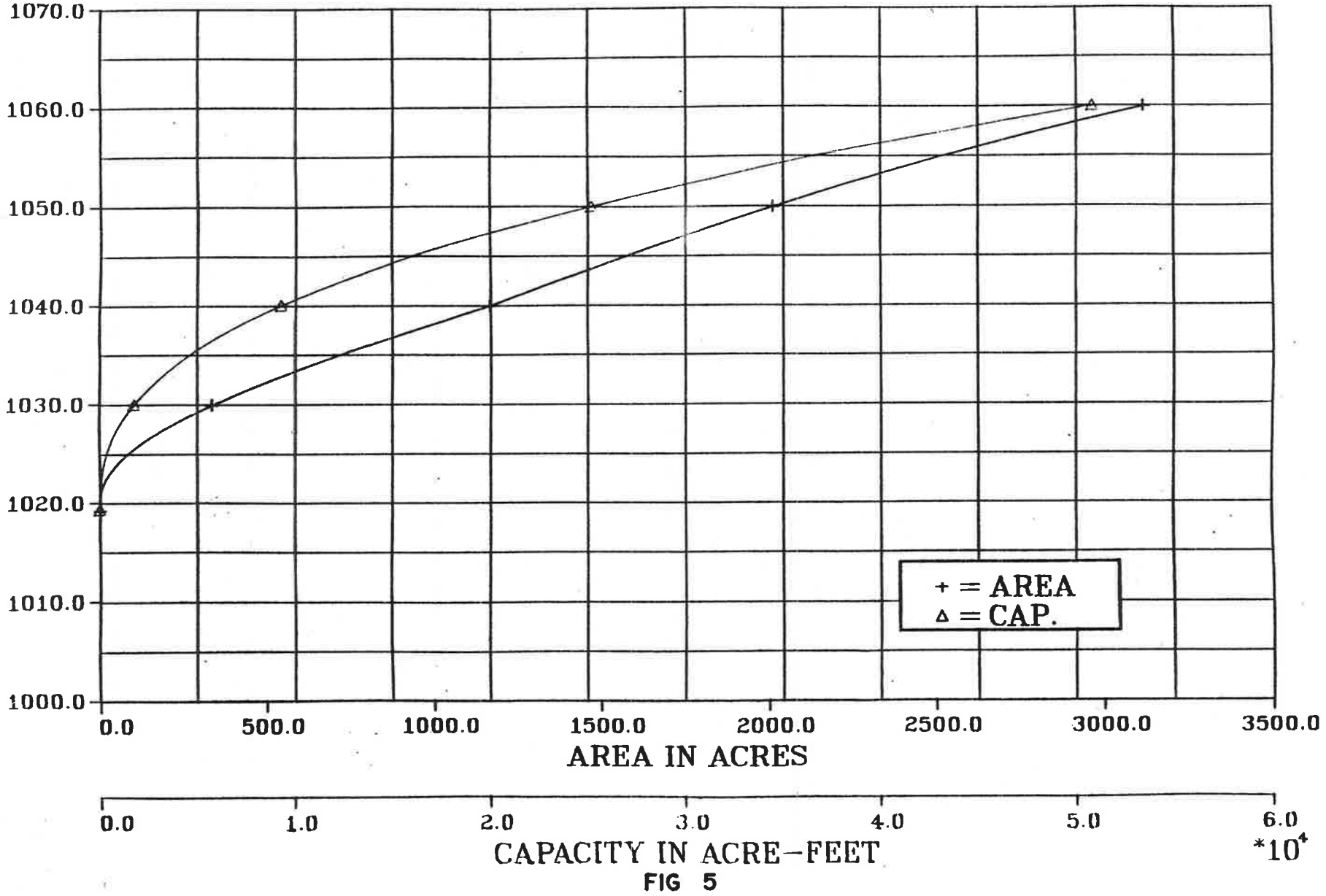


FIG 5

of a 72-inch diameter, 240 feet long reinforced concrete pipe with a 6-foot by 18-foot drop inlet structure set at elevation 1,042 msl, and a 400-foot wide emergency spillway at elevation 1,053 msl.

The routing of the 100-year event yielded a 769 cfs outflow. Inflow would cause the reservoir to rise to an elevation of 1050.0 msl. The 100-year inflow and outflow hydrographs are shown in Figure 6.

Topographic conditions indicate the emergency spillway control elevation should be 1053.0 msl. The emergency spillway should be an open trapezoidal channel with a 400-foot bottom and 3:1 side slopes. The control section is 100 feet long with no slope. The outlet section is 1,300 feet long and the inlet section is 950 feet long. Both the inlet and outlet sections have a slope of 1 percent. The spillway would be located in the north abutment. The location of the emergency spillway, embankment, low level pipe and principle spillway are shown in Figure 7.

A hydrograph for a 30 percent probable maximum precipitation (PMP) event was simulated on the HEC-1 model and routed through the principal and emergency spillways. The .3 PMP inflow is 3,305 cfs. The routing of the .3 PMP event yielded a 1,195 cfs outflow. The event caused the reservoir to rise to elevation 1053.4 msl. Therefore, to handle the event, the top of the dam should be set at 1,057.0 msl, which would allow for a 3.6 foot freeboard. The 30 percent PMP inflow and outflow hydrographs are shown in Figure 8.

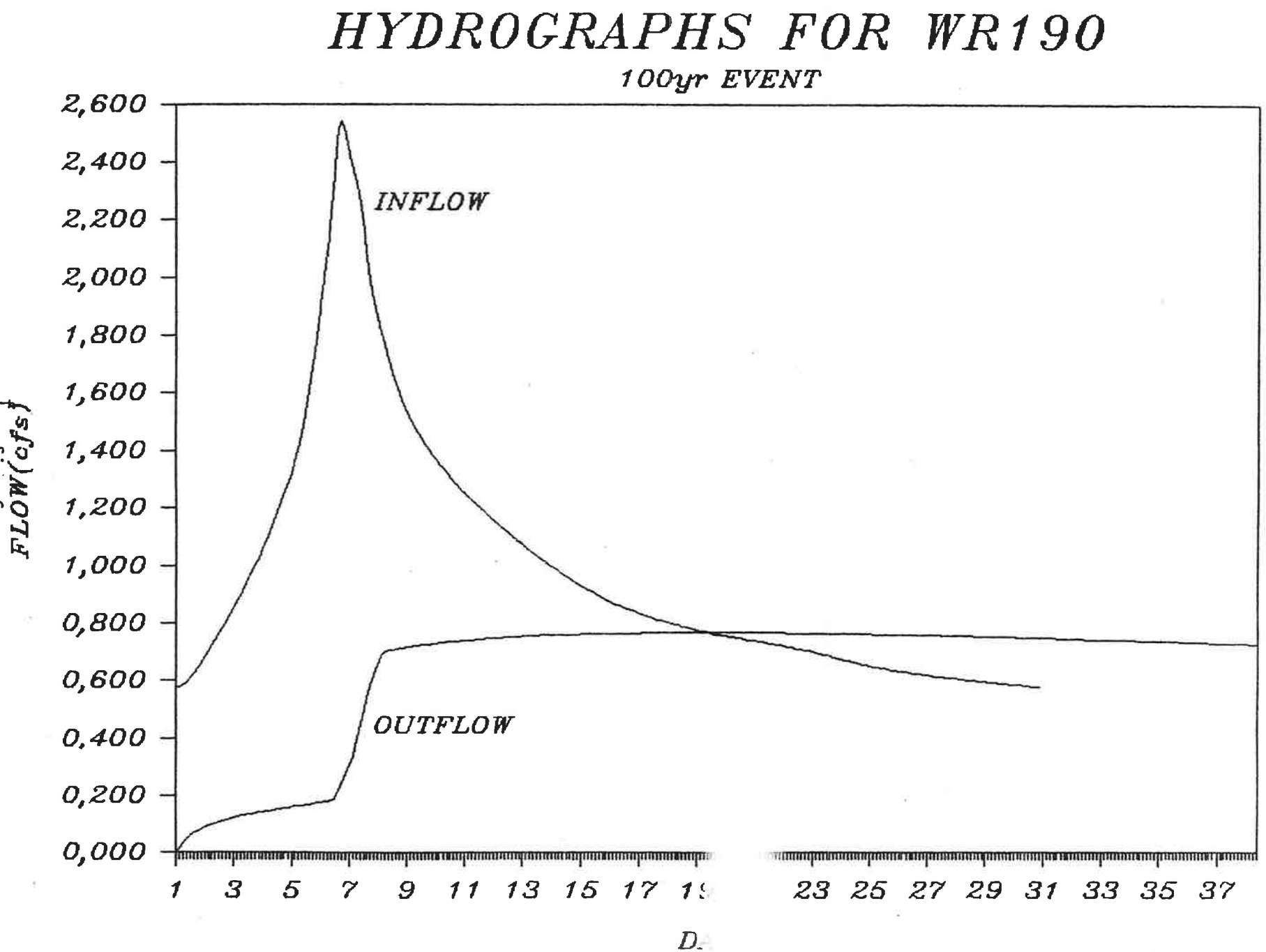
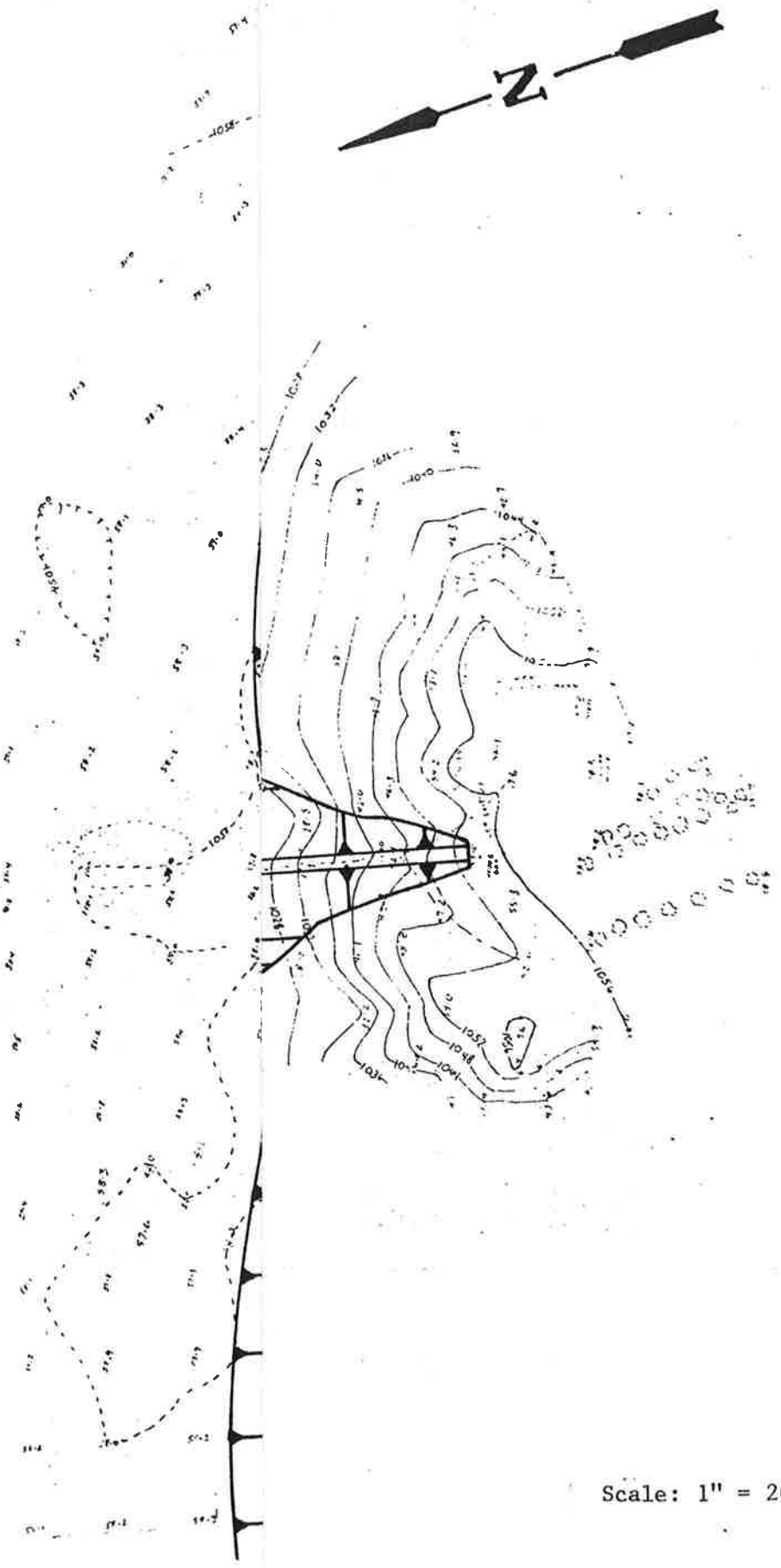
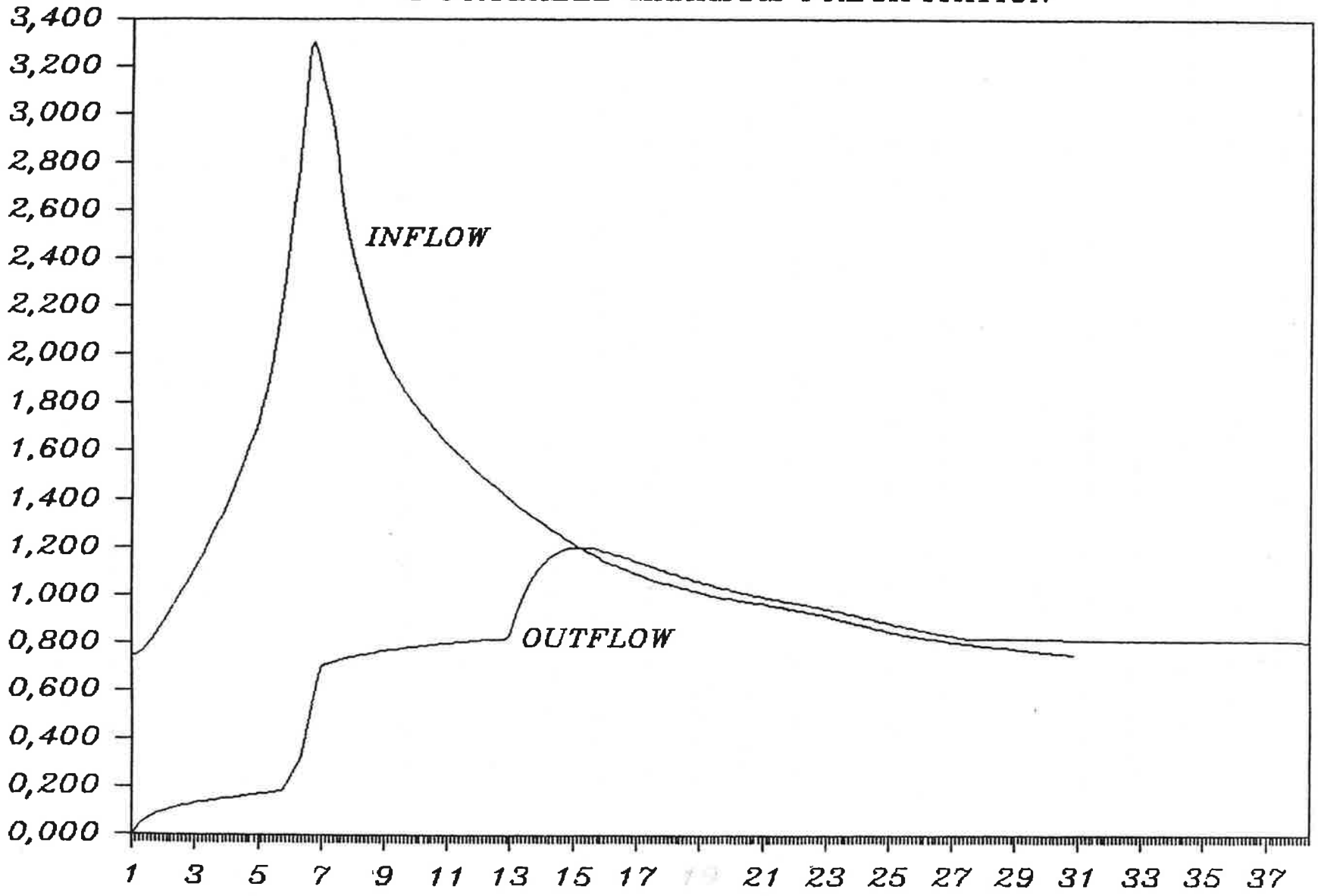

HYDROGRAPHS FOR WR190
100yr EVENT
2,600
2,400
2,200
2,000
1,800
1,600
1,400
1,200
1,000
0,800
0,600
0,400
0,200
0,000
INFLOW
OUTFLOW
FLOW(cfs)
1 3 5 7 9 11 13 15 17 19
23 25 27 29 31 33 35 37
D

fig. 6


N
Scale: 1" = 200'

HYDROGRAPHS FOR WR190

.3 PROBABLE MAXIMUM PRECIPITATION



-26-

fig. 8

Historic Flood Event Analysis:

The Corps of Engineers analyzed downstream effects of the proposed dam based on specific flood events. The historic flood event analysis method routed specific historic flood events down the Wild Rice River and through Fargo on the Red River. Models of the individual floods were run with and without the proposed dam in place. The flood years used in the HEC-1 models were 1966, 1969, 1975, 1978, and 1979.

After the existing condition models were developed for the five flood events, a preliminary rating curve for the proposed spillway at the WR-190 dam was put into the model. The modified models were used to compare flows under existing conditions to modelled flows with the dam in place. Selected points where the effects of the proposed dam were considered include the WR-190 site, Abercrombie along the Wild Rice River, the mouth of the Wild Rice River where it enters the Red River main stem, and the Fargo gaging station on the Red River. A summary of the results is given in Table 5.

It should be noted that a preliminary rating curve for the spillway was used. The peaks which resulted from routing flows through the proposed dam would be reduced slightly further using a revised rating curve.

Table 5 indicates the dam would have an effect on larger flows at the dam site. The peak flows farther downstream are not significantly changed with the proposed dam in place. The total Wild Rice River flow at Abercrombie is reduced less than one percent. The total Red River

TABLE 5. EXISTING AND MOFIFIED 1-DAY PEAK FLOWS AT GIVEN LOCATIONS FOR WR-190

	YEAR									
	1966		1969		1975		1978		1979	
LOCAT.	EXIST	MODIF	EXIST	MODIF	EXIST	MODIF	EXIST	MODIF	EXIST	MODIF
WILD RICE RIVER AT										
WR-190	867	699	2032	1059	399	377	566	534	606	569
ABERC.	2820	2800	9360	9275	3440	3424	4850	4827	5900	5879
MOUTH	3043	3021	9677	9592	4371	4355	5031	5008	5811	5785
FARGO	3043	3021	9677	9592	4371	4355	5031	5008	5811	5785
RED RIVER										
BELOW MOUTH OF WRR	10095	10081	24492	24407	11752	11748	16789	16762	17001	16964
AT FARGO	10600	10578	24800	24715	13100	13099	17000	16973	17200	17163

Flows have not been rounded to allow effects of WR-190 to be shown.

Taken from Feb. 17, 1986, Corps of Engineers "WR-190 Dam Site Analysis".

flow is reduced by less than 0.5 percent at Fargo. Changes of this magnitude are generally not considered meaningful with respect to the level of accuracy of the modelling process.

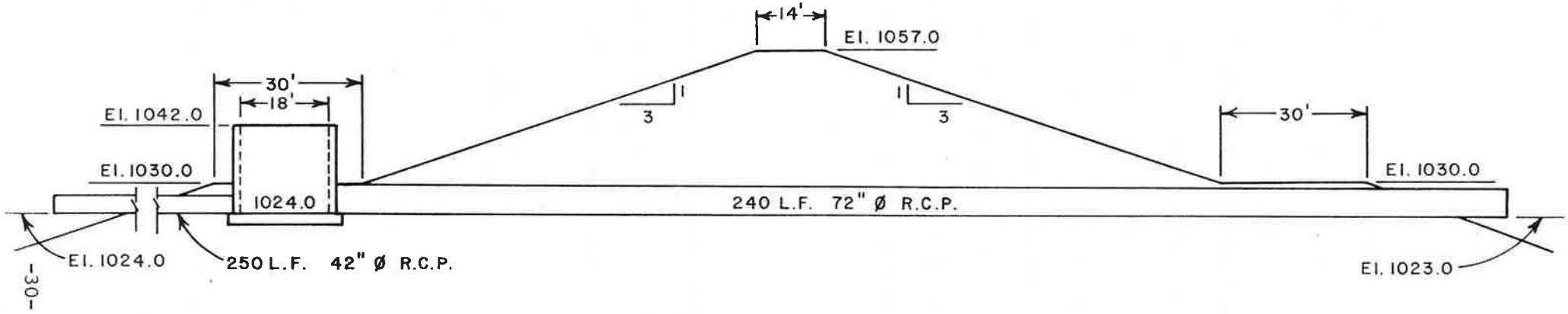
The Corps' February 17, 1986 report concluded that the peak flows from the upper part of the Wild Rice River basin tend to occur after the peaks on the lower part of the basin have passed.

In analyzing the Wild Rice River basin, the Antelope Creek subbasin appears to have the major impact on the timing and intensity of the peak discharge of the Wild Rice River from its confluence with the Wild Rice River to the Red River. The November 1982 Moore Engineering report indicates that approximately 75 percent of the peak discharge on the Wild Rice River at the confluence with Antelope Creek is from Antelope Creek.

Embankment:

A 14-foot crest width is recommended for the embankment. Side slopes of 3:1 are recommended to achieve stability considering the marginal foundation conditions. Three to one side slopes can be maintained without great difficulty.

Thirty-foot wide berms are recommended to provide stability during construction and also to provide access for maintenance equipment to the toes of the dam; the marshy floodplain deposits are too soft to reliably support heavy equipment. A typical cross-section of the dam is shown in Figure 9.



W R-190

SWC PROJECT NO. 1792

SECTION THRU SPILLWAY

Scale: 1"=30'

FIGURE 9

Foundation:

Recommended foundation preparation includes removal of the vegetation and black topsoils from beneath the upstream half of the dam and removal of approximately 5 feet of the vegetation, topsoil, and top blanket from beneath the downstream half of the dam. The excavation would result in the upstream half of the dam being 2 to 3 feet above normal ground water level. Excavation under the downstream half of the dam would extend down to the ground water level. The vegetation and topsoil should be salvaged for top dressing on the dam. The upstream face of the embankment should be seeded with a flood resistant grass to control erosion. The soft and wet material may be cast downstream of the downstream toe and later spread to increase the top blanket thickness.

Underseepage Control:

A toe drain is recommended under the downstream half of the dam to reduce the hydraulic head under the downstream slope and berm. The exact length and thickness would be determined during final design.

It is also recommended that wick drains under the downstream toe be considered during final design. These drains would reduce the hydraulic head beneath the top blanket downstream of the dam and reduce the possibility of voids forming.

Abutments:

A drainage blanket or trench drains in the downstream groin area and in the riverbank immediately downstream of the dam should be considered in the final design to collect and control seepage.

Additional Investigation:

Before final plans could be completed, additional soil borings and laboratory testing would be necessary to adequately define the soils.

At least four additional borings should be taken upstream and four additional borings taken downstream of the proposed centerline to determine blanket thickness and the depth of the pervious foundation. Field permeability tests should be run in the pervious foundation material to substantiate permeability estimates based only on grain size. At least two additional borings should be completed in each of the abutments to further define the strata. Field permeability tests are recommended if permeable layers are encountered.

At least three tube samples should be obtained and consolidation tests should be run to obtain an estimate of the amount and duration of settlement in the soft to medium clay plug encountered in Boring ST-7.

Unconsolidated, undrained and drained shear tests should be run on samples of the clay and clayey silt from the top blanket and the borrow area soils. Stability analyses for the construction and long-term conditions should then be performed.

A source of sand and gravel and processed aggregate should be located. These materials will likely be needed for fill and trench drains and gravel surfacing of the berms and crest.

Cost Estimate:

As proposed, the WR-190 Dam is estimated to cost $645,000. This does not include land or flood easement costs. Table 6 shows the breakdown of these costs.

TABLE 6
WR-190 Dam Cost Estimate

	Item	Quantity	Units	Unit Price	Total
1.	Mobilization	1	LS		5,000
2.	Water Control	1	LS		20,000
3.	Stripping	60,000	SY	.25	15,000
4.	Waste Stripping	20,000	CY	.75	15,000
5.	Embankment	180,000	CY	1.10	198,000
6.	Water for Compaction	2,000	M. Gal.	2.50	5,000
7.	Concrete	285	C.Y.	300.00	85,500
8.	Rebar	30,000	LBS.	.50	15,000
9.	72-inch Dia. RCP	240	LF	250.00	60,000
10.	42-inch Dia. RCP	250	LF	150.00	37,500
11.	Rock Riprap	200	CY	25.00	5,000
12.	Rock Riprap Filter	100	CY	15.00	1,500
13.	Drains		LS		15,000
14.	Seeding	10	Ac.	350.00	3,500
15.	Fencing		LS		5,000
	Subtotal				$476,000
	Additional Soils Investigation				20,000
	Contingencies				49,000
	Engineering				50,000
	Contract Administration				50,000
	TOTAL				$645,000

VI. Summary

The feasibility of constructing a dry dam on the Wild Rice River has been examined. The dam site, known as WR-190, is located in the NW 1/4 Section 25, Township 132 North, Range 52 West, in Richland County. A large portion of the watershed can be considered non-contributing due to the many depressions upstream of the dam site which act as storage areas for runoff.

The soils survey indicated the presence of suitable embankment material in the emergency spillway borrow area. The foundation consists of a semi-permeable blanket over pervious alluvial deposits. Relatively impermeable silt is encountered at a depth of approximately 24 feet. Seepage through the foundation and under and around the abutments could cause a stability problem. Consolidation of the foundation soils could be substantial and occur over a long period of time.

It is necessary to conduct additional borings upstream and downstream of the dam site to determine blanket thickness and depth of the pervious foundation. Additional borings are also necessary in the abutments. A number of tests on samples taken during the soils investigation should be conducted before final plans are considered.

The WR-190 Dam would be an earth-filled embankment having a height of 38 feet above the stream bottom. The upstream and downstream face would have a slope of 3:1. Approximately 180,000 cubic yards of material would be incorporated into the structure. Hydraulic features include an emergency spillway, principal spillway, and a low level pipe. The

principal spillway will be a 72-inch inch diameter pipe through the embankment. On the upstream end, a 6-foot X 18-foot drop structure is proposed. A 42-inch diameter low level pipe is also included. The emergency spillway will be a 400 foot wide channel with 3:1 side slopes. It will be located just north of the dam as shown in Figure 7. The upstream face of the embankment will be seeded with a flood resistant grass (reed canary grass or substitute) to control erosion. The cost to construct WR-190 Dam is estimated to be $645,000.

The "Wild Rice River, North Dakota WR-190 Dam Site Analysis" completed by the St. Paul District, Corps of Engineers, included a historical flood event, frequency, and synthetic analysis of the Wild Rice River basin and the WR-190 dam site. The report indicated that peak flows in the upper part of the Wild Rice River basin tend to occur after the peaks on the lower part of the basin have passed. The report indicated the Wild Rice River one day peak flows at Abercrombie for the 1966, 1969, 1975, 1978, and 1979 flood events would be reduced less than one percent by the proposed WR-190 Dam. Table 3 summarizes the insignificant downstream changes in peak flows as a result of the proposed dam. The Antelope Creek subbasin appears to have the major impact on the timing and intensity of the peak flow on the downstream portion of the Wild Rice River.

VII. Conclusions and Recommendations

The WR-190 Dam does appear to be feasible from a technical standpoint. However, the primary purpose of the WR-190 Dam is to provide downstream flood protection. The proposed structure will provide flood protection immediately downstream of the dam site. Further downstream, flood protection will not be significant.

Due to the minimal flood protection benefits of the proposed WR-190 Dam downstream of Mantador, it is recommended that a dam site be considered on Antelope Creek. Peak discharges on the Wild Rice River are attributable to the peak discharge from Antelope Creek. The decision to proceed with the project must be determined by the Richland County Water Resource Board.

APPENDIX A

Agreement For Investigation of a

Dry Dam on the

Wild Rice River Near Wyndmere

#1792

SWC Project ~~#1508~~
May, 1984

A G R E E M E N T

Investigation of a Dry Dam on the
Wild Rice River Near Wyndmere

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 Richland County Water Resource Board, hereinafter referred to as the Board, acting through its Chairman, Elroy Stein.

II. PROJECT, LOCATION, AND PURPOSE

The Board wishes to investigate the feasibility of constructing a dry dam on the Wild Rice River for the purpose of flood control. The proposed dam site is located south and west of the City of Wyndmere in the NW quarter of Section 25, Township 132 North, Range 52 West. This site was studied in the Wild Rice River Watershed Hydrologic Analysis and Flood Retention Study completed in November 1982. In this study, the site was identified as Site WR-190.

III. PRELIMINARY INVESTIGATION

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

1. Review the hydrology from the Wild River River Watershed Hydrologic Analysis and Flood Retention Study.
2. A topographic survey of the site, including the emergency spillways and any borrow areas.

3. Other field surveys necessary to establish control for baselines, centerlines and elevations of bench marks.

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

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

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

7. A preliminary design of the dam.

8. A preliminary cost estimate.

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

IV. DEPOSIT - REFUND

The Board shall deposit a total of $7,000.00 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

VERNON FAHY
State Engineer

DATE:

May 30, 1984

WITNESS:

David A. Sprynczatyk

RICHLAND COUNTY WATER RESOURCE BOARD
By:

Beverly Stone

~~BEROY STEIN~~
Chairman

DATE:

June 30, 1984

WITNESS:

Phyllis A. Hansen

APPENDIX B

Log of Borings

WR-190

SWC Project #1792

*Taken from Braun Engineering and Testing
Subsurface Investigation BND84-062 dated March 13, 1985

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-1

LOCATION: - see attached sketch -

DATE: 11/21/84 **SCALE:** 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev. 54.9	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
50.9	4	SM-SC	6" Silty Clay topsoil over SAND, fine to medium grained, trace roots, a little silt & clay, yellowish brown, moist, low to medium dense (alluvium)	7 20		
48.4	6½	CL	SANDY SILTY CLAY, low plasticity, a little gravel, pale brown, moist, hard (till)	41		
45.9	9	SM	SILTY SAND, very fine grained, yellowish brown, moist, dense (glacial drift)	43		
36.9	18	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, a few dessication cracks, yellowish brown to brown, moist, very stiff (till)	30 28 25		
32.9	22	ML	SILT, brown, moist, dense (drift)	31		
23.9	31	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, brown mottled grayish brown & pale brown, moist, hard (till)	38 48		
			Water level not encountered with 29½' of hollow-stem auger in ground.		*	*Water level not encountered to dry cave-in depth of 28.3' immediately after withdrawal of auger.

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-2

LOCATION: - see attached sketch -

DATE: 11/21/84 **SCALE:** 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev. 33.7	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
32.2	1½	OL	ORGANIC SILTY CLAY, low plasticity, a little sand, a little *	26		frozen to 6"
29.7	4	ML-CL	SANDY SILT, slightly plastic, trace roots, yellowish brown, moist, medium dense (lacustrine deposit)	18		See grain size analysis
		SM	SILTY SAND, very fine grained, grayish brown, moist, medium dense (lacustrine deposit)	TW		
24.7	9			10		See grain size analysis
		ML	SILT, brown, wet, medium dense (lacustrine deposit)	14		See grain size analysis
21.7	12	ML-CL	CLAYEY SILT, slightly plastic, gray, moist (lacustrine deposit)	TW		
19.7	14	ML	SILT, gray, moist, dry (lacustrine deposit)	35		
15.7	18	SM	SILTY SAND, very fine grained, grayish brown to gray, water-bearing, dense (lacustrine deposit)	39		(**) Water level down 24.2' with 29½' of hollow-stem auger in ground. (***) Water level down 14.6' immediately after withdrawal of auger.
				38		
02.7	31			46		
			*roots & humus, black, moist, very stiff (topsoil) (**) (***)			

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-3 (Sheet 1 of 2)

LOCATION: - see attached sketch -

DATE: 11/6&7/84 **SCALE:** 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
25.1						
24.1	1	OL	ORGANIC SILTY CLAY, low plasticity, a little roots & humus, *	5		LL=34, PL=26, PI=8, MC=32.8, OC=3.4
22.6	2½	SM	SILTY SAND, fine grained, gray wet, loose (alluvium)	4		See grain size analysis
21.1	4	ML-CL	SANDY SILT, slightly plastic, a little organic material, very **			
		SM	SILTY SAND, fine grained, non to slightly plastic, a few seams organic silt, dark gray, waterbearing, loose (alluvium)	5		
				11		See grain size analysis
				7		*black, wet, rather soft (topsoil)
12.1	13	SM	SILTY SAND, fine grained, gray, waterbearing, loose (alluvium)	5		**wet, rather soft (alluvium)
				4		***(lacustrine deposit)
				5		See sieve analysis
				5		
03.1	22	SM	SILTY SAND, fine to medium grained, gray, waterbearing, medium dense to dense (alluvium)	30		See sieve analysis
01.1	24	SM	SILTY SAND, fine to medium grained, brownish gray, waterbearing, dense (lacustrine deposit)	44		
98.1	27	SM	SILTY SAND, fine grained, dark gray, waterbearing, medium dense (lacustrine deposit)	28		
95.6	29½	ML	SILT, nonplastic, gray mottled dark gray, moist, medium dense,***	29		
94.1	31					
			- Log continued on Sheet 2 -			

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-3 (Sheet 2 of 2)

LOCATION: - see attached sketch)

DATE: 11/6&7/84 **SCALE:** 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
94.1	31		- Log continued from Sheet 1 -			
93.1	32	ML	SILT - cont. SILT, some fine sand, dark gray, waterbearing, medium dense (lacustrine deposit)	25		See grain size analysis
90.6	24½	ML	SILT, dark gray, moist, dense (lacustrine deposit)	38		
88.1	37	SM	SILTY SAND, very fine grained, dark gray, waterbearing, medium dense to dense (lacustrine deposit)	25 44 24		
79.1	46			28		
			Water level down 12.2' with 45' of hollow-stem auger in ground. Water level down 4.4' immediately after withdrawl of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-4

LOCATION: - see attached sketch -

DATE: 11/8/84 **SCALE:** 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
25.4						
23.9	1½	OL	ORGANIC SILTY CLAY, low plasticity, a little roots & humus, black, wet, rather soft (topsoil)	4		LL=37, PL=27, PI=10 MC=29.9, OC=3.8
21.4	4	CL	SILTY CLAY, some fine sand, dark gray mottled light gray, very wet, soft (alluvium)	3		LL=39, PL=24, PI=15 MC=37.4
18.4	7	ML-CL	SANDY SILT, slightly plastic, a little clay, trace organic materials, gray mottled dark gray & brown, very wet, rather soft *	6		
16.4	9	SM	SILTY SAND, fine grained, with seams silty clay, dark gray, waterbearing, loose (alluvium)	10		
		ML-CL	SANDY SILT, slightly plastic, a little clay, dark gray, medium dense to loose (alluvium)	12		See grain size analysis
11.9	13½			6		
		SM	SILTY SAND, fine to coarse grained, with some seams silty sand and silty clay, gray to dark gray, waterbearing, loose (alluvium)	7		See sieve analysis
04.4	21			10		

*(alluvium)

Water level down 15.3' with 19½' of hollow-stem auger in ground.

Water level down 4.6' immediately after withdrawal of auger.

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-5

LOCATION: - see attached sketch -

DATE: 11/21/84 SCALE: 1"=4'

Elev. 23.9	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
		ML-CL	6" topsoil over SANDY SILT, slightly plastic, trace roots, dark gray, wet, soft (alluvium)	4		
				3		
				3		
15.9	8					
		SM	SILTY SAND, fine grained, gray waterbearing, medium dense (alluvium)	10		
13.9	10	SM	SILTY SAND, fine grained, brown, waterbearing (alluvium)	TW		
11.9	12	SM	SILTY SAND, fine grained, dark gray, waterbearing, loose (alluvium)	6		See grain size analysis
9.4	14½	SM	SILTY SAND, fine grained, trace fibers, dark gray, water-*	8		
07.9	16	SM	SAND, fine grained, some seams silty fine sand, dark gray, waterbearing, loose (alluvium)			
04.9	19	SM	SILTY SAND, fine grained, water-bearing, medium dense (lacustrine deposit)	23		See grain size analysis
02.9	21					

*bearing, loose (alluvium)

Water level down 4.9' with 19½' of hollow-stem auger in ground.

Water level down 4.2' immediately after withdrawal of auger.

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-6 (Sheet 1 of 4)
LOCATION: - see attached sketch -
DATE: 11/8-19/84 **SCALE:** 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
24.1						
22.6	1½	OL	ORGANIC SILTY CLAY, low plasticity, a little roots & humus, *	5		*black, wet, rather soft (topsoil)
		CL	SILTY CLAY, low plasticity, dark gray, very wet, rather soft (alluvium)	4		
20.1	4	SM	SILTY SAND, fine to very fine grained, gray to very dark gray, waterbearing, loose to very loose (alluvium)	7		
				4		
15.1	9	ML	SANDY SILT, non to slightly plastic, a little clay, trace organic material, very dark gray, waterbearing, loose (alluvium)	6		
12.1	12	SM	SILTY SAND, very fine grained, gray, waterbearing, very loose (alluvium)	4		See sieve analysis
				4		boring advanced below 15 feet with rotary bit & drilling mud
06.1	18	SM	SILTY SAND, very fine grained, trace roots, dark gray, waterbearing, loose (alluvium)	4		
				6		See grain size analysis
02.1	22	SM	SILTY SAND, fine grained, gray waterbearing, loose (alluvium)	7		
00.1	24	ML	SILT, non to slightly plastic, dark gray, moist, medium dense (lacustrine deposit)	22		See grain size analysis
97.1	27	ML	SANDY SILT, nonplastic, dark gray, moist, medium dense (lacustrine deposit)	20		
93.1	31			23		
			- Log continued on Sheet 2 -			

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-6 (Sheet 2 of 4)

LOCATION:
- see attached sketch -

DATE: 11/8-19/84 **SCALE:** 1"=4"

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
93.1	31		- Log continued from Sheet 1 -			
			SANDY SILT (continued)			
91.1	33	ML	SILT, non to slightly plastic, dark gray, medium dense, moist (lacustrine deposit)	20		
				20		
				25		
76.1	48	ML	SANDY SILT, dark gray, moist, medium dense (lacustrine deposit)	25		
63.1	61			24		
			- Log continued on Sheet 3 -			

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-6 (Sheet 3 of 4)

LOCATION: - see attached sketch -

DATE: 11/8-19/84 **SCALE:** 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
63.1	61					
			SANDY SILT (continued)			
56.1	68					
		CH	FAT CLAY, high plasticity, with seams silty clay, dark gray, wet, medium (lacustrine deposit)			LL=54, PL=32, PI=22 MC=41.4
				7		qp= ½ to 1½ tsf (pocket penetrometer estimate of unconfined compressive strength)
						LL=54, PL=27, PI=27 MC=40.1
				8		qp=1¼ tsf
39.1	85					
		CH	FAT CLAY, high plasticity, with seams silty clay, dark gra, wet to moist, rather stiff (lacustrine deposit)			LL=52, PL=31, PI=21 MC=41.0
33.1	91			10		qp=1¼ tsf
			- Log continued on Sheet 4 -			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-6 (Sheet 4 of 4)

LOCATION: - see attached sketch -

DATE: 11/8-19/84 SCALE: 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
33.1	91		- Long continued from Sheet 3 -			
			FAT CLAY (continued)			
23.1	101			14		LL=55, PL=32, PI=23 MC=41.3 qp= ½ to 1½ tsf
			Water level down 2.2' with 9' of hollow-stem auger in ground. Water level down 2.3' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-7 (Sheet 1 of 2)

LOCATION: - see attached sketch -

DATE: 11/20/84 **SCALE:** 1"=4'

Elev. 22.6	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
21.1	1½	OL	ORGANIC SILTY CLAY, low plasticity, a little roots & humus, *	6		*black, wet, medium (alluvium)
19.1	3½	CL	SILTY CLAY, low plasticity, trace roots, dark gray, wet, rather soft (alluvium)	5		
13.6	9	ML-CL	SANDY SILT, slightly plastic, a little clay, trace roots & stems, a few lenses fine sand, dark gray, very wet, soft (alluvium)	3 2		
05.6	17	CL & SC	Alternating seams SILTY CLAY & CLAYEY SAND, with some thin seams fine to coarse sand, gray, medium to stiff (alluvium)	7 13 11		
98.6	24	SM-SC	SILTY SAND, slightly plastic, with some seams silty clay, trace organic materials, gray, water-bearing, loose (alluvium deposit)	6		
91.6	31	ML	SANDY SILT, gray, moist, medium dense to dense (lacustrine deposit)	39 25		
			- Log continued on Sheet 2 -			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-7 (Sheet 2 of 2)
	LOCATION: - see attached sketch -
	DATE: 11/20/84 SCALE: 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
91.6	31		- Long continued from Sheet 1 -			
			SANDY SILT (continued)			
86.6	36			26		
			Water level down 6.5' with 34½' of hollow-stem aguer in ground. Water level down 3.4' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-8 LOCATION: - see attached sketch -
	DATE: 11/20/84 SCALE: 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev. 34.4	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
32.9	1½	OL	ORGANIC SANDY SILT, a little roots & humus, black, moist, *	3		
30.4	4	ML	SANDY SILT, trace roots, dark grayish brown, moist loose (alluvium)	2/6		
27.4	7	ML	SANDY SILT, yellowish brown, moist, loose (alluvium)	7		See grain size analysis
11.4	23	ML	SILT, yellowish brown to gray below 15', moist, medium dense to dense (lacustrine deposit)	18		
				23		See grain size analysis
				27		
				41		See grain size analysis
				41		
06.4	28	ML-CL	SANDY SILT, slightly plastic, a little clay, gray, moist, dense (lacustrine deposit)	46		(**)Water level down 27.9' with 29½' of hollow-stem auger in ground.
03.4	31	SM	SILTY SAND, fine grained, gray, waterbearing, very dense (lacustrine deposit)	58		
			* very loose (topsoil) (**)			

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-9

LOCATION: - see attached sketch -

DATE: 11/22/84 **SCALE:** 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
49.1		CL	SANDY SILTY CLAY, medium plasticity, a little gravel, yellowish brown, moist, rather stiff to very stiff (till)	11 26		
45.2	4	SM	SILTY SAND, fine grained, grayish brown, moist, dense to very dense (lacustrine deposit)	30 35 57 67 51		See grain size analysis See grain size analysis
31.1	18	ML	SILT, brown, waterbearing, dense (lacustrine deposit)	44		See grain size analysis (*)Water level not encountered with 29½' of hollow-stem auger in ground. (**)Water level not encountered to dry cave-in depth of 17.2' immediately after withdrawal of auger.
24.1	25	ML	SILT, gray, moist, dense (lacustrine deposit)	31		
18.1	31			46		
			(*) (**)			

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-11 LOCATION: - see attached sketch -
	DATE: 11/22/84 SCALE: 1"=4'

Elev. 58.1	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
56.6	1½	CL	SILTY CLAY, low plasticity, some fine sand, black, moist, medium*	8		
54.1	4	ML-CL	SILT, slightly plastic, a little clay, yellowish brown, moist, loose (alluvium)	4/11		
49.6	8½	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, yellowish brown to brown, moist, very stiff to hard (till)	TW 41		
47.1	11	SM	SILTY SAND, fine grained, grayish brown, damp, very dense (lacustrine deposit)	92		

*(topsoil)

Water level not encountered with 9½' of hollow-stem auger in ground.

Water level not encountered to dry cave-in depth of 9.4' immediately after withdrawal of auger.

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-13

LOCATION: - see attached sketch -

DATE: 11/22/84 **SCALE:** 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
57.9						
56.4	1½	SM-SC	SAND, slightly plastic, trace roots & humus, black to brown,*	7		
53.9	4	SW-SM	SAND, fine to coarse grained, with some gravel, a little silt, brown, damp, medium dense (alluvium)	26		
51.4	6½	ML	SILT, pale yellow, moist, medium dense (alluvium)	22		
48.9	9	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, yellowish brown, moist, very stiff(till)	17		
46.9	11	SM-SC	SILTY SAND, fine grained, slightly plastic, a little clay, brown, moist, dense (lacustrine deposit)	44		

Water level not encountered with 9½' of hollow-stem auger in ground.

Water level not encounterered to dry cave-in depth of 9.0' immediately after withdrawal of auger.

*moist, loose (topsoil)

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-15

LOCATION: - see attached sketch -

DATE: 11/22/84 **SCALE:** 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
58.1						
56.6	1½	SM-SC	SILTY SAND, slightly plastic, a little clay, trace roots & humus,*	8		
		CL	SANDY SILTY CLAY, medium plasticity, a little gravel, brown mottled gray & brown, moist, very stiff to hard (till)	19		
				36		
				25		
47.1	11			51		

*black, moist, loose (topsoil)

Water level not encountered with 9½' of hollow-stem auger in ground.

Water level not encountered to dry cave-in depth of 9.7' immediately after withdrawal of auger.

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-17

LOCATION: - see attached sketch -

DATE: 11/22/84 **SCALE:** 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
57.9						
56.4	1½	CL	SILTY CLAY, low plasticity, trace roots & humus, black, moist, *	12		
54.4	3½	CL	SILTY CLAY, low plasticity, yellowish brown, moist, very stiff (alluvium)	26		
		CL	SANDY SILTY CLAY, medium plasticity, a little gravel, dessication cracks, brown, moist, very stiff (till)	27		
				30		
46.9	11			27		
			*rather stiff (topsoil) Water level not encountered with 9½' of hollow-stem auger in ground. Water level not encountered to dry cave-in depth of 8.8' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-19 LOCATION: - see attached sketch -
	DATE: 11/22/84 SCALE: 1"=4'

Elev. 58.0	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
56.0	2	CL	SILTY CLAY, low plasticity, trace roots & humus, black, moist, medium (topsoil)	7		
54.0	4	CL	SANDY SILTY CLAY, low plasticity, a little gravel, brown, moist, hard (till)	9/28		
47.0	11	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, dessication cracks, brown, moist, hard to stiff (till)	56 26 23		
			Water level not encountered with 9½' of hollow-stem auger in ground. Water level not encountered to dry cave-in depth of 9.6' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-21
	LOCATION: - see attached sketch -
	DATE: 11/22/84 SCALE: 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
56.7						
55.2	1½	CL	SILTY CLAY, low plasticity, trace roots & humus, black, moist, *	7		
50.2	6½	ML-CL	SILT, slightly plastic, a little clay, pale yellow, moist, medium dense (alluvium)	23 25		
45.7	11	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, brown, moist, very stiff (till)	23 28		
			*medium (topsoil) Water level not encountered with 9½' of hollow-stem auger in ground. Water level not encountered to dry cave-in depth of 9.2' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-23
	LOCATION: - see attached sketch -
	DATE: 11/23/84 SCALE: 1"=4'

Elev. 53.1	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
		CL	6" topsoil over SANDY SILTY CLAY, low plasticity, a little gravel, brown, moist, rather stiff to hard (till)	12		
49.1	4	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, moist, very stiff to hard (till)	44		
				TW		
				28		
42.1	11			35		
			Water level not encountered with 9½' of hollow-stem auger in ground. Water level not encountered to dry cave-in depth of 9.2' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

BORING: ST-25

LOCATION: - see attached sketch -

DATE: 11/23/84 **SCALE:** 1"=4'

Elev. 58.4	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
56.4	2	OL	ORGANIC SANDY SILT, slightly plastic, a little roots & humus, a little clay, black, moist, *	7		
54.4	4	ML-CL	SANDY SILT, slightly plastic, trace gravel, brown, moist, medium dense (till)	25		
		CL	SANDY SILTY CLAY, medium plasticity, a little gravel, brown mottled gray, hard to very stiff (till)	48		
				26		
47.4	11			25		
			*medium (topsoil) Water level not encountered with 9½' of hollow-stem auger in ground. Water level not encountered to dry cave-in depth of 9.2' immediately after withdrawal of auger.			

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORING

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	BORING: ST-27
	LOCATION: - see attached sketch -
	DATE: 11/22/84 SCALE: 1"=4'

Elev.	Depth	ASTM D2487 Symbol	Description of Materials (ASTM D2488)	BPF	WL	Tests or Notes
54.2		CL	10" topsoil over SILTY CLAY, medium plasticity, a little sand, brown, medium to hard (till)	8 33 53		
48.2	6	CL	SANDY SILTY CLAY, medium plasticity, a little gravel, a few seams silty fine sand, brown to yellowish brown, moist, hard (till)	32 41		
43.2	11					

Water level not encountered with 9½' of hollow-stem auger in ground.

Water level not encountered to dry cave-in depth of 8.8' immediately after withdrawal of auger.

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORINGS

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

DATE: 11/23/84

SCALE: 1"=4'

BORING: B-10
SURF. ELEV: 1058.1
LOCATION: - see attached sketch -

Depth	Description of Materials (ASTM D2488)	ASTM D2487	WL
1½	TOPSOIL	CL	
2	SILTY CLAY	CL	
	SANDY SILTY CLAY	CL	
10			
	Water level not encountered when probing boring immediately after withdrawal of auger.		

BORING: B-12
SURF. ELEV: 1057.7
LOCATION: - see attached sketch -

Depth	Description of Materials (ASTM D2488)	ASTM D2487	WL
1½	TOPSOIL	CL	
	SANDY SILTY CLAY See grain size analysis, moisture-density, pinhole dispersion & permeability test results.	CL	
10			
	Water level not encountered when probing boring immediately after wtihdrawal of auger.		

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORINGS

BRAUN ENGINEERING TESTING

PROJECT: BND84-062 SUBSURFACE INVESTIGATION
Proposed Dam
S. of Wyndmere, ND

DATE: 11/23/84

SCALE: 1"=4'

BORING: B-14

SURF. ELEV: 1058.0

LOCATION: - see attached sketch -

Depth	Description of Materials (ASTM D2488)	ASTM D2487	WL
2	TOPSOIL	CL	
10	SANDY SILTY CLAY	CL	
	Water level not encountered when probing boring immediately after withdrawal of auger.		

BORING: B-16

SURF. ELEV: 1058.0

LOCATION: - see attached sketch -

Depth	Description of Materials (ASTM D2488)	ASTM D2487	WL
1½	TOPSOIL	CL	
10	SANDY SILTY CLAY	CL	
	Water level not encountered when probing boring immediately after withdrawal of auger.		

(See Report and Standard Plates for evaluation and descriptive terminology.)

LOG OF BORINGS

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ENGINEERING TES

PROJECT:	DATE:
BND84-062 SUBSURFACE INVESTIGATION Proposed Dam S. of Wyndmere, ND	11/23/84
	SCALE: 1"=4'

(See Report and Standard Plates for evaluation and descriptive terminology.)

BORING: B-26	LOCATION:
SURF. ELEV: 1052.0	- see attached sketch -

Depth	Description of Materials (ASTM D2488)	ASTM D2487	WL
0.7	TOPSOIL	CL	
	SANDY SILTY CLAY	CL	
10			
	Water level not encountered when probing boring immediatley after withdrawal of auger.		

BORING: B-28	LOCATION:
SURF. ELEV: 1053.1	- see attached sl

Depth	Description of Materials (ASTM D2488)	AS D2
1	TOPSOIL	
	SANDY SILTY CLAY See grain size analysis, moisture-density, pinhole dispersion & permeability test results.	
10		
	Water level not encountered when probing boring immediatley after withdrawal of auger.	

APPENDIX C

"Wild Rice River, ND

WR-190 Dam Site Analysis"

Prepared by St. Paul District

Corps of Engineers

WILD RICE RIVER, NORTH DAKOTA
WR-190 DAMSITE ANALYSIS

February 17, 1986

Wild Rice River, North Dakota

WR-190 DAMSITE ANALYSIS

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Sections

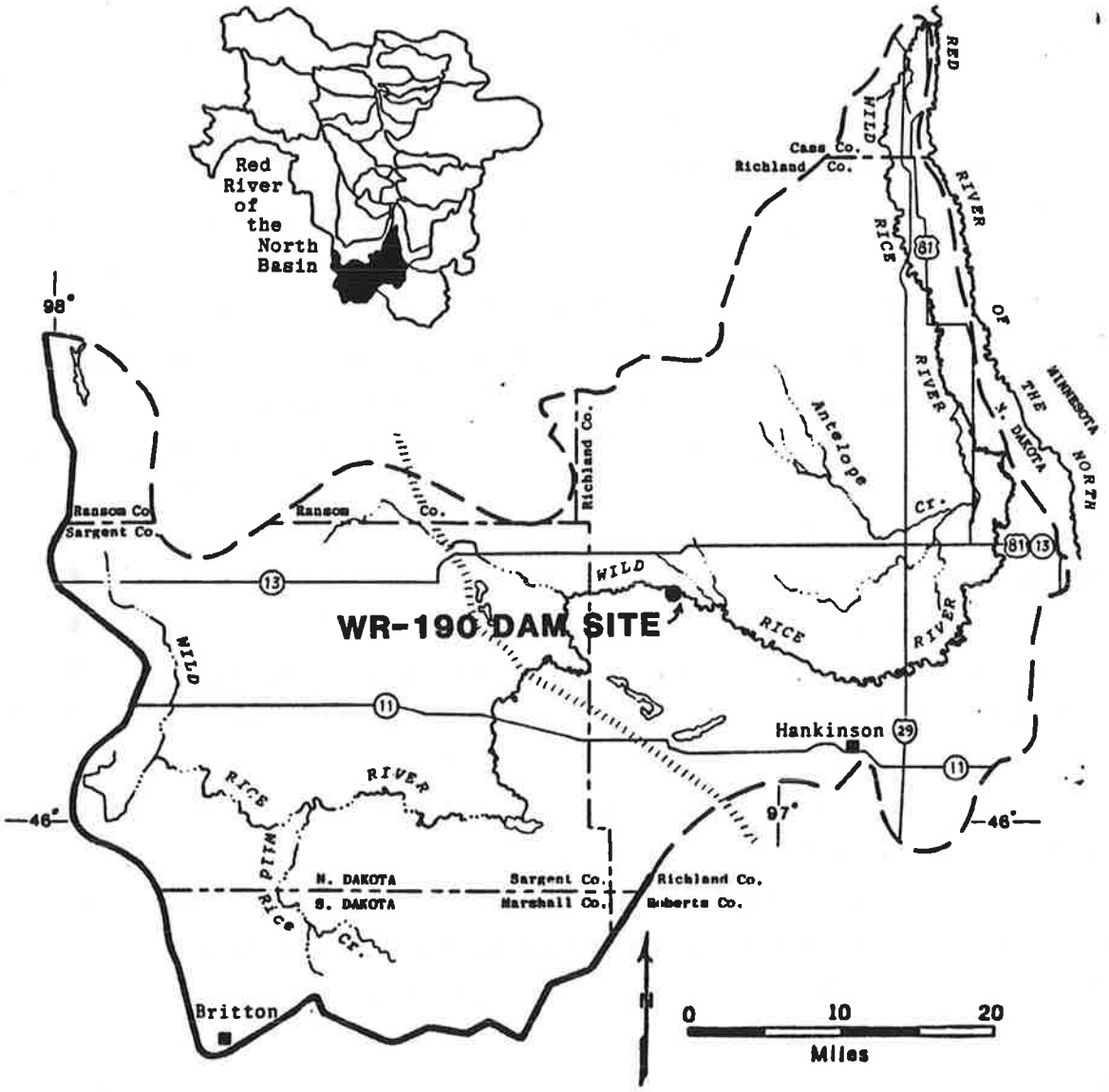
INTRODUCTION

As requested by the North Dakota State Water Commission (NDSWC), the effects of a proposed dam on the Wild Rice River main stem identified as WR-190 were looked at. See Figure 1 for the location of this site.

Base data for this analysis was obtained from the Moore Engineering Report entitled "Wild Rice River Watershed, Hydrologic Analysis and Flood Retention Study," dated November 1982. Data for the preliminary spillway rating curve was obtained from the NDSWC. Additional information to complete this work was acquired from other sources as needed. One major data base which was used and built upon for this analysis was a timing analysis done by the St. Paul District, Corps of Engineers. (See "Timing Analysis Report" dated December 1985 for further information on this study.)

To determine the downstream effects of the proposed WR-190 dam on the Wild Rice and Red Rivers, two methods of analysis were used. Both employed HEC-1 computer models for the assessment. The first was based on specific flood events, the second on a synthetic model using frequency curves.

In addition to the specific analysis of the damsite, the NDSWC also requested that frequency curves be developed at selected points within the Wild Rice basin. They have been included in this report and can be found between the two damsite evaluations. They were positioned here since the synthetic analysis is based on developed frequency curves.



Source: Gulf South Research Institute.

Figure I. WILD RICE RIVER SUBBASIN

METHOD 1 - HISTORIC FLOOD EVENT ANALYSIS

This method routed specific historic flood events down the Wild Rice tributary and through Fargo on the Red River main stem. Models of the individual floods were run with and without the proposed dam in place; then the two flows were compared.

The flood years used in the HEC-1 models were 1966, 1969, 1975, 1978, and 1979. For four of the models - 1966, 1969, 1978, and 1979 - data on the Red River main stem had been developed as part of the timing analysis conducted by the Corps in 1985. The 1975 flood was modeled specifically for this study from the headwaters to Fargo. (It is anticipated that the remainder of the main stem will be modeled for this flood event at a later date and incorporated into the original timing analysis study.)

The inflows for the WR-190 damsite were determined by using the nearest gaging station upstream of the proposed site at Cayuga. Local flows between this gaging station and the WR-190 site were obtained in the following manner. The drainage area above the Cayuga gage at 955 square miles was obtained from the USGS. At WR-190 the drainage area was calculated to be 1,230 square miles. The ratio of the drainage area between these two locations with that at Cayuga is 0.288. This figure was used to multiply the flows at the Cayuga gage to obtain the local flows for the area between Cayuga and WR-190. For each flood event, the flows at Cayuga were routed to WR-190. From this point the local flows were added to the routed flows to obtain the total inflow at the WR-190 damsite.

Local flows were also determined for the area between the damsite and the nearest downstream gage which was used in the Red River main stem timing analysis. This gage is located at Abercrombie. To obtain flow data in this reach, the WR-190 inflows were then routed to Abercrombie and compared with the gaged flows at this location. The difference between the inflows from the WR-190 site and the gaged flows is therefore the

local flow for this area. From Abercrombie to points downstream, data from the Red River main stem models were used. An explanation of these latter models can be obtained from the Corps Timing Analysis Report.

After the existing conditions models were developed for the five flood events as described above, the rating curve for the proposed spillway at the WR-190 dam was put into the model. With the dam in place, the modified models were used to determine the downstream effects for each flood event.

Computer runs with and without the spillway rating curve allowed comparisons of existing flows and modelled flows with the dam in place. Tables and plots were developed at selected points to trace the possible effects of the proposed dam. These included the WR-190 site and Abercrombie along the Wild Rice River; the mouth of this tributary where it enters the Red River main stem; and the nearest major gaging station downstream of this confluence, Fargo. Section A contains tables of these flows. Plots of the Wild Rice River and Red River flows can be found in Section B. A summary of the results is given below in Table 1.

From Table 1 and the data in Sections A and B, it can be seen that WR-190 does have an effect on larger flows at the damsite. It should be noted that the rating curve for the spillway used in this study was only preliminary. Although the smaller peaks did not seem to change significantly with the two runs, these also may be reduced when a more refined rating curve is developed for the final design of the dam. It can also be seen from Table 1 that the 1-day peak flows farther downstream of the dam are NOT significantly changed with the proposed dam in place. In 1969, for instance, the peak reductions at the WR-190 reference point were significantly larger than for any of the other four flood events. At the remaining selected locations below the damsite, however, the change in peak was less than 1 percent. In fact, the total Red River flow is reduced by less than 0.5 percent at Fargo.

TABLE 1, EXISTING AND MODIFIED 1-DAY PEAK FLOWS AT GIVEN LOCATIONS FOR WR-190

	YEAR									
	1966		1969		1975		1978		1979	
LOCAT.	EXIST	MODIF	EXIST	MODIF	EXIST	MODIF	EXIST	MODIF	EXIST	MODIF
WILD RICE RIVER AT										
WR-190	867	699	2032	1059	399	377	566	534	606	569
ABERC.	2820	2800	9360	9275	3440	3424	4850	4827	5900	5879
MOUTH	3043	3021	9677	9592	4371	4355	5031	5008	5811	5785
FARGO	3043	3021	9677	9592	4371	4355	5031	5008	5811	5785
RED RIVER										
BELOW MOUTH OF WRR	10095	10081	24492	24407	11752	11748	16789	16762	17001	16964
AT FARGO	10600	10578	24800	24715	13100	13099	17000	16973	17200	17163

Flows have not been rounded to allow effects of WR-190 to be shown.

Based on the tables and plots produced for the various flows, it appears that there is at least one major reason for this lack of reduction farther downstream of the proposed damsite. The peak flows from the upper part of the basin tend to occur after the peaks on the lower part of the basin have passed. This difference in timing becomes even greater after the flows are routed downstream.

FREQUENCY ANALYSIS

A frequency analysis for the Wild Rice gaging stations was also requested by the NDSWC. The following stations were included:

Rutland (Wild Rice main stem)
Cayuga (Wild Rice main stem)
Lidgerwood (Grass Lake Tributary)
Mantador (Wild Rice main stem)
Dwight (Antelope Creek)
Abercrombie (Wild Rice main stem)

Figure 2 shows the locations of the six sites. This analysis was done following the guidelines of WRC Bulletin #17B and data obtained from WATSTORE. For those stations currently in use, data was obtained up to Water Year 1984.

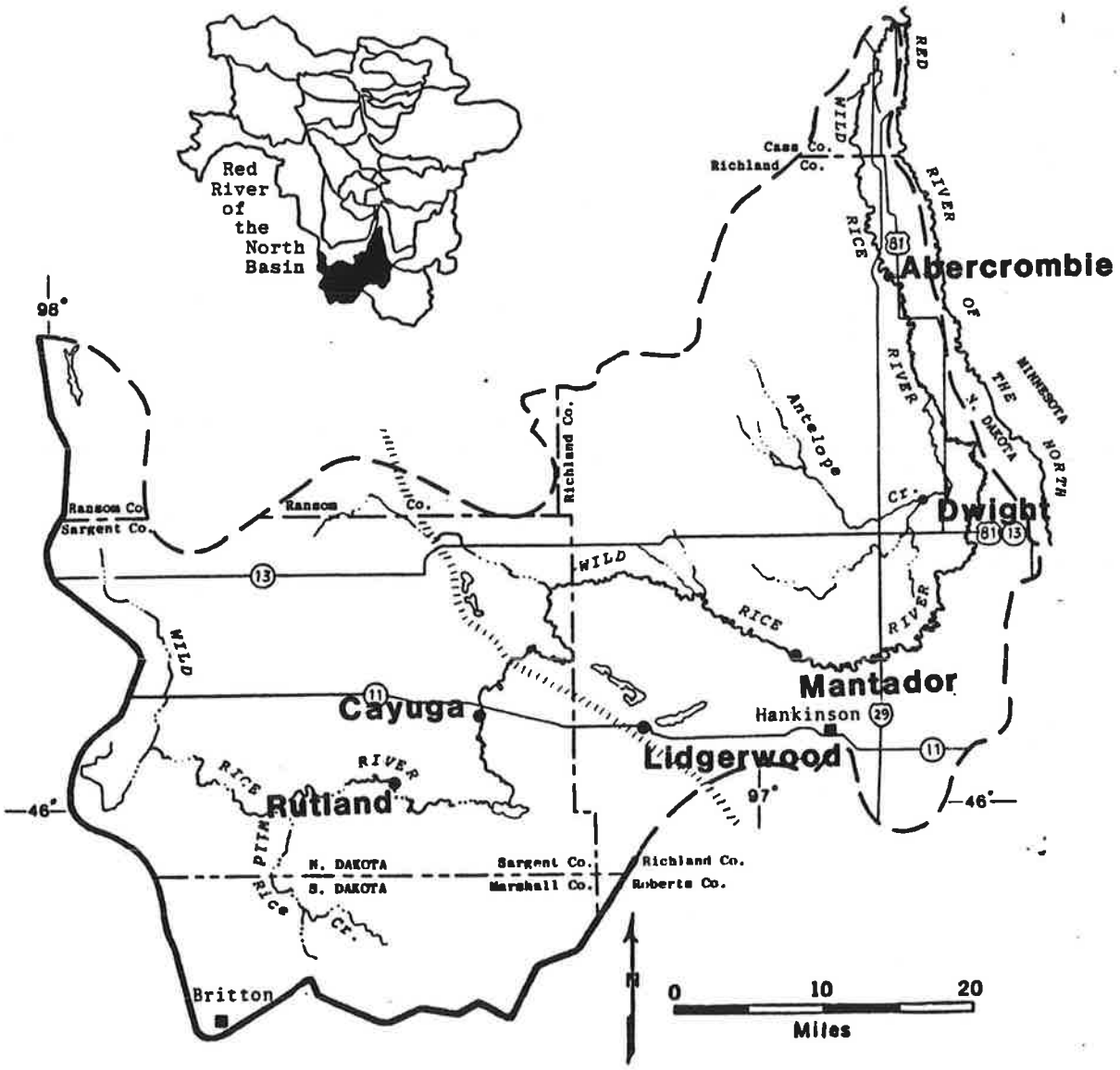


Figure 2

GAGING STATIONS
Wild Rice River

The following methods were used to obtain the adopted frequency curves. The station data from WATSTORE was put into computer program HECWRC to compute the frequency curves. Where possible, historic data was also included. A skew map has recently been developed by the St Paul District. The base data was therefore run both with and without a generalized skew value. In all cases, the adopted frequency curves presented include the generalized skew value. Section C contains tables of the output from the frequency analysis. The adopted frequency values have been labeled and are the last curve data given in each table. These results are summarized in Table 2 below.

TABLE 2. ADOPTED FREQUENCY DATA FOR WILD RICE RIVER, ND.
GENERALIZED SKEW IS -0.2 FOR ALL LOCATIONS

LOCATION	MEAN LOG / STAND. DEVIA.	COMP. SKEW / ADOPTED SKEW	COMPUTED DISCHARGE IN CFS — EXCEEDENCE FREQUENCY IN PERCENT (RETURN PERIOD IN YEARS) 10 (10)	4 (25)	2 (50)	1 (100)	0.2 (500)
WILD RICE RIVER NEAR RUTLAND	1.9821 0.6404	-0.5177 -0.3	602	1080	1560	2130	3930
WILD RICE RIVER NEAR CAYUGA	2.2902 0.4758	0.2041 -0.1	785	1280	1740	2300	4000
GRASS LAKE TRIB NEAR LIDGERWOOD	0.8268 0.5358	-0.6742 -0.3	31	51	69	90	150
WRR TRIB. NEAR MANTADOR	0.7923 0.7279	1.0573 0.1	54	123	212	345	946
WILD RICE RIVER NEAR MANTADOR	2.3922 0.4694	0.2673 0.0	986	1640	2270	3050	5540
ANTELOPE CREEK NEAR DWIGHT	2.5680 0.6697	-0.3847 -0.3	2520	4660	6810	9480	17900
WILD RICE RIVER NEAR ABERCROMBIE	2.9147 0.5596	-0.5767 -0.4	4020	6510	8730	11200	18100

Low outliers were taken into account in determining the adopted frequency curves. All low outliers which were determined by standard methods presented in Bulletin #17B were included in the analysis.

Many of the stations used for the frequency analysis had only a short period of record. A two-station comparison procedure as set forth in Bulletin #17B was therefore looked at as a means of adjusting the logarithmic mean and standard deviation of the short-term records. The long-term station in the basin is located at Abercrombie. After inclusion of a low outlier and historic data to the records at this particular station, the skew was -0.5767. Even with the generalized skew value added to this computation, the adopted skew was only -0.4 (rounded value). Equations for the two station comparison in Bulletin #17B are based on the assumption that there is a skewness of zero. Since this was not the case at Abercrombie, it was determined that it would not be valid to proceed with these computations.

Besides the general work described above, which was done on all stations, additional input was required at the following three stations.

1. Cayuga - It was necessary to add a low outlier to the Cayuga frequency analysis. The difference between the two lowest flows and the next highest flows was such that it required the use of two outliers instead of just one. (See the data presented in Section C, Table C-2 for confirmation of this determination.)

2. Dwight - The frequency analysis on Antelope Creek was adjusted for a high outlier. This was warranted based on the fact that the highest peak of record is 2.4 times greater than the second highest peak. It is also known that this particular peak was the largest since 1943. (See Section C, Table C-6 for actual data on what has been described.)

3. Abercrombie - The 1969 flood at this station is known to be the largest event since 1897. It was considered reasonable to make an

adjustment to account for this fact. This was accomplished by considering the 1969 event as a high outlier. (See Section C, Table C-7.)

METHOD 2 - SYNTHETIC ANALYSIS

In this analysis synthetic hydrographs were developed for the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flood events. These were then routed through the proposed dam site with and without the dam in place.

The synthetic hydrographs were developed using gaged data at Cayuga. After adjusting the volume data for the two low outliers as previously discussed in the frequency analysis, it was then modified by using the Regional Frequency Program from HEC to obtain means and standard deviations corrected for adjacent data. The final step involved the adjustment of this modified volume data to the adopted peak curve. This was accomplished by plotting the means versus standard deviations and the means versus the skews. This data was then used to compute the adopted frequency curves for Cayuga. Table 3 gives the adopted volume frequency curves for Cayuga.

In order to obtain smooth hydrogrph patterns at Cayuga, the adopted volume frequency curves were run through HEC's Balance Hydrograph Program. The 1969 flood event was used as the first pattern hydrograph. Following this first computer run, the resulting 100-year flood was used as the pattern hydrograph. The time interval was changed at this point from a 24-hour value to 3 hours. This allowed the use of a 30-day volume frequency curve with 240 values for the HEC-1 models.

The inflow hydrographs for WR-190 were determined by routing the Cayuga hydrographs to the dam site. For local flows at this point, a ratio of the Cayuga hydrographs was used similar to what was done for the historic event analysis. These two hydrographs were then added together to obtain the total inflow hydrograph at WR-190 for a given event. It should be noted that the inflow peaks at the dam site are not significantly higher than the flows above Cayuga. The reason for this is that the local flow has a chance to run off before the flow from upstream of Cayuga arrives at the Wr-190 site. Section D contains the synthetic inflow hydrographs for

WR-190. Table 4 below, shows the peak inflows and outflows possible for the dam. (The preliminary rating curve discussed in the historic anlysis was also used here.)

TABLE 3, Adopted Volume Frequency Curves - Wild Rice River Near Cayuga

	Peak	1-Day	3-Day	7-Day	15-Day	30-Day	60-Day
MEAN	2.290	2.190	2.102	1.996	1.855	1.706	1.493
STANDARD DEVIATION	0.478	0.503	0.526	0.551	0.587	0.627	0.680
ADOPTED SKEW	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7
COMPUTED FREQUENCY (percent/return period)							
0.2 / 500-YR	4000	3280	2670	2080	1570	1164	779
0.5 / 200-YR	2960	2460	2040	1620	1240	934	635
1 / 100-YR	2300	1930	1620	1300	1010	767	526
2 / 50-YR	1740	1470	1250	1010	791	609	421
4 / 25-YR	1280	1080	925	760	596	462	320
10 / 10-YR	785	665	571	472	371	287	198
20 / 5-YR	493	414	355	293	228	175	119
50 / 2-YR	199	161	134	108	80	59	37

TABLE 4, Existing and Modified Peak Flows at WR-190

EVENT	INFLOW	OUTFLOW
500-YR	4060	2403
200-YR	3235	1086
100-YR	2542	995
50-YR	1937	897
25-YR	1424	788
10-YR	877	616
5-YR	545	461
2-YR	212	199

Wild Rice River, North Dakota

WR-190 DAMSITE ANALYSIS

SECTION A

Table of Contents

1966 FLOWS

FLOOD OF 1966
STARTING DATE OF 1 MARCH
24 HOUR VALUES

WILD RICE RIVER AT WR-190
COMPUTED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	50.	147.	179.	230.	278.	448.	685.	800.	860.
867.	832.	693.	696.	739.	687.	607.	532.	472.	426.
390.	357.	332.	313.	286.	253.	222.	199.	179.	163.
150.	142.	135.	125.	113.	106.	105.	105.	105.	102.
100.	97.	94.	91.	88.	85.	84.	86.	89.	88.
83.									

MODIFIED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	30.	112.	173.	210.	262.	354.	480.	566.	617.
657.	684.	694.	694.	697.	699.	693.	677.	651.	618.
577.	530.	448.	368.	314.	269.	232.	206.	186.	168.
154.	144.	137.	128.	117.	108.	105.	105.	105.	104.
101.	98.	95.	92.	89.	86.	85.	85.	88.	89.
85.									

WILD RICE RIVER AT ABERCROMBIE
COMPUTED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	20.	190.	550.	1090.	1680.	2320.	2800.	2820.	2740.
2600.	2140.	1380.	900.	755.	790.	860.	1030.	1050.	1120.
1140.	1080.	982.	880.	769.	634.	519.	430.	369.	329.
300.	275.	257.	238.	225.	208.	195.	188.	178.	172.
163.	160.	163.	165.	172.	170.	155.	146.	155.	168.
165.									

MODIFIED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	20.	189.	549.	1086.	1673.	2310.	2786.	2800.	2707.
2545.	2052.	1258.	751.	593.	634.	726.	926.	980.	1086.
1143.	1123.	1063.	993.	904.	778.	657.	552.	467.	404.
354.	313.	282.	255.	237.	216.	201.	192.	182.	175.
165.	162.	164.	166.	173.	171.	156.	146.	156.	168.
165.									

WILD RICE RIVER AT MOUTH
COMPUTED

0.	2.	23.	73.	201.	455.	888.	1442.	2035.	2595.
2958.	3043.	2886.	2601.	2131.	1568.	1115.	939.	928.	1027.
1116.	1196.	1221.	1219.	1160.	1057.	940.	813.	685.	567.
475.	409.	363.	330.	305.	282.	264.	246.	231.	217.
206.	198.	190.	185.	183.	183.	185.	187.	184.	177.
169.									

MODIFIED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	2.	23.	73.	201.	454.	887.	1439.	2028.	2585.
2944.	3021.	2849.	2543.	2042.	1449.	971.	783.	777.	896.
1014.	1127.	1187.	1223.	1202.	1135.	1049.	943.	824.	702.
595.	507.	439.	385.	343.	308.	282.	259.	239.	224.
211.	202.	194.	187.	185.	185.	186.	187.	185.	178.
169.									

RED RIVER BELOW MOUTH OF WILD RICE RIVER
COMPUTED

464.	464.	464.	472.	478.	470.	471.	471.	470.	471.
476.	513.	654.	1011.	1755.	3029.	4485.	6361.	7750.	8997.
10095.	9950.	8176.	8091.	7052.	5810.	4705.	4333.	4288.	4588.
4835.	4573.	4011.	3577.	3252.	2902.	2516.	2196.	2080.	1970.
1863.	1769.	1697.	1632.	1563.	1515.	1470.	1420.	1387.	1366.
1395.	1522.	1746.	1934.	2074.	2226.	2419.	2557.	2667.	2662.
2580.									

WILD RICE RIVER AT FARGO
COMPUTED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	2.	23.	73.	201.	455.	888.	1442.	2035.	2595.
2958.	3043.	2886.	2601.	2131.	1568.	1115.	939.	928.	1027.
1116.	1196.	1221.	1219.	1160.	1057.	940.	813.	685.	567.
475.	409.	363.	330.	305.	282.	264.	246.	231.	217.
206.	198.	190.	185.	183.	183.	185.	187.	184.	177.
169.									

MODIFIED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	2.	23.	73.	201.	454.	887.	1439.	2028.	2585.
2944.	3021.	2849.	2543.	2042.	1449.	971.	783.	777.	896.
1014.	1127.	1187.	1223.	1202.	1135.	1049.	943.	824.	702.
595.	507.	439.	385.	343.	308.	282.	259.	239.	224.
211.	202.	194.	187.	185.	185.	186.	187.	185.	178.
169.									

RED RIVER AT FARGO
COMPUTED

464.	464.	464.	480.	490.	470.	471.	471.	470.	471.
476.	520.	654.	1011.	1755.	3100.	4500.	6500.	7800.	9000.
10400.	10600.	8176.	8700.	7800.	6500.	5200.	4800.	4700.	5000.
5300.	5000.	4250.	3700.	3400.	3000.	2550.	2196.	2080.	1970.
1870.	1790.	1720.	1660.	1580.	1530.	1480.	1420.	1387.	1366.
1395.	1530.	1810.	2000.	2100.	2240.	2480.	2610.	2730.	2730.
2630.									

1969 FLOWS

FLOOD OF 1969
STARTING DATE OF 1 APRIL
24 HOUR VALUES

WILD RICE RIVER AT WR-190
COMPUTED

5.	9.	43.	78.	101.	117.	423.	881.	1118.	1389.
1789.	2032.	1996.	1886.	1818.	1741.	1641.	1518.	1372.	1226.
1092.	950.	791.	660.	576.	517.	460.	411.	378.	350.
335.	335.	332.	338.	328.	304.	281.	267.	250.	237.
226.	214.	204.	196.	188.	186.	177.	164.	157.	152.
148.	146.	145.	142.	137.	131.	125.	119.	114.	108.
103.									

MODIFIED

0.	8.	29.	67.	94.	112.	301.	511.	623.	713.
786.	857.	910.	948.	978.	1003.	1024.	1039.	1049.	1056.
1059.	1058.	1053.	1044.	1033.	1020.	1003.	985.	967.	946.
924.	901.	876.	848.	817.	782.	743.	696.	632.	559.
433.	263.	199.	201.	190.	186.	181.	169.	159.	153.
149.	147.	145.	143.	139.	134.	127.	121.	116.	110.
104.									

WILD RICE RIVER AT ABERCROMBIE
COMPUTED

10.	10.	9.	11.	15.	25.	43.	1080.	3980.	7520.
9360.	9250.	8460.	7430.	6310.	5320.	4620.	4040.	3590.	3200.
2880.	2580.	2320.	2090.	1860.	1650.	1440.	1260.	1100.	966.
857.	761.	667.	601.	547.	510.	484.	454.	434.	421.
412.	398.	384.	360.	328.	312.	275.	255.	242.	223.
214.	208.	205.	202.	188.	180.	172.	164.	154.	147.
140.									

MODIFIED

5.	5.	4.	6.	10.	20.	37.	1071.	3963.	7481.
9275.	9088.	8188.	7019.	5746.	4614.	3805.	3166.	2708.	2353.
2102.	1896.	1750.	1646.	1549.	1477.	1403.	1352.	1308.	1274.
1246.	1214.	1167.	1134.	1100.	1069.	1041.	1000.	965.	934.
904.	865.	817.	747.	655.	571.	465.	385.	325.	274.
244.	225.	215.	208.	192.	183.	173.	165.	155.	148.
142.									

WILD RICE RIVER AT MOUTH
COMPUTED

10.	10.	10.	10.	10.	9.	11.	61.	195.	364.
1480.	4375.	7881.	9677.	9519.	8687.	7627.	6483.	5473.	4757.
4163.	3700.	3299.	2969.	2659.	2390.	2151.	1914.	1697.	1481.
1297.	1132.	994.	883.	784.	689.	622.	566.	529.	502.
472.	451.	437.	427.	412.	397.	372.	339.	322.	285.
264.	251.	232.	223.	216.	213.	209.	195.	187.	178.
170.									

MODIFIED

5.	5.	5.	5.	5.	4.	6.	56.	190.	358.
1471.	4358.	7842.	9592.	9357.	8415.	7216.	5919.	4767.	3942.
3289.	2818.	2452.	2191.	1975.	1820.	1707.	1603.	1524.	1444.
1389.	1340.	1302.	1272.	1237.	1189.	1155.	1119.	1088.	1059.
1018.	982.	950.	919.	879.	830.	759.	666.	581.	475.
394.	334.	283.	253.	233.	223.	215.	199.	190.	179.
171.									

RED RIVER BELOW MOUTH OF WILD RICE RIVER
COMPUTED

540.	540.	540.	540.	540.	545.	762.	1886.	3891.	6093.
9461.	14123.	21431.	24492.	23604.	21332.	19554.	17974.	16690.	15209.
13530.	11950.	10864.	9975.	9283.	8740.	8197.	7851.	7358.	6906.
6462.	6067.	5728.	5432.	5136.	4839.	4592.	4345.	4197.	3704.
3555.	3358.	3227.	3137.	3062.	3027.	2952.	2809.	2762.	2745.
2754.	2741.	2702.	2673.	2666.	2663.	2649.	2625.	2597.	2568.
2550.									

WILD RICE RIVER AT FARGO
COMPUTED

10.	10.	10.	10.	10.	9.	11.	61.	195.	364.
1480.	4375.	7881.	9677.	9519.	8687.	7627.	6483.	5473.	4757.
4163.	3700.	3299.	2969.	2659.	2390.	2151.	1914.	1697.	1481.
1297.	1132.	994.	883.	784.	689.	622.	566.	529.	502.
472.	451.	437.	427.	412.	397.	372.	339.	322.	285.
264.	251.	232.	223.	216.	213.	209.	195.	187.	178.
170.									

MODIFIED

5.	5.	5.	5.	5.	4.	6.	56.	190.	358.
1471.	4358.	7842.	9592.	9357.	8415.	7216.	5919.	4767.	3942.
3289.	2818.	2452.	2191.	1975.	1820.	1707.	1603.	1524.	1444.
1389.	1340.	1302.	1272.	1237.	1189.	1155.	1119.	1088.	1059.
1018.	982.	950.	919.	879.	830.	759.	666.	581.	475.
394.	334.	283.	253.	233.	223.	215.	199.	190.	179.
171.									

RED RIVER AT FARGO
COMPUTED

545.	545.	546.	546.	546.	552.	772.	1910.	3940.	6170.
9580.	14300.	21700.	24800.	23900.	21600.	19800.	18200.	16900.	15400.
13700.	12100.	11000.	10100.	9400.	8850.	8300.	7950.	7450.	6993.
6543.	6143.	5800.	5500.	5200.	4900.	4650.	4400.	4250.	3751.
3600.	3400.	3267.	3175.	3099.	3063.	2987.	2844.	2796.	2779.
2788.	2775.	2736.	2707.	2699.	2696.	2682.	2657.	2629.	2599.
2581.									

1975 FLOWS

FLOOD OF 1975
STARTING DATE OF 1 JUNE
24 HOUR VALUES

WILD RICE RIVER AT WR-190
COMPUTED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	1.	4.
7.	9.	8.	6.	6.	5.	4.	2.	38.	159.
395.	399.	268.	177.	115.	73.	46.	30.	21.	15.
12.	11.	12.	15.	16.	16.	15.	13.	12.	9.
8.	7.	7.	7.	6.	5.	5.	3.	3.	2.
2.									

MODIFIED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	2.
6.	9.	9.	7.	6.	5.	4.	3.	24.	113.
306.	377.	343.	221.	131.	87.	54.	35.	24.	17.
13.	11.	12.	14.	16.	16.	15.	14.	12.	10.
9.	8.	7.	7.	6.	6.	5.	4.	3.	2.
2.									

WILD RICE RIVER AT ABERCROMBIE
COMPUTED

45.	40.	34.	33.	30.	25.	21.	19.	17.	16.
14.	11.	9.	8.	11.	12.	14.	16.	81.	614.
1060.	1240.	1230.	1100.	953.	796.	728.	576.	1080.	1510.
2160.	2860.	3130.	3440.	3160.	2740.	2280.	1890.	1630.	1420.
1330.	1220.	1110.	964.	816.	668.	565.	496.	443.	377.
318.	280.	327.	401.	362.	289.	252.	200.	147.	107.
92.									

MODIFIED

45.	40.	34.	33.	30.	25.	21.	19.	17.	16.
14.	11.	9.	8.	11.	12.	14.	16.	81.	614.
1060.	1240.	1230.	1099.	953.	796.	728.	576.	1080.	1510.
2159.	2856.	3120.	3424.	3139.	2721.	2270.	1891.	1639.	1433.
1344.	1232.	1120.	971.	821.	671.	567.	497.	444.	378.
318.	280.	328.	402.	363.	289.	252.	201.	148.	107.
92.									

WILD RICE RIVER AT MOUTH
COMPUTED

61.	57.	53.	51.	50.	51.	42.	36.	44.	44.
41.	37.	33.	38.	34.	37.	44.	39.	76.	412.
659.	766.	1092.	1372.	1457.	1462.	1407.	1280.	1487.	1999.
2369.	3044.	3570.	3979.	4298.	4314.	4371.	3990.	3504.	2954.
2470.	2077.	1776.	1610.	1459.	1328.	1154.	851.	590.	490.
425.	378.	330.	279.	245.	280.	351.	322.	260.	218.
173.									

MODIFIED

61.	57.	53.	51.	50.	51.	42.	36.	44.	44.
41.	37.	33.	38.	34.	37.	44.	39.	76.	412.
659.	766.	1092.	1372.	1457.	1462.	1406.	1280.	1487.	1999.
2369.	3044.	3570.	3978.	4294.	4304.	4355.	3969.	3485.	2944.
2471.	2086.	1789.	1624.	1471.	1338.	1161.	856.	593.	492.
426.	379.	331.	279.	245.	281.	352.	323.	260.	218.
174.									

RED RIVER BELOW MOUTH OF WILD RICE RIVER
COMPUTED

1108.	1092.	1076.	1068.	1053.	1057.	1043.	998.	985.	981.
977.	984.	981.	966.	968.	976.	1008.	1017.	1142.	2417.
3366.	3799.	4045.	4212.	4552.	4687.	4466.	4057.	5151.	7152.
8908.	10051.	10861.	11391.	11752.	11392.	10732.	9825.	8737.	7471.
6258.	5234.	4520.	4042.	3710.	3500.	3227.	2472.	1928.	1806.
1682.	1585.	1508.	1440.	1356.	1328.	1301.	1251.	1170.	1095.
1049.									

WILD RICE RIVER AT FARGO
COMPUTED

61.	57.	53.	51.	50.	51.	42.	36.	44.	44.
41.	37.	33.	38.	34.	37.	44.	39.	76.	412.
659.	766.	1092.	1372.	1457.	1462.	1407.	1280.	1487.	1999.
2369.	3044.	3570.	3979.	4298.	4314.	4371.	3990.	3504.	2954.
2470.	2077.	1776.	1610.	1459.	1328.	1154.	851.	590.	490.
425.	378.	330.	279.	245.	280.	351.	322.	260.	218.
173.									

MODIFIED

61.	57.	53.	51.	50.	51.	42.	36.	44.	44.
41.	37.	33.	38.	34.	37.	44.	39.	76.	412.
659.	766.	1092.	1372.	1457.	1462.	1406.	1280.	1487.	1999.
2369.	3044.	3570.	3978.	4294.	4304.	4355.	3969.	3485.	2944.
2471.	2086.	1789.	1624.	1471.	1338.	1161.	856.	593.	492.
426.	379.	331.	279.	245.	281.	352.	323.	260.	218.
174.									

RED RIVER AT FARGO
COMPUTED

1120.	1100.	1080.	1070.	1060.	1070.	1050.	1000.	1000.	1000.
995.	1000.	995.	986.	986.	1000.	1040.	1040.	1200.	2790.
3970.	4440.	4490.	4500.	4750.	4900.	4750.	4360.	5800.	8350.
10600.	11900.	12800.	13100.	13100.	12500.	11600.	10600.	9450.	8100.
6800.	5650.	4850.	4300.	3930.	3700.	3400.	2500.	1850.	1730.
1610.	1520.	1460.	1400.	1320.	1280.	1250.	1210.	1140.	1060.
1020.									

1978 FLOWS

FLOOD OF 1978
STARTING DATE OF 1 MARCH
24 HOUR VALUES

WILD RICE RIVER AT WR-190
COMPUTED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	3.	33.	311.	472.	339.	319.	336.
300.	237.	190.	227.	414.	528.	560.	566.	543.	508.
465.	463.	466.	461.	439.	391.	360.	223.	134.	157.
197.	252.	271.	268.	250.	248.	271.	267.	244.	219.
191.									

MODIFIED

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	2.	21.	202.	385.	400.	345.	331.
320.	269.	203.	210.	328.	432.	484.	519.	534.	530.
512.	491.	479.	472.	462.	440.	402.	317.	160.	143.
184.	233.	267.	270.	257.	247.	262.	270.	253.	227.
200.									

WILD RICE RIVER AT ABERCROMBIE
COMPUTED

2.	2.	2.	2.	2.	2.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
4.	5.	30.	200.	500.	800.	1300.	2100.	4400.	4850.
4800.	4250.	3200.	2350.	1910.	1930.	1990.	1940.	1870.	1350.
910.	700.	691.	694.	678.	638.	584.	501.	458.	436.
403.	382.	370.	352.	328.	275.	296.	300.	272.	260.
255.									

MODIFIED

2.	2.	2.	2.	2.	2.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
4.	5.	30.	200.	500.	800.	1299.	2095.	4387.	4827.
4770.	4223.	3182.	2344.	1913.	1939.	1998.	1940.	1854.	1316.
863.	649.	647.	665.	667.	641.	596.	518.	479.	462.
436.	421.	409.	384.	349.	285.	298.	299.	270.	258.
255.									

WILD RICE RIVER AT MOUTH
COMPUTED

2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	5.	14.	51.	234.	556.	890.	1488.	2307.
4605.	5031.	4937.	4350.	3282.	2432.	1995.	2013.	2070.	1998.
1909.	1380.	940.	730.	720.	721.	703.	659.	603.	519.
475.	452.	419.	397.	384.	364.	341.	288.	308.	311.
283.									

MODIFIED

2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	5.	14.	51.	234.	556.	890.	1487.	2302.
4592.	5008.	4907.	4323.	3264.	2426.	1998.	2022.	2078.	1998.
1893.	1346.	893.	679.	676.	692.	692.	662.	615.	536.
496.	478.	452.	436.	423.	396.	362.	298.	310.	310.
281.									

RED RIVER BELOW MOUTH OF WILD RICE RIVER
COMPUTED

416.	416.	416.	416.	416.	421.	445.	476.	481.	480.
497.	478.	461.	457.	457.	450.	455.	457.	447.	454.
463.	494.	540.	565.	631.	909.	1636.	3555.	5333.	7407.
9877.	13629.	16292.	16789.	15321.	14319.	13134.	12246.	11246.	10271.
9283.	8098.	7160.	6261.	5748.	5234.	4877.	4374.	3829.	3360.
3013.	2716.	2471.	2328.	2270.	2294.	2391.	2433.	2483.	2491.
2448.									

WILD RICE RIVER AT FARGO
COMPUTED

2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	5.	14.	51.	234.	556.	890.	1488.	2307.
4605.	5031.	4937.	4350.	3282.	2432.	1995.	2013.	2070.	1998.
1909.	1380.	940.	730.	720.	721.	703.	659.	603.	519.
475.	452.	419.	397.	384.	364.	341.	288.	308.	311.
283.									

MODIFIED

2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	5.	14.	51.	234.	556.	890.	1487.	2302.
4592.	5008.	4907.	4323.	3264.	2426.	1998.	2022.	2078.	1998.
1893.	1346.	893.	679.	676.	692.	692.	662.	615.	536.
496.	478.	452.	436.	423.	396.	362.	298.	310.	310.
281.									

RED RIVER AT FARGO
COMPUTED

420.	420.	420.	421.	421.	427.	450.	482.	487.	486.
503.	484.	467.	463.	463.	455.	460.	462.	452.	460.
469.	500.	546.	572.	638.	919.	1655.	3600.	5400.	7500.
10001.	13800.	16500.	17000.	15513.	14499.	13299.	12400.	11387.	10400.
9400.	8200.	7250.	6340.	5820.	5300.	4936.	4425.	3872.	3395.
3044.	2744.	2498.	2356.	2299.	2323.	2420.	2462.	2512.	2519.
2474.									

1979 FLOWS

FLOOD OF 1979
STARTING DATE OF 1 APRIL
24 HOUR VALUES

WILD RICE RIVER AT WR-190
COMPUTED

3.	3.	3.	3.	6.	7.	7.	121.	179.	157.
194.	346.	541.	601.	473.	375.	329.	339.	370.	443.
515.	568.	596.	606.	602.	587.	558.	519.	472.	423.
384.	351.	314.	281.	258.	240.	223.	201.	180.	164.
149.	136.	125.	114.	103.	94.	87.	82.	74.	66.
60.	53.	49.	48.	48.	49.	49.	46.	42.	42.
39.									

MODIFIED

0.	3.	2.	3.	5.	7.	7.	75.	165.	169.
177.	288.	412.	490.	511.	472.	411.	353.	354.	395.
445.	489.	529.	550.	561.	568.	569.	563.	549.	515.
465.	416.	353.	310.	267.	246.	229.	209.	187.	169.
154.	140.	128.	117.	107.	97.	89.	83.	77.	69.
62.	56.	51.	49.	48.	49.	49.	47.	44.	42.
40.									

WILD RICE RIVER AT ABERCROMBIE
COMPUTED

4.	5.	5.	6.	10.	15.	10.	50.	75.	150.
680.	1550.	3060.	5000.	5900.	5800.	5590.	4790.	4400.	3740.
3220.	2760.	2370.	1950.	1590.	1280.	1090.	996.	945.	902.
860.	819.	760.	703.	649.	642.	600.	546.	509.	484.
455.	422.	388.	362.	330.	312.	295.	265.	238.	211.
186.	169.	158.	148.	134.	124.	109.	97.	91.	83.
71.									

MODIFIED

1.	2.	2.	3.	7.	13.	8.	49.	74.	148.
675.	1542.	3049.	4986.	5879.	5769.	5549.	4748.	4367.	3725.
3222.	2771.	2378.	1947.	1572.	1247.	1046.	947.	899.	864.
838.	816.	777.	738.	698.	697.	654.	594.	549.	515.
477.	438.	400.	372.	338.	319.	301.	270.	242.	215.
189.	172.	161.	150.	136.	126.	111.	98.	92.	84.
72.									

WILD RICE RIVER AT MOUTH
COMPUTED

4.	4.	4.	5.	6.	9.	11.	23.	41.	77.
268.	680.	1491.	2787.	4130.	5188.	5811.	5725.	5333.	4790.
4175.	3648.	3123.	2658.	2235.	1852.	1524.	1282.	1118.	1022.
963.	917.	867.	816.	761.	716.	674.	632.	596.	556.
518.	486.	454.	422.	390.	361.	338.	312.	288.	261.
233.	209.	188.	171.	158.	146.	134.	120.	109.	99.
92.									

MODIFIED

1.	1.	2.	2.	4.	6.	9.	21.	39.	76.
266.	676.	1485.	2777.	4116.	5169.	5785.	5691.	5296.	4757.
4153.	3640.	3125.	2663.	2235.	1841.	1499.	1246.	1075.	978.
924.	889.	856.	822.	785.	756.	723.	684.	646.	599.
553.	513.	475.	437.	401.	370.	345.	318.	293.	266.
237.	212.	191.	174.	161.	148.	136.	122.	111.	100.
93.									

RED RIVER BELOW MOUTH OF WILD RICE RIVER
COMPUTED

624.	624.	625.	662.	850.	1189.	1480.	1601.	1580.	1590.
1730.	2470.	3881.	6147.	8580.	11019.	13601.	16300.	17001.	16600.
15699.	14500.	13100.	12001.	10400.	8801.	6819.	5341.	4400.	3861.
3481.	3251.	3140.	3100.	3101.	3110.	3111.	3120.	3051.	2881.
2750.	2630.	2540.	2482.	2435.	2391.	2343.	2289.	2240.	2201.
2173.	2144.	2118.	2099.	2083.	2066.	2054.	2038.	2024.	2012.
2002.									

WILD RICE RIVER AT FARGO
COMPUTED

4.	4.	4.	5.	6.	9.	11.	23.	41.	77.
268.	680.	1491.	2787.	4130.	5188.	5811.	5725.	5333.	4790.
4175.	3648.	3123.	2658.	2235.	1852.	1524.	1282.	1118.	1022.
963.	917.	867.	816.	761.	716.	674.	632.	596.	556.
518.	486.	454.	422.	390.	361.	338.	312.	288.	261.
233.	209.	188.	171.	158.	146.	134.	120.	109.	99.
92.									

MODIFIED

1.	1.	2.	2.	4.	6.	9.	21.	39.	76.
266.	676.	1485.	2777.	4116.	5169.	5785.	5691.	5296.	4757.
4153.	3640.	3125.	2663.	2235.	1841.	1499.	1246.	1075.	978.
924.	889.	856.	822.	785.	756.	723.	684.	646.	599.
553.	513.	475.	437.	401.	370.	345.	318.	293.	266.
237.	212.	191.	174.	161.	148.	136.	122.	111.	100.
93.									

RED RIVER AT FARGO
COMPUTED

631.	631.	632.	670.	860.	1199.	1500.	1621.	1600.	1610.
1750.	2500.	3931.	6217.	8670.	11119.	13801.	16500.	17200.	16800.
15899.	14700.	13300.	12101.	10500.	8901.	6899.	5401.	4450.	3901.
3521.	3291.	3180.	3140.	3141.	3150.	3151.	3160.	3091.	2911.
2780.	2660.	2570.	2512.	2435.	2391.	2343.	2289.	2240.	2201.
2173.	2144.	2118.	2099.	2083.	2066.	2054.	2038.	2024.	2012.
2002.									

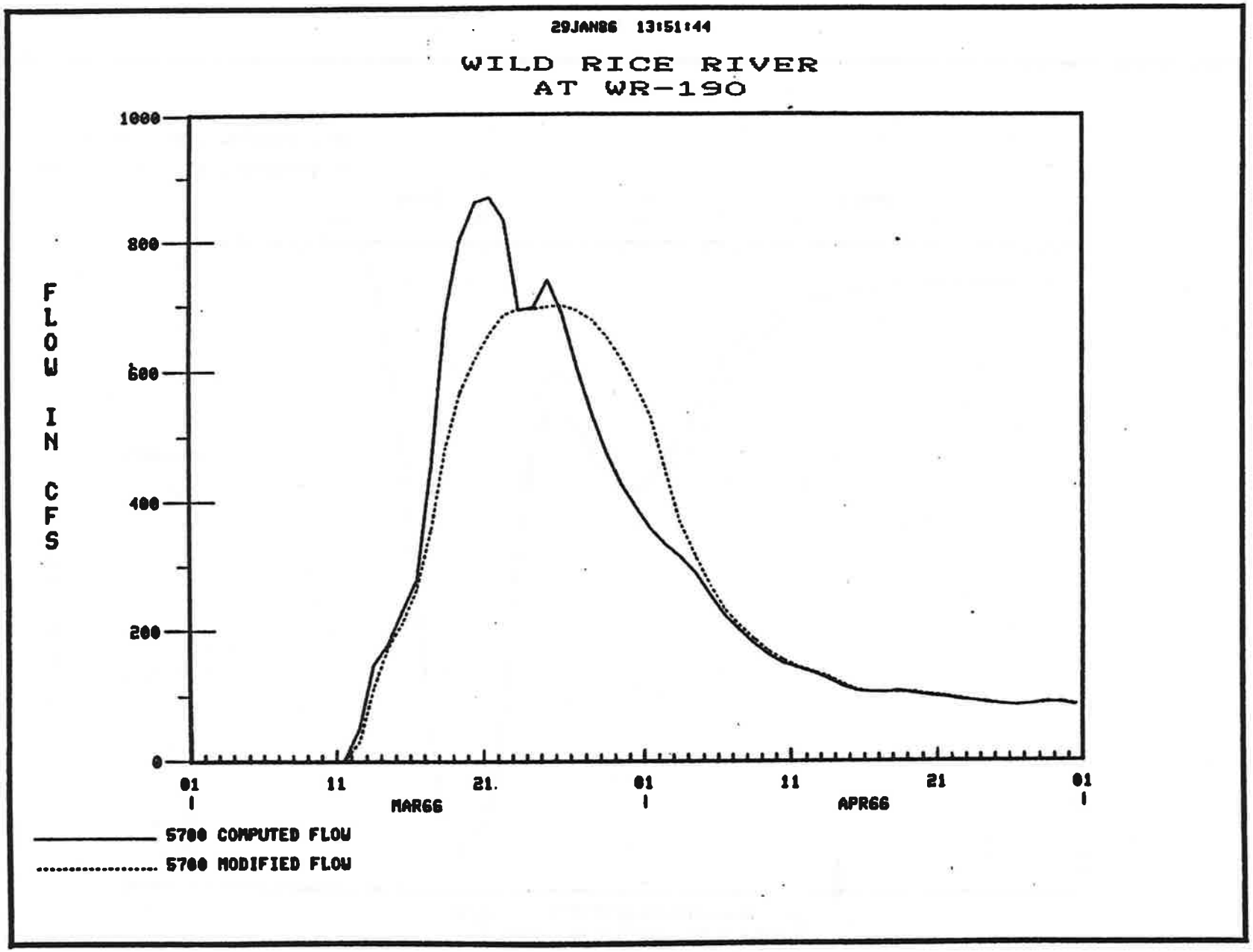
Wild Rice River, North Dakota

WR-190 DAMSITE ANALYSIS

SECTION B

Table of Contents

1966 FLOWS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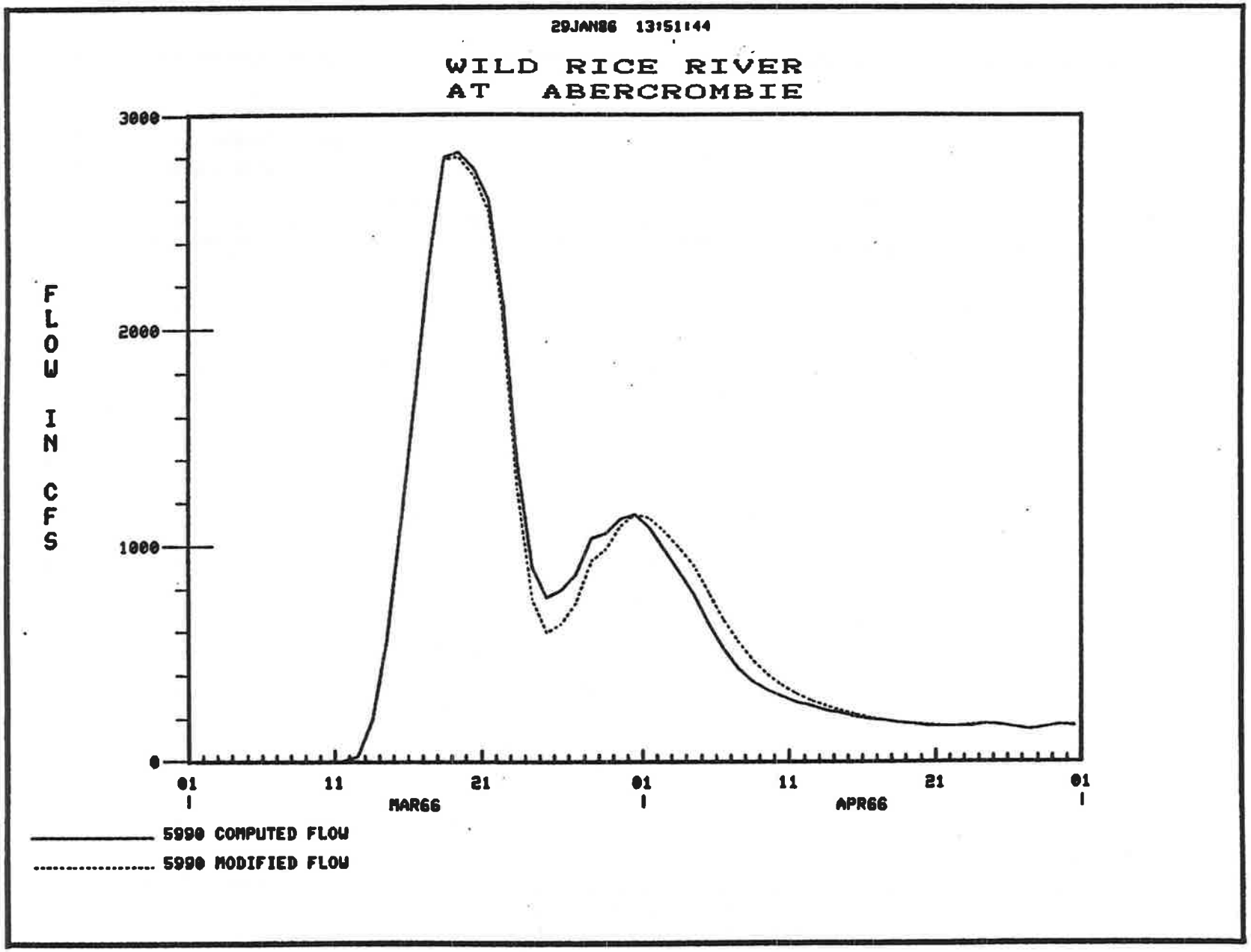
WILD RICE RIVER
AT WR-190
FLOW IN CFS
1000
800
600
400
200
0
01
11
21.
01
11
21
01
MAR86
APR86
5700 COMPUTED FLOW
5700 MODIFIED FLOW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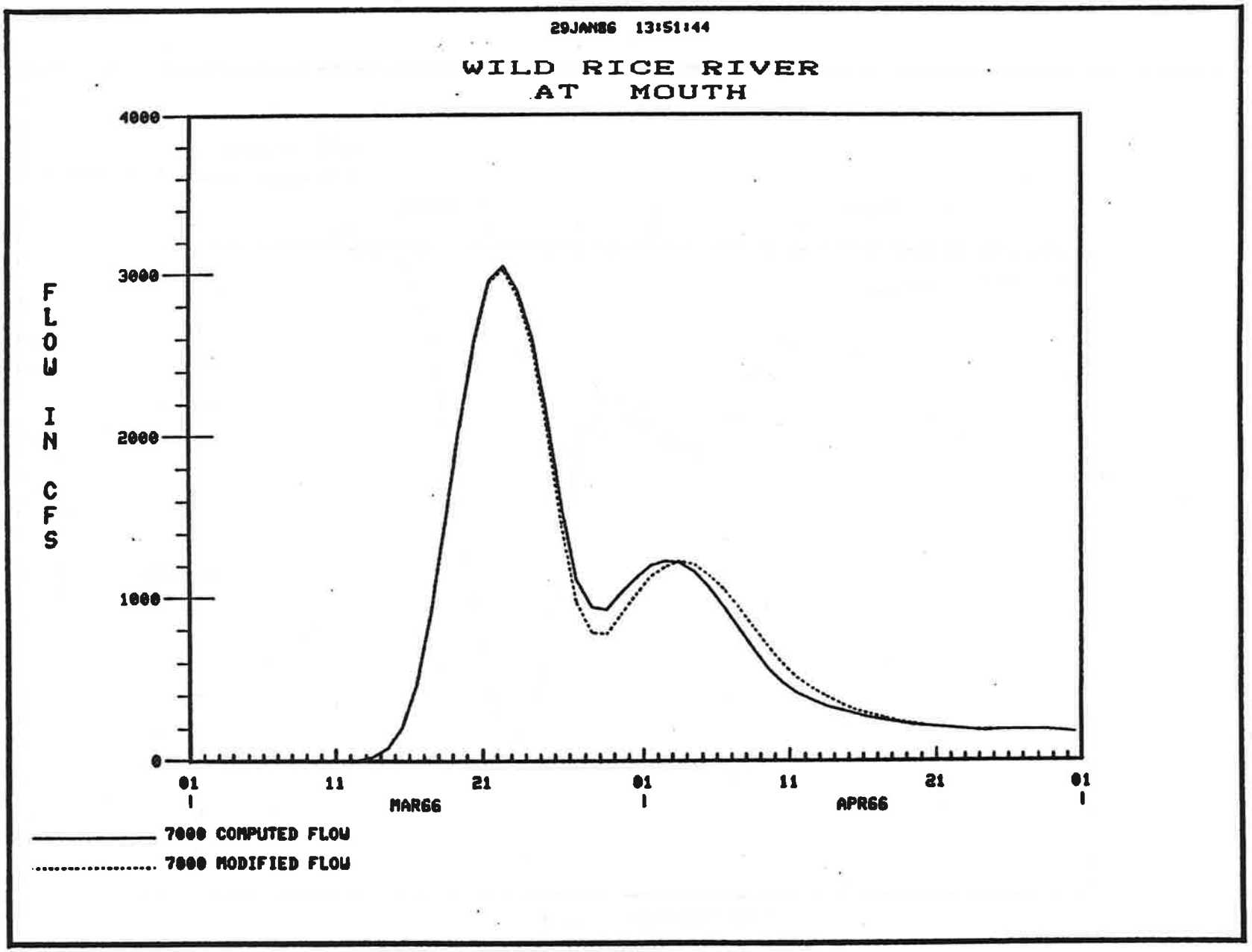
WILD RICE RIVER
AT ABERCROMBIE
FLOW IN CFS
3000
2000
1000
0
01
11
21
01
11
21
01
MAR66
APR66
5990 COMPUTED FLOW
5990 MODIFIED FLOW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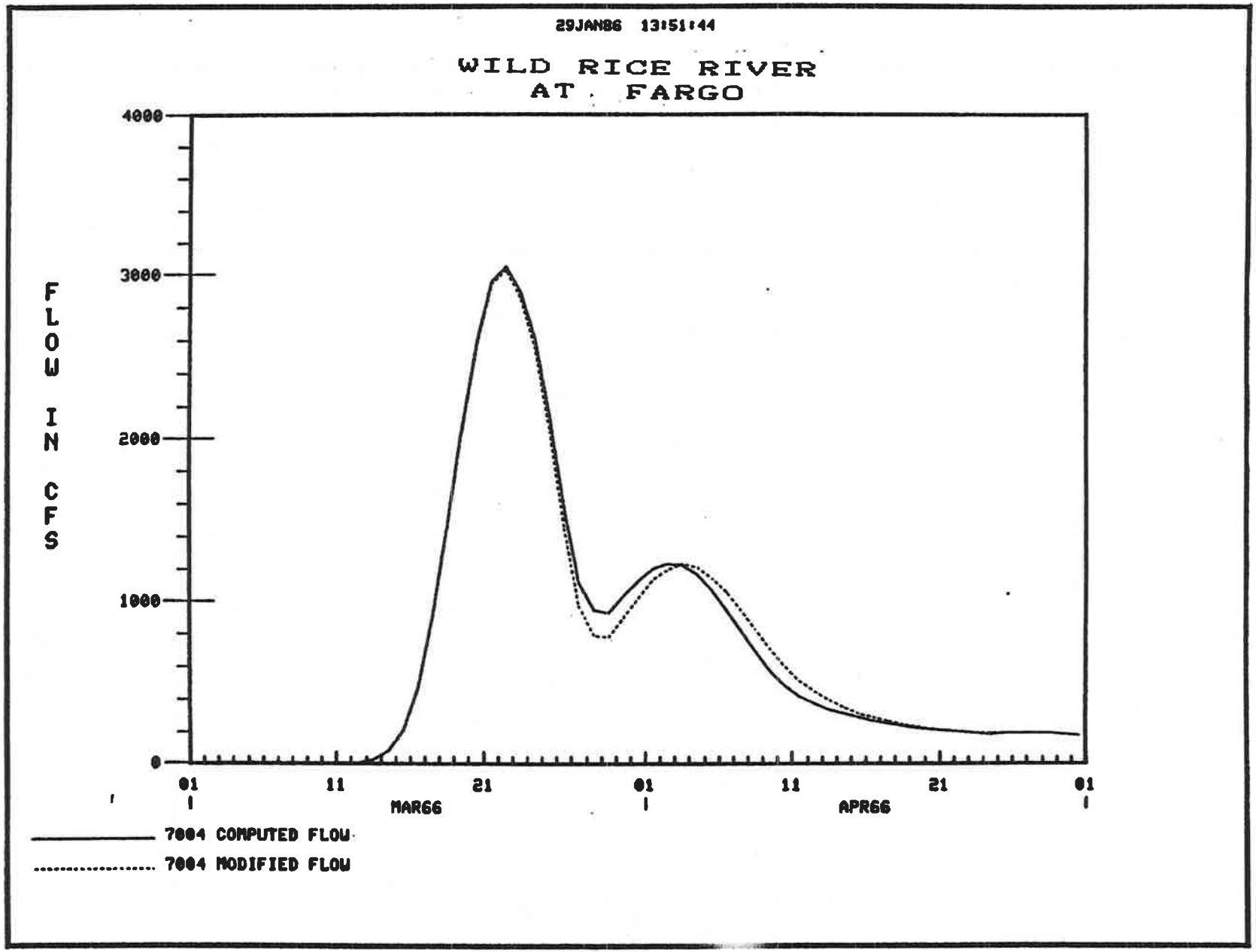
WILD RICE RIVER
AT MOUTH
FLOW IN CFS
4000
3000
2000
1000
0
01
11
21
01
11
21
01
MAR86
APR86
7000 COMPUTED FLOW
7000 MODIFIED FLOW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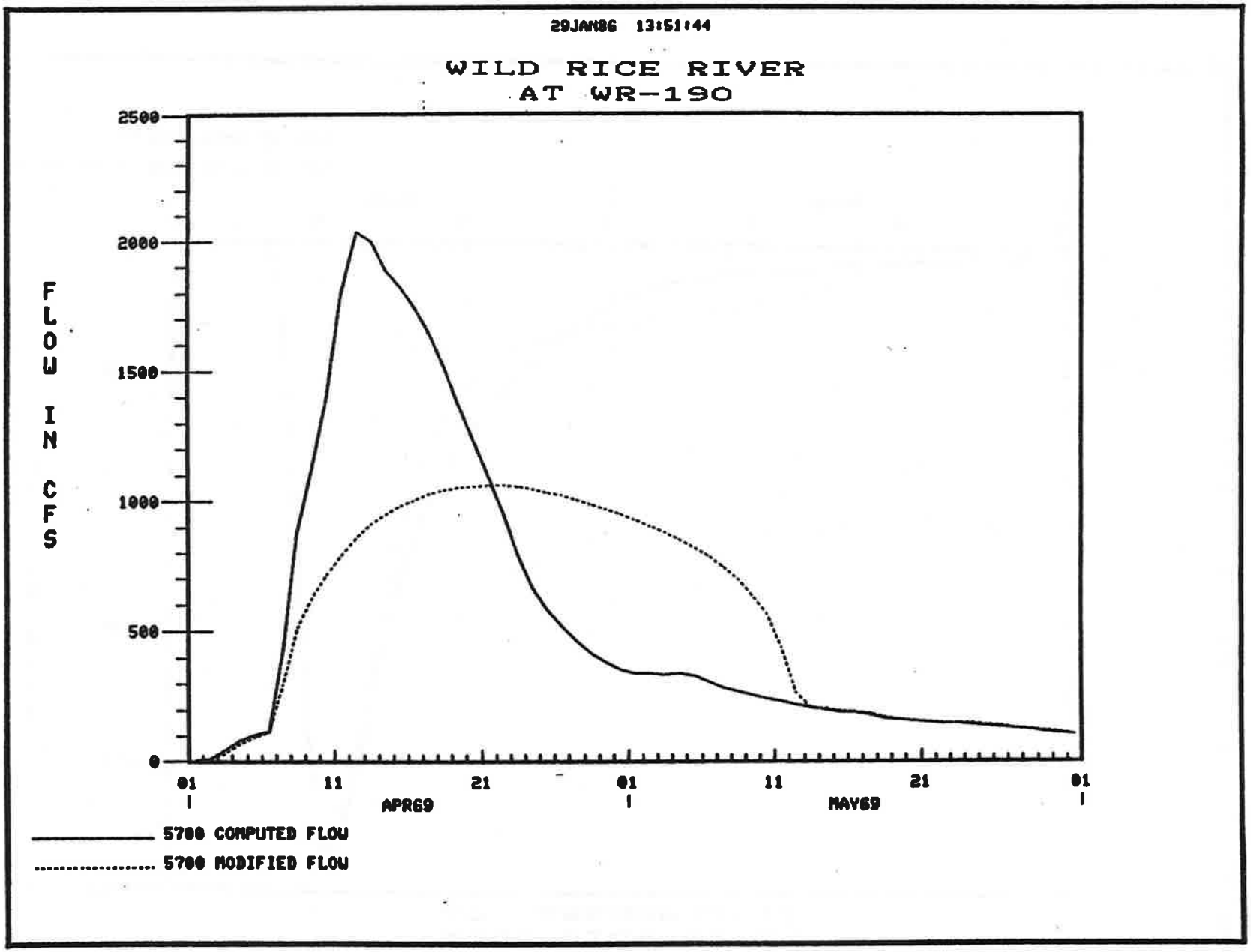
WILD RICE RIVER
AT FARGO
FLOW IN CFS
4000
3000
2000
1000
0
01
11
21
01
11
21
01
MAR66
APR66
7004 COMPUTED FLOW
7004 MODIFIED FLOW

1969 FLOWS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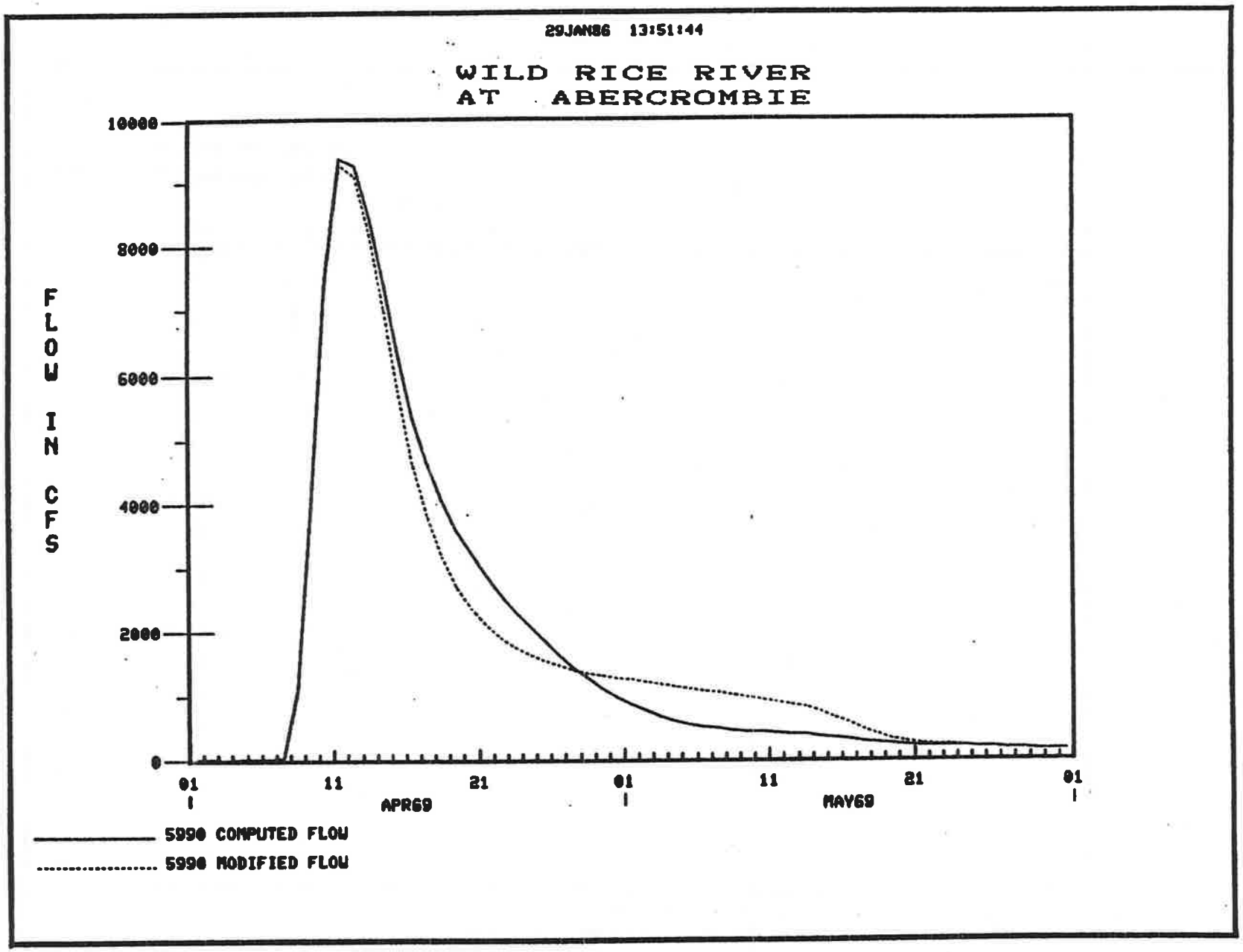
WILD RICE RIVER
AT WR-190
FLOW IN CFS
2500
2000
1500
1000
500
0
01
11
21
01
11
21
01
APR69
MAY69
5700 COMPUTED FLOW
5700 MODIFIED FLOW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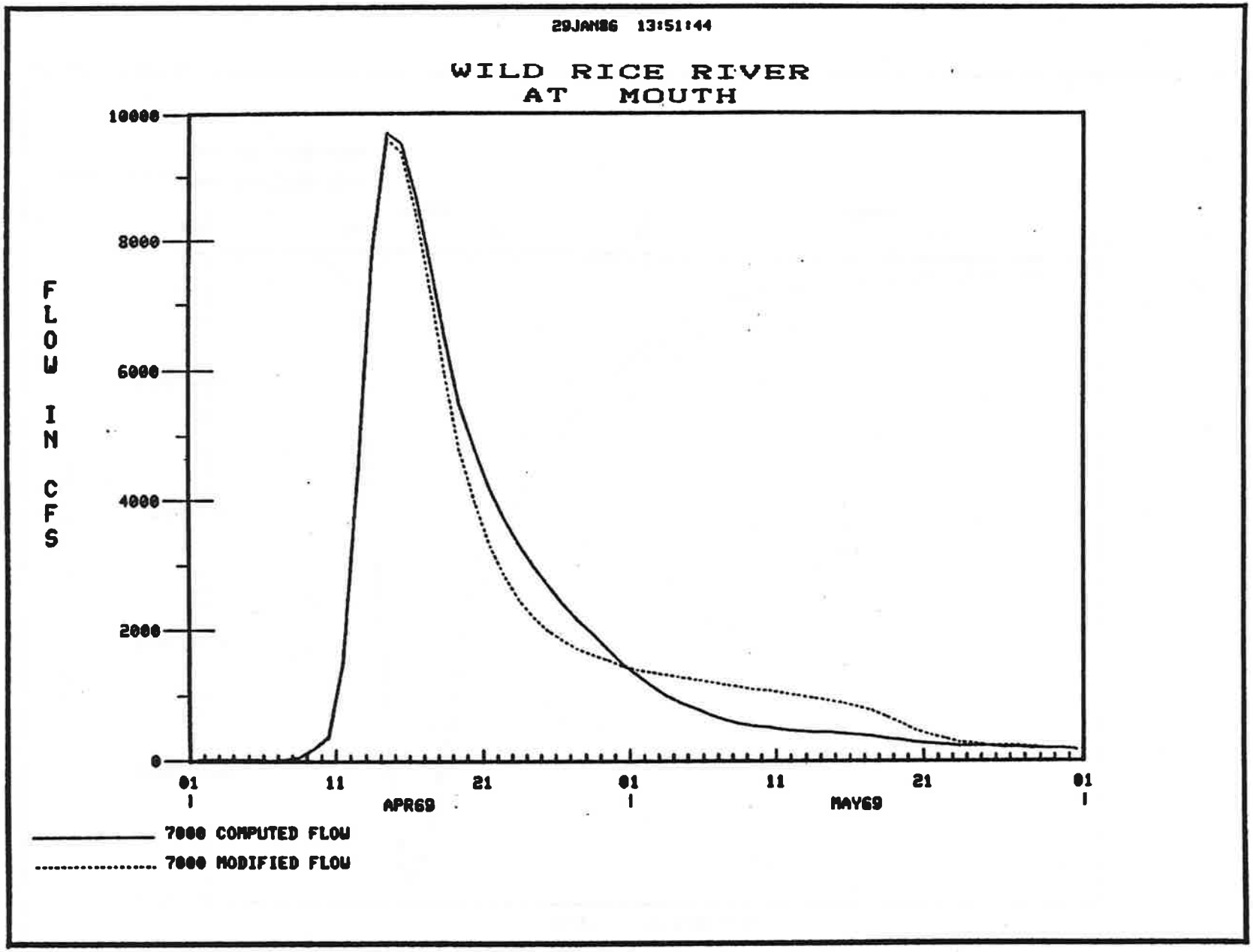
WILD RICE RIVER
AT ABERCROMBIE
FLOW IN CFS
10000
8000
6000
4000
2000
0
01
11
21
01
11
21
01
APR69
MAY69
5990 COMPUTED FLOW
5990 MODIFIED FLOW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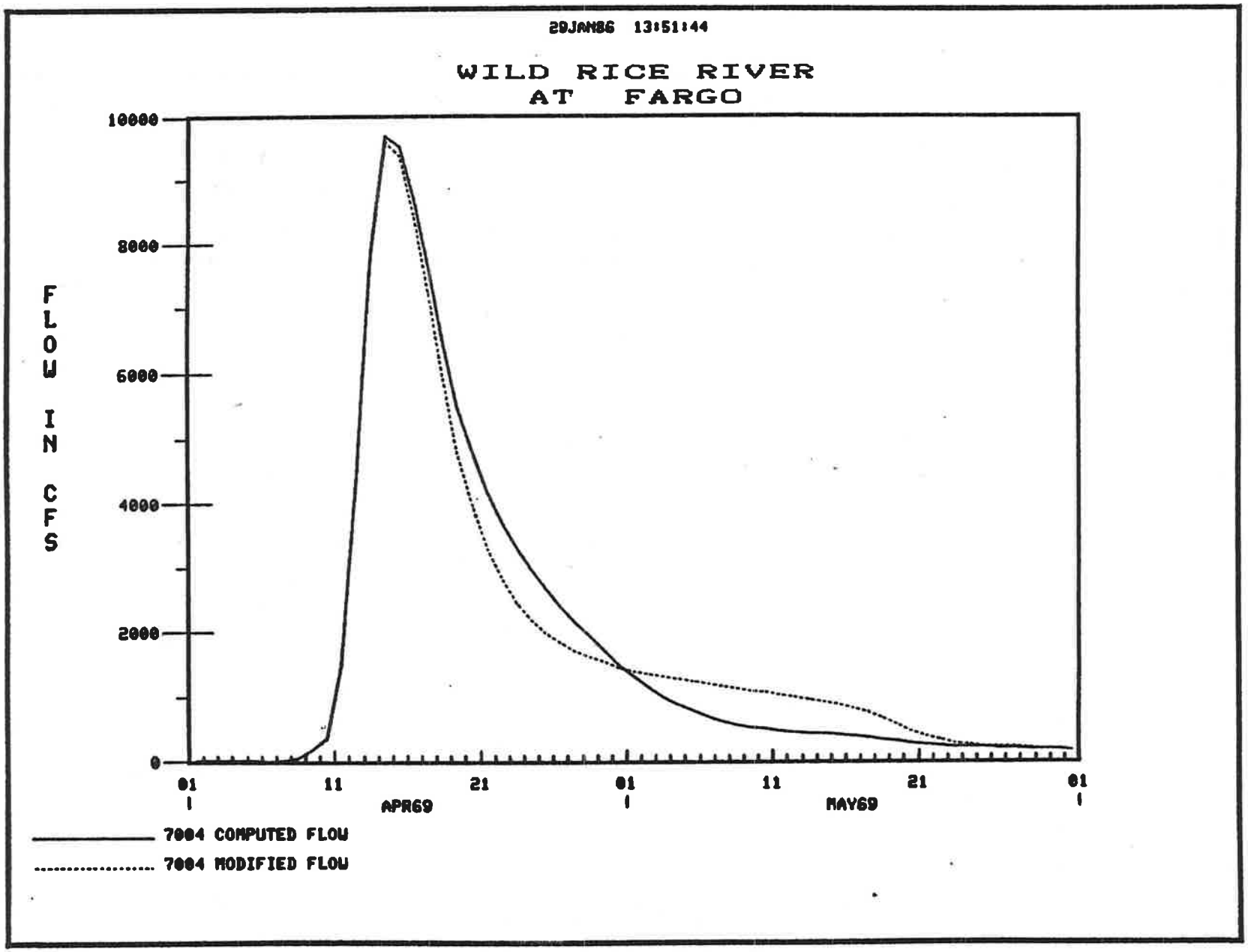
WILD RICE RIVER
AT MOUTH
10000
8000
6000
4000
2000
0
FLOW IN CFS
01
11
21
01
11
21
01
APR69
MAY69
7000 COMPUTED FLOW
7000 MODIFIED FLOW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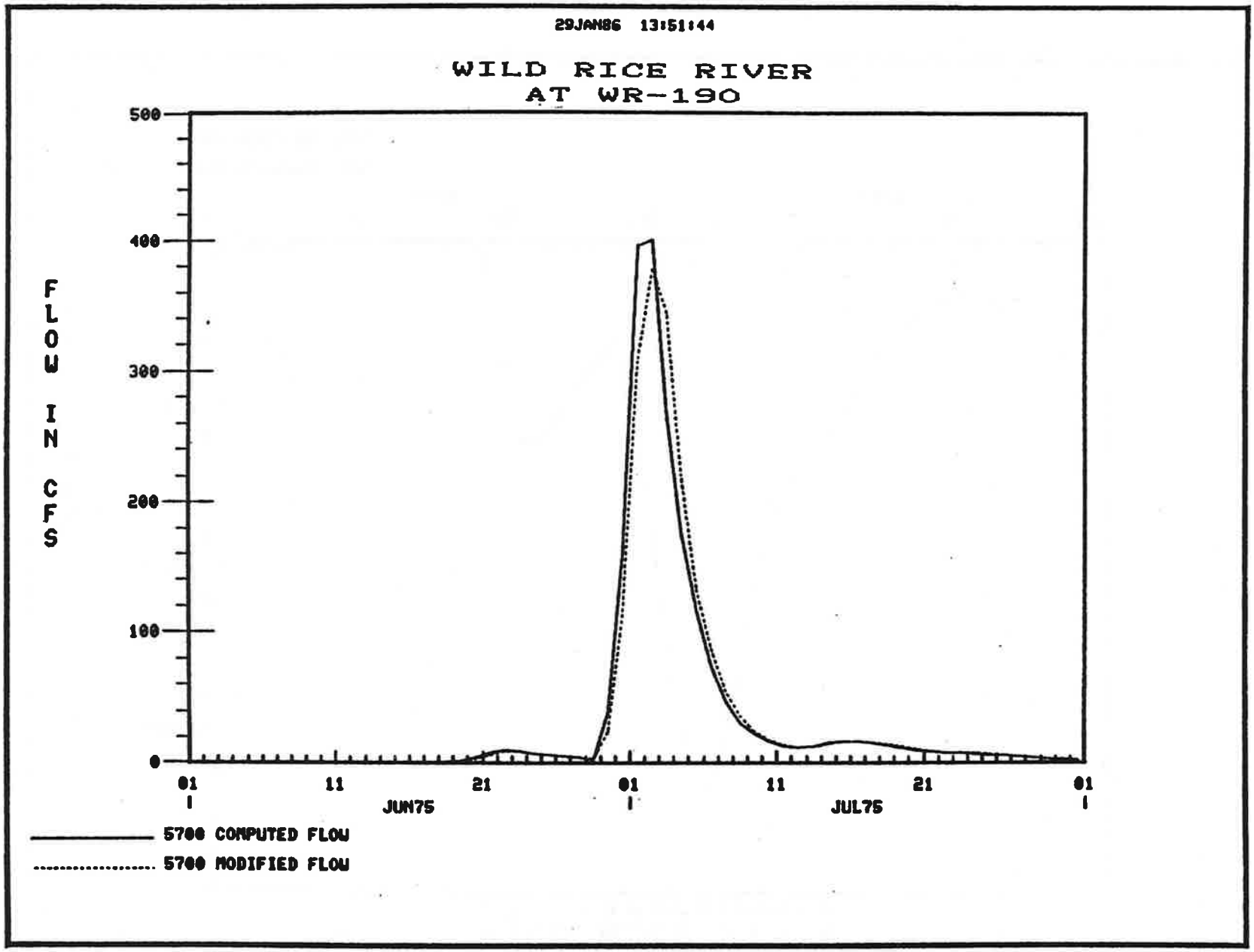
WILD RICE RIVER
AT FARGO
FLOW IN CFS
10000
8000
6000
4000
2000
0
01
11
21
01
11
21
01
APR69
MAY69
7004 COMPUTED FLOW
7004 MODIFIED FLOW

1975 FLOWS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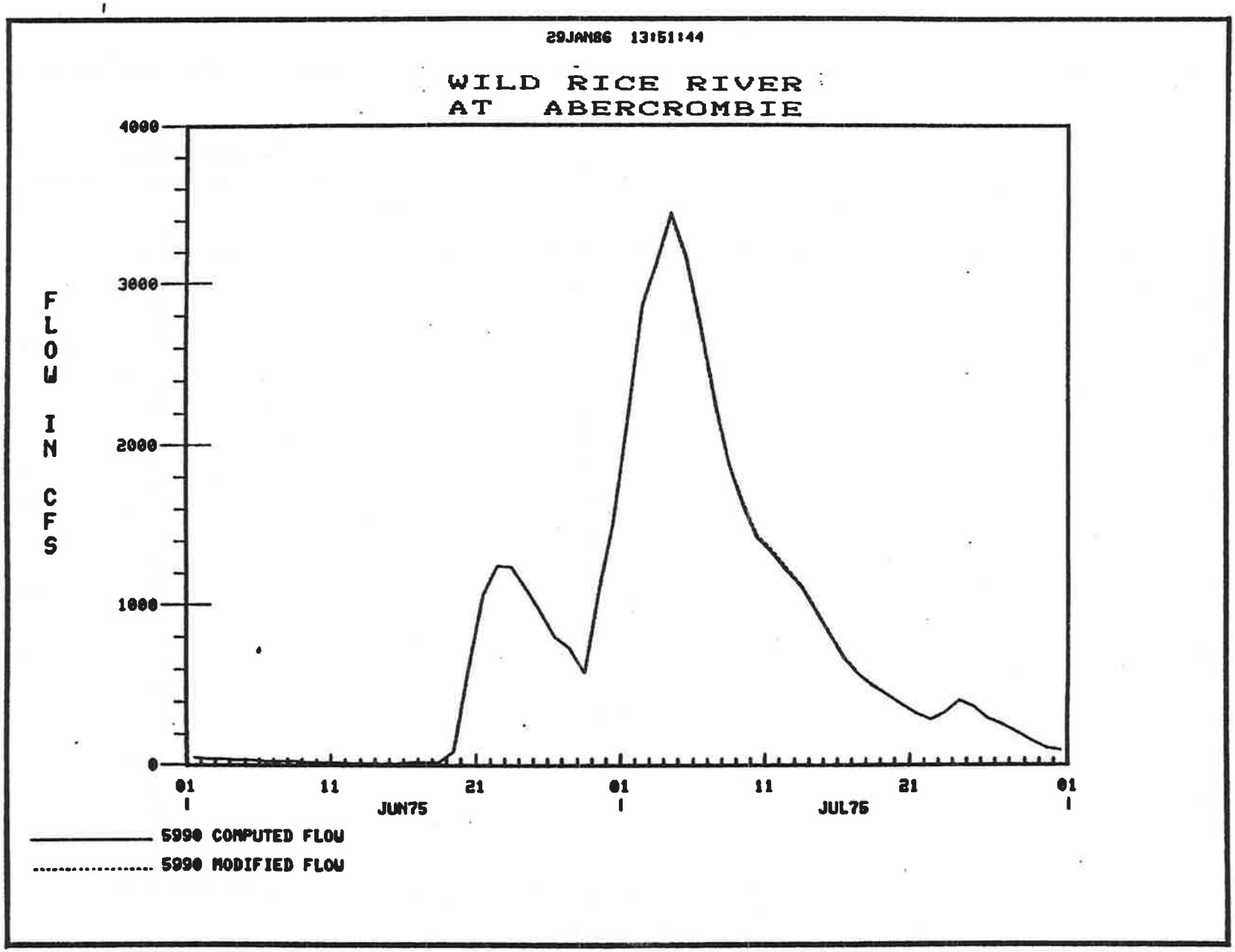
WILD RICE RIVER
AT WR-190
FLOW IN CFS
500
400
300
200
100
0
01
11
21
01
11
21
01
JUN75
JUL75
5700 COMPUTED FLOW
5700 MODIFIED FLOW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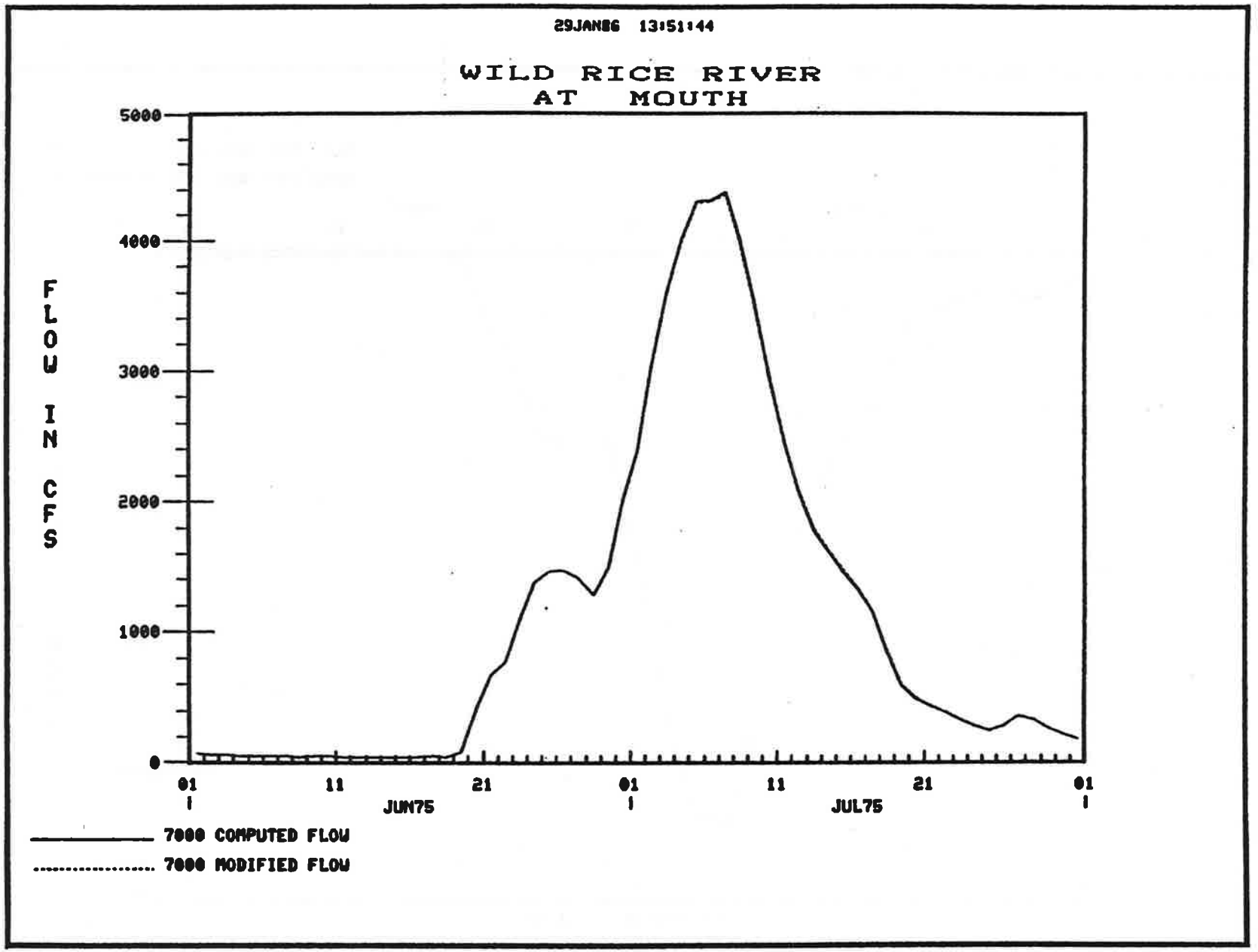
WILD RICE RIVER
AT ABERCROMBIE
FLOW IN CFS
4000
3000
2000
1000
0
01
11
21
01
11
21
01
JUN75
JUL75
5990 COMPUTED FLOW
5990 MODIFIED FLOW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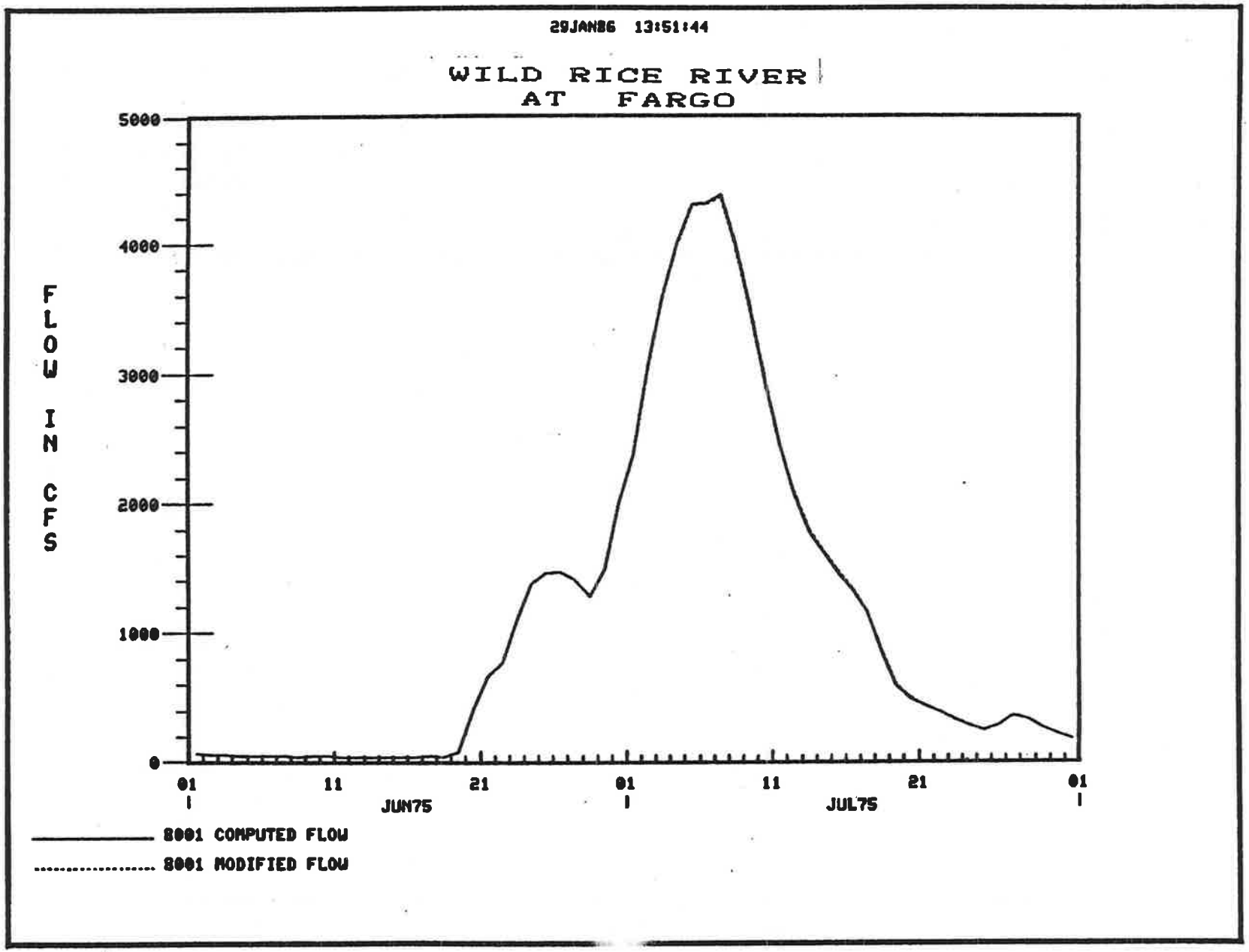
WILD RICE RIVER
AT MOUTH
5000
4000
3000
2000
1000
0
FLOW IN CFS
01
11
21
01
11
21
01
JUN75
JUL75
7000 COMPUTED FLOW
7000 MODIFIED FLOW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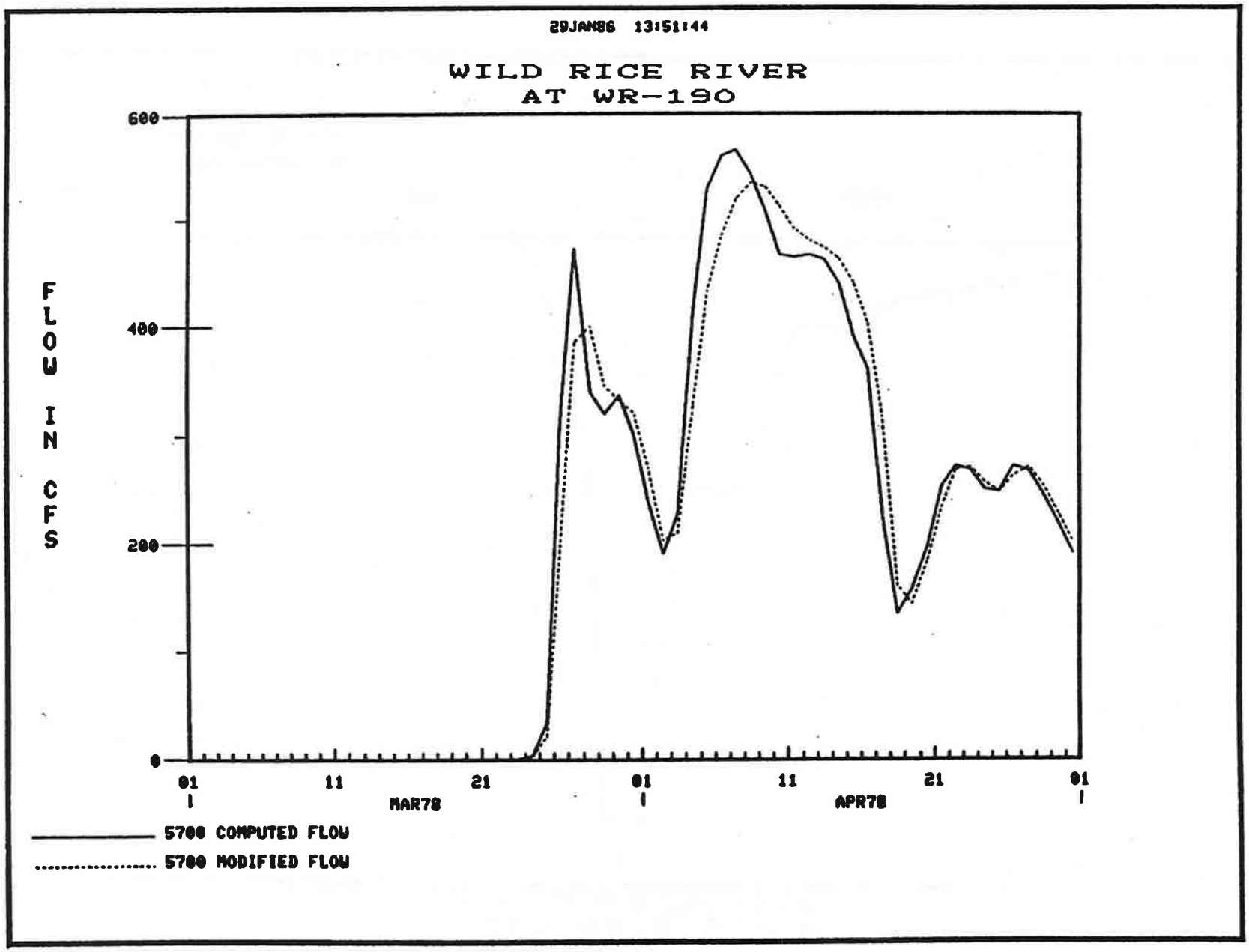
WILD RICE RIVER
AT FARGO
FLOW IN CFS
5000
4000
3000
2000
1000
0
01
11
21
01
11
21
01
JUN75
JUL75
8001 COMPUTED FLOW
8001 MODIFIED FLOW

1978 FLOWS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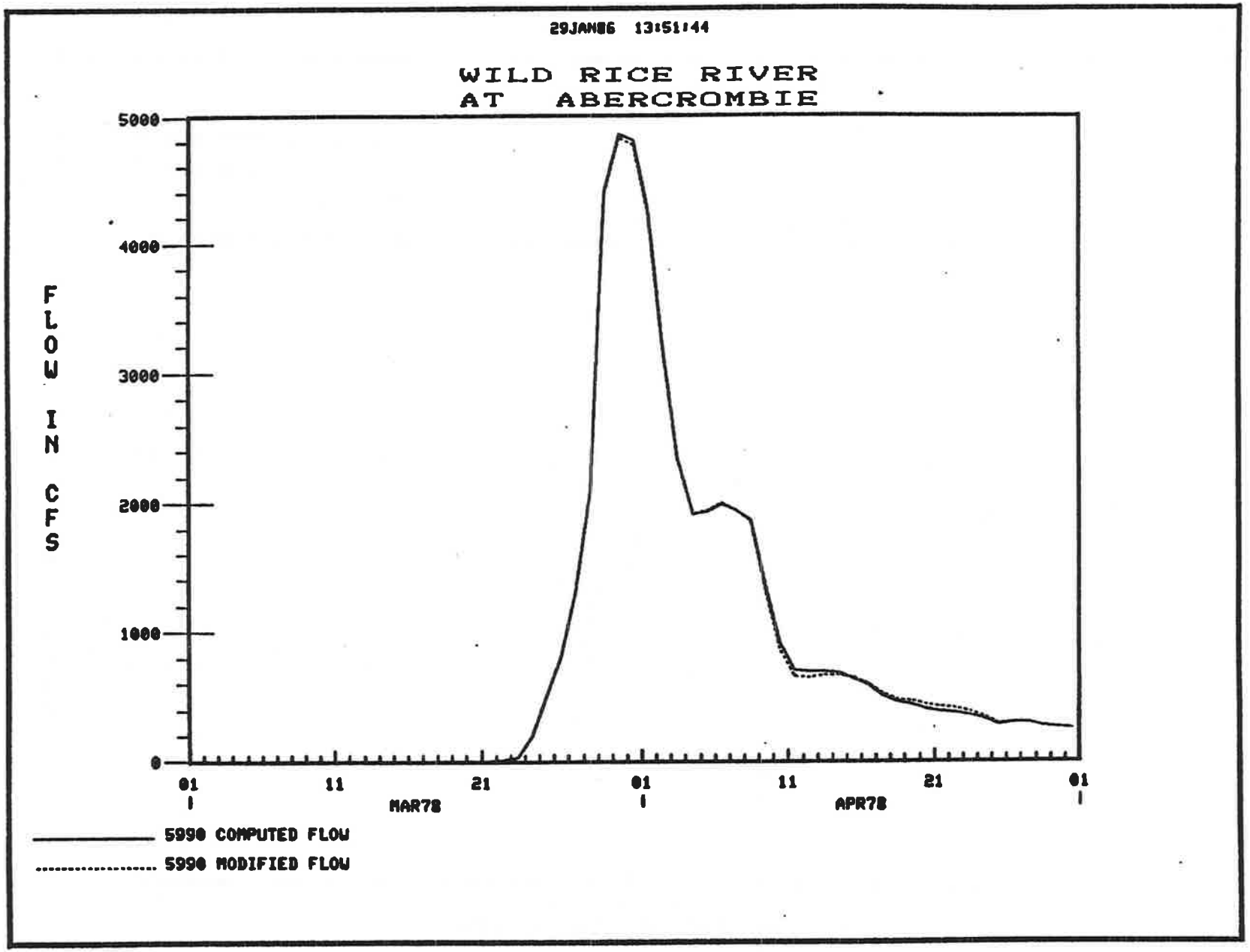
AT WR-190
600
400
200
0
FLOW IN CFS
01
11
21
01
11
21
01
MAR78
APR78
5700 COMPUTED FLOW
5700 MODIFIED FLOW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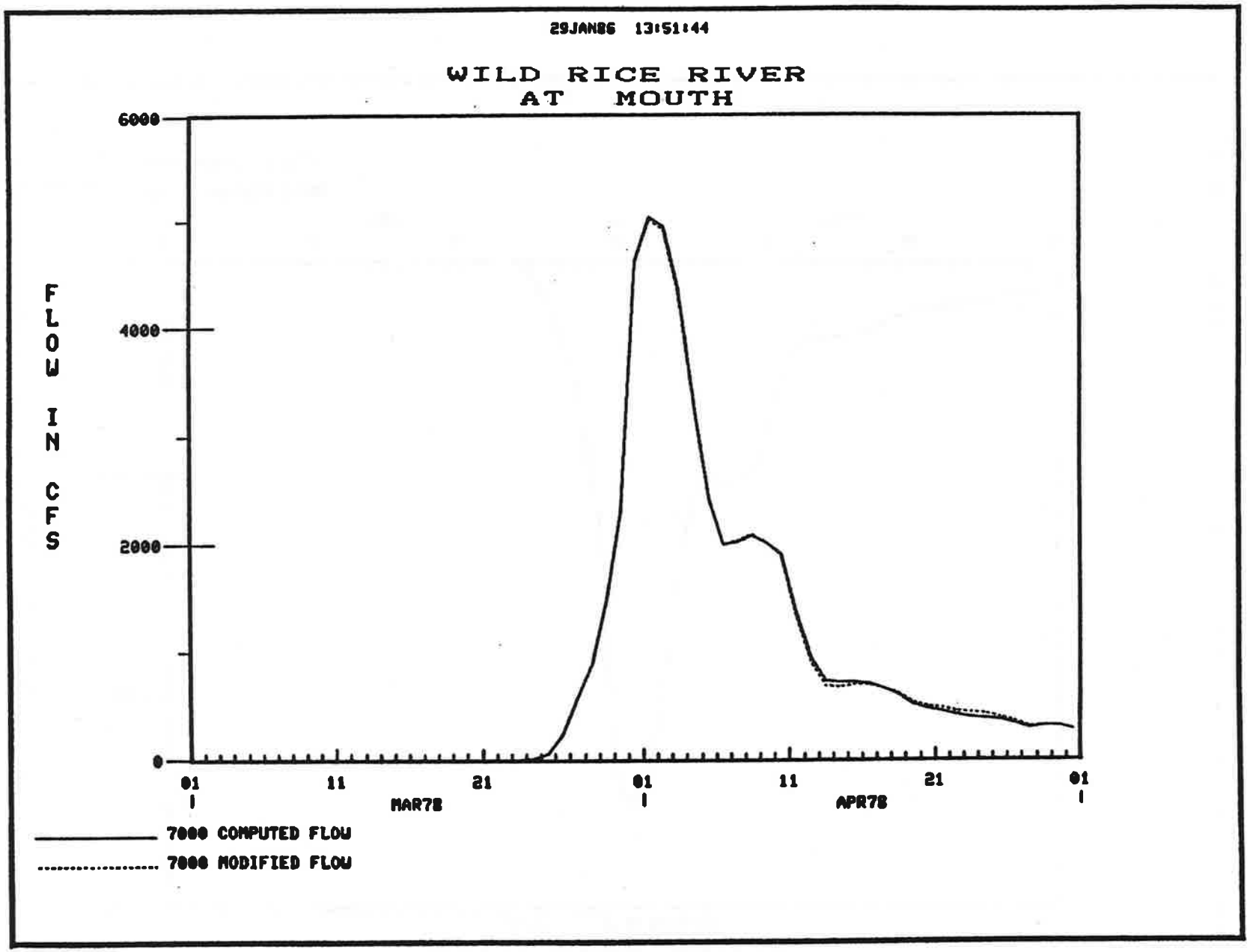
WILD RICE RIVER
AT ABERCROMBIE
FLOW IN CFS
5000
4000
3000
2000
1000
0
01
11
21
01
11
21
01
MAR78
APR78
5990 COMPUTED FLOW
5990 MODIFIED FLOW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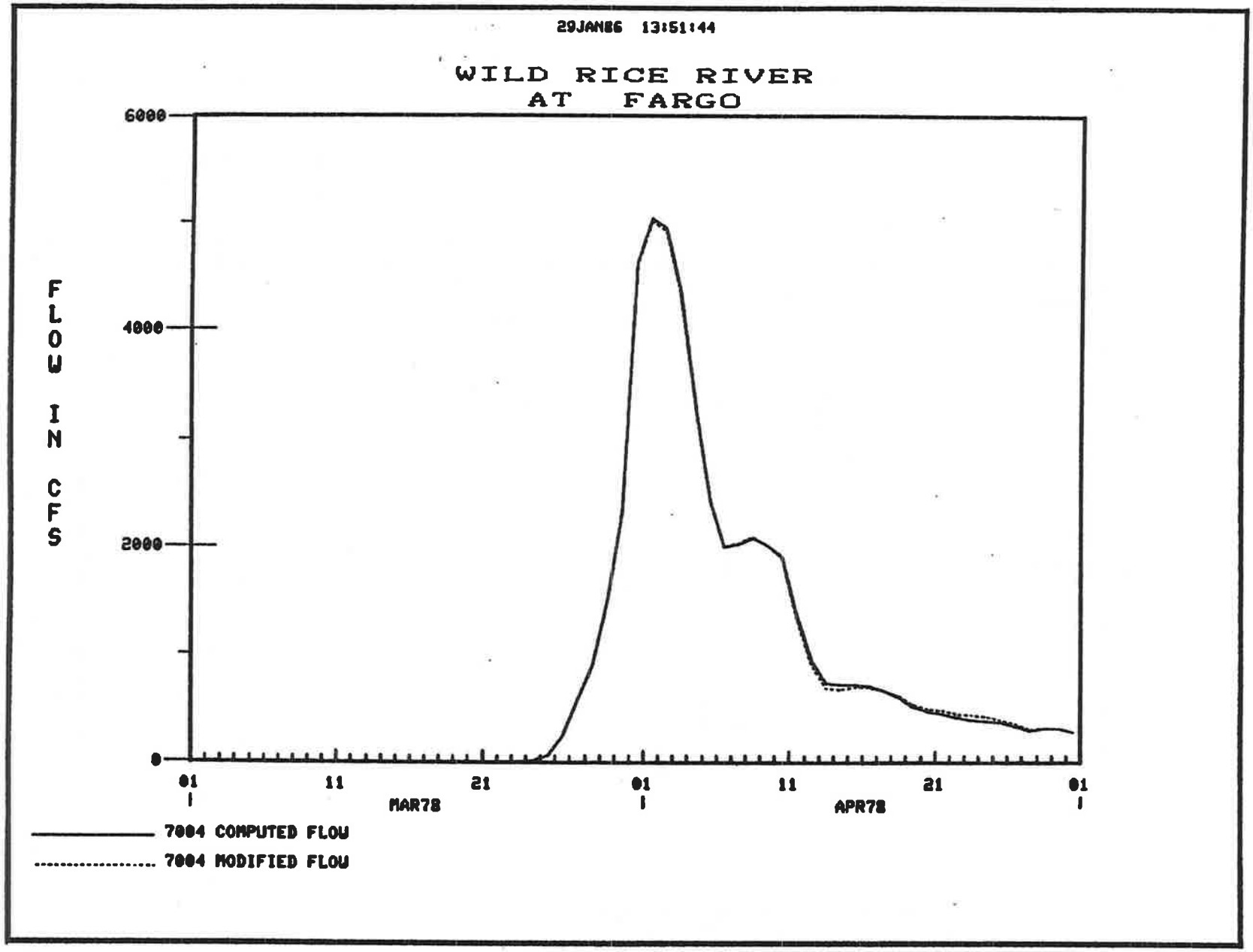
WILD RICE RIVER
AT MOUTH
FLOW IN CFS
6000
4000
2000
0
01
11
21
01
11
21
01
MAR78
APR78
7000 COMPUTED FLOW
7000 MODIFIED FLOW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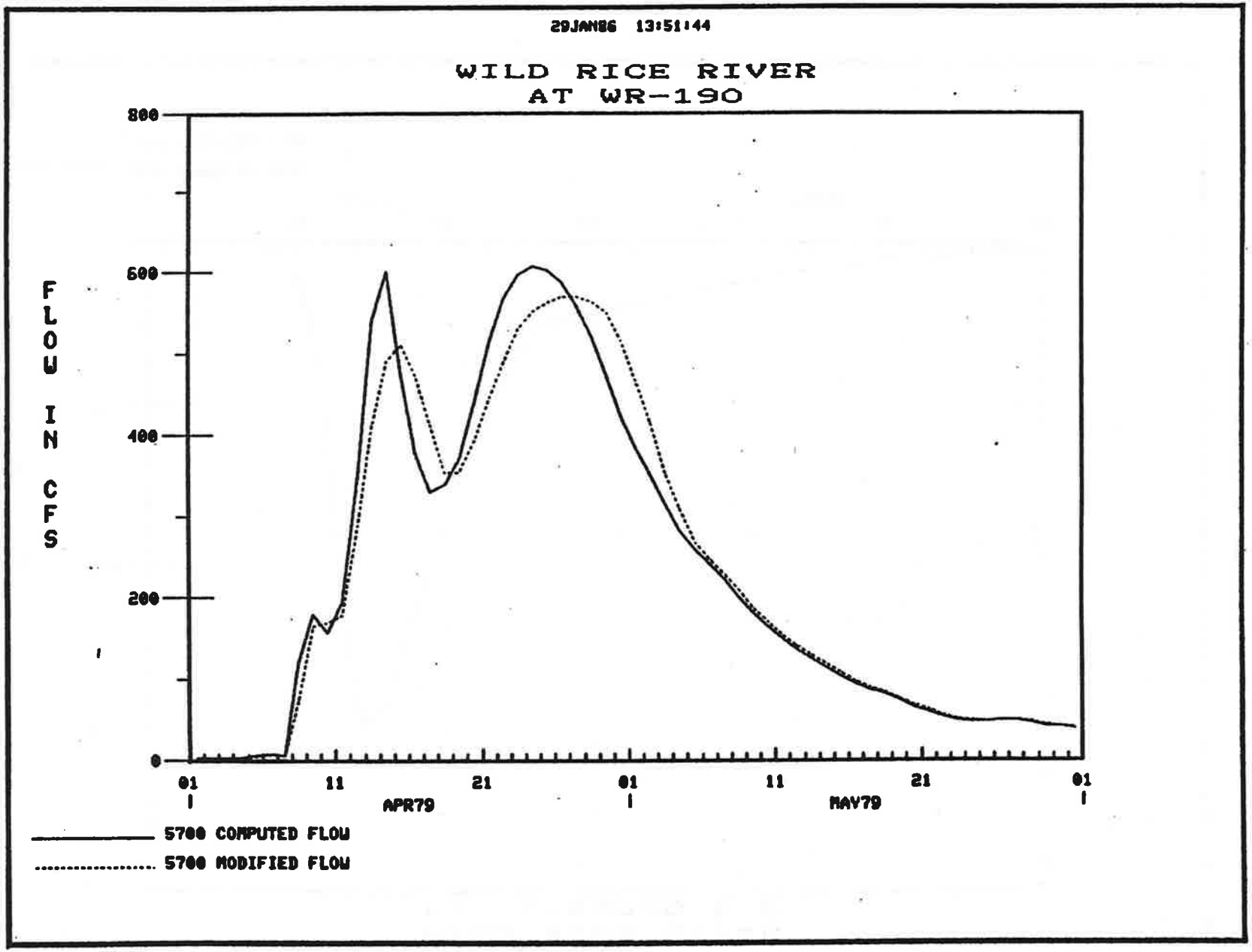
WILD RICE RIVER
AT FARGO
6000
4000
2000
0
FLOW IN CFS
01
11
21
01
11
21
01
MAR78
APR78
7004 COMPUTED FLOW
7004 MODIFIED FLOW

1979 FLOWS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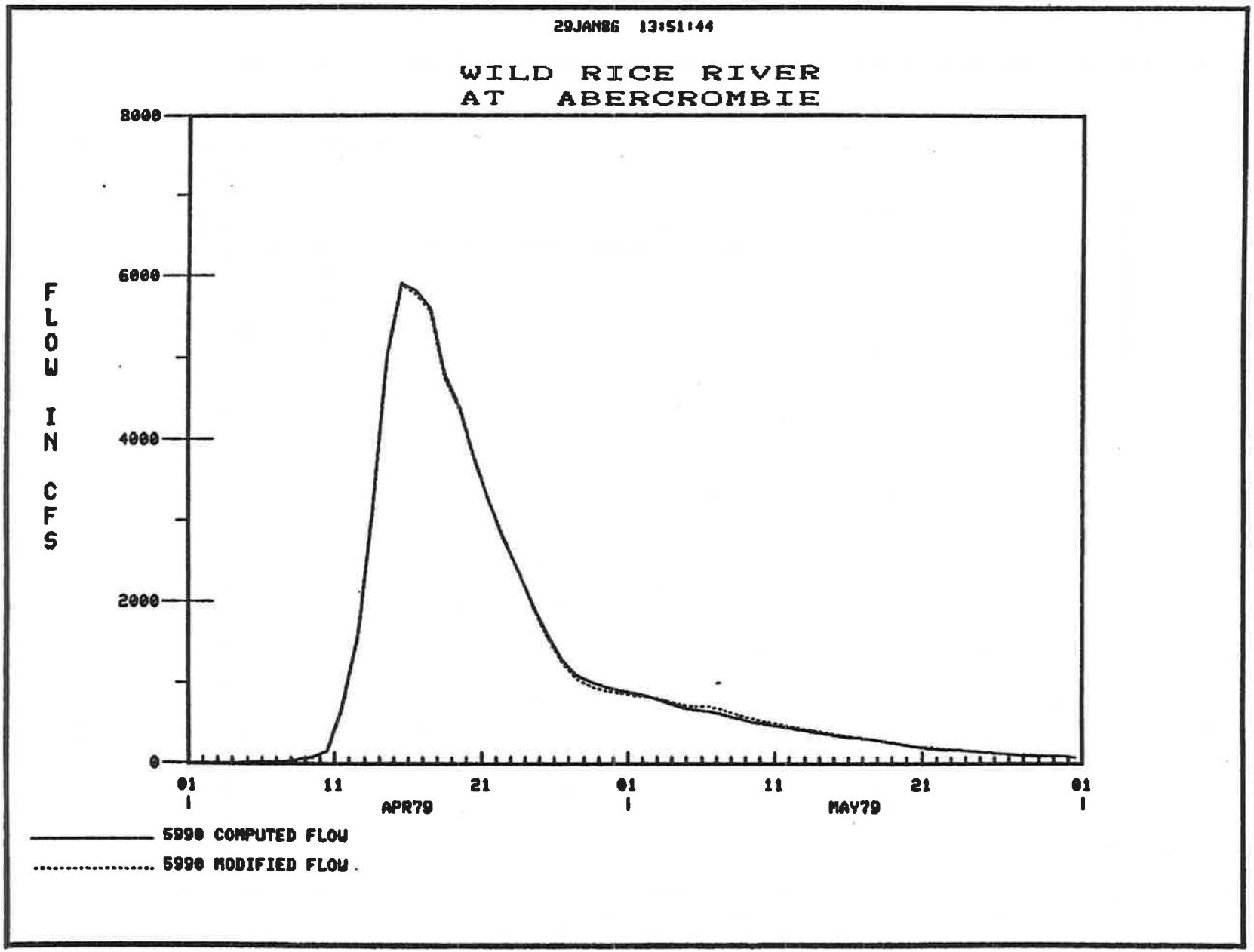
WILD RICE RIVER
AT WR-190
800
600
400
200
0
FLOW IN CFS
01
11
21
01
11
21
01
APR79
MAY79
5700 COMPUTED FLOW
5700 MODIFIED FLOW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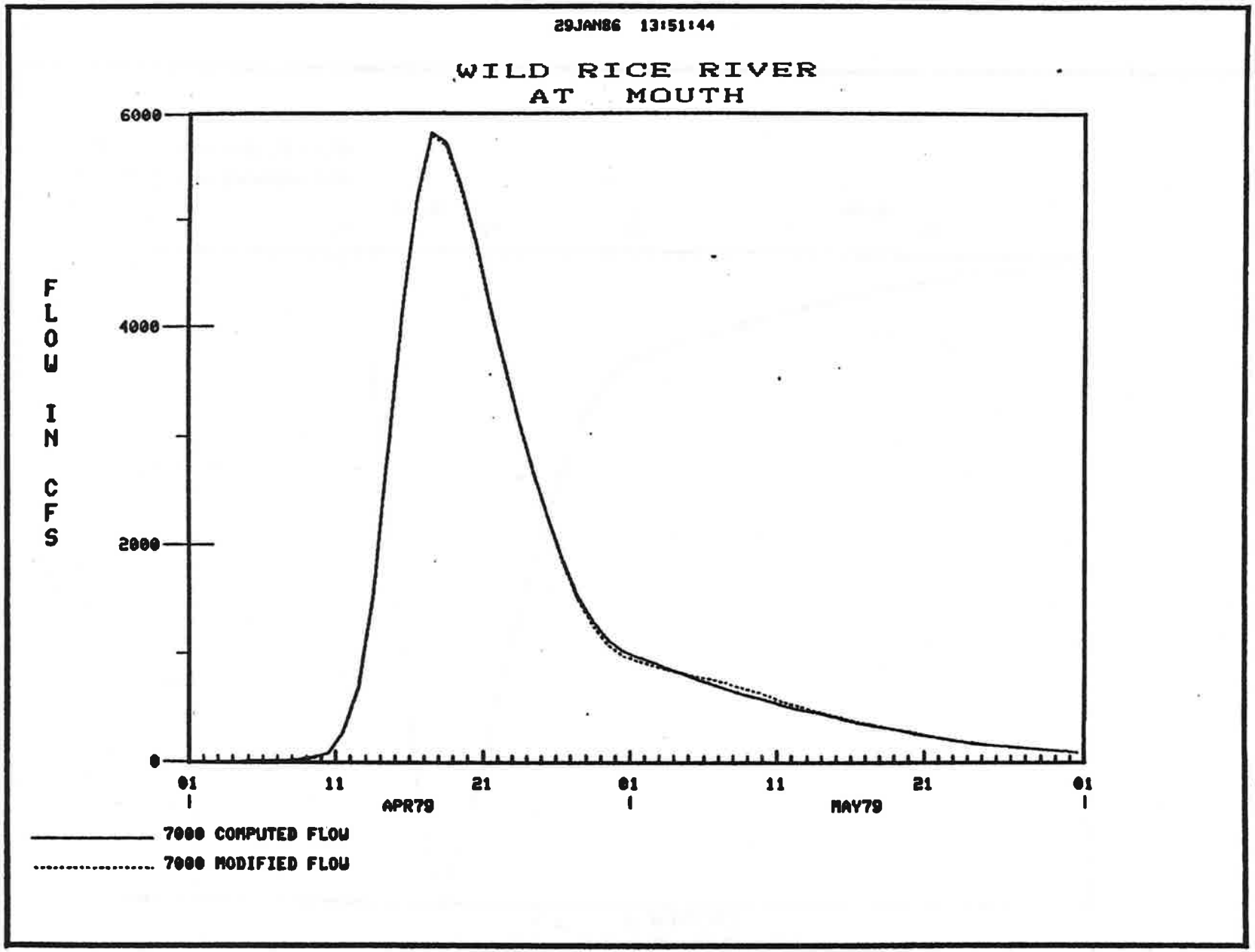
WILD RICE RIVER
AT ABERCROMBIE
8000
6000
4000
2000
0
FLOW IN CFS
01
11
21
01
11
21
01
APR79
MAY79
5990 COMPUTED FLOW
5990 MODIFIED FLOW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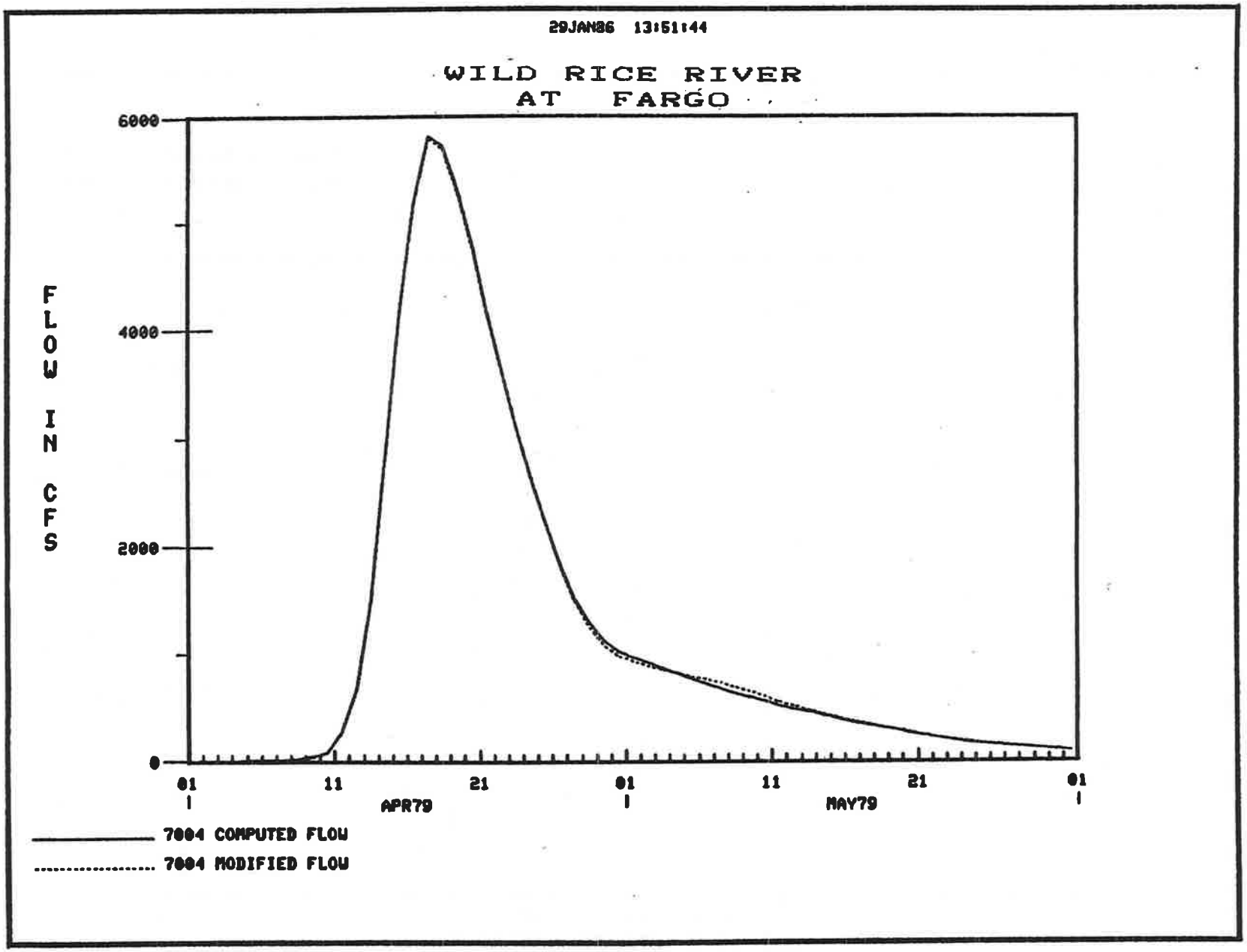
WILD RICE RIVER
AT MOUTH
6000
4000
2000
0
FLOW IN CFS
01
11
21
01
11
21
01
APR79
MAY79
7000 COMPUTED FLOW
7000 MODIFIED FLOW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WILD RICE RIVER
AT FARGO
FLOW IN CFS
6000
4000
2000
0
01
11
21
01
11
21
01
APR79
MAY79
7004 COMPUTED FLOW
7004 MODIFIED FLOW

Wild Rice River, North Dakota

WR-190 DAMSITE ANALYSIS

SECTION C

Table of Contents

TABLE C-1

TT WILD RICE RIVER NEAR RUTLAND
TT INST. PEAK DISCHARGES
TT LAT. 460120 LONG. 097304
TT DATUM 1197.73 NGVD
TT STATION NUMBER 05051600
TT
TT DRAINAGE AREA = 546 CON. AREA = 296

SYSTEMATIC EVENTS
23 EVENTS TO BE ANALYZED

-FREQUENCY CURVE- WRR ND NR RUTLAND

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
2780.	3820.	0.002	9720.	1240.
2150.	2780.	0.005	6970.	995.
1710.	2120.	0.010	5210.	822.
1320.	1560.	0.020	3730.	658.
968.	1100.	0.040	2510.	504.
577.	622.	0.100	1310.	320.
339.	354.	0.200	685.	198.
108.	108.	0.500	184.	65.
29.	27.	0.800	50.	15.
14.	12.	0.900	25.	6.
7.	6.	0.950	14.	2.
2.	1.	0.990	5.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	1.9821	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6404	HIGH OUTLIERS	0
COMPUTED SKEW	-0.5177	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-0.5000	SYSTEMATIC EVENTS	23

TABLE C-1 CONT.

-PLOTTING POSITIONS- WRR ND NR RUTLAND

.....EVENTS ANALYZED.....				..... ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS
0	0	1960	102.	1	1969	1270.	0.0299
0	0	1961	3.	2	1966	660.	0.0726
0	0	1962	135.	3	1978	600.	0.1154
0	0	1963	68.	4	1972	435.	0.1581
0	0	1964	46.	5	1979	365.	0.2009
0	0	1965	173.	6	1967	257.	0.2436
0	0	1966	660.	7	1976	210.	0.2863
0	0	1967	257.	8	1965	173.	0.3291
0	0	1968	91.	9	1984	150.	0.3718
0	0	1969	1270.	10	1962	135.	0.4145
0	0	1970	39.	11	1975	133.	0.4573
0	0	1971	70.	12	1980	130.	0.5000
0	0	1972	435.	13	1960	102.	0.5427
0	0	1973	13.	14	1968	91.	0.5855
0	0	1974	30.	15	1971	70.	0.6282
0	0	1975	133.	16	1963	68.	0.6709
0	0	1976	210.	17	1964	46.	0.7137
0	0	1978	600.	18	1970	39.	0.7564
0	0	1979	365.	19	1974	30.	0.7991
0	0	1980	130.	20	1982	20.	0.8419
0	0	1982	20.	21	1973	13.	0.8846
0	0	1983	8.	22	1983	8.	0.9274
0	0	1984	150.	23	1961	3.	0.9701

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 23 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.448

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 2.6

HIGH OUTLIER TEST

BASED ON 23 EVENTS, 10 PERCENT OUTLIER TEST VALUES K(N) = 2.448

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 3545.

TABLE C-1 CONT.

-SKEW WEIGHTING -

BASED ON 23 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.263
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	516	0.114	-0.20

ADOPTED
-FREQUENCY CURVE- WRR ND NR RUTLAND

.....FLOW,CFS.....			...CONFIDENCE LIMITS...	
	EXPECTED	EXCEEDANCE		
COMPUTED	PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
3930.	5990.	0.002	15200.	1650.
2830.	3930.	0.005	9930.	1250.
2130.	2780.	0.010	6910.	990.
1560.	1910.	0.020	4610.	758.
1080.	1260.	0.040	2900.	555.
602.	656.	0.100	1380.	333.
337.	353.	0.200	680.	197.
103.	103.	0.500	175.	62.
28.	27.	0.800	48.	14.
14.	12.	0.900	25.	6.
8.	6.	0.950	15.	3.
2.	1.	0.990	5.	1.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	1.9821	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6404	HIGH OUTLIERS	0
COMPUTED SKEW	-0.5177	LOW OUTLIERS	0
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.3000	SYSTEMATIC EVENTS	23

TABLE C-2

```
TT      WILD RICE RIVER NEAR CAYUGA
TT      INST. PEAK DISCHARGES
TT      LAT. 460730  LONG. 0972140
TT      DATUM  1095.64
TT      STATION NUMBER 05051700
TT
TT      DRAINAGE AREA = 955  390-NONCON.
TT

**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS    516   0.114   -0.20

**SYSTEMATIC EVENTS**
     23 EVENTS TO BE ANALYZED


-SKEW WEIGHTING -
-----------------------------------------------------------------
BASED ON  23 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =  0.401
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =  0.114
-----------------------------------------------------------------


-FREQUENCY CURVE-  WRR ND NR CAYUGA
*****************************************************************
*........FLOW,CFS........*             *...CONFIDENCE LIMITS...*
*            EXPECTED    * EXCEEDANCE  *                        *
*  COMPUTED  PROBABILITY * PROBABILITY * 0.05 LIMIT 0.95 LIMIT *
*-----------------------*-------------*------------------------*
*     7200.      10800.  *   0.002     *    29800.       2890.  *
*     5240.       7210.  *   0.005     *    19700.       2210.  *
*     3970.       5160.  *   0.010     *    13800.       1750.  *
*     2900.       3550.  *   0.020     *     9230.       1340.  *
*     2010.       2340.  *   0.040     *     5790.        979.  *
*     1100.       1200.  *   0.100     *     2720.        579.  *
*      601.        631.  *   0.200     *     1290.        335.  *
*      169.        169.  *   0.500     *      301.         96.  *
*       41.         38.  *   0.800     *       73.         19.  *
*       18.         16.  *   0.900     *       35.          7.  *
*        9.          7.  *   0.950     *       19.          3.  *
*        2.          1.  *   0.990     *        6.          0.  *
*****************************************************************
*   FREQUENCY CURVE STATISTICS   *     STATISTICS BASED ON      *
*--------------------------------*------------------------------*
*  MEAN LOGARITHM        2.1821  *  HISTORIC EVENTS          0  *
*  STANDARD DEVIATION    0.6983  *  HIGH OUTLIERS       0      *
*  COMPUTED SKEW        -1.1755  *  LOW OUTLIERS        0      *
*  GENERALIZED SKEW     -0.2000  *  ZERO OR MISSING     0      *
*  ADOPTED SKEW         -0.4000  *  SYSTEMATIC EVENTS       23  *
*****************************************************************
```

TABLE C-2 CONT.

-PLOTTING POSITIONS- WRR ND NR CAYUGA

.....EVENTS ANALYZED.....				.....	ORDERED EVENTS.....			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS	
0	0	1957	150.	1	1969	1710.	0.0299	
0	0	1958	131.	2	1962	1080.	0.0726	
0	0	1959	54.	3	1966	757.	0.1154	
0	0	1960	123.	4	1975	636.	0.1581	
0	0	1961	2.	5	1979	600.	0.2009	
0	0	1962	1080.	6	1978	499.	0.2436	
0	0	1963	107.	7	1972	488.	0.2863	
0	0	1964	153.	8	1965	375.	0.3291	
0	0	1965	375.	9	1967	309.	0.3718	
0	0	1966	757.	10	1976	185.	0.4145	
0	0	1967	309.	11	1970	177.	0.4573	
0	0	1968	55.	12	1964	153.	0.5000	
0	0	1969	1710.	13	1957	150.	0.5427	
0	0	1970	177.	14	1958	131.	0.5855	
0	0	1971	55.	15	1960	123.	0.6282	
0	0	1972	488.	16	1973	114.	0.6709	
0	0	1973	114.	17	1963	107.	0.7137	
0	0	1974	53.	18	1971	55.	0.7564	
0	0	1975	636.	19	1968	55.	0.7991	
0	0	1976	185.	20	1959	54.	0.8419	
0	0	1977	4.	21	1974	53.	0.8846	
0	0	1978	499.	22	1977	4.	0.9274	
0	0	1979	600.	23	1961	2.	0.9701	

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 23 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.448

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 3.0

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 22 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.429

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 4708.

-SKEW WEIGHTING -

BASED ON 23 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.306
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

TABLE C-2 CONT.

-FREQUENCY CURVE- WRR ND NR CAYUGA

FLOW,CFS			CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
4810.	6810.	0.002	16500.	2170.
3650.	4810.	0.005	11500.	1720.
2870.	3600.	0.010	8460.	1410.
2180.	2610.	0.020	5960.	1120.
1590.	1810.	0.040	3980.	852.
943.	1020.	0.100	2060.	540.
558.	582.	0.200	1080.	336.
186.	186.	0.500	306.	114.
54.	51.	0.800	90.	28.
27.	24.	0.900	48.	12.
15.	12.	0.950	28.	6.
4.	3.	0.990	10.	1.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.2286	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6057	HIGH OUTLIERS	0
COMPUTED SKEW	-0.8910	LOW OUTLIERS	1
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.4000	SYSTEMATIC EVENTS	23

NO GENERALIZED SKEW

-FREQUENCY CURVE- WRR ND NR CAYUGA

FLOW,CFS			CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
1840.	1980.	0.002	5170.	907.
1700.	1840.	0.005	4680.	847.
1560.	1690.	0.010	4210.	788.
1400.	1500.	0.020	3660.	714.
1200.	1280.	0.040	3010.	622.
872.	914.	0.100	2030.	470.
590.	609.	0.200	1260.	329.
208.	208.	0.500	378.	120.
47.	43.	0.800	83.	23.
18.	15.	0.900	34.	7.
7.	5.	0.950	15.	2.
1.	0.	0.990	3.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.1821	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6983	HIGH OUTLIERS	0
COMPUTED SKEW	-1.1755	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-1.2000	SYSTEMATIC EVENTS	23

TABLE C-2 CONT.

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 23 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.448

2 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 3.0
OR INPUT BASE OF 5.0

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 2 LOW OUTLIER(S)

HIGH OUTLIER TEST

BASED ON 21 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.408

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 2755.

-SKEW WEIGHTING -

BASED ON 23 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =-99.000
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.302

-FREQUENCY CURVE- WRR ND NR CAYUGA

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
5960.	10200.	0.002	20000.	2790.
4030.	5970.	0.005	11900.	2020.
2930.	3960.	0.010	7890.	1550.
2080.	2590.	0.020	5060.	1160.
1430.	1670.	0.040	3130.	847.
811.	881.	0.100	1530.	519.
485.	505.	0.200	812.	326.
188.	188.	0.500	277.	127.
77.	74.	0.800	114.	46.
49.	46.	0.900	76.	26.
34.	31.	0.950	56.	17.
18.	14.	0.990	32.	7.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.2902	HISTORIC EVENTS	0
STANDARD DEVIATION	0.4758	HIGH OUTLIERS	0
COMPUTED SKEW	0.2041	LOW OUTLIERS	2
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	0.2000	SYSTEMATIC EVENTS	23

TABLE C-2 CONT.

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	516	0.114	-0.20

2 LOW OUTLIERS

-SKEW WEIGHTING -

BASED ON 23 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.232
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

ADOPTED
-FREQUENCY CURVE- WRR ND NR CAYUGA

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
4000.	5960.	0.002	11800.	2010.
2960.	4000.	0.005	8000.	1560.
2300.	2920.	0.010	5780.	1270.
1740.	2090.	0.020	4040.	1000.
1280.	1450.	0.040	2720.	770.
785.	842.	0.100	1470.	504.
493.	512.	0.200	829.	331.
199.	199.	0.500	293.	135.
78.	75.	0.800	116.	46.
47.	44.	0.900	74.	25.
31.	27.	0.950	51.	15.
14.	11.	0.990	26.	5.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.2902	HISTORIC EVENTS	0
STANDARD DEVIATION	0.4758	HIGH OUTLIERS	0
COMPUTED SKEW	0.2041	LOW OUTLIERS	2
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.1000	SYSTEMATIC EVENTS	23

TABLE C-3

```
TT      GRASS LAKE TRIB NEAR LIDGERWOOD
TT      LAT. 460445  LONG. 0971140
TT      INST. PEAK DISCHARGES
TT      STATION NUMBER 05051800
TT
TT      DRAINAGE AREA = 0.6
TT
```

SYSTEMATIC EVENTS
16 EVENTS TO BE ANALYZED

NOTE - ADOPTED SKEW EQUALS COMPUTED SKEW AND PRELIMINARY FREQUENCY STATISTICS ARE FOR THE CONDITIONAL FREQUENCY CURVE BECAUSE OF ZERO OR MISSING EVENTS.

-FREQUENCY CURVE- GRASS LAKE TRIB NR LIDGERWOOD

FLOW, CFS		EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY		0.05 LIMIT	0.95 LIMIT
89.	119.	0.002	277.	45.
74.	95.	0.005	218.	39.
64.	78.	0.010	177.	34.
53.	63.	0.020	138.	30.
43.	48.	0.040	102.	25.
29.	31.	0.100	62.	18.
20.	20.	0.200	37.	12.
8.	8.	0.500	12.	5.
2.	1.	0.800	3.	1.
0.	0.	0.900	0.	0.
0.	0.	0.950	0.	0.
0.	0.	0.990	0.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	0.9255	HISTORIC EVENTS	0
STANDARD DEVIATION	0.4736	HIGH OUTLIERS	0
COMPUTED SKEW	-0.5916	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	2
ADOPTED SKEW	-0.5916	SYSTEMATIC EVENTS	16

TABLE C-3 CONT.

-FREQUENCY CURVE- GRASS LAKE TRIB NR LIDGERWOOD

FLOW,CFS COMPUTED	FLOW,CFS EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS 0.05 LIMIT	CONFIDENCE LIMITS 0.95 LIMIT
85.	112.	0.002	295.	41.
72.	92.	0.005	236.	35.
62.	76.	0.010	193.	31.
52.	62.	0.020	151.	27.
42.	48.	0.040	113.	23.
29.	31.	0.100	68.	16.
19.	20.	0.200	41.	11.
8.	8.	0.500	13.	5.
3.	2.	0.800	4.	1.
1.	1.	0.900	2.	1.
1.	1.	0.950	1.	0.
0.	0.	0.990	1.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	0.8268	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5358	HIGH OUTLIERS	0
COMPUTED SKEW	-0.6742	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	2
ADOPTED SKEW	-0.7000	SYSTEMATIC EVENTS	16

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	516	0.114	-0.20

NOTE - ADOPTED SKEW EQUALS COMPUTED SKEW AND PRELIMINARY FREQUENCY STATISTICS ARE FOR THE CONDITIONAL FREQUENCY CURVE BECAUSE OF ZERO OR MISSING EVENTS.

THEREFORE, FREQUENCY CURVE DATA WITH GENERALIZED SKEW AND NO LOW OUTLIERS IS THE SAME AS FIRST FREQUENCY CURVE GIVEN ABOVE.

TABLE C-3 CONT.

-PLOTTING POSITIONS- GRASS LAKE TRIB NR LIDGERWOOD

.....EVENTS ANALYZED.....				..... ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS
0	0	1958	2.	1	1967	36.	0.0427
0	0	1959	8.	2	1972	34.	0.1037
0	0	1960	0.	3	1962	22.	0.1646
0	0	1961	0.	4	1971	19.	0.2256
0	0	1962	22.	5	1966	15.	0.2866
0	0	1963	4.	6	1965	12.	0.3476
0	0	1964	8.	7	1969	12.	0.4085
0	0	1965	12.	8	1964	8.	0.4695
0	0	1966	15.	9	1970	8.	0.5305
0	0	1967	36.	10	1959	8.	0.5915
0	0	1968	2.	11	1963	4.	0.6524
0	0	1969	12.	12	1968	2.	0.7134
0	0	1970	8.	13	1958	2.	0.7744
0	0	1971	19.	14	1973	1.	0.8354
0	0	1972	34.	15	1960	0.	0.8963
0	0	1973	1.	16	1961	0.	0.9573

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 14 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.213

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 0.8
BASED ON THE STATISTICS AFTER 2 ZERO OR MISSING EVENTS DELETED

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 0 LOW OUTLIER(S)
AND/OR 2 ZERO OR MISSING EVENT(S)

HIGH OUTLIER TEST

BASED ON 14 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.213
0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 94.

TABLE C-3 CONT.

-SKEW WEIGHTING -

BASED ON 16 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.370
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

ADOPTED
-FREQUENCY CURVE- GRASS LAKE TRIB NR LIDGERWOOD

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
150.	255.	0.002	647.	64.
114.	172.	0.005	441.	51.
90.	125.	0.010	319.	43.
69.	89.	0.020	222.	34.
51.	61.	0.040	147.	26.
31.	35.	0.100	76.	17.
19.	20.	0.200	40.	11.
7.	7.	0.500	12.	4.
2.	2.	0.800	4.	1.
1.	1.	0.900	2.	1.
1.	1.	0.950	2.	0.
0.	0.	0.990	1.	0.

MEAN LOGARITHM	0.8268	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5358	HIGH OUTLIERS	0
COMPUTED SKEW	-0.6742	LOW OUTLIERS	0
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	2
ADOPTED SKEW	-0.3000	SYSTEMATIC EVENTS	16

TABLE C-4

TT WILD RICE RIVER TRIB NEAR MANTADOR
TT LAT. 461015 LONG. 0970415
TT INST. PEAK DISCHARGES
TT STATION NUMBER 05051900
TT
TT DRAINAGE AREA = 15.7 CON. AREA = 4.3

SYSTEMATIC EVENTS
16 EVENTS TO BE ANALYZED

-FREQUENCY CURVE- WRR ND TRIB NR MANTADOR

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
7140.	79800.	0.002	164000.	1260.
2480.	12900.	0.005	36900.	547.
1090.	3600.	0.010	11700.	286.
472.	1070.	0.020	3600.	146.
198.	334.	0.040	1080.	72.
59.	76.	0.100	206.	26.
22.	24.	0.200	56.	11.
5.	5.	0.500	9.	2.
1.	1.	0.800	3.	1.
1.	1.	0.900	2.	0.
1.	1.	0.950	2.	0.
0.	0.	0.990	1.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	0.7923	HISTORIC EVENTS	0
STANDARD DEVIATION	0.7279	HIGH OUTLIERS	0
COMPUTED SKEW	1.0573	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	1.1000	SYSTEMATIC EVENTS	16

TABLE C-4 CONT.

-PLOTTING POSITIONS- WRR ND TRIB NR MANTADOR

.....EVENTS ANALYZED.....				..... ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS
0	0	1958	2.	1	1969	210.	0.0427
0	0	1959	3.	2	1970	130.	0.1037
0	0	1960	2.	3	1971	48.	0.1646
0	0	1961	1.	4	1972	30.	0.2256
0	0	1962	3.	5	1966	10.	0.2866
0	0	1963	2.	6	1967	7.	0.3476
0	0	1964	3.	7	1965	4.	0.4085
0	0	1965	4.	8	1964	3.	0.4695
0	0	1966	10.	9	1962	3.	0.5305
0	0	1967	7.	10	1959	3.	0.5915
0	0	1968	1.	11	1958	2.	0.6524
0	0	1969	210.	12	1963	2.	0.7134
0	0	1970	130.	13	1960	2.	0.7744
0	0	1971	48.	14	1973	2.	0.8354
0	0	1972	30.	15	1961	1.	0.8963
0	0	1973	2.	16	1968	1.	0.9573

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 16 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.279

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 0.1

HIGH OUTLIER TEST

BASED ON 16 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.279

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 283.

TABLE C-4 CONT.

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	516	0.114	-0.20

-SKEW WEIGHTING -

BASED ON 16 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.459
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

ADOPTED
-FREQUENCY CURVE- WRR ND TRIB NR MANTADOR

.....FLOW,CFS.....		EXCEEDANCE	...CONFIDENCE LIMITS...	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
946.	3000.	0.002	9510.	255.
544.	1270.	0.005	4390.	164.
346.	661.	0.010	2340.	114.
212.	341.	0.020	1180.	76.
123.	171.	0.040	564.	49.
54.	64.	0.100	185.	24.
25.	27.	0.200	68.	12.
6.	6.	0.500	12.	3.
1.	1.	0.800	3.	1.
1.	1.	0.900	2.	0.
0.	0.	0.950	1.	0.
0.	0.	0.990	0.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	0.7923	HISTORIC EVENTS	0
STANDARD DEVIATION	0.7279	HIGH OUTLIERS	0
COMPUTED SKEW	1.0573	LOW OUTLIERS	0
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	0.1000	SYSTEMATIC EVENTS	16

TABLE C-5

TT 05052000 WILD RICE RIVER NEAR MANTADOR, N.D.
TT INST PEAK DISCHARGES
TT LAT. 46 10'20" LONG. 97 00'35"
TT D.A. = 1357 MI2 CON. AREA = 807
TT PERIOD OF RECORD 1943-51, 1952,1973,1975 PARIAL-RECORD
TT GAGE DATUM 997.78 FT. MSL (1929)
TT PRIOR TO 1949 STAFF GAGE AT SAME SITE AND DATUM
TT FLOOD IN SPRING 1943 REACHED A STAGE OF 12.8 FT., FLOODMARKS
TT SOME REGULATION BY FISH AND WILDLIFE REFUGES, OF WHICH LAKE
TT TEWAUKEN IS THE LARGEST. SOME SMALL DIVERSIONS FOR IRRIGATION
TT 1952-73,75 ARE ANNUAL MAXIMUM DISCHARGE FOR CREST-STAGE
TT PARTIAL-RECORD STATION

SYSTEMATIC EVENTS
31 EVENTS TO BE ANALYZED

-PLOTTING POSITIONS- WRR ND NR MANTADOR

.....EVENTS ANALYZED.....					..... ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS	
0	0	1944	476.	1	1969	2360.	0.0223	
0	0	1945	938.	2	1952	2200.	0.0541	
0	0	1946	300.	3	1962	1240.	0.0860	
0	0	1947	554.	4	1945	938.	0.1178	
0	0	1948	150.	5	1966	878.	0.1497	
0	0	1949	105.	6	1975	743.	0.1815	
0	0	1950	485.	7	1947	554.	0.2134	
0	0	1951	275.	8	1950	485.	0.2452	
0	0	1952	2200.	9	1944	476.	0.2771	
0	0	1953	129.	10	1965	435.	0.3089	
0	0	1954	75.	11	1972	345.	0.3408	
0	0	1955	99.	12	1946	300.	0.3726	
0	0	1956	156.	13	1967	299.	0.4045	
0	0	1957	160.	14	1963	275.	0.4363	
0	0	1958	250.	15	1951	275.	0.4682	
0	0	1959	10.	16	1958	250.	0.5000	
0	0	1960	138.	17	1970	208.	0.5318	
0	0	1961	34.	18	1964	161.	0.5637	
0	0	1962	1240.	19	1957	160.	0.5955	
0	0	1963	275.	20	1956	156.	0.6274	
0	0	1964	161.	21	1948	150.	0.6592	
0	0	1965	435.	22	1960	138.	0.6911	
0	0	1966	878.	23	1953	129.	0.7229	
0	0	1967	299.	24	1949	105.	0.7548	
0	0	1968	92.	25	1955	99.	0.7866	
0	0	1969	2360.	26	1968	92.	0.8185	
0	0	1970	208.	27	1954	75.	0.8503	
0	0	1971	40.	28	1973	75.	0.8822	
0	0	1972	345.	29	1971	40.	0.9140	
0	0	1973	75.	30	1961	34.	0.9459	
0	0	1975	743.	31	1959	10.	0.9777	

TABLE C-5 CONT.

-FREQUENCY CURVE- WRR ND NR MANTADOR

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
5560.	7360.	0.002	14300.	2920.
4120.	5110.	0.005	9860.	2260.
3200.	3800.	0.010	7210.	1820.
2420.	2760.	0.020	5100.	1430.
1760.	1930.	0.040	3450.	1080.
1060.	1110.	0.100	1860.	691.
646.	664.	0.200	1040.	441.
241.	241.	0.500	348.	168.
85.	82.	0.800	125.	53.
48.	45.	0.900	74.	27.
30.	27.	0.950	49.	15.
12.	9.	0.990	22.	5.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.3652	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5233	HIGH OUTLIERS	0
COMPUTED SKEW	-0.2416	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-0.2000	SYSTEMATIC EVENTS	31

-FREQUENCY CURVE- WRR ND NR MANTADOR

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
8220.	12400.	0.002	22600.	4170.
5410.	7320.	0.005	13400.	2930.
3860.	4860.	0.010	8790.	2200.
2690.	3190.	0.020	5620.	1610.
1820.	2050.	0.040	3480.	1150.
1020.	1080.	0.100	1710.	690.
601.	620.	0.200	918.	428.
234.	234.	0.500	323.	168.
98.	96.	0.800	138.	64.
64.	61.	0.900	94.	39.
46.	43.	0.950	70.	26.
25.	22.	0.990	42.	12.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.3922	HISTORIC EVENTS	0
STANDARD DEVIATION	0.4694	HIGH OUTLIERS	0
COMPUTED SKEW	0.2670	LOW OUTLIERS	1
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	0.3000	SYSTEMATIC EVENTS	31

TABLE C-5 CONT.

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	50520	0.114	-0.20

-SKEW WEIGHTING -

BASED ON 31 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.181
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

-FREQUENCY CURVE- WRR ND NR MANTADOR

FLOW,CFS EXPECTED COMPUTED	FLOW,CFS EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS 0.05 LIMIT	CONFIDENCE LIMITS 0.95 LIMIT
5560.	7360.	0.002	14300.	2920.
4120.	5110.	0.005	9860.	2260.
3200.	3800.	0.010	7210.	1820.
2420.	2760.	0.020	5100.	1430.
1760.	1930.	0.040	3450.	1080.
1060.	1110.	0.100	1860.	691.
646.	664.	0.200	1040.	441.
241.	241.	0.500	348.	168.
85.	82.	0.800	125.	53.
48.	45.	0.900	74.	27.
30.	27.	0.950	49.	15.
12.	9.	0.990	22.	5.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.3652	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5233	HIGH OUTLIERS	0
COMPUTED SKEW	-0.2416	LOW OUTLIERS	0
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.2000	SYSTEMATIC EVENTS	31

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 31 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.577

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 10.4

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

TABLE C-5 CONT.

HIGH OUTLIER TEST

BASED ON 31 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.577

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 5174.

-SKEW WEIGHTING -

BASED ON 31 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.183
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

ADOPTED
-FREQUENCY CURVE- WRR ND NR MANTADOR

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
5540.	7570.	0.002	13800.	2980.
3990.	5060.	0.005	9170.	2260.
3050.	3670.	0.010	6560.	1800.
2270.	2610.	0.020	4560.	1400.
1640.	1800.	0.040	3050.	1050.
986.	1040.	0.100	1650.	672.
613.	630.	0.200	939.	436.
247.	247.	0.500	342.	178.
99.	97.	0.800	140.	65.
62.	58.	0.900	91.	37.
42.	38.	0.950	64.	23.
20.	17.	0.990	34.	9.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.3922	HISTORIC EVENTS	0
STANDARD DEVIATION	0.4694	HIGH OUTLIERS	0
COMPUTED SKEW	0.2670	LOW OUTLIERS	1
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	0.0000	SYSTEMATIC EVENTS	31

TABLE C-6

```
TT    05052500  ANTELOPE CREEK AT DWIGHT, N.D.
TT    INST PEAK DISCHARGES
TT    LAT. 46 18'50"     LONG 96 44'05"
TT    D.A.=294 MI2  CON. AREA = 278
TT    PERIOD OF RECORD 1943-49,1950-73,1975 PARTIAL-RECORD
TT    GAGE DATUM 920 FT.
TT    A STAGE OF 16.0 FT. OCCURRED IN APR 1943
TT    1950-73,75 ARE ANNUAL MAX. DISCHARGE FOR CREST-STAGE
TT    PARTIAL-RECORD STATION
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SPECIAL STATION INFORMATION

	IYRA	IYRL	NOUTL	BASEPK
SI	1943	0	1	0.

SYSTEMATIC EVENTS

31 EVENTS TO BE ANALYZED

-FREQUENCY CURVE- ANTELOPE CK NR DWIGHT

FLOW,CFS			CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
8870.	10100.	0.002	25600.	4190.
7520.	8470.	0.005	20900.	3620.
6410.	7150.	0.010	17200.	3150.
5260.	5770.	0.020	13500.	2650.
4090.	4420.	0.040	9980.	2120.
2570.	2710.	0.100	5730.	1400.
1530.	1580.	0.200	3100.	870.
435.	435.	0.500	756.	256.
85.	80.	0.800	148.	43.
31.	27.	0.900	59.	13.
12.	10.	0.950	26.	4.
2.	1.	0.990	5.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.5239	HISTORIC EVENTS	0
STANDARD DEVIATION	0.7730	HIGH OUTLIERS	0
COMPUTED SKEW	-0.8633	LOW OUTLIERS	0
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-0.9000	SYSTEMATIC EVENTS	31

TABLE C-6 CONT.

-FREQUENCY CURVE- ANTELOPE CK NR DWIGHT

.....FLOW,CFS.....			...CONFIDENCE LIMITS...	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
15000.	19700.	0.002	45900.	6920.
11000.	13700.	0.005	31400.	5320.
8450.	10100.	0.010	22600.	4240.
6250.	7200.	0.020	15600.	3270.
4400.	4890.	0.040	10200.	2400.
2470.	2630.	0.100	5060.	1440.
1380.	1430.	0.200	2550.	848.
410.	410.	0.500	657.	258.
105.	100.	0.800	170.	57.
48.	44.	0.900	84.	23.
25.	21.	0.950	47.	10.
7.	5.	0.990	15.	2.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.5680	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6697	HIGH OUTLIERS	1
COMPUTED SKEW	-0.3847	LOW OUTLIERS	1
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-0.4000	SYSTEMATIC EVENTS	31
		HISTORIC PERIOD	33

TABLE C-6 CONT.

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	50525	0.114	-0.20

-SKEW WEIGHTING -

BASED ON 31 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.244
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

-FREQUENCY CURVE- ANTELOPE CK NR DWIGHT

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
23900.	32900.	0.002	87100.	9820.
16800.	21700.	0.005	56300.	7260.
12400.	15200.	0.010	38600.	5580.
8730.	10300.	0.020	25200.	4130.
5820.	6580.	0.040	15300.	2900.
2990.	3210.	0.100	6850.	1600.
1530.	1590.	0.200	3110.	871.
376.	376.	0.500	648.	221.
78.	74.	0.800	137.	39.
32.	29.	0.900	61.	14.
15.	12.	0.950	31.	5.
3.	2.	0.990	8.	1.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.5239	HISTORIC EVENTS	0
STANDARD DEVIATION	0.7730	HIGH OUTLIERS	0
COMPUTED SKEW	-0.8633	LOW OUTLIERS	0
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.4000	SYSTEMATIC EVENTS	31

TABLE C-6 CONT.

-PLOTTING POSITIONS- ANTELOPE CK NR DWIGHT

.....EVENTS ANALYZED.....					...ORDERED EVENTS...			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS	
0	0	1944	460.	1	1969	9000.	0.0210	
0	0	1945	868.	2	1952	3670.	0.0519	
0	0	1946	1360.	3	1975	1800.	0.0838	
0	0	1947	1160.	4	1951	1700.	0.1158	
0	0	1948	120.	5	1972	1650.	0.1477	
0	0	1949	270.	6	1946	1360.	0.1796	
0	0	1950	893.	7	1962	1300.	0.2116	
0	0	1951	1700.	8	1966	1300.	0.2435	
0	0	1952	3670.	9	1967	1250.	0.2754	
0	0	1953	578.	10	1947	1160.	0.3074	
0	0	1954	111.	11	1965	1080.	0.3393	
0	0	1955	341.	12	1950	893.	0.3713	
0	0	1956	237.	13	1945	868.	0.4032	
0	0	1957	134.	14	1953	578.	0.4351	
0	0	1958	50.	15	1944	460.	0.4671	
0	0	1959	2.	16	1955	341.	0.4990	
0	0	1960	78.	17	1963	295.	0.5309	
0	0	1961	10.	18	1971	288.	0.5629	
0	0	1962	1300.	19	1949	270.	0.5948	
0	0	1963	295	20	1956	237.	0.6267	
0	0	1964	120.	21	1973	169.	0.6587	
0	0	1965	1080.	22	1957	134.	0.6906	
0	0	1966	1300.	23	1970	134.	0.7226	
0	0	1967	1250.	24	1948	120.	0.7545	
0	0	1968	20.	25	1964	120.	0.7864	
0	0	1969	9000.	26	1954	111.	0.8184	
0	0	1970	134.	27	1960	78.	0.8503	
0	0	1971	288.	28	1958	50.	0.8822	
0	0	1972	1650.	29	1968	20.	0.9142	
0	0	1973	169.	30	1961	10.	0.9461	
0	0	1975	1800.	31	1959	2.	0.9780	

NOTE- PLOTTING POSITIONS BASED ON-HISTORIC PERIOD (H) = 33
NUMBER OF HISTORIC EVENTS PLUS HIGH OUTLIERS(Z) = 1
WEIGHTING FACTOR FOR SYSTEMATIC EVENTS (W) = 1.0667

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 31 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.577

1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 3.4

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 LOW OUTLIER(S)

TABLE C-6 CONT.

HIGH OUTLIER TEST

BASED ON 30 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.563

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 19569.
OR INPUT BASE OF 9000.

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 1 HIGH OUTLIER(S)
AND 0 HISTORIC EVENT(S)

-SKEW WEIGHTING -

BASED ON 33 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.184
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

ADOPTED
-FREQUENCY CURVE- ANTELOPE CK NR DWIGHT

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
17900.	24600.	0.002	57500.	8080.
12700.	16300.	0.005	37500.	6020.
9480.	11600.	0.010	26100.	4680.
6810.	7950.	0.020	17400.	3520.
4660.	5220.	0.040	10900.	2530.
2520.	2690.	0.100	5200.	1470.
1380.	1430.	0.200	2540.	845.
399.	399.	0.500	639.	251.
104.	99.	0.800	169.	57.
49.	45.	0.900	85.	23.
26.	22.	0.950	48.	11.
7.	5.	0.990	16.	2.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.5680	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6697	HIGH OUTLIERS	1
COMPUTED SKEW	-0.3847	LOW OUTLIERS	1
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.3000	SYSTEMATIC EVENTS	31
		HISTORIC PERIOD	33

TABLE C-7

```
TT  05053000  WILD RICE RIVER NEAR ABERCROMBIE, N.D.
TT  INST. PEAK DISCHARGES
TT  LAT 46 28'05"  LONG 96 47'00"  DA.=2082 MI2  CON. AREA = 1490
TT  PERIOD OF RECORD 1932-1980     GAGE DATUM 907.94 FT. (1929)
TT  PRIOR TO 1939 NONRECORDING GAGE AT SITE 420 FT. DOWNSTREAM
TT  AT DATUM 5.0 FT. LOWER. 1939-52 NONRECORDING GAGE AT SITE
TT  0.75 MI DOWNSTREAM AT PRESENT DATUM.  SOME REGULATION BY FISH
TT  AND WILDLIFE SERVICE RESERVOIRS OF WHICH LAKE TAWAUKON IS THE
TT  LARGEST. SOME SMALL DIVERSIONS FOR IRRIGATION.  FLOOD IN
TT  SPRING OF 1897 REACHED A STAGE OF 27.5 PRESENT SITE AND DATUM,
TT  FROM FLOODMARKS POINTED OUT BY LOCAL RESIDENTS.


**SPECIAL STATION INFORMATION**
    IYRA    IYRL   NOUTL  BASEPK
SI  1897       0      1       0.


**SYSTEMATIC EVENTS**
     52 EVENTS TO BE ANALYZED


-FREQUENCY CURVE-  WRR ND NR ABERCROMBIE
*************************************************************************
*........FLOW,CFS........*             *...CONFIDENCE LIMITS...*
*            EXPECTED    * EXCEEDANCE  *                       *
*  COMPUTED  PROBABILITY * PROBABILITY * 0.05 LIMIT 0.95 LIMIT *
*-----------------------*-------------*-----------------------*
*    12300.     13300.   *   0.002     *    23300.       7580.  *
*    10600.     11300.   *   0.005     *    19400.       6590.  *
*     9120.      9660.   *   0.010     *    16400.       5790.  *
*     7630.      8010.   *   0.020     *    13400.       4930.  *
*     6110.      6360.   *   0.040     *    10300.       4040.  *
*     4110.      4210.   *   0.100     *     6570.       2810.  *
*     2660.      2700.   *   0.200     *     4030.       1880.  *
*      961.       961.   *   0.500     *     1340.        697.  *
*      267.       260.   *   0.800     *      376.        178.  *
*      122.       115.   *   0.900     *      182.         74.  *
*       60.        55.   *   0.950     *       96.         33.  *
*       14.        11.   *   0.990     *       26.          6.  *
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
*   FREQUENCY CURVE STATISTICS   *     STATISTICS BASED ON      *
*--------------------------------*-----------------------------*
*  MEAN LOGARITHM        2.9023  *  HISTORIC EVENTS          0  *
*  STANDARD DEVIATION    0.6104  *  HIGH OUTLIERS        0     *
*  COMPUTED SKEW        -0.7552  *  LOW OUTLIERS         0     *
*  GENERALIZED SKEW    -99.0000  *  ZERO OR MISSING      0     *
*  ADOPTED SKEW         -0.8000  *  SYSTEMATIC EVENTS       52 *
*************************************************************************
```

TABLE C-7 CONT.

-FREQUENCY CURVE- WRR ND NR ABERCROMBIE

FLOW,CFS		EXCEEDANCE	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY	PROBABILITY	0.05 LIMIT	0.95 LIMIT
13400.	14800.	0.002	25300.	8330.
11000.	12000.	0.005	20100.	7000.
9230.	9930.	0.010	16400.	5990.
7540.	7980.	0.020	12900.	4980.
5890.	6150.	0.040	9690.	3980.
3860.	3960.	0.100	5970.	2710.
2480.	2520.	0.200	3630.	1800.
934.	934.	0.500	1260.	695.
293.	286.	0.800	402.	202.
148.	141.	0.900	214.	94.
81.	75.	0.950	124.	47.
24.	20.	0.990	42.	11.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.9147	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5596	HIGH OUTLIERS	1
COMPUTED SKEW	-0.5767	LOW OUTLIERS	1
GENERALIZED SKEW	-99.0000	ZERO OR MISSING	0
ADOPTED SKEW	-0.6000	SYSTEMATIC EVENTS	52
		HISTORIC PERIOD	88

GENERALIZED SKEW

	ISTN	GGMSE	SKEW
GS	530	0.114	-0.20

-SKEW WEIGHTING -

BASED ON 52 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = 0.158
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = 0.114

TABLE C-7 CONT.

-FREQUENCY CURVE- WRR ND NR ABERCROMBIE

.....FLOW,CFS.....			...CONFIDENCE LIMITS...	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
23300.	26900.	0.002	48900.	13300.
17600.	19800.	0.005	35300.	10400.
13800.	15200.	0.010	26600.	8390.
10500.	11300.	0.020	19300.	6570.
7630.	8070.	0.040	13300.	4930.
4510.	4660.	0.100	7300.	3060.
2660.	2700.	0.200	4020.	1870.
877.	877.	0.500	1220.	635.
254.	247.	0.800	358.	168.
125.	119.	0.900	187.	76.
68.	63.	0.950	108.	38.
20.	17.	0.990	37.	9.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.9023	HISTORIC EVENTS	0
STANDARD DEVIATION	0.6104	HIGH OUTLIERS	0
COMPUTED SKEW	-0.7552	LOW OUTLIERS	0
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.4000	SYSTEMATIC EVENTS	52

-FREQUENCY CURVE- WRR ND NR ABERCROMBIE

.....FLOW,CFS.....			...CONFIDENCE LIMITS...	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
19200.	22000.	0.002	38400.	11400.
14800.	16500.	0.005	28300.	9100.
11900.	13000.	0.010	21800.	7460.
9190.	9850.	0.020	16200.	5940.
6820.	7190.	0.040	11500.	4550.
4180.	4310.	0.100	6550.	2920.
2560.	2600.	0.200	3760.	1850.
914.	914.	0.500	1240.	677.
289.	282.	0.800	398.	197.
150.	144.	0.900	217.	94.
85.	79.	0.950	130.	49.
28.	23.	0.990	48.	13.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.9234	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5671	HIGH OUTLIERS	0
COMPUTED SKEW	-0.5509	LOW OUTLIERS	1
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.4000	SYSTEMATIC EVENTS	52

TABLE C-7 CONT.

-PLOTTING POSITIONS- WRR ND NR ABERCROMBIE

.....EVENTS ANALYZED.....					..... ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS		RANK	WATER YEAR	FLOW,CFS	MEDIAN PLOT POS
0	0	1933	75.		1	1969	9540.	0.0079
0	0	1934	15.		2	1979	6000.	0.0232
0	0	1935	513.		3	1943	5500.	0.0425
0	0	1936	415.		4	1952	5400.	0.0618
0	0	1937	540.		5	1978	4900.	0.0811
0	0	1938	318.		6	1962	3610.	0.1004
0	0	1939	1350.		7	1975	3600.	0.1197
0	0	1940	300.		8	1984	2970.	0.1390
0	0	1941	608.		9	1966	2850.	0.1583
0	0	1942	579.		10	1945	2840.	0.1776
0	0	1943	5500.		11	1965	2820.	0.1969
0	0	1944	956.		12	1953	2500.	0.2162
0	0	1945	2840.		13	1947	2450.	0.2355
0	0	1946	2320.		14	1946	2320.	0.2548
0	0	1947	2450.		15	1950	2300.	0.2741
0	0	1948	729.		16	1972	2100.	0.2934
0	0	1949	650.		17	1967	2050.	0.3127
0	0	1950	2300.		18	1951	1890.	0.3320
0	0	1951	1890.		19	1980	1800.	0.3513
0	0	1952	5400.		20	1982	1550.	0.3706
0	0	1953	2500.		21	1963	1460.	0.3899
0	0	1954	800.		22	1939	1350.	0.4092
0	0	1955	550.		23	1944	956.	0.4285
0	0	1956	750.		24	1976	870.	0.4478
0	0	1957	408.		25	1954	800.	0.4671
0	0	1958	262.		26	1956	750.	0.4864
0	0	1959	222.		27	1948	729.	0.5057
0	0	1960	640.		28	1949	650.	0.5250
0	0	1961	36.		29	1960	640.	0.5443
0	0	1962	3610.		30	1974	630.	0.5635
0	0	1963	1460.		31	1941	608.	0.5828
0	0	1964	415.		32	1942	579.	0.6021
0	0	1965	2820.		33	1970	556.	0.6214
0	0	1966	2850.		34	1955	550.	0.6407
0	0	1967	2050.		35	1937	540.	0.6600
0	0	1968	127.		36	1935	513.	0.6793
0	0	1969	9540.		37	1971	508.	0.6986
0	0	1970	556.		38	1973	426.	0.7179
0	0	1971	508.		39	1964	415.	0.7372
0	0	1972	2100.		40	1936	415.	0.7565
0	0	1973	426.		41	1957	408.	0.7758
0	0	1974	630.		42	1938	318.	0.7951
0	0	1975	3600.		43	1940	300.	0.8144
0	0	1976	870.		44	1983	265.	0.8337
0	0	1977	91.		45	1958	262.	0.8530
0	0	1978	4900.		46	1959	222.	0.8723
0	0	1979	6000.		47	1968	127.	0.8916
0	0	1980	1800.		48	1977	91.	0.9109
0	0	1981	26.		49	1933	75.	0.9302
0	0	1982	1550.		50	1961	36.	0.9495
0	0	1983	265.		51	1981	26.	0.9688
0	0	1984	2970.		52	1934	15.	0.9881

TABLE C-7 CONT.

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*-----------------------------------------------------------------*
* NOTE- PLOTTING POSITIONS BASED ON-HISTORIC PERIOD (H) =  88   *
*       NUMBER OF HISTORIC EVENTS PLUS HIGH OUTLIERS(Z) =   1   *
*       WEIGHTING FACTOR FOR SYSTEMATIC EVENTS  (W) = 1.7059  *
*******************************************************************


-OUTLIER TESTS  -
-------------------------------------------------------------------
LOW OUTLIER TEST
---------------

BASED ON  52 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.783

      1 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF     16.0

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR  1 LOW OUTLIER(S)


-----------------
HIGH OUTLIER TEST
-----------------

BASED ON  51 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.775

     0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF   29717.
                                  OR INPUT BASE OF    9540.

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR  1 HIGH OUTLIER(S)
                                         AND  0 HISTORIC EVENT(S)

-------------------------------------------------------------------


-SKEW WEIGHTING -
-------------------------------------------------------------------
BASED ON  88 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW =  0.093
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW =  0.114
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TABLE C-7 CONT.

ADOPTED
-FREQUENCY CURVE- WRR ND NR ABERCROMBIE

FLOW, CFS		EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY		0.05 LIMIT	0.95 LIMIT
18100.	20700.	0.002	35800.	10800.
14000.	15600.	0.005	26500.	8640.
11200.	12300.	0.010	20500.	7100.
8730.	9350.	0.020	15300.	5670.
6510.	6850.	0.040	10900.	4360.
4020.	4140.	0.100	6250.	2810.
2470.	2510.	0.200	3620.	1800.
895.	895.	0.500	1210.	666.
287.	281.	0.800	394.	197.
151.	144.	0.900	217.	95.
86.	80.	0.950	131.	50.
28.	24.	0.990	49.	14.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.9147	HISTORIC EVENTS	0
STANDARD DEVIATION	0.5596	HIGH OUTLIERS	1
COMPUTED SKEW	-0.5767	LOW OUTLIERS	1
GENERALIZED SKEW	-0.2000	ZERO OR MISSING	0
ADOPTED SKEW	-0.4000	SYSTEMATIC EVENTS	52
		HISTORIC PERIOD	88

Wild Rice River, North Dakota

WR-190 DAMSITE ANALYSIS

SECTION D

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WILD RICE RIVER NORTH DAKOTA
INFLOW HYDROGRAPHS FOR WR-190
3 HOUR VALUES

2-YEAR FLOOD

43.	43.	43.	44.	45.	46.	47.	48.	49.	51.
53.	55.	57.	58.	59.	61.	62.	64.	66.	68.
70.	72.	74.	76.	77.	79.	83.	89.	94.	98.
102.	106.	109.	113.	117.	122.	127.	134.	141.	149.
158.	168.	175.	184.	195.	211.	212.	208.	202.	195.
191.	185.	178.	170.	163.	157.	153.	149.	145.	142.
138.	135.	132.	130.	128.	126.	124.	122.	121.	119.
117.	115.	114.	113.	112.	111.	109.	108.	107.	106.
105.	104.	102.	98.	94.	92.	90.	88.	87.	85.
84.	83.	82.	81.	80.	79.	79.	78.	77.	76.
76.	75.	75.	74.	73.	72.	72.	71.	71.	70.
70.	69.	69.	68.	67.	67.	66.	66.	65.	65.
64.	64.	64.	63.	63.	62.	62.	62.	61.	61.
61.	59.	59.	58.	58.	58.	58.	58.	58.	58.
57.	57.	57.	57.	56.	56.	56.	56.	56.	56.
55.	55.	55.	55.	54.	54.	54.	54.	54.	54.
54.	53.	53.	53.	53.	53.	53.	53.	52.	52.
52.	52.	52.	52.	52.	51.	51.	51.	51.	50.
50.	50.	49.	49.	49.	49.	49.	48.	48.	48.
48.	48.	47.	47.	47.	47.	47.	47.	46.	46.
46.	46.	46.	45.	45.	45.	45.	45.	45.	45.
45.	44.	44.	44.	44.	44.	44.	44.	44.	44.
44.	44.	44.	44.	43.	43.	43.	43.	43.	43.
43.	43.	43.	43.	43.	43.	43.	42.	42.	42.

5-YEAR FLOOD

134.	134.	136.	138.	142.	146.	150.	154.	159.	164.
169.	174.	178.	181.	185.	189.	194.	199.	205.	210.
216.	221.	227.	233.	239.	245.	253.	263.	272.	281.
289.	298.	307.	317.	328.	339.	352.	367.	384.	404.
427.	448.	463.	483.	508.	542.	546.	536.	521.	511.
505.	493.	476.	455.	438.	423.	412.	401.	392.	383.
377.	371.	366.	360.	355.	350.	344.	340.	335.	330.
326.	322.	318.	315.	311.	308.	304.	301.	298.	294.
292.	289.	286.	281.	276.	273.	269.	266.	263.	260.
257.	255.	253.	250.	247.	245.	243.	241.	238.	236.
234.	232.	230.	228.	226.	224.	222.	220.	218.	216.
214.	213.	211.	209.	208.	206.	204.	203.	201.	200.
199.	197.	196.	195.	193.	193.	191.	190.	189.	188.
187.	185.	185.	186.	186.	186.	186.	185.	185.	184.
184.	183.	182.	182.	181.	180.	179.	179.	178.	178.
177.	177.	176.	176.	175.	175.	174.	174.	173.	173.
172.	172.	172.	171.	171.	170.	170.	169.	168.	168.
167.	166.	166.	165.	165.	164.	164.	163.	162.	161.
160.	160.	159.	159.	158.	157.	156.	155.	155.	154.
153.	152.	152.	151.	151.	150.	150.	149.	149.	148.
148.	147.	147.	146.	146.	146.	145.	144.	144.	144.
143.	143.	143.	142.	142.	142.	141.	141.	141.	141.
140.	140.	140.	139.	139.	139.	138.	138.	138.	138.
137.	137.	137.	136.	136.	136.	136.	135.	135.	134.

10-YEAR FLOOD

224.	225.	227.	231.	236.	243.	250.	257.	264.	272.
280.	289.	295.	300.	306.	313.	321.	329.	338.	347.
356.	365.	375.	385.	395.	406.	417.	431.	444.	457.
469.	482.	497.	513.	530.	548.	567.	592.	619.	650.
688.	721.	745.	777.	817.	870.	877.	861.	838.	822.
812.	793.	765.	732.	705.	682.	663.	646.	630.	617.
607.	599.	589.	581.	572.	564.	556.	548.	540.	533.
526.	519.	513.	508.	502.	497.	491.	485.	480.	475.
471.	466.	461.	456.	451.	447.	442.	437.	433.	429.
425.	421.	417.	413.	409.	405.	401.	397.	393.	390.
387.	383.	380.	376.	373.	370.	366.	363.	360.	357.
354.	351.	348.	346.	343.	340.	338.	335.	333.	330.
328.	326.	324.	322.	320.	318.	316.	314.	312.	310.
309.	307.	307.	308.	309.	309.	309.	309.	308.	307.
306.	305.	304.	303.	301.	300.	299.	298.	297.	296.
295.	294.	293.	292.	291.	291.	290.	289.	288.	287.
287.	286.	286.	285.	284.	283.	282.	281.	280.	279.
278.	277.	276.	275.	274.	273.	272.	271.	270.	268.
267.	266.	265.	264.	263.	261.	260.	259.	257.	256.
255.	254.	253.	252.	251.	250.	249.	248.	247.	247.
246.	245.	245.	244.	243.	242.	241.	240.	240.	239.
239.	238.	237.	237.	236.	236.	235.	235.	234.	234.
233.	233.	232.	232.	231.	231.	230.	230.	229.	229.
228.	228.	227.	227.	226.	226.	225.	225.	224.	224.

25-YEAR FLOOD

362.	363.	367.	373.	381.	392.	403.	415.	427.	440.
452.	465.	475.	481.	491.	502.	514.	526.	541.	555.
570.	585.	600.	616.	632.	650.	668.	690.	710.	731.
750.	772.	795.	820.	848.	879.	913.	954.	999.	1051.
1112.	1167.	1207.	1260.	1326.	1413.	1424.	1398.	1360.	1333.
1316.	1285.	1239.	1184.	1140.	1103.	1072.	1045.	1020.	994.
977.	961.	945.	931.	916.	902.	889.	877.	865.	853.
842.	831.	821.	812.	803.	794.	785.	776.	768.	760.
753.	746.	738.	730.	722.	715.	708.	701.	693.	687.
680.	674.	668.	661.	654.	648.	642.	636.	630.	624.
619.	613.	608.	602.	597.	592.	587.	582.	577.	572.
567.	562.	557.	553.	549.	545.	540.	536.	533.	529.
525.	521.	518.	515.	512.	509.	506.	503.	500.	497.
494.	493.	493.	497.	498.	499.	499.	498.	497.	496.
494.	493.	491.	489.	487.	485.	483.	481.	479.	478.
476.	475.	473.	472.	471.	470.	469.	467.	466.	464.
463.	462.	461.	460.	459.	457.	456.	454.	453.	451.
449.	448.	446.	445.	443.	441.	440.	438.	436.	434.
432.	430.	428.	426.	424.	422.	420.	418.	415.	414.
412.	410.	408.	407.	405.	404.	402.	401.	399.	398.
397.	396.	395.	394.	393.	392.	390.	389.	388.	386.
386.	385.	384.	383.	382.	381.	380.	379.	379.	378.
377.	376.	375.	374.	374.	373.	372.	371.	370.	370.
369.	368.	367.	366.	366.	365.	364.	363.	362.	361.

50-YEAR FLOOD

470.	471.	477.	485.	496.	510.	524.	540.	556.	572.
589.	606.	622.	633.	647.	663.	680.	696.	716.	735.
755.	775.	795.	816.	838.	861.	884.	909.	932.	958.
981.	1008.	1038.	1071.	1106.	1149.	1205.	1266.	1332.	1404.
1489.	1566.	1624.	1703.	1798.	1919.	1937.	1904.	1853.	1816.
1791.	1742.	1675.	1598.	1537.	1485.	1443.	1405.	1370.	1334.
1300.	1272.	1246.	1223.	1201.	1181.	1163.	1146.	1129.	1113.
1098.	1084.	1071.	1059.	1048.	1036.	1024.	1013.	1001.	991.
982.	972.	963.	957.	949.	942.	934.	926.	917.	909.
901.	893.	884.	875.	866.	858.	851.	843.	834.	827.
820.	813.	806.	798.	792.	785.	777.	771.	764.	758.
751.	744.	738.	732.	727.	721.	716.	711.	706.	701.
696.	691.	687.	683.	679.	675.	671.	666.	663.	659.
655.	652.	649.	652.	652.	652.	651.	649.	648.	646.
643.	641.	639.	636.	633.	631.	628.	626.	624.	622.
620.	618.	616.	614.	613.	612.	610.	609.	607.	605.
603.	602.	600.	599.	597.	595.	593.	591.	589.	587.
585.	583.	581.	579.	577.	575.	572.	570.	567.	565.
562.	559.	557.	555.	552.	549.	546.	543.	541.	539.
536.	534.	532.	530.	528.	525.	523.	522.	520.	518.
517.	516.	514.	513.	511.	509.	508.	506.	504.	503.
502.	501.	499.	498.	497.	496.	495.	494.	493.	492.
491.	489.	489.	488.	487.	485.	484.	483.	482.	481.
480.	479.	478.	477.	476.	475.	474.	473.	472.	471.

100-YEAR FLOOD

577.	578.	585.	595.	609.	626.	643.	662.	682.	702.
722.	744.	765.	785.	806.	829.	853.	876.	901.	927.
952.	977.	1003.	1030.	1057.	1086.	1117.	1152.	1184.	1219.
1250.	1285.	1324.	1366.	1412.	1467.	1541.	1621.	1706.	1800.
1910.	2015.	2103.	2218.	2350.	2516.	2542.	2500.	2433.	2380.
2333.	2259.	2167.	2063.	1981.	1912.	1856.	1807.	1761.	1713.
1667.	1629.	1594.	1564.	1535.	1510.	1486.	1463.	1442.	1421.
1403.	1384.	1368.	1353.	1338.	1324.	1308.	1293.	1279.	1265.
1253.	1242.	1230.	1217.	1204.	1193.	1182.	1170.	1158.	1148.
1137.	1127.	1116.	1105.	1094.	1084.	1075.	1064.	1054.	1044.
1036.	1026.	1017.	1008.	999.	991.	981.	973.	965.	957.
948.	940.	932.	925.	918.	911.	904.	898.	891.	884.
878.	872.	866.	862.	856.	852.	847.	841.	836.	832.
827.	822.	818.	814.	810.	807.	803.	800.	797.	794.
790.	787.	784.	780.	777.	774.	771.	768.	766.	763.
760.	758.	756.	754.	752.	750.	748.	746.	744.	742.
740.	738.	736.	734.	732.	730.	728.	725.	723.	720.
718.	715.	712.	710.	707.	705.	702.	699.	696.	692.
689.	686.	683.	680.	677.	674.	670.	667.	664.	661.
658.	655.	652.	650.	647.	644.	642.	640.	638.	636.
634.	632.	631.	629.	627.	625.	623.	620.	619.	617.
615.	614.	612.	611.	610.	608.	607.	606.	604.	603.
602.	600.	599.	598.	596.	595.	594.	593.	591.	590.
589.	587.	586.	585.	584.	582.	581.	580.	578.	577.

200-YEAR FLOOD

692.	693.	701.	714.	730.	750.	771.	793.	818.	842.
866.	892.	917.	941.	967.	995.	1023.	1050.	1081.	1112.
1142.	1173.	1204.	1236.	1268.	1303.	1342.	1396.	1442.	1489.
1532.	1577.	1626.	1679.	1737.	1807.	1907.	2012.	2123.	2242.
2381.	2517.	2644.	2799.	2976.	3203.	3235.	3181.	3096.	3026.
2950.	2847.	2724.	2590.	2483.	2394.	2322.	2260.	2202.	2140.
2074.	2021.	1973.	1933.	1895.	1862.	1831.	1803.	1776.	1751.
1728.	1705.	1684.	1665.	1647.	1629.	1610.	1592.	1574.	1558.
1543.	1529.	1512.	1486.	1463.	1445.	1427.	1410.	1394.	1380.
1366.	1354.	1340.	1326.	1312.	1300.	1289.	1277.	1264.	1253.
1243.	1231.	1221.	1209.	1199.	1188.	1177.	1167.	1158.	1148.
1137.	1128.	1118.	1110.	1101.	1093.	1085.	1077.	1069.	1061.
1053.	1046.	1040.	1034.	1027.	1022.	1016.	1009.	1003.	998.
992.	987.	982.	977.	972.	967.	963.	959.	955.	951.
947.	943.	939.	935.	931.	928.	924.	921.	918.	915.
911.	908.	906.	904.	901.	899.	897.	894.	892.	889.
887.	884.	882.	880.	878.	875.	872.	869.	866.	863.
860.	857.	854.	851.	848.	845.	842.	838.	834.	830.
826.	823.	819.	816.	812.	808.	803.	799.	795.	792.
789.	785.	782.	779.	776.	773.	769.	767.	765.	763.
760.	758.	756.	754.	751.	749.	747.	744.	742.	740.
738.	736.	734.	733.	731.	729.	728.	726.	725.	723.
722.	720.	718.	717.	715.	714.	712.	711.	709.	708.
706.	704.	703.	701.	700.	698.	697.	695.	694.	692.

500-YEAR FLOOD

835.	835.	841.	852.	866.	886.	907.	930.	955.	982.
1008.	1037.	1066.	1100.	1136.	1172.	1208.	1243.	1281.	1318.
1356.	1393.	1431.	1471.	1511.	1552.	1595.	1661.	1718.	1778.
1833.	1890.	1949.	2013.	2081.	2157.	2280.	2410.	2546.	2688.
2853.	3021.	3199.	3405.	3616.	3937.	4047.	4060.	4018.	3976.
3900.	3795.	3667.	3515.	3385.	3269.	3168.	3077.	2994.	2910.
2804.	2716.	2637.	2568.	2506.	2450.	2400.	2354.	2312.	2273.
2237.	2203.	2172.	2143.	2117.	2092.	2065.	2040.	2017.	1994.
1973.	1953.	1933.	1898.	1866.	1839.	1814.	1790.	1767.	1747.
1727.	1710.	1692.	1674.	1655.	1639.	1624.	1608.	1591.	1576.
1562.	1548.	1534.	1519.	1506.	1493.	1479.	1466.	1453.	1442.
1428.	1416.	1404.	1393.	1382.	1371.	1361.	1350.	1340.	1330.
1321.	1311.	1302.	1294.	1286.	1279.	1271.	1263.	1255.	1248.
1240.	1234.	1226.	1214.	1202.	1192.	1184.	1176.	1169.	1162.
1156.	1151.	1145.	1139.	1134.	1129.	1124.	1119.	1115.	1111.
1107.	1103.	1099.	1096.	1093.	1091.	1088.	1084.	1081.	1078.
1075.	1072.	1070.	1067.	1064.	1061.	1057.	1054.	1051.	1047.
1044.	1040.	1036.	1032.	1029.	1025.	1022.	1018.	1013.	1009.
1004.	1000.	996.	991.	987.	982.	977.	972.	968.	963.
959.	955.	950.	947.	943.	939.	935.	931.	928.	926.
923.	920.	917.	914.	911.	909.	906.	903.	900.	897.
894.	892.	890.	888.	886.	884.	882.	880.	878.	876.
874.	872.	870.	868.	866.	864.	862.	861.	859.	857.
855.	853.	851.	849.	848.	846.	844.	842.	840.	838.