US Army Corps of Engineers
St. Paul District

Emergency Outlet Plan

Devils Lake, North Dakota

Devils Lake, North Dakota - 29 May 1996

Technical Appendices
12 August 1996

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Engineer Dist.,St Paul 6b. OFFICE SYMBOL *(If applicable)*	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS *(City, State, and ZIP Code)* 190 5th St. E. St. Paul, MN 55101-1638	7b. ADDRESS *(City, State, and ZIP Code)*
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL *(If applicable)*	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS *(City, State, and ZIP Code)*	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*
Devils Lake, North Dakota Emergency Outlet Plan ; Technical Appendices.

12. PERSONAL AUTHOR(S)

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT *(Year, Month, Day)*	15. PAGE COUNT
	FROM ____ TO ____	960812	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
WATER LEVELS
DEVILS LAKE (ND)

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The Devils Lake Emergency Outlet Plan consolidates available information on a plan that could help reduce the Devils Lake flooding problem. The plan examines engineering feasibility, effectiveness and potential impacts. While the plan lacks much field data to verify existing conditions and a full assessment of impacts, it will be a common reference point for discussions among interested parties regarding the practicability and implementability of an emergency outlet.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE *(Include Area Code)* / 22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

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OUTLET SELECTION CRITERIA APPENDIX

GENERAL

1. The basic outlet plan chosen for the EOP was selected on the basis of a number of criteria -- engineering feasibility and availability of information, relative effectiveness, views of the Spirit Lake Nation, costs, potential impacts, acceptability to downstream interests, compatibility with an inlet, and construction time.

2. The candidate judged to offer the best balance between those criteria was a pumped-storage plan to move lake water over the divide (high ground) between Devils Lake and the Sheyenne River via the Twin Lakes outlet route. Basically, this plan involves pumping water at a peak discharge rate of 200 cfs into a series of three pools created by earthfill dams; the pools act like a step ladder to successively raise the water up to the top of the divide. At that point, the water flows down to the Sheyenne in an open channel, with a series of drop structures to absorb the energy of the flowing water.

3. The following sections discuss the selection criteria and qualitative assessment that led to the selection of the Twin Lakes outlet plan.

ENGINEERING FEASIBILITY / AVAILABILITY OF INFORMATION

4. The degree of confidence in a plan's engineering feasibility is directly related to the availability of information. Both the Corps of Engineers (COE) and the North Dakota State Water Commission (NDSWC) had previously examined the pumped-storage option for the Twin Lakes and Peterson Coulee outlet routes. Therefore, the EOP effort could draw on those preliminary data to refine a concept that was already considered fundamentally sound.

5. Other alternatives and variations have varying degrees of appeal at first glance, but either are too costly or lack sufficient information for a confident assessment of feasibility. For instance, the pipeline options considered in the Contingency Plan could reduce environmental effects along the outlet route, but they were several times more costly than the pumped-storage option. Likewise, variations (such as a Minnewaukan Road raise or Ziebach Pass closure) which might improve outlet water quality (WQ) and allow larger releases would increase costs and implementation complexity considerably. Also, in May 1996, Spirit Lake Nation representatives noted that, in a series of community meetings, Tribal members had expressed opposition to options which would isolate portions of the lake. Therefore, these variations were dropped from consideration for the EOP.

6. After the Contingency Plan was issued 15 February 1996, a "new" alternative was proposed to release Devils Lake waters through Stump Lake to the Sheyenne or Goose River with a Freeze-Thaw-Evaporation (FTE) plant to freshen the water. This alternative was not selected for the EOP because field tests of the FTE process have not been done at the scale needed for a Devils Lake outlet nor under climatic conditions replicating those in the Devils Lake region. Therefore, there are too many unanswered questions at this time to ensure that the Tasker's "engineeringly feasible" goal would be met. Furthermore, this alternative would cost significantly more than the Twin Lakes pumped-storage outlet.

7. A gravity-flow tunnel is another alternative that was not included in the Contingency Plan and not considered for the EOP. Geotechnical information is too sparse at this time to develop a failsafe tunnel design without large factors of safety to cover unknowns. Even without those contingencies, a tunnel is one of the most expensive candidates.

RELATIVE EFFECTIVENESS

8. The outlet's effectiveness, measured in terms of how much it could lower Devils Lake (or prevent its rise), depends on the outflow rate, which is limited by the Sheyenne's bank-full capacity and sulfate standard and, further downstream, Total Dissolved Solids (TDS) and sulfate standards on the Red River of the North and objectives at the International Border between Canada and the United States, all of which constrain the "window" for Devils Lake releases.[1]

9. The Devils Lake Feasibility Study will determine the Sheyenne River's bank-full channel capacity and examine sulfate dynamics in the lake and river. However, those results were not yet available for the EOP exercise. Therefore, the EOP initially assumed a bank-full capacity of 500 cfs and sulfate concentrations of 100 mg/l in the Sheyenne and 800 mg/l in Devils Lake, a set of conditions which would allow a maximum outlet capacity of 250 cfs. Flow-duration records for the river show that 250- and 200-cfs outlet capacities would be usable about 5 and 6 percent of the time, respectively. That suggests that the additional 50-cfs capacity would be used just 1 percent of the time, producing no significant additional drawdown; therefore, in the initial set of assumptions for the EOP, it was considered more cost-effective to use a 200-cfs capacity.

10. During the EOP, the COE tested the sensitivity of costs and effectiveness to assumptions of bank-full capacity and lake sulfate concentration. As those analyses proceeded, it became apparent that a larger bank-full capacity and the diluted sulfate concentrations at the current historically high lake stages made larger outlet capacities practicable. Therefore, the EOP also looked at a outlet capacity of 300 cfs.

11. Because the WQ of Devils Lake inflows and river water is comparable, another approach is to capture and outlet Devils Lake inflow before it mixes with lake water, which would allow releases limited just by the river's bank-full capacity. One such variation is to raise the Minnewaukan Flats Road to act as a dam capturing Big Coulee's inflows. However, that approach incurs significantly higher costs for the Flats Road raise, longer pipelines and channels, bigger pump stations, etc. Also, because of the relative timing of the spring runoff in the river and Devils Lake inflows, much of the Devils Lake inflow would have to be bypassed into the West Bay until the river fell below bank-full stage, largely eliminating the advantage of this approach and raising the question of whether the limited advantage is worth the added cost, a question which would not be answered during the EOP. Therefore, this approach was not incorporated in the EOP. Likewise, consideration of a Ziebach Pass closure and possible benefits from overall freshening of the West Bay were considered beyond the scope of the EOP effort and will be deferred to the Feasibility Study.

VIEWS OF THE SPIRIT LAKE NATION

12. Almost every outlet route crosses some part of the Ft. Totten Reservation; therefore, support of the Spirit Lake Nation is paramount. At a mid-1995 meeting of the Tribal Chairman, Tribal Council members, other local representatives, COE, and Bureau of Reclamation (BOR), the Tribal Chairman expressed a preference for the Twin Lakes route over the Peterson Coulee route. Recent discussions between the COE, Tribal Emergency Management/Indian

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[1] The North Dakota standard for sulfate concentration in the Sheyenne River is 450 mg/l. There is no TDS standard for the Sheyenne River. North Dakota and Minnesota standards for TDS and sulfate for the Red River of the North are 500 mg/l and 250 mg/l, respectively. Objectives at the International Border match the Red River standards.

Health Service, and Bureau of Indian Affairs (BIA) Real Estate Office suggest that the Tribal position has not changed.

13. As noted earlier, those discussions also indicated that Tribal members generally oppose blocking off parts of the lake, e.g., using a Minnewaukan Flats Road raise as a dam to capture incoming fresh water from Big Coulee. Conversely, acceptability of a Ziebach Pass closure may depend on whether a roadway was included to provide an alternative to Highway 57, which will have to be closed in 1996 during periods of high winds and waves. Tribal representatives have also indicated a strong interest in protecting aquifers. The latter position weighed against the gravity-flow channel, which would cut through the Spiritwood Aquifer according to available geotechnical information.

COSTS

14. Consideration was given to first costs (e.g., for planning, engineering, design, real estate, and construction) and operation, maintenance, and replacement (OM&R) costs. Based on a preliminary life-cycle cost analysis using cost estimates from the Contingency Plan, the COE judged that the Twin Lakes pumped-storage alternative was the least-cost alternative.

15. That analysis assumed that, initially, the outlet would be operated 8 years to help bring the lake down to a desirable level, followed by sequences of 5 years of downtime and 2 years of operation for the remainder of the assumed 50-year project life. The results indicated that, in terms of overall average annual costs for interest and amortization (I&A) of first costs plus OM&R, the lower first costs of the Twin Lakes pumped-storage outlet more than compensated for its higher OM&R costs when compared to a gravity-flow channel which has lower OM&R costs but a first cost about twice that of the pumped-storage alternative.

POTENTIAL ENVIRONMENTAL AND CULTURAL IMPACTS

16. Impact assessments must look at Devils Lake itself, the outlet route, and receiving waters downstream. The alternative outlet routes have basically similar potential environmental and cultural impacts along the route itself. However, some alternatives offer possible advantages to Devils Lake (e.g., an east-end outlet releasing the lake's worst quality water might, over many years, freshen the lake). Other alternatives might be preferable for downstream WQ or outlet effectiveness (e.g., diverting Big Coulee directly to the river before it mixes with lake water). Therefore, selection involved trade-offs and compromises between impacts, costs (including possible mitigation costs), effectiveness, acceptability to downstream interests, etc.

ACCEPTABILITY TO DOWNSTREAM INTERESTS

17. Most Devils Lake residents understand and accept that downstream folks might sympathize with the Devils Lake situation, but will oppose any plan that inflicts some degree of Devils Lake's problems on them. That is why any plan releasing poor quality water from the east end of Devils Lake would be strongly opposed. The EOP's commitment to minimizing adverse downstream impacts is reflected (a) in the choice of the Twin Lakes route, which would release fresher water from the west end of the lake and (b) in the adoption of operating constraints to meet downstream WQ standards and to keep flows within the channel (bank-full) capacity.

COMPATIBILITY WITH AN INLET

19. Should an emergency outlet be built, several factors favor leaving it in place indefinitely -- an investment exceeding $20,000,000, major right-of-way (ROW) work, the certainty that the lake will rise again at some point in the

future, etc. Consequently, the EOP had to be considered in terms of likely permanency.

20. In addition, Congress, through Public Law 102-377, has directed the COE to conduct a feasibility study to investigate, among other things, lake stabilization ("to include inlet and outlet controls"). Therefore, when selecting the outlet route for the EOP, the COE was obligated to consider compatibility with potential inlet options that might be looked at during the Devils Lake Feasibility Study.

21. For example, during the 1995 interagency, collaborative process to develop a concept-level Plan of Study for the Devils Lake Feasibility Study, one inlet plan that was suggested would release Garrison Diversion Unit (GDU) water into the Sheyenne River upstream of Devils Lake. The mix of river and GDU water could be withdrawn from the river by a pump station built at the southern end of the Twin Lakes route and delivered by pipeline up to the divide. The water would then back-flow north through the EOP's pools to Devils Lake. No effort was made during the EOP exercise to put a cost estimate on an inlet concept; the only consideration was the engineering compatibility of the EOP and an inlet.

CONSTRUCTION TIME

22. By definition, an emergency outlet should be built in the minimum amount of time. At first glance, the construction time was not particularly dependent on outlet route. Nonetheless, the sheer magnitude of a Devils Lake outlet job and constraints on the construction season due to the harsh winter conditions suggest a construction period of between 1½ - 2 years. Also, construction time would be sensitive to options, e.g., incorporating the Ziebach Pass closure or an FTE plant would add to the duration.

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

GEOTECHNICAL AND GEOLOGIC ENGINEERING APPENDIX

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GEOTECHNICAL AND GEOLOGIC ENGINEERING APPENDIX

GENERAL

1. The Devils Lake Contingency Report dated 15 February 1996 was used to identify possible emergency outlet alignments and plans. After a short review of the alternatives, the design team used engineering feasibility, relative effectiveness, Tribal position, first cost, O&M cost, environmental and cultural impacts, compatibility with inlet, and construction time to select one alternative for further study. The major features of the plan were identified, typical sections drafted, and alignment and locations selected.

2. During the brainstorming meeting, the design team selected the pumped storage/open channel combination and the Twin Lakes alignment (plates 1 and 2) for the emergency outlet to the Sheyenne River. The plan includes ponding water in three reaches with three embankments, an emergency spillway for one embankment, three pump stations, 42,400 feet of channel, 19 gabion control structures and a maximum pumping capacity of 200 cfs.

TOPOGRAPHY AND GEOLOGY

3. The topography and geology of the Devils Lake area is diverse and is a consequence of its glacial history. Glaciers invaded the Devils Lake basin several times during the Pleistocene Epoch and laid down a thick mantle of drift on top of an eroded bedrock surface. The generalized geologic cross-section on Plate 3 shows the major topographic features which are reflective of the bedrock surface and the type of glacial deposit. The most distinctive topographic areas include the closed lake basin, outwash plains, low-relief moraine and the high-relief moraine. Since the glaciers left the region approximately 10,000 years ago, the topography has changed very little.

4. Depth to bedrock in the region varies from near the surface to 200 feet. The bedrock is impervious clay shale of the Pierre Formation. Fractures in the upper zone of the shale, however, store and transmit small quantities of water to wells. Buried valley aquifers are, as the name implies, glacial and preglacial valleys that were filled and covered during glaciation. Sandy phases in these valleys are now major aquifers in the region. One of the major aquifers for the area, referred to the Spiritwood aquifer, is of this type and it underlies the Devils Lake chain. The dominant glacial sediment is till. Till is a mixture of sand, silt, and clay and is the most widely spread throughout the area. Most of the till is not an aquifer, although sandier phases may supply limited groundwater for some. Sand and gravel beds and channels occur within and at the surface of the till. These sandy phases yield water to wells. The Lacustrine sediments of importance are primarily silt and clay deposited in Devils Lake. Geologic evidence indicates that over the last 4,000 years the lake has dried up completely five or six times, and it has overflowed into the Sheyenne River at least twice. These sediments are not important as an aquifer but retard seepage into or out of the lake. Surficial outwash material are the near-surface sand and gravel deposits, typically glacial meltwater channels, developed during the waning glacial time. Locally, the outwash is an important groundwater resource.

5. Plate 4 shows a plan view of the proposed alignment on a generalized geologic map of north-central North Dakota. The project alignment essentially begins in the old closed lake basin of Devils Lake and continues south along a surficial outwash deposit which cuts through the high-relief moraine to the Sheyenne River. The soils at the inlet channel are assumed to be lake-bed silts and clays. The embankment foundations and the majority of outlet channel excavation is assumed to be in the glacial outwash sands and gravels. The Pierre shale is not expected to be encountered along this alignment. A 1987 draft study done by the COE comparing possible alignments for such a

channel indicated this alignment as one with minimal groundwater impacts. The previous study had limited site-specific groundwater data, as does this overview. It is recognized that further development of any plan will require a substantial subsurface investigation including characterizing the hydrogeology of the affected area. A more detailed subsurface data search and exploration program of this Twin Lakes alignment is planned for the Devils Lake Feasibility Study.

SUBSURFACE INVESTIGATION

6. Borings have not been taken along the Twin Lakes alignment for the emergency outlet or for any other project, Federal, State, or local. Therefore, the design features chosen were based on professional judgment using the general geology of the area. Prior to plans and specifications, borings and laboratory testing is necessary to verify the functionality of the design features.

DESIGN PARAMETERS

7. Design parameters were not selected for this plan because technical analyzes were not performed. Engineering judgment was used to determine the main conceptual features of each embankment, channel side slopes, and pump station foundations.

DAMS

General

8. The three dams are earth embankments constructed of borrow material taken from channel excavation along the alignment. It is assumed that the borrow material will be suitable for the embankment, but material used for the impervious core, riprap and pervious drains will be brought in from off site. All three embankments are of similar design, a 20-foot top width, 1-vertical-on-2.5-horizontal side slopes, an impervious core surrounded by random fill, and a pervious drain and toe drain.

9. It is assumed that the embankments, foundations, and abutments are stable under all conditions of construction and operation. Seepage through the embankment, foundation and abutments would be controlled with the features selected to prevent excessive uplift pressures, piping, and sloughing. Freeboard was selected to be 5 feet in order to prevent overtopping by waves and allowance for unanticipated settlement of the foundation. Seepage control measures vary between embankments depending on the geology of the area where the embankments are located.

10. The 20-foot top width and 1-vertical-on-2.5 side slopes are the minimum values which should be used for these embankments. The top width and side slopes were selected because of the emergency nature of this study and an attempt to reduce construction time. The top width and side slopes need to be verified by analysis before construction.

11. It is assumed that significant seepage will not occur through the abutment. If seepage is determined to be a potential problem, seepage control consisting of flattening the side slopes of the embankment at the abutment would be done. Based on the USGS quadrangle map (10-foot contours), the embankment abutment slopes are not steep. Therefore, potential differential settlements resulting in tension cracks of the impervious core should not result. If analysis indicates that tension cracks do appear possible, then it may be necessary to widen the impervious core to reduce seepage potential.

12. A slurry-type cutoff trench was selected for the two embankments located where the foundations are sand and gravel. The trench is assumed to have a 4-

foot width and a depth of 40 feet. Standard construction techniques are assumed for the trench, which can be accomplished with dragline, backhoe, or trenching machines. It is assumed that the foundation does not contain an excessive amount of boulders in the lower portion of the trench, which would make construction more difficult. The slurry trench will not tie into an impervious zone totally cutting off seepage and, therefore, a toe drain is required to help control the seepage.

Dam #1

13. The earth dam has a top elevation of 1455, with a 20-foot top width, 1-vertical-on-2.5-horizontal side slopes, an impervious core surrounded by random fill, a pervious drain along the impervious core, relief wells in the vicinity of the pump station, and a toe drain. A typical cross section through the channel centerline is shown on plate 5.

14. Pump station #1 is located at the toe of the embankment as shown on plate 5. The maximum head across the dam is 26.5 feet, assuming that Devils Lake is allowed to be drawn down to elevation 1423.5. The inlet and outlet channel bottoms are 1423.5 and 1440, respectively. During pumping operations, the outlet channel will be ponded at elevation 1450. The pump station is designed to allow flow from the outlet channel to the inlet channel if interior drainage requires drawing down the pond between embankments #1 and #2.

15. The impervious core has a top elevation of 1453, with a 10-foot top width and 0.6-vertical-on-1-horizontal side slopes. The core top width of 10 feet is the minimum for construction equipment. Considerable amount of excavation is recommended between the intake and output channels because of uncertainly in the shear strength of the lacustrine clay and to increase the width of the impervious core to reduce the potential for seepage and piping.

16. The impervious core will tie into an inspection trench, which is backfilled with the same material as the impervious core. The inspection trench will have a 10 foot bottom width and 1-vertical-on-2-horizontal side slopes. The inspection trench will determine if any sand seams or unsatisfactory material exist directly below the dam. The size of the inspection trench may increase in depth after borings are taken, which will be done prior to final design and construction.

17. The impervious core is surrounded with random fill. It is not known if the material excavated from the inlet and outlet channels are predominately pervious, impervious, or truly random in nature. The geology shows that the foundation changes from lacustrine clays in the vicinity of Devils Lake to sands and gravels at approximately station 100+00. Where the exact dividing line is will need to be determined from borings taken along the channel alignment. Because of high lake and groundwater, most of the inlet channel and some of the outlet channel will be excavated in the wet. It was assumed that most of the random fill will come from the outlet channel, and that the material will be suitable for embankment fill. If the material from channel excavation is not suitable, borrow sites will be located in the area of the dam and the channel material brought to a disposal site. Because of these uncertainties, the final zoning of the dam may change, but the cost should not significantly change if suitable material can be found close to the site. The subsurface exploration program will help determine the final design of the embankment.

18. Because of the large random nature of the embankment, an inclined and horizontal drainage layer (sand drain) has been included within the dam to help control seepage and isolate the downstream (north slope) zone from effects of through seepage. The horizontal drainage layer will tie into a toe drain (plate 6) which has a perforated PVC pipe. The toe drain will keep the north toe from getting soft from seepage exiting on the slope. The toe drain

will have flushing and observation risers spaced every 150 feet for the length of the dam. The perforated pipe will exit into the pump station.

19. To control uplift pressures on the north slope of the embankment, relief wells will be constructed. Four relief wells, 40 feet in length are placed in the area of the pump station and are designed to flow without pumping. It is assumed that the relief well screens are 8 inches in diameter with an 11-inch gravel pack for a total diameter of 30 inches. It has been found that horizontal berms downstream (north slope for this project) of dams tend to trap and concentrate runoff from the upper slope surface tending to cause erosion of the lower slope. Therefore, a shallow ditch will be included in the final design ditch to handle surface runoff.

20. Riprap and bedding will provide erosion protection of the slopes on both the north and south portions of the embankment. St. Paul District standard riprap and bedding designs are used. On the south slope, the design calls for 12 inches of riprap and 6 inches of bedding. The riprap and bedding will run the entire length of the slope, from the top of the embankment to the toe. The north slope will have 18 inches of riprap and 9 inches of bedding to protect the slope from wave action.

The riprap and bedding will run from elevation 1445 to the toe of the slope. It is assumed that the pump station will be operational and will draw down the lake below elevation 1440 shortly after construction. If the operation plan is different, the riprap will need to extend above elevation 1445. All other areas will be protected with 12 inches of top soil and seed.

Dam #2

21. The dam's embankment has a top elevation of 1477, with a 20-foot top width, 1- vertical-on-2.5-horizontal side slopes, an impervious core surrounded by random fill, a pervious drain along the impervious core, a toe drain and slurry cutoff trench. A typical cross section through the channel centerline is shown on plate 5.

22. Pump station #2 is located at the toe of the embankment as shown on plate 5. The maximum head across the dam is 21 feet. The inlet channel (outlet channel of embankment 1) has a bottom elevation of 1439 at the toe of the dam. Pumping operations will pond water on the south side of the embankment to elevation 1470. The pump station is designed to allow flow from the outlet channel to the inlet channel if interior drainage requires drawing down the ponded water between embankments #2 and #3.

23. The impervious core has a top elevation of 1473, with a 10-foot top width and 0.6-vertical-on-1-horizontal side slopes. The core top width of 10 feet is considered to be the minimum for construction equipment. In the area of the maximum head, the foundation is over-excavated and the width of the impervious core base increased to reduce the potential for seepage and piping. In addition, a slurry trench 40 feet in length and 4 feet in thickness will tie into the impervious inspection trench and core.

24. Prior to installing the slurry trench, an inspection trench 5 feet deep with a 10-foot bottom width and 1-vertical-on-2-horizontal side slopes will be excavated. The inspection trench will identify unsatisfactory foundation conditions and will allow containment of the slurry trench operations.

25. The impervious core is surrounded with random fill. It is not known if the material excavated from the inlet channel (outlet channel of embankment #1) is predominately pervious, impervious, or truly random in nature. The geology indicates that the foundation from approximately station 100+00 to 680+00 is predominately sands and gravels. However, portions of the channel are excavated through wetland areas which could have a layer of clay or muck

above the sand and gravel. The thickness of this layer needs to be determined from borings taken along the channel alignment. Because of high groundwater, some of the channel will be excavated in the wet. It was assumed that the material will be suitable for embankment fill. If the material from channel excavation is not suitable, borrow sites will be located in the area of the dam and the channel material brought to a disposal site. Because of these uncertainties, the final zoning of the dam may change, but the cost should not significantly change if suitable material can be found close to the site. The subsurface exploration program will help determine the final design of the embankment.

26. Because of the large random nature of the embankment, an inclined and horizontal drainage layer (sand drain) has been included within the upstream (water flows from Devils Lake to Sheyenne River) portion of the dam to help control seepage and isolate the upstream zone from effects of through seepage. The horizontal drainage layer will tie into a upstream toe drain with a perforated pipe. The toe drain will keep the north toe from getting soft from seepage exiting on the slope. The toe drain will have flushing and observation risers spaced every 150 feet for the length of the dam. The perforated pipe will exit into the pump station.

27. Uplift pressures at the north slope of the embankment are not expected to be of concern if the foundation is predominately sands and gravels. If a thin layer of impervious material (5 feet or less) is present, over-excavation of the foundation may be necessary for the entire length of the dam.

28. Riprap and bedding will provide erosion protection of the slopes on both the north and south portions of the embankment. Standard riprap and bedding designs are used. On both the north and south slopes, the design calls for 12 inches of riprap and 6 inches of bedding. The riprap and bedding will run the entire length of the south slope, from the top of the embankment to the toe. The north slope will have riprap and bedding from elevation 1455 to the toe of the slope. All other areas will be protected with 12 inches of top soil and seed.

Dam #3

29. The dam's embankment has a top elevation of 1500, with a 20-foot top width, 1-vertical-on-2.5-horizontal side slopes, an impervious core surrounded by random fill, a upstream pervious drain along the impervious core, a toe drain and slurry cutoff trench. A typical cross section through the channel centerline is shown on plate 5.

30. Pump station #3 is located at the toe of the embankment as shown on plate 5. The maximum head across the dam is 25 feet. A short inlet channel is required to provide adequate depth for the pump station intake. The bottom elevation of the inlet channel is 1460 at the toe of the dam. Pumping operations will pond water on the south side of the embankment to elevation 1495 for approximately 3000 feet, until it flows into the outlet channel to the Sheyenne River. The pump station also designed to allow flow from the outlet channel to the inlet channel if interior drainage requires drawing down the ponded area.

31. The impervious core has a top elevation of 1498, with a 10-foot top width and 0.6-vertical-on-1-horizontal side slopes. The core top width of 10 feet is considered to be the minimum for construction equipment. In the area of maximum head, the foundation is over-excavated and the width of the impervious core base increased to reduce the potential for seepage and piping. In addition, a slurry trench 40 feet in length and 4 feet in thickness will tie into the impervious core.

32. Prior to installing the slurry trench, an inspection trench 5 feet deep

with a 10-foot bottom width and 1-vertical-on-2-horizontal side slopes will be excavated. The inspection trench will identify unsatisfactory foundation conditions and will allow containment of the slurry trench operations.

33. The impervious core is surrounded with random fill. It is assumed that the material excavated from the outlet channel to the Sheyenne River is predominately random in nature. The geology shows that the foundation at depth is predominately sands and gravels. However, the channel is only a few feet deep from the outlet of the pond to the Sheyenne River, which is assumed to be more random then pervious. In addition, portions of the channel are excavated through wetland areas which could have a layer of clay or muck above the more pervious material, although only a small portion of the total excavation is assumed to contain clay or muck. Borings taken along this alignment will verify if the excavation is random or predominately sands and gravels.

34. Because of high groundwater, some of the channel will be excavated in the wet. It was assumed that the material would still be suitable for embankment fill, and other borrow sites are not required. The subsurface exploration program will help verify the excavated material and, therefore, the final design of the embankment.

35. Because of the large random nature of the embankment, an inclined and horizontal drainage layer (sand drain) has been included within the upstream portion of the dam to help control seepage and isolate the north zone from effects of through seepage. The horizontal drainage layer will tie into a north toe drain, which has a perforated pipe. The toe drain (plate 6) will keep the north toe from getting soft from seepage exiting on the slope. The toe drain will have flushing and observation risers spaced every 150 feet for the length of the dam. The perforated pipe will exit into the pump station.

36. Uplift pressures at the north slope of the embankment are not expected to be of concern if the foundation is predominately sands and gravels. If a thin layer of impervious material (5 feet or less) is present, over-excavation of the foundation may be necessary for the entire length of the dam.

37. Riprap and bedding will provide erosion protection of the slopes on both the north and south portions of the embankment. Standard riprap and bedding designs are used. On both the north and south slopes, the design calls for 12 inches of riprap and 6 inches of bedding. The riprap and bedding will run the entire length of the south slope, from the top of the embankment to the toe. The north slope will have riprap and bedding from elevation 1475 to the toe of the slope. All other areas will be protected with 12 inches of top soil and seed.

Road Raises

38. Existing roads which cross the outlet alignment will either be raised or abandoned. Roads to be raised are shown on plate 7. The existing road embankments will be raised using random fill, with 12 inches of riprap and 6 inches of bedding placed on the side slopes. The road embankments will have a 10-foot-by-10-foot RCP box culvert passing through. The culverts will be placed on 12 inches of aggregate bedding.

CHANNELS

Intake Channel From Devils Lake

39. The intake channel from Devils Lake to pump station #1 runs for approximately 7,300 feet (Station 0+00 to 73+00). The depth of the channel varies from 0 feet at station 0+00 to a maximum depth of 27.5 feet at the toe of Dam #1. The channel has a 10-foot bottom width and 1-vertical-on-5-horizontal side slopes. At the pump station, the channel is 30 feet wide with 1-

vertical-on-5-horizontal side slopes. The side slopes are assumed stable for the lacustrine clay foundation, which geology estimates runs up to elevation 1453 in this area. No stability analysis was done to verify that these slopes are stable and meet COE criteria. During final design, slope stability will be analyzed and changes made if necessary.

40. It is assumed that, at the time of construction, Devils Lake will be at elevation 1440 to 1441 and approximately 6,400 feet of the inlet channel will be excavated totally in the wet. The remaining 1,000 feet of the channel will be partially excavated in the dry. It is assumed that the portion above elevation 1440 (assumed groundwater elevation) will be excavated in the dry, while the lower portion of the channel would be excavated in the wet. Under these conditions, it is likely that some sloughing of the side slopes will occur and localized over-excavation, sand drains, and dewatering wells are necessary to excavate the channel to full depth. After the lake level has been stabilized at a lower elevation, the channel side slopes will need to be reshaped in the areas of sloughing. It is assumed that 20 percent (1,280 feet) of the channel excavated under water will need repair. The remaining 1,000 feet of channel will have either sand drains or dewatering wells. For cost estimating purposes, it is assumed that sand drains are spaced every 25 feet for 500 feet and 4-inch diameter dewatering wells with an average depth of 25 feet and spaced 25 feet apart are necessary for the remaining length of channel. It is also assumed that six 4-inch diameters wells, 40 feet in depth are necessary at the pump station. Other than top soil and seed, no other erosion control measures are used in the channel.

Channel between Dams #1 and #2

41. The channel between Dams #1 and #2 (plate 6) runs for approximately 9,000 feet (Station 74+00 to 164+60). The depth of the channel varies from 11 feet at Dam #1 to a depth of 15 feet at the toe of Dam #2. The channel has a 10-foot bottom width and 1-vertical-on-4-horizontal side slopes. The side slopes are assumed stable for the lacustrine clay and sand and gravel foundation. The lacustrine clay should pinch out quickly somewhere around ground elevation 1453; therefore, the majority of the channel will be excavated in sand and gravel. No stability analysis was done to verify that these slopes are stable and meet COE criteria. During final design, stability will be analyzed using the computer program utexas3.

42. During construction, some sloughing of the slopes is possible and dewatering of portions of the area may be necessary. It is assumed that the channel will be excavated in the dry except for those areas below the water table and areas shown on the USGS quadrangle sheets to be wetlands. Because of the pervious nature of the foundation, it is assumed that the channel below the water table can be constructed in 2-foot stages. This will minimize the areas of sloughing without increasing the overall construction time of the channel excavation. However, because of uncertainties in the foundation it is assumed that 20 percent (1,800 feet) of the channel will need dewatering wells. The wells are 4 inches in diameter with an average depth of 15 feet and spaced 25 feet apart. It is also assumed that six 4-inch diameter wells, 25 feet in depth are necessary at the pump station. Other than topsoil and seed no other erosion control measures are used in the channel.

Outlet Channel to the Sheyenne River

43. The channel between Pool #3 and the Sheyenne River runs for nearly 28,000 feet (Station 401+50 at the southern end of Pool #3 to 678+90 at the river). The depth of the channel varies for its entire length by only a few feet, with a maximum depth of approximately 4 feet. Nineteen gabion drop structures with a maximum drop of 3 feet are strategically located along the entire channel length. The drop structure locations are shown on plate 2. The channel has a 30-foot bottom width and 1-vertical-on-4-horizontal side slopes. The side

slopes are assumed stable for the sand and gravel foundation. No stability analysis was done to verify that these slopes are stable and meet COE criteria. During final design stability will be analyzed.

44. It is assumed that the channel will be excavated in the dry, but water control will need to be done to re-route the existing stream running along this alignment. No special dewatering measures are assumed because of the shallow depth of the channel. If localized sloughing of the side slopes occurs because of a high groundwater table, the channel may be excavated in shallow cuts, which will allow the channel to drain. Other than topsoil and seed no other erosion control measures are used in the channel.

STRUCTURES

Pump Stations

45. The three pump stations are of similar design (see plate 5). It was assumed that all three pump stations would be placed on piles, 40 feet in length. Pile and bearing capacity analysis was not done for this design. It is assumed that the foundations would experience settlement and that the piles would prevent any excessive differential settlements. During final design, the number, length, and type of piles need to be determined. For cost estimating purposes, timber piles are assumed.

Spillway

46. Dam #2 will have a emergency concrete spillway constructed away from the pump station and inlet channel (see plate 8 for design details). The spillway will empty into a channel which will connect into the inlet channel (outlet channel of Dam #1). The spillway channel will have 60 inches of riprap and 12 inches of bedding.

Drop Structures

47. Gabions will be used to construct drop structures along the outlet channel to the Sheyenne River. The gabion structures will use PVC baskets, because Devils Lake water may be corrosive to metal baskets. The typical gabion structure is shown on plate 9. The gabions will be placed on geotextile fabric as a separator between the fine sand and gravel and the coarse rock-filled baskets. The baskets will be filled with field stone with a 6-inch maximum size.

SOURCE OF CONSTRUCTION MATERIAL

Riprap versus Field Stone

48. Riprap and gabion stone will be transported from a combination of sources, including sand and gravel operations, rock quarries, and field stone piles. Steep embankment slopes may require angular quarried stone to maintain a stable slope. Experience has shown that field stone using standard riprap gradations and placed on steep embankment slopes is not very stable unless the thickness is increased.

Impervious Core Material

49. Glacial till will be used for the impervious core. Glacial till is available within 6 miles of the embankment sites. The exact borrow site location will be determined during preparation of plans and specifications.

Pervious Material

50. It is assumed that a source of pervious material for the sand drain, toe

drain, riprpap bedding, culvert bedding, and concrete aggregate is available within 10 miles of the site. If an active sand and gravel pit is not currently available, geology of the area indicates that a pit could be opened close to the site.

CONSTRUCTIBILITY

Dams

51. All the dam embankments will be constructed in the dry. Dam #1 will be constructed where the natural ground surface is approximately elevation 1451. The foundation excavated below the groundwater surface will be dewatered prior to embankment construction. The same dewatering wells will be used for excavating the channels upstream and downstream of the dam/pump station.

52. Based on USGS quadrangle maps and photographs taken in June 1996, Dam #2 will be constructed in an area where cofferdams are required to dewater the site during construction. The existing natural channel, which flows into Twin Lakes, will be diverted during construction. It is assumed that a diversion channel will be excavated around the site while the dam is being constructed in the dry. The low-head cofferdams will have a 10-foot top width with 1-vertical-on-5-horizontal side slopes. The cofferdams will be constructed of random fill, and dewatering wells will be used to draw down the groundwater and keep the site dry. An upstream toe drain will keep the dewatered side of the slope stable and dry. It is assumed that the natural water level will not exceed elevation 1454; therefore, the cofferdams will have a top elevation of 1459 to provide 5 feet of freeboard. The existing natural channel depth is not known; it is assumed to be at elevation 1452. Erosion control will be provided by 12 inches of riprap and 6 inches of bedding. For cost estimating purposes, it is assumed that 5,000 cubic yards of random fill are needed to construct the two cofferdams and eight 4-inch diameter wells, 40 feet in depth are required to dewater the site.

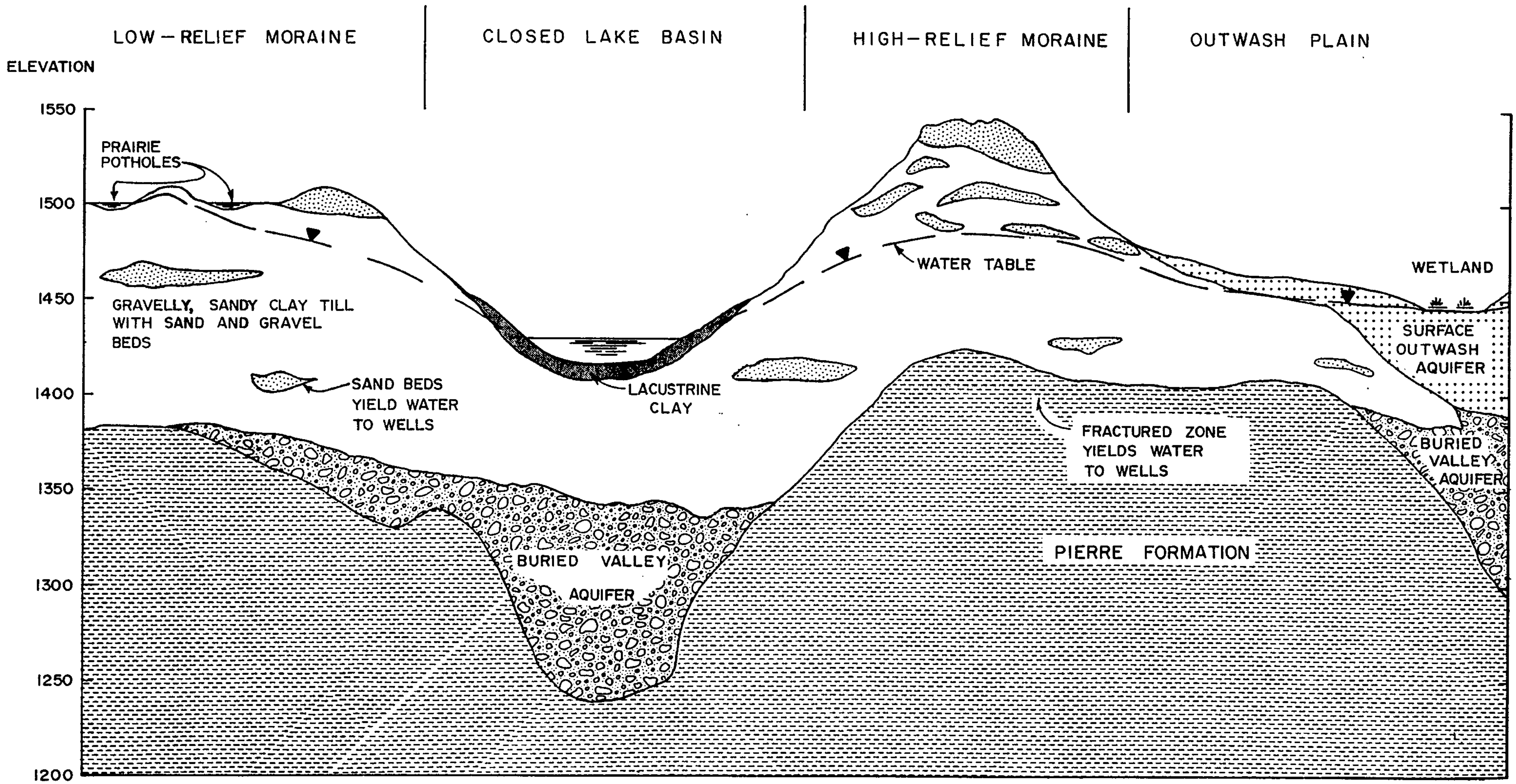
53. Dam #3 is located in an area which photographs taken in June 1996 show an existing wetland. It is assumed that sump pumps and dewatering wells will be used to draw the water table down during embankment construction. Low-head cofferdams of similar design to Dam #2's cofferdams are required to prevent local interior drainage from flooding the construction site.

Access Roads

54. Access roads are required to all embankment sites. The estimated 3 miles of permanent access roads will be constructed similar to existing gravel-surfaced roads in the area.

Outlet Channel to the Sheyenne River

55. The outlet channel to the Sheyenne River will be constructed from downstream (south) to upstream (north). The existing natural channel will be diverted and the outlet channel excavated in 2-foot lifts to allow groundwater to drain naturally.

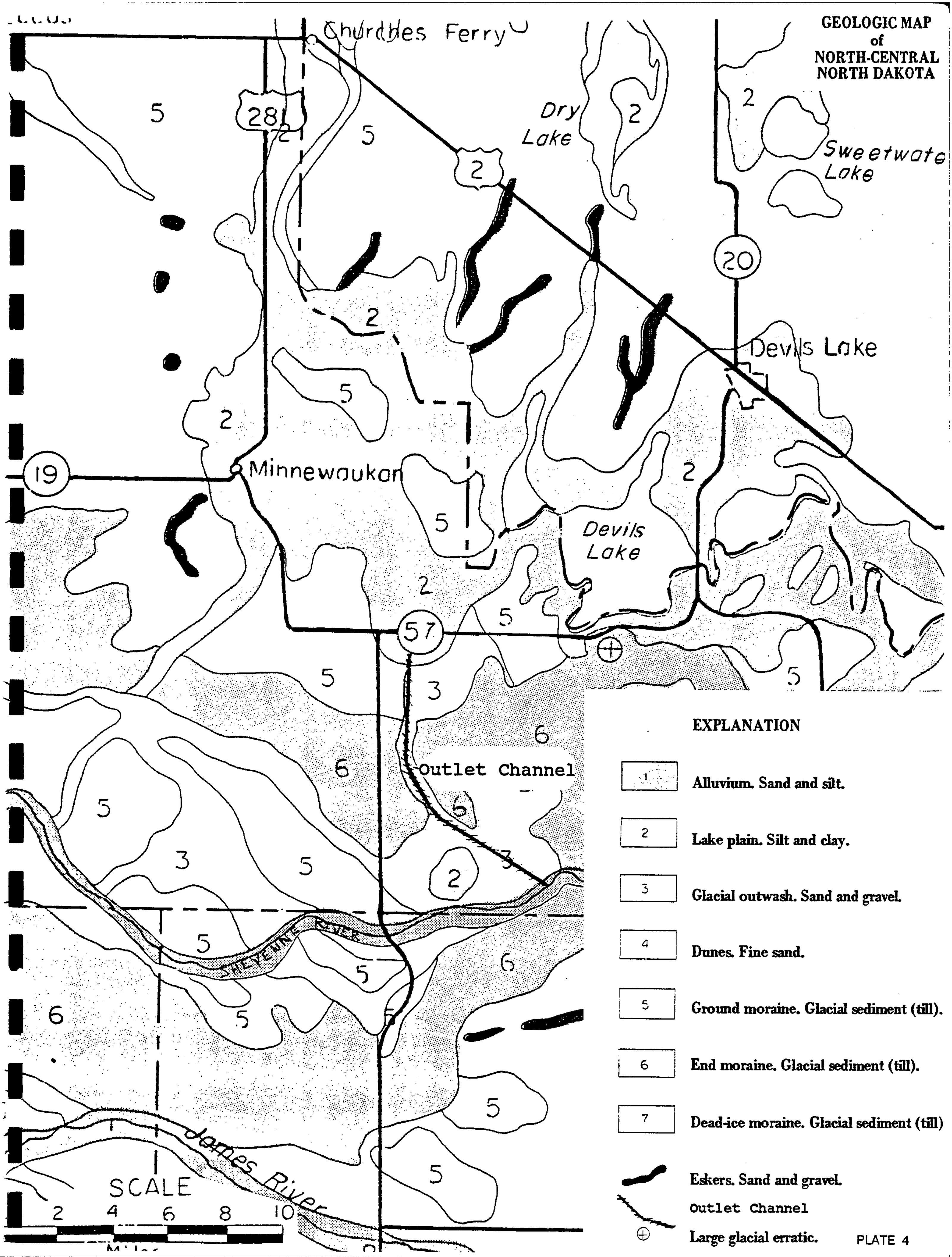


GENERALIZED GEOLOGY OF THE DEVILS LAKE AREA

DEVILS LAKE, NORTH DAKOTA
GENERAL GEOLOGY

PLATE 9

PLATE 3



GEOLOGIC MAP of NORTH-CENTRAL NORTH DAKOTA

PLATE 4

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

STRUCTURAL ENGINEERING APPENDIX

STRUCTURAL ENGINEERING APPENDIX

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STRUCTURAL ENGINEERING APPENDIX

PURPOSE

1. This appendix describes the methodology and assumptions used in the analysis and design of miscellaneous structures and other associated features for the Devils Lake Emergency Outlet in North Dakota.

2. Rational for the design and location of the structures is summarized in other sections. Plates showing the general arrangement and typical appurtenances are presented following this report (see Plates 1 through 8).

REFERENCES

3. The applicable sections of the following references were used to formulate design criteria and to determine allowable stresses in the various structural components:

a. EM 1110-2-2000, Standard Practice for Concrete for Civil Works Structures, dated 1 Feb 94.

b. EM 1110-2-2104, Strength Design for Reinforced - Concrete Hydraulic Structures, dated 30 Jun 92.

c. EM 1110-2-2105, Design of Hydraulic Steel Structures, dated 31 May 94.

d. EM 1110-2-2200, Gravity Dam Design, dated 30 Jun 95.

e. EM 1110-2-2400, Structural Design of Spillways and Outlet Works, dated 2 Nov 64.

f. EM 1110-2-2502, Retaining and Flood Walls, dated 29 Sep 89.

g. ETL 1110-2-256, Sliding Stability for Concrete Structures, dated 24 Jun 81.

h. ETL 1110-2-307, Flotation Stability Criteria for Concrete Hydraulic Structures, dated 20 Aug 87.

i. ETL 1110-2-310, Stability Criteria for Existing Navigation Structures on Rock Foundations, dated 17 Dec 87.

j. ACI 318-95, Building Code Requirements for Reinforced Concrete.

4. Documents directly supporting this Structural Engineering Appendix are the Hydraulic Engineering Appendix; Geotechnical and Geologic Engineering Appendix; and Mechanical, Electrical, and Architectural Engineering Appendix.

5. Supporting documentation for structures presented in this appendix are contained in a separate, bound document entitled Devils Lake Emergency Outlet Plan, Supporting Design Computations.

DESIGN CRITERIA

Design Criteria and Assumptions

6. The major structural design criteria and assumptions used in analysis and design of the emergency outlet plan appurtenances at Devils Lake are described

in the following paragraphs.

7. Structures: All structures will be designed in conformance with the ultimate strength design using EM 1110-2-2104.

8. Concrete and Reinforcement: Reinforcement will be ASTM A615 Grade 60,000 psi yield stress. Concrete design strength will be 4,500 psi.

9. Unit weights used for analysis are as follows:

Reinforced Concrete	150 pcf
Water	62.4 pcf
Steel	490 pcf
Earth/Rock	See Soil Parameters

Soil Parameters

10. Exact soil parameters for the analysis of the structures are not available and are assumed to be as represented for this work as follows:

TABLE 1: Shear Strength Parameters for use in Stability Analysis

MATERIAL TYPE	UNIT WEIGHT (pcf)		SHEAR STRENGTH	
	Moist	Saturated	c (psf)	ϕ (degrees)
Existing Embankment Fill (CL)	121	122	0	33
New Embankment Fill (CL)	121	122	0	33
Glacial Till	124	125	0	33
Pervious Fill	125	130	0	32
Riprap	135	135	0	36

Hydraulic Loading

11. Hydraulic loads, if any, were obtained from hydraulic profiles presented in the Hydraulic Considerations Section.

Seepage Control

12. The design of the spillway and structures has been developed so that seepage through the dam embankment will not be increased for the normal pool condition. Above normal pool, the embankment and spillway should not experience under-seepage. In the unlikely event of water penetrating the embankment structures, free draining under-slab filters have been incorporated into the design to prevent the build-up of pressures and to drain seepage to tailwater.

Frost Protection

13. The structures are provided with insulation where necessary to limit potential frost heave to less than 1 inch. The structural elements of the spillway have been designed to accommodate frost heave.

DESIGN OF THE STRUCTURAL APPURTENANCES

Spillway (Plate 1)

14. The spillway is a reinforced concrete slab-on-grade structure comprised of a crest slab, chute slab, and stilling basin. Associated structures are the spillway training walls and the approach riprap.

15. The spillway structural concepts were developed considering the following factors:

a. Spacing of contraction joints to control cracking due to volume changes from annual and daily temperature and shrinkage effects.

b. Expected flow velocities against the chute and apron slabs.

c. Provision of properly designed drains and filters under the slab elements to prevent excess uplift from embankment seepage and severe ice formation during the winter, and to prevent piping of foundation or embankment material from any possible crack or opening of a joint that may occur in slabs.

d. Settlement and upstream creep of the top of the embankment dam.

e. Differential frost heave due to local variations in freezing and thawing of the subgrade material below the slab elements.

f. Provision of reinforcing to control shrinkage and temperature cracking and to control stresses produced if the flexible slabs lost soil support.

g. Provision of sulphate resistant cement and air-entrained concrete for durability.

16. Contraction joints are spaced no further apart than 20+ feet in thin and moderately thick concrete elements.

17. Crack control is important to prevent large quantities of water penetrating the slab elements when the spillway is operating under flood conditions so that uplift and erosion control does not become a serious consideration. The selected length of slab elements also affects the reinforcement requirements due to settlement effects with edge support only.

18. The maximum flow velocity on the chute slab will be in the range of 35 feet per second.

19. A crest slab varying from 5 feet at the upstream end to 3 feet at the downstream end.

20. A 2-foot 6-inch chute slab with articulated joints connects the crest with the stilling basin. Joints are detailed to prohibit penetration by high velocity water and to prevent damage from forces produced by differential settlement or rebound under and across the joint.

21. A drain system is provided under the chute slab and apron slab for the purpose of preventing uplift pressures during operation that could lift the spillway slabs, ensuring free drainage of water emanating from the dam embankment. The drainage system is designed to allow water to exit by gravity with minimal ponding behind and below a slab element. The drainage system is also designed to prevent dam material from piping out of any longitudinal cracks or joint openings that may occur where water could enter upstream at a higher elevation and leave downstream at a lower elevation, producing undesir-

able cavities under a slab. The two-stage drain is designed to be self-filtering to control washout in the unlikely event of significant water penetration and high flows.

22. The proposed connection of flexible chute slab to crest slab allows for ample settlement and longitudinal up and down slop movement along the chute slab axis. The chute slab is connected to the crest by dowel action and slab seat only. The slab is free to move on its seat upstream or downstream along the dowels. A compressible filler allows for upstream movement. A covering steel plate and expanding waterstop permit the slabs to separate without allowing sediments to fill the space created and thus prevent the chute slab from expanding upstream due to thermal stresses in the summer.

23. Some small amount of differential settlement may occur under the concrete slab elements due to variable values of "elastic" subgrade reaction. However, changes in load from the existing condition are small and post-construction movement due to load changes are considered to be insignificant.

24. With the depth of concrete and granular drain materials provided and the insulation layer, it is estimated that frost heave and subsequent subsidence will not exceed 1 inch and will be activated in a relatively uniform manner. All components of the spillway structure are assumed to be capable of tolerating movement of this order of magnitude.

<u>Pump Stations</u> (Plates 2-6)

25. The design follows the provision of EM 1110-2-3104. Consideration was given to functional and space requirements. Since the structures have an expected life of 50 years or more, materials were chosen accordingly.

26. The pumping stations are expected to be permanent, low-maintenance, and secure structures. The pumping stations should be constructed of fire-resistant and non-combustible materials and structural steel. A structural steel frame with a metal skin will afford lower costs. Acoustical problems will be reduced by means of insulation.

27. Floors consist of Portland cement concrete with a wood finish.

28. Grating will be used for indoor and outdoor locations.

29. The crane will be installed and is independent of the building envelope.

30. The presently assumed foundation material has to be verified in the final design. Sufficient soil sampling and testing shall be done prior to selecting the type and extent of foundation work.

31. At the present time, a pile foundation has been selected. The piles and structures have to withstand horizontal loads. Battering the piles is one method to effectively counter this force.

32. A sheet pile cut-off is provided at the intake side of the station to prevent erosion.

33. Seepage concerns are addressed in the <u>Spillway</u> discussion above.

<u>Culvert</u> (Plate 7)

34. The design assumes AASHTO criteria for life load with consideration of local conditions such as fill, flow, etc.

35. The life loads assumed are H 20 loadings.

36. The culverts are constructed of prefabricated components.

Gabions (Plate 8)

37. Gabions are used to provide drop structures (check dams) for the flow of pumped water from the top of the divide to the Sheyenne River.

38. Gabions are rectangular, compartmented, stone-filled baskets made from coated steel wire mesh (although alternate material may be considered to preclude corrosion from the high salinity Devils Lake water).

39. Gabions are flexible structures. They adjust to changes in the channel. Several basket sizes will be employed.

40. Correct size and care in construction to prevent large voids insures stability as well as permeability of the structure.

41. Application of geotextile fabric beneath a gabion structure revetment will improve the performance of the system. Undermining will be minimized.

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX

MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX

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MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX

1. GENERAL. Three pump stations will be provided to pump Devils Lake water over the drainage divide and into the Sheyenne River. Each pump station will be rated at 200-cfs (cubic feet per second) capacity. Each pump station will have four pumps. Pump Station #1 is closest to Devils Lake. Pump Station #3 is closest to the Sheyenne River. Each pump station has been designed to accommodate larger pumps and could be adapted to pump 300 cfs with no change in station structure. The reader is referred to the STRUCTURAL ENGINEERING APPENDIX -- Plate 2 - Pump Station Plan, Sections & Table; Plate 3 - Fuel Oil System Elevations & Schematics; Plate 4 - Typical Pump Station Electrical Plan, Diagram & Schedules; Plate 5 - Outlet Box Plan and Section; and Plate 6 - Pipe Profile.

1.1 The pump stations are similar to each other. Each pump station is assumed to have diesel-driven pumps (versus electric motor-driven pumps). 100-amp electrical service will be provided for power to run lights, ventilators, telemetry system, etc. A generator will be provided for backup emergency power.

1.2 An analysis for electric operation of the pumps is provided below. Operating costs for both diesel-powered pumps and electric motor-driven pumps are provided. In summary, the diesel drive option will have a lower first cost but higher operating cost. Analyses showed that operating costs with diesel engines would be 40 percent higher than with electric motors.

1.3 The substructure and wetwell of each pump station will be concrete set on piles. A pre-engineered metal superstructure will be used at each pump station. Overhead garage doors on each side of the building will allow removal of the diesel engines and gearboxes. A crane and girder system will be installed in the pump stations for servicing and hoisting the pumping equipment.

1.4 The pump stations cannot be operated in the winter without damage to the pumps. The design, including the fuel system, assumes winter shutdown. Six months of pumping per year of operation was assumed in the operational cost analysis.

2. MECHANICAL DESIGN. Single-stage vertical propeller pumps will be utilized at Pump Stations #1 and #2. Double-stage propeller pumps will be used at Pump Station #3. Both electric motor- and diesel engine-driven pumps were considered. Paragraph 5 (below) details this analysis. The diesel-driven pumps were selected for the following reasons:

a) The output capacities of the pump stations need to be varied based on Sheyenne River flows and various environmental factors in Devils Lake. The speed of the diesel engine can be easily varied, thus changing the output capacity of the pumps. Electric pumps would require the installation of variable frequency drives.

b) Lower total first cost (initial capital cost).

c) Eliminates need to provide large electric service to operate the pumps.

d) Although the hourly operating costs for the diesel drive option are higher, the pump stations will likely be operated infrequently. There could be periods when the stations are idle for up to 10 years or more. When the pump stations are operated, they will likely not be operated at full capacity. Thus, the actual life-cycle operating costs between the diesel drive and electric motor option would be minimal.

2.1 Equipment Summary. The pumping plant consists of a vertical propeller pump, right angle gear drive, and a diesel engine. Caterpillar diesel engines were investigated for this design. The diesel engine and right angle gear drive are connected by a drive shaft and torque coupling. An equipment summary for each pump station is provided below:

(a) Vertical propeller pumps (4 total)
(b) Diesel engines (4 total)
(c) Right angle gear drives (4 total)
(d) Generator for emergency backup power (1 total)
(e) Fuel oil furnace
(f) Power roof ventilators
(g) Manual chain hoist and crane girders
(h) Trash racks
(i) Fuel oil storage tank
(j) Day tanks
(k) Sluice gates

2.2 Pump Data. The pumps in Stations #1 and #2 are rated at 200 hp. Pump Station #3 will need pumps that are capable of pumping against a higher head. This will require two-stage pumps and engines rated at 225 hp. The following is a summary of the pump data:

(a) Pump size: 30 inches
(b) Pump horsepower for Stations #1 and #2: 200
(c) Pump horsepower for Station 3: 225
(d) Pump driver: Right angle gear drive and diesel engine
(e) Pump capacity: 22,500-gpm per pump
(f) Pump head: 25 feet at Stations #1 and #2; 30 feet at Station #3
(g) Pump RPM: 580
(h) Pump discharge pipe size: 30 inches

2.3 Fuel System. The diesel engines and generator will operate on either #1 or #2 fuel oil. A 10,000-gallon fuel storage tank will be provided. Day tanks are provided for each diesel engine and the generator. The 10,000-gallon tank will provide enough fuel for all four pumps running continuously for 10 days. Each day tank will be sized for 24 hours continuous operation of the diesel engines. No provisions are included for winter operation of the fuel system. The storage tanks should be emptied before winter shutdown and filled again prior to spring startup.

2.4 Diesel Engines. Factors to consider include duty cycle, speed, and horsepower. The engines will likely experience intermittent duty or operating at part load or full load at frequent intervals. The final duty cycle needs to be further coordinated. For the cooling system, either a radiator or a water heat exchanger system could be used. Water from the wetwell of the pump station would be used in the heat exchanger system. The design at this point will assume a radiator cooling system will be utilized. The radiators need to be mounted either outside the building or inside and exhausted through the wall. The diesel engine will include several safety shutdowns, including high water temperature and low oil pressure. The following are design data for the diesel engine:

Fuel type: #1 or #2 diesel
Fuel system: Direct injection
Number cylinders: 8
Duty rating: Intermittent
Engine RPM: 2400 or 2800
Starting: Electric, DC, gear-driven starter
Fuel Consumption: 10 gallons per hour at full load

2.5 Right Angle Gear Drives. The right angle gear drives transfer power from the diesel engine to the pump. The output RPM (to match the pump) needs to be 580.

2.6 Crane and Girder System. A manual chain hoist and trolley will be installed in the station for removal of the gear drives, diesel engines, and pumps. The girder system will allow the hoist to be positioned virtually anywhere within the building.

2.7 Winter Operation. The pump stations are not designed for winter operation. These stations will need to be shut down sometime in November before winter freeze-up. The stations can be started in the spring after the lakes along the outlet alignment have melted. This will likely be in late April or early May.

2.8 Sluice gates versus stop logs for water control into the pump station. The design drawings for the pump stations show four sluice gates for controlling water into the pump stations. Sluice gates at the pump bay inlets are a better alternative for inlet control than stop logs. The sluice gates would be easier to operate and provide a better seal against water leaking into the station. Provisions will be included for portable power operation of the gates.

3. ELECTRICAL DESIGN.

3.1 Power Distribution System. Electrical service will be provided for lights, ventilators, furnace, and other miscellaneous equipment. Electrical service is also provided for operation of the telemetry system. Providing a small electrical service to operate this equipment will be relatively inexpensive. It will also eliminate the need to run a generator constantly and will provide a more reliable power source for the telemetry system. Pumps will be diesel engine driven. It was assumed that electrical service for each pump station would be provided by Ottertail Power Company and backed up by a diesel emergency generator set.

3.2 Service. The electrical service will be rated 100 amps, three-phase, four-wire, 120/208 volts. Emergency backup power will be derived from a 20-kVA diesel generator set located on the pump station operating floor. Fuel for the generator set will be obtained from the pump station's main fuel tank. The service will include an automatic transfer switch to control the emergency generator in the event the pump station's commercial power supply fails. The Electrical Calculations Worksheet shows the service computations.

3.3 Service Option No. 1 For Electric Motor-Driven Pumps. This option includes a 750kVA, three-phase, 4,160-volt electrical service and motor control center to operate four 200-hp electric pump motors and general building electrical loads. This option would eliminate the diesel engines. This option does not include an emergency generator set. An economic analysis is included in this document. The primary drawback to this option is the high cost associated with bringing this large electric service into each pump station, including approximately 8 miles of transmission line to a new substation at Pump Station #1. The new substation would provide 4,160-volt service to all three pump stations via an estimated 10 miles of distribution feeder to Pump Stations #2 and #3. All three pump stations would be metered from the substation. In addition, a motor control center would be required at each pump station. The estimated cost for providing electrical service and a motor control center is $317,000 per pump station.

3.4 Grounding. The site grounding electrode system will be include a combination of driven electrodes and connection to the embedded re-enforcing mat in the floor slab of the station's wet well. All pump discharge piping and building structural steel will be bonded together and connected to station grounding electrode system.

3.5 Service Disconnect. The service disconnect and overcurrent protection will be provided by a 100-amp, 3-pole, fused disconnect switch with service equipment listing. An automatic transfer switch will be included to control operation of the emergency generator set. A 60-amp, 3-pole, fused disconnect switch will provide overcurrent protection for the generator. A riser diagram of the proposed electric service is shown on the electrical drawings.

3.6 Panelboard. The building panelboard will include space for up to 30 single-pole circuit breakers and be rated 120/208 volts, 3-phase, 4-wire, 125 amps "Main Lugs Only." Circuit breakers will be "Bolt-on" design. The panelboard will be equipped with a UL-listed surge arrestor for added protection of the telemetry equipment.

3.7 Service Equipment Enclosures. All enclosures will be the manufacturer's standard indoor, NEMA 1 design.

3.8 Wire and Conduit System. The electrical distribution system will include insulated copper conductors installed in Electrical Metallic Tubing (EMT) indoors and PVC conduit outdoors. Outdoor conduits located in areas exposed to possible damage will be galvanized rigid steel (GRS) type. All wire and cable will be specified in accordance with the Corps standard guide specification for hydraulic structures.

3.9 Exterior Lighting. One 50-watt, high-pressure sodium light fixture will be installed on each of the four exterior walls for general site lighting. The lights will be controlled from the station's circuit breaker panelboard and used only as required. The trash rack area of the each station will include two 500-watt halogen floodlights for night removal of trash from the station inlet. The floodlights will be controlled from light switches located inside the pump station.

3.10 Interior Lighting. Interior light level for the pump station operating room will be 30 footcandles. This is in accordance with Illuminating Engineering Society of North America (IES) recommended levels. Lighting will consist of two-tube industrial fluorescent light fixtures with energy efficient F32T8 lamps and solid-state ballasts. The lamps will be controlled for a 20-amp, 3-pole lighting contactor located above the panelboard in a NEMA 1 enclosure.

3.11 Receptacles. Receptacles rated 15 amps, 120 volts will be provided for use with hand powertools. Each receptacle will include integral Ground-Fault protection.

3.12 Furnace. A 20-amp circuit will be provided to power the furnace blower motor and controls. The furnace will be controlled with a wall-mounted thermostat.

3.13 Room Exhausters. The operating room will include two room exhausters to assist in the removal of heat generated by the diesel engines. Each exhauster fan motor will require a 3-pole 20-amp circuit. An additional manual disconnect safety switch will be installed adjacent to each exhauster fan motor for maintenance. Both room exhausters will be thermostatically-controlled.

3.14 Pump Controls. Each pump will include a diesel engine monitoring and control package with an analog speed control input and engine status alarm output for the telemetry system. Flow meters located in the discharge of each pump will report each pump's discharge flow rate via the telemetry system. Level sensors will be installed to report the tailwater and pool stage information through the telemetry system.

3.15 Telemetry System. All pump stations will be controlled from one location. The location will be determined during final design. Each pump station will include a process control and communications computer to perform Supervisory Control and Data Acquisition (SCADA) functions. Data to and from the pump stations will be transmitted via UHF radio. Catalog cuts showing typical equipment is included with this appendix. Items monitored at each station will include:

Tailwater and headwater elevations
Pump discharge rate in GPM
Pump engine status
Electric power failure
Emergency generator status
Building security, unauthorized access alarm

3.16 Item(s) controlled at each station will include:

Pump motor speed/desired discharge rate

4. ARCHITECTURAL DESIGN. The structural and architectural design of all three pump stations is the same. A pre-engineered metal superstructure will be used. Both the walls and roof will utilize insulated metal panels. Insulated panels will allow the inside of the building to be heated to 40 degrees during the winter. It will also provide sound insulating value for the area around the pump stations. Overhead garage doors will be located on each side of the building. One or two service doors will be installed and skylights will be installed.

4.1 The operating floor elevation of the pump stations was set 20 feet above the wetwell floor elevation. At Pump Station #1, the operating floor is currently set at elevation 1440. Depending on the construction schedule for this project, this may have to be set higher if Devils Lake rises to or above that level. The top of the trash rack at this pump station may also have to be set higher.

5. COMPARISON OF DIESEL-DRIVEN VERSUS ELECTRIC MOTOR-DRIVEN PUMPS.

5.1 Electric Motor Driven Pump Option. An alternate method of driving the pumps is to use electric motors.

Advantages of electric motor-drive pumps:

(a) Quieter operation
(b) Electric motor replaces both gear drive and diesel engine; less equipment
(c) Hourly operating cost is less expensive -- An analysis of operating costs between diesel drive pumps and electric drive pumps is included in the attached calculations assuming that the pump stations would be operated for 7 months per year, 2⅓ months each at full, three-fourths, and one-half capacity. During preparation of the 15 February 1996 *Devils Lake, North Dakota, Contingency Plan*, a basic electric rate of 3.58 cents per KwHr was quoted by Ottertail Power Company; this rate was used in the analysis for the Emergency Outlet Plan (EOP). Ottertail Power Company also indicated that, because of the large size and electrical consumption of the proposed pumping plant in the *Contingency Plan*, it would not impose a monthly electrical demand charge for the project; the EOP analysis also assumed demand charges would not be imposed. Under this scenario, the annual costs would be $320,000 for the electric option and $450,000 for the diesel drive option. (However, the EOP's pump stations are considerably smaller then the stations

investigated for the *Contingency Plan;* therefore, it is possible that OtterTail Power may impose a demand charge.)
(d) Less maintenance

Disadvantages of electric motor-drive pumps:

(a) Need to bring in large electric service to operate pumps
(b) Requires motor control center and variable frequency drive for the pumps
(c) May have monthly electrical demand charges throughout life of project
(d) Higher first cost -- The electric option would require a large (750kVA, three-phase, 4,160-volt) electrical service and large motor control center at an estimated cost of $317,000 per pump station. In comparison, the diesel drive option will only require a fuel storage tank, day tanks, and piping.

5.2 Diesel Driven Pump Option. The diesel drive option will have a higher hourly operating cost than a electric motor. This factor, plus the noise generated by the diesel engines and the need to refuel the storage tank, are probably the biggest drawbacks to this option. The Caterpillar engine manufacturer representative was consulted to determine fuel consumption rates. A 10-gallon per hour consumption rate can be expected under full load conditions. This option will have a considerably lower first cost, however. Both the large electric service and motor control center can be avoided. Based on discussions with Ottertail Power Company, an estimated savings of $317,000 per station can be expected. The following are the advantages and disadvantages of using the diesel engine-driven pumps:

Advantages of diesel engine-drive pumps:

(a) Eliminates need for motor control center
(b) Pump speed and capacity can be easily varied -- Pump station output must be varied depending on Sheyenne River flow and Devils Lake and river sulfate concentrations to comply with bank-full and water quality standards. Diesel engine speed can easily be adjusted to change the output capacity of the pumps. In contrast, electrically-driven pumps would require installation of variable frequency drives.
(c) Lower first cost
(d) Eliminates need for large electric service

Disadvantages of diesel engine-drive pumps:

(a) Noisy (although the silencer will eliminate some of the noise)
(b) Large fuel source and refueling -- The 200-hp diesel engines are estimated to consume 10 gallons/hour at full load, i.e., 40 gallons/hour per pump station, 120 gallons/hour for the three pump stations. Each pump station has a 10,000-gallon fuel storage tank, equivalent to about 10 days operation at full load. Tanker service could be a problem in the spring when load limits are imposed on roads.
(c) More maintenance
(d) Higher hourly operational cost. This factor will be diminished over the life of the project, however, because the stations can only be operated for 7 months out of the year, and it is expected that the stations will be idled for long periods of time when Devils Lake's elevation is low.

6. COMPARISON OF 300-CFS VERSUS 200-CFS PUMP STATION. Depending on the flow rate of the Sheyenne River, concentration of saline in Devils Lake, and other environmental factors, it may be possible to pump more than 200 cfs into the Sheyenne River. The pump stations are designed to accommodate larger pumps.

Thus, no change in the substructure or superstructure is anticipated. A 300-cfs station would utilize four 42-inch pumps, each rated for 75 cfs or 33,760 gpm. Pump horsepower would change from 200 at Pump Stations #1 and #2 and 225 at Pump Station #3 to 300.

6.1 Cost. The station structural and architectural cost would not change. The electrical cost for 100-amp service, lights, telemetry, etc. would not change. The right angle gear drives selected are rated for 300-horsepower pumps, and would not change. A summary of changes is listed below:

(a) Station structure: No change
(b) Electrical: No change
(c) Sluice gates: Change from 6-foot-by-6-foot to 7-foot-by-7-foot
(d) Right angle gear drive: No change
(e) Diesel engines: Increase from 200 and 225 hp to 300 hp at an estimated 50-percent in cost.
(f) Pumps: Increase to 75 cfs each at an estimated 50-percent in cost.
(g) Telemetry: No change
(h) Fuel storage tank: Change to 15,000 gallon from 10,000 gallon capacity
(i) Pipelines: Increase in size from 30 inches to 42 inches

SUPPORTING COMPUTATIONS

1. Pump Selection

> 200-cfs per pump station * (448.8 gpm / 1 cfs) ≈ 90,000 gpm per pump station

> Four pumps per pump station, each rated at 90,000 gpm / 4 pumps = 22,500 gpm

> Maximum static pumping head:

Pump Station	Static pumping head
#1	20 feet
#2	21 feet
#3	25 feet

Total dynamic head (= Static head plus friction losses) will be larger.

> Assume 30-inch pumps and ductile iron discharge pipes.

22,500 gpm → velocity = 10 fps → velocity head = 1.55 ft;
Δh (head loss) = 0.856 ft per 100 feet of pipe

> Calculate pump horsepower:

Pump hp = Q * h / [(3960) * (Efficiency)]

where Q = flow (gpm) = 22,500
H = total head (ft). Assume head losses + velocity head = 5 ft. Therefore, H (#1) = 20 + 5 = 25, H (#2) = 21 + 5 = 26, H (#3) = 25 + 5 = 30.
Efficiency = 78% = 0.78 (assumed)

Pump hp (#1) = (22,500 * 25) / (3960 * 0.78) = 182 ==> 200 hp
Pump hp (#2) = (22,500 * 26) / (3960 * 0.78) = 189 ==> 200 hp
Pump hp (#3) = (22,500 * 30) / (3960 * 0.78) = 218 ==> 225 hp

> Selection of gear drive

Gear ratio = Diesel drive rpm / pump rpm = 2800 / 580 = 4.82

With a 2,400 rpm diesel drive, gear ratio = 4.13. Need to transmit 200 hp.

2. Operating Costs[1]

a. Compare annual operating costs between 200-cfs diesel drive and electric motor drive pump stations. Use the following assumptions:

- $0.0358/kwh power cost (from Ottertail Power Company)
- 10 gallons/hour fuel consumption for diesel engines, full load (from Ziegler)
- $1/gallon diesel fuel cost
- Maximum 7 months pumping per year, 1 May to 30 November. [We anticipate that most years, the pumping window will be 15 May to 15 November, i.e., 6 months; therefore, the 7-month scenario should be considered a likely maximum.]

[1] In addition, an assumed 1 percent of first costs is used to estimate labor, equipment, etc. for maintenance, testing, and other operation, maintenance, and replacement (OM&R) activities during operation and downtime.

o Pumping one-third of the time (70 days) each at full capacity, three-fourths capacity, and one-half capacity.
o 1 kw = 1 hp to calculate electric rates
o No demand charges

> Electric motor drive

o Four 200-hp motors per pump station
  = 800 hp per pump station * 1 kw/hp
  = 800 kw at full capacity
  = 600 kw at three-fourths capacity
  = 400 kw at one-half capacity

o 70 days * 24 hours/day = 1680 hours

o Full capacity: 800 kw * 1680 hours * $0.0358/kwh = $48,115
  Three-fourths capacity: 600 kw * 1680 hours * $0.0358/kwh = $36,086
  One-half capacity: 400 kw * 1680 hours * $0.0358/kwh = $24,058

  Electrical motor drive cost per year = $108,259 * 3 pump stations
  = $324,778 ==> $320,000/year

  Total annual OM&R cost not operating (downtime) = 1% of first cost (say $22,398,000) = **$220,000**

  Total annual OM&R cost while operating = $320,000 + 1% of first cost (say $22,398,000) = $320,000 + $220,000 = **$540,000**

> Diesel drive

o Four 200-hp motors per pump station
  = 4 * 10 gallons/hour fuel consumption = 40 gph at full capacity
  = 30 gph at three-fourths capacity
  = 20 gph at one-half capacity

o Full capacity: 40 gph * 1680 hours * $1/gallon = $67,200
  Three-fourths capacity: 30 gph * 1680 hours * $1/gallon = $50,400
  One-half capacity: 20 gph * 1680 hours * $1/gallon = $33,600

  Diesel drive cost per year = $151,200 * 3 pump stations
  = $453,600 ==> $450,000/year

  Total annual OM&R cost not operating (downtime) = 1% of first cost (say $21,463,000) = **$210,000**

  Total annual OM&R cost while operating = $320,000 + 1% of first cost (say $21,463,000) = $450,000 + $210,000 = **$660,000**

b. Compare annual operating and OM&R costs for 200- and 300-cfs diesel drive pump stations.

> 200-cfs option: See above calculation of operating cost of $450,000/year and OM&R cost of $660,000/year.

> 300-cfs option: Assume same pumping scenario (70 days each at full, three-fourths, and one-half capacity). Assume fuel consumption is approximately proportional to pump capacity.

o 60 gph at full capacity
  45 gph at three-fourths capacity
  30 gph at half capacity

o Full capacity: 60 gph * 1680 hours * $1/gallon = $100,800
Three-fourths capacity: 45 gph * 1680 hours * $1/gallon = $75,600
One-half capacity: 30 gph * 1680 hours * $1/gallon = $50,400

Diesel drive cost per year = $226,800 * 3 pump stations
= $680,400 ==> $680,000/year

Total annual OM&R cost not operating (downtime) = 1% of first cost (say $24,041,000) = $240,000

Total annual OM&R cost while operating = $320,000 + 1% of first cost (say $24,041,000) = $680,000 + $240,000 = $920,000

c. Compute cost per 100,000 ac-ft of water pumped.

> Electrical power drive -- 200-cfs peak capacity

o Assume 7-month scenario used above.

o One year's volume = [(200 cfs * 70 days) + (150 cfs * 70 days) + (100 cfs * 70 days)] * 24 hrs/day * 60 min/hr * 60 sec/min / 43,560 sq ft/acre = 62,479 ac-ft

Therefore, 100,000 ac-ft would cost
100,000 ac-ft / 62,479 ac-ft/year = 1.600 years * $540,000/year
= $860,000

> Diesel drive -- 200-cfs peak capacity

o Assume 7-month scenario used above.

o One year's volume = 62,479 ac-ft

Therefore, 100,000 ac-ft would cost
100,000 ac-ft / 62,479 ac-ft/year = 1.600 years * $660,000/year
= $1,060,000

> Diesel drive -- 300-cfs peak capacity

o Assume 7-month scenario used above.

o One year's volume = [(300 cfs * 70 days) + (225 cfs * 70 days) + (150 cfs * 70 days)] * 24 hrs/day * 60 min/hr * 60 sec/min / 43,560 sq ft/acre = 93,719 ac-ft

Therefore, 100,000 ac-ft would cost
100,000 ac-ft / 93,719 ac-ft/year = 1.067 years * $920,000/year
= $980,000

OTTER TAIL POWER COMPANY
Fergus Falls, Minnesota
ELECTRIC RATE SCHEDULE

Volume I, Sheet 95
Rate Designation M-54N, Page 1 of 1
Original

MUNICIPAL PUMPING SERVICE

Rate Zones 1 & 9 Code 44-872

APPLICATION OF SCHEDULE: This rate schedule is available for municipal or other governmental use only. It shall apply to electric service for motor driven pumps for use at water pumping and treating plants, sewage disposal and treating plants and sewage lift stations and all lighting and other electrical requirements incidental to the operation of such plants and lift stations. Municipal buildings adjacent to, but not incidental to the pumping operation, may not be served at this rate except upon approval of Otter Tail Power Company where separate metering is not practical for a small connected load. Service shall be at the available secondary voltage, and where the electric supply is three-phase, the municipality shall provide the necessary wiring and equipment for its single phase requirements.

Where electric service is provided at an available primary voltage, billing for energy shall be reduced by 2% to compensate the municipality for transformer losses.

The rate schedule and monthly minimum shall apply to each meter in service except that where service through a meter is for electric space heating only the energy on this meter shall be added to the pumping meter for billing purposes. Seasonal service is not permitted.

RATE:	First 2500	kwh or less used per month	- 6.068¢ per kwh
	Next 1500	kwh used per month	- 4.480¢ per kwh
	Excess	kwh used per month	- 3.578¢ per kwh

MONTHLY MINIMUM CHARGE: $3.45 for each metering point.

COST OF ENERGY ADJUSTMENT: The energy charges under this schedule are subject to a Cost of Energy Adjustment as provided for in Rate Designation M-60M, or any amendments or superseding provisions applicable thereto.

TAX REFORM ACT CREDIT ADJUSTMENT: A tax credit adjustment of 4.27% shall be subtracted from all billings. N

PAYMENT: Refer to Payment Policy Rate Schedule, Rate Designation M-62N, superseding amendments, or provisions allowed by law.

REGULATIONS: General Rules and Regulations govern use under this schedule.

ADJUSTMENT FOR MUNICIPAL PAYMENTS: Bills under this rate schedule may be subject to adjustment for certain payments to municipalities as provided in the General Rules and Regulations.

NORTH DAKOTA PUBLIC
SERVICE COMMISSION
Approved: March 24, 1993
Case No. PU-401-93-104

RATES EFFECTIVE with bills rendered
on and after March 24, 1993, in ND

APPROVED ...

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: DEVILS LAKE OUTLET PLAN	COMPUTED BY: TMP	DATE: 6/27/96	SHEET: 1	3
	SUBJECT TITLE: O & M COSTS 300 cfs PUMP STATIONS	CHECKED BY:	DATE:	CONTRACT NO.:	

COMPUTE OPERATING COSTS FOR PUMP STATIONS ASSUMING THEY ARE EACH RATED AT 300 cfs

USE following ASSUMPTIONS:

- COMPUTE diesel OPERATING COSTS ONLY
- ASSUME $1/gallon fuel oil
- ASSUME 6 months PUMPING PER YEAR
  180 DAYS TOTAL
  60 DAYS PUMPING AT MAXIMUM CAPACITY (300 cfs)
  60 DAYS 3/4 CAPACITY (225 cfs)
  60 DAYS 1/2 CAPACITY (150 cfs)
- 15 gallons PER hour fuel consumption
- PUMPING HEADS identical TO 200 cfs option
- 4 PUMPS PER STATION (3 PUMP STATIONS)
- 33,750 gpm PER PUMP
- 300 hp engines Required

CENCS14 23JAN92

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: DEVILS LAKE OUTLET PLAN	COMPUTED BY: TMP	DATE: 6/27/96	SHEET: 2	3
	SUBJECT TITLE: O & M COSTS 300 CFS PUMP STATION	CHECKED BY:	DATE:	CONTRACT NO.:	

DIESEL PUMPING COSTS

AT MAXIMUM CAPACITY (300 cfs) have 60 gallons per hour fuel consumption

3/4 capacity have 45 gallons/hr consumption

1/2 capacity have 30 gallons/hr consumption

60 DAYS (1440 hrs) MAX CAPACITY

FUEL COST = (60 gallons/hr)(1440 hrs)($1/gallon)
= $86,400

60 DAYS, 3/4 CAPACITY

FUEL COST = (45)(1440)(1)
= $64,800

60 DAYS, 1/2 CAPACITY,

FUEL COST = $43,200

TOTAL FUEL COST = $86,400 + $64,800 + $43,200
= $194,400

Since we have 3 PUMP STATIONS

YEARLY TOTAL FUEL COST = 3 X $194,400 = **$583,200**

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Devils Lake Outlet Plan	COMPUTED BY: TMP	DATE:	SHEET: 3	3
	SUBJECT TITLE: O & M Costs 300 cfs Pump Stations	CHECKED BY:	DATE:	CONTRACT NO.:	

COMPUTE TOTAL WATER VOLUME PUMPED

AT 300 cfs:

$$\text{VOLUME} = (300\ ft^3/sec)\left(60\ \frac{sec}{min}\right)\left(60\ \frac{min}{hr}\right)\left(24\ \frac{hrs}{day}\right)60\ \text{DAYS}$$

$= 1,555,200,000\ ft^3$

$= 35,703$ ACRE-FEET

AT 225 cfs, 60 DAYS

VOLUME = 26,776 ACRE-FEET

AT 150 cfs, 60 DAYS

VOLUME = 17,851 ACRE-FEET

TOTAL VOLUME = **80,331 ACRE-FEET**

COST PER 100,000 ACRE-FEET

$$= \left(\frac{100,000}{80,331}\right)(583,200) = \$725,996 / 100,000\ \text{Ac-ft}$$

CENCS14 23JAN92

315 2nd Street SE
PO Box 2220
Jamestown ND 58402-2220
701 252-0540

December 12,1995

OTTERTAIL
Power Company

Byron Nelson
U. S. Army Corp of Engineers
190 Fifth Street East
St. Paul, MN 55101

Dear Byron:

It was a pleasure talking with you on Monday afternoon. The information was not ready on Monday evening, but we have compiled the following information for your review. It will cover the project well:

• Tapping of the 230 kVA Line	$287,500
• Breakers on 230 kVA Line (if required)	$287,500
• Transformer 230 kVA to 41.6 kVA	$172,500
• Transmission Line 41.6 kVA	$345,000
• Substation to 4160 Vac	$287,500

Total Electric Construction Cost of Project $1,380,000

This estimate is subject to change without notice, and is contingent on equipment and labor availability. Prices are rough order of magnitude. We believe the system can be completed in 6 months ARO based on current projections.

Please find the enclosed spreadsheets covering the cost per kWh for the system. As I referred to in my fax the 3.58¢ rate is the North Dakota Municipal Pumping Service Rate that we will augment with the provision of interruptible service. The reason for the provision is the size of the load. It allows us to give you this low rate and removes any demand charges. At this rate, your cost per year is approxiamately $1,482,000 in an average year. I arrived at this by using one month at full load and 7 months at half load. A full load month is approxiamately $329,000 and a half load month is approxiamately $165,000 per month. Your estimate would be for 7 months of operation is approxiamately $1,320,000.

I hope this information is helpful to your in your planning and Otter Tail Power Company hopes to serve you in the future. Please remember Otter Tail Power Company has **THE ENERGY** *to serve you* in Devils Lake, and wishes you and the Army Corp of Engineers success with the project. Please call if you have questions.

Seasons greetings,

Paul C. Garnaas
Industrial Services Engineer

cc: Duane Bartsch - Industrial Services Fergus Falls
Wayne Thompson - Devils Lake Division Engineer
Richard Prozinski - Devils Lake Division Manager

The energy charge component is subject to adjustment based on changes in the average system energy production rate. At this time, however, changes are not projected over the term of the rate.

COST OF INVESTMENT TO SERVE:

Cost of facilities:

Estimated range of $1,200,000.00 to $3,400,000.

The low end estimate uses 41.6 KV transmission line and manual switching. The pumping capacity of the station would probably have to be down sized in order to use the 41.6 KV transmission.

The $3,400,000.00 estimate includes 11.5 miles of 115 KV transmission line with motor operated switches at the tap and dual transformers with tap changers and circuit switches at the station.

These estimates are very preliminary and could vary greatly depending upon customer considerations and requirements.

Monthly Charge for Investment to Serve:

The Corps has indicated that their preference would involve paying facility costs in full at completion of construction.

ASSUMPTIONS:

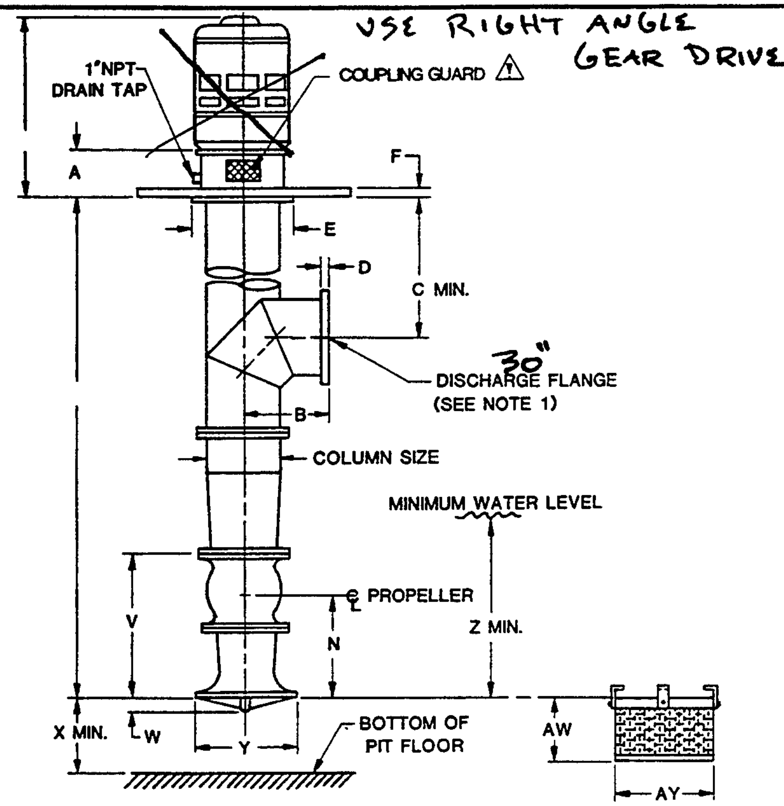
1. The water pipeline load will qualify for the Load Development Rate.

2. There will be no distribution losses involved in providing service to this load.

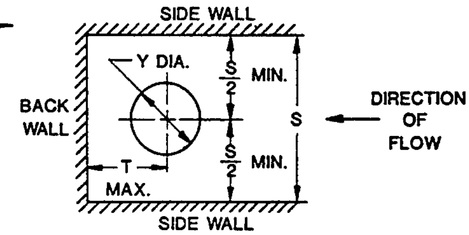
3. The facility estimate does not provide for a distribution system past the substation in providing service to this load.

4. Power quality requirements will be able to be addressed through the standard substation configuration. The cost of other equipment needed to address further power quality problems arising from the pipeline facility will result in an increase in dedicated improvement costs.

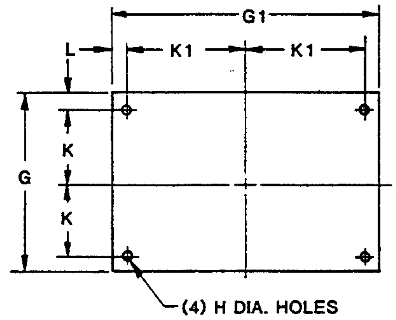
USE RIGHT ANGLE GEAR DRIVE



OPTIONAL STRAINER



PIT TOP VIEW



BOTTOM VIEW OF BASEPLATE

⚠ WARNING

DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARDS IN PLACE.
ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARDS CAN RESULT IN SEVERE BODILY INJURY.

DISCHARGE HEAD DIMENSIONS														
PUMP SIZE	COLUMN SIZE	A	B	C	D	E	F	G	H	K	L	G1	K1	MIN. OPENING REQUIRED
10	10	12	20	16	3/4	11 1/2	3/4	29	7/8	12 1/2	2	36	16	21x28
10,12	12	12	22	20 1/2	3/4	17 5/8	3/4	29	7/8	12 1/2	2	41	18 1/2	21x33
12,14	14	14	24	20 1/2	3/4	17 5/8	1	31	7/8	13 1/2	2	43	19 1/2	23x35
14,16	16	14	29	25	3/4	20	1	35	1	15 1/2	2	49	22 1/2	27x41
16,20	20	16	33	25	3/4	20	1 1/4	45	1	20 1/2	2	55	25 1/2	37x47
20,24	24	16	38	35 1/2	1	28 1/2	1 1/4	50	1	23	2	62	29	42x54
24,30	30	19	46	35 1/2	1	34 1/2	1 1/2	53	1 1/8	24	2 1/2	74	34 1/2	44x65
30	36	19	52	42	1	40 1/2	1 3/4	65	1 1/8	30	2 1/2	83	39	56x74

PUMP DIMENSIONS												
PUMP SIZE	N	S	T	V		W	X		Y	Z	STRAINER	
				1 STG.	2 STG.		WITHOUT STRAINER	WITH STRAINER			AW	AY
10	7 1/4	36	13 3/4	17 1/2	30 3/8	3	6	8	15 1/2	51	5	15 1/2
12	9	42	15 3/4	21 1/2	37	3 1/2	6	12	18	54	9	18
14	11	48	19 1/2	26	44 1/2	4	7	11	21	54	8	20 3/4
16	12	54 1/2	22 1/4	30	51 1/2	4 1/4	8	10	24 1/2	57	7	24
20	16	73	32 1/2	38 1/2	66	6	12	12	35	60	9	35
24	19	84	38	43 5/8	74 3/8	6 1/2	14	14	40	60	8	40
30	22	96	42	51 3/4	89	7 1/2	14	14	42	64	11	42

NOTE 1: DIMENSIONS ARE PER ANSI-25 LB. STANDARDS EXCEPT FOR THICKNESS D.

ER2-12874

DRAWN BY: RET | DATE: 6-13-85 | CHECKED BY: [signature] | DATE: 6/11/85 | ENGINEERING APPROVAL: [initials] | DATE: 6/85 | MARKETING APPROVAL: DER | DATE: 6/85 | DRAWING NUMBER: 24LYA2364L

REV.	DATE	ECN NO.
1	2/1/86	EC2-13179

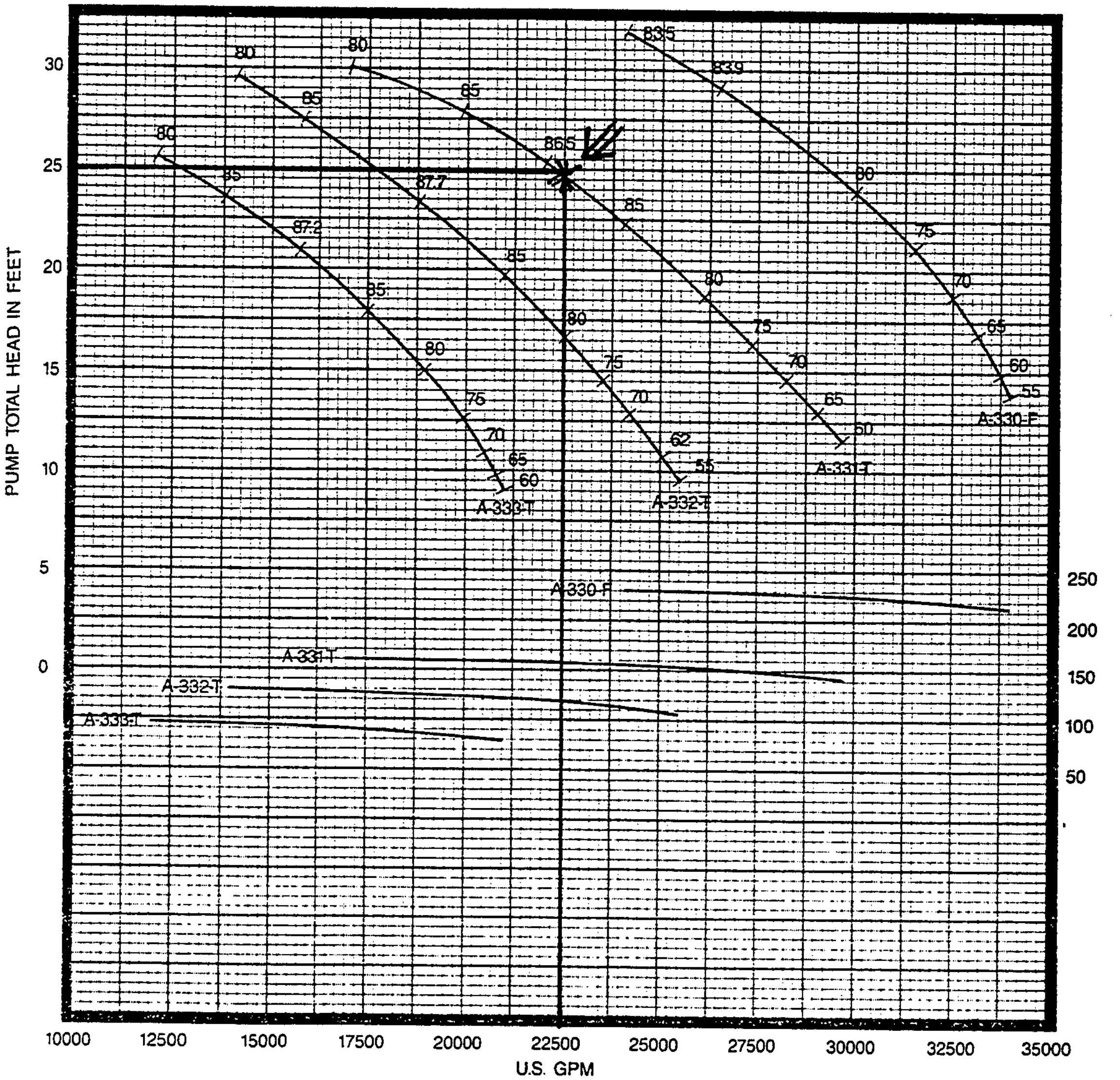
CUSTOMER | P.O.
JOB NAME
PUMP SIZE & MODEL | STAGES | GPM | TDH | RPM | ROT
MOTOR | HP | FRAME | PHASE | HERTZ | VOLTS | ENCL
CERTIFIED FOR | CERTIFIED BY | DATE

Fairbanks Morse Pump Corporation

SETTING PLAN FIGURE 8312

UG DISCHARGE HEAD

SIZE C | DWG. NO. 24LYA2364L



30" 8312

580 RPM

1 STAGE

30" COLUMN

30" FABRICATED STEEL ELBOW

2-7/16" LINESHAFT

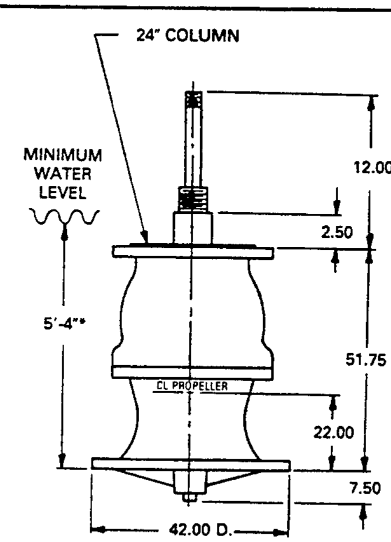
3-1/2" ENCLOSING TUBE

PUMP STATION 1 & 2

DATA	VALUE	
PUMP SHAFT DIAMETER	2.9375 IN.	
MAXIMUM SPHERE SIZE	4.50 IN.	
Kt (THRUST FACTOR)	185 LBS./FT.	
Ka (TOTAL ROTOR WEIGHT)	310 LBS.	
Ks (SETTING CONSTANT)	15.9 LBS./FT.	
WK^2	195 LBS.-FT.^{2}	
BOWL ASSEMBLY WEIGHT	2500 LBS.	
EYE AREA: PROPELLER NO. A-330-F	367.8 SQ. IN.	4 VANE
PROPELLER NO. A-331-T	367.8 SQ. IN.	3 VANE
PROPELLER NO. A-332-T	367.8 SQ. IN.	3 VANE
PROPELLER NO. A-333-T	367.8 SQ. IN.	3 VANE
PROPELLER NO.		
PROPELLER NO.		

HYDRAULIC PERFORMANCE IS CONTINGENT ON FURNISHING THE PUMP WITH SPECIFIED AMOUNT OF CLEAR, FRESH, NON-AERATED WATER NOT TO EXCEED 85° F.

PUMP PERFORMANCE SHOWN IS BOWL ASSEMBLY WITH 10 FEET OF COLUMN INCLUDING A STANDARD ABOVE GROUND DISCHARGE ELBOW. ADDITIONAL COLUMN LOSSES SHOULD BE ADDED WHEN SETTINGS ARE DEEPER THAN 10 FEET AND/OR FOR OTHER DISCHARGE ARRANGEMENTS.



*This value is the minimum submergence required to prevent vortexing only. This value may need to be increased to provide adequate NPSHA.

8000 PROPELLER PUMPS
PUMP PERFORMANCE

30″
8312

580 RPM

2 STAGE

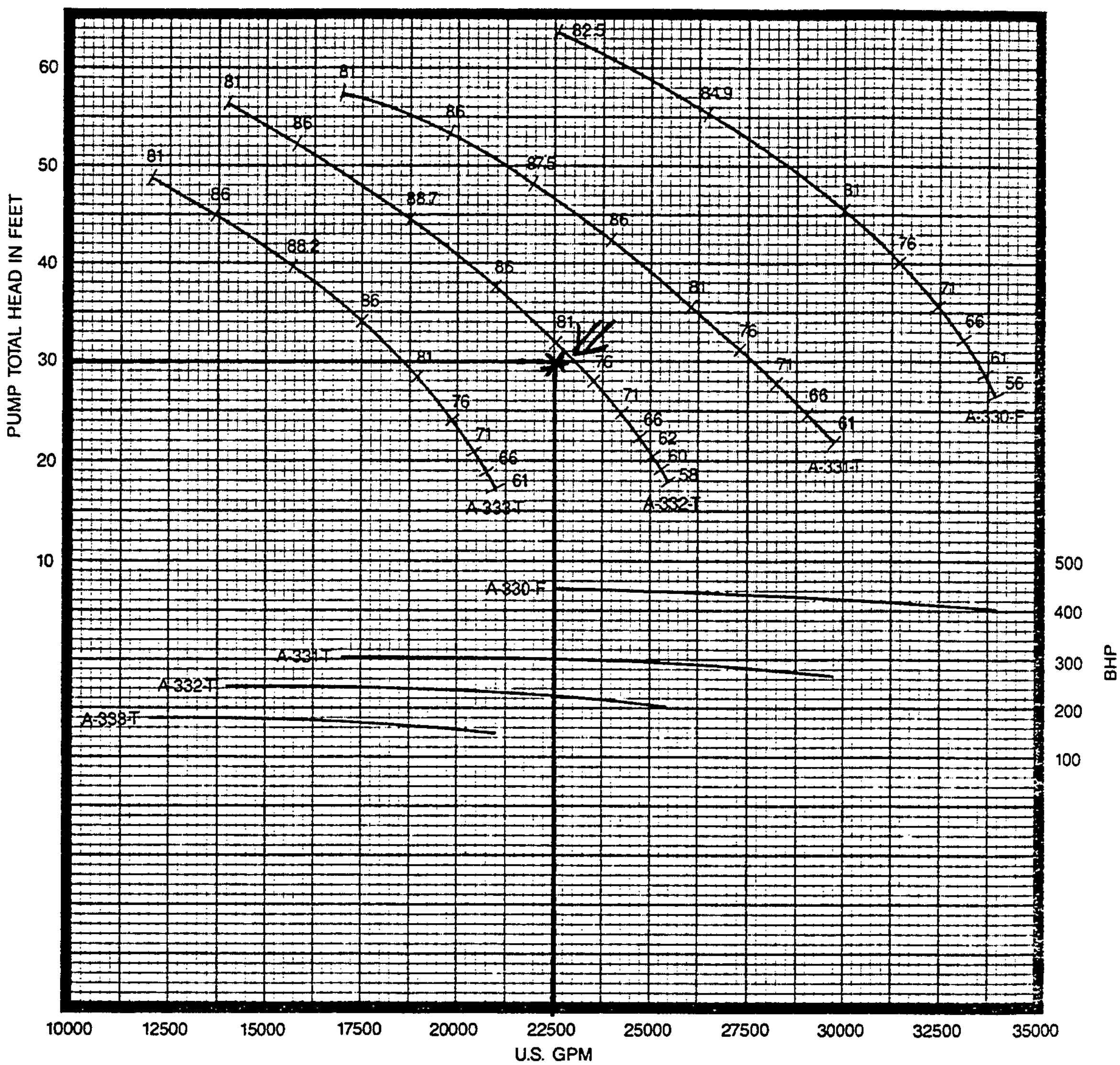
30″ COLUMN

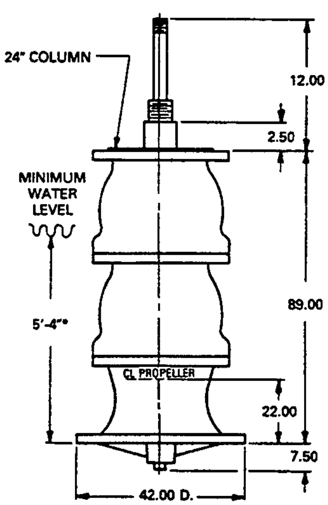
30″ FABRICATED STEEL ELBOW

2-15/16″ LINESHAFT

5″ ENCLOSING TUBE

PUMP STATION #3





*This value is the minimum submergence required to prevent vortexing only. This value may need to be increased to provide adequate NPSHA.

DATA	VALUE	
PUMP SHAFT DIAMETER	2.9375 IN.	
MAXIMUM SPHERE SIZE	4.50 IN.	
Kt (THRUST FACTOR)	185 LBS./FT.	
Ka (TOTAL ROTOR WEIGHT)	620 LBS.	
Ks (SETTING CONSTANT)	23.0 LBS./FT.	
WK²	390 LBS.-FT.²	
BOWL ASSEMBLY WEIGHT	4300 LBS.	
EYE AREA: PROPELLER NO. A-330-F	367.8 SQ. IN.	4 VANE
PROPELLER NO. A-331-T	367.8 SQ. IN.	3 VANE
PROPELLER NO. A-332-T	367.8 SQ. IN.	3 VANE
PROPELLER NO. A-333-T	367.8 SQ. IN.	3 VANE
PROPELLER NO.		
PROPELLER NO.		

HYDRAULIC PERFORMANCE IS CONTINGENT ON FURNISHING THE PUMP WITH SPECIFIED AMOUNT OF CLEAR, FRESH, NON-AERATED WATER NOT TO EXCEED 85° F.

PUMP PERFORMANCE SHOWN IS BOWL ASSEMBLY WITH 10 FEET OF COLUMN INCLUDING A STANDARD ABOVE GROUND DISCHARGE ELBOW. ADDITIONAL COLUMN LOSSES SHOULD BE ADDED WHEN SETTINGS ARE DEEPER THAN 10 FEET AND/OR FOR OTHER DISCHARGE ARRANGEMENTS.

K 25 29

LARGE INDUSTRIAL PUMP DRIVES

Publication ID: 87
Publication Date: NOVEMBER 1989

Company: MARMON GROUP INC/ AMARILLO GEAR CO

DESIGN

GEARS. All drives are furnished with spiral bevel gears manufactured by Amarillo Gear Company in our modern plant using the latest Gleason equipment.

Optimum tooth contact and maximum performance is insured by computer aided design analysis and strict adherence to the latest AGMA standards.

BEARINGS. Three thrust bearing arrangements are offered in each model to insure that the proper bearing is available for even the most unusual application. By designing all bearings to have lives which exceed AGMA recommendations and which are selected only from leading bearing manufacturers. maximum reliability is obtained.

HOUSINGS. Carefully designed and precision machined housings insure correct gear and bearing alignment while providing the stiffness, shock resistance and dampening characteristics required.

SHAFTS. Made from heat treated alloy steel properly sized to give maximum life and minimum deflection.

LUBRICATION. Cooled and filtered oil is delivered under pressure to all gears and bearings by a gear driven positive displacement oil pump. An oil to water shell and tube heat exchanger insures that oil is delivered at the proper temperature and viscosity. In the event cooling water is not available, oil to air coolers are available. Please contact our factory.

DRY WELL CONSTRUCTION. Amarillo Gear Company was an early pioneer in the use and perfection of this unique sealing arrangement which provides maximum protection against output shaft leakage.

EFFICIENCY. Efficiency varies with speed, power and thrust, with normal ranges being 96-98%. Contact factory for actual values for your application.

NON-REVERSE CLUTCHES. Available on all models if required.

SERVICE. In the event that service is required, Amarillo Gear Company prides itself in its ability to supply parts and/or service personnel with minimum notice.

MODEL PREFIX DESIGNATION:

Hollow Shaft Drives:

SL Standard Thrust Capacity
S Heavy Thrust Capacity, 1.35 Times Standard Capacity
SH Extra Heavy Thrust Capacity 2 Times Standard Capacity

Solid Shaft Drives:

SSL Standard Thrust Capacity
SS Heavy Thrust Capacity, 1.35 Times Standard Capacity
SSH Extra Heavy Thrust Capacity, 2 Times Standard Capacity

SELECTION. The following information is required to make proper selection:

1. Horsepower requirement
2. Input and output r.p.m.
3. Service Factor
4. External thrust
5. Whether hollow or solid output shaft is required
6. Whether non-reverse is required

Divide input r.p.m. by output r.p.m. to find the required gear ratio. Select the closest ratio from Table #1. Proceed down the ratio column until the required horsepower rating is found under the pump r.p.m. (Interpolate as required for intermediate rating).

All ratings listed in this catalog include a 1.5 service factor. In the event a service factor other than 1.5 is required, divide 1.5 by the required service factor and then multiply the results by the table rating to get the drive rating with the new service factor.

Check thrust capacity of selection to verify that it is equal to or less than the rating. If your requirement is greater than the rated value, contact our factory.

Verify the rotation with drawings in Figures #1 - #4.

Example: A solid shaft right angle gear drive is to connect a diesel engine transmitting 1200 hp at 1800 r.p.m. and a vertical pump at 720 r.p.m. A 1.5 service factor is required and the pump will develop 15,000 lbs. downthrust at duty.

$$\frac{1800}{720} = 2.5 \text{ (Ratio Reduction)}$$

From Table #1 we find that the Model 1500 5:2 ratio rates 1013 hp and the Model 1800 5:2 rates 1443 hp at 720 r.p.m. The correct selection is then the Model 1800. The SSL thrust bearing rating exceeds the pump thrust, therefore, the model number would be SSL1800 5:2 ratio.

Had a 1.25 service factor been required, then 1.5/1.25 = 1.2. The Model 1500 rated 1013 hp at 720 r.p.m. The horsepower rating with a 1.25 S.F. = 1.2 X 1013 = 1215 hp. The 1500 thrust rating exceeds the pump thrust, therefore, the Model SSL1500 5:2 would be the proper selection for a 1.25 S.F.

NOTE: All thrust ratings listed are for continuous service. Higher thrust loads are allowed for intermittent service or momentary operation conditions. Our experienced sales staff is ready to assist you at all times in making a final selection.

WARRANTY

The Amarillo Right Angle Gear Drive is guaranteed against defects in workmanship and material for a period of one year after installation when operated under normal service at rated capacity. Within the above stated period the manufacturer will replace defective parts returned transportation prepaid. The guarantee will not apply to repairs made outside the factory without the consent of the manufacturer, or to drives that have been subject to abuse, accident, neglect, or improper installation. No warranty is made in regard to bearings, trade accessories, machinery, or other articles of merchandise not manufactured by us. No responsibility will be assumed for overloading the rated capacity of the thrust bearing. (The thrust capacity of the drive should be verified by the pump manufacturer with whose equipment the drive is used.) This warranty is expressly made in lieu of any warranties otherwise implied by law.

Amarillo Right Angle Gear Drives have been adapted for a wide range of industrial applications too numerous to mention in this catalog. Please contact our engineering department for special or unusual applications.

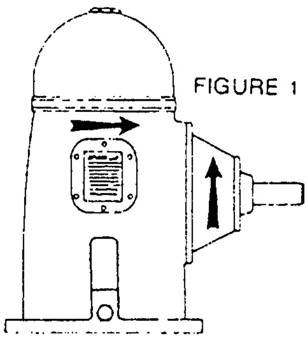


FIGURE 1

HORIZONTAL—CW
VERTICAL—CCW

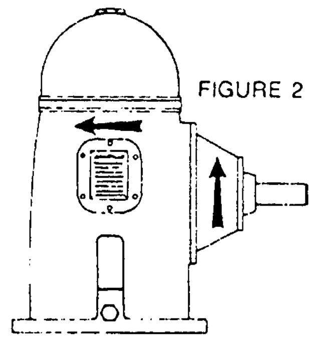


FIGURE 2

HORIZONTAL—CW
VERTICAL—CW

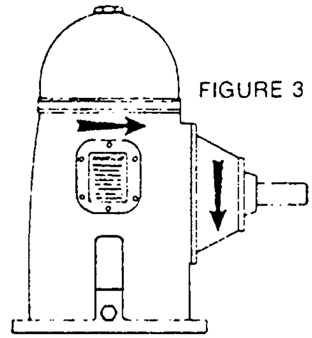


FIGURE 3

HORIZONTAL—CCW
VERTICAL—CCW

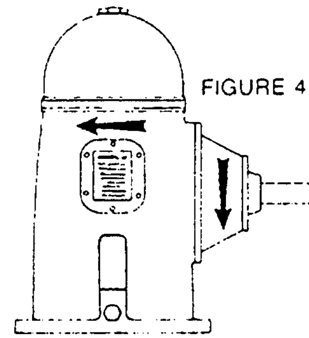


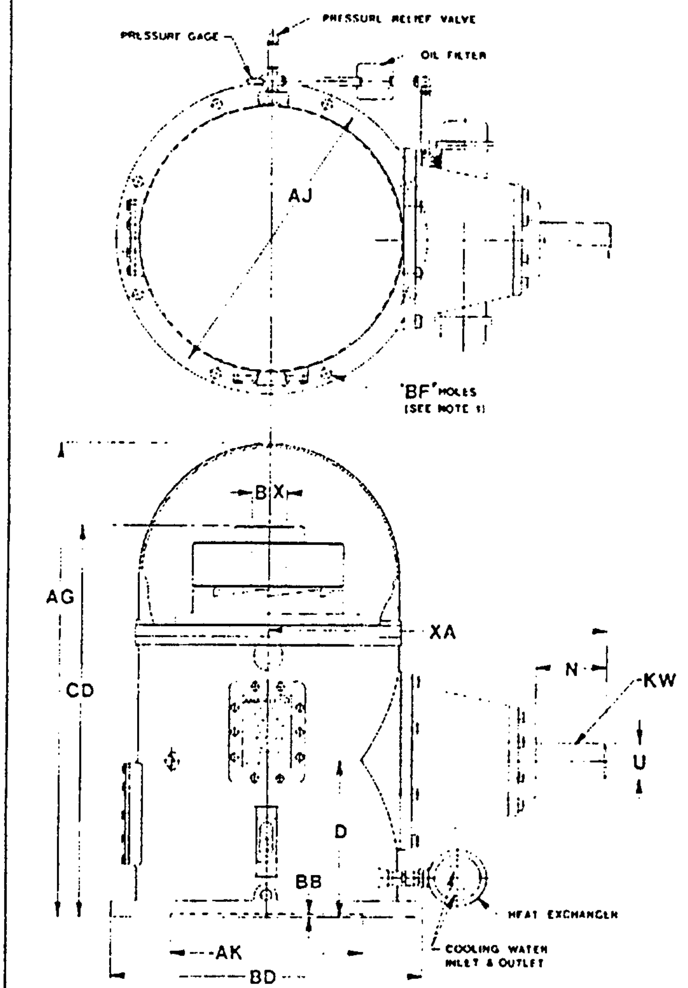
FIGURE 4

HORIZONTAL—CCW
VERTICAL—CW

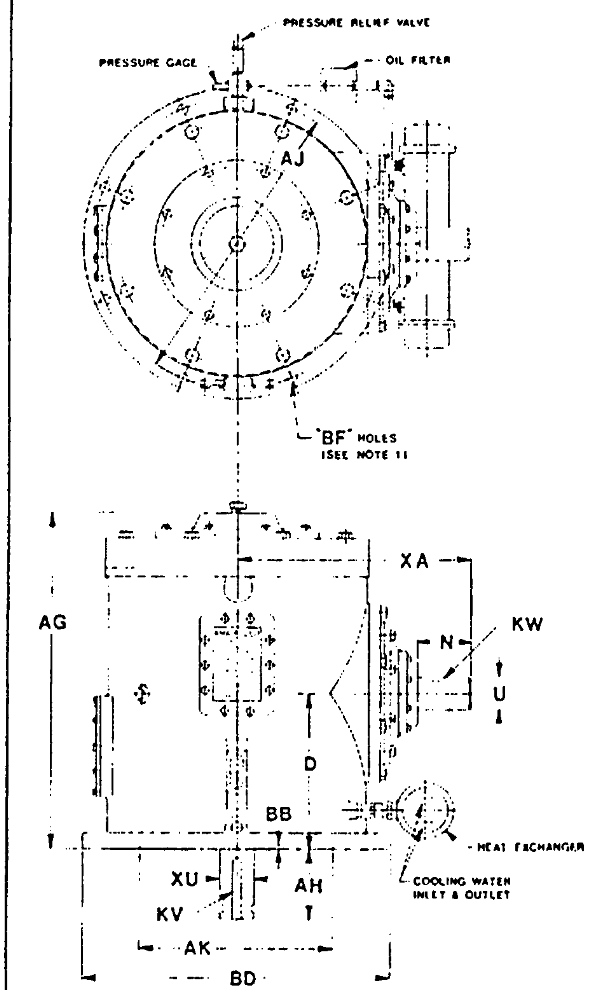
RATIOS AND ROTATIONS: The ratio of a drive is defined as the ratio of the horizontal input speed to vertical output speed. For example, a 2:1 ratio would have a horizontal speed of twice the vertical speed. There are four rotational schemes available as shown in figures 1, 2, 3, and 4. Figure 1 is denoted as standard rotation. Figures 2, 3, and 4 are special rotation. CW—Clockwise; CCS—Counter-clockwise

TABLE 1
POWER AND THRUST RATINGS

MODEL	VERT SHAFT RPM	** THRUST RATING	RATIO 1.00	1.25	1.33	1.50	1.75	2.0	2.5	3.0	3.50	4.0	4.50	5.0	5.50	6.0
1000A	250	32980					253	263	279	255	257	225	228	212	205	190
	340	30075					335	349	369	337	341	298	302	281	272	252
	430	28060					415	432	457	418	422	369	374	348	337	312
	580	25590					543	558	564	547	523	483	490	456	442	408
	720	23920					644	649	657	645	609	586	594	553	536	
	870	22615					735	741	750	736	695	694	686			
	960	22060					787	794	803	788	745	743				
	1160	20850					899	907	917	900	850					
	1460	19385					1056	1065	1077							
1200	250	32980	209	282	282	275	303	308	316	304	305	289	290	273	273	248
	340	30075	277	373	373	365	400	407	418	402	403	382	384	361	361	328
	430	28060	343	462	462	452	495	503	516	497	498	472	475	447	447	405
	580	25590	450	605	605	591	647	658	675	649	614	617	585	584	584	529
	720	23920	546	734	734	717	784	797	818	755	715	718	681	679	679	
	870	22615	647	868	868	848	926	942	966	862	816	820	777			
	960	22060	706	947	947	925	1010	1026	1053	924	874	878				
	1160	20850	834	1118	1118	1093	1191	1211	1242	1055	998					
	1460	19385	1020	1366	1366	1335										
	1760	18400	1200													
1500	250	32980	276	352	352	344	352	352	352	352	352	352	352	334	341	305
	340	30075	367	478	467	456	478	478	478	478	478	478	469	442	451	404
	430	28060	454	605	578	564	605	605	605	605	605	591	580	547	558	499
	580	25590	596	816	756	739	816	816	816	816	816	773	758	714	729	652
	720	23920	723	1013	917	897	1013	1013	1013	1013	959	937	918	866		
	870	22615	856	1218	1085	1061	1224	1224	1224	1165	1133	1107				
	960	22060	934	1329	1184	1157	1351	1351	1351	1248	1235					
	1160	20850	1104	1569	1398	1366	1632	1632	1632	1425						
	1460	19385	1351	1917	1708	1669										
	1760	18400	1589													



TYPE "SL"



TYPE "SSL"

TABLE 2
DIMENSIONS

MODEL	1:1 THROUGH 5:2 RATIOS				3:1 AND GREATER RATIOS				SL		SSL	D	AJ	AK	BB	BD	BF	BX MAX	AH	XU	KV	WEIGHT
	XA	N	U	KW	XA	N	U	KW	AG	CD	AG											
1000A	33 1/8	6	3.749	7/8 x 7/16	24 1/4	6	3.186	3/4 x 3/8	50 1/8	38 5/8	33 5/8	17	28 3/4	22.000	1/4	30 1/2	1 1/16	4	8	3.998	1 x 1/2	2280
1200	38	8	3.998	1 x 1/2	26 3/8	6	3.748	7/8 x 7/16	54	45	37	18	28 3/4	22.000	1/4	30 1/2	1 1/16	4	8	3.998	1 x 1/2	3090
1500	38	8	3.998	1 x 1/2	26 3/8	6	3.748	7/8 x 7/16	54	45	37	18	28 3/4	22.000	1/4	30 1/2	1 1/16	4	8	3.998	1 x 1/2	3145
1800	42 3/4	8	4.498	1 x 1/2	31 1/4	8	3.998	1 x 1/2	65 1/4	54 1/4	45	23 1/2	37 1/2	32.000	1/4	40	1 5/16	4 1/2	8	4.498	1 x 1/2	5800
2200	47 1/2	9	5.248	1 1/4 x 5/8	37 1/8	8	4.498	1 x 1/2	77	66 1/8	56 1/2	27 1/2	42	32.000	3/8	46	1 5/16	5 1/4	9	5.248	1 1/4 x 5/8	8500
2600	50	9	6.498	1 1/2 x 3/4	38 1/2	8	4.748	1 1/4 x 5/8	81	70	60 3/8	31	46	40.000	3/8	50	1 5/16	6 1/2	9	6.498	1 1/2 x 3/4	10400
3000	55	10 1/2	7.248	1 3/4 x 7/8	41 1/2	9	5.498	1 1/4 x 5/8	85	74	64 3/8	33	55	50.000	3/8	60	1 9/16	7 1/4	10 1/2	7.248	1 3/4 x 7/8	12300
3400	58	11	7.623	1 3/4 x 7/8	45 5/8	10	5.993	1 1/2 x 3/4	99 1/2	88 1/8	77 5/8	38 1/2	55	50.000	1/2	60	1 9/16	7 3/4	11	7.748	1 3/4 x 7/8	14200
3800	60	12	8.248	2 x 1	46	11	7.248	1 3/4 x 7/8	105	93	84	40	62	58.000	1/2	66	1 9/16	8 1/4	12	8.248	2 x 1	17000
4200	64	12	8.748	2 x 1	50	12	7.748	2 x 1	108	97	87	45	68	64.000	1/2	72	1 9/16	9 1/4	12	9.248	2 1/4 x 1 1/8	19100
4600	67	13 1/2	9.248	2 1/2 x 1 1/4	53	12 1/4	8.248	2 x 1	118	107	97	48	72	68.000	1/2	76	1 13/16	9 3/4	13 1/2	9.748	2 1/4 x 1 1/8	21200
5000	70	13 1/2	9.498	2 1/2 x 1 1/4	56	13	8.873	2 x 1	128	117	107	51	76	72.000	1/2	80	1 13/16	10	13 1/2	9.998	2 1/4 x 1 1/8	23400
5400	75	14	9.748	2 1/2 x 1 1/4	59	13 1/2	9.248	2 1/2 x 1 1/4	132	121	110	55	80	76.000	1/2	84	1 13/16	10 3/8	14	10.373	2 1/4 x 1 1/8	26000
5800	79	14 3/4	9.998	2 1/2 x 1 1/4	63	14	9.498	2 1/2 x 1 1/4	136	125	115	59	84	80.000	1/2	88	2 1/8	10 1/2	14 3/4	10.498	2 1/4 x 1 1/8	29000
6200	83	15 1/2	10.498	2 1/2 x 1 1/4	66	14	9.748	2 1/2 x 1 1/4	140	129	119	63	88	84.000	1/2	92	2 1/8	10 3/4	15 1/2	10.748	2 1/2 x 1 1/4	32000

1. MODELS 1000A - 1500 HAVE 4-"BF" HOLES EQ SP., 45° OFF CENTER LINES. MODELS 1800 - 6200 HAVE 8-"BF" HOLES EQ SP., 22°30' OFF CENTER LINES.
2. CATALOG DIMENSIONS ARE SUBJECT TO VARIATION. REQUEST CERTIFIED DRAWINGS FOR CONSTRUCTION PURPOSES.

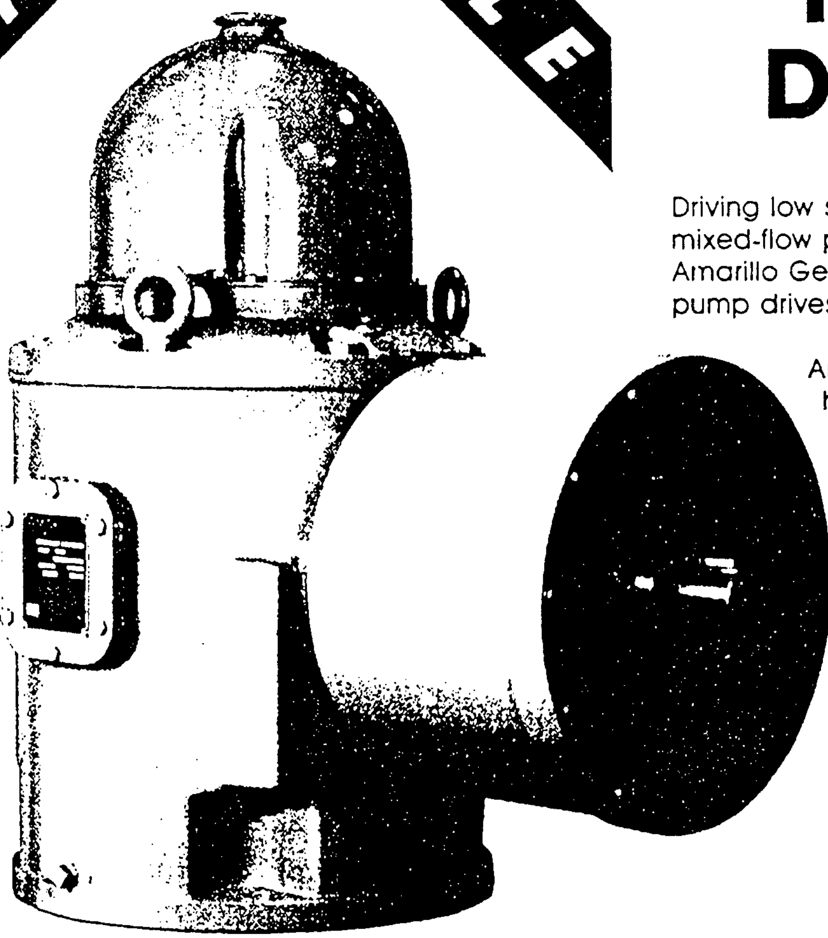
5

FORM # PP

K-25 27

RIGHT ANGLE

PROPELLER PUMP DRIVES



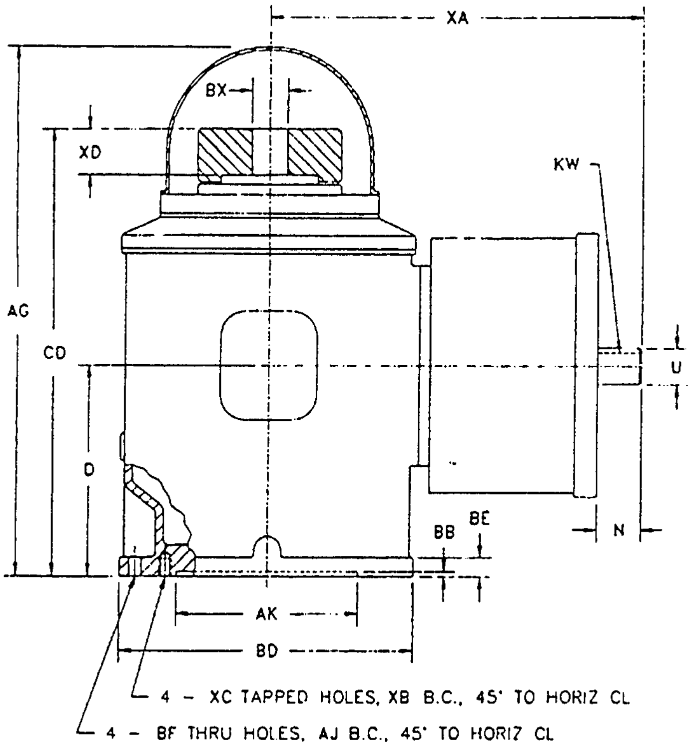
Driving low speed propeller type or mixed-flow pumps is not a problem with Amarillo Gear Company's new propeller pump drives.

Amarillo Gear Company has been manufacturing the industry's most dependable spiral bevel right angle gear drives for over 50 years. We now offer a product line especially for low speed pumps that is engineered and manufactured to meet Amarillo's reputation for quality and reliability.

MEMBER OF AGMA

DRIVE LOW SPEED PUMPS

AMARILLO GEAR COMPANY
Post Office Box 1789, Amarillo, TX 79105 ☎ 806/622-1273
2401 Sundown Lane (79118) FAX 806/622-3258



DIMENSIONS

MODEL	P3	P5	P6	P8
D	11 1/2	13 3/4	17	18
N	3 9/16	4 1/16	5	7
N 3:1 AND GREATER	--	--	--	5 1/2
U	1.999	2.436	3.748	3.998
U 4:1 AND GREATER	1.874	--	--	--
U 3:1 AND GREATER	--	--	3.186	3.748
KW	1[illegible] 1/4	5/8 X 5/16	7/8 X 7/16	1 X 1/2
KW 4:1 AND GREATER	3/8 X 3/16	--	--	--
KW 3:1 AND GREATER	--	--	3/4 X 3/8	7/8 X 7/16
AG	29 3/4	36	50 1/8	54
CD	24 3/8	29 1/4	38 5/8	45
AJ	14 3/4	18 1/4	28 3/4	28 3/4
AK	(3) 13.500	13.500	22.000	22.000
BB	1/4	1/4	1/4	1/4
BD	16 1/2	20	30 1/2	30 1/2
BE	1	1 1/8	1 7/8	1 7/8
BF	11/16	11/16	1 1/16	1 1/16
XA	22 1/16	21 1/2	35 1/8	40
XA 3:1 AND GREATER	--	--	25 1/2	28 1/2
XB	--	14 3/4	26	26
XC	--	5/8-11NC	3/4-10NC	3/4-10NC
XD	2 1/2	3	3 3/4	5
BX MAX	(1) 2	2 3/4	4	(2) 4
WT LBS	580	1020	2280	3145

(1) 2 3/16 BORE AVAILABLE IN MODEL P3 AT EXTRA COST.
(2) 4 1/4 BORE AVAILABLE IN MODEL P8 AT EXTRA COST.
(3) P3 REQUIRES A DISCHARGE BASE OPENING OF AT LEAST 9-1/4 DIAMETER.

HORSEPOWER AND THRUST RATINGS

MODEL	VERT SHAFT RPM	THRUST RATING	RATIO 2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
P3	250	10900	75	92	85	79	83	77	72	67	67
	340	9950	100	120	112	98	107	103	96	90	88
	430	9250	129	142	139	115	126	121	115	112	110
	580	8500	174	175	171	142	155	150	143		
	720	8100	211	204	199	165	181				
	870	7700	242	233	227	189					
	960	7500	260	250	244						
P5	250	13000	148	174	145	145	145	145	145	139	138
	340	11900	201	231	192	192	192	192	192	185	184
	430	11100	254	286	238	238	238	238	238	229	228
	580	10150	343	367	313	313	313	313	313		
	720	9500	426	427	380	380	380				
	870	9000	488	488	450						
P6	250	32980	263	279	255	257	225	228	212	205	190
	340	30075	349	369	337	341	298	302	281	272	252
	430	28060	432	457	418	422	369	374	348	337	312
	580	25590	558	564	547	523	483	490	456		
	720	23920	649	657	645	609	586				
	870	22615	741	750	736						
P8	250	32980	441	416	395	370	360	354	334	341	305
	340	30075	583	551	523	490	477	469	442	451	404
	430	28060	721	681	646	606	590	580	547	557	499
	580	25590	943	891	845	792	771	758	715		
	720	23920	1142	1079	1024	959					
	870	22615	1350	1273							

POWER RATINGS INCLUDE A 1.5 SERVICE FACTOR.
CONTACT FACTORY FOR APPLICATIONS NOT COVERED IN THE ABOVE TABLES.

ZIEGLER CAT
ZIEGLER POWER SYSTEMS

901 WEST 94TH STREET
MINNEAPOLIS, MN 55420-4299
612/888-4121
800/352-2812

To:	Mr. Tim Paulus	Phone:	612-290-5530
		Fax:	612-290-5805
Company:	U.S. Army Corps of Engineers		
From::	Loren E. Bahls		
Company:	Ziegler Power Systems Div. of Ziegler Inc.	Phone:	612-888-4121 ext. 5816
		Fax:	612-887-5822
Address:	901 West 94th Street Minneapolis, MN. 55420		
Date:	June 20, 1996		
Time:	12:17 PM	Pages:	Pages (including this one) 7
Re:	3208 CAT diesel		

As previously discussed, I've attached the basic specifications for the 3208 CAT diesel engine.

Ziegler Power Systems would like to offer our assistance in designing and packaging this engine with ancillary equipment to meet your pumping requirements.

Please call if you have any questions or comments.

Sincerely,

Loren E. Bahls

Loren E. Bahls
Sr. Sales Engineer

FAX Transmission

CATERPILLAR®

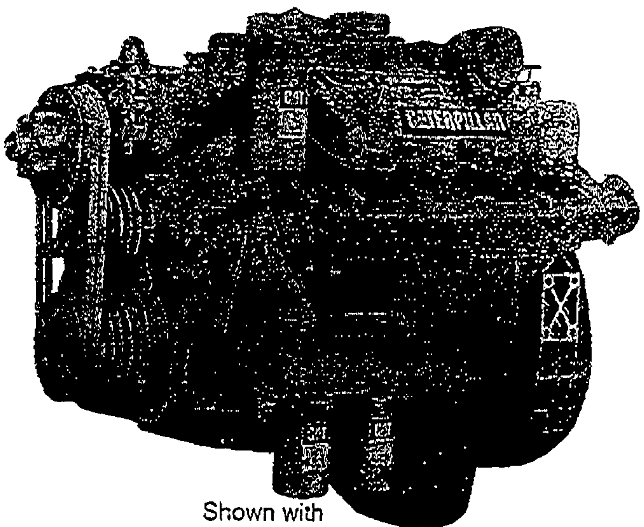
Industrial Engine 3208

125-330 bhp/93-246 bkW
2400-2800 rpm

SPECIFICATIONS

V-8, 4-Stroke-Cycle Diesel

Bore—in (mm)	4.5 (114)
Stroke—in (mm)	5.0 (127)
Displacement—cu in (L)	636 (10.4)
Low Idle — rpm	650
Combustion System	Direct Injection
Rotation (from flywheel end)	Counterclockwise
Capacity for Liquids—U.S. gal (L)	
Cooling System (engine only)	6.3 (23.8)
Lube Oil System (refill) (T & ATAAC)	5.0 (18.9)
Lube Oil System (refill) (NA)	3.0 (11.4)
Engine Weight, Net Dry (approx)—lb (kg)	
Turbocharged (T & ATAAC)	1,450 (658)
Naturally Aspirated (NA)	1,325 (601)



Shown with Optional Equipment

CATERPILLAR ENGINE FACILITIES ISO 9001 CERTIFIED

FEATURES

- **FUEL ECONOMY**
  Full range governor, automatic variable timing advance, and excellent fuel economy over entire operating range.
- **TOP PERFORMANCE**
  Largest displacement in rating class with over 300,000 in service.
- **RELIABILITY AND DIESEL DURABILITY**
  Diesel tough components, wide choice of rebuild options, and long engine life. Excellent startability at cold temperatures.
- **LOW MAINTENANCE COSTS**
  Simple adjustments, easy servicing and maintenance-free fuel system.

STANDARD EQUIPMENT

Air Inlet System
air cleaner adapter (T & NA), air inlet connection to engine, rear turbocharger exhaust outlet (T & ATAAC), aftercooler core connections to engine (ATAAC)

Control System
governor, mechanical

Cooling System
thermostats and housing; jacket water pump, belt driven, centrifugal

Exhaust System
exhaust manifold, dry; exhaust outlet, dry, flanged (NA)

Flywheel and housing
flywheel, SAE #2 or 3
flywheel housing, SAE #2 or 3
SAE standard rotation

Fuel System
fuel filter, fuel transfer pump, fuel priming pump, water separator (not installed)

Lube System
positive crankcase ventilation valve (T & NA), oil cooler, oil filler and dipstick, oil filter, oil pan, lubricating oil, lubricating oil pump, breather (ATAAC)

Mounting System
support, front

Protection System
shutdown, solenoid, 12 V (energized to run)

General
paint, Caterpillar yellow; vibration damper and guard; lifting eyes,

OPTIONAL EQUIPMENT

Air Compressor

Air Intake
air cleaner

Alternator

Control
engine mounted governor

Cooling
radiator, fan

Exhaust
fittings, mufflers

Instrumentation
gauges

Power Takeoffs
auxiliary drives, enclosed clutches

Starting
electric (12V or 14V)

CATERPILLAR®

3208 INDUSTRIAL ENGINE

PERFORMANCE DATA

Air-To-Air Aftercooled – Phase II

Rating Level	E	D	C	B	A
Rated rpm	2600	2600	2600	2400	2400
Engine Power @ rpm	330 bhp (246 bkW)	315 bhp (235 bkW)	300 bhp (224 bkW)	280 bhp (209 bkW)	275 bhp (205 bkW)

rpm	2600	2200	1700	2600	2200	1700	2600	2200	1700	2400	2000	1500	2400	2000	1500
bhp	330	321	270	315	306	257	300	292	245	280	262	206	275	259	202
lb/bhp-hr	.395	.377	.367	.391	.373	.362	.386	.372	.357	.378	.362	.355	.378	.362	.354
gal/hr	18.6	17.3	14.2	17.6	16.3	13.3	16.6	15.5	12.5	15.2	13.5	10.5	14.8	13.4	10.2

bkW	246	240	201	235	229	192	224	218	183	209	196	154	205	193	151
g/bkW-hr	240	229	223	238	227	220	235	226	217	230	220	216	230	220	215
L/hr	70.5	65.4	53.6	66.6	61.7	50.3	62.8	58.6	47.3	57.4	51.1	39.6	56.2	50.6	38.6

Turbocharged – Phase II

Rating Level	E	D	C	B	A
Rated rpm	2600	2600	2600	2400	2400
Engine Power @ rpm	295 bhp (220 bkW)	285 bhp (213 bkW)	275 bhp (205 bkW)	245 bhp (183 bkW)	230 bhp (172 bkW)

rpm	2600	2200	1700	2600	2200	1700	2600	2200	1700	2400	2000	1500	2400	2000	1500
bhp	295	277	229	285	267	219	275	256	210	245	221	173	230	207	163
lb/bhp-hr	.380	.367	.368	.377	.362	.362	.375	.358	.357	.358	.350	.358	.357	.347	.352
gal/hr	16.0	14.5	12.0	15.3	13.8	11.3	14.7	13.1	10.8	12.5	11.0	8.9	11.7	10.2	8.2

bkW	220	207	170	213	199	164	205	191	157	183	164	129	172	154	121
g/bkW-hr	231	223	224	229	220	220	228	218	217	218	213	218	217	211	214
L/hr	60.6	54.8	45.4	58.1	52.1	42.9	55.6	49.7	40.7	47.5	41.6	33.7	44.4	38.7	30.9

Turbocharged – 250 (C)

Rating Level	C	B	A
Rated rpm	2600	2400	2400
Engine Power @ rpm	250 bhp (187 bkW)	225 bhp (168 bkW)	200 bhp (149 bkW)

rpm	2600	2200	1700	2400	2000	1500	2400	2000	1500
bhp	250	246	207	225	207	165	200	189	153
lb/bhp-hr	.406	.385	.373	.385	.365	.357	.390	.360	.354
gal/hr	14.5	13.4	11.0	12.4	10.7	8.4	11.1	9.6	7.7

bkW	187	183	155	168	154	123	149	141	114
g/bkW-hr	247	234	227	234	222	217	237	219	215
L/hr	55.0	50.8	41.8	46.9	40.6	31.8	42.2	36.5	29.1

Turbocharged – 225 (C)

Rating Level	C	A
Rated rpm	2600	2400
Engine Power @ rpm	225 bhp (168 bkW)	200 bhp (149 bkW)

rpm	2600	2200	1700	2400	2000	1500
bhp	225	229	190	200	189	153
lb/bhp-hr	.406	.378	.362	.390	.360	.354
gal/hr	13.1	12.2	9.8	11.1	9.6	7.7

bkW	168	171	142	149	141	114
g/bkW-hr	247	230	220	237	219	215

3208 INDUSTRIAL ENGINE

CATERPILLAR®

PERFORMANCE DATA

Naturally Aspirated – 210 (C)

Rating Level	C	B	A
Rated rpm	2800	2400	2400
Engine Power @ rpm	210 bhp (157 bkW)	175 bhp (131 bkW)	150 bhp (112 bkW)

rpm	2800	2300	1800	2400	2000	1500	2400	2000	1500
bhp	210	194	161	175	161	128	150	135	106
lb/bhp-hr	.426	.395	.393	.381	.372	.386	.377	.362	.355
gal/hr	12.8	10.9	9.0	9.6	8.5	7.1	8.1	6.9	5.4

bkW	157	145	120	131	120	95	112	100	79
g/bkW-hr	259	240	239	232	226	235	229	220	216
L/hr	48.3	41.2	34.2	36.2	32.2	26.7	30.6	26.3	20.3

Naturally Aspirated – 175 (C)

Rating Level	C	B	A
Rated rpm	2800	2400	2400
Engine Power @ rpm	175 bhp (131 bkW)	150 bhp (112 bkW)	125 bhp (93 bkW)

rpm	2800	2300	1800	2400	2000	1500	2400	2000	1500
bhp	175	163	136	150	136	108	125	116	93
lb/bhp-hr	.403	.377	.363	.377	.363	.357	.381	.362	.354
gal/hr	10.1	8.7	7.1	8.1	7.0	5.5	6.8	6.0	4.7

bkW	131	122	101	112	102	80	93	86	69
g/bkW-hr	245	229	221	229	221	217	232	220	215
L/hr	38.1	33.1	26.7	30.6	26.6	20.7	25.7	22.6	17.7

3208 INDUSTRIAL ENGINE

CATERPILLAR

RATING CURVES

ATAAC ————
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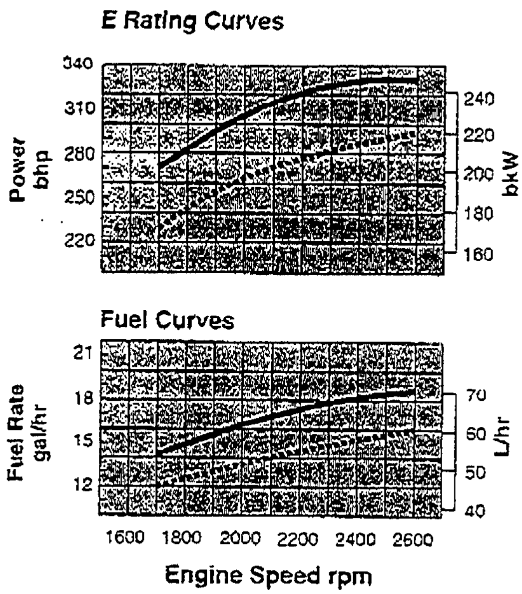

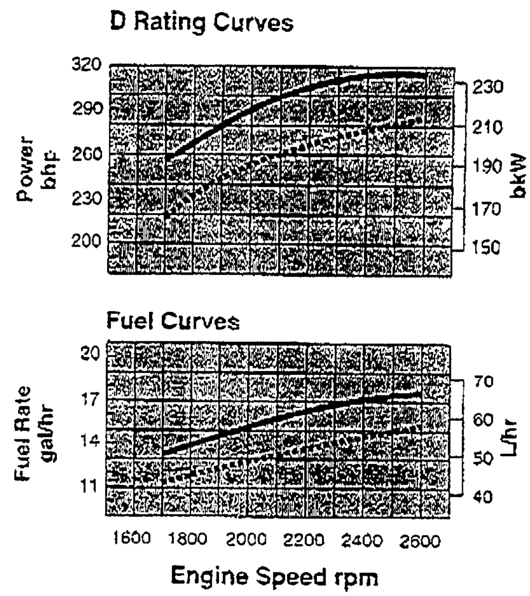

INDUSTRIAL RATINGS

IND-E

IND-E ratings are for service where speed and power are required for a short time for initial starting or sudden overload. For emergency service where standard power is unavailable. The maximum horsepower and speed capability of the engine can be utilized for a maximum of 15 uninterrupted minutes followed by one hour at intermittent or duration of the emergency. Operating limits are:

1. Time at full load not to exceed 5% of the duty cycle or 15 minutes max.
2. Load factor limited to 35%.
3. The maximum horsepower and speed capability of the engine can be utilized for a maximum of 15 minutes followed by one hour at intermittent or duration of the emergency.
4. Typical operating hours per year is 500.

Examples of an IND-E industrial application are:

1. *Standby centrifugal water pumps*
2. Oil field well servicing
3. Crash trucks
4. Gas turbine starters

IND-D

IND-D ratings are for service where rated power is required by period overloads. The maximum horse-power and speed capability of the engine can be utilized for a maximum of 30 uninterrupted minutes followed by one hour at intermittent. Operating limits are:

1. Time at full load not to exceed 10% of the duty cycle or 30 min max.
2. Load factor limited to 50%.
3. Full load operation to a maximum of 30 minutes followed by one hour at intermittent.
4. Typical operating hours per year is 1500.

Examples of an IND-D industrial application are:

1. Offshore cranes
2. Runway snowblowers
3. Water well drills
4. Portable air compressors
5. Fire pump certification power (advertised power)

3208 INDUSTRIAL ENGINE **CATERPILLAR®**

RATING CURVES

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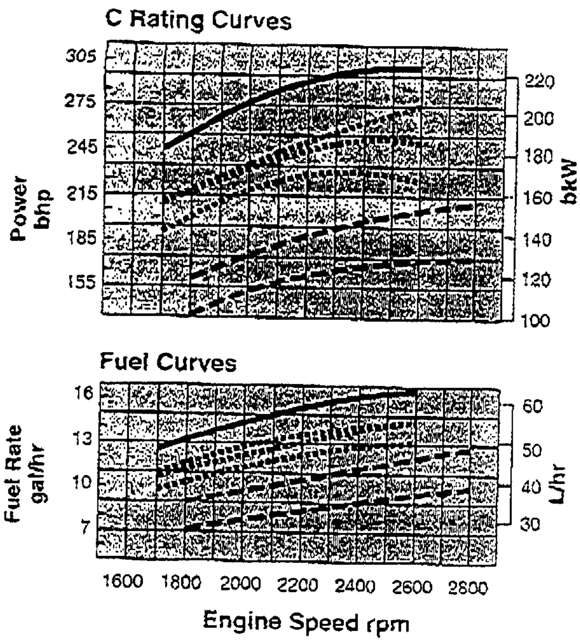

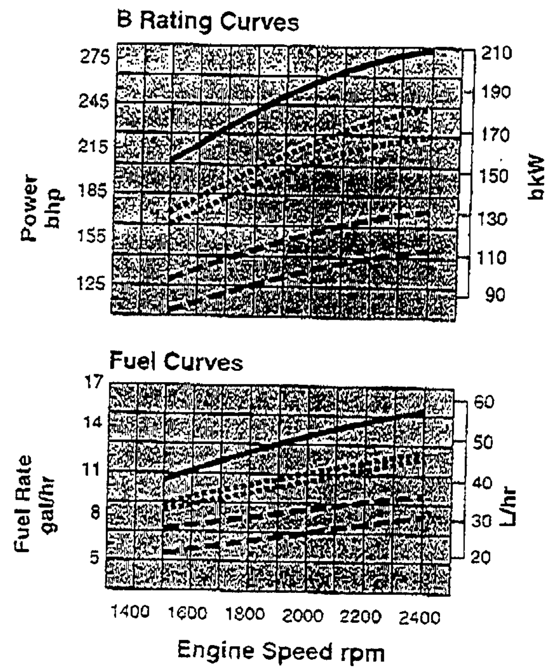

INDUSTRIAL RATINGS/cont'd

IND-C (INTERMITTENT)

IND-C ratings are for service where power and/or speed are cyclic. The horsepower and speed of the engine which can be utilized for one uninterrupted hour followed by one hour of operation at or below the continuous rating. Operating limits are:

1. Time at full load not to exceed 50% of the duty cycle or one hour max.
2. Load factor limited to 70%.
3. Full load operation limited to one uninterrupted hour followed by one hour of operation at or below the continuous rating.
4. Typical operating hours per year is 3000 hours.

Examples of an IND-C industrial application are:

1. Agricultural tractors, harvesters, and combines
2. Truck – off highway
3. Fire pump application power (90% of certified power)
4. Blast hole drills
5. Rock crushers and wood chippers with high torque rise
6. Oil field hoisting

IND-B

IND-B ratings are for moderate-duty service where power and/or speed are cyclic.
Operating limits are:

1. Time at full load not to exceed 80% of the duty cycle.
2. Load factor limited to 85%.
3. Typical operating hours per year is 4000 hours.

Examples of an IND-B industrial application are:

1. Irrigation where normal pump demand is 85% of engine rating
2. Oil field mechanical pumping/drilling
3. Stationary/plant air compressors

CATERPILLAR®

3208 INDUSTRIAL ENGINE

ATAAC ———

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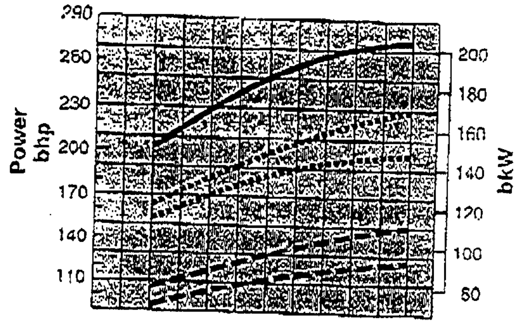
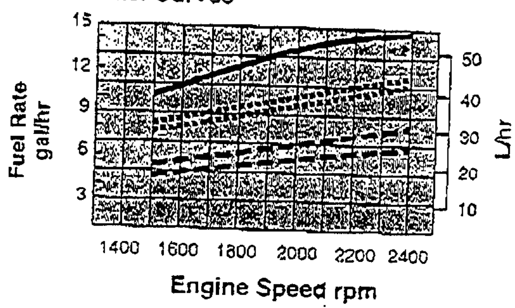
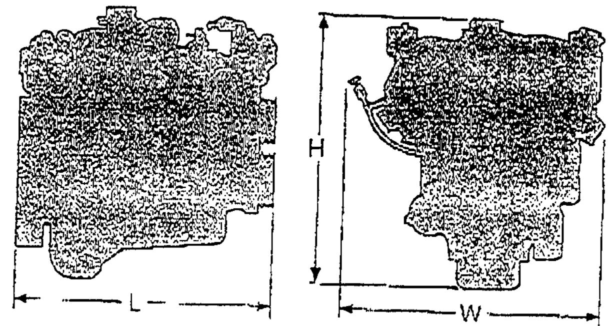
A Rating Curves



Fuel Curves



DIMENSIONS



	L		H		W	
	in	mm	in	mm	in	mm
(T)	37.0	940	35.8	909	36.7	932
(NA)	37.5	953	33.8	858	31.7	805
(ATAAC)	37.0	940	36.5	928	36.7	932

INDUSTRIAL RATINGS/cont'd

IND-A (CONTINUOUS)

Continuous ratings are for heavy-duty service when the engine is operated at rated load and speed up to 100% of the time without interruption or load cycling. Operating limits are:

1. No hour or load factor limitation.
2. Continuous operation at full load.
3. Average load factor to approach 100%.
4. Typical operating hours per year is over 4000 hrs.

Examples of an IND-A industrial application are:

1. Pipeline pumping
2. Ventilation
3. Customer specs

RATING DEFINITIONS & CONDITIONS

Ratings are based on SAE J1349 standard conditions. These ratings also apply at ISO3046/1, DIN6271 and BS5514 standard conditions.

Additional ratings are available for specific customer requirements. Consult your Caterpillar dealer.

Fuel rates are based on ISO3046 and on fuel oil of 35° API (60° F or 16° C) gravity having an LHV of 18,390 Btu/lb (42 780 kJ/kg) when used at 85° F (29° C) and weighing 7.001 lbs/U.S. gal. (838.9 g/L).

Materials and specifications are subject to change without notice.

CATERPILLAR®

Cat Products

ENGINES

Service and Support
Engine Markets/ Product Information
Spec Sheet Library
History

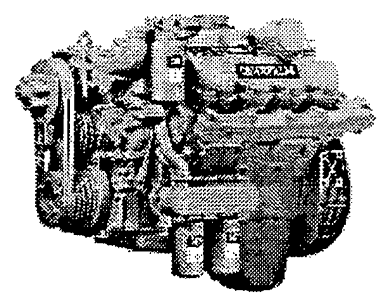
Fire Pump
Electrical Power Generation
Industrial Diesel
Industrial Gas
Petroleum
Marine
On-Highway Truck

[Fire Pump][Electrical Power Generator][Industrial Diesel][Industrial Gas]
[Petroleum][Marine][On-Highway Truck]

Industrial Power

Caterpillar 3208 Industrial Engines

The legendary Cat 3208, with the largest displacement in its rating class, boasts over 300,000 engines in service. A perennial performer, the Cat 3208 offers a high output, low cost alternative in the industrial market.



Features include

- One piece block assembly.
- Large displacement.
- Proven reliability.
- Outstanding parts availability.
- Simple adjustments for easy servicing.
- Maintenance free fuel system.

Available Ratings

Industrial Rating Family

	E	D	C	B	A
RPM Rating	**2600**	**2600**	**2600**	**2400**	**2400**
	kW/hp	**kW/hp**	**kW/hp**	**kW/hp**	**kW/hp**
3208ATA	246/330	235/315	224/300	209/280	205/275

3208T	220/295	213/285	205/275	183/245	172/230
3208T			187/250	168/225	149/200
3208T			168/225		149/200

Industrial Rating Family

	C	B	A
RPM Rating	**2800**	**2400**	**2400**
	kW/hp	**kW/hp**	**kW/hp**
3208NA	157/210	131/175	112/150
3208NA	131/175	112/150	93/125

Ratings Definitions

Configuration - eight cylinder, 90 deg vee
Bore x Stroke - 114 x 127 mm (4.5 x 5.0 in)
Displacement - 10.4L (636 cu in)
Fuel System - Caterpillar direct injection

Weight
Naturally
Aspirated - 601 kg (1325 lb)

Turbocharged/
Aftercooled - 658 kg (1450 lb)

Dimensions	**Length**		**Width**		**Height**	
	mm	**in**	**mm**	**in**	**mm**	**in**
Naturally Aspirated	953	37.5	805	31.7	858	33.8
Turbocharged	940	37.0	932	36.7	909	35.8
Turbocharged/ Aftercooled	940	37.0	932	36.7	928	36.5

CATERPILLAR INC 16E D 1963997 0009875 5

CATERPILLAR

INDUSTRIAL ENGINE

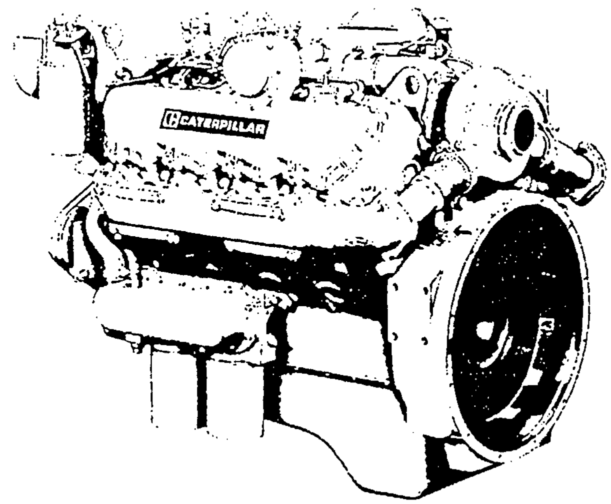
3208

135 - 250 hp

K-33-33-99

Features

- Fuel Economy — full-range governor . . . automatic variable timing advance . . . excellent fuel economy over entire operating range
- Reliability and Diesel Durability — diesel tough components . . . wide choice of rebuild options . . . long engine life
- Top Performance — largest displacement in rating class . . . over 300,000 in service
- Low Maintenance Costs — simple adjustments . . . easy servicing . . . maintenance-free fuel system



Standard Equipment

- Air Intake, inlet connection
- Cooling
  jacket water pump
- Exhaust, dry manifold
- Governor, mechanical
- Fuel
  primary and transfer pumps, filter, water separator
- Lubricating
  oil filter, oil pump
- Flywheel and Flywheel Housing

Accessory Equipment

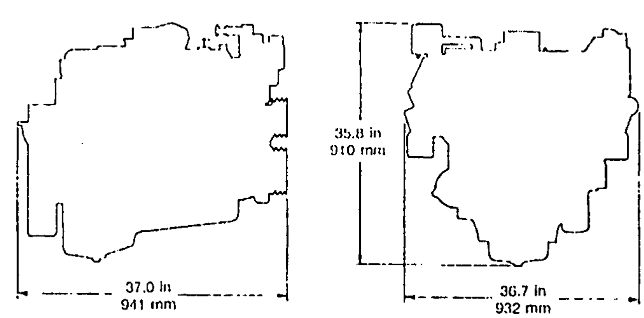
- Air Intake
  air cleaner, precleaner, service indicator
- Control, engine mounted
- Cooling, radiator, fan
- Exhaust
  adapters and fittings, mufflers
- Instruments and Gauges
  service meter, engine mounted instrument panel, tachometer and tachometer drive
- Power Takeoffs
  enclosed clutches, auxiliary drives, air compressor and drive
- Protection Devices
  contactor, solenoid shutoffs
- Starting, electric

Specifications

V8, 4-Stroke-Cycle Diesel

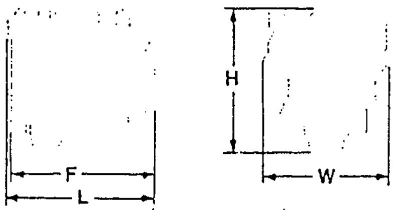
Bore — in (mm)	4.5 (114)
Stroke — in (mm)	5.0 (127)
Displacement — cu in (liter)	636 (10.4)
Low Idle — rpm	650
Rotation (from flywheel end)	ccw
Capacity for Liquids—U.S. gal (liter)	
Cooling System (engine only)	6.3 (23.8)
Lube Oil System (refill)	5.0 (18.9)
Weight, Net Dry (approximate)—lb (kg)	
Turbocharged (T)	1,450 (658)

Dimensions

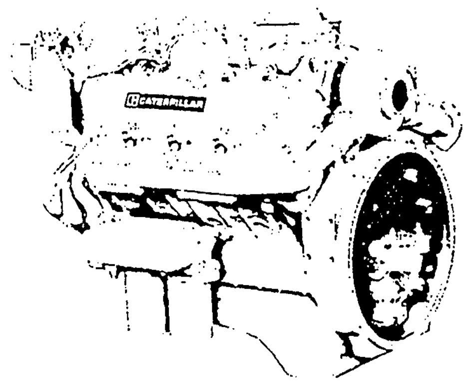


3208 V8 ENGINE

Bore × Stroke	4.5 × 5.0 in	114 × 127 mm
Displacement	636 cu in	10.4 liter
Weight (dry)		
Naturally Aspirated	1325 lb	601 kg
Turbocharged	1450 lb	658 kg



F 36.1 in 916 mm
L 36.3 in 921 mm
W 36.7 in 932 mm
H 35.8 in 910 mm

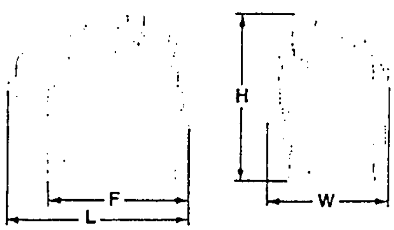


		Naturally Aspirated	Naturally Aspirated	Turbocharged	Turbocharged
Intermittent Rating	hp	175	210	225	250
	kW	130	157	168	186
	rpm	2800	2800	2600	2600
Continuous Rating	hp	125	150	200	200
	kW	93	112	149	149
	rpm	2400	2400	2400	2400

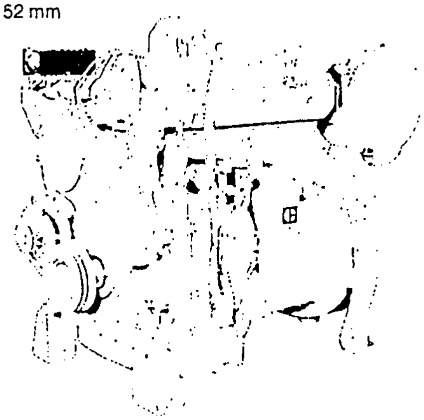
3300 FAMILY

3304B
IN LINE 4

Bore × Stroke	4.75 × 6.0 in	121 × 152 mm
Displacement	425 cu in	7.0 liter
Weight (dry) Industrial		
Turbocharged	1690 lb	767 kg
Naturally Aspirated	1675 lb	760 kg



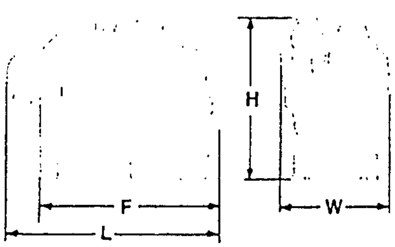
F 38.3 in 972 mm
L 50.3 in 1278 mm
W 32.8 in 832 mm
H 45.8 in 1164 mm



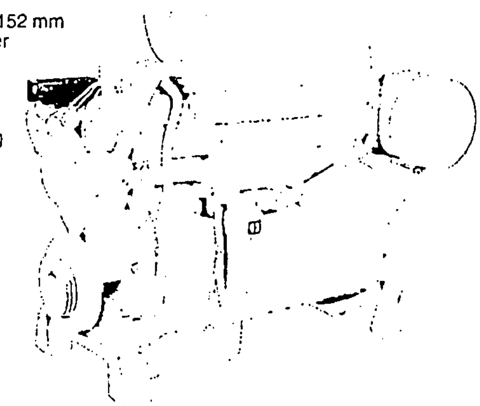
		Naturally Aspirated	Turbocharged
Intermittent Rating	hp	100	165
	kW	75	123
	rpm	2200	2200
Continuous Rating	hp	85	125
	kW	64	93
	rpm	2000	2000

3306B
IN LINE 6

Bore × Stroke	4.75 × 6.0 in	121 × 152 mm
Displacement	638 cu in	10.5 liter
Weight (dry) Industrial		
Naturally Aspirated	2050 lb	931 kg
Turbocharged	2160 lb	981 kg
Turbocharged-Aftercooled	2220 lb	1008 kg



F 50.0 in 1270 mm
L 62.1 in 1577 mm
W 33.0 in 837 mm
H 46.1 in 1171 mm



		Naturally Aspirated	Turbocharged	Turbocharged	Turbocharged	Turbocharged Aftercooled
Intermittent Rating	hp	152	200	225	250	270
	kW	113	149	168	186	201
	rpm	2200	2200	2200	2200	2200
Continuous Rating	hp	125	155	170	190	215
	kW	93	116	127	142	160
	rpm	2000	2000	2000	2000	2000

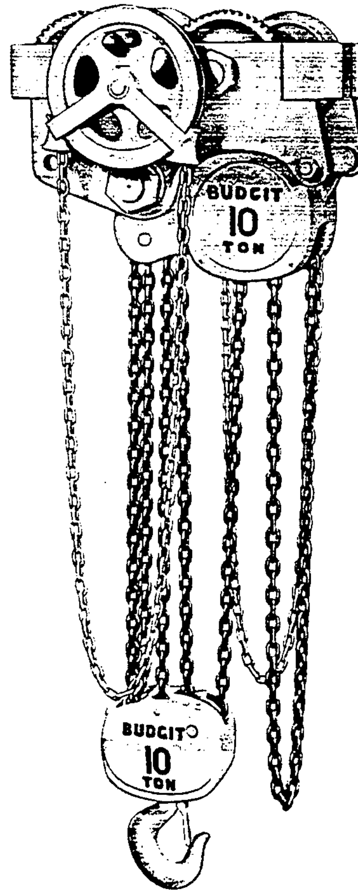
BUDGIT Aluminum Army Type Trolley Hoists 1 to 10 Ton Capacities

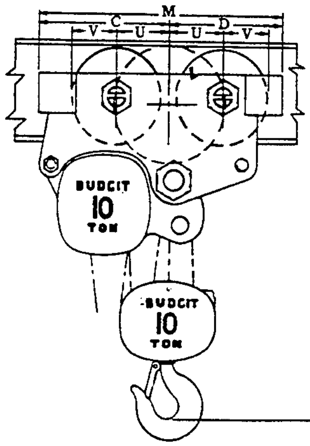
Hand Geared Type

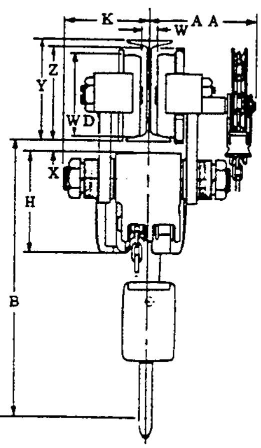
BUDGIT Aluminum Army Type Trolley Hoists with Hand Geared Trolley sections are integrally built trolley and hand chain hoist combinations, offering exceptional high hook lifts and headroom advantages. Their construction is identical to the Push Type models except that wheel flanges on one side are geared and meshed with a pinion driven by a hand wheel and hand chain.

Hook Latches on all Models

Spark and Corrosion Resistant Models Available







OUTLINE DIMENSIONS

Capacity in Tons	B Min.	C	D	H	K	M	U	V	W Min.	X Min.	Y: Adjustable to fit these Beam Sizes (inches) Min. Depth	Y: Min. Flange Width	Y: Max. Flange Width	Z	AA Max.	WD	Min. Rad. Curve
1	12 5/8	7 3/8	7 3/8	7 5/16	4 7/8	14 3/4	3 5/8	3	7/8		5	3	5	5 3/8	9 13/16	4	2'0"
1 1/2**	15 1/8	8 3/8	8 3/8	10	5 1/2	16 3/4	3 15/16	3 3/8	1 1/8	3/4	6	3 5/16	6	6 1/4	10	4 7/8	3'6"
2**											6	3 5/16	6				
3*	19 13/16	10 5/8	10		6 13/16	20 5/8	4 21/32	4 1/16			8	4	7 1/4	7 3/4	11 7/8	6 1/2	4'0"
4*	20 5/16										8	4	7 1/4				
5*	21 1/16	11 1/2	11		7 7/8	22 1/2	4 7/8	4 3/4	1 3/8		10	4 3/4	8	9 1/2	12 5/16	8	4'6"
6*	21 11/16										10	4 3/4	8				
8*	22 7/8	14	12		8 5/8	26	5 5/8		1 1/8		10	4 3/4	8		12 7/8		5'0"
10*	23 5/8										10	4 3/4	8				

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED

NOTE: *These trolleys will operate on wide flange I-Beams with flange taper 0° to 15° (American Standard I-Beam Flange Taper is 9°) providing their flange widths do not exceed flange width of largest American Standard Section I-Beam as listed in column "Y". On the larger sizes apply to factory. On I-Beam monorail installations check clearance for passage of switches and radii of curves.

**These trolleys cannot be used on 6" I-Beam if beam is attached directly to cross supporting truss or beam. Geared trolley wheel will interfere. Use 7" I-Beam or spacers between 6" I-Beam and cross truss.

SIZES, CATALOG NUMBERS AND SPECIFICATIONS

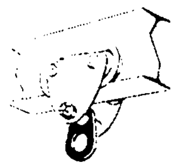
Catalog Number Standard Model	Capacity in Tons	Net Weight in Pounds	Std. Lift in Feet	No. of Parts of Load Chain	Headroom-Min. Distance from Bott. of I-Beam to Hook Saddle (inches)	Hand Chain Pull in Lbs. to Lift Full Load	Hand Chain Overhaul in Feet to Lift Load One Foot
3315	1	93	8	1	12 5/8	60	36 1/2
3314	1 1/2	149			15 1/8	60	55
3316	2	150	8		15 1/8	80	55
3317	3	267	8	2	19 13/16	62	110
3318	4	288			20 5/16	83	
3319	5	377	8	3	21 1/16	72	165
3320	6	389			21 11/16	86	
3321	8	529		4	22 7/8	89	220
3322	10	537		5	23 5/8	92	275

NOTE: Available with lifts longer than standard. See price sheet. Equipped with Hook Latches.

AVAILABLE WITH BUDGET AUDIO LIFT REGULATORS. To order chain block with regulator installed, add prefix letter "R" to chain block catalog number (Example: 3315 with regulator becomes R3315). Outline dimensions do not change. Net weights increase 2 pounds on 1 thru 10 ton models. See price sheet.

BUDGIT Hand Chain Hoists OPTIONS AND ACCESSORIES

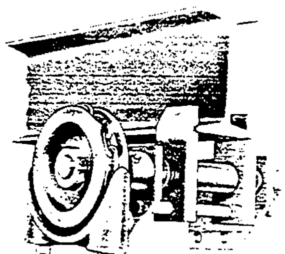
TROLLEY ADAPTER LINKS



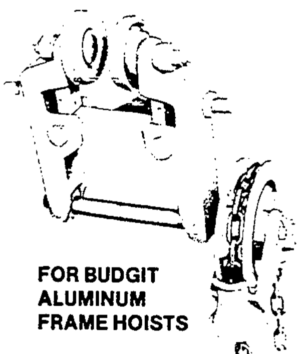
BUDGIT I-Beam Trolleys are designed to carry hoists of the same rated capacity. Adapter Links make it possible to hang hoists of smaller capacity than trolley.

Catalog No. 281 .... For ¼ and ½ Ton Trolleys
Catalog No. 282 .... For 1 Ton Trolley
Catalog No. 283......... For 2 and 3 Ton Trolleys

TRACK CLAMPS



FOR BUDGIT STEEL FRAME HOISTS



FOR BUDGIT ALUMINUM FRAME HOISTS

For aluminum frame hoists — CATALOG NO. 905334
For steel frame hoists — CATALOG NO. 905331

Quick acting track clamps can be supplied with any BUDGIT trolley or trolly hoist. Clamps are available as trailer type for BUDGIT aluminum frame hoists and built into the trolley for BUDGIT steel frame hoists or cast iron wheel trolleys. Steel jaws of track clamps are grooved to bite and hold firmly to the flange of the runway beam, and will hold trolley fully loaded up to rated capacity. Clamp is designed so no additional load pressures are applied to trolley wheels when clamp is actuated.

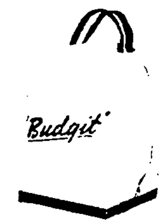
NOTE: When ordering, give complete I-Beam dimensions and include catalog number, capacity and length of lift for hoist it is to be used on. Apply to factory for outline dimensions.

BULLARD SWING GATE HOOKS

Bullard swing gate hooks have gates of heavy cast construction that are ideal for rugged service applications. Swing gate unlocks and opens 90° providing 100% of the full hook throat opening. Swing gate is spring loaded to snap shut and lock in closed position . . . retaining the load.

CARRYING CASE

FOR 500, 1000 AND 2000 POUND ALUMINUM CHAIN HOISTS CATALOG NO. 98



The ideal way to carry the BUDGIT Aluminum Hand Chain Hoist from job to job. Case is made of durable, dust-tight yellow canvas, sewed and riveted to a rigid base plate, with leather carrying handle and easy-to-use full zipper opening. For ¼, ½ and 1-ton capacity hoists.

SPARK AND CORROSION RESISTANT MODELS

Spark and Corrosion Resistant Model is designed for service in certain hazardous atmospheres and areas where resistance to corrosion is vitally important. These models have: bronze alloy hooks; bronze hook sleeves; special chrome nickel stainless steel alloy load chains; and bronze alloy hand chains. To order, apply to factory advising application conditions and job requirements.

HAND CHAIN OPTIONS

Natural finish steel hand chains are furnished as standard. Special plated or bronze hand chain is optional extra and can be ordered for all BUDGIT hand chain operated hoists, hand geared trolleys and hand geared crane assemblies.

Plated hand chain provides a corrosion resistant finish for outdoor and other corrosive applications and appreciably reduces friction against the walls of the chain guide. Less effort is required to raise or lower loads.

Bronze hand chain is a spark resistant and corrosion resistant material providing greater protection for the more corrosive and hazardous atmospheres.

AUDIO LIFT REGULATOR

OVERLOAD DEVICE FOR BUDGIT HAND CHAIN HOISTS

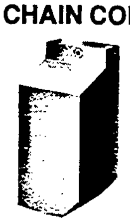
Load-limiting, overload-warning device for use on all BUDGIT Aluminum Hand Chain Hoists. Device audibly signals operator when excessive overload conditions exist, as in lifting a load beyond rated hoist capacity. As hoist loading continues, Regulator cuts in and hoist hand chain revolves without lifting load further. Load is under control of load brake at all times.

Available factory installed.

To order Aluminum Hand Chain Hoist with Audio Lift Regulator installed, add letter "R" prefix to catalog number of Chain Hoist ordered.

CHAIN CONTAINERS FOR HAND CHAIN HOISTS

FOR ALUMINUM FRAME HOISTS



FOR STEEL FRAME HOISTS

These receptacles receive the slack load chain as it reeves over the load sheave. In this way, slack chain is kept from interfering, and from marring or scratching any load with finished surfaces. Compact design helps maintain best possible headroom. Containers are available for all types of BUDGIT aluminum and steel frame hand chain hoists and trolley hoists.

NOTE: When ordering, give catalog number and length of lift for hoist it is to be used on. Apply to factory for weights.

Aluminum Frame Hoist	Steel Frame Hoist*	Maximum Hoist Lift in Feet Container will Accommodate						
		¼, ½ & 1 Ton	2 Ton	3 and 4 Ton	5 and 6 Ton	8 Ton	10 Ton	12 Ton
–	905341	10	–	–	–	–	–	–
904560	–	20	–	–	–	–	–	–
904561	–	35	–	–	–	–	–	–
904562	905342	–	10	–	–	–	–	–
904563	905343	–	20	10	–	–	–	–
904564	905344	–	40	20	12	10	8	–
904565	905345	–	60	30	20	15	12	10
904566	905346	–	80	40	26	20	16	13

*For Hook Suspended Hoists Only. Apply to factory for Low Headroom Trolley Hoists.

Apply to factory for containers for longer lifts.

SPECIFICATIONS

Design and Construction Features

BUDGIT Aluminum Hand Chain Hoists and Army Type Trolley Hoists

The following specifications are suggested specifications covering the BUDGIT Aluminum Hand Chain Hoist, HI-CAP Hand Chain Hoists and Army Type Trolley Hoists. Hand chain hoists are also known as hand hoists, chain blocks and chain falls.

SUSPENSION FRAME

The frame shall be cast structural aluminum alloy machined to rigidly hold hoist gear train in perfect alignment.

GEAR CASE COVER

The gear case cover shall be structural aluminum alloy machined to form a rugged impact resistant sealed gear case.

GEAR TRAIN

Gear train shall be a simple reduction of heat treated steel gears arranged so that the load is carried by gear teeth on each side of the load gear. The pinion shafts shall be of steel, heat treated for maximum durability and wear resistance and ground for concentricity and fit. All gearings shall be supported between anti-friction bearings with no overhung gears. All connections between gears and shaft shall be by means of splines cut from the solid.

LOAD WHEELS

Load pocket wheels shall be four-pocket heat treated steel castings. Idler wheels in multiple reeved models shall also be four-pocket heat treated steel castings.

LOAD BRAKE

The load brake shall be of the ratchet and pawl actuated Weston self-adjusting type to securely hold the load at any level and provide smooth precise control in lowering. The brake flange shall be steel fully machined and heat treated with ACME ground thread. Ratchet wheel shall be steel heat treated and finish ground and shall operate on an anti-friction bearing for smooth lowering. The brake hub shall be corrosion resistant bronze alloy and hand chrome plated for long wear.

OPERATING PARTS ENCLOSED

All operating parts of hand chain hoists and trolley hoists shall be enclosed to protect them against dirt. Gears shall be enclosed in a tightly sealed housing and lubricated with extra pressure type lubricant.

LOAD CHAIN

Load chain shall be heat treated alloy steel coil type hoisting chain carburized for surface hardness and wearability.

LOAD HOOKS

On hook type units, 1 through 10 ton capacity, the forged steel lower hook is one size smaller than the upper hook. The forged steel hooks shall be full swiveling and equipped with spring-type hook latches.

SPECIFICATIONS FOR OPTIONAL EQUIPMENT

OVERLOAD PROTECTION DEVICE

(AUDIO LIFT REGULATOR)

A roller-detent overload device shall, when ordered by purchaser, be built into the hand chain wheel to prevent the hoist from lifting dangerous overloads. The device shall allow the hoist to lift rated capacity loads and cause the hoist to refuse to lift excessive overloads.

SPARK RESISTANT CONSTRUCTION

The hoist shall, when ordered by purchaser, have hoist parts made of spark resistant materials of construction on exposed operating parts for use in certain hazardous atmospheres and to resist corrosion.

IMPORTANT HOIST SAFETY DATA

The hand chain hoists offered in this catalog meet the American National Standards Institute Specifications ANSI B 30.16 entitled "Overhead Hoists."

Wall Safety Poster illustrating safe hoisting practices for hand chain operated hoists is available, order from your BUDGIT distributor. Ask for Bulletin No. 18000-126-78.

BUTLER® **13122/BUT**
BuyLine 3770

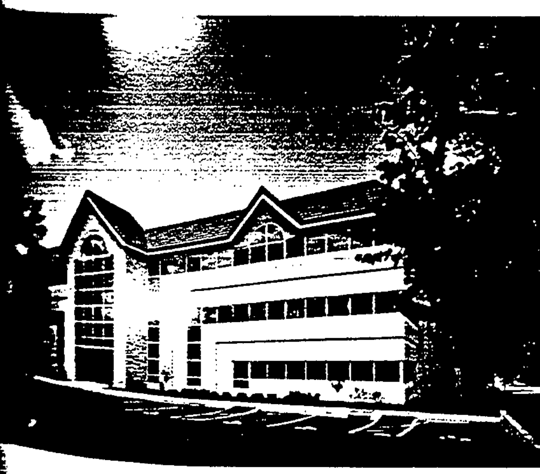
utler®
uilding Systems

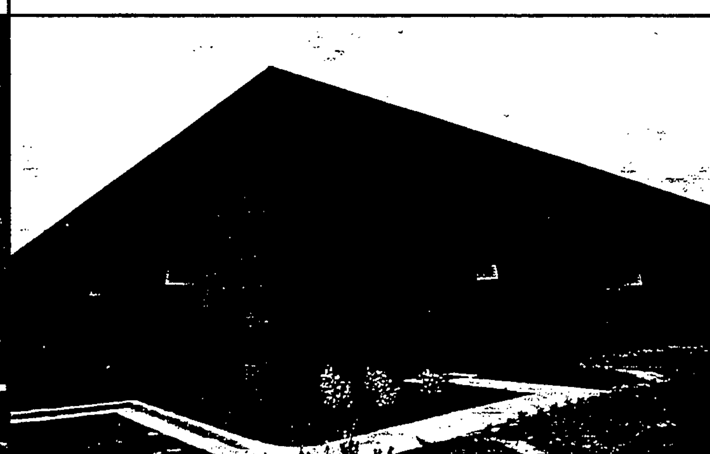
L ... ark™

Landmark™ systems offer designs with flat roof profiles, large open bays, straight or tapered columns and open web trusses for utility access.

Widespan™

The Widespan™ system offers an almost unlimited number of modular or clear span frame design options with low roof profiles.





Multi-Story

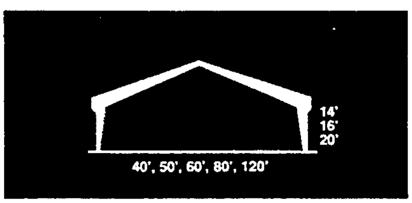
Butler Multi-Story systems can be used for buildings up to 10 stories. Each project is designed based on architectural requirements.

Delta Joist™

The Delta Joist™ system provides a uniquely designed and competitively priced solution for today's masonry or concrete wall construction market.

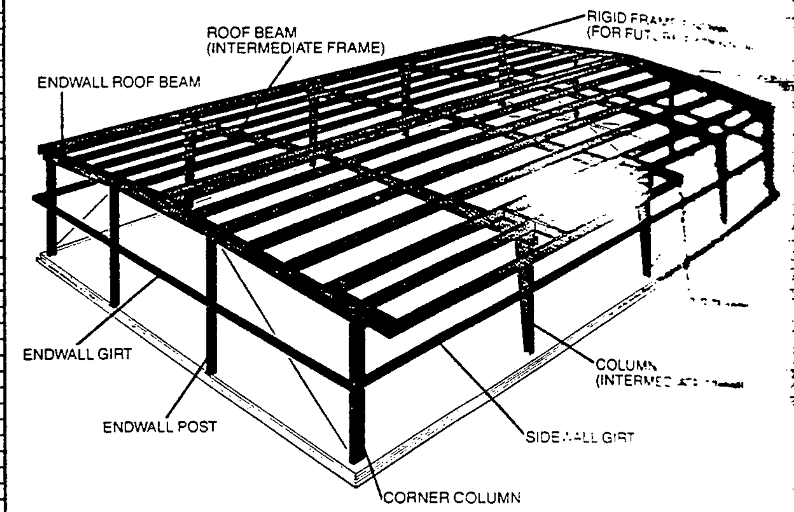
Widespan™
Building System

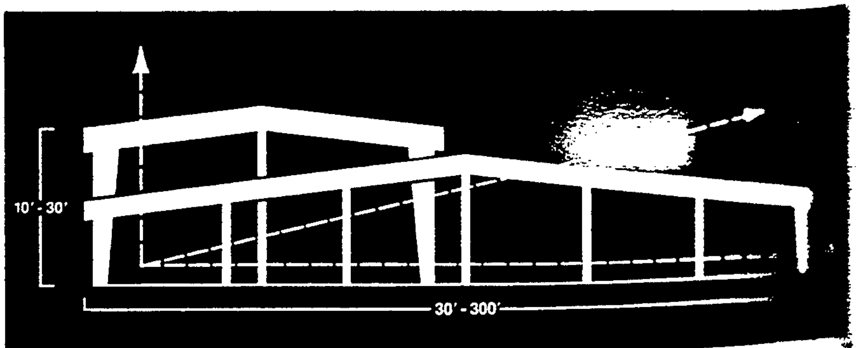
Height
10′–30′, ⅛″ increments
Width
30′–300′, 6″ increments
Columns
Straight or tapered
Bay sizes
16′–30′, 6″ increments
Modules
Clearspan 30′–150′, 6″ increments
Modular 40′–60′ modules, 6″ increments to widths of 300′
Roof systems
MR-24® and CMR-24® standing seam systems, Butlerib® II roof
Wall systems
Broad array of metal systems, exposed/concealed fasteners (see back cover)
Roof slope
¼:12 to 1:12 single or double slope—.001″ increments
Secondary framing
Z-shaped purlins and girts
Factory prepunching
Structurals — Yes
Roof systems — Available
Wall systems — Available
Endwalls
Expandable available



RF provides a high roof slope and ample gable area for ventilation, indoor tennis, overhead installation of utilities and cranes, storage or a studio ceiling effect.

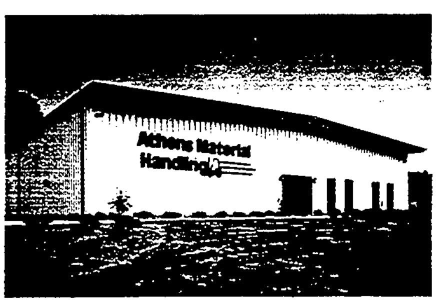
Basic Widespan Components



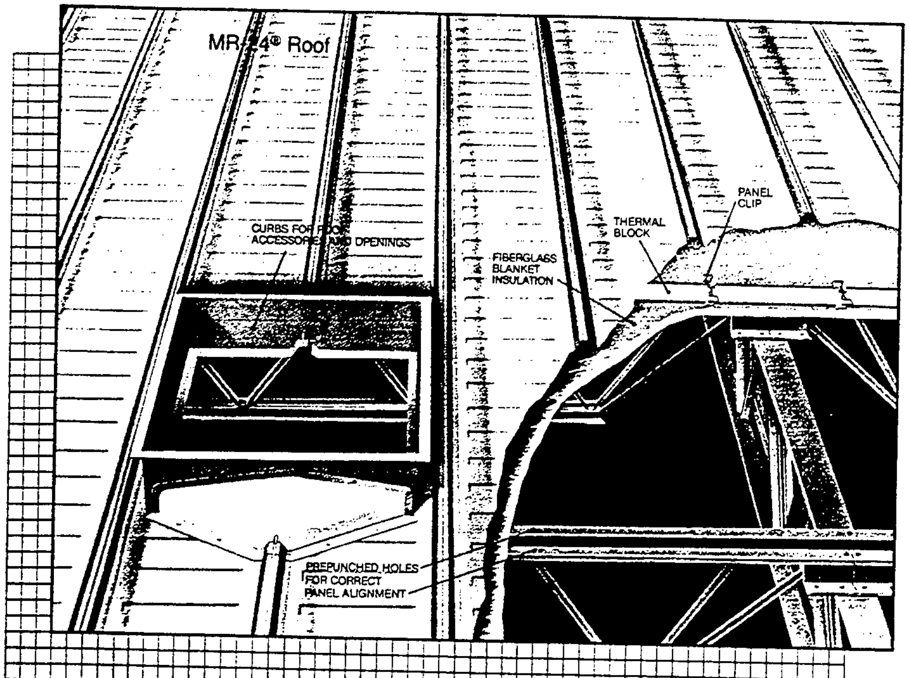


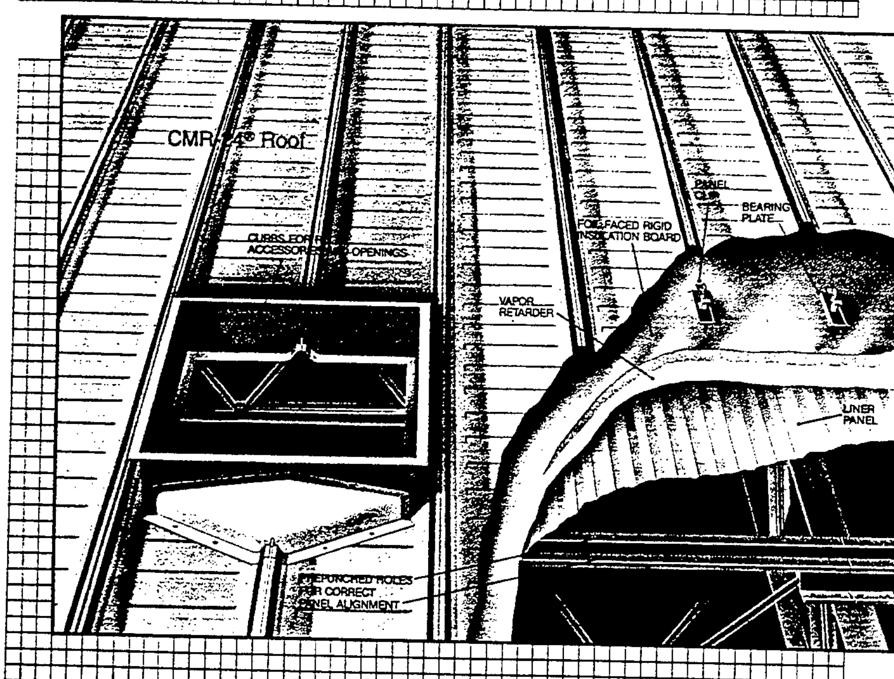
The Butler Envelope

The Butler Envelope System offers an almost unlimited number of framing options to give you the exact building size and design you need. The LRF Envelope offers clearsp... of space, w... specially designed ... ings, uses a minimum ... columns.



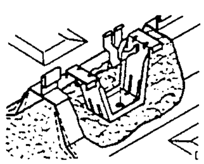
Roof Systems





Roof Movement

As temperatures change, the roof expands or contracts. Unless the roof is designed to accommodate this movement, fasteners will work loose on metal roofs — and cracks, blisters and splits will appear on built up roofs.



The MR-24 and CMR-24 roofs are designed to accommodate roof movement. They are attached to the building's structure with a special clip and tab assembly formed ... the tab can m... entire roof can ... freely.

The MR-24® Roof S...

The MR-24 roof is ... metal membrane, co... entire building. The ... together with a Pittsb... lock standing seam, ... with the unique clip f... seam.

Recent ... independent ... that the MR-24 roof is ... specified standing sea... market, with over 60... feet installed since its ... 1969.*

The CMR-24® Roof ...

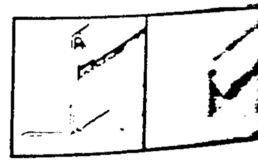
The CMR-24 roof sys... an interior steel liner ... insulat... gives the ... interior a finished lo... energy savings, thr... layer of rigid insulati...

Weathertightness

You're assured of we... performance becaus... exclusive Pittsburgh ... standing seam.

Du... ...llation ... each roof panel are ... formed by machine ... 360° seam. Inside th... applied sealant elim... for even tiny capillar...

Our unique desig... seam and our sliding ... assure you of weath... with optional warra... 20 ye...



*According to Arch...

...lift

...-24 and the C... highest rating ...rs' Laboratori... the Class 90 rati... in lower ins... your new buil...

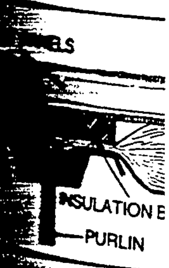
...avings

...roof systems a... energy, few... ...blems.

... when thicker ... conventional ... may be reduc... insulation may ... inevitable deter... ...ce.

... the MR-24 an... metal and m... forces of expa..., insulation th... roof deteriorati... metal roofs are ... ...on is often cr... where the roof is ... structural mem... thermal short c... energy effici... roof is installed v... blocks to elimi... circuits.

...ELS



...'s rigid insul... the interior s... -24 roof, givir... ...al efficienc...

... Values | Butler T... Actual "U"

.12
.08
.05

.10
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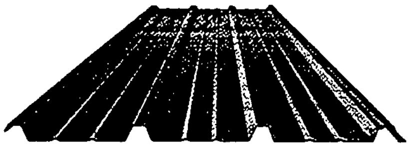
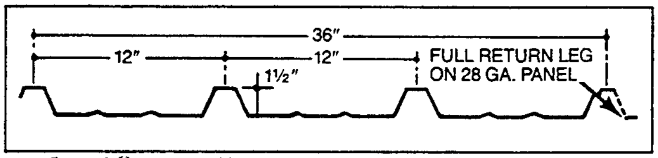
...ailable.

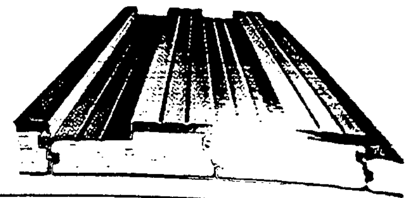
Wall and Fascia Systems

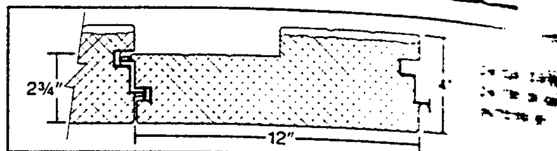




Butlerib® II Wall System

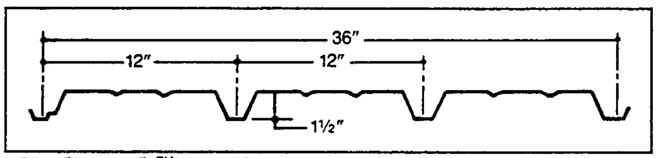
Butlerib II Wall System is the basic covering system for Butler buildings. Available in 26 or 28 Ga.





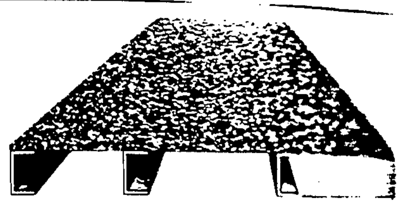
Thermal Monopanl® Wall System

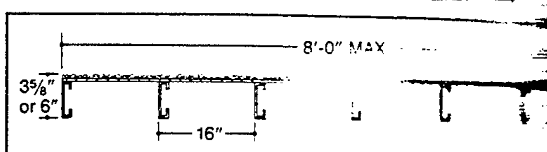
The energy-efficient Monopanl system features a ... fiberglass insulation and prefinis... panel



Shadowrib™ Wall System

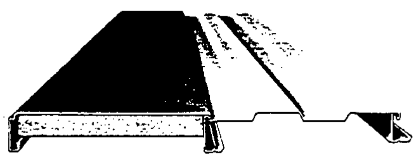
An economical architectural wall system incorporating semi-concealed fasteners with the capability to use up to 10 inches of insulation. Available in 26 or 28 Ga.

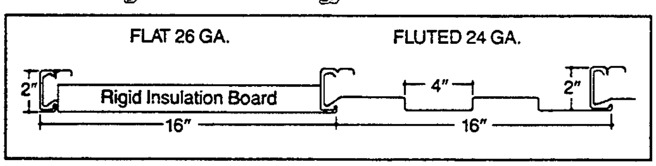




ButlerStone™ Wall System

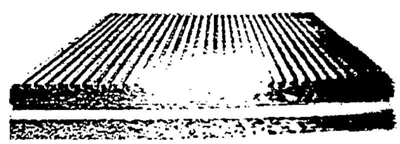
A factory assembled steel frame and aggregate ... the beauty of stone with the economy of lightweight ... finished panels.

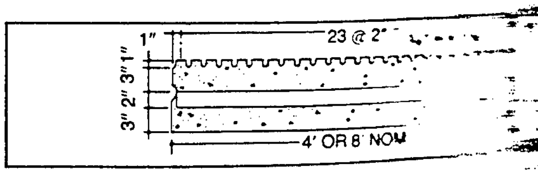




StylWall® II Wall System

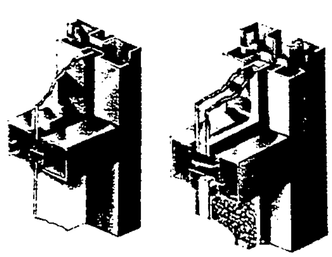
Featuring a stucco-embossed surface and concealed fasteners, the StylWall® system is available in both flat wall and fluted wall designs. The flat wall system features a factory-installed rigid insulation board.





Corewall® Wall System

A prestressed concrete ... properties with a variety of ...

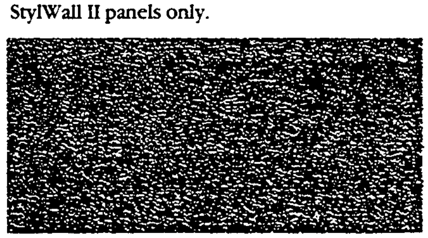


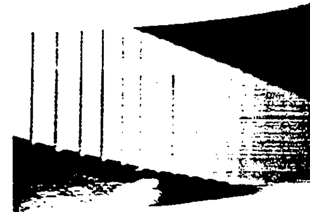
VF-2000™ — VF-3000™

VF Wall System units are designed to complement any of Butler's wall systems.

Texture-Cote™ Finish System

Texture-Cote is a hard, aggregate fiber reinforced polymer finish with the attractive appearance of stucco. Available on flat StylWall II panels only.





Fascia Systems

Butler fascia panel ... for precise fit with ... Fascia styles include ... gate, metal panels and ...

For More Information

Review all the benefits of Butler systems with your local Butler Builder.® He's a knowledgable, independent systems contractor who can be an invaluable aid in your planning.

You'll find your local Butler Builder listed in the White Pages under "Butler Mfg. Co. Builder." If no Butler Builder is listed, please contact:

Butler Manufacturing ...
Department S-184
P.O. Box 419917
Kansas City, MO 64141-...
(816) 968-3...

I. Electrical Equipment Load List.

A. 120/208 volt, 3 phase.

1. Lighting and receptacle loads.			
	@ 4 VA/sq. ft.	1,650 sq.ft.	6,600 VA
2. 50 Watt, HPS, Security Lights.			
	@ 66 VA	4 ea.	264 VA
3. 500 Watt, Quartz, Floodlights.			
	@ 500 VA	2 ea.	1,000 VA
4. 2-hp exhaust fan			
	@ 2,954 VA	2 ea.	5,908 VA
5. 1-hp furnace fan and controls			
	@ 1,657 VA	1 ea.	1,657 VA
6. Battery Chargers			
	@ 240 VA	5 ea.	1,200 VA
6. Future capacity @ 6,000 VA.			
	@ 6,000 VA	1 ea.	6,000 VA
		Total Connected Load:	22,629 VA

Service Size (Amps): **63 Amps**

(Connected load)/(208 volts x 1.73)

B **Choose 100 Amp, 120/208 Volt, 3 phase, 4 wire electrical Service.**

II. OPTION NO. 1, Electrical Equipment Load List.

A. 120/208 volt, 3 phase.

1. Total connected load from I.A.			
	@ 23 kVA/sq. ft.	1 ea.	23 kVA

B. 4,160 volt, 3phase.

1. 200 hp pump motors. @24 amps			
	@ 171 kVA	4 ea.	684 kVA
2. 25% of largest motor			
	@ 43 kVA	1 ea.	43 kVA
		Total Connected Load:	750 kVA

Service Size (Amps): **104 Amps**

(Connected load)/(4160 volts x 1.73)

C. **Choose 104 Amp, 4160 Volt, 3 phase, 4 wire electrical Service rated 750 kVA.**

DEPARTMENT OF THE ARMY
St. Paul District, Corps of Engineers
Design Branch
190 5th Street East
St. Paul, Minnesota 55101-1479

PROJECT: Devils Lake Pump Station
SUBJECT: Lighting Design
SOURCE PROGRAM: Electric 9
DATE: JUNE 12, 1996
PREPARED BY: Byron D. Nelson

1. Computer lighting design for pump station operating room; Design level 30 Foot candles with industrial fluorescent fixtures with 2 - F32T8 lamps each.

```
+--------------------------------------------------------------------------------+
|                      LIGHTING CALCS - ZONAL CAVITY METHOD                      |
|--------------------------------------------------------------------------------|
|+----------------------------+                                                  |
|| Room Length    (ft): 55    | Room Square Footage ............. :    1650.0    |
|| Room Width     (ft): 30    |                                                  |
|| Ceiling Height(ft): 22     | Ceiling Cavity Ratio ................ :  0.52    |
|| Fixture Height(ft): 20     | Percent Ceiling Effective Reflectance : 26       |
|| Work Height    (ft): 2.5   |                                                  |
|| Footcandle Level  : 30     | Room Cavity Ratio ................... :  4.5     |
||                            |                                                  |
|| % Clg. Reflectance: 30     | Floor Cavity Ratio .................. :  0.64    |
|| % Wall Reflectance: 30     | Percent Floor Effective Reflectance . : 18       |
|| % Floor Reflectnce: 20     |                                                  |
||                            | Fixture Type: Industrial Fixture (2-Fluorescent)|
|| Maintenance Factor: .8     | Fixture CU  : .35       Lamps/Fixture  : 2       |
||                            | Lumens/Lamp : 2850      Lumens/Fixture : 5700    |
|+----------------------------+ Lamp Type   : F32T8                              |
|                                                                                |
|                                                                                |
|                  Calculated Number Of Fixtures Required:  31                   |
|                                                                                |
+--------------------------------------------------------------------------------+
```

DEPARTMENT OF THE ARMY
St. Paul District Corps of Engineers
Design Branch
190 5th St. East
St. Paul, MN 55101-1479

ONAN CORPORATION
GenSize 2
Version 3.20

Project Name: DEVILS LAKE PUMP STATIONS
File Name: SPPAUL1

Project Parameters:

Duty:.............: Stationary Prime (Diesel Only)
Voltage:..........: 120/208 WYE
Frequency.........: 60
Max. Temp. Rise...: 105
Max. VDIP%........: 30
Max. Altitude.....: 1500
Altitude Scale....: Feet
Max. Amb. Temp....: 105
Temperature Scale.: Fahrenheit
Cooling System....: Remote
Fuel Type.........: Diesel

Load Listing

Load Number: 1 Load Type: Battery Charger Phase 3

Load Name: (Pump motor chargers) Output KVA 2
Comment:

Battery Charging Non Linear Load
Output KVA: 2

Using all default answers.
Full Load Efficiency: 90

Phase: 3

Power Factor: 90

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
2.0	2.2	1.0	.90	2.0	2.2	1.0	.90

Load Number: 2 Load Type: Motor HP Phase 3

Load Name: (RX-1) Output HP 2
Comment:

Motor HP:2.00

Motor Shaft KW:1.5

Motor is low inertia
Code Letter:F

Motor RKW:1.9
Motor RKVA:2.4

Start Power Factor:.42
Motor Phase: 3
Motor LR-KVA:10.6
Motor SKVA:10.6

Motor Start Method:Across the line

Load Factor: 100

Run Power Factor:.78

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
4.4	10.6	9.6	.42	1.9	2.4	1.5	.78

Load Number: 3 Load Type: Motor HP Phase 3

Load Name: (RX-2) Output HP 2
Comment:

Motor HP:2.00 Motor Shaft KW:1.5

Motor is low inertia Motor RKW:1.9
Code Letter:F Motor RKVA:2.4

Start Power Factor:.42 Motor Start Method:Across the line
Motor Phase: 3
Motor LR-KVA:10.6
Motor SKVA:10.6 Load Factor: 100

Run Power Factor:.78

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
4.4	10.6	9.6	.42	1.9	2.4	1.5	.78

Load Number: 4 Load Type: Receptacles Phase 3

Load Name: Input KW: 1.2
Comment:

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
1.2	1.3	.6	.90	1.2	1.3	.6	.90

Load Number: 5 Load Type: Fluorescent Light Phase 3

Load Name: (Operating Room) Output KW: 3.2
Comment:

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
3.2	3.4	1.1	.95	3.2	3.4	1.1	.95

Load Number: 6 Load Type: Discharge Light Phase 1

Load Name: (Exterior Security) Output KW: .4
Comment:

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
.3	.4	.2	.85	.4	.4	.2	.90

Load Number: 7 Load Type: Incandescent Light Phase 1

Load Name: (Trash Rack Floodlght) Output KW: 1
Comment:

SKW:	SKVA:	SKVAR:	SPF:	RKW:	RKVA:	RKVAR:	RPF:
1.0	1.0	0	1.00	1.0	1.0	0	1.00

Step Sequence/Load

Step Number: 1 Surge KW: 12 Surge SKVA: 24

Step Name:
Comment:

Load #	Qty	SKW	SKVA	SKVAR	SPF	RKW	RKVA	RKVAR	RPF
1	1	2.0	2.2	1.0	.90	2.0	2.2	1.0	.90
2	1	4.4	10.6	9.6	.42	1.9	2.4	1.5	.78
3	1	4.4	10.6	9.6	.42	1.9	2.4	1.5	.78
4	1	1.2	1.3	.6	.90	1.2	1.3	.6	.90
Step Total:		12.1	24.7	20.8	.49	7.0	8.4	4.6	.83
Cumulative:		12.1	24.0			7.0	8.3	4.6	

ONAN CORPORATION GenSize 2 Version 3.20

--R U N N I N G------			-----M A X----S U R G E--At Specified Voltage---			
KW	KVA	PF	KW	Occurs in Step	KVA	Occurs in Step
7	8	.84	12	1	24	1

Recommended GenSet Model: 20DGAB

GenSet Voltage: 208-240/380-480

Nominal KW	Duty	Specified Voltage	Freq.	Specified	Alternator Recommended
18	Prime	120/208 WYE	60	105	105

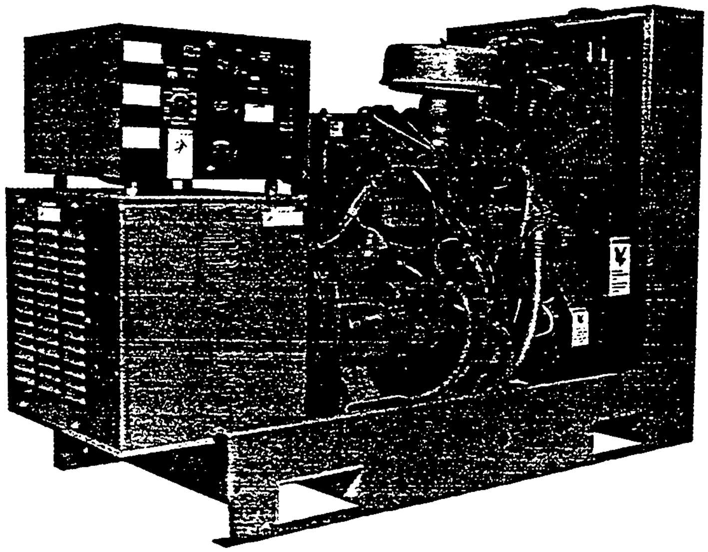
When operated at 1500 Feet Altitude and 105 degrees Fahrenheit Ambient the operating performance is:

* GenSet selected with one GenSet. *

Maximum KW	Voltage Dip	Freq. Dip	Excitation
18	12%	2%	Shunt

20 DGAB 60 Hz
16 DGAB 50 Hz
Diesel-Fueled Generator Set

	STANDBY	PRIME
60 Hz	20 kW 25 kVA	18 kW 23 kVA
50 Hz	16 kW 20 kVA	14 kW 18 kVA



Generator Set Features

- Single-source design, manufacturing and testing of all set components and accessories by Onan Corporation.
- Accepts 100% of nameplate kW rating in one step, in compliance with NFPA 110, Paragraph 5-13.2.6.
- Engine torque-matched excitation system provides quick recovery from transient speed dips.
- Low reactance generator design offers low waveform distortion with non-linear loads and provides excellent motor starting capabilities.

Standard Equipment

ENGINE
Cummins 4-cycle diesel engine.

ALTERNATOR
Brushless Onan AC alternator provides broad range reconnectible output.

CONTROL PANEL
Vibration isolated control with analog instrumentation.

VOLTAGE REGULATOR
Electronic voltage regulator utilizes asynchronous power transitor operation that provides immunity from SCR loads.

COOLING SYSTEM
High ambient 122° F (50° C) system.

SKID BASE
Supports the alternator and engine. Battery rack and cooling system mount to the skid base. Integral vibration isolation.

Generator Set Testing

The Prototype Test Support (PTS) program is our commitment to verifying the integrity of our designs and products.

Before the generator sets are put into production, prototype models are subjected to demanding tests with typical/atypical loads and transients anticipated in service.

Production models earn the PTS seal only after meeting the performance criteria established by the program.

Single-Source Warranty

All generator set components and systems are covered by a limited one-year warranty. Optional two- and five-year extended programs are available.

Standard Models are CSA certified.

16 DGAB 50Hz Operating Data

Extended Stack			105°C Alt		
110/190 220/380	120/208 240/415	127/220 254/440	110/190 220/380	120/208 240/415	127/220 254/440
2.51	2.10	1.88	3.06	2.56	2.29
0.16	0.13	0.12	0.20	0.16	0.15
0.14	0.11	0.10	0.18	0.15	0.13
0.14	0.11	0.10	0.16	0.14	0.12
0.05	0.04	0.03	0.07	0.05	0.05

Extended Stack	105°C Alt
Broad Range	Broad Range
17	17
104	90
107	106

110/190	115/200	120/208	127/220	220/380	230/400	240/415	254/440	110/220*
61	58	56	52	30	29	28	26	61

STANDBY				PRIME			
1/4	1/2	3/4	Full	1/4	1/2	3/4	Full
4	8	12	16	4	7	11	14
0.6	1.0	1.3	1.7	0.5	0.8	1.2	1.5
2	4	5	6	2	3	5	6

STANDBY				PRIME			
6.0	ft	1.8	m	6.0	ft	1.8	m
11.5	ft	3.5	m	11.5	ft	3.5	m
1280	Btu/Min	1.4	MJ/Min	1160	Btu/Min	1.2	MJ/Min
630	Btu/Min	0.7	MJ/Min	580	Btu/Min	0.6	MJ/Min
3.0	US Gal	11	L	3.0	US Gal	11	L
33	Gal Min	125	L/Min	33	Gal/Min	125	L/Min
3.7	psi	26	kPa	3.7	psi	26	kPa
32	ft	9.8	m	32	ft	9.8	m
0.6	HP	0.4	kW	0.6	HP	0.4	kW
50	cfm	1.4	cu m/min	50	cfm	1.4	cu m/min
5	in H2O	1.2	kPa	5	in H2O	1.2	kPa
230	cfm	6.5	cu m/min	230	cfm	6.5	cu m/min
2000	cfm	57	cu m/min	2000	cfm	57	cu m/min
5.0	sq ft	0.5	sq m	5.0	sq ft	0.5	sq m
4.0	sq ft	0.4	sq m	4.0	sq ft	0.4	sq m
0.5	in H2O	125	Pa	0.5	in H2O	125	Pa
150	cfm	4.2	cu m/min	135	cfm	3.8	cu m/min
850	°F	454	°C	800	°F	427	°C
41	in H2O	10.2	kPa	41	in H2O	10.2	kPa
27	bhp	20	kWm	25	bhp	18	kWm
95	psi	654	kPa	83	psi	574	kPa
907	ft/min	4.61	m/s	907	ft/min	4.61	m/s
1850	±50 rpm			1850	±50 rpm		
3	kW			3	kW		

Rated power available up to 2600 ft (793 m) at ambient temperatures up to 77°F (25°C). Above 2600 ft (793 m), derate at 3% per 1000 ft (305 m) and 1% per 10°F (2% per 11°C) above 77°F (25°C).

Voltage Selections

60 Hz, 1800 rpm, 3-phase, Reconnectible Broad Range

- ☐ 120/208V ☐ 240/416V
- ☐ 127/220V ☐ 254/440V
- ☐ 139/240V ☐ 277/480V
- ☐ 120/240V*

60 Hz, 1800 rpm, 1-phase Specific Voltage

- ☐ 120/240V

60 Hz, 1800 rpm 3-phase, Specific Voltage

- ☐ 220/380V ☐ 347/600V

50 Hz, 1500 rpm, 3-phase, Specific Voltage

- ☐ 110/190V ☐ 220/380V
- ☐ 115/200V ☐ 230/400V
- ☐ 120/208V ☐ 240/415V
- ☐ 127/220V ☐ 254/440V
- ☐ 100/200V ☐ 115/230V
- ☐ 110/220V* ☐ 120/240V

50 Hz, 1500 rpm, 1-phase

- ☐ 100/200V ☐ 115/230V
- ☐ 110/220V ☐ 120/240V

***Single-phase power can be taken in capacities up to 2/3 of the rated 3-phase kVA with the standard broad range generator. Contact your authorized distributor for availability of optional extended range generators for full nameplate power output.**

Standby Ratings

The standby power rating is applicable for supplying emergency power for the duration of normal power interruption. No overload capability is available for this rating.

Prime Power Ratings

The prime power rating is applicable for supplying electric power in lieu of commercially purchased power. Prime power is the maximum power available at variable load for an unlimited number of hours. A 10% overload capability is available for prime power ratings per BS 5514 and DIN 6271.

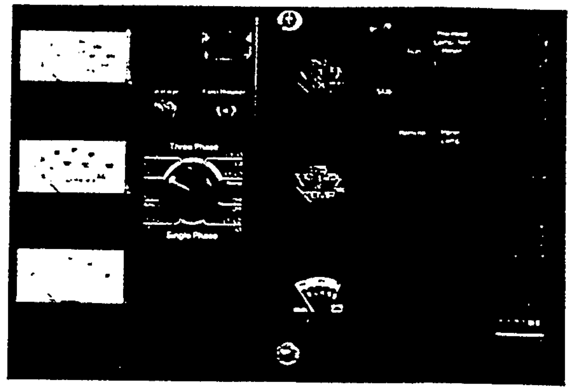
For peak shaving, interruptible service or base load applications, consult your authorized distributor.

Ratings and performance exceed conditions set forth in ISO 3046.

Note: Ratings and performance data apply to standby rating with number 2 diesel fuel. Contact an authorized distributor for operating characteristics at other than stated conditions.

Detector™ Control System

- Monitors engine performance and AC power output.
- Controls generator set start and shutdown.
- Automatic remote start.
- DC panel lighting.
- Vibration Isolators protect control panel electronics and circuitry from generator set vibration.
- Analog Instrumentation displays performance trends Rugged. Non-fluctuating, easy to read.



Control panel shown includes optional AC Meters and 12-Light Monitoring System.

☐ Standard Control Features

- Run-stop-remote switch
- Remote starting, 12-volt, 2 wire
- Coolant temperature gauge
- Field circuit breaker
- Engine preheat switch
- DC voltmeter
- Oil pressure gauge
- Running time meter
- Fault reset switch
- Lamp test switch
- Cycle cranking
- 7-light engine monitor with individual 1/2 amp relay signals and a common alarm contact for each of the following conditions:

RUN (green light)
PRE-WARNING FOR LOW OIL PRESSURE (yellow light)
PRE-WARNING FOR HIGH COOLANT TEMP (yellow light)
LOW OIL PRESSURE SHUTDOWN (red light)
HIGH COOLANT TEMPERATURE SHUTDOWN (red light)
OVERCRANK SHUTDOWN (red light)
OVERSPEED SHUTDOWN (red light)

☐ Optional NFPA 110 12-Light Monitor

Engine monitor with individual 1/2 amp relay signals and common external alarm contact for each of the following conditions:

RUN (green light)
PRE-WARNING FOR LOW OIL PRESSURE (yellow light)
PRE-WARNING FOR HIGH COOLANT TEMP (yellow light)
LOW OIL PRESSURE SHUTDOWN (red light)
HIGH COOLANT TEMPERATURE SHUTDOWN (red light)
OVERCRANK SHUTDOWN (red light)
OVERSPEED SHUTDOWN (red light)
SWITCH OFF (flashing red light – indicates generator set not in automatic start mode)
LOW COOLANT TEMPERATURE (yellow light)
LOW FUEL (yellow light)
TWO CUSTOMER SELECTED FAULTS (red light)

☐ Optional AC Meter Package

Order with NFPA 110 monitor to meet code requirements.

- AC voltmeter (dual range)
- AC ammeter (dual range)
- Voltmeter/ammeter phase selector switch with an off position
- Frequency meter
- AC Rheostat (panel mounted) for ±5% voltage adjust

Generator Set Options

Engine

- ☐ 120-volt 1000 W coolant heater (thermostatically controlled)
- ☐ 240-volt 1000 W coolant heater (thermostatically controlled)
- ☐ Electronic governor
- ☐ Heavy-duty air cleaner with restriction indicator

Cooling System

- ☐ Remote radiator cooling

Alternator

- ☐ Anti-condensation heater
- ☐ Full single phase output
- ☐ Severe environment insulation

Control Panel

- ☐ Remote fault signal dry contact relay package
- ☐ Run relay package
- ☐ Low coolant level shutdown
- ☐ Time delay start/stop
- ☐ Control anti-condensation space heater
- ☐ Oil temperature gauge
- ☐ Tachometer
- ☐ Wattmeter
- ☐ Power factor meter
- ☐ Emergency stop

Exhaust System

- ☐ Industrial-grade exhaust silencer
- ☐ Residential-grade exhaust silencer
- ☐ Critical-grade exhaust silencer

Generator Set

- ☐ Main line circuit breaker
- ☐ Battery charger, equalizer, float-type
- ☐ Batteries
- ☐ Spring isolators
- ☐ Remote annunciator panel
- ☐ Weather-protective enclosure with mounted silencer
- ☐ 2-year standby warranty
- ☐ 2-year prime power warranty*
- ☐ 5-year standby power warranty
- ☐ Export box packaging

*Available in North America only.

20 DGAB 60Hz Operating Data

Reactances

(per unit, based on standby rating, with tolerance of ±10%)

	Extended Stack				105°C Alt			
	120/208 240/416	139/240 277/480	220/380	347/600	120/208 240/416	139/240 277/480	220/380	347/600
Synchronous	2.20	1.66	2.64	1.78	2.53	1.90	3.03	2.11
Direct Axis Transient	0.12	0.09	0.14	0.11	0.16	0.12	0.19	0.13
Direct Axis Subtransient	0.10	0.07	0.11	0.10	0.13	0.10	0.16	0.12
Negative Sequence	0.10	0.07	0.11	0.10	0.13	0.10	0.16	0.12
Zero Sequence	0.02	0.02	0.03	0.03	0.04	0.03	0.05	0.04

Motor Starting

	Broad Range	380 V	600 V	Broad Range	380 V	600 V
Maximum Surge kW	21	21	21	21	21	21
Maximum kVA (90% Sustained Voltage)	125	125	125	108	108	108
Alternator Data Sheet Number	107	107	107	106	106	106

Full Load Current

	120/208	127/220	139/240	220/380	240/416	254/440	277/480	347/600	120/240*
(Amps @ Standby Rating)	69	66	60	38	35	33	30	24	69

Fuel

	STANDBY				PRIME			
Fuel Consumption — Load	1/4	1/2	3/4	Full	1/4	1/2	3/4	Full
kW	5	10	15	20	5	9	14	18
US gph	0.8	1.2	1.6	2.1	0.7	1.1	1.5	1.9
L/hr	3	5	6	8	3	4	6	7

	STANDBY				PRIME			
Maximum Fuel Lift	6.0	ft	1.8	m	6.0	ft	1.8	m
Maximum Fuel Return Head	11.5	ft	3.5	m	11.5	ft	3.5	m
Cooling								
Heat Rejection To Coolant	1550	Btu/Min	1.6	MJ/Min	1400	Btu/Min	1.5	MJ/Min
Heat Radiated To Room	780	Btu/Min	0.8	MJ/Min	710	Btu/Min	0.7	MJ/Min
Coolant Capacity (with radiator)	3.0	US Gal	11	L	3.0	US Gal	11	L
Coolant Flow Rate	40	Gal/Min	151	L/Min	40	Gal/Min	151	L/Min
Maximum Coolant Friction Head	3.7	psi	26	kPa	3.7	psi	26	kPa
Maximum Coolant Static Head	32	ft	9.8	m	32	ft	9.8	m
Radiator Fan Load	1.0	HP	0.7	kW	1.0	HP	0.7	kW
Air								
Combustion Air	60	cfm	1.7	cu m/min	60	cfm	1.7	cu m/min
Maximum Air Cleaner Restriction	5	in H2O	1.2	kPa	5	in H2O	1.2	kPa
Alternator Cooling Air	275	cfm	7.8	cu m/min	275	cfm	7.8	cu m/min
Radiator Cooling Air	2400	cfm	68	cu m/min	2400	cfm	68	cu m/min
Minimum Air Opening to Room	5.0	sq ft	0.5	sq m	5.0	sq ft	0.5	sq m
Minimum Discharge Opening	4.0	sq ft	0.4	sq m	4.0	sq ft	0.4	sq m
Maximum Restriction at Radiator Discharge (static)	0.5	in H2O	125	Pa	0.5	in H2O	125	Pa
Exhaust								
Gas Flow (Full Load)	177	cfm	5.0	cu m/min	160	cfm	4.5	cu m/min
Gas Temperature	950	°F	510	°C	900	°F	482	°C
Maximum Back Pressure	41	in H2O	10.2	kPa	41	in H2O	10.2	kPa
Engine								
Gross Engine Power Output	33	bhp	25	kWm	30	bhp	23	kWm
BMEP	99	psi	685	kPa	90	psi	619	kPa
Piston Speed	1088	ft/min	5.53	m/s	1088	ft/min	5.53	m/s
Overspeed Limit	2100	±50 rpm			2100	±50 rpm		
Regenerative Power	4	kW			4	kW		

Derating Factors

Rated power available up to 2200 ft (671 m) at ambient temperatures up to 77°F (25°C). Above 2200 ft (671 m), derate at 3% per 1000 ft (305 m) and 1% per 10°F (2% per 11°C) above 77°F (25°C).

16 DGAB 50Hz Operating Data

Extended Stack			105°C Alt		
110/190 220/380	120/208 240/415	127/220 254/440	110/190 220/380	120/208 240/415	127/220 254/440
2.51	2.10	1.88	3.06	2.56	2.29
0.16	0.13	0.12	0.20	0.16	0.15
0.14	0.11	0.10	0.18	0.15	0.13
0.14	0.11	0.10	0.16	0.14	0.12
0.05	0.04	0.03	0.07	0.05	0.05

Broad Range	Broad Range
17	17
104	90
107	106

110/190	115/200	120/208	127/220	220/380	230/400	240/415	254/440	110/220*
61	58	56	52	30	29	28	26	61

STANDBY				PRIME			
1/4	1/2	3/4	Full	1/4	1/2	3/4	Full
4	8	12	16	4	7	11	14
0.6	1.0	1.3	1.7	0.5	0.8	1.2	1.5
2	4	5	6	2	3	5	6

STANDBY				PRIME			
6.0	ft	1.8	m	6.0	ft	1.8	m
11.5	ft	3.5	m	11.5	ft	3.5	m
1280	Btu/Min	1.4	MJ/Min	1160	Btu/Min	1.2	MJ/Min
630	Btu/Min	0.7	MJ/Min	580	Btu/Min	0.6	MJ/Min
3.0	US Gal	11	L	3.0	US Gal	11	L
33	Gal/Min	125	L/Min	33	Gal/Min	125	L/Min
3.7	psi	26	kPa	3.7	psi	26	kPa
32	ft	9.8	m	32	ft	9.8	m
0.6	HP	0.4	kW	0.6	HP	0.4	kW
50	cfm	1.4	cu m/min	50	cfm	1.4	cu m/min
5	in H2O	1.2	kPa	5	in H2O	1.2	kPa
230	cfm	6.5	cu m/min	230	cfm	6.5	cu m/min
2000	cfm	57	cu m/min	2000	cfm	57	cu m/min
5.0	sq ft	0.5	sq m	5.0	sq ft	0.5	sq m
4.0	sq ft	0.4	sq m	4.0	sq ft	0.4	sq m
0.5	in H2O	125	Pa	0.5	in H2O	125	Pa
150	cfm	4.2	cu m/min	135	cfm	3.8	cu m/min
850	°F	454	°C	800	°F	427	°C
41	in H2O	10.2	kPa	41	in H2O	10.2	kPa
27	bhp	20	kWm	25	bhp	18	kWm
95	psi	654	kPa	83	psi	574	kPa
907	ft/min	4.61	m/s	907	ft/min	4.61	m/s
1850	±50 rpm			1850	±50 rpm		
3	kW			3	kW		

Rated power available up to 2600 ft (793 m) at ambient temperatures up to 77°F (25°C). Above 2600 ft (793 m), derate at 3% per 1000 ft (305 m) and 1% per 10°F (2% per 11°C) above 77°F (25°C).

Voltage Selections

60 Hz, 1800 rpm, 3-phase, Reconnectible Broad Range

- ☐ 120/208V
- ☐ 240/416V
- ☐ 127/220V
- ☐ 254/440V
- ☐ 139/240V
- ☐ 277/480V
- ☐ 120/240V*

60 Hz, 1800 rpm, 1-phase Specific Voltage

- ☐ 120/240V

60 Hz, 1800 rpm 3-phase, Specific Voltage

- ☐ 220/380V
- ☐ 347/600V

50 Hz, 1500 rpm, 3-phase, Specific Voltage

- ☐ 110/190V
- ☐ 220/380V
- ☐ 115/200V
- ☐ 230/400V
- ☐ 120/208V
- ☐ 240/415V
- ☐ 127/220V
- ☐ 254/440V
- ☐ 100/200V
- ☐ 115/230V
- ☐ 110/220V*
- ☐ 120/240V

50 Hz, 1500 rpm, 1-phase

- ☐ 100/200V
- ☐ 115/230V
- ☐ 110/220V
- ☐ 120/240V

*Single-phase power can be taken in capacities up to 2/3 of the rated 3-phase kVA with the standard broad range generator. Contact your authorized distributor for availability of optional extended range generators for full nameplate power output.

Standby Ratings

The standby power rating is applicable for supplying emergency power for the duration of normal power interruption. No overload capability is available for this rating.

Prime Power Ratings

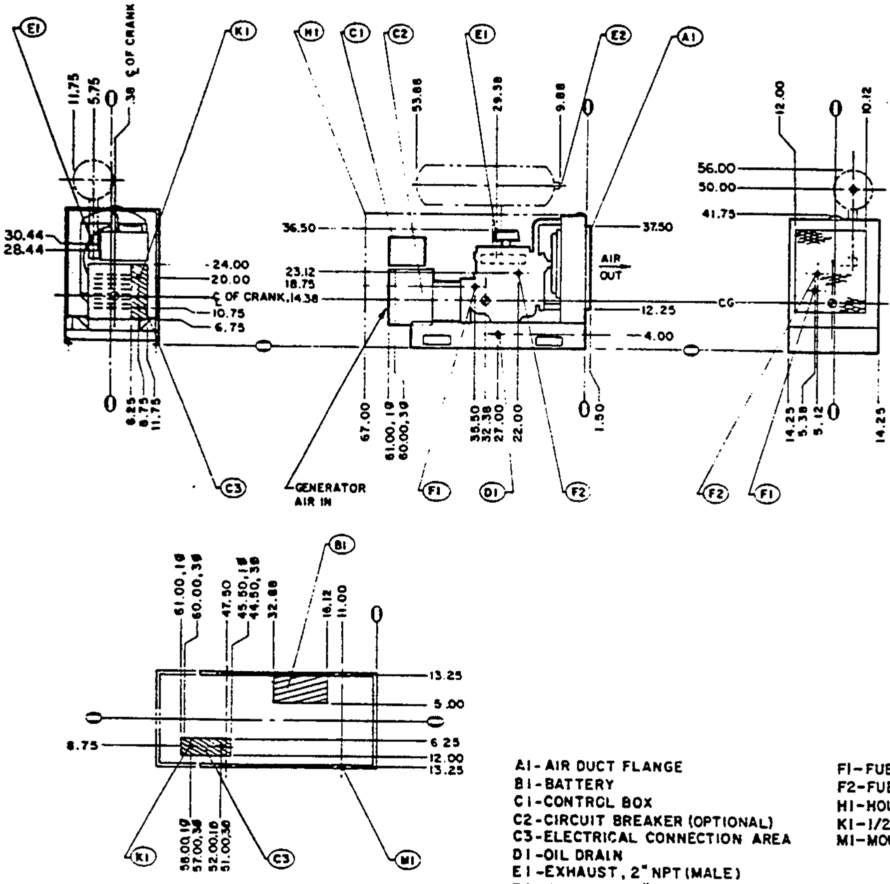
The prime power rating is applicable for supplying electric power in lieu of commercially purchased power. Prime power is the maximum power available at variable load for an unlimited number of hours. A 10% overload capability is available for prime power ratings per BS 5514 and DIN 6271.

For peak shaving, interruptible service or base load applications, consult your authorized distributor.

Ratings and performance exceed conditions set forth in ISO 3046.

Note: Ratings and performance data apply to standby rating with number 2 diesel fuel. Contact an authorized distributor for operating characteristics at other than stated conditions.

Outline Drawing
60 Hz: 20 DGAB
50 Hz: 16 DGAB



A1 - AIR DUCT FLANGE
B1 - BATTERY
C1 - CONTROL BOX
C2 - CIRCUIT BREAKER (OPTIONAL)
C3 - ELECTRICAL CONNECTION AREA
D1 - OIL DRAIN
E1 - EXHAUST, 2" NPT (MALE)
E2 - EXHAUST, 3" NPT (MALE)

F1 - FUEL IN, 1/4" NPTF; W/FLEX - 1/4" NPT MALE
F2 - FUEL OUT, 1/8" NPTF; FUEL LINES - 1/4" INV SAE MALE
H1 - HOUSING (OPTIONAL)
K1 - 1/2" KO (4 PLACES)
M1 - MOUNTING HOLES (.6250, 4 PLACES)

Obtain Installation Drawing 500-2024

This drawing is for informational purposes only. For specific construction details, obtain installation outline drawing from your distributor.

Dry Weight

Unhoused:	1125 lbs./511 kg.
Housed:	1350 lbs./613 kg.

Wet Weight

Unhoused:	1161 lbs./527 kg.
Housed:	1386 lbs./629 kg.

See your distributor for more information.

Onan

Onan Corporation
1400 73rd Avenue N. E.
Minneapolis, MN 55432
612-574-5000
Telex: 275477
Fax: 612-574-8087

Backfeed to a utility system can cause electrocution and/or property damage. Do not connect to any building's electrical system except through an approved device or after building main switch is opened.

ONAN
Diesel Sets

20 DGAB 60HZ
16 DGAB 50HZ

INDUSTRIAL
SECTION 1

ISSUE DATE: 01-NOV-90
EFFECTIVE DATE: 15-JAN-91

TOTAL BASE LIST PRICE $10,236

Must select one feature only from each category in first column. Select optional items from indented columns.

FEATURE DESCRIPTION	FEATURE OPTION	LIST PRICE
KILOWATT RATING (PICK ONE)		
[ ] Rating–60Hz,Standby Power	L032	STD
[ ] Rating–60Hz,Prime Power	L033	0
[ ] Rating–50Hz,Standby Power	L036	0
[ ] Rating–50Hz,Prime Power	L037	0
MODEL BRAND (PICK ONE)		
[ ] Model Brand–Cummins	P074	0
[ ] Model Brand–Cummins/Onan	P077	STD
VOLTAGE (PICK ONE)		
[ ] Voltage–Broad Range (Select Voltage)	R113	STD
[ ] Voltage–346/600,3Ph Wye	R114 E	0
[ ] Voltage–1PH,3W, NonReconn	R123	0
VOLTAGE CONNECTION (PICK NONE OR ONE)		
[ ] Voltage–277/480,3Ph Wye	R002	0
[ ] Voltage–240/416,3Ph Wye	R003	0
[ ] Voltage–110/190,3Ph Wye	R004	0
[ ] Voltage–127/220,3Ph Wye	R020	0
[ ] Voltage–255/440,3Ph Wye	R023	0
[ ] Voltage–110/220,3Ph Delta	R028	0
[ ] Voltage–230/400,3Ph Wye	R029	0
[ ] Voltage–115/230,1Phase	R041	0
[ ] Voltage–110/220,1Phase	R046	0
[ ] Voltage–115/200,3Ph Wye	R050	0
[ ] Voltage–139/240,3Ph Wye	R067	0
[ ] Voltage–115/230,3Ph Delta	R071	0
[ ] Voltage–120/208,3Ph Wye	R098	0
[ ] Voltage–220/380,3Ph Wye	R099	0
[ ] Voltage–120/240,1Phase	R104	0
[ ] Voltage–120/240,3Ph Delta	R106	0
ALTERNATOR ACCESSORIES (PICK NONE, ONE OR MANY)		
[ ] Heater–Alternator	A222	144
[ ] Altr–12Ld,Full 1Ph Output	B125	301
[ ] Altr Insl–Severe Envrnmnt	J049 E	371
[ ] Switch–Volt Reconnection	K490	453
ENGINE GOVERNOR (PICK NONE OR ONE)		
[ ] Eng Gov–Barb Colman Isoch	A259	891
MAIN LINE CIRCUIT BREAKER (PICK NONE OR ONE)		
[ ] Circuit Brkr–120/240V,1P	K481	235

N/C — No Charge   E — Extended Lead Time   S — Ship Loose

ONAN
Diesel Sets

20 DGAB 60HZ
16 DGAB 50HZ

INDUSTRIAL
SECTION 1

ISSUE DATE: 01-NOV-90
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TOTAL BASE LIST PRICE $10,236

Must select one feature only from each category in first column. Select optional items from indented columns.

FEATURE DESCRIPTION	FEATURE OPTION	LIST PRICE
MAIN LINE CIRCUIT BREAKER CONTINUED		
[ ] Circuit Brkr–120/208V,3P	K482	383
[ ] Circuit Brkr–120/240V,3P	K483	383
[ ] Circuit Brkr–227/480V,3P	K484	349
[ ] Circuit Brkr–220/380V,3P	K491	349
[ ] Circuit Brkr–347/600V,3P	K492	349
CIR BREAKER ACCESSORIES (PICK NONE, ONE OR MANY)		
[ ] Shunt Trip–Line Cir Brkr	K361	236
ENGINE CONTROL PANEL (PICK ONE)		
[ ] Eng Control–Detector 12	H461	383
[ ] Eng Control–Detector 7	H462	STD
ALTERNATOR CONTROL PANEL (PICK ONE)		
[ ] AC Control–with Meters	K001	383
[ ] AC Control–No Meters	K994	STD
CONTROL ACCESSORIES (PICK NONE, ONE OR MANY)		
[ ] Htr–Control Cabnt,w/Tstat	A167	197
[ ] Shutdown–Low Coolant Lvl	H389	146
[ ] Tachometer	K145	383
[ ] Wattmeter	K185	1,038
[ ] Gauge–Eng Oil Temperature	K486	139
[ ] Stop Switch–Emergency	K796	151
[ ] Relay–Over/Under Voltage	K881	416
[ ] Relay–Over/Under Freq	K906	485
PRE-HEAT RELAY OPTIONS (PICK ONE)		
[ ] Preheat Relay	KA43	STD
[ ] Time Delay–Start/Stop	K634	230
RUN RELAY (PICK NONE OR ONE)		
[ ] Run Relay–One 3PDT	K858	49
[ ] Run Relays–Two 3PDT	K909	78
[ ] Run Relays–Three 3PDT	K974	107
REMOTE ANNUNCIATOR RELAY (PICK NONE OR ONE)		
[ ] Rmt Ann Rly Assy–7 Cntcts	H465	114
[ ] Rmt Ann Rly Assy–12Cntcts	H466	302
ENGINE COOLING SYSTEM (PICK ONE)		
[ ] Eng Cooling–Remote	E043	-309

N/C — No Charge   E — Extended Lead Time   S — Ship Loose

ONAN
Diesel Sets

20 DGAB 60HZ
16 DGAB 50HZ

INDUSTRIAL
SECTION 1

ISSUE DATE: 01-NOV-90
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TOTAL BASE LIST PRICE $10,236

Must select one feature only from each category in first column. Select optional items from indented columns.

FEATURE DESCRIPTION	FEATURE OPTION	LIST PRICE
ENGINE COOLING SYSTEM CONTINUED		
[ ] Eng Cooling-Radiator,50C	E074	STD
ENGINE AIR CLEANER (PICK ONE)		
[ ] Eng Air Cleanr-Heavy Duty	D036	165
[ ] Eng Air Cleanr-Norml Duty	D041	STD
ENG EXHAUST ACCESSORIES (PICK NONE, ONE OR MANY)		
[ ] Rain Cap-Exhaust	0155-0987	16
[ ] Exh Tube-2 In Flex,NPT	0155-2355-04	47
ENGINE EXHAUST MUFFLER (PICK NONE OR ONE)		
[ ] Exh Muffler-Critical,Mtd	A076	328
[ ] Exh Muffler-INDUSTRIAL	0155-2063-09	83
[ ] Exh Muffler-Residential	0155-2064-09	109
[ ] Exh Muffler-Critical	0155-2065-09	130
FUEL TANK (PICK NONE OR ONE)		
[ ] Fuel Supply Tank-In Hsg	C007	383
[ ] Day Tank-3.5 Gal,Set Mtd	C119	800
[ ] Day Tank-Overhead Supply	C129	805
[ ] Day Tank-Under Grd Supply	C130	805
FUEL SYSTEM ACCESSORIES (PICK NONE, ONE OR MANY)		
[ ] Alarm Switch-Low Fuel Lvl	0309-0240	322
ENGINE COOLANT HEATER (PICK NONE OR ONE)		
[ ] Coolant Htr-120V,1Ph	H036	124
[ ] Coolant Htr-240V,1Ph	H074	124
AGENCY APPROVAL (PICK NONE, ONE OR MANY)		
[ ] Certification-CSA	L039	0
HOUSING (PICK NONE, ONE OR MANY)		
[ ] Housing-Weather Protect	F001	863
STANDARD TEST (PICK ONE)		
[ ] Test-Std Quality Control	L009	STD
TESTING (PICK NONE, ONE OR MANY)		
[ ] Test Record-Strip Chart	L010	281
[ ] Test-Extnd,Cont Ld,1Hr	L011	244

ONAN
Diesel Sets

20 DGAB 60HZ
16 DGAB 50HZ

INDUSTRIAL
SECTION 1

ISSUE DATE: 01-NOV-90
EFFECTIVE DATE: 15-JAN-91

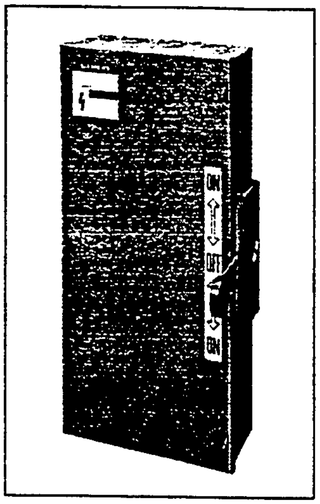
TOTAL BASE LIST PRICE $10,236

Must select one feature only from each category in first column. Select optional items from indented columns.

FEATURE DESCRIPTION	FEATURE OPTION	LIST PRICE
TESTING CONTINUED		
[ ] Test-Extnd,Cont Ld,2Hr	L012	468
[ ] Test-Extnd,Cont Ld,4Hr	L013	936
[ ] Test-Extnd,Cont Ld,8Hr	L014	1,264
[ ] Test-Extnd,Stndby Ld,1Hr	L015	244
[ ] Test-Extnd,Stndby Ld,2Hr	L016	468
[ ] Test-Extnd,Stndby Ld,4Hr	L017	936
[ ] Test-Extnd,Stndby Ld,8Hr	L018	1,264
[ ] Test-Varied Ld,1Hr,2 Step	L019	244
[ ] Test-Varied Ld,2Hr,2 Step	L020	468
[ ] Test-Varied Ld,4Hr,2 Step	L021	936
[ ] Test-Varied Ld,6Hr,3 Step	L022	1,092
[ ] Test Record-Sfty Shutdwns	L023	208
[ ] Test Record-Exhaust Temp	L024	42
[ ] Test Record-Amb Temp/Pres	L025	42
[ ] Test Record-Certified	L026	52
[ ] Test Witness-Independent	L027	281
[ ] Test-Independent Lab	L038	296
WARRANTY (PICK ONE)		
[ ] Warranty-1 Yr Base	L028	STD
~~[ ] Warranty-2 Yr Standby~~	~~L029~~	~~180~~
~~[ ] Warranty-5 Yr Basic~~	~~L030~~	~~448~~
~~[ ] Warranty-5 Yr Comprhnsive~~	~~L031~~	~~806~~
~~[ ] Warranty-2 Yr Prime Power~~	~~L040~~	~~1,389~~
PACKING FOR SHIPMENT (PICK ONE)		
[ ] Packing-Skid,Poly Bag	A322	STD
[ ] Packing-Export Box	A323	164
[ ] Packing-Crated	A347	164
APPLICATION OPTIONS (PICK NONE, ONE OR MANY)		
[ ] Annunciator-Remote	0300-2751	338
[ ] Batt Chargr-12V/0.3A,120V	0305-0175	157
[ ] Batt Chargr-12V,2A,2Stage	0305-0325	276
[ ] BattChgr-12V,120/208/240V	0305-0347	445
[ ] Batt Charger-12V/10A,480V	0305-0395	445
[ ] Batt Chrgr-12V/2Amp,120V	0305-0513	260
[ ] Safety Hasps-Housing	0406-0687	47
[ ] Battery-12V.560 CCA	0416-0795	122

DELETED

N/C — No Charge   E — Extended Lead Time   S — Ship Loose



DESCRIPTION

Double throw switches are intended to transfer loads from one power source to another. All 30 to 600A double throw switches are suitable for use as service equipment and are UL listed.

A cover interlock is provided on 30, 60, 100 and 200 ampere units. The operating handle may be padlocked in the top, bottom or neutral positions.

DOUBLE THROW SWITCHES

System	Amps	240 Volt AC — 250 Volt DC 2-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price	240 Volt AC — 250 Volt DC 3-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price	600 Volt AC 3-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price
Fusible	30	—		—		F321DTK	$ 795.	FR321DTK	$1300.	F351DTK	$1600.	—	
	60	—		—		F322DTK	1440.	FR322DTK	1930.	F352DTK	1610.	—	
	100	—		—		F323DTK	2370.	FR323DTK	2600.	F353DTK	2840.	FR353DTK③	$3310.
	200	F224DTK③	$2720.	FR224DTK③	$3690.	F324DTK	3410.	FR324DTK	4620.	F354DTK	4200.	FR354DTK③	4920.
	400	—		—		F325DTK	7250.	—		F355DTK②	7420.	—	
	600	—		—		F326DTK②	9150.	—		—		—	

System	Amps	240 Volt AC — 250 Volt DC 2-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price	240 Volt AC — 250 Volt DC 3-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price	600 Volt AC 2-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price
Non-Fusible	30	NF221DTK③	$ 390.	—		NF321DTK	$ 478.	—		NF251DTK③	$ 510.	—	
	60	NF222DTK③	620.	—		NF322DTK	685.	—		NF252DTK③	720.	—	
	100	NF223DTK③	860.	—		NF323DTK	1120.	NFR323DTK③	$1600.	NF253DTK③	1100.	—	
	200	NF224DTK③	1240.	NFR224DTK③	$1710.	NF324DTK	1770.	NFR324DTK③	2390.	NF254DTK③	1510.	NFR254DTK③	$ 2850.
	400	NF225DTK③	3780.	NFR225DTK③	5010.	NF325DTK	4900.	—		NF255DTK③	4250.	NFR255DTK③	7900.
	600	—				NF326DTK	6920.	—		NF256DTK③	5960.	NFR256DTK③	10900.
	800	—		—		NF327DTK③	16270.	—		—		—	

Amps	600 Volt AC 3-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price	Type 12 Cat. No.	List Price	Type 4 Cat. No.	List Price	4-Pole Type 1 Cat. No.	List Price	Type 3R① Cat. No.	List Price	6-Pole Type 3R① Cat. No.	List Price
30	NF351DTK	$ 675.	NFR351DTK	$ 1100.	NF351HDTK③	$1150.	NF351SSDTK③	$2760.	—		NFR451DTK③	$2530.	NFR651DTK③	$5270.
60	NF352DTK	835.	NFR352DTK	1310.	NF352HDTK③	1470.	NF352SSDTK③	3600.	—		NFR452DTK③	2700.	NFR652DTK③	5050.
100	NF353DTK	1310.	NFR353DTK	2070.	NF353HDTK③	1920.	NF353SSDTK③	5380.	—		NFR453DTK③	4050.	NFR653DTK③	7580.
200	NF354DTK	1960.	NFR354DTK	2890.	NF354HDTK③	4290.	NF354SSDTK③	6530.	NF454DTK③	$2640.	NFR454DTK③	4700.	—	
400	NF355DTK	5000.	NFR355DTK	7630.	—		—		—		—		—	
600	NF356DTK	7280.	NFR356DTK	11130.	—		—		—		—		—	
800	NF357DTK③	18110.	NFR357DTK③	27200.	—		—		—		—		—	

① For hubs see page 18 — 200A switches do not have hub provisions.
② Switches shipped with T-fuse configuration only. Adaptable for J-fuses on 400 amp.
③ Consult sales office for availability.
④ Standard Hp rating-switch with J-fuse kit has following: 240V ac 124 Hp, 480V ac 250 Hp, 600V ac 300 Hp
⑤ Standard Hp Rating - time delay fuses not required.

LUG DATA

Switch Ampere Range	Number of Cables Per Terminal	Cu and/or Al	Wire Range
30 Type 1 30 Type 3R	1 pc. 1 pc.	Cu or Al Cu or Al	#14 to #6 #12 to #2
60	1 pc.	Cu or Al	#14 to #2
100 200 400	1 pc. 1 pc. 2 pcs. or 1 pc.	Cu or Al Cu or Al Cu or Al Cu or Al	#12 to 1/0 #6 to 300 kcmil #1/0 to 300 kcmil 250 to 750 kcmil
600 Fusible	2 pcs.	Cu or Al	#2 to 600 kcmil
600 Non-Fusible	2 pcs.	Cu or Al	250 to 500 kcmil
800	3 pcs.	Cu or Al	250 to 500 kcmil

MAXIMUM HORSEPOWER RATINGS
FUSED (With Time Delay Fuses)

Ampere Rating	1 Phase AC 240V	480V	600V	3 Phase AC 240V	480V	600V	250V DC
30	3	7½	10	7½	15	20	5
60	10	20	25	15	30	50	10
100	15	30	40	30	60	75	20
200	15	50	50	60	125	150	40
400	—	—	—	125	100④	125④	50
600	—	—	—	75⑤	—	—	50

ACCESSORIES

Description		Catalog Number	List Price
Auxiliary Switch	All "K" Suffix Ratings	DS200EK1 (1) "A"—(1) "B" DS200EK2 (2) "A"—(2) "B"	$212. 422.
Neutral Kits	30-60-100A 200A	DT100NK DT200NK	117. 184.
	400A non-fuse only 600A non-fuse only 400-600A fusible 800A	DT400NK DT600NK DS800NK DS800NK	200. 245. 290. 290.
Ground Lug Kit (included with 400-800A)	30-60-100A 200A 400-600-800A	DS100GK DS200GK DS468GK	7. 92. 160.
J Fuse Adapter	400A, 600V	DT400JK	380.

NON-FUSED

Ampere Rating	1 Phase AC 240V	480V	600V	3 Phase AC 240V	480V	600V	250V DC
30	3	7½	10	10	15	20	5
60	10	20	25	20	50	60	10
100	20	30	50	40	75	100	20
200	15	50	50	60	125	150	40
400-800	—	—	—	125	250	350	50

DISCOUNT SCHEDULE A

I-T-E® Enclosed Switches
Double Throw-Dimensions

Figure 1 Catalog Number	Dimensions – (Inches)								
	A	B	C	D	E	F	G	H	I
F224DTK	51.36	47.00	50.75	11.25	19.15	16.00	19.57	1.75	6.19
F321DTK - F322DTK - F323DTK	37.02	33.50	36.62	9.89	11.62	9.25	11.95	1.56	4.65
F351DTK - F352DTK - F353DTK	37.02	33.50	36.62	9.89	11.62	9.25	11.95	1.56	4.65
F324DTK - F354DTK	51.36	47.00	50.75	11.25	19.15	16.00	19.57	1.75	6.19
F325DTK - F355DTK	74.73	69.50	74.31	14.12	24.90	20.25	25.34	2.38	8.88
F326DTK	86.09	80.75	85.65	14.12	27.00	22.25	27.44	2.38	8.88
FR224DTK	51.36	47.00	50.75	11.25	19.15	16.00	19.57	1.75	6.19
FR321DTK - FR322DTK - FR323DTK	37.02	33.50	36.62	9.89	11.62	9.25	11.95	1.56	4.65
FR353DTK	37.02	33.50	36.62	9.89	11.62	9.25	11.95	1.56	4.65
FR324DTK - FR354DTK	51.36	47.00	50.75	11.25	19.15	16.00	19.57	1.75	6.19
NF221DTK - NF222DTK - NF223DTK	25.02	21.50	24.62	9.89	11.62	9.25	11.95	1.56	4.65
NF251DTK - NF252DTK - NF253DTK	25.02	21.50	24.62	9.89	11.62	9.25	11.95	1.56	4.65
NF224DTK - NF254DTK	37.86	33.50	37.25	11.25	19.15	16.00	19.57	1.75	6.19
NF225DTK - NF255DTK	54.25	49.00	53.80	12.50	22.66	18.00	23.08	2.38	7.25
NF256DTK	63.75	58.50	63.31	14.12	23.66	19.00	24.08	2.38	8.88
NF321DTK - NF322DTK - NF323DTK	25.02	21.50	24.62	9.89	11.62	9.25	11.95	1.56	4.65
NF351DTK - NF352DTK - NF353DTK	25.02	21.50	24.62	9.89	11.62	9.25	11.95	1.56	4.65
NF324DTK - NF354DTK	37.86	33.50	37.25	11.25	19.15	16.00	19.57	1.75	6.19
NF325DTK - NF355DTK	54.25	49.00	53.80	12.50	22.66	18.00	23.08	2.38	7.25
NF326DTK - NF356DTK	63.75	58.50	63.31	14.12	23.66	19.00	24.08	2.38	8.88
NF327DTK - NF357DTK	63.75	58.50	63.31	14.12	23.66	19.00	24.08	2.38	8.88
NF454DTK	37.86	33.50	37.25	11.25	19.15	16.00	19.57	1.75	6.19
NFR224DTK - NFR254DTK	37.86	33.50	37.25	11.25	19.15	16.00	19.57	1.75	6.19
NFR225DTK - NFR255DTK	54.25	49.00	53.80	12.50	22.66	18.00	23.08	2.38	7.25
NFR256DTK	63.75	58.50	63.31	14.12	23.66	19.00	24.08	2.38	8.88
NFR323DTK	25.02	21.50	24.62	9.89	11.62	9.25	11.95	1.56	4.65
NFR351DTK - NFR352DTK - NFR353DTK	25.02	21.50	24.62	9.89	11.62	9.25	11.95	1.56	4.65
NFR324DTK - NFR354DTK	37.86	33.50	37.25	11.25	19.15	16.00	19.57	1.75	6.19
NFR355DTK	54.25	49.00	53.80	12.50	22.66	18.00	23.08	2.38	7.25
NFR356DTK	63.75	58.50	63.31	14.12	23.66	19.00	24.08	2.38	8.88
NFR357DTK	63.75	58.50	63.31	14.12	23.66	19.00	24.08	2.38	8.88
NFR451DTK - NFR452DTK - NFR453DTK	25.02	21.50	24.62	9.89	17.34	14.97	17.69	1.56	4.65
NFR454DTK	37.86	33.50	37.25	11.25	19.15	16.00	19.57	1.75	6.19
NFR651DTK - NFR652DTK - NFR653DTK	25.02	21.50	24.62	9.89	17.34	14.97	17.69	1.56	4.65
Figure 2									
NF351HDTK - NF352HDTK - NF353HDTK	25.02	26.06	24.62	10.17	11.62	9.00	11.95	26.88	5.53
NF351SSDTK - NF352SSDTK - NF353SSDTK	25.02	26.06	24.62	10.17	11.62	9.00	11.95	26.88	5.53
Figure 3									
NF354HDTK - NF354SSDTK	37.91	39.75	37.47	11.65	19.16	15.75	19.58	41.02	6.48

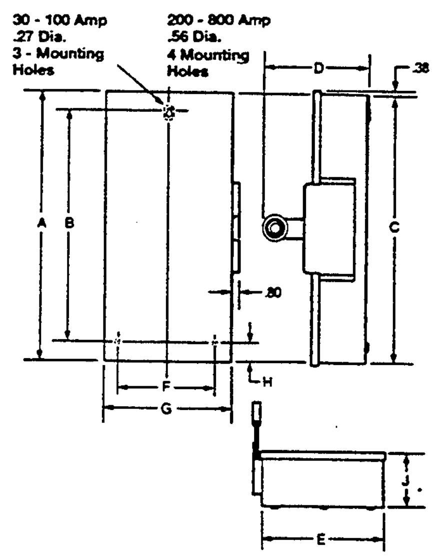


Figure 1
Type 1 and 3R
30 – 800 Ampere

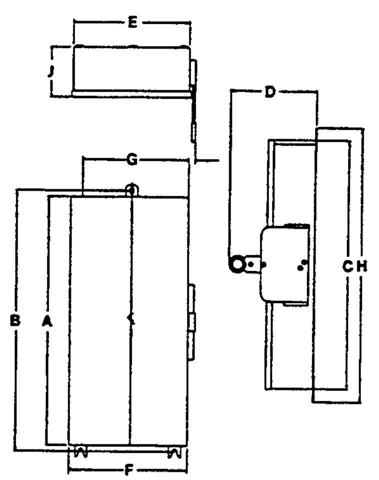


Figure 2
Type 4 / 4X and 12
30 – 100 Ampere

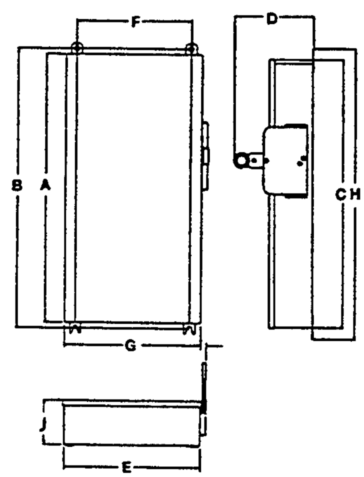
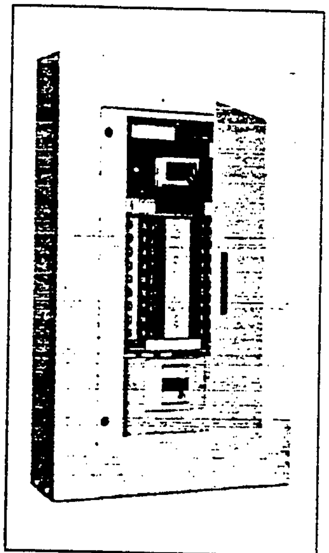
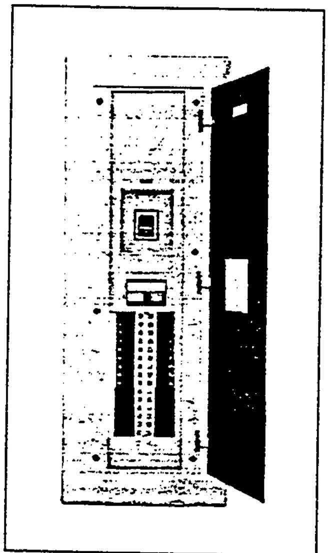


Figure 3
Type 4 / 4X and 12
200 Ampere

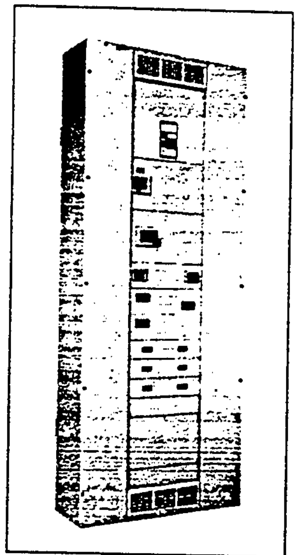
Siemens Sentron™ Panelboards
Circuit Breaker, Fusible, Lighting, Power and Distribution Reference Guide



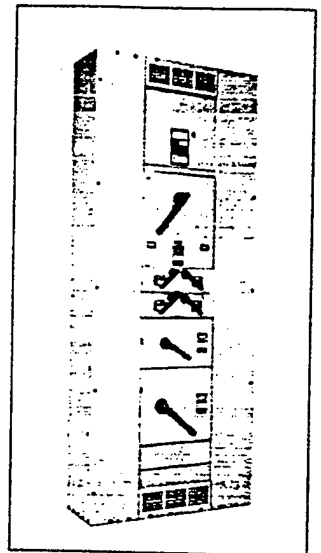
Circuit Breaker Lighting Panelboard Types S1, S2



Circuit Breaker Lighting Panelboard Type S3



Circuit Breaker Power and Distribution Panelboard S4, S5



Vacu-Break® Fusible Power and Distribution Panelboard F1, F2

FEATURES

Siemens offers a complete line of lighting and power distribution panelboards, along with a full range of fusible and circuit breaker devices. Also, two and three pole breakers are physically interchangeable with an equivalent number of one pole breakers.

Sentron™ Lighting and Appliance Panelboards are those having more than 10% of their overcurrent devices rated at 30 amperes or less for which neutral connections are provided. As required by Underwriters Laboratories and the National Electric Code, Sentron™ Lighting and Appliance panelboards meet the 42 circuit rule which states "not more than 42 overcurrent devices (other than those provided for in the mains) of a lighting and appliance panelboard shall be installed in any one cabinet or cutout box. (A 2-pole breaker shall be considered two overcurrent devices; a 3-pole breaker shall be considered three overcurrent devices.)"

Sentron™ Lighting, Power and Distribution Panelboards have the neutral and phase lugs at the same end.

All Siemens panelboards as standard have lugs suitable for copper and aluminum cables.

Siemens panelboards can be labeled as "Suitable for use as Service Entrance" if they comply with applicable articles of the National Electric Code.

Application: LIGHTING—Control centers for lighting and power circuits in commercial and industrial installations as well as residential where extensive electrical systems are involved.

POWER AND DISTRIBUTION—Control centers for power and distribution circuits as well as service equipment in larger commercial and industrial installations.

Ratings: LIGHTING—1 phase, 3 wire, 3 phase, 3 or 4 wire; 120 through 600 Volts ac; 50–600 amperes; main lug only, 50–600 amperes main breakers; 400 amperes maximum branch.

POWER AND DISTRIBUTION—1 phase, 3 wire; 3 phase, 3 or 4 wire; 240/120 through 600 Volts ac; 250 Volts dc; 50–1200 amperes; 1200 amperes maximum branch circuit breakers and 600 ampere maximum fusible switches.

Specifications: All panelboards are listed by Underwriters' Laboratories, Inc. Interiors are listed under File #E2269. Boxes and fronts are listed under file #E4016. All panelboards, except Motor Starter, meet Federal Specification W-P-115b, dated June 8, 1984.

Standards: Interiors – UL 67, NEMA PB1
Boxes – UL 50

REFERENCE GUIDE

Description	Maximum Volts AC	Mains Rating Amperes			Branch Rating Amperes	Maximum Interrupting Rating Symmetrical Amperes③			Page Number
		MLO	MB	MS		240	480	600	
Circuit Breaker—Unassembled									
S1	240	250	250	N/A	15–100①	200,000	—	—	209
S2	480Y/277V	250	250	N/A	15–100①	200,000	100,000	—	209
S3	480Y/277V	600	600	N/A	15–100	200,000	150,000	—	209–210
Circuit Breaker—Assembled									
S1	240	250	250	N/A	15–100①	200,000	—	—	213–216
S2	480Y/277V	250	250	N/A	15–100①	200,000	100,000	—	217–220
S3	600V	600	600	N/A	15–100②	200,000	150,000	100,000	221–228
S4	600V	1200	600	N/A	15–600	200,000	200,000	200,000	229–234
S5	600V	1200	1200	N/A	15–1200	200,000	200,000	200,000	235–240
S1—Column Type	240	250	250	N/A	15–70	200,000	—	—	249–251
S2—Column Type	480Y/277V	250	250	N/A	15–40	200,000	100,000		252–255
Fusible—Assembled									
F1	600V	1200	—	200	30–200	200,000	200,000	200,000	241–244
F2	600V	1200	—	1200	30–1200	200,000	200,000	200,000	245–248

① S1 and S2 panels can have 1 subfeed breaker up to 250 amperes.
② 225 and 400A breaker except for QJ are mounted subfeed. Limitations apply. See page 213.
③ S1, S2, S3, S4, S5, F1 and F2 Panelboards have been tested to UL67 Panelboard Standards and successfully passed short circuit current withstand test. The short circuit current rating is limited to the lowest current interrupting rating at the supply voltage of any device installed.

TYPE S1

240 VOLTS AC, MAXIMUM
250 AMPERE MAINS
250 AMPERE MAXIMUM BRANCH
UL SHORT CIRCUIT RATING—200,000A IR MAXIMUM

Meets 1993 NEC wire bending requirement, section 373-6.

PANELBOARDS

Listed by Underwriters' Laboratories, Inc., under "Panelboards". File #E2269 for interiors and #E4016 for boxes and fronts. Meet Federal Specification W-P-115b dated June 8, 1984, for Type I, Class 1.

SERVICE

240 Volts AC, Maximum. 1 Phase, 3 Wire; 3 Phase, 3 Wire; or 3 Phase, 4 Wire.

PANELBOARD FRONTS AND DOORS

Standard panelboards are furnished with trim featuring concealed fasteners and hinges with a flush door lock. All are factory assembled for ease of installation. Fronts are fabricated from code gauge steel and finished ANSI-61.

MAIN BREAKERS

BL, BLH, HBL, ED2, BQDH, ED4, ED6, HED4, QJ2, QJH2, QJ2-H, FXD6, FD6, HFD6 frame main breakers are mounted horizontally.

MAIN BREAKER PANEL CONNECTORS ①

Ampere Rating	Connectors Suitable for Cu or Al
100	(1)—#14–1/0 AWG
125	(1)—#4–1/0 AWG
225	(1)—#4 AWG–300 kcmil
250	(1)—#4/0 AWG–350 kcmil Al (1)—#6/0 AWG–350 kcmil Cu

MAIN LUG CONNECTORS

Ampere Rating	Connectors Suitable for Cu or Al
125	(1)—#6 AWG–350 kcmil
250	(1)—#6 AWG–350 kcmil

BRANCH BREAKER SYMMETRICAL INTERRUPTING CAPACITY

Based on Underwriters Test Procedure
Meet Federal Specification W-C375b dated July 22, 1975.

BOXES

20" wide, 5.75" deep

- End walls are blank as standard. End walls with knockouts will be supplied at no charge on 5.75" deep panels if requested.

GUTTERS

125/250	Main Lug	Main Breaker	Branch Breaker
	10.5"	—	—
BL, BLH, HBL	—	8.5"	6.375"
QJL, QJH2, QJ2H	—	6.5"	6.5"
ED4, ED6, HED4	—	6.125"	6.125"
FXD6, FD6, HFD6	—	5.25"	5.25"

WEIGHT—APPROXIMATE:

Total panelboard weight when filled with a normal quantity of breakers and accessories is:

- About 3 lbs. per inch of box height.

GAUGE STEEL OF BOXES, FRONTS

BOXES

Width	Height	Gauge Steel
20"	32, 38, 44"	#16

FRONTS—Surface, Flush

Width	Height	Gauge Steel
20"	32, 38, 44"	#14

INTEGRATED EQUIPMENT SHORT CIRCUIT RATINGS

The term "Integrated Equipment Short Circuit Rating" refers to the application of series connected circuit breakers in a combination that allows some breakers to have lower individual interrupting ratings than the available fault current. This is permitted as long as the series combination has been tested and certified by UL.

The table below lists specific main and branch breaker series combinations that are marked on all S1 panels. All combinations shown have been tested for use in S1 panelboards and are UL listed. Other combinations are available. See pages 205–207.

These series ratings must be specified on order at time of entry.

MAIN AND BRANCH BREAKER SERIES COMBINATIONS

SERIES RATING COMBINATIONS②

Voltage	Short Circuit Rating	Main Breaker	Branch Breaker
240V	22,000	BLH, QJH2	BL
	42,000	QJ2H	BL, BLH, QJH2
	65,000	HBL, ED4, ED6 FXD6, FD6	BL, BLH
		FXD6, FD6	QJ2, QJ2H, QJH2
		JXD2, JXD6, JD6, LXD6, LD6	BLH, QJH2, QJ2H
	100,000	HED4, HED6, HFD6	BL, BLH, HBL
		HFD6	QJ2, QJH2, QJ2H
	200,000	CED6	BL, BLH, HBL, ED4, HED4
		CFD6	BL, BLH, HBL, ED2, ED4, QJ2, QJH2, QJ2H, FXD6, FD6, HFD6

① Connector ranges indicated do not apply to all main breaker types. Refer to molded case circuit breaker standard pressure wire connector chart (pages 98–99) for the connector range of a specific frame.
② The short circuit rating applies whether the main breaker shown is a main in the panelboard or remote in another panelboard or switchboard. See pages 205–207 for any amperage limitations, and additional series ratings.

Siemens Sentron™ Panelboards
Circuit Breaker
Lighting and Distribution

TYPE S1

MAIN LUGS ONLY ① ②
240 VOLTS MAXIMUM

Maximum Panel Amps	Maximum 1-Pole Circuits	Box Height (Inches)	208Y/120V 3 Phase, 4 Wire Catalog Number	208Y/120V List Price	120/240V 1 Phase, 3 Wire Catalog Number ③	120/240V List Price
125	18	32	S1C18ML125ATS	$ 725.	S1A18ML125ATS	$ 657.
	30	38	S1C30ML125ATS	918.	S1A30ML125ATS	839.
	42	44	S1C42ML125ATS	1088.	S1A42ML125ATS	1020.
250	18	32	S1C18ML250ATS	793.	S1A18ML250ATS	703.
	30	38	S1C30ML250ATS	963.	S1A30ML250ATS	873.
	42	44	S1C42ML250ATS	1145.	S1A42ML250ATS	1065.

MAIN CIRCUIT BREAKER ① ② ③ ④
240 VOLTS MAXIMUM

Maximum Panel Amps	Maximum 1-Pole Circuits	Box Height (Inches)	208Y/120V 3 Phase, 4 Wire Catalog Number	208Y/120V List Price	120/240V 1 Phase, 3 Wire Catalog Number ③	120/240V List Price
100	18	32	S1C18BL100ATS	$1009.	S1A18BL100ATS	$ 918.
	30	38	S1C30BL100ATS	1190.	S1A30BL100ATS	1088.
	42	44	S1C42BL100ATS	1428.	S1A42BL100ATS	1269.
125	18	32	S1C18E4125ATS	1484.	S1A18E4125ATS	1393.
	30	38	S1C30E4125ATS	1665.	S1A30E4125ATS	1563.
	42	44	S1C42E4125ATS	1903.	S1A42E4125ATS	1744.
225	18	32	S1C18QJ225ATS	2040.	S1A18QJ225ATS	1700.
	30	38	S1C30QJ225ATS	2210.	S1A30QJ225ATS	1870.
	42	44	S1C42QJ225ATS	2391.	S1A42QJ225ATS	2051.
250	18	32	S1C18FX250ATS	2390.	S1A18FX250ATS	2050.
	30	38	S1C30FX250ATS	2560.	S1A30FX250ATS	2220.
	42	44	S1C42FX250ATS	2741.	S1A42FX250ATS	2401.

NOTE: Price branch devices from page 215.

ALTERNATE MAIN BREAKER SELECTION ③ ④

Amperes	Breaker Type	Maximum Interrupting Rating (KA)	Catalog Number	List Price	Available Trip Values
100	BL	10	BL	STD	50, 60, 70, 80, 90, 100
	BLH	22	LH	$ 60.	50, 60, 70, 80, 90, 100
	HBL	65	HL	360.	50, 60, 70, 80, 90, 100
	BQCH/BQD	65	BD	360.	50, 60, 70, 80, 90, 100
	ED4	65	E4	110.	50, 60, 70, 80, 90, 100
125	ED4	65	E4	STD	50, 60, 70, 80, 90, 100, 110, 125
	HED4	100	H4	475.	50, 60, 70, 80, 90, 100, 110, 125
225	QJ2	10	QJ	STD	60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225
	QJH2	22	QH	70.	60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225
	QJ2-H	42	Q2	137.	60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225
	FXD6	65	FX	125.	250
	FD6	65	F6	164.	250
	HFD6	100	HF	1553.	250
250	FXD6	65	FX	STD	70, 80, 90, 100, 110, 125, 150, 175, 200, 225
	FD6	65	F6	320.	70, 80, 90, 100, 110, 125, 150, 175, 200, 225
	HFD6	100	HF	1680.	70, 80, 90, 100, 110, 125, 150, 175, 200, 225

① Catalog number is for aluminum main bus. For optional copper main bus change "A" in position 11 to "C".
② Panels are top feed, surface mounted. For bottom feed change "T" in position 12 to "B". For flush mounting, change "S" in position 13 to "F".
③ Replace fifth and sixth position in panelboard catalog number, with alternate main breaker code. Use price adders from this table.
④ Horizontally mounted.

On Route/On Time:

☐ = 1-Day Service
☐ = Std. Quick-Ship Program

TYPE S1

BRANCH BREAKER SELECTION
BRANCH CIRCUIT BREAKERS—120/240 and 240 Volts AC

Breaker Types	Number of Poles	Ampere Rating	List Price Installed	Maximum Interrupting Rating (KA) 120V	120/240V	240V
BL	1	15, 20, 25, 30, 35, 40, 45, 50, 55, 60 70	$ 19. 36.	— —	10 10	— —
	2	15, 20, 25, 30, 35, 40, 50, 60 70 80, 90, 100 15, 20, 30, 40, 50, 60 70 90, 100	38. 73. 124. 95. 116. 164.	— — — — — —	10 10 10 — — —	— — — 10 10 10
	3	15, 20, 25, 30, 35, 40, 45, 50, 55, 60 70 80, 90, 100	125. 169. 188.	— — —	— — —	10 10 10
BLH	1	15, 20, 30, 40, 50, 55, 60 70	29. 70.	— —	22 22	— —
	2	15, 20, 30, 40, 50, 60 70 90, 100	74. 113. 177.	— — —	22 22 22	— — —
	3	15, 20, 30, 40, 50, 60 70 80, 90, 100	193. 257. 274.	— — —	— — —	22 22 22
HBL	1	15, 20, 30, 40, 50	55.	—	65	—
	2	15, 20, 30, 40, 50, 60 70, 80, 90, 100	135. 358.	— —	65 65	— —
	3	15, 20, 30, 40, 50, 60 70, 80, 90, 100	248. 425.	— —	— —	65 65
BLF	1	15, 20, 30	125.	10	—	—
BLHF	1	15, 20, 30	247.	22	—	—
BGL	2 3	15, 20, 30 15, 20, 30	79. 109.	10 —	— 10	— —
BLE	1	15, 20, 30	200.	10	—	—
SUBFEED BREAKERS—LIMIT ONE PER PANEL①②						
QJ2 QJH2 QJ2-H	2 3 2 3 2 3	60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225	375. 780. 830. 1006. 955. 1247.	— — — — — —	— — — — — —	10 10 22 22 42 42
ED4	2 3 2 3	15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100 110, 125 110, 125	376. 481. 669. 805.	— — — —	— — — —	65 65 — —
HED4	2 3 2 3	15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100 110, 125 110, 125	613. 691. 1122. 1292.	— — — —	— — — —	100 100 — —
FXD6	2 3	70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250	1078. 1362.	— —	— —	65 65
FD6	2 3	70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250	1240. 1565.	— —	— —	65 65
HFD6	2 3	70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250	2153. 2663.	— —	— —	100 100

Future provisions for Subfeed breakers 2-pole **$100.**
3-pole **100.**

① When applying in 42 circuit panel, see lighting and appliance panelboard definition on page 204. Also reference NEC article 384-16.
② No increase in box height. Space is already built into S1 panel.

On Route/On Time:

☐ = 1-Day Service

Siemens Sentron™ Panelboards
Modifications
Additions

TYPE S1

When required, special constructions or additions to standard panelboards may be specified for all **factory-assembled** Lighting and Distribution Panelboards. Below are listed many of those available for S1 panelboards. *In no case do these apply to* ***Narrow*** *(Column) Width Lighting Panelboards or* ***Unassembled*** *Panelboards.*

1. MISCELLANEOUS

Description	List Price
Type 3R ① or 3R/12 20" wide	$ 760.
Type 3R or 3R/12 24" wide	1043.
24" Wide Enclosure Type 1	205.

2. GASKETED—(No Knockouts)

Sealed Box, Gaskets between Trim and Box	$600.

3. PAINTED FINISH

Standard Color (ANSI 61)—box only	$145.

4. SPECIAL FRONT AND DOOR ARRANGEMENTS

Front Hinged to Box—Standard Door Over Interior, hinged front exposes wiring gutter (surface only)	$145.
Door-in-Door Construction (surface or flush)	320.

5. FRONT AND DOOR ACCESSORIES

Nameplate—laminated, engraved	$44.
Metal Card Holder	57.

6. SERVICE ENTRANCE LABEL

TYPE S1 Panelboards are factory labelled suitable for use as service entrance equipment when NEC requirements are met. Panelboard cannot have more than six main disconnects, unless it is a lighting and appliance branch panelboard. Lighting and appliance branch panelboards are limited to two main disconnects. See page 204 for definition of lighting and appliance panelboard.

7. GROUNDING OF PANELBOARDS (Add to Base Price)②

Non-Insulated Equipment Ground Bar	$ Std.
Copper Non-Insulated Ground Bar	$31. per panel
Al. Insulated Equipment Ground Bar	31. per panel
Cu Insulated Equipment Ground Bar	62. per panel

8. FEED-THRU LUGS ③

Ampere Rating	List Price	Connector Cu/Al Wire Range	Unit Space (Inches)
250	$160.	(1)—#6 AWG-350 kcmil	None④

9. CIRCUIT BREAKER ACCESSORIES

Type	List Price Each

HANDLE BLOCKING DEVICE-Blocks handle in either the "ON" or "OFF" position

BL, BLH, HBL, BQD	$15.
QJ2, QJLH, QJH2	25.
FXD6, FD6, HFD6	25.

PADLOCKING DEVICE—Padlocks in "OFF" position

BL, BLH, HBL, BQD	$15.
QJ2, QJ2H, QJH2	25.
FXD6, FD6, HFD6	25.

10. MAIN BUS

Standard main bus, is tin plated aluminum. For tin plated copper main bus, add from the table for each panel⑤.

Bus	Catalog ⑥ Number	List Price
Cu Bus (Tin Plated)	C	$169.

11. SHUNT TRIP ON MAIN OR BRANCH ⑦ ⑧

BL, BLH, HBL, BQD	$ 80.
QJ2, QJ2H, QJH2, ED2, ED4, ED6, HED4, HED6	130.
FXD6, FD6, HFD6	330.

12. MISCELLANEOUS

200% Capacity Neutral	$150.
Copper Neutral Lugs	100.
Copper Main Lugs 125A	104.
Copper Main Lugs 250A	164.

① Specify type 3R or 3R/12 on order entry.
② Ground bar shipped with interior. For Factory installation in box add $100 list to prices below.
③ Not available in panels with subfeed breakers. For use with main lug or main breaker panels. No increase in box size. Mounts opposite end of incoming.
④ S1 panelboards include unit space for 1 subfeed breaker or feed-thru lugs.
⑤ Includes copper neutral cross bar. For copper neutral branch lugs, add from table in item #12.
⑥ Change position 11 in catalog number from "A" to "C". Add list price to panelboard.
⑦ Shunt trip on BL, BLH and HBL branch breakers adds 1" to breaker width. Each shunt trip takes up 1 pole space in an S1 panel.
⑧ 3-pole BL, BLH and HBL breakers not available with shunt trips as main breakers.

On Route / On Time:
☐ = 1-Day Service
☐ = Std. Quick-Ship Program

MCG

MEDIUM-DUTY AC POWER LINE PROTECTION

Protects sensitive equipment from damaging transient overvoltages!

Protects without power interruption!

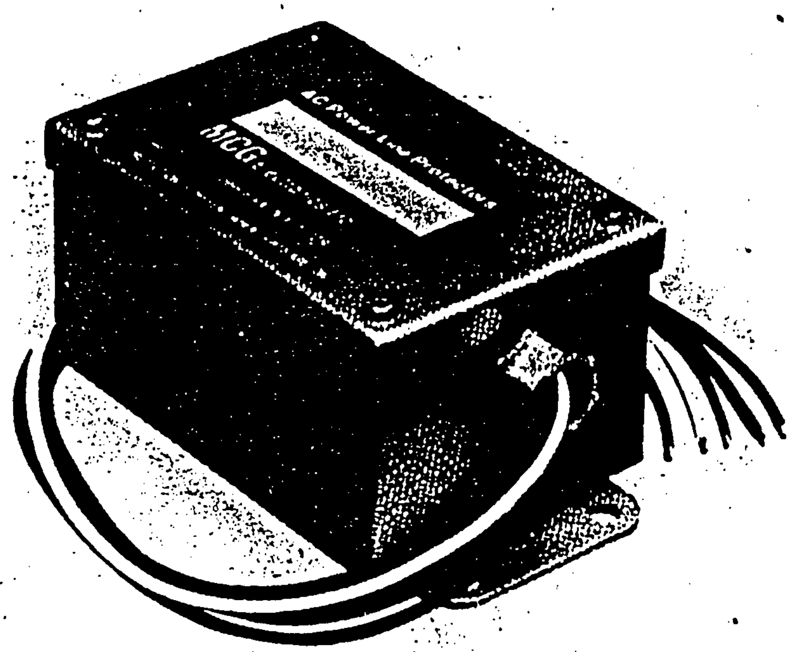
The MCG Series medium-duty protectors install at the local branch panel (load side) or at the equipment to provide very substantial transient overvoltage protection for one or more pieces of equipment.

Operating in nanoseconds, the shunt connected medium duty protectors will vigorously clamp lightning and transient overvoltages on the AC power lines to safe levels whenever the clamping threshold is exceeded.

After each transient, the protector recovers automatically - without power interruption! Nuisance circuit breaker tripping, so common with gas arrestor and crowbar devices is no longer a problem.

Long life and maintenance free operation make these units an excellent choice for remote and unattended stations or situations where "more than ordinary" protection makes sense. The protector is enclosed in a moisture proof housing to insure reliable operation in any environmental condition.

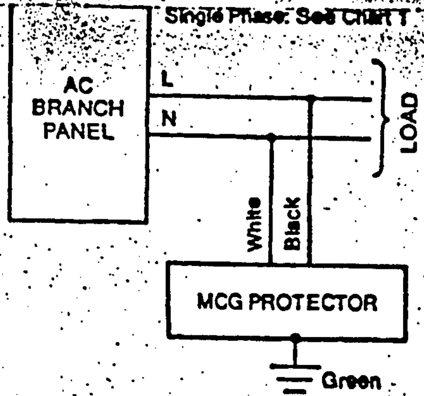
To use - install protector at branch panel and connect in shunt (on load side) to AC lines to be protected.

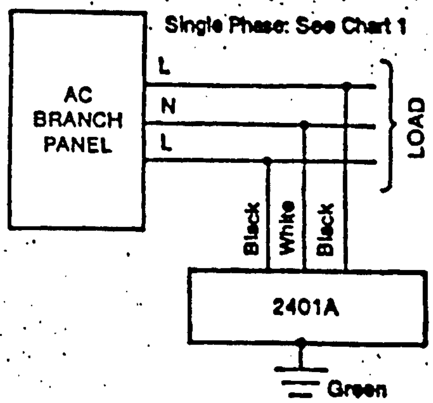


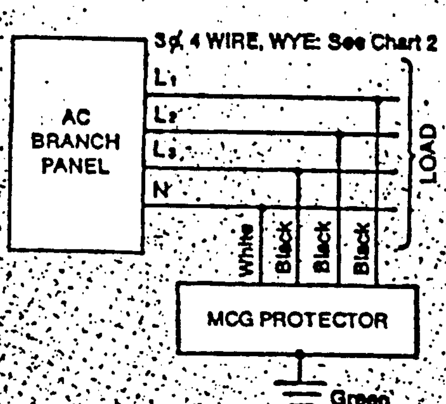
Protection for
Single phase
3ϕ, 4 wire, Wye
3ϕ, 3 wire, Delta

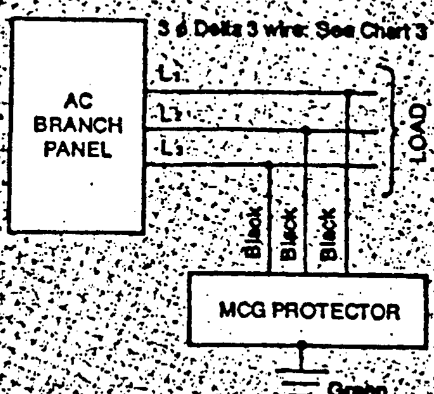
3535 A-02

MCG ELECTRONICS
12 BURT DRIVE • DEER PARK, NEW YORK 11729 • (516) 586-5125 • TELEX 645518









NOTE: The protectors should be operated on "Load" side of branch service panel.

SELECTION GUIDE

1. For 1ϕ use Chart 1, for 3ϕ 4W use Chart 2, for 3ϕ, 3W Delta use Chart 3.
2. Select the proper voltage range from the chart. Model No. is directly below the voltage.
3. Models can be used on lines requiring moderate local protection. For substantial lightning protection, use MCG heavy duty Series 2000 models.

CHART 1: SINGLE PHASE

Line Voltage	120 VAC	120/240V	240 VAC	277VAC	480 VAC
Model	1201	2401A	2401	2701	4801
Clamp V (1 ma)	235V pk	235V (L-N)	413V pk	430V pk	900V pk
Joule (watt-sec)	240J	480J	480J	480 J	480J

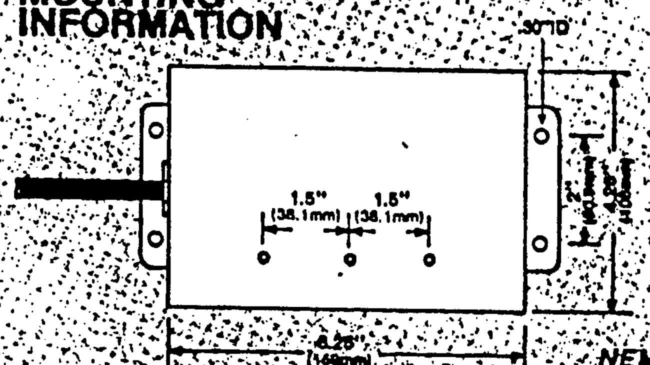
CHART 2: 3ϕ, 4 WIRE, WYE

Line Voltage	120/208 VAC	220/380 VAC	277/480 VAC
Service	WYE, 4W	WYE, 4 W	WYE, 4W
Model	2403Y	3803Y	4803Y
Clamp V (1 ma)	235V (L-N)	430 (L-N)	430V (L-N)
Joule (watt-sec)	240J	480J	480J

CHART 3: 3ϕ, 3 WIRE, DELTA

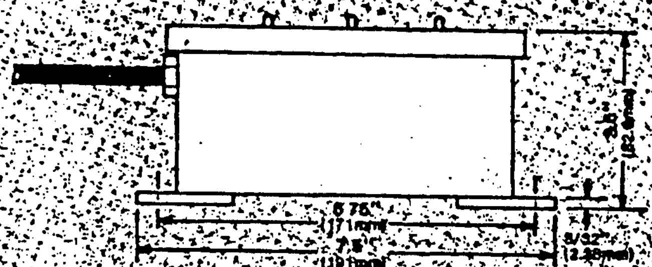
Line Voltage	120 VAC	240 VAC	380 VAC	480 VAC
Service	Delta, 3 W	Delta, 3 W	Delta, 3 W	Delta, 3 W
Model	1203D	2403D	3803D	4803D
Clamp V (1 ma)	235V (L-L)	430V (L-L)	690V (L-L)	900V (L-L)
Joule (watt-sec)	240J	480J	480J	480J

MOUNTING INFORMATION



NEMA 12
14 Gauge Steel
Grey Finish

"3-5 LEADS 36" (1m)

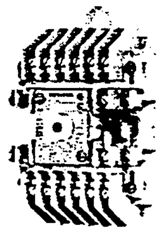


Shipping Weight: 15 lbs.

MCG ELECTRONICS INC.
12 BURT DRIVE • DEER PARK, NEW YORK 11729 • (516) 586-5125 • TELEX 645518

Siemens Control Products
Lighting Contactors
20 Amp-Multi-Pole-Type CLM Mechanically Held

CLASS CLM



Ordering Information
- Catalog number of contactor.
- Catalog number of kits..

Additional References
- For enclosed contactors order the contactor catalog number and the enclosure kit catalog number separately. All kits are for field installation. For factory modifications see page 391.
- All kits listed on this page only apply to the 20 amp contactors listed on this page and do not apply to the 30 thru 400 amp contactors listed on page 338.
- For dimensions see bottom of this page.

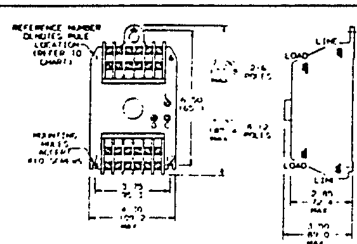
Maximum Ampere Rating	Number of Poles	Coil Voltage	Open Type: Catalog Number	Open Type: List Price Each $
20	2	120V	CLM22031	295.
	3	120V	CLM32031	313.
	4	120V	CLM42031	327.
	6	120V	CLM62031	507.
	8	120V	CLM82031	564.
	10	120V	CLM102031	627.
	12	120V	CLM122031	721.
	2	240V	CLM22061	295.
	3	240V	CLM32061	313.
	4	240V	CLM42061	327.
	6	240V	CLM62061	507.
	8	240V	CLM82061	564.
	10	240V	CLM102061	627.
	12	240V	CLM122061	721.
	2	277V	CLM22071	295.
	3	277V	CLM32071	313.
	4	277V	CLM42071	327.
	6	277V	CLM62071	507.
	8	277V	CLM82071	564.
	10	277V	CLM102071	627.
	12	277V	CLM122071	721.
	2	480V	CLM22091	295.
	3	480V	CLM32091	313.
	4	480V	CLM42091	327.
	6	480V	CLM62091	507.
	8	480V	CLM82091	564.
	10	480V	CLM102091	627.
	12	480V	CLM122091	721.

The CLM Lighting Contactors can be used with metal halide, mercury vapor, quartz halogen, tungsten and fluorescent lighting. They provide reliable and convenient lighting control in numerous applications, such as industrial plants, schools, hospitals, office buildings, shopping centers, airports, stadiums . . . literally everywhere lighting is required.

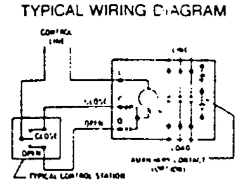
The CLM's are listed under UL 508 with no derating when used open or enclosed.

Optional solid-state control modules are available to allow control of the 20 Amp CLM lighting contactors directly from energy management systems, microprocessors, photoelectric cells, timers and similar control devices. They permit programmable time scheduling of loads, automatic control of lighting near windows to allow the use of natural ambient lighting levels and manual override of all lighting circuits from any number of local control stations or from a central location. These optional modules are integrally mounted onto the base of the 20 Amp lighting contactor.

Dimensions—Open Contactor ③



TYPICAL WIRING DIAGRAM



☐ = Std. Quick-Ship Program

ENCLOSURE KITS ③

Catalog Number	Description	List Price Each
ENC1F46	Surface Mounted NEMA 1 Enclosure	$ 60.
ENC2F46T	Surface Mounted NEMA 12 and 3R Enclosure ①	204.
ENCSF46T	Surface Mounted NEMA 4 Stainless Steel Enclosure ②	504.
ENCFCLM20	Flush Mount NEMA 1 Enclosure	162.

MAIN CONTACT BLOCK KITS ③

Catalog Number	Poles	Location	List Price Each
CLM4097331	2	(Top or bottom)	$180.
CLM4097332	3	(Top)	202.
CLM4097333	4	(Top or bottom)	247.
CLM4097334	6	(Top or bottom)	292.

SOLID STATE CONTROL MODULE KITS ③

Catalog Number	Accessory	Description	List Price Each
CLM4379771	47	2 Wire Control 120VAC, 50/60 HZ	$289.
CLM4379772		2 Wire Control 24VAC/VDC, 50/60 HZ	
CLM4379773		2 Wire Control 240/277VAC, 50/60 HZ	
CLM4379774		2 Wire Control 12VAC/VDC, 50/60 HZ	
CLM4379781	48	3 Wire Control 120VAC, 50/60 HZ	316.
CLM4379782		3 Wire Control 24 VAC/VDC, 50/60 HZ	
CLM4379783		3 Wire Control 240/277VAC, 50/60 HZ	
CLM4379784		3 Wire Control 12VAC/VDC, 50/60 HZ	
CLM4379791	49	Start/Stop Control 120VAC, 50/60 HZ	337.
CLM4379792		Start/Stop Control 24VAC/VDC, 50/60 HZ	
CLM4379793		Start/Stop Control 240/277VAC, 50/60 HZ	
CLM4379794		Start/Stop Control 12VAC/VDC, 50/60 HZ	

MISCELLANEOUS KITS ③

Catalog Number	Description	List Price Each
CLM4097341	Coil Kit 110/120V; 50/60 HZ	$54.
CLM4097342	Coil Kit 208/240V; 50/60 HZ	72.
CLM4097343	Coil Kit 277V; 50/60 HZ	63.
CLM4097344	Coil Kit 440/480V; 50/60 HZ	72.
KXS5CLM	On-Off SEL Switch Kit (NEMA 1 only)	48.
P30KS50CLM	On-Off SEL Switch Kit (NEMA 12, 3R, 4)	33.
CLM4097291	Auxiliary Contact Kit 10AMP, 1 Form C Contacts	67.
CLM4097292	Auxiliary Contact Kit 10AMP, 2 Form C Contacts	135.

MAXIMUM AC VOLTAGE AND AMP RATINGS ③

Load Type	Amperes Continuous	Poles to Load: 1 for 1 Phase	Poles to Load: 2 for 1 Phase, 3 for 3 Phase
Tungsten	20	250 V ac	
Ballast	20	347 V ac	600 V ac
General	30	347 V ac	600 V ac

MAXIMUM DC VOLTAGE AND AMP RATINGS ③

Load Type	Amperes Continuous	Poles to Load: 2 in Series	Poles to Load: 3 in Series
General	20	125 V dc	250 V dc

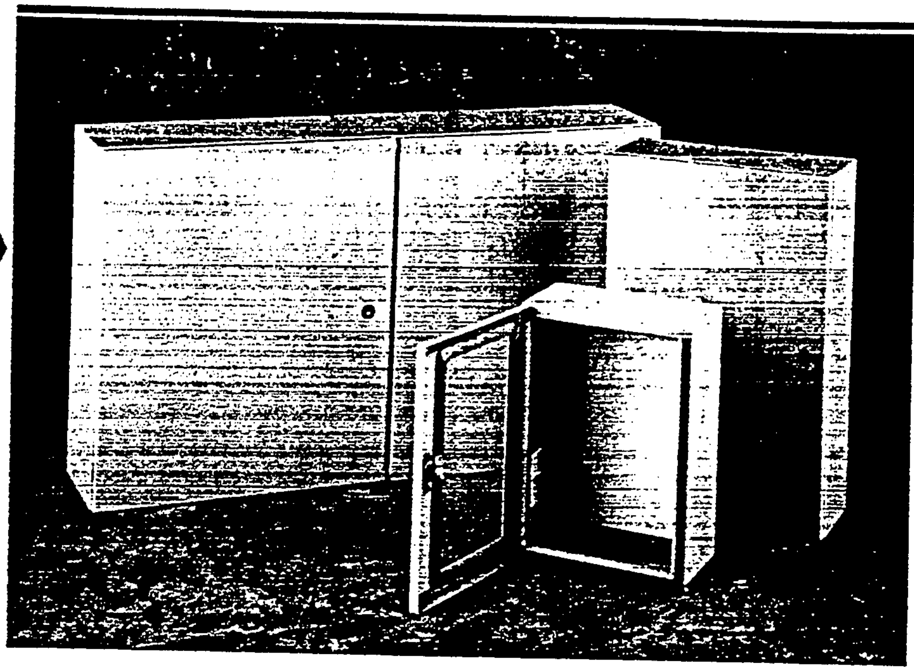
① NEMA Type 12 Enclosures are UL listed for NEMA Type 3R for outdoor applications. Watertight conduit hubs or equivalent provision for watertight connection at the conduit entrance shall be used.

② For NEMA Type 4 painted steel enclosure replace the 5th digit "S" in the catalog number with "4".

③ All kits and ratings only apply to the 20 Amp contactors listed on this page.

CONCEPT™ Wall-Mount Enclosures

NEW



Industry Standards

- CONCEPT single-door and flush-mount models
  UL508 Type 4 and Type 12
  NEMA/EEMAC Type 4, Type 12, and Type 13
  CSA Type 4 and Type 12
  VDE IP66
  IEC 529, IP66
- CONCEPT window-door models
  UL508 Type 4
  NEMA/EEMAC Type 4
  CSA Type 4
  VDE IP66
  IEC 529, IP66
- CONCEPT two-door models
  UL508 Type 12
  NEMA/EEMAC Type 12
  CSA Type 12
  VDE IP66
  IEC 529, IP55

Price List Page 4.02

Application

CONCEPT™ enclosures house and protect your sensitive electrical or electronic components from harsh, dirty environments. For use in installations where dirt, dust, oil, water, or other contaminants are present. Streamlined styling, flush latching, and an attractive durable finish complement any high-tech electronic equipment.

Construction

- Manufactured from 16 or 14 gauge steel
- Seams continuously welded and ground smooth
- Minimum width body flange provides maximum door opening
- Body flange trough excludes liquids and contaminants
- Panel mounting studs fit optional CONCEPT panels and other accessories
- Mounting holes in back of body for direct mounting or for optional external mounting feet
- Hidden hinges for clean aesthetic appearance
- Standard 120 degree door opening or optional hinge kit for 230 degree maximum door opening
- Doors are interchangeable and easily removable by pulling captive hinge pins
- Hinge mounting brackets for wire management or optional accessories
- Seamless foam-in-place one piece gasket provides oil-tight and dust-tight seal against contaminants
- Self-grounding latch system with double seal provides maximum protection against leakage
- Integral body grounding stud
- Furnished hardware kit consists of panel mounting nuts, grounding hardware, and sealing washers for wall mounting holes
- Installation instructions for enclosure and accessories are provided

CONCEPT single-door enclosures

- Door bar on hinge side for wire management and grounding
- Additional door bar and center stiffener on larger doors for extra rigidity
- Provisions on door for thermoplastic data pocket
- Quarterturn latches (or a 3-point latch system on larger enclosures) furnished with flush slotted insert. Optional handles or inserts are available.

CONCEPT window-door enclosures

- Clear polycarbonate window is mounted flush with door surface
- Quarterturn latch(es) include flush slotted insert. Optional handles are available.

CONCEPT flush-mount enclosures

- Mounting frame extends completely around enclosure
- Quarterturn latch(es) furnished with slotted insert. Optional handles or inserts are available.

CONCEPT two-door enclosures

- Overlapping door design provides full width access
- Door bars on each door for wire management and grounding
- Provision on right door for thermoplastic data pocket
- 3-point latch system on right door furnished with flush slotted insert. Optional handles or inserts are available.

Finish

ANSI 61 gray polyester powder coating inside and out over phosphatized surfaces. Optional panels are white.

Accessories

See General Accessories index page 492.

Adjustable Mounting Kit
Corrosion Inhibitors
Data Pocket
Dead Front Kit
DIN Rail Kit
Door Stop Kit
Electric Heater
Fan Cooling Products
Grid Straps
Handles and Latches
Hinge Kit, 180°
Key Inserts
Lighting Kits
Mounting Channels
Mounting Feet Kit
Panel Conversion Kit
Panels (See tables)
Panels, NEMA
Pole Mounting Kit
Rack Mounting Angles
Swing-Out Panel Kit
Swing-Out Rack Frames
Terminal Kit Assembly
Wiring Duct

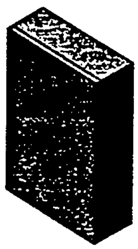
Cross Reference

CONCEPT™ Enclosures for Flange-Mounted Disconnects (page 302)

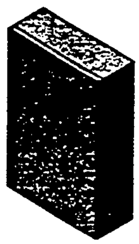
CONCEPT™ Single-Door Stainless Steel Enclosures (page 358)

Single Door Type 12 and 13 Enclosures (page 258)

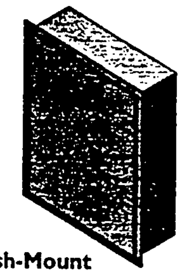
The CONCEPT™ Enclosure Group Accessory Selection Guide



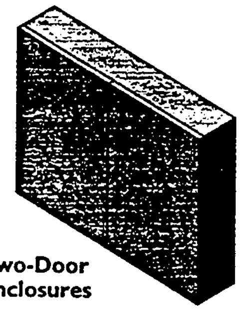
Steel or Stainless Steel **Enclosures**



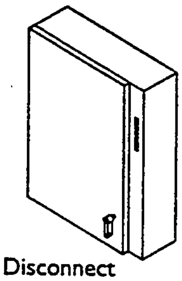
Steel or Stainless Steel **Window-Door Enclosures**



Flush-Mount Enclosures

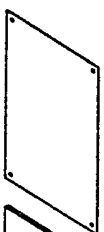


Two-Door Enclosures

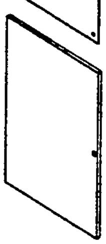


Disconnect Enclosures

Internal Accessories

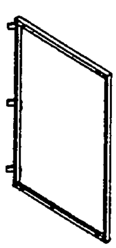


Steel Panel
page 526

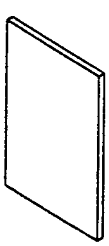


Swing-Out Panel
page 526

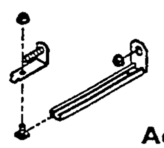
Panel Conversion Kit
page 527



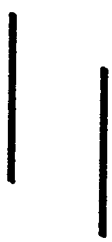
Swing-Out Rack Frame
page 528



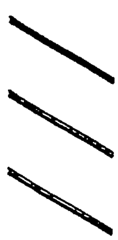
Dead Front Kit
page 527



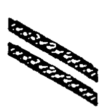
Adustable Mounting Kit
page 526



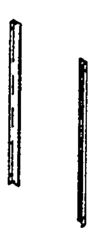
Mounting Channels
page 527



DIN Rail Kit
page 527



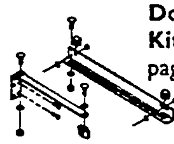
Grid Straps
page 528



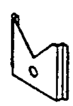
Rack Mounting Angles
page 528

Door Accessories

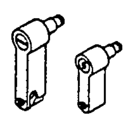
180° Hinge Kit
page 529



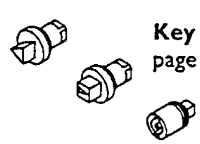
Door Stop Kit
page 529



Data Pocket
page 529

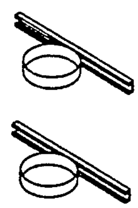


Handles and Latches
page 529

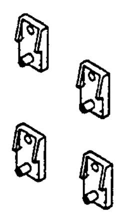


Key Inserts
page 529

External Accessories



Pole Mounting Kit
page 529



Mounting Foot Kit
page 529

C2505-1

Standard Sizes CONCEPT Single-Door Wall-Mount Enclosures

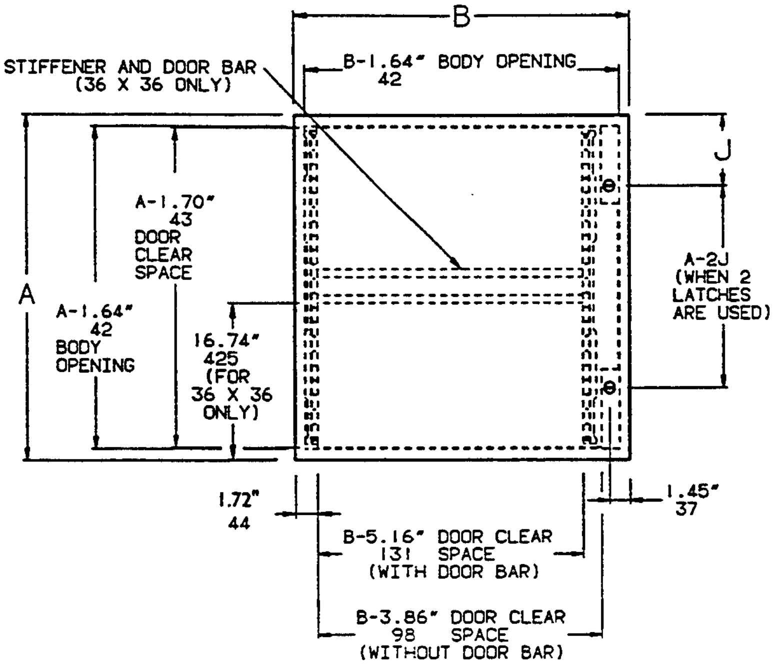
NEW

Enclosure Catalog Number	Door Gauge	Body Gauge	Enclosure Size A x B x C inch	(millimeter)	* CONCEPT Panel Catalog Number	Panel Size D x E inch	(mm)	Mounting G x H inch	(mm)	Latches qty	Latches style	J inch	(mm)
C-SD12126	16	16	12.00x12.00x6.00	(305x305x152)	C-P1212	10.20x10.20	(259x259)	10.50x10.50	(267x267)	1	Quarterturn	6.00	(152)
C-SD16126	16	16	16.00x12.00x6.00	(406x305x152)	C-P1612	14.20x10.20	(361x259)	14.50x10.50	(368x267)	1	Quarterturn	8.00	(203)
C-SD16166	16	16	16.00x16.00x6.00	(406x406x152)	C-P1616	14.20x14.20	(361x361)	14.50x14.50	(368x368)	1	Quarterturn	8.00	(203)
C-SD16206	16	16	16.00x20.00x6.00	(406x508x152)	C-P2016	18.20x14.20	(462x361)	14.50x18.50	(368x470)	1	Quarterturn	8.00	(203)
C-SD20166	16	16	20.00x16.00x6.00	(508x406x152)	C-P2016	18.20x14.50	(462x361)	18.50x14.50	(470x368)	1	Quarterturn	10.00	(254)
C-SD20206	16	16	20.00x20.00x6.00	(508x508x152)	C-P2020	18.20x18.20	(462x462)	18.50x18.50	(470x470)	1	Quarterturn	10.00	(254)
C-SD24166	16	16	24.00x16.00x6.00	(610x406x152)	C-P2416	22.20x14.20	(564x361)	22.50x14.50	(572x368)	1	Quarterturn	12.00	(305)
C-SD24206	16	16	24.00x20.00x6.00	(610x508x152)	C-P2420	22.20x18.20	(564x462)	22.50x18.50	(572x470)	1	Quarterturn	12.00	(305)
C-SD24246	14	16	24.00x24.00x6.00	(610x610x152)	C-P2424	22.20x22.20	(564x564)	22.50x22.50	(572x572)	2	Quarterturn	5.00	(127)
C-SD16128	16	16	16.00x12.00x8.00	(406x305x203)	C-P1612	14.20x10.20	(361x259)	14.50x10.50	(368x267)	1	Quarterturn	8.00	(203)
C-SD16168	16	16	16.00x16.00x8.00	(406x406x203)	C-P1616	14.20x14.20	(361x361)	14.50x14.50	(368x368)	1	Quarterturn	8.00	(203)
C-SD16208	16	16	16.00x20.00x8.00	(406x508x203)	C-P2016	18.20x14.20	(462x361)	14.50x18.50	(368x470)	1	Quarterturn	8.00	(203)
C-SD20168	16	16	20.00x16.00x8.00	(508x406x203)	C-P2016	18.20x14.20	(462x361)	18.50x14.50	(470x368)	1	Quarterturn	10.00	(254)
C-SD20208	16	16	20.00x20.00x8.00	(508x508x203)	C-P2020	18.20x18.20	(462x462)	18.50x18.50	(470x470)	1	Quarterturn	10.00	(254)
C-SD20248	16	16	20.00x24.00x8.00	(508x610x203)	C-P2420	22.20x18.20	(564x462)	18.50x22.50	(470x572)	1	Quarterturn	10.00	(254)
C-SD24168	16	16	24.00x16.00x8.00	(610x406x203)	C-P2416	22.20x14.20	(564x361)	22.50x14.50	(572x368)	1	Quarterturn	12.00	(305)
C-SD24208	16	16	24.00x20.00x8.00	(610x508x203)	C-P2420	22.20x18.20	(564x462)	22.50x18.50	(572x470)	1	Quarterturn	12.00	(305)
C-SD24248	14	16	24.00x24.00x8.00	(610x610x203)	C-P2424	22.20x22.20	(564x564)	22.50x22.50	(572x572)	2	Quarterturn	5.00	(127)
C-SD24308	14	16	24.00x30.00x8.00	(610x762x203)	C-P3024	28.20x22.20	(716x564)	22.50x28.50	(572x724)	2	Quarterturn	5.00	(127)
C-SD30208	14	16	30.00x20.00x8.00	(762x508x203)	C-P3020	28.20x18.20	(716x462)	28.50x18.50	(724x470)	2	Quarterturn	5.00	(127)
C-SD30248	14	16	30.00x24.00x8.00	(762x610x8.00)	C-P3024	28.20x22.20	(716x564)	28.50x22.50	(724x572)	2	Quarterturn	5.00	(127)
C-SD30308	14	14	30.00x30.00x8.00	(762x762x203)	C-P3030	28.20x28.20	(716x716)	28.50x28.50	(724x724)	2	Quarterturn	5.00	(127)
C-SD36248	14	14	36.00x24.00x8.00	(914x610x203)	C-P3624	34.20x22.20	(869x564)	34.50x22.50	(876x572)	2	Quarterturn	5.00	(127)
C-SD36308	14	14	36.00x30.00x8.00	(914x762x203)	C-P3630	34.20x28.20	(869x716)	34.50x28.50	(876x724)	2	Quarterturn	5.00	(127)
C-SD36368	14	14	36.00x36.00x8.00	(914x914x203)	C-P3636	34.20x34.20	(869x869)	34.50x34.50	(876x876)	2	Quarterturn	5.00	(127)
C-SD202012	16	16	20.00x20.00x12.00	(508x508x305)	C-P2020	18.20x18.20	(462x462)	18.50x18.50	(470x470)	1	Quarterturn	10.00	(254)
C-SD242012	16	16	24.00x20.00x12.00	(610x508x305)	C-P2420	22.20x18.20	(564x462)	22.50x18.50	(572x470)	1	Quarterturn	12.00	(305)
C-SD242412	14	16	24.00x24.00x12.00	(610x610x305)	C-P2424	22.20x22.20	(564x564)	22.50x22.50	(572x572)	2	Quarterturn	5.00	(127)
C-SD302412	14	16	30.00x24.00x12.00	(762x610x305)	C-P3024	28.20x22.20	(716x564)	28.50x22.50	(724x572)	2	Quarterturn	5.00	(127)
C-SD303012	14	14	30.00x30.00x12.00	(762x762x305)	C-P3030	28.20x28.20	(716x716)	28.50x28.50	(724x724)	2	Quarterturn	5.00	(127)
C-SD362412	14	14	36.00x24.00x12.00	(914x610x305)	C-P3624	34.20x22.20	(869x564)	34.50x22.50	(876x572)	2	Quarterturn	5.00	(127)
C-SD363012	14	14	36.00x30.00x12.00	(914x762x305)	C-P3630	34.20x28.20	(869x716)	34.50x28.50	(876x724)	2	Quarterturn	5.00	(127)
C-SD363612	14	14	36.00x36.00x12.00	(914x914x305)	C-P3636	34.20x34.20	(869x869)	34.50x34.50	(876x876)	2	Quarterturn	5.00	(127)
C-SD423612	14	14	42.00x36.00x12.00	(1067x914x305)	C-P4236	40.20x34.20	(1021x869)	40.50x34.50	(1029x876)	1	3-point	21.00	(533)
C-SD482412	14	14	48.00x24.00x12.00	(1219x610x305)	C-P4824	46.20x22.20	(1173x564)	46.50x22.50	(1181x572)	1	3-point	24.00	(610)
C-SD483612	14	14	48.00x36.00x12.00	(1219x914x305)	C-P4836	46.20x34.20	(1173x869)	46.50x34.50	(1181x876)	1	3-point	24.00	(610)
C-SD603612	14	14	60.00x36.00x12.00	(1524x914x305)	C-P6036	58.20x34.20	(1478x869)	58.50x34.50	(1486x876)	1	3-point	30.00	(762)
C-SD242416	14	14	24.00x24.00x16.00	(610x610x406)	C-P2424	22.20x22.20	(564x564)	22.50x22.50	(572x572)	2	Quarterturn	5.00	(127)
C-SD363016	14	14	36.00x30.00x16.00	(914x762x406)	C-P3630	34.20x28.20	(869x716)	34.50x28.50	(876x724)	2	Quarterturn	5.00	(127)
C-SD483616	14	14	48.00x36.00x16.00	(1219x914x406)	C-P4836	46.20x34.20	(1173x869)	46.50x34.50	(1181x876)	1	3-point	24.00	(610)
C-SD242420	14	14	24.00x24.00x20.00	(610x610x508)	C-P2424	22.20x22.20	(564x564)	22.50x22.50	(572x572)	2	Quarterturn	5.00	(127)
C-SD302420	14	14	30.00x24.00x20.00	(762x610x508)	C-P3024	28.20x22.20	(716x564)	28.50x22.50	(724x572)	2	Quarterturn	5.00	(127)
C-SD363020	14	14	36.00x30.00x20.00	(914x762x508)	C-P3630	34.20x28.20	(869x716)	34.50x28.50	(876x724)	2	Quarterturn	5.00	(127)

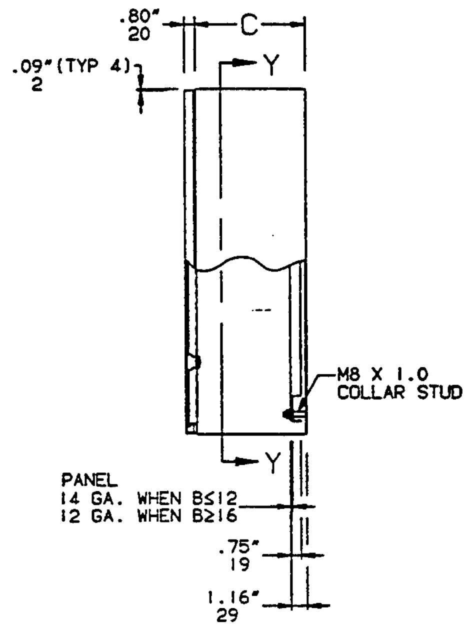
Millimeter dimensions ( ) are for reference only; do not convert metric dimensions to inch.

* Panels must be ordered separately. Optional NEMA size panels require conversion kit catalog number C-CPM4 (see page 527).

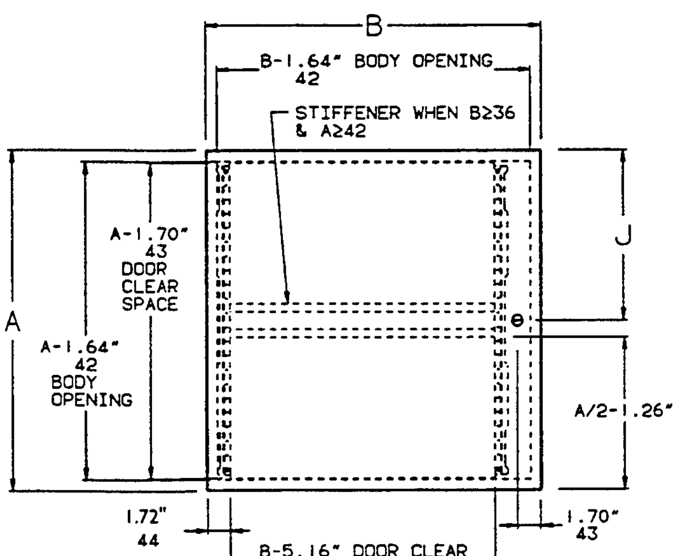
■ CONCEPT™ Single-Door Wall-Mount Enclosures



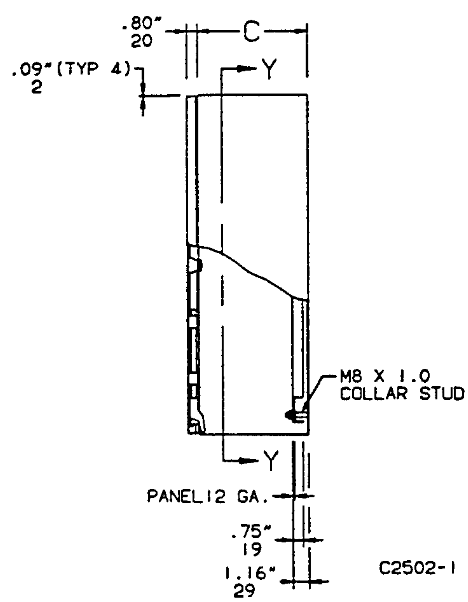
Single-Door Enclosure with Quarterturn Latching



NOTE: 1. Large data pocket provision when A = 30.00 (762) or more and B = 20.00 (508) or more. (Exception: large data pocket when A x B = 24.00 x 30.00.)
2. No data pocket provision when B = 12.00 (305).
3. Panels have flanges along sides which are more than 22.20 inches (564) long, except C-P2420 and C-P2424 which have flanges on two-sides.



Single-Door Enclosure with 3-Point Latching



C2502-1

Inch / Millimeter

For Section Y-Y see page 255

NEW

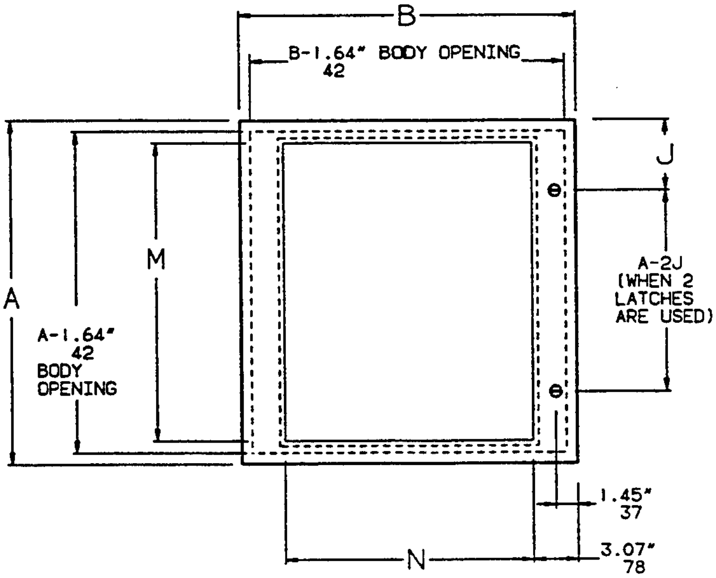
Standard Sizes CONCEPT Single-Door Wall-Mount Enclosures with Windows

Enclosure Catalog Number	Door Gauge	Body Gauge	Enclosure Size A x B x C	* CONCEPT Panel Catalog Number	Panel Size D x E	Mounting G x H	Window Size M x N	Latches qty	Latches style	J
C-SD12126W	16	16	12.00x12.00x6.00 (305x305x152)	C-P1212	10.20x10.20 (259x259)	10.50x10.50 (267x267)	8.74x7.10 (222x180)	1	Quarterturn	6.00 (152)
C-SD16126W	16	16	16.00x12.00x6.00 (406x305x152)	C-P1612	14.20x10.20 (361x259)	14.50x10.50 (368x267)	12.74x7.10 (324x180)	1	Quarterturn	8.00 (203)
C-SD20166W	16	16	20.00x16.00x6.00 (508x406x152)	C-P2016	18.20x14.20 (462x361)	18.50x14.50 (470x368)	16.74x11.10 (425x282)	1	Quarterturn	10.00 (254)
C-SD20206W	16	16	20.00x20.00x6.00 (508x508x152)	C-P2020	18.20x18.20 (462x462)	18.50x18.50 (470x470)	16.74x15.10 (425x384)	1	Quarterturn	10.00 (254)
C-SD24206W	16	16	24.00x20.00x6.00 (610x508x152)	C-P2420	22.20x18.20 (564x462)	22.50x18.50 (572x470)	20.74x15.10 (527x384)	1	Quarterturn	12.00 (305)
C-SD24246W	14	16	24.00x24.00x6.00 (610x610x152)	C-P2424	22.20x22.20 (564x564)	22.50x22.50 (572x572)	20.74x17.68 (527x449)	2	Quarterturn	5.00 (127)
C-SD16128W	16	16	16.00x12.00x8.00 (406x305x203)	C-P1612	14.20x10.20 (361x259)	14.50x10.50 (368x267)	12.74x7.10 (324x180)	1	Quarterturn	8.00 (203)
C-SD20168W	16	16	20.00x16.00x8.00 (508x406x203)	C-P2016	18.20x14.20 (462x361)	18.50x14.50 (470x368)	16.74x11.10 (425x282)	1	Quarterturn	10.00 (254)
C-SD20208W	16	16	20.00x20.00x8.00 (508x508x203)	C-P2020	18.20x18.20 (462x462)	18.50x18.50 (470x470)	16.74x15.10 (425x384)	1	Quarterturn	10.00 (254)
C-SD24208W	16	16	24.00x20.00x8.00 (610x508x203)	C-P2420	22.20x18.20 (564x462)	22.50x18.50 (572x470)	20.74x15.10 (527x384)	1	Quarterturn	12.00 (305)
C-SD24248W	14	16	24.00x24.00x8.00 (610x610x203)	C-P2424	22.20x22.20 (564x564)	22.50x22.50 (572x572)	20.74x17.68 (527x449)	2	Quarterturn	5.00 (127)
C-SD30248W	14	16	30.00x24.00x8.00 (762x610x203)	C-P3024	28.20x22.20 (716x564)	28.50x22.50 (724x572)	26.74x17.68 (679x449)	2	Quarterturn	5.00 (127)
C-SD202012W	16	16	20.00x20.00x12.00 (508x508x305)	C-P2020	18.20x18.20 (462x462)	18.50x18.50 (470x470)	16.74x15.10 (425x384)	1	Quarterturn	10.00 (254)
C-SD242012W	16	16	24.00x20.00x12.00 (610x508x305)	C-P2420	22.20x18.20 (564x462)	22.50x18.50 (572x470)	20.74x15.10 (527x384)	1	Quarterturn	12.00 (305)
C-SD242412W	14	16	24.00x24.00x12.00 (610x610x305)	C-P2424	22.20x22.20 (564x564)	22.50x22.50 (572x572)	20.74x17.68 (527x449)	2	Quarterturn	5.00 (127)
C-SD302412W	14	16	30.00x24.00x12.00 (762x610x305)	C-P3024	28.20x22.20 (716x564)	28.50x22.50 (724x572)	26.74x17.68 (679x449)	2	Quarterturn	5.00 (127)
C-SD242416W	14	14	24.00x24.00x16.00 (610x610x406)	C-P2424	22.20x22.20 (564x564)	22.50x22.50 (572x572)	20.74x17.68 (527x449)	2	Quarterturn	5.00 (127)
C-SD242420W	14	14	24.00x24.00x20.00 (610x610x508)	C-P2424	22.20x22.20 (564x564)	22.50x22.50 (572x572)	20.74x17.68 (527x449)	2	Quarterturn	5.00 (127)
C-SD302420W	14	14	30.00x24.00x20.00 (762x610x508)	C-P3024	28.20x22.20 (716x564)	28.50x22.50 (724x572)	26.74x17.68 (679x449)	2	Quarterturn	5.00 (127)

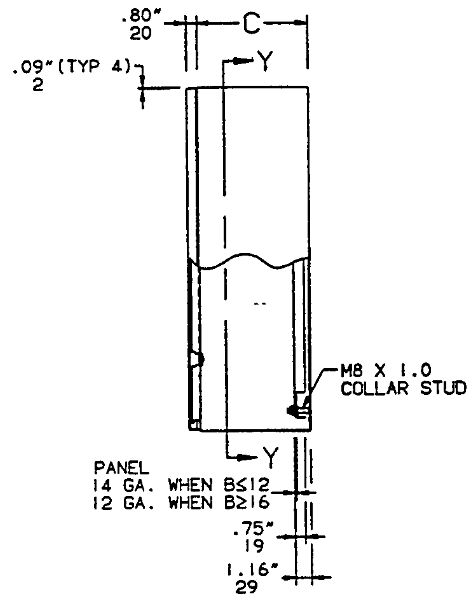
Millimeter dimensions ( ) are for reference only; do not convert metric to inch.

* Panels must be ordered separately. Optional NEMA size panels require conversion kit catalog number C-CPM4 (see page 527).

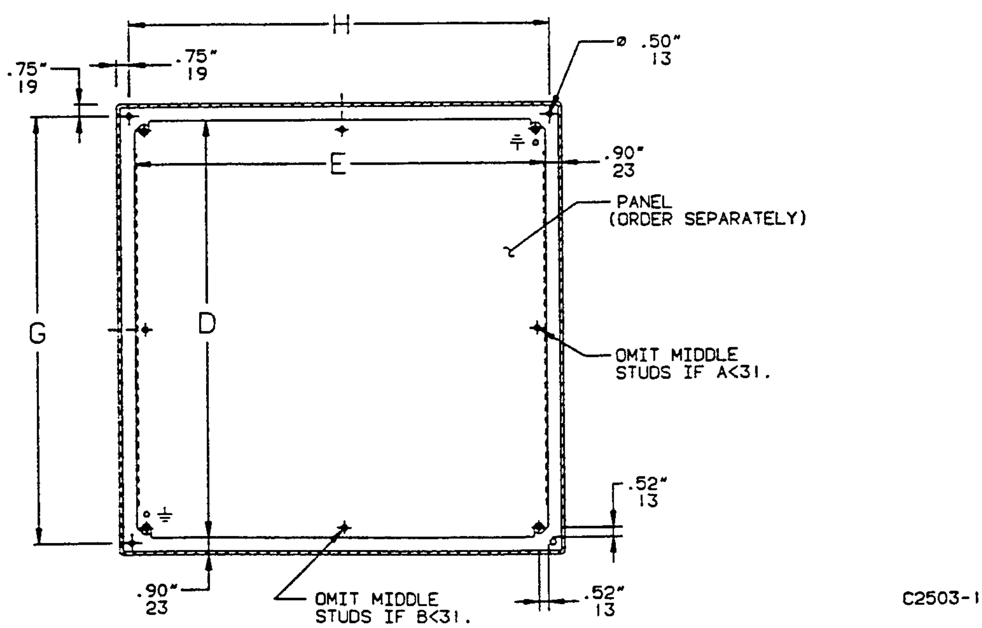
■ **CONCEPT™ Single-Door Wall-Mount Enclosures with Windows**



Window-Door Enclosure with Quarterturn Latching



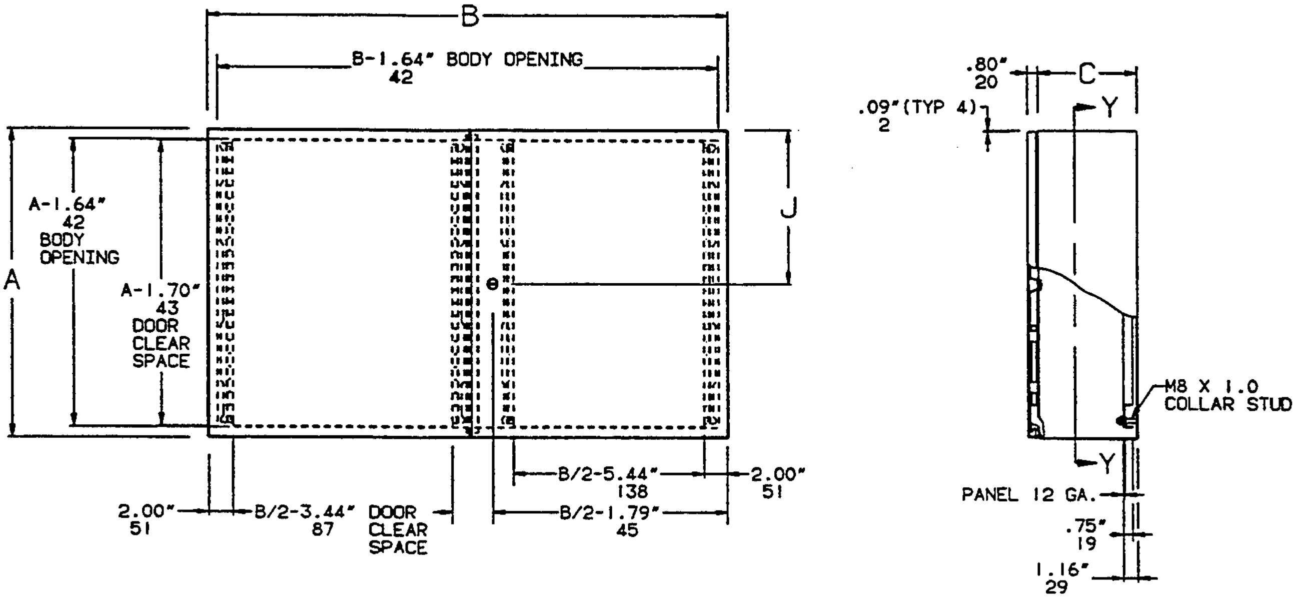
NOTE: Panels have flanges along sides which are more than 22.20 inches (564) long.



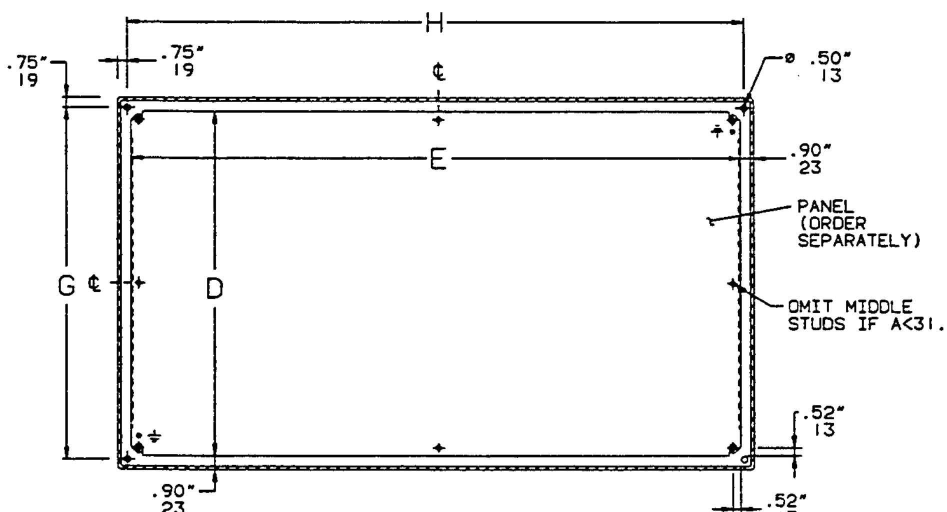
SECTION Y-Y
with CONCEPT panel installed

Inch
Millimeter

■ CONCEPT™ Two-Door Enclosures



NOTE: 1. Large data pocket provision when A = 30.00 (762) or more and B = 20.00 (508) or more.
2. Panels have flanges along sides which are more than 22.20 inches (564) long.



Inch
Millimeter

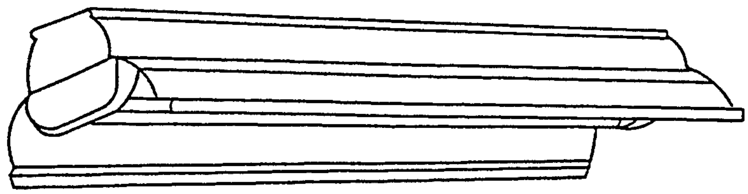
SECTION Y-Y
with CONCEPT panel installed

C2504-1

Standard Sizes CONCEPT Two-Door Enclosures

Enclosure Catalog Number	Door Gauge	Body Gauge	Enclosure Size A x B x C inch	(millimeter)	* CONCEPT Panel Catalog Number	Panel Size D x E inch	(mm)	Mounting G x H inch	(mm)	Latches qty	style	J inch	(mm)
C-TD24428	14	14	24.00x42.00x8.00	(610x1067x203)	C-P2442	22.20x40.20	(564x1021)	22.50x40.50	(572x1029)	1	3-point	12.00	(305)
C-TD30488	14	14	30.00x48.00x8.00	(762x1219x203)	C-P3048	28.20x46.20	(716x1173)	28.50x46.50	(724x1181)	1	3-point	15.00	(381)
C-TD306012	14	14	30.00x60.00x12.00	(762x1524x305)	C-P3060	28.20x58.20	(716x1478)	28.50x58.50	(724x1486)	1	3-point	15.00	(381)
C-TD364812	14	14	36.00x48.00x12.00	(914x1219x305)	C-P4836	34.20x46.20	(869x1173)	34.50x46.50	(876x1181)	1	3-point	18.00	(457)
C-TD366012	14	14	36.00x60.00x12.00	(914x1524x305)	C-P6036	34.20x58.20	(869x1478)	34.50x58.50	(876x1486)	1	3-point	18.00	(457)

Millimeter dimensions ( ) are for reference only; do not convert metric dimensions to inch.
• Panels must be ordered separately.

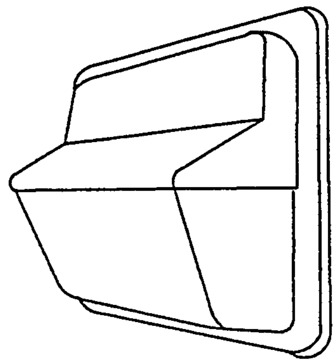


TYPE 230
Suspension Mounted, Industrial,
Open Type Fluorescent Fixture, 4-Foot

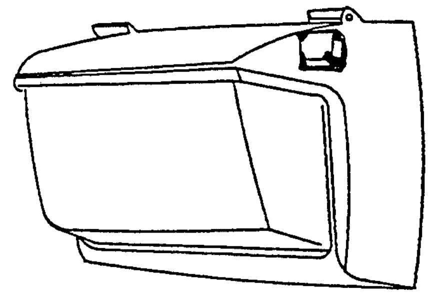
First-Suffix	Second-Suffix	Description
A		Two lamps
B		Three lamps
	1	8 to 15 percent uplight
	2	18 to 25 percent uplight

Fixture shall conform to UL 1570. Standard ballast(s) shall be the Class P, high power factor type approved for the application by the Certified Ballast Manufacturers. Channel housing, end fittings, and reflector shall be constructed with die-formed, cold-rolled steel. Reflector finish shall be porcelain enamel, baked white enamel or aluminum oxide.

Fixture type indicated on this sheet shall also conform to requirements specified and indicated in the contract documents.



TYPE 501



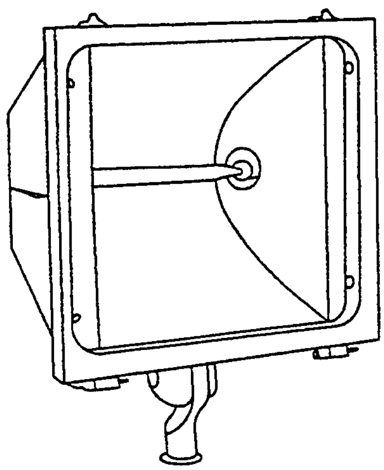
TYPE 502

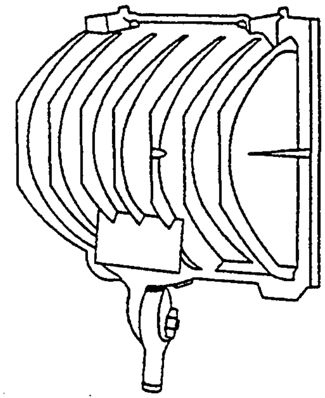
High Intensity Discharge Fixture for Exterior Wall Mounting, Medium Output

Suffix	Description
	Rated for:
A	50 watt high pressure sodium lamp
B	70 watt high pressure sodium lamp
C	100 watt high pressure sodium lamp
D	150 watt high pressure sodium lamp
E	175 watt metal halide lamp

Fixture shall conform to UL 1572 and shall be rated for use in wet locations. The fixture housing, door assembly, and backplate shall be die-cast aluminum. The door assembly shall have integral cast aluminum hinges. The door assembly shall be held securely to the fixture housing with a stainless steel safety strap when the door is in the open position. The door assembly shall be held firmly against a sealing gasket between the fixture door and housing by stainless steel latches or with stainless steel or brass captive screws when the fixture door is closed. The refractor shall be prismatic borosilicate glass or polycarbonate resin. The refractor shall be gasketed and securely held in the door frame, but shall be easily removed for replacement with a common tool. The reflector shall be aluminum with the manufacturer's standard commercial product finish suitable for the type and rating of the lamp. The fixture shall have manufacturers standard protective coating. Cast knockouts shall be provided in the backplate for recessed outlet box mounting. Ballast shall be of the high power factor type. Ballast shall be of the lead-peak autotransformer type metal halide for lamps and the regulating type for high pressure sodium lamps. Ballast shall be capable of starting and operating the lamp at ambient temperatures from minus 20 degrees F to 105 degrees F. The fixture shall be prewired, and shall have a field adjustable, mogul base glazed porcelain lampholder.

Fixture types indicated on this sheet shall also conform to requirements specified and indicated in the contract documents.





TYPE 508

Front View Back View

500-Watt, Tungsten Halogen (Quartz-Iodine) Floodlight

Suffix	Description
A	NEMA type 5 x 2 light distribution
B	NEMA type 5 x 3 light distribution
C	NEMA type 5 x 5 light distribution

Fixture shall conform to UL 1572 and NEMA FA 1, and shall be the heavy duty enclosed type. The housing shall be die-cast aluminum with cast-in fins for heat dissipation. The manufacturer's standard commercial product finish shall be provided on all interior and exterior metal surfaces. The reflector shall be aluminum which shall be suitably finished for the type and rating of the lamp. The lens shall be thermal shock and impact resistant glass securely held in a door frame equipped with gaskets as required to prevent the entrance of insects and light leakage. The fixture housing shall include a horizontal adjustment incorporated in the mounting arm, between the mounting arm and the fixture housing, or as an accessory attached to the mounting arm consistent with the standard practice of the fixture manufacturer. The fixture shall be prewired, and shall have a high-temperature, metal-encased, spring-loaded glazed porcelain lampholder.

Fixture type indicated on this sheet shall also conform to requirements specified and indicated in the contract documents.

Model SBC3 Process Control & Communications Computer

Consolidated Electric Co.

141 South Lafayette Freeway Saint Paul, Minnesota 55107-1420 USA 612/224-9474 Fax 612/224-3628

The SBC3 Computer is a highly-integrated, 16-bit microprocessor-based system with extensive application in;

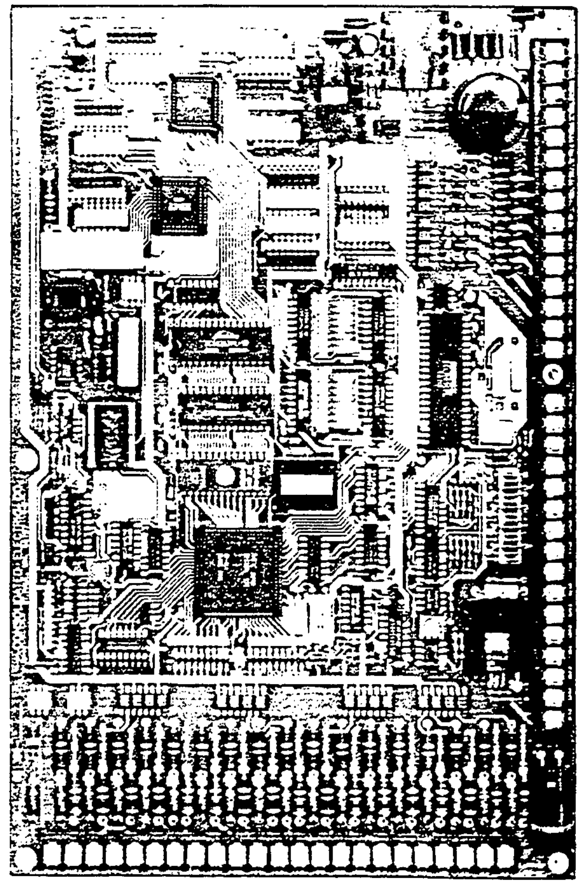
- *monitoring of remote facilities*
- *telemetry of analog values*
- *supervisory control of water/wastewater or process systems*
- *process control of water/wastewater pumping automation*

The SBC3 Computer has standard interfaces for communication over;

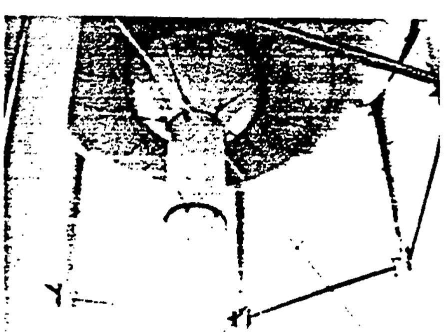
- *Leased, full-time, voice-grade telephone circuits*
- *The Telco dial-up network via auto-dial/auto-answer*
- *Local network (twisted pair) via RS-485 modem interface*
- *Radio channels via FM VHF/UHF; direct or via repeaters*
- *Fixed Cellular Telephone Radio Systems*
- *Microwave Radio Systems*

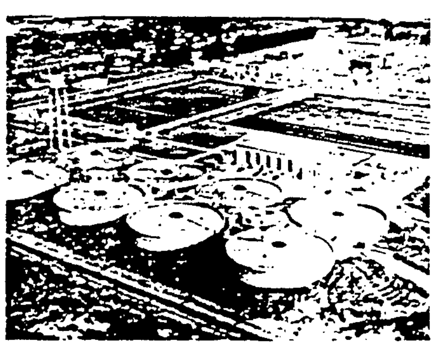
The SBC3 is offered in a number of different configurations to meet particular application needs. It has up to the following numbers of on-board inputs and outputs;

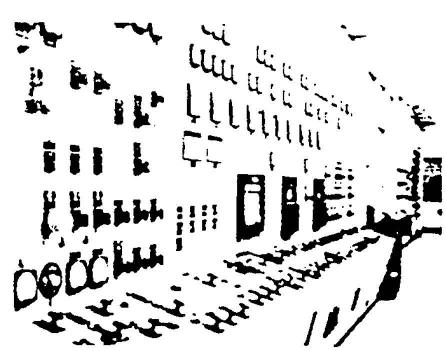
- *17-ON/OFF Status Inputs (including one High-speed Interrupt)*
- *9 - ON/OFF ¼ amp Control/Alarm Outputs (including one Watchdog/Alarm)*
- *8 - Analog (12-bit binary/4,096 count) Analog Inputs; six external 1-5 VDC or 4-20 mADC at terminals plus one on-board/committed DC battery voltage/AC line condition monitor and one broad-range temperature sensor*
- *48 - Expansion I/O lines at six 8-bit headers (for flat cable connection; 8-conductors plus 8-interleaved grounds) for use with the UCI Controller Interface and/ or any of the family of Consolidated CMZ I/O modules*

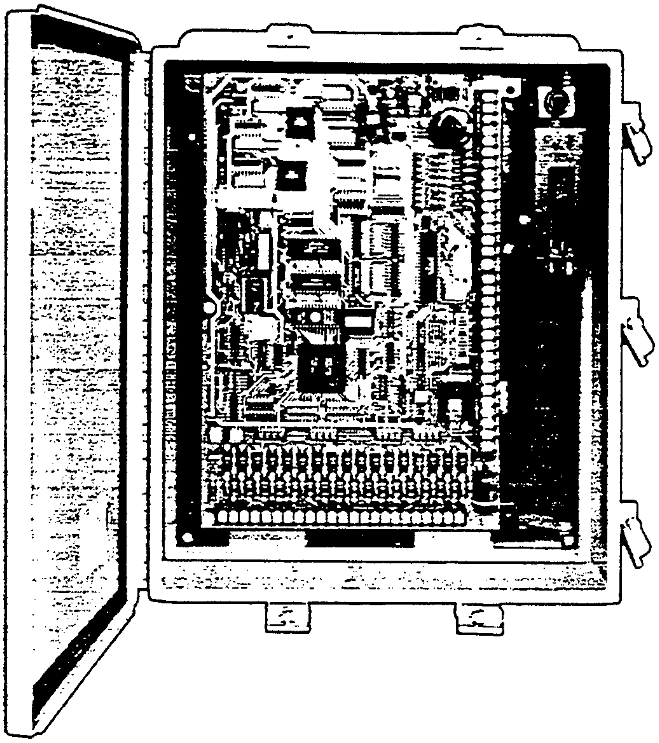


The front view of the SBC3 Single Board Computer.









An SBC3-based Bulletin E985 RTU shown with FM UHF radio in a NEMA 4, 16" x 14" x 6" housing.

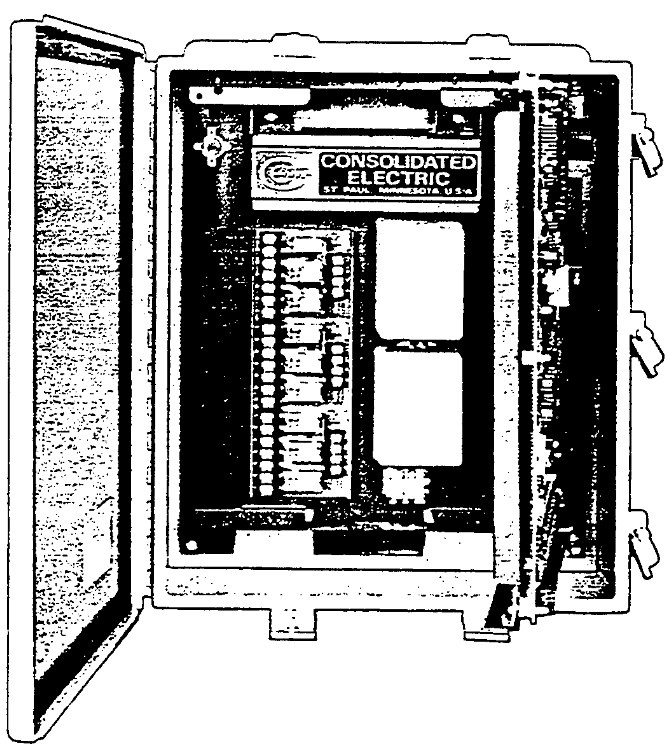
Each of the 17 ON/OFF Inputs and 9 Outputs has an on-board LED indicator. Inputs are activated by external switched or open-collector circuit connection to the I/O section Common (isolated from the processor section of the assembly). The high speed interrupt accepts pulses at up to a 40 pps rate. The nine output circuits each have an individual open-collector driver conservatively rated at 1/4 amp at up to 30 VDC.

The ninth ON/OFF output is controllable by the microprocessor (uP) but also by the on-board watchdog which continuously monitors meaningful activity. In the event of a cessation of activity the watchdog resets the uP and de-activates (with a continuing uP failure) the 9th output driver; thus indicating the occurrence of an abnormal condition. This output is available to operate an independent alarm system or a redundant control arrangement in a "failsafe control" application. It is typically used to operate a Monitor Relay having a form C (SPDT) load contact. An on-board switch also allows manual resetting of the processor.

The optional SBC3 Hinged Chassis mounts within a standard family of NEMA enclosures and provides mounting for the power supply terminals and fused switch, the 120 VAC line transient protection, one or two UL-approved class 2 transformers and a number of optional accessories on its back pan. The SBC3 itself mounts on a swing-out portion of the chassis. The CMK20 (dual) and CMK30 (triple) Load Relay Modules listed herein as optional accessories mount in a plastic track on the base of the SBC3 chassis. One or two tracks are available; an 8¼" long on the left and an 11" long on the right. The left track is available in most arrangements while the right track is disallowed if radio or phone line protective elements are mounted on the right. A full track of three (3) CMK30 modules on the left track accommodates eight (8) load control relays plus a monitor relay. This combination complements the nine (9) output drivers of the SBC3 and these relays can be driven by the SBC3 power system if the FM radio option is not furnished. If the radio and load relay options are both used an additional 12 VDC power supply is required.

All job connections are at barriered, wire clamp type, UL-recognized terminal blocks each accepting one or two AWG 14-22 wires. Discrete (ON/OFF) inputs and outputs have an independent on-board power supply, are optically-isolated (1500 volts), and designed to meet the IEEE 472-Surge Withstand Capability Standard requirements.

The SBC3 combines a high performance microprocessor with a powerful, event-driven, multi-tasking operating system well suited to communications/ process control data manipulation. CMOS construction gives a low power requirement and reliable performance under high noise/ temperature conditions.



The SBC3 shown with its swing-out chassis open to show the power connection terminal block, dual Class 2 power transformers, standby batteries and motor starter control and the monitor load relays.

Adequate on-board ROM and RAM (up to 128K bytes of ROM and 256K bytes of RAM) and efficient programs together with an 8-bit address and an 8-bit configuration switch and crystal-controlled real-time clock allow the SBC3 to respond to a broad range of demanding job requirements.

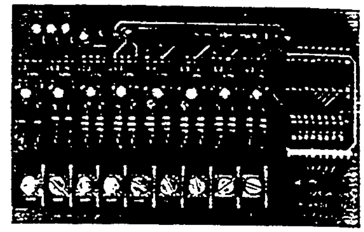
The SBC3 has dual serial ports with individually-programmable baud rates. Both are available at RS-232 levels at a header and one is jumper-selectable to alternatively operate a Bell 103-compatible, on-board, 300 bps FSK modem; suited for leased line or dial-up network connection and FCC Part 68 approved. Telephone connections are made at an RJ11 connector.

The SBC3 has an optional, socketed 4-character LCD alphanumeric display which can show static or scrolling messages as they are enabled by a particular software program and called up via the configuration switch set. Uses include display of pressures, levels, flow rates, temperature, logged values, communication failures and a broad range of diagnostic routines.

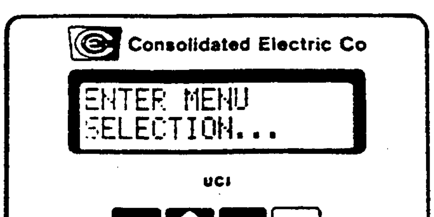
The SBC3 operates with one or two, off-board, UL-listed, class 2 isolation transformers having 120 VAC primaries.

It has dual/isolated on-board DC power supplies and optional off-board battery back-up systems for extensive continued operation under AC power failure conditions. AC/DC conversion, 12 VDC regulation and battery-charging elements are on-board.

The SBC3 Computer assembly itself is a compact 9" wide by 13.4" high by 1-1/2" deep. It can be furnished for panel-mounting in a low-profile format but is more often furnished on a hinged-chassis with overall dimensions of 14-3/4" high, 12-7/8" wide, 5-1/4" deep for installation in a NEMA type enclosure with nominal outside dimensions of 16" high, 14" wide, 6" deep (exclusive of the mounting feet). The hinged chassis assembly incorporates standard and optional elements including; an incoming AC power terminal block, a UL recognized fused control power switch, the class 2 transformers (for the uP system and the isolated I/O section), dual batteries, pilot circuit control load relays and a 1, 2 or 4 watt FM VHF/UHF radio and antenna connection/lightning arrester. All standard NEMA enclosure types and materials are available.



The CMZ27 Eight-Circuit, Optically-Coupled ON/OFF Interface Input Module. One of the extensive family of I/O modules available for use with the SBC3 expansion port headers.



The UCI Universal Operator Interface

SBC3 Standard Configurations

The SBC3 Single Board Computer is offered in five standard configurations of features with dash number designations as here listed. In addition to the variables listed, the Selectable Plug-in Elements, Mounting and Accessory Options and Standard or Custom Software Elements as also listed below or specified on a "per order" basis are applied to these assemblies to configure an RTU or Process Controller assembly best suited to a particular application.

The SBC3-01 assembly is the most complete of the five units having all of the possible fixed, on-board hardware elements in place. The other dash numbers differ from the -01 by having less capability as indicated in the chart.

MODEL	TYPICAL APPLICATION
SBC3-01	Complete Process Control/Communications
SBC3-02	16-Function Lift Station Monitor RTU
SBC3-03	Elevated Tank System Pressure Telemetry RTU
SBC3-04	Minimum ON/OFF Controller
SBC3-05	Pump Station Controller with Dual Analog

Variable Capabilities

Dash Number Designators	-01	-02	-03	-04	-05
Isolated ON/OFF Inputs	17	17	1	9	9
Isolated ON/OFF Outputs	9	1	1	5	5
On-board Analog Sensors; battery DC volts & temp	2	0	2	0	2
External Analog Inputs; 1-5 VDC or 4-20 mADC	6	0	2	0	2
Parallel Expansion Ports; 8-bit headers for CMZ mods	6	0	0	0	0
FSK Tone Leased Phone Line 300 BPS Modem	X	X	X	X	X
FCC-Reg., Bell 103-Comp. Auto-Dial/Answer Modem	X	X	X	X	X
Cable Interface at J1 Header for Optional FM Radio	X	X	X	X	X

Selectable Plug-In Elements

The following are optional components which will plug into the board but will not affect the build selection; only what is furnished with a particular job and plugged in prior to operation/test.

1. Four Character Alphanumeric LCD/LED Display
2. 82C55 Exp. Port Chips; One per 3 Ports
3. Real Time Clock
4. RAM chips; list for selection
5. Battery-backed RAM chip
6. EPROMs; As per job requirement

Mounting and Accessory Options

1. Hinged Chassis with power terminal block ON/OFF fused switch and class 2 power transformer.
2. Battery; 12 VDC, 1.5 AH Gelled Electrolyte for computer section.
3. Isolated I/O section power supply class 2 transformer.
4. Battery; 12 VDC, 1.5 AH Gelled Electrolyte for isolated I/O section.
5. CMM11 RS-485 Twisted Pair Network Modem. Snap-track mount. 3" x 4".
6. FM VHF/UHF 1/2/4 Watt Radio with RFI-shielding housing/lightning arrester/antenna connector.
7. CMK20 Load Relay Module; 2 relays with 10 Amp (resistive), form C contacts.
8. CMK30 Load Relay Module; 3 relays; 2 with form A, 1 with form C contacts.
9. Sealed, 3-element gas tube lightning arrester for use with leased phone line applications.

Standard SBC3 Communication Options

The four most-common communication options of the SBC3 are described here. Options 1 and 2 operate as standard at 300 bits per second in a half-duplex mode. The dual RS-232 modem outputs are each programmable to operate at any standard E.I.A. data transfer rate up to 18.2 KBPS. All accessing and communication is under uP/software control. Optional interfaces operate at higher speeds and in half or full-duplex modes.

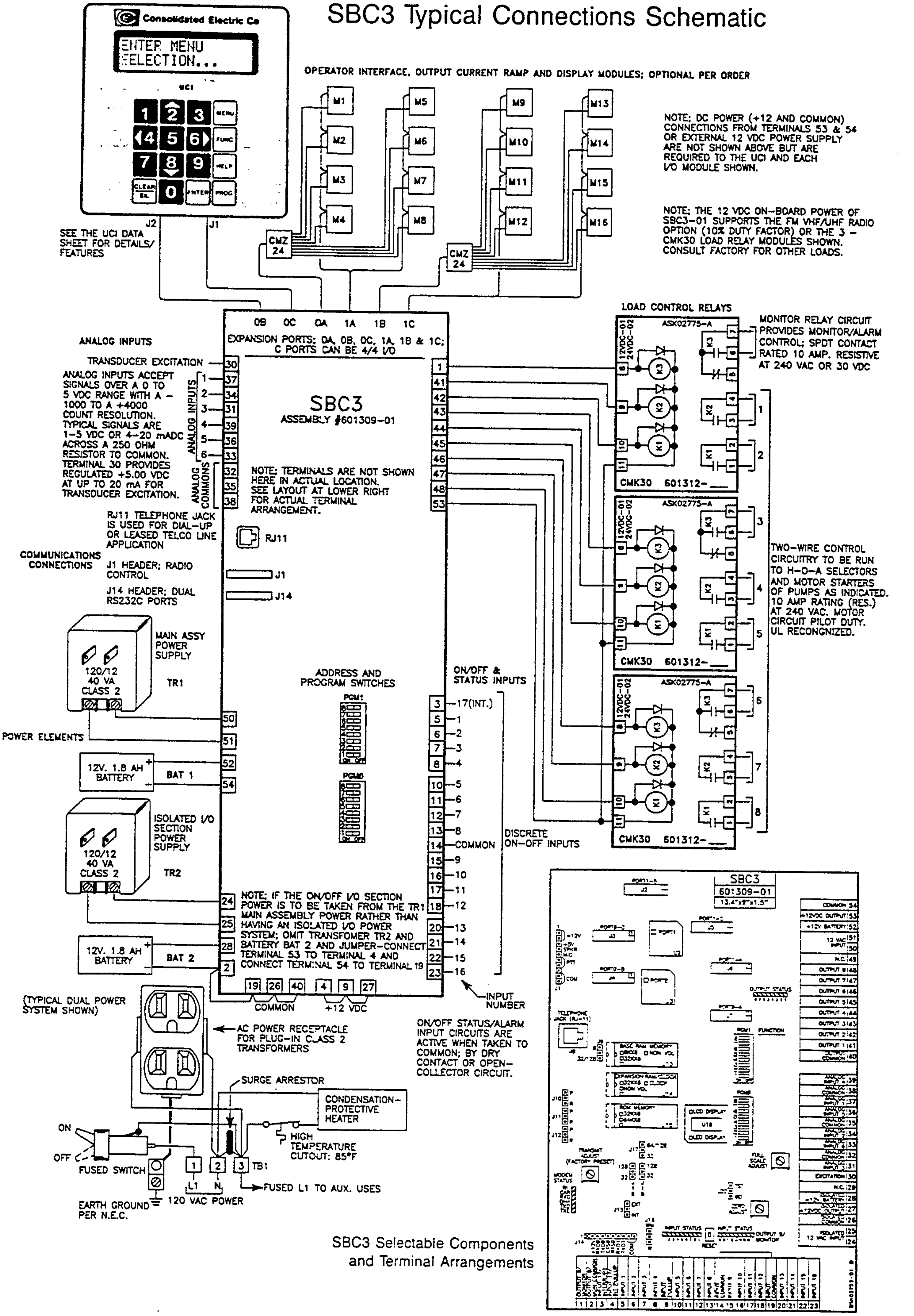
1. Voice-Grade #3001 Leased, Full-Time Telco Circuit. The telephone circuit connection and earth ground are brought to the three screw post terminals of a sealed 3-element lightning arrestor located on the lower right side of the SBC3 base chassis. An RJ11 plug/screw lug cable is furnished connecting the lightning arrestor to the RJ11 modem jack on the SBC3 computer assembly. The cable length is sufficient to allow hinging of the chassis and access to the transformers, batteries, load relays and power connections of the base chassis.

2. Dial-Up Telco Network. The FCC-registered (FCC Reg. #G8A3G2-17115-MD-R), on-board, Bell 103-compatible auto-dial (10 PPS pulse)/auto-answer modem of the SBC3 complies with part 68 of the FCC rules and is connected to the dial-up network using the RT11 jack of the SBC3 assembly. A 24" long cable with RJ11 plugs is furnished to allow connection from the SBC3 jack to the Telco jack to be located near the assembly.

3. RS485 Twisted Pair Local Area Network. The RS485 Short Haul Modem is snap-track mounted on the upper right side of the SBC3 back chassis and factory cable connected to the J14 header as an RS232 interfaced serial port zero. Twisted pair cable connections are made at the barriered, clamp type terminals of the CMM11 RS485 Modem. The twisted pair network can accommodate up to 16 units, distances of several miles and speeds of up to 9600 bps depending on system configuration.

4. FM VHF/UHF Radio. A variety of radios can be accommodated with the SBC3. The standard unit is housed in a die-cast, RFI-shielding aluminum housing and located in the upper right section of the SBC3 based chassis. It has a 1, 2 or 4 watt output with up to a 100% duty cycle. It is furnished with a lightning arrestor and BNC antenna cable connector for RG8/U cable. The cable connection faces downward to allow the recommended arrangement of having all connections and cable entrances to the SBC3 assembly at/from the bottom.

SBC3 Typical Connections Schematic



SBC3 Selectable Components and Terminal Arrangements

Expansion Port Cable-Connected I/O Modules

The SBC3 Expansions Ports are provided to give ON/OFF and analog I/O capability in excess of that provided by the single board SBC3-01 assembly. The ports are used with flat cable assemblies and the Consolidated CMZ Input/Output Modules Family. A selection of the more popular CMZ Modules is shown here.

CMZ20 Quad Input Analog-to-Binary Digital Conversion/Dual Control Output Module

Up to four 1-5 VDC or 4-20 mADC inputs. Screw terminal block (AWG #22-14). 12-bit binary conversion. Dual 16-conductor flat cable to module header 12 VDC power. 3" x 5½".

CMZ21 Analog-to-BCD Digital Conversion/Status Input Module

Single 1-5 VDC or 4-20 mADC input. 12 VDC power. Screw terminal block (AWG #22-14). Converts to 12 or 13-line BCD (0-99.9 or 0-199.9). Remaining 3 or 4 lines available for dry contact inputs. Analog manual mode switch and 20-turn pot, spanning (to 15% of input) offset (to 75%) and rate-of-change limiting ("quelling"). Two 16-conductor flat cables to module headers. 3" x 7".

CMZ22 Binary Digital-to-Analog (1-5 VDC or 4-20 mADC) Module

Single 16-conductor flat cable to module header. 7 or 8-bit (plus status line if 7-bit) from system. Low single-output resolution compliment to CMZ20 module; multiplexable. Screw terminals (AWG #22-14). 1-5 VDC output into 10K ohms (12 VDC power); 4-20 mADC output into 600 ohms (24 VDC power). 3" x 2¾".

CMZ24 Open-Collector (8) ½ Amp Outputs Module with LED Indicators

8-circuit, 12 VDC module power, open collector circuits will sink up to ½ amp each at up to 30 VDC with series resistors for incandescent lamp loads. Multiplexable. Screw terminals (AWG #22 to 14). 3" x 4". Single 16-conductor flat cable to module header.

CMZ25 BCD (12/13-line) Digital-to-Analog Output Module

Dual 16-conductor flat cable connections to module header. 12 or 13-line BCD is converted to 1-5 VDC (into 10K ohms or greater resistance) or 4-20 mADC (into 600 ohms or less load) output. Compliment to CMZ21 Input Module. 3 or 4 status lines have indicating LEDs and open collector outputs. Screw terminals (AWG #22-14). 3" x 4¼".

CMZ27 Opto-Isolated Inputs (8) Module with LED Indicators

Voltage inputs (12, 24 or 120) are optically isolated and provided with a common neutral connection and screw/clamp/barrier terminals accepting AWG #20-12 wiring. LED indicators show system inputs. Multiplexable. Module is 12 VDC powered. Single 16-conductor flat cable to module header. 4" x 5".

CMZ28 Dry Contact Isolated Inputs (8) Module with LED Indicators

8-circuit, 12 VDC-powered. Input circuits are powered by module and draw 15 mA each. Screw/clamp/barrier terminals accept AWG #20-12 wiring. LED indicators show system inputs. Multiplexable. Single 16-conductor flat cable to module header. 3" x 5".

CMZ30 Quad Load Relay Module with LED Indicators

Each relay has its SPDT silver-cad-oxide contact circuit brought to the screw/clamp/barrier terminal block sized for AWG #20-12 wiring. LED indicators show relay operation. Single 16-conductor flat cable to module header can be multi-dropped to drive two CMZ30 Modules. 12 VDC module power (30 mA load per relay). 3" x 5".

CMZ31 Pulse-Counting Input Module;16-Bit

For accepting pulses over a 0-1000 Hz range from flow transducers, remote telemetry systems or similar applications. 12 VDC powered. Input pulse shaping. Output latches hold upon command from uP to give valid data while counter continues to accept/count incoming signals. Auto roll-over when full. Multiplexable. Dual 16-conductor flat cables to module header plus Hold Command input. 3" x 4".

CMZ36 Data Latch Module

8-bit, 12 VDC powered module, provides multiplexed operation and opto-isolation of CMZ22 or CMZ25 analog output modules connected to it. The isolated CMZ22 or CMZ25 module requires an independent/isolated power supply.

DM4 or DM8 LED Display Module

For displaying status or alarm functions on the face of a control panel. Custom engraved legend plates correlate with each of 4 or 8 LEDs. 12 VDC power. Single 16-conductor flat cable to expansion header. 2⅞" wide x 5⅞" high.

MM114 4-Digit Numeric LED Display Module

For displaying analog values digitally up to 9999 count. ½" high numerals. Dual flat cable connected to expansion headers. 12 VDC power. Flush mounts on control panel face. 1-7/8" high x 3-3/4" wide.

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MB00429-688

Cat. File E10.0010

Consolidated Electric Bulletin D1000 Computer Based Systems have been designed with the user in mind. Operator interaction is accomplished through the use of CRT displayed "Menus" and questions, with keyboard-input responses. Within each D1000 system, an "Operation Menu" is the primary menu and is used to gain access to all Software Modules.

The Bulletin D1000 Software Module family is constantly being improved upon and added-to to meet the challenging requirements of today's Water, Wastewater and Industrial Process Applications.

A. Standard Hardware

The Consolidated Electric Bulletin D1000 System requires the following Computer Hardware configuration as a minimum:

A1. **Bulletin D1000, Model SBC3 Central Telemetry Module**
a) For communication with remote transceiver units (RTUs)
b) For local inputs/outputs

A2. **IBM PS-2 (2/386) -or- compatible microcomputer** with the following features:
a) 512 KB random access memory
b) 1.2 MB 5¼" floppy -or- 1.44 MB 3½" diskette drive
c) 40 MB or larger hard disk drive
d) 1 serial communications port
e) DOS release 3.0 or greater

A3. **Color Video Graphics Array (CVGA) Support**
a) Enhanced Graphics Adapter with memory expansion option to support 640 x 480 pixel graphics resolution in 16 colors

A4. **CVGA Color Monitor**
a) 14" (standard)
b) 20" (optional)

A5. **System Printer**
a) 9-pin dot matrix (standard)
b) 24-pin dot matrix (optional)
c) Color printer (optional)
d) Laser printer (optional)

A6. **Tape Backup Units** (optional)

A7. **Uninterruptable Power Supply (UPS)** (optional)

A8. **Operator Consoles and Enclosures** (optional)

A9. **System Graphic Display Panels** (optional)

B. Standard Software

B1. **Operator Access Security Codes.** This module is used to eliminate unauthorized system tampering and to monitor tasks performed.

Each operator's name is entered via the keyboard and assigned a 4-digit keyboard-configurable access code number. This access code number is also assigned a security level from 1-9, with the lower numbers assigned to low security menu items (silence alarms, maintenance tasks performed, etc.) and the higher numbers assigned to high security menu items (configure access codes, configure control and alarm setpoints, etc.).

B2. **Real-Time Calendar/Clock.** This is a standard hardware module with software support. This provides a keyboard-settable year/month/day/date/hour/minute/second calendar clock, with the clock displayed on the CRT screen.

This module is interactive with many of the software modules (alarm input date/time logging, information recall date, etc.).

B3. **System Graphic Displays.** With this module, tanks, pumps valves and other equipment can be graphically displayed similar to the actual piece of equipment in appearance and location.

Booster pumps are shown as concentric circles with line extensions to symbolize intake and discharge. Vertical Turbine Pumps are shown as capped rectangles with a descending line for intake. Valves are shown as a boxed "X" with a Rectangle to symbolize the actuator.

The following colors are used to depict status.
Green - Running or Open
Cyan (light blue) - Off or Closed
Yellow - Required
Magenta (red) - Failed or Alarm
Blue - Tank Level or Flow Rate

See Screen Display Printout - SK02332

B4. **System Control.** Custom system control is accomplished using several control sub-modules.

a) Soft H-O-A Switches. Software hand-off-automatic selector switches can operate equipment in "hand" from the keyboard or "auto" when called for by the software generated automatic control system setpoints. When used with the graphic display module, the H-O-A status will be shown with the associated equipment symbol.

See Screen Display Printout - SK02332

b) FOFO (First-On/First-Off) Alternators. FOFO automatic alternation can be provided to equalize the usage of several pumps of equal size. When a pump is required, the FOFO alternator calls for the pump which has been off the longest since the last operation and when the pumps have met the demand condition, the pump which will be shutoff first is the one which has been running the longest.

c) Control Matrix. The control matrix program consists of a matrix screen display with multiple stage inputs and multiple control outputs. Stage inputs typically come from the software generated analog differential setpoint control modules. Outputs typically go directly to pump or valve control circuits, automatic alternators, the G450 Alarm Annunciation Module or the P/C-M Maintenance Module.

See Screen Display Printout - SK02337

B5. **Analog Bargraphs and Setpoints.** This module displays an analog variable as a segmented bargraph display and is calibrated in engineering units with graphic and digital indication.

Keyboard-configurable control and alarm setpoints are also displayed both graphically and digitally adjacent to the analog display.

The differential setpoints are typically used to control pumps and valves (see system control) and the non-differential setpoints typically are alarm setpoints which in turn are provided as inputs to the G450 Alarm Annunciator Module.

See Screen Display Printout - SK02336

B6. **Analog Trending.** This module is basically a software chart recorder, showing the trend of the monitored analog (pressure, level, flow, speed, etc.) inputs. Each trend display can be based on a 24 hour, 7 or 30 day recall time frame. The display will be shown on the color monitor, and can be printed out on demand or the trending information can be transferred from the hard disc to the floppy disc for long term data storage and recall.

See Screen Display Trend Printouts

B7. **G450 Status Monitoring And Alarm Annunciation.** This module provides status monitoring and alarm annunciation upon an input change of state. Upon alarm activation or a status change, the keyboard-configurable English language description of the alarm or status condition complete with time and date, shall be 1) displayed on the monitor screen, 2) logged in system memory for future recall and 3) printed out on the printer for record keeping purposes. Simultaneously, the audible alarm horn shall sound for alarm conditions. Each input can be classified as a non-alarm (status) or alarm condition with an alarm priority level of 1 to 7 (the higher number being a more critical alarm). Separate notification systems; automatic telephone dialer, paging system, graphic display subsystems, etc., can be activated in response to each classification. Acknowledgment of an alarm condition is by entry of an operator access code, which is also entered into the system memory for recall purposes.

Typical status and alarm inputs include:

1) Power failure and return to normal (with any new alarms not present before power failure printed out)
2) Local and remote discrete inputs (status; pump run, pump off, switch open/closed, alarm abnormal level, flow, pressure, intruder entry, equipment failure, telephone system/data failure)
3) Local and remote analog (flow, pressure, level) inputs via bargraph alarm setpoints (see control module)
4) Maintenance task required from accumulated run time totalizer or system calendar clock (see P/C-M Module).

Alarms and acknowledgments can be recalled by alarm type, date or time. Status inputs can be recalled by date, time or input number.

B8. **Automatic Telephone Dialer with G450 Alarm Input Matrix.** This module can be used in conjunction with the G450 module to provide automatic telephone dialing with voice synthesized speech describing the particular alarm condition to the called party. The automatic telephone dialer can be programmed to call up to ten phone numbers in each of two (or more) directories. On-call personnel names and phone numbers, sequence of phone numbers to be called and dialer enable/disable switch are operator keyboard configurable.

An alarm dialer configuration screen display is provided to tie any G450 alarm input to any of the dialer channels. The dialer can contain as few as sixteen and as many as 1000 channels.

See Screen Display Printout SK02337

B9. **Accumulated Equipment Run Time Totalizer.** This module is used in conjunction with the G450 status monitoring function to provide accumulated run time totalization of non-alarm "equipment" status inputs to the G450 system. Accumulated equipment run time(s) are digitally represented on the CRT screen display and can be printed out on demand.

The assimilated equipment run time(s) can be transferred to the P/C-M preventative and corrective maintenance scheduling and record keeping software module if preventative maintenance is desired based on accumulated equipment run time(s).

B10. **P/C-M Preventative and Corrective Maintenance Scheduling and Record Keeping.** This module provides an equipment log and monitor for performance of preventative maintenance tasks. Each piece of equipment may have up to three (3) maintenance tasks. The desired maintenance intervals may be entered via the CRT terminal keyboard. The interval for each maintenance task may be selected on the basis of calendar time or actual equipment run time.

When a maintenance task is due, the computer will sound the sonalert and a message will be logged stating the required maintenance. Entering the "Silence" command will silence the sonalert. However, the operator must enter an acknowledgment via the keyboard along with the appropriate security code to acknowledgment the maintenance notification. The printer will then log the acknowledgment.

When a maintenance task is performed, the operator must enter into the computer a maintenance task completion message. This message shall be logged on the printer and in memory for a "tasks performed" recall which can be displayed on the screen and printed out as required. This entry shall reset the maintenance interval.

Additionally, a maintenance report can be printed out at a keyboard- settable time stating all required maintenance. This report will print out every day, adding new tasks as they come to their scheduled run/calendar intervals as entered. Items will be deleted from the list once the appropriate maintenance task completion message is entered.

B11. **Report Generation.** Provisions can be made for custom software to execute standard report forms. Wastewater Facility Monthly Operation Report (form 92-15-7) as required by the New York State Department of Environmental Conservation (NYDEC) is an existing module; EPA Form 3320-1, National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Report (DMR) is currently in development.

Reports can be generated based on automatically monitored or keyboard entered data. Calculations can be performed and information formatted to print out onto standard forms as required.

B12. **Power Conservation Load Reduction Module.** This module is under development to be used in conjunction with D1000 Control Systems. This module will include time-based keyboard- configurable setpoints for each piece of controlled equipment providing load shedding during peak power demand periods.

Additional power utility and alarm inputs to control the mode of operation as well as emergency override of the conservation modes can be provided.

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

HYDRAULIC ENGINEERING APPENDIX

HYDRAULIC ENGINEERING APPENDIX

1. Channels

The channels were designed to minimize costs and also to maintain the proposed conditions under operating and non-operating levels as close as possible to the existing water levels to minimize impacts on wetlands and groundwater. From Devils Lake to the drainage divide, channels with a bottom slope of 0.0001 were used. From the drainage divide to the Sheyenne River, the channel generally follows an existing coulee. A series of gabion drop structures helps lower the water into the Sheyenne River. The channels were designed to have non-erosive velocities, and riprap protection for the channel is not proposed. For both the downstream channel (drainage divide to Sheyenne River) and the intake (upstream) channel, the following assumptions were used in the design:

- USGS quadrangle maps (10-foot contours) were used to determine existing ground and surface water profiles along the diversions

- No HEC-2 models were developed, all design is based on normal depth computations

- A minimum bottom width of 10 feet was used for constructability reasons (30-foot bottom width for the downstream channel)

- Side slopes of 1-vertical-on-4-horizontal (1V:4H), with 1V:5H from the lake to Dam/Pump Station #1

The following assumptions were used for the downstream channel portions:

- The maximum allowable design velocity was 2.5 feet per second (fps) using a low Manning's "n" (roughness value) of 0.025. This maximum velocity is based on the soils in the area, because it was assumed that there might not be adequate vegetative cover. The channel would flow for long periods of time (up to 7 months each year), and it was assumed that this would kill any vegetation that had developed, leaving bare slopes.

- The high friction "n" value was obtained from Figure 7-14b of Chow's *Open Channel Hydraulics*. This curve is for high vegetal retardance. The high vegetal retardance curve was used because the channel would be unused and dry for long periods of time when Devil Lake was low (not requiring outlet operation) or the Sheyenne River was high (precluding outlet operation). This would allow development of heavy vegetation prior to resumption of outlet operation.

The channel slope for the downstream channel was computed using the above assumptions for maximum velocity and a 30-ft bottom width channel cross section. The bottom width was increased from the 10-foot width used for channels in the upstream portion of the outlet design to allow raising the bottom elevations. It was necessary to raise the bottom elevations to reduce the impact on groundwater and wetlands and to increase the stability of the channel side slopes. After the channel slopes were set by the maximum velocity criteria, the normal depths for the high friction case were determined. These normal depths were used to determine the elevation of the design bottom, which was set so that the normal design water surface would not exceed the natural ground elevation. Hydraulic data on the channel are shown in Figures 1 and 2 and the following table.

DOWNSTREAM CHANNEL HYDRAULIC PROPERTIES

DESIGN DISCHARGE	BOTTOM WIDTH	BOTTOM SLOPE	LOW n	DESIGN VELOCITY (low n)	HIGH n	NORMAL DEPTH (high n)
200 cfs	30 ft	0.0008	0.025	2.5 fps	0.065	3.7 ft

Besides the water pumped from Devils Lake, the channel also has to handle some of the existing local runoff to the coulee. By having the top of the excavated channel at about the existing ground elevation, most of the local runoff should flow above and outside the new channel. Basically, the proposed design is adding a maximum of 200 cfs to the existing coulee and also adding 200 cfs of channel capacity; therefore, the design should have minimal impact on local runoff.

The upstream channel (from Devils Lake to the Pump Station #1) was kept as flat as practicable to minimize excavation. The bottom slope used was 0.0001. A bottom width of 10 feet was used. Side slopes of 1V:5H were used for this channel for slope stability reasons. The channel between the Pump Stations #1 and #2 has a slope of 0.0001, a bottom width of 10 feet and 1V:4H side slopes. These channels were designed to insure that they would normally be submerged, and it was assumed that this submergence would prevent high vegetal retardance. Accordingly, a design "n" value of 0.035 was used. The normal depth for 200 cfs was then computed, and the channel bottom set that distance below the desired design water surface elevation. For the channel into Devils Lake, this was the design lake elevation. Hydraulic properties for the upstream channels are shown in the following table.

UPSTREAM CHANNEL HYDRAULIC PROPERTIES

DESIGN DISCHARGE	DESIGN VELOCITY	BOTTOM WIDTH	BOTTOM SLOPE	HIGH n	SIDE SLOPE	NORMAL DEPTH
200 cfs	1.0 fps	10 ft	0.0001	0.035	1V:3H	6.5 ft
200 cfs	1.0 fps	10 ft	0.0001	0.035	1V:4H	6.0 ft
200 cfs	0.9 fps	10 ft	0.0001	0.035	1V:5H	5.7 ft

2. Gabion Drop Structures

Drop structures are used to lower the flow to the Sheyenne River. The Sheyenne River valley is about 80 feet lower than the upland drainage divide, and the existing coulee is quite steep, with slopes of about 0.1 to 2.0 percent. However, the natural coulee that the outlet would follow has significant wetland portions which slow flow. A series of gabion drop structures are proposed to prevent excessive velocities and the need for riprap or concrete channels and to preserve as much as practical of the existing wetland character of the coulee. The channel slope between drop structures is the same as shown above under "channels." The height of each drop is 3 feet. The bottom width of the drop structures was set the same as the channel bottom width. The gabions at the crest of the drops will be grouted with concrete for protection. For this preliminary design, the locations of the nineteen drop structures were set by having a drop structure each time the design flood profile intersected the natural ground elevation. For the final design, the location of the drop structures may be modified to increase the ponding of water during normal conditions.

As a safety factor, the gabion drop structures were designed to be stable for a flow of 400 cfs rather than the design 200 cfs. The 400-cfs design accounts for the addition of some local inflow froom runoff events. The required stilling basin lengths are from the drop structure equations in *Open Channel Flow* by Henderson. The following table summarizes the data for the drop structures.

DROP STRUCTURE HYDRAULIC PROPERTIES

DESIGN DISCHARGE	STRUCTURE BOTTOM WIDTH	TAILWATER NORMAL DEPTH	DROP HEIGHT	BASIN LENGTH
200 cfs	30 ft	3.7 ft	3.0 ft	18 ft
400 cfs	30 ft	5.4 ft	3.0 ft	25 ft (proposed)

Due to the high salinity of Devils Lake water, there is a concern that metal wire gabions would be subject to corrosion. Therefore, the proposed gabions should be completely nonmetal.

3. Pump Stations

The diversion plan includes pumping the flow over the drainage divide between the Devils Lake drainage area and the Sheyenne River drainage area. The hydraulic design of the pump stations was only to the detail needed to do a preliminary cost estimate. The size of the pump stations is equal to the 200-cfs design discharge. It is anticipated that each pump station will have a minimum of four pumps. The static heads to pump against are given in the following table.

PUMP STATION HYDRAULIC PROPERTIES

PUMP STATION	DESIGN TAILWATER	DESIGN HEADWATER	STATIC HEAD
#1	1428-1445	1450	5-22 ft
#2	1450	1470	21 ft
#3	1470	1495	25 ft

Pump Stations #2 and #3 would pump into lakes or channels that will have the design operating level higher than the existing lake level. It is assumed that the lakes would be returned to their existing level during non-operating periods. The conduits from the pump station would go over the dam embankment and would have gates at their downstream end. When Devils Lake goes down, the conduits at Dams #1 and #2 would operate as siphons to lower the lakes along the diversion back to their normal levels. They could also be used as siphons in the event of a heavy rain while the diversion was operating to prevent the lakes along the diversion from bouncing too high. When Devils Lake hits the trigger elevation, Pump Stations #1 and #2 would be operated to fill the lakes along the diversion to their operating levels. Once the lakes are filled, Pump Station #3 would be operated according to the operating plan.

The speed of the diesel drive motor could be varied to vary the pumping rate. If later studies change the drive to electric, it would be more difficult to have a variable pumping rate. If this resulted in "step-function"-type operation, it could hinder the drawdown of Devils Lake. Pumping for the operating plan will be based on (1) Sheyenne River bank-full capacity and actual river flow and (2) the actual water quality of the Sheyenne River and Devils Lake.

The pool behind Dam #2 is 448 acres at elevation 1470 and will be allowed some bounce so that Pump Stations #1 and #2 can operate in an efficient manner. Operation would maintain Pool #1 (Twin Lakes (Sta 140+00)) at 1450. The normal lake stage for Twin Lakes is not known. The 1951 USGS quadrangle map shows it at elevation 1447, but there is a more recent estimate of 1455. During operation, Pool #2 would raise four unnamed lakes from station 163+00 to 317+00, north of Plainview School No. 2, to elevation 1470. The normal elevation of these lakes is unknown. Pool #2 would also maintain a fifth (southernmost) unnamed lake at 1470. The 1951 USGS quadrangle map shows this lake at elevation 1467; however, based on June 1996 photographs, this lake is estimated to presently be at 1475. Pool #3 would be a small (12-acre) impoundment at the top of the divide.

4. Road Crossings

Proposed road crossings were sized to have a 0.6-foot head loss at the design discharge. Losses are based free-surface flow. Expansion and contraction losses were computed for the free-surface flow using an expansion coefficient of 0.8 and a contraction coefficient of 0.6. The crown of the culverts were set about 2 feet higher than the water surface for freeboard. The results are shown in the following table.

ROAD CROSSING MINIMUM DIMENSIONS

DESIGN DISCHARGE	CROSSING SIZE
200 cfs	One 6 ft high-by-10 ft wide box culvert

5. Local Inflow

The peak inflows to the diversion from local rainfalls was computed using USGS regression equations. It was assumed the contributing drainage area was 50 percent of the total area for the 2- to 5-year floods, and 100 percent of the total area for the 100- and 500-year floods. After the drainage computations had been computed, Dam #2 was moved to about station 165+00. It was estimated that about half the drainage area from Devils Lake to station 230+00 would enter the outlet project between station 160+00 and 230+00. This makes the drainage area between station 160+00 and 370+00 about 27.1 + 27.3/2 = 40.8 square miles.

LOCAL INFLOWS

		PEAK DISCHARGE - CFS					
DIVERSION STATION	DRAINAGE AREA	2-YR	10-yr	25-yr	50-yr	100-yr	500-yr
LAKE to 230+00	27.3 sq mi	41	211	362	499	1045	1732
230+00 to 370+00	27.1 sq mi	41	210	361	497	1040	1724
370+00 to RIVER	58.1 sq mi	67	348	601	829	1737	2887
160+00 to 370+00	40.8 sq mi	53	275	474	654	1369	2273

6. Dams

Three dam embankments are proposed -- #1 at about station 74+00, #2 at station 160+00, and #3 at station 370+00. There is no significant storage behind Dams #1 and #3 during diversion operation, and their failure would pose little hazard; therefore, no emergency spillway was proposed for them. The top of Dams #1 and #3 is set 5 feet over the normal operating pool. Because these embankments are not considered hazardous, 3 feet of freeboard would be adequate. The extra 2 feet of freeboard should help contain any pool increases due to local inflow while the diversion is operating. Failure of Dam #2 would pose a safety risk and, therefore, a spillway is proposed. A significant amount of water (not computed at this time) would be stored behind Dam #2 at elevation 1470 during operation. The normal pool operating elevation lakeward of Dam #2 is 1450. The combination of significant storage and a 20-foot head would create a significant hazard if the embankment failed.

The emergency spillway for Dam #2 is designed for a local inflow 0.1-percent (1000-year) flood of 2750 cfs. The attenuation of the peak through the pool was not computed. The standard project flood (SPF) has not been computed. The 1000-year flood was obtained by extending the frequency curve found in paragraph 4 (assuming 100 percent of the drainage area is contributing -- station 165+00 to 370+00). The proposed spillway is a 100-foot wide uncontrolled concrete crest at elevation 1470. The computed head is about 4.0 feet, giving a surcharge pool of 1474. According to ER 1110-8-2(FR), 3 feet of freeboard is adequate, and the embankment was set at 1477. The spillway crest transitions to the 1V:2.5H embankment slope and follows that slope to the stilling basin. The velocity at the toe, assuming no friction loss, is 37.4 fps. The 27-foot length of the stilling basin is from Equation 7-1 of EM 1110-2-1603 using a K of 1.7. The stilling basin is at elevation 1451.5. The tailwater at the stilling basin for a flow of 2750 cfs was assumed to be 3 feet above the natural ground elevation of 1455.

7. Sheyenne River Channel Capacity

For this analysis the Sheyenne River capacity was assumed to be 500 cfs. There are current studies to refine this value, but they are not completed.

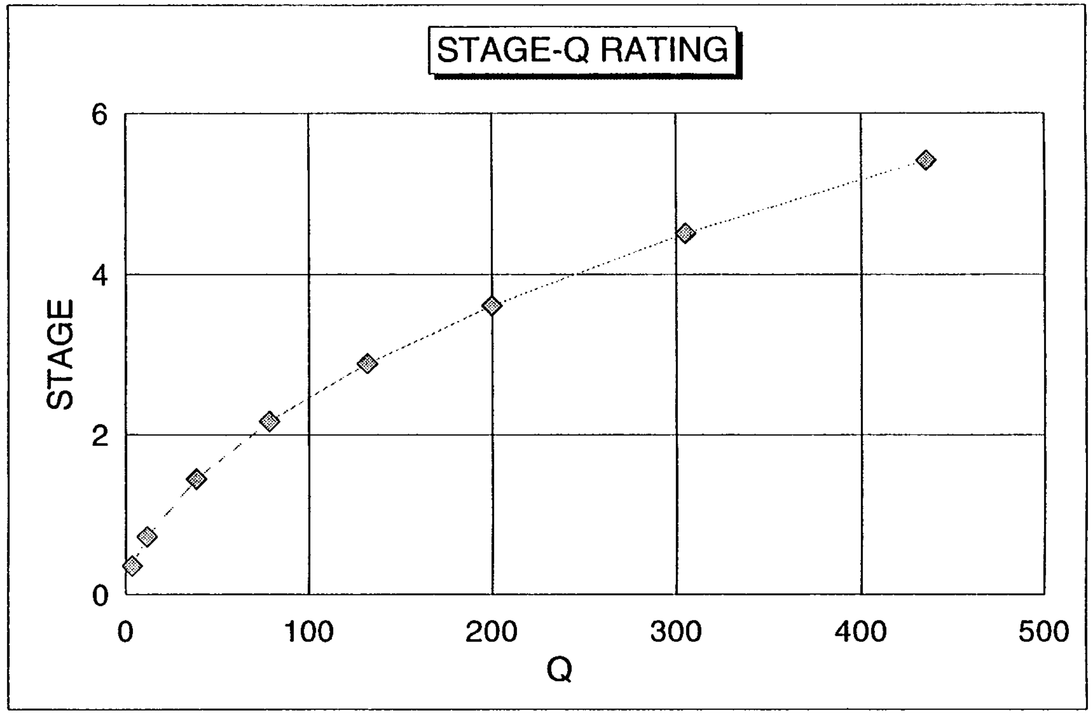
8. Diversion Design for 300 cfs

Ongoing studies indicate a lot of variability in Devils Lake and Sheyenne River sulfate concentrations. In addition, the bank-full channel capacity of the Sheyenne River might be greater than 500 cfs. This would allow higher outflows from Devils Lake. A sensitivity check was done for a 300-cfs design peak outflow rate. For 300 cfs, the 30-foot bottom width channel would be increased to 50 feet. The gabion drop structures would be widened the same amount. The length of the gabion structures was based on 400 cfs and was assumed to not change; however, the 6-foot-by-10-foot (minimum size) box culverts would be increased to two 6-foot-by-8-foot box culverts. A 10-foot-by-10-foot box culvert would have adequate capacity to handle a 300-cfs flow.

DEVILS LAKE-TWIN LAKES OUTLET-LOW ROUGHNESS
TRAPEZOID-RECTANGULAR CHANNEL NORMAL DEPTH
PAT FOLEY 24-Jun-96

ENTER:		
SIDE SLOPE=	4.0	(ENTER 0 FOR RECT)
SLOPE=	0.0008	
MANNINGS N=	0.065	
BOTTOM WIDTH=	30	FT
DISCHARGE=	200	CFS

COMPUTATION RESULTS	- NORMAL DEPTH	
AREA=	160.2	SQ FT
WETTED PERI=	59.7	FT
HYD RADIUS=	2.68	FT
VELOCITY=	1.2	
FR NUMBER=	0.13	
NORMAL DEPTH=	3.61	FT



HYDRAULIC DATA TABLE

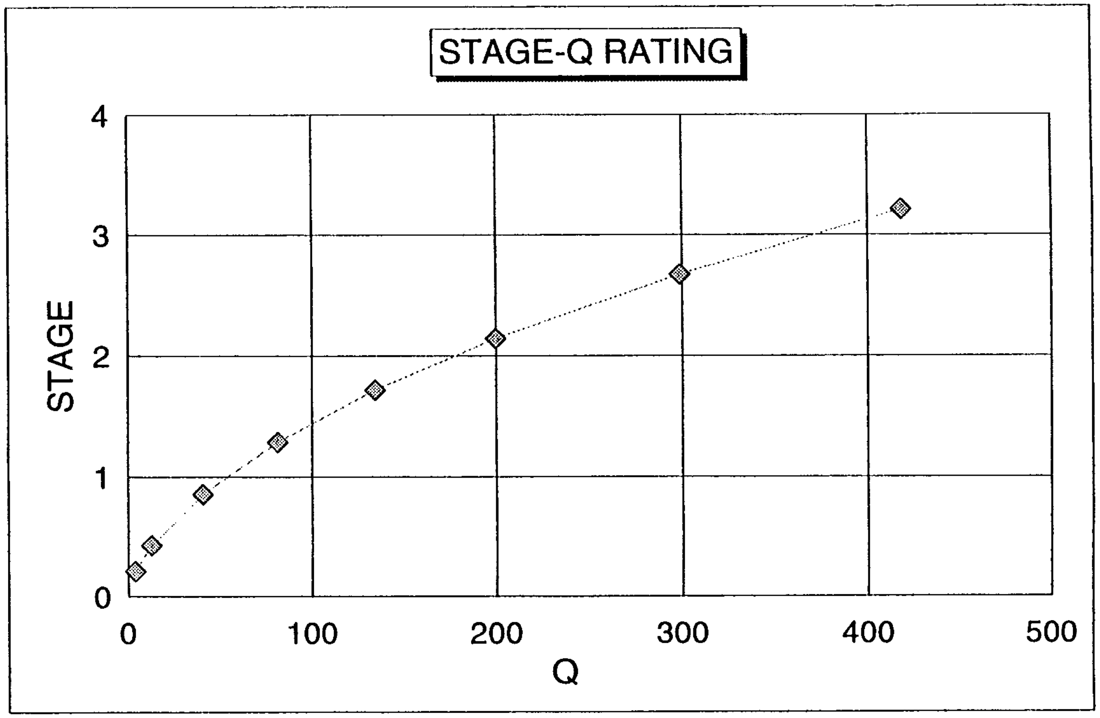
DEPTH	AREA	WETTED PER.	HYD RADIUS	DISCHARGE	VELO	FR NUM
0.36	11.3	33.0	0.34	4	0.3	0.10
0.72	23.7	35.9	0.66	12	0.5	0.11
1.44	51.6	41.9	1.23	38	0.7	0.12
2.16	83.6	47.8	1.75	78	0.9	0.12
2.89	119.9	53.8	2.23	132	1.1	0.13
3.61	160.2	59.7	2.68	200	1.2	0.13
4.51	216.5	67.2	3.22	305	1.4	0.14
5.41	279.4	74.6	3.74	435	1.6	0.14

Figure 1

DEVILS LAKE-TWIN LAKES OUTLET-LOW ROUGHNESS
TRAPEZOID-RECTANGULAR CHANNEL NORMAL DEPTH
PAT FOLEY 02-Jul-96

ENTER:		
SIDE SLOPE=	4.0	(ENTER 0 FOR RECT)
SLOPE=	0.0008	
MANNINGS N=	0.025	
BOTTOM WIDTH=	30	FT
DISCHARGE=	200	CFS

COMPUTATION RESULTS	- NORMAL DEPTH	
AREA=	82.5	SQ FT
WETTED PERI=	47.6	FT
HYD RADIUS=	1.73	FT
VELOCITY=	2.42	
FR NUMBER=	0.32	
NORMAL DEPTH=	2.14	FT



HYDRAULIC DATA TABLE

DEPTH	AREA	WETTED PER.	HYD RADIUS	DISCHARGE	VELO	FR NUM
0.21	6.6	31.8	0.21	4	0.6	0.23
0.43	13.6	33.5	0.40	12	0.9	0.25
0.86	28.6	37.1	0.77	40	1.4	0.28
1.28	45.1	40.6	1.11	81	1.8	0.30
1.71	63.1	44.1	1.43	135	2.1	0.31
2.14	82.5	47.6	1.73	200	2.4	0.32
2.67	108.8	52.1	2.09	299	2.7	0.33
3.21	137.5	56.5	2.43	418	3.0	0.34

Figure 2

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

REAL ESTATE APPENDIX

REAL ESTATE PLAN

(1) Project Name and Location

Devils Lake, North Dakota, Emergency Outlet Project. This project has a reach of approximately 13 miles from its intake channel at the southern tip of Devils Lake's West Bay to the confluence of its outlet channel with the Sheyenne River in Twin Tree Township, approximately 10 miles northeast of Sheyenne, North Dakota. This project is located on the Devils Lake Sioux Reservation.

(2) General Description of the Project

The project consists of channels, three dams with pump stations, three permanent accesses to the dams/pump stations, and ponding (temporary storage) areas behind the dams. All lands are located on the Devils Lake Sioux Reservation. Eight private ownership tracts, 15 allotment tracts, and 1 tribal tract have been tentatively identified by the attached drawing. Acreages and construction areas for the project were furnished by the Design Branch, St. Paul District, COE. The breakdown according to the various types of estates required per feature is as follows:

Item	Acres
Fee	7.5
Easement	
Permanent channel	85.0
Permanent flowage	270.0
Permanent access	24.0
Temporary work area	76.0
TOTAL	462.5

a. According to the approximate alignment, there are no federally-owned lands within the proposed project alignment. If the alignment were to move farther west, the US Fish and Wildlife Service (USFWS) owns S½SW¼ Sec. 21, T. 152 N., R. 66 W, in close proximity to Twin Lakes.

b. Devils Lake is not considered a navigable stream; therefore, no project lands are within the navigational servitude.

c. Assuming the local sponsor is a State of North Dakota agency, the local sponsor owns the lakebeds of all lakes in the State; however, the Spirit Lake Nation is contesting this ownership on reservation lands.

(3) Indication of the Number and Cost of Public Law 91-646 Relocations to be Accomplished within Project

Given the preliminary nature of the drawing furnished to the Real Estate Division, St. Paul District, COE, and the fact that no specific project alignment has been provided, no comment can be made on the likelihood of P.L. 91-646 relocations being required within the project area. At present, none have been identified.

(4) Assessment of Sponsor's Land Acquisition Experience

a. Assuming the State agency that would serve as local sponsor is the ND State Water Commission (NDSWC), this local sponsor's land acquisition experience is typical of that of other State entities. The sponsor has quick take authority and a working knowledge of the proper procedures to be followed pursuant to Public Law 91-646, as amended. The Real Estate Division would provide the guidance and assistance that the sponsor requires to complete this project.

b. The acquisition of allotment and Tribal lands will require coordination with the Bureau of Indian Affairs (BIA) for making offers and closings. The negotiations can be conducted with the allottees and are considered settled upon agreement of 51 percent of the allottees for each tract. These allotment ownerships can contain numerous percentages of ownership requiring negotiations with more than one or two landowners. The Tribal Council must meet and approve any conveyance of Tribal lands. For those tracts which are allotment lands being condemned, the Corps will complete these acquisitions as will be provided for in the Project Cooperation Agreement (PCA). Specific Congressional approval is needed to condemn Tribal lands.

c. Additional discussion of ownership types and real estate procedures is provided in Exhibit A -- Devils Lake Real Estate -- which is attached.

(5) Baseline Cost Estimate

The baseline cost estimate is $293,000.

(6) Project Map

The attached map is very preliminary in nature and was furnished to the Real Estate Division on 20 June 1996. It gives only a broad general overview of the real estate which will be required for this project. COE regulations require that right-of-way drawings capable of defining each specific legal description of a parcel required for project construction, operation, and maintenance be provided to the Real Estate Division for proper project definition/acquisition.

(7) Present or Anticipated Mineral Activity in Project Area

At present, no data have been furnished to the Real Estate Division providing any means of defining mineral deposits which may be located within or adjacent to the proposed project.

(8) Discussion Regarding the Use of Proposed Non-Standard Estimates

Based upon discussions with the COE Project Manager, we do not anticipate the use of any non-standard estates. If the use of a non-standard estate is contemplated, it will be forwarded to Real Estate, COE Headquarters (CERE-AP), for approval under separate cover prior to acquisition by the local sponsor or COE.

(9) Schedule for Real Estate Acquisition

A project schedule has not been determined; therefore, a schedule for real estate acquisition cannot be established at this time. A minimum 1-year timetable from PCA signing to Real Estate Certification is required.

(10) Facilities to be Relocated

As of this date the Real Estate Division has not been provided with sufficient information to determine whether there will be any relocations which fall within Real Estate Division purview or within Project Manager purview. An Attorney's Opinion of Compensability will be submitted when final plans showing the need for relocations are available.

(11) Landowner Attitude

The landowners within the project area by-and-large want this project to be completed as soon as possible.

(12) Additional Comments

a. Suitable borrow sites have been identified and will be addressed in more detail at a later date. It is anticipated that borrow material will be purchased as part of the construction contract.

b. The tentative nature of the preliminary cost estimate furnished in this document is herein underscored again. No final alignment for the subject project has yet been provided to the Real Estate Division, and the only drawing provided to the Division is attached. Therefore, no bona fide real estate cost estimate can be accomplished. The baseline number given is based on limited information.

c. The 1936 Flood Control Act established three major prerequisites of a local sponsor. The sponsor must (1) provide the lands, easements, and rights-of-way needed to build the project; (2) pledge to perform operation and maintenance of the constructed facilities for the anticipated life of the project; and (3) agree to indemnify and hold the United States Government harmless from any and all claims or damages resulting from construction, operation, and maintenance of the project. While the NDSWC can very capably acquire the real estate and perform project operations and maintenance, the ability to indemnify the United States is contravened by Article 1, Section 9 of the North Dakota Constitution. In 1995, the North Dakota legislature passed legislation which created an interim limited waiver of sovereign immunity for State agencies. This waiver remains effective only through 31 July 1997 and limits the State's liability exposure to $750,000 per occurrence. During the 1996 election, the citizens of North Dakota will vote on a referendum to reestablish the State's sovereign immunity. Regardless of the outcome of this referendum, there is inadequate indemnification as required by the 1936 Flood Control Act. If the NDSWC does become the local sponsor for this project, it will be incumbent upon the North Dakota legislature to pass specific language waiving the State's sovereign immunity for this project in order for the project to proceed.

EXHIBIT A

DEVILS LAKE REAL ESTATE

All of lands involved in project construction lie within the Devils Lake Sioux Reservation. There are three types of ownerships on potential project lands -- fee lands (Indian and non-Indian with Trust restrictions removed), tribal lands, and Indian allotment lands.

FEE LANDS

There are no restrictions on the non-Federal Sponsor (assumed to be the North Dakota State Water Commission) in obtaining fee or lesser estates (channel, flowage, levee, access, and work easements) from these individuals. Failing agreement on acquisition of the interests, the Sponsor can exercise its power of eminent domain and condemn the lands by payment of just compensation.

TRIBAL LANDS

Tribal lands within Reservations were created by treaty or Executive Order which withdrew the lands from public domain to be placed into Reservation status. The designation of a Reservation carries with it no fee title to the lands, but merely a right of the tribe to use and occupy the land on a communal basis. Fee ownership remains in the Federal Government subject to a Trust relationship between the Government and tribe. However, once designated a Reservation, Indian occupation is considered sacred and cannot be interfered with except by the Government. The Trust relationship between the Government and Indians is to insure that no improvident alienation of tribal lands occurs. Tribes may form governments and regulate the tribe's use and occupation of the lands. The Spirit Lake Nation is governed by a Tribal Council.

Discussions with BIA real estate personnel for the Spirit Lake Nation indicated that the procedure for acquisition of a real estate interest (including easements and a license for survey purposes) in tribal lands involves approaching the Tribal Council with the proposal. The Tribal Council has the authority to enter into real estate transactions for estates less than fee interests; fee title resides with the Federal Government. The BIA approves the form of conveyance, and the Secretary of Interior approves the transaction. President Clinton's Memorandum for the Heads of Executive Departments and Agencies, dated April 29, 1994, requires that tribal governments be consulted with regard to Executive Branch activities having an impact on tribes and that negotiations be conducted on a government-to-government basis.

If the Tribal Council does not agree to the transaction or if the interest required is fee, either an outright Congressional conveyance of the interest or Congressional approval of condemnation of the interest is required. Condemnation would have to be initiated by the Federal Government and the tribe paid just compensation for the taking.

ALLOTMENT LANDS

After passage of the General Allotment Act (25 USCS 334), individual tribal members were encouraged to occupy specific tracts of public domain land or Reservation land and be awarded an allotment of the tract. Tract allotment was followed by the issuance of a patent covering the tract. A patent established certain beneficial use rights in the allotted tract to the individual tribal members. The patents granted to individual Indian allottees, however, retained fee title in the Government subject to Trust provisions for the protection of the individual allottee. Those Trust reservations were initially for a period of years (25 in most cases), but have been extended. The result is that individual allottees cannot alienate their lands without Government (BIA) approval.

To acquire interests in allotment land, the Sponsor would obtain ownership lists from the BIA showing the individual allottees from whom interests are to be acquired. The Sponsor can negotiate acquisition of the estate needed up to and including fee acquisition. The BIA would approve both the form of the conveyance of the estate and approve the alienation of fee or lesser estate in its capacity as trustee/fiduciary for the allottee.

25 CFR Section 169 et seq. (which implements 25 USC 323) provides that the Secretary of Interior has authority to grant rights-of-way (presumably including easements of the types that would be required for the emergency outlet project) and licenses to conduct surveys without approval of individual allottees if (1) the allottee is incompetent; (2) the tract is owned by multiple owners, a majority of whom agree to the grant; (3) the owner's whereabouts are unknown; (4) the allottee is deceased and heirship has not been determined; or (5) ownership is so numerous that the Secretary determines joinder of all owners is too burdensome.

Failing a negotiated acquisition of an estate with the individual allottee(s) and the BIA as trustee, or acquisition of easements from the BIA without allottee approval, condemnation must be initiated by the Federal Government in Federal Court. That process is time consuming and would likely require at least 6 months from the date the decision was made that condemnation would be necessary.

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

EFFECTIVENESS APPENDIX

EFFECTIVENESS APPENDIX

INTRODUCTION

Two analyses were conducted to show the effectiveness of an outlet from Devils Lake to the Sheyenne River. One method involved a pumped-flow duration analysis; the second involved a 10-year simulation from 1 October 1985 to 30 September 1995 assuming the outlet was operational. Additional sensitivity simulations were done for two alternative pump capacities and for one alternative bank-full channel capacity.

PUMPED FLOW DURATION

The pumped flow duration analysis was done by first determining the flow duration relationship for the Sheyenne River at the proposed outlet insertion point to the river. Discharges for the Sheyenne River were based on flows measured at the U.S. Geological Survey (USGS) gage at Warwick, ND (No. 05056000). This is a continuous recording station with a period of record from October 1949 to present. The contributing drainage area at this gage is approximately 760 square miles. The drainage area at the outlet insertion point is estimated at 645 square miles. Therefore, flows recorded at Warwick were reduced by the ratio of the drainage areas (0.85). **Figure 1** shows the flow duration curve of the Sheyenne River at the discharge point based on mean daily flows.

Pumped flows to the Sheyenne River are constrained by two variables: Sheyenne River bank-full channel capacity and water quality. The most restrictive water quality parameter is assumed to be sulfate (SO_4) and, therefore, this parameter was adopted as the key index for meeting water quality standards on the Sheyenne River. The State standard for sulfate is 450 mg/l. Criteria for releases from Devils Lake were simulated as if the Lake was a reservoir operating for a downstream control point so as not to exceed downstream bank-full capacity and SO_4 concentrations. The criteria for releases were based on SO_4 being a conservative parameter (i.e., nondecaying) and, therefore, mixing from the higher concentration of SO_4 from Devils Lake can be based on the following mass balance equation:

(Equation 1)

$$(Q_S C_S + Q_D C_D) / (Q_S + Q_D) = 450\ mg/l$$

where: Q_s = Discharge Sheyenne River (cfs)
C_s = Sulfate concentration Sheyenne River (mg/l)
Q_D = Discharge Devils Lake (cfs)
C_D = Sulfate concentration Devils Lake (mg/l)

Knowing the SO_4 concentration for the Sheyenne River and Devils Lake and the flow on the Sheyenne River, the allowable release from Devils Lake that will not exceed the SO_4 standard for the Sheyenne River can be determined by solving the above equation for Q_D. **Figure 2** shows possible Devils Lake releases as a function of flow on the Sheyenne River for various SO_4 concentrations and bank-full capacities.

The maximum release from Devils lake is the minimum value of the two constraining variables (i.e., SO_4 or bank-full capacity). Therefore, when Devils Lake is experiencing typical (say, 800 mg/l) sulfate concentrations, under low-flow conditions on the Sheyenne River, releases are restricted by water quality because the river flow provides only limited dilution. Alternatively, for high-flow conditions on the Sheyenne River, Devils Lake releases are restricted by the bank-full channel capacity to avoid downstream flooding. Conversely, when Devils Lake is experiencing non-typical (say, 400 mg/l) sulfate concentrations (such as during the current historic high lake levels), dilution is not a factor, and releases are restricted solely by bank-full capacity under low- or high-flow conditions on the river.

The above relation was also used as a basis for the primary operational criterion for the 10-year simulation described later in this report.

Using the river flow-duration curve presented in **Figure 1**, and the relation presented in **Figure 2** and **Equation 1**, **Figure 3** was developed as an aid for converting the river flow-duration curve to an outlet release-duration curve. That is accomplished by adjusting the river flow-duration curve to reflect the reduced amount of time available for releases during high flows.

To illustrate this concept with an example, it is assumed that the Sheyenne River's SO_4 concentration is 100 mg/l and bank-full capacity of 500 cfs. Devils Lake's SO_4 concentration is assumed to be 800 mg/l. Based on **Equation 1**, during low flows on the Sheyenne, river flow could dilute an equal volume of outlet outflow to satisfy the 450 mg/l standard. Therefore, no adjustment in the flow duration curve is required for low flows (i.e., flows less than 250 cfs).

For high flows, the duration percentages would be reduced by the percentages defined by the shaded portion of **Figure 3**. The shaded portion was developed as follows: Given the sulfate and bank-full capacity assumptions made above, the maximum outlet release rate would be 250 cfs corresponding to a river flow of 250 cfs. Figure 1 shows that river flows equal or exceed 250 cfs 5 percent of the time. However, outlet releases could exceed 250 cfs 0 percent of the time. Therefore, this point of the release-duration curve is derived by reducing the 250-cfs river flow-duration percentage by 5 percent (5 percent - 5 percent = 0 percent).

The minimum release rate would be 0 cfs corresponding to a river flow of 500 cfs. Figure 1 shows that river flows equal or exceed 500 cfs approximately 2 percent of the time. Therefore, this point of the release-duration curve is derived by reducing the corresponding 0-cfs river flow-duration percentage by 2 percent (100 percent - 2 percent = 98 percent). This high-flow adjustment reflects the percent of time that one could not make releases because the river flow equals or exceeds 500 cfs.

Intermediate points on the release-duration curve are developed in a similar fashion.

Figure 4 shows the resulting outlet release-flow duration curve for the specified conditions. By integrating the area under this curve, the average annual release is calculated at approximately 30 cfs. This does not account for additional restrictions because of seasonality (i.e., outlet operation is assumed to cease during the winter), nor does it account for times when releases are not needed due to a lower lake level. Therefore, the actual average annual release would be expected to be somewhat less than 30 cfs.

Figures 5 and **6** show similar adjustments for an alternate set of constraining conditions: Sulfate concentrations for Devils Lake and the Sheyenne River are assumed to be 600 mg/l and 100 mg/l, respectively, and bank-full channel capacity is assumed to be 600 cfs. Based on **Equation 1**, the corresponding release from Devils Lake would be 2.33 times the river flow up to bank-full capacity. To develop the water quality-constrained portion of the release-duration curve, one would adjust river flow-duration curve ordinates (i.e., river flow values) by multiplying them by 2.33 up to the point where the total of river flow plus release flow equals the assumed 600-cfs bank-full capacity (i.e., 180 cfs river flow plus 420 cfs release flow).

The channel capacity-constrained portion of the release-duration curve is developed as follows: Outlet releases could exceed 420 cfs 0 percent of the time. This point of the release-duration curve is derived by reducing the 420-cfs release-duration (i.e., adjusted river flow-duration) percentage by 7 percent (see **Figure 1** and **Figure 5**'s inverted triangles or **Figure 6**'s squares), i.e., 7 percent - 7 percent = 0 percent.

The minimum release rate would be 0 cfs corresponding to a river flow of 600 cfs. **Figure 6** (squares) shows that river flows equal or exceed 600 cfs approximately 1.6 percent of the time. Therefore, this point of the release-duration curve is derived by reducing the corresponding 0-cfs river flow-duration percentage by 1.6 percent (100 percent - 1.6 percent = 98.4 percent). This high-flow adjustment reflects the percent of time that one could not make releases because the river flow equals or exceeds 600 cfs.

Intermediate points on the release-duration curve are developed in a similar fashion. **Figure 7** shows the resulting release-flow duration curve for the specified conditions. The average annual flow that could be released is approximately 70 cfs.

10-YEAR SIMULATION

The second method used to evaluate the effectiveness of an outlet from Devils Lake to the Sheyenne River was the simulation of the last 10 years with and without the proposed project. The actual period of simulation extended from 1 October 1985 to 30 September 1995 based on a daily time interval. To reconstruct inflows during this period a simple mass balance was done based on the following equation:

(Equation 2)

$$\Delta S = I - E + P$$

or

(Equation 3)

$$S_2 - S_1 = I - E + P$$

Where: S_2 = Storage at the end of the period
S_1 = Storage at the beginning of the period
I = Inflow volume during the period
E = Evaporation volume during the period
P = Precipitation volume during the period

By knowing S_2, S_1, and E, one can solve for I. Net evaporation is the difference between precipitation and evaporation on the lake. Actual precipitation and evaporation estimates were not used in the mass balance; instead, average values for the period of record were used. The difference between the actual values and average values are accounted for in the calculated inflows. This was not considered a problem as long as the calculated inflows were used with the corresponding average estimates of net evaporation in the simulation model because the differences between with- and without-project storage are due to releases. Because inflow estimates were made in this way, some inflow values are negative. The inflow estimates also include residuals, such as groundwater seepage or errors in estimates.

Table 1 shows the average net lake losses.

TABLE 1
AVERAGE NET LAKE LOSS

MONTH	Average Gross Lake Evaporation (inches)	Average Precipitation (inches)	Average Net Lake Loss (inches)
January	0.16	0.76	-0.60
February	0.22	0.48	-0.26
March	0.62	0.97	-0.35
April	1.50	1.35	+0.15
May	3.00	2.45	+0.55
June	4.00	3.05	+0.95
July	4.90	2.98	+1.92
August	6.00	2.80	+3.20
September	4.50	2.13	+2.37
October	2.70	1.22	+1.48
November	0.75	0.85	-0.10
December	0.23	0.66	-0.43

Precipitation estimates were based on long-term monthly averages from climatological records at Langdon, ND. Evaporation estimates were based on "Evaporation from Lakes and Reservoirs," by Adolph F. Meyer.

Once inflows were estimated, they were plugged into the outlet release model for Devils Lake along with the corresponding net evaporation rates.

The 10-year daily sulfate concentration series for Devils Lake (West Bay) was constructed based on sulfate and specific conductance measurements by the USGS and the North Dakota Department of Health and Consolidated Laboratories. Conductivity data and the relationship between sulfate and conductivity (sulfate = 0.4255 x conductance - 251) were used as the basis for the 10-year time series. Daily values were computed by linear interpolation between monitored values.

The 10-year daily sulfate concentration series for the Sheyenne River at Warwick was constructed based on sulfate and specific conductance measurements by the USGS. One of two equations was used to predict sulfate concentration from specific conductance depending on whether conductance was greater or less than 555 μsiemens/cm (sulfate = 0.115 x conductance or sulfate = 0.190 x conductance - 44, respectively). Daily values were computed by linear interpolation between monitored values.

The outlet release model simply calculated the flow that could be pumped to the Sheyenne River. It began with a known storage as of 1 October 1985. The mass balance equation used in this model is as follows:

(Equation 4)

$$\Delta S = I - E - O$$

where: S = Change in storage
I = Inflow volume during the period
E = Evaporation volume during the period
O = Outflow volume from Devils Lake due to releases

Outflow from Devils Lake was determined from **Equation 1** and other criteria such as available channel capacity. The decision order is as follows:

1. Pump if Devils Lake is above the trigger elevation (1428.0).
2. Determine the maximum volume to pump based solely on dilution (**Equation 1**).
3. Determine the maximum volume to pump based solely on available channel capacity.
4. Pump the minimum volume of steps 2 & 3.
5. If the date is in December, January, February, March, or April, do not pump.
6. If calculated release flow exceeds outlet peak capacity; release at peak capacity.

Evaporation is an important part of the sequential analysis, and the volume of evaporated water depends upon the surface area of the reservoir, which is a function of storage. Average storage during the period was not computed to determine the average surface area; instead, the actual storage/area for the period was used. Because of the large surface area of the lake, any period (day) area and corresponding volume is essentially identical to the next period (day) and, therefore, not very sensitive to a change in storage. The cumulative error is considered to be negligible.

Figure 8 shows the number of days of releases at various rates greater than 5 cfs for an unlimited peak outlet capacity and assumed channel capacity of 500 cfs. There were 3,117 days that releases were equal to or less than 5 cfs. **Figure 9** shows similar information for an assumed channel capacity of 600 cfs.

These figures show that if a maximum pump capacity of 200 cfs was chosen most of the releases would occur at rates lower than 200 cfs. Ordinarily, releases would not occur very often at the higher rates reflected in **Figures 4** and **7**. This is primarily a function of the low sulfate concentration at the end of the simulation period when the lake was very high and sulfate was diluted below 500 mg/l. This is best viewed in **Figure 10** which shows the SO_4 concentration history superimposed with lake level history. The SO_4 concentrations were very high (above 1500 mg/l) earlier in the simulation and did not fall below 1000 mg/l until 1992. When the lake water is diluted, it reduces or avoids having the river's sulfate standard being the limiting constraint to releases during low Sheyenne River flows.

Sensitivity simulations were made assuming various channel capacities for the Sheyenne River and maximum pump capacities. **Table 2** lists the elevation reduction and volume pumped as of 30 September 1995, and **Figure 11** shows the elevation reduction as a function of outlet design peak capacity.

TABLE 2
ELEVATION AND VOLUME PUMPED

Channel Capacity (cfs)	Pump Capacity (cfs)	Elevation (feet)	Elevation Reduction (feet)	Volume Pumped (ac-ft)	Average Release Rate (cfs)
500	200	34.00	1.09	80,632	11
500	300	33.71	1.38	100,385	14
500	458[a]	33.44	1.65	119,478	16
600	200	33.98	1.11	81,509	11
600	300	33.65	1.44	104,788	14
600	557[a]	33.12	1.97	141,899	20

[a] Maximum release based on water quality and bank-full channel capacity constraints.

Figures 12 to 17a show the with- and without-project lake elevation "histories" over the entire 10-year period and focusing on 1994-1995. The end result on 30 September 1995 is a reduction in elevations ranging from of 1.09 to 1.97 feet depending on the specified condition. Further reductions in lake level would be achieved had the simulations continued beyond 30 September 1995; however, that flow information on the Sheyenne River has not been published. The value of the pump however is to stem the long term increase in lake level rather than to negate any immediate "flood event."

Figures 18 to 23 show the outflow "histories." A near constant rate of releases at 200 cfs and 300 cfs occurs in 1995 for design peak capacities of 200 and 300 respectively.

Figures 24 to 29 show the effect of these releases on the Sheyenne River in terms of discharge. Significant additions were made near the end of the simulation period. The released flow did not add to the peak discharge on the Sheyenne River nor did the Sheyenne River exceed channel capacity when releases were occurring.

The corresponding impact on the Sheyenne River SO_4 concentrations is shown in **Figures 30 to 35.** The graphs clearly show that when releases were occurring, the SO_4 reached the 450 mg/l standard. However, during this 10-year period this did not occur very often. It would be projected to continue until the lake receded to its trigger elevation of 1428 or during winter periods when releases are not scheduled.

Another important impact of releases from Devils Lake is that the volume lost due to these releases will be felt long into the future when this volume could be used as a buffer to low lake levels during a future drought. This effect would increase cumulatively with each ac-ft released from Devils Lake. Only an inlet to the lake would mitigate this effect by replacing the lost water during lower lake levels.

The above simulations showed that, in 1987 and 1994, when the lake's SO_4 concentration was high, operation was severely restricted by the Sheyenne River's 450-mg/l SO_4 standard. Conversely, in 1995, as the lake level continued to rise and its SO_4 concentration was diluted, the outlet's output significantly increased as the constraint on operation shifted to bank-full capacity or pumping capability. Therefore, it was apparent that outlet effectiveness would be improved by using a fresher source of discharge water. Consequently, sensitivity tests were run assuming that the Big Coulee (which is comparable to Sheyenne River in SO_4) could be tapped for the outlet. These tests used the same constraints -- a trigger elevation of 1428, 200-cfs peak pumping capacity, 7-month pumping window, 500-cfs bank-full capacity in the river, and 450-mg/l SO_4 standard in the river.

Scenario A assumed that Big Coulee water could be pumped to the Sheyenne River before mixing with Devils Lake water. Because the SO_4 concentration in coulee water is below the river's SO_4 standard, coulee water could be pumped without running into the SO_4 constraint. Either the design pumping capacity or bank-full capacity would then be the limiting factor, with excess coulee inflow bypassed into the West Bay. This scenario produced a with-project lake elevation on 30 September 1995 of 1433.53, a drawdown of 1.56 feet from the without-project figure.

Scenario B assumed that, when coulee inflows decreased to the point where there was additional pumping or bank-full capacity, West Bay water would be added to the outlet flow until the total discharge matched the design peak pumping capacity or until the mix of coulee, West Bay, and river water reached either the 500-cfs bank-full capacity or 450-mg/l SO_4 standard. This scenario increased the computed drawdown to a calculated 2.13 feet. The estimated 0.57 feet of additional drawdown (above that achieved tapping Big Coulee's inflows alone) is on the high side, because the initial draw-off of fresher coulee inflows would cause West Bay waters to be somewhat more saline than the data used in the analysis.

Figure 36 shows Scenario B's with- and without-project lake elevation "histories" over the entire 10-year simulation period. The end result on 30 September 1995 is a calculated lake elevation of 1432.96, a reduction of 2.13 feet from the without-project level.

SHEYENNE R., ND

FLOW DURATION @ INSERTION POINT

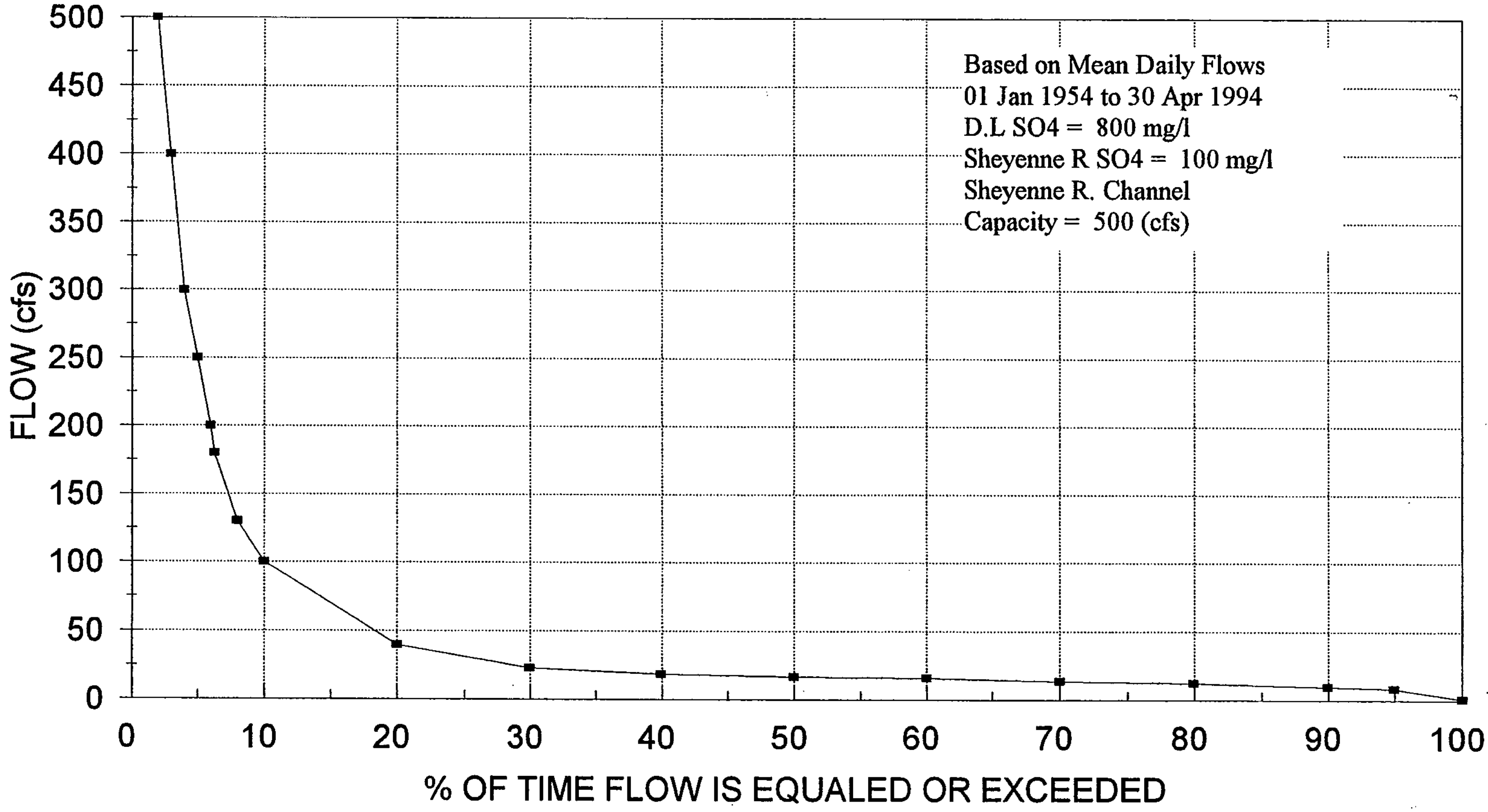


FIGURE 1

DEVILS LAKE, ND
PUMP CAPACITY CONSTRAINTS

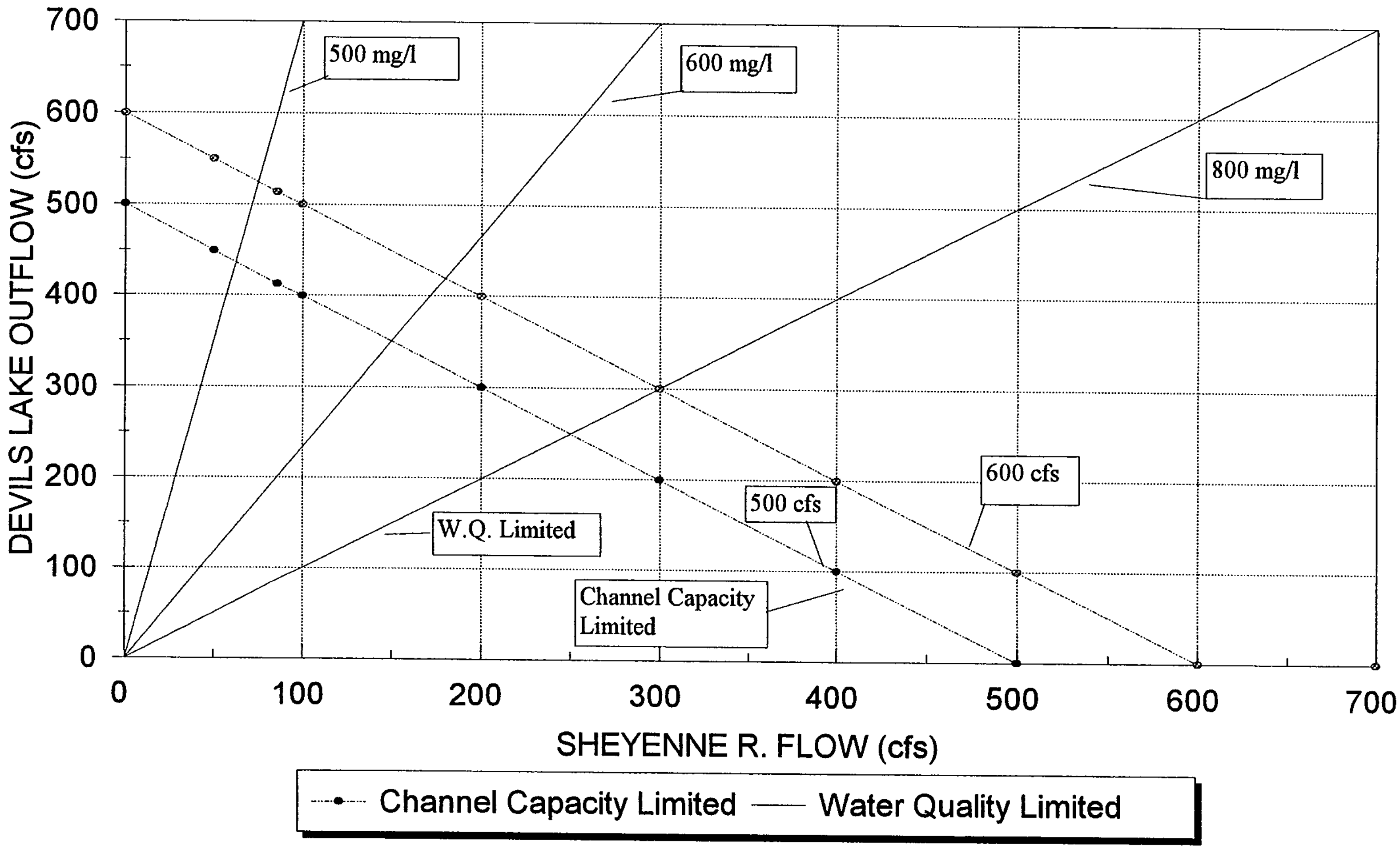


FIGURE 2

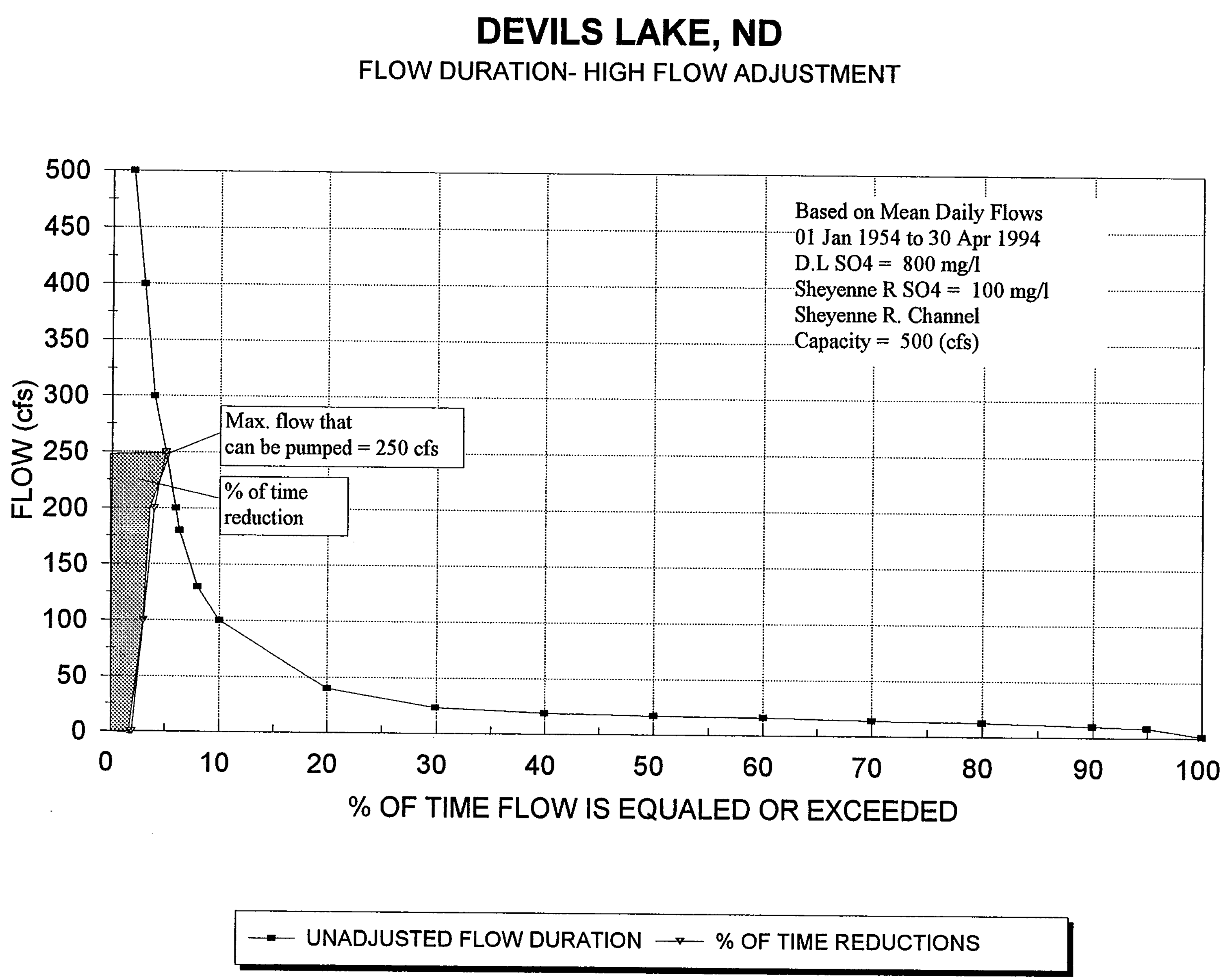
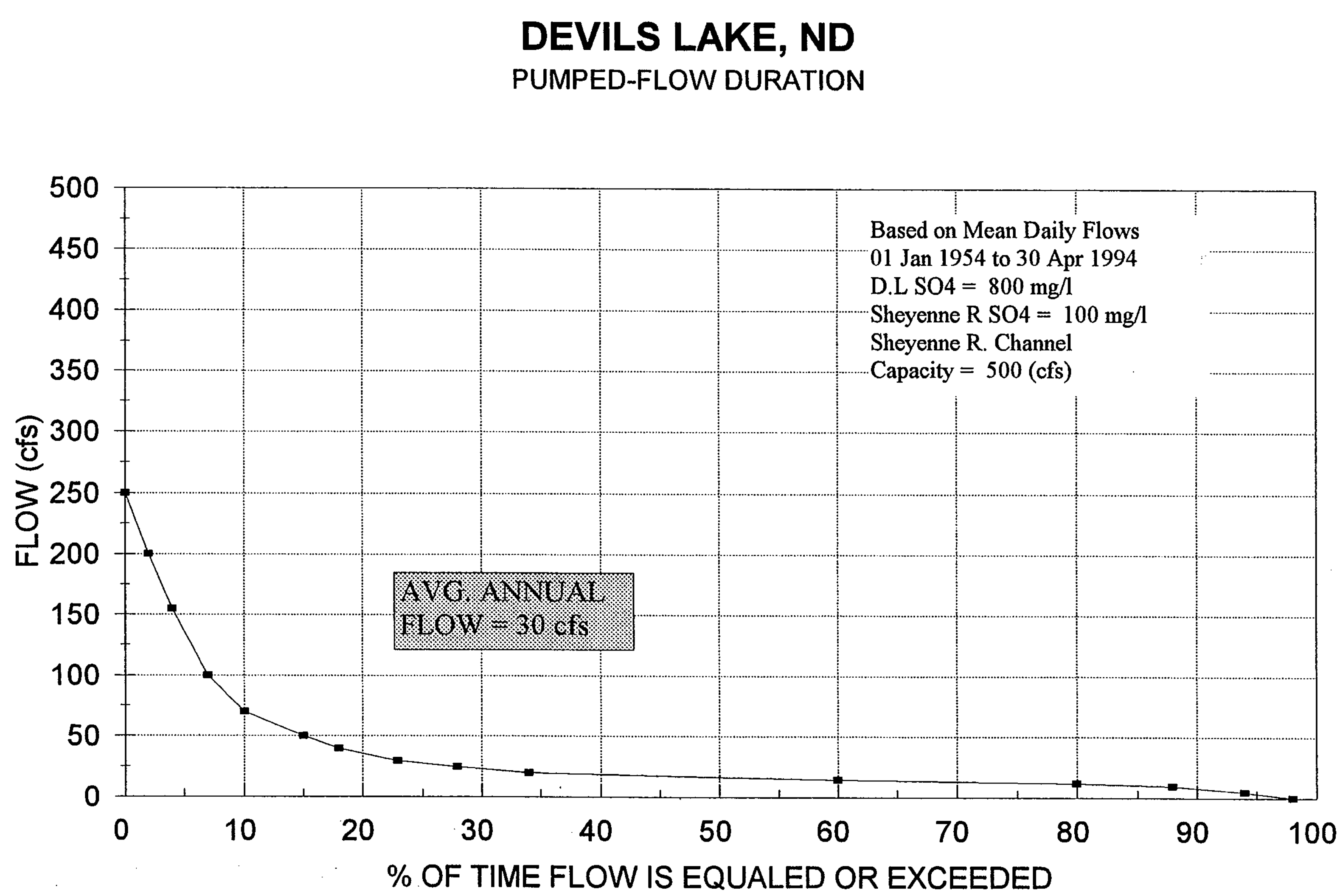

DEVILS LAKE, ND
FLOW DURATION- HIGH FLOW ADJUSTMENT
FLOW (cfs)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
% OF TIME FLOW IS EQUALED OR EXCEEDED
Based on Mean Daily Flows
01 Jan 1954 to 30 Apr 1994
D.L SO4 = 800 mg/l
Sheyenne R SO4 = 100 mg/l
Sheyenne R. Channel
Capacity = 500 (cfs)
Max. flow that
can be pumped = 250 cfs
% of time
reduction
UNADJUSTED FLOW DURATION
% OF TIME REDUCTIONS

FIGURE 3



DEVILS LAKE, ND
PUMPED-FLOW DURATION
FLOW (cfs)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
% OF TIME FLOW IS EQUALED OR EXCEEDED
Based on Mean Daily Flows
01 Jan 1954 to 30 Apr 1994
D.L SO4 = 800 mg/l
Sheyenne R SO4 = 100 mg/l
Sheyenne R. Channel
Capacity = 500 (cfs)
AVG. ANNUAL
FLOW = 30 cfs

FIGURE 4

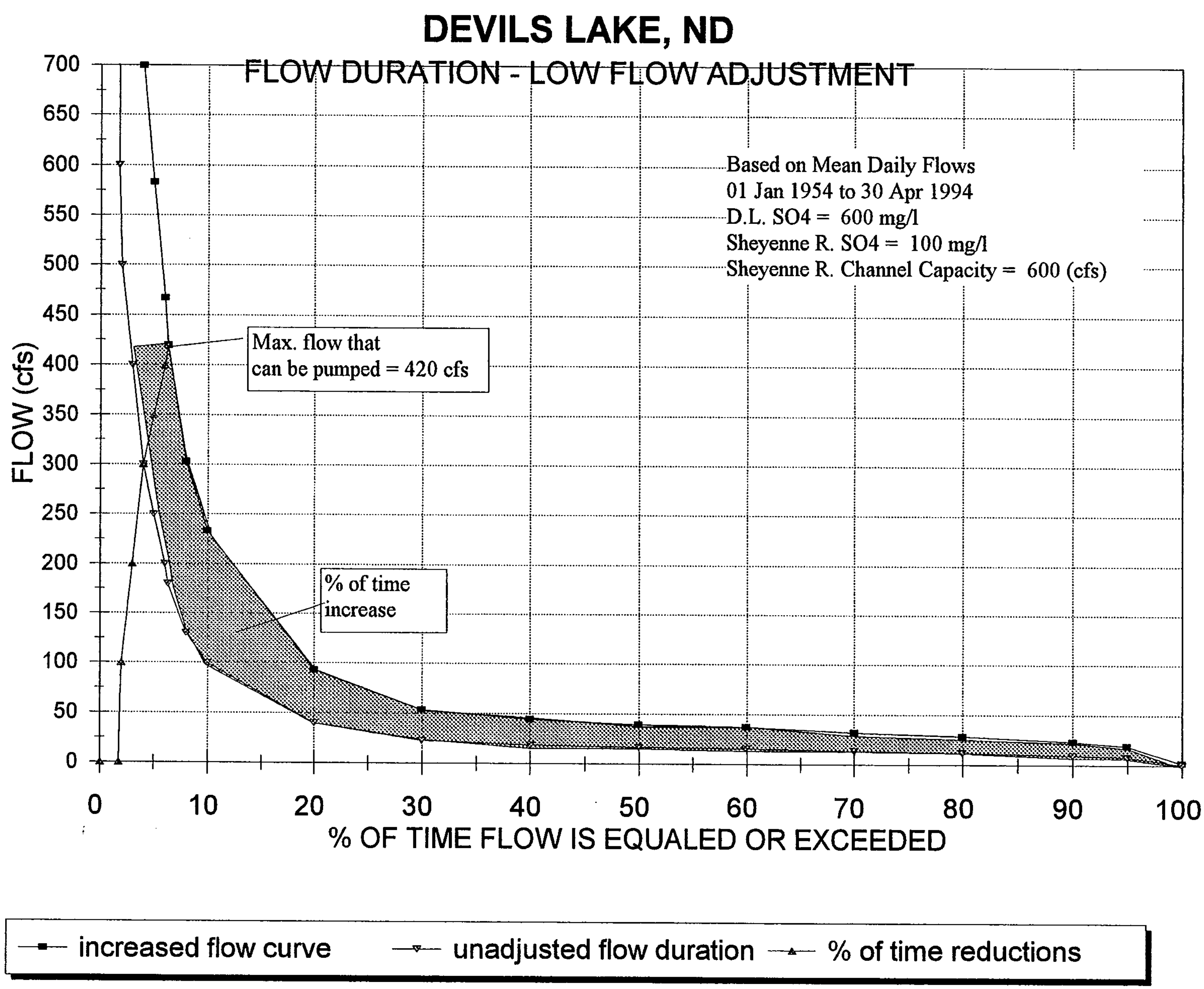

DEVILS LAKE, ND
FLOW DURATION - LOW FLOW ADJUSTMENT
Based on Mean Daily Flows
01 Jan 1954 to 30 Apr 1994
D.L. SO4 = 600 mg/l
Sheyenne R. SO4 = 100 mg/l
Sheyenne R. Channel Capacity = 600 (cfs)
Max. flow that
can be pumped = 420 cfs
% of time
increase
FLOW (cfs)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
0
10
20
30
40
50
60
70
80
90
100
% OF TIME FLOW IS EQUALED OR EXCEEDED
increased flow curve
unadjusted flow duration
% of time reductions

FIGURE 5

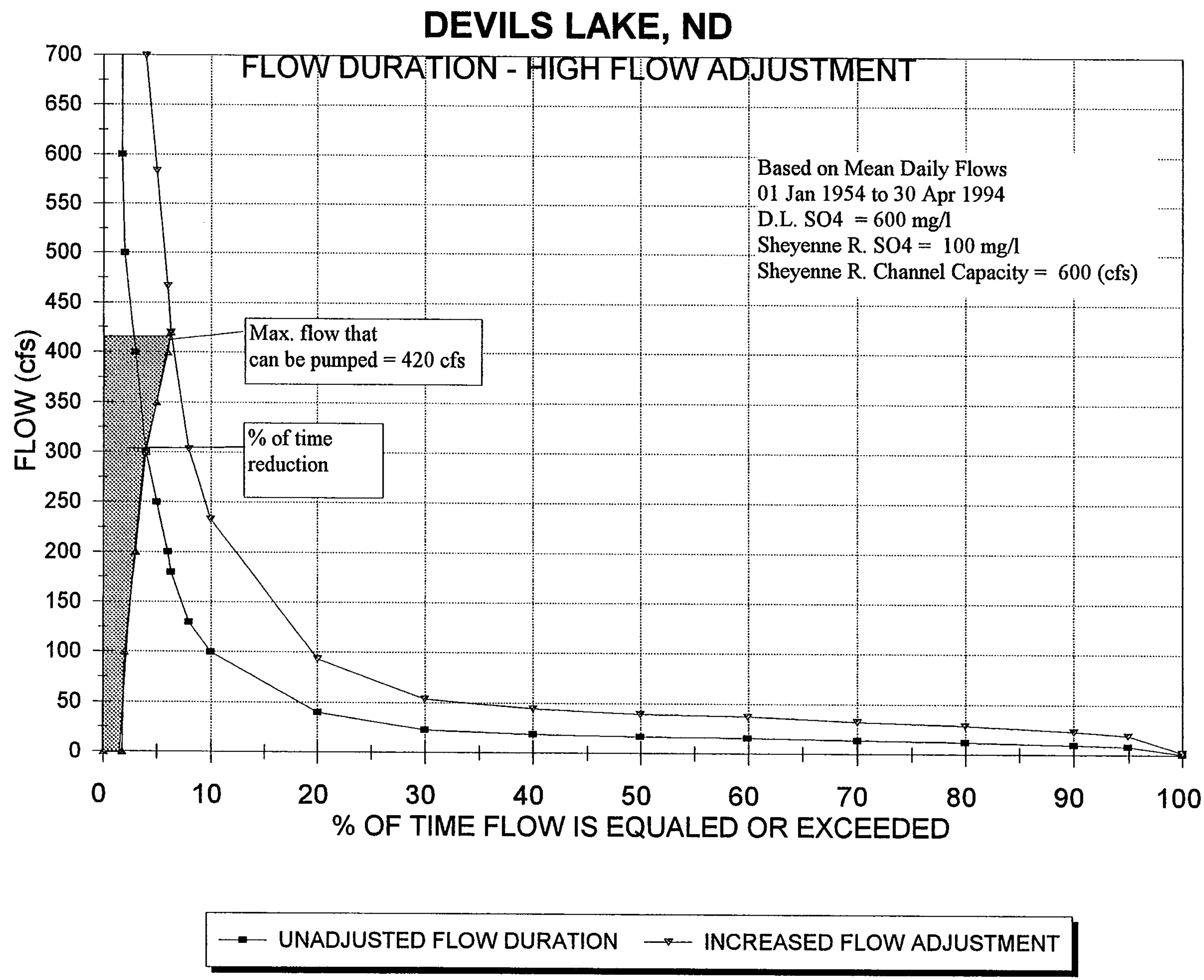

DEVILS LAKE, ND
FLOW DURATION - HIGH FLOW ADJUSTMENT
FLOW (cfs)
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
100
% OF TIME FLOW IS EQUALED OR EXCEEDED
Based on Mean Daily Flows
01 Jan 1954 to 30 Apr 1994
D.L. SO4 = 600 mg/l
Sheyenne R. SO4 = 100 mg/l
Sheyenne R. Channel Capacity = 600 (cfs)
Max. flow that can be pumped = 420 cfs
% of time reduction
UNADJUSTED FLOW DURATION
INCREASED FLOW ADJUSTMENT

FIGURE 6

DEVILS LAKE, ND

PUMPED-FLOW DURATION

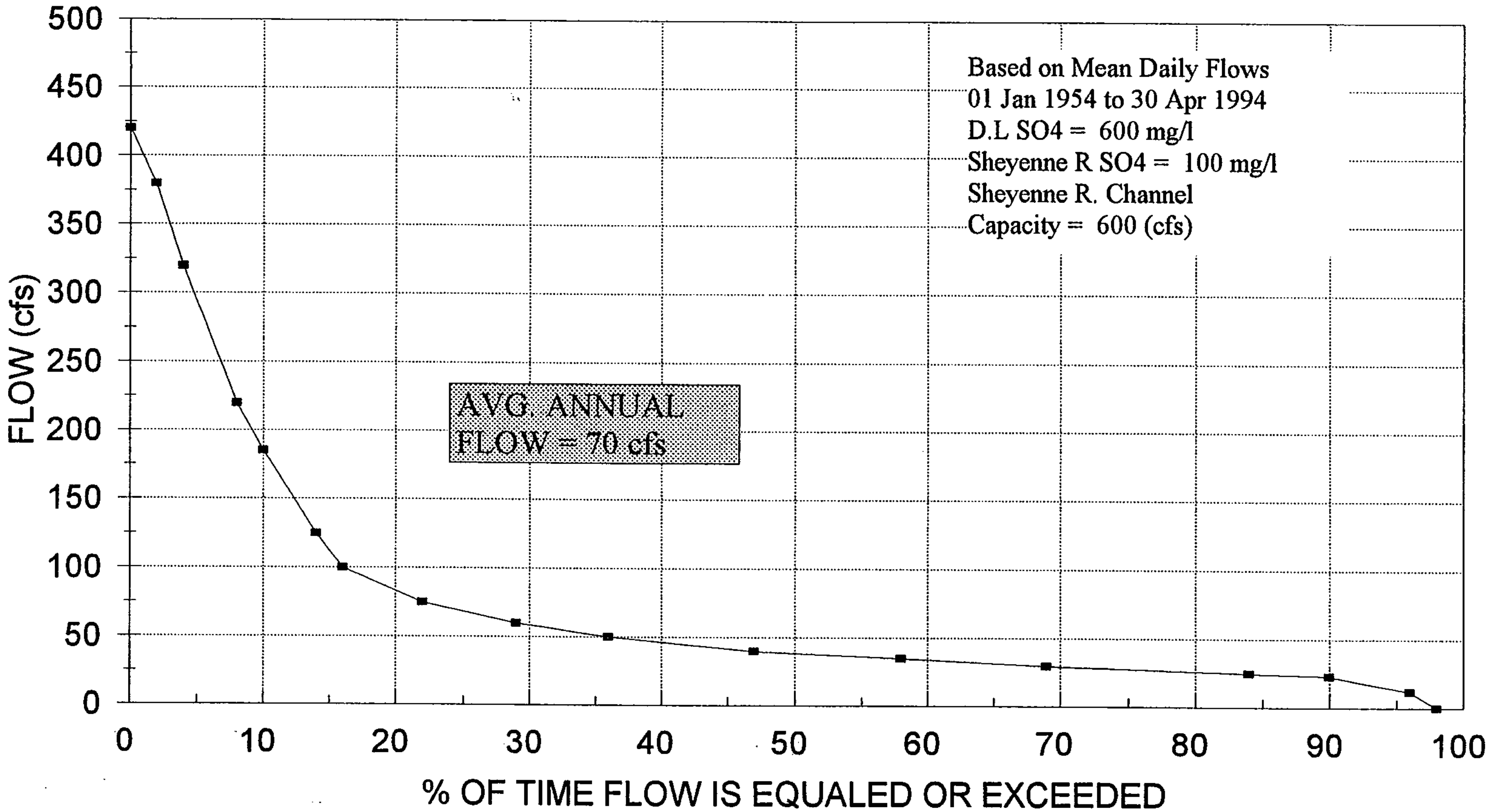


FIGURE 7

DEVILS LAKE

NO. OF DAYS AT PUMPING RATES > 5 CFS

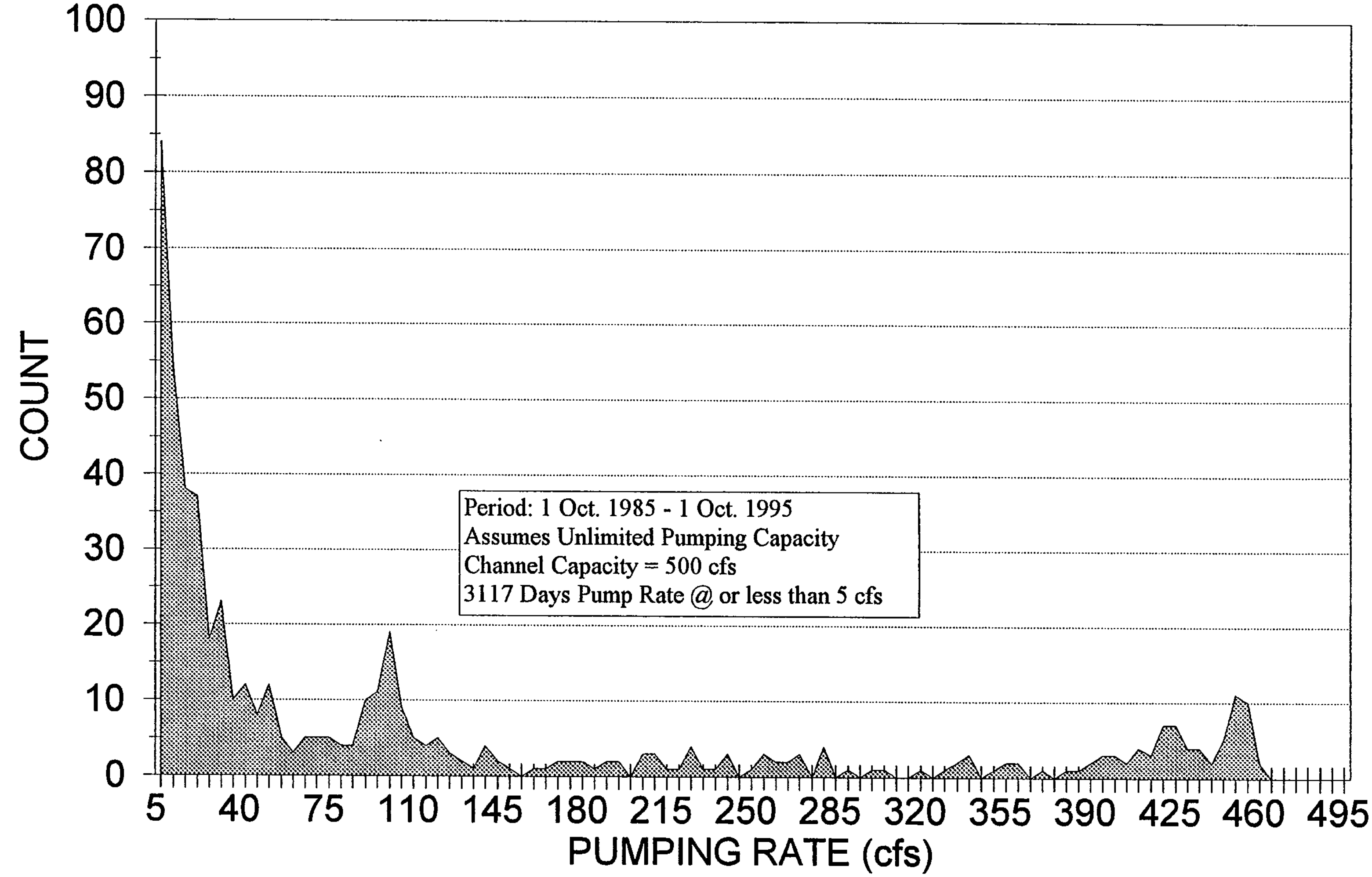


FIGURE 8

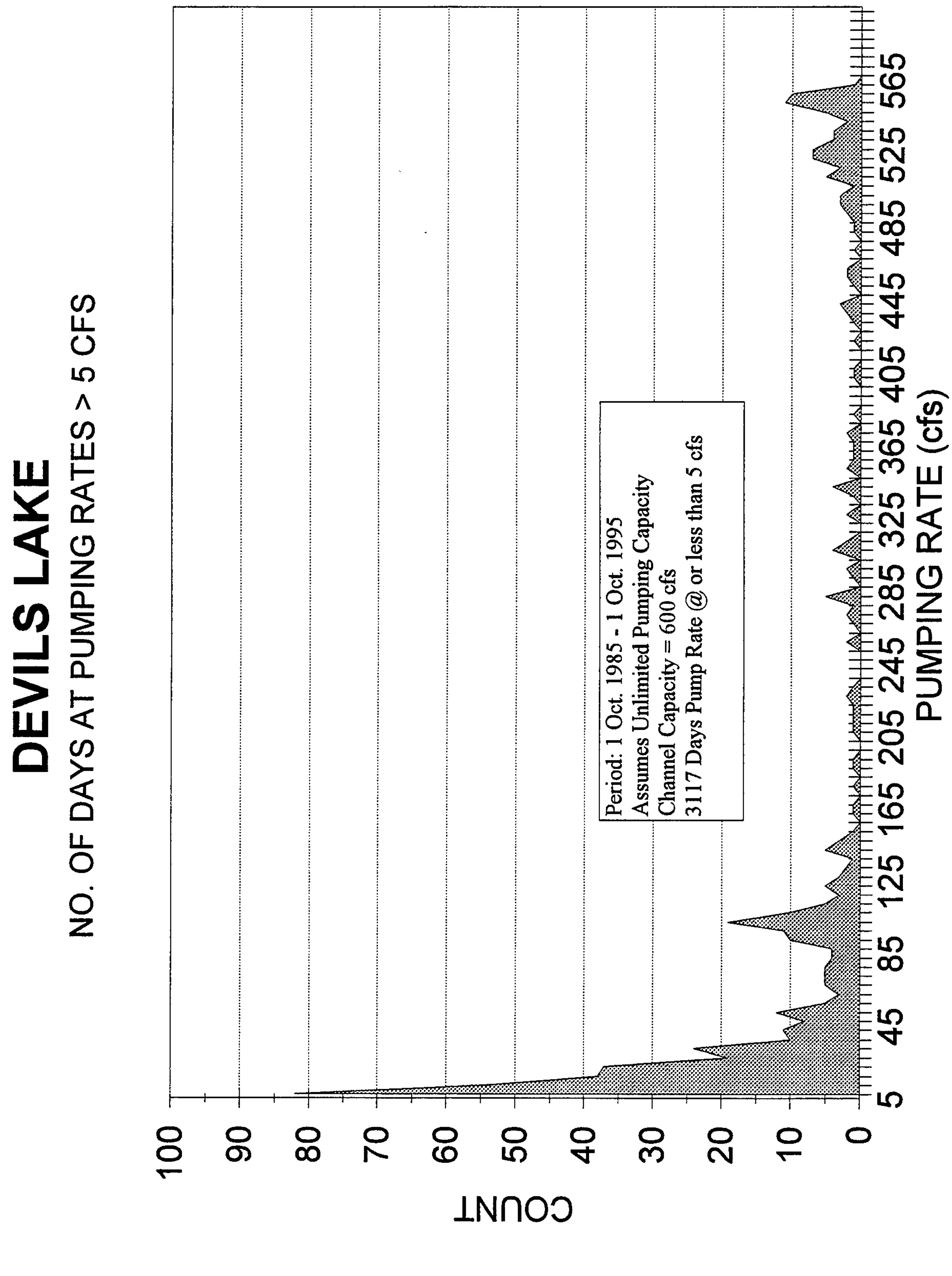

DEVILS LAKE
NO. OF DAYS AT PUMPING RATES > 5 CFS
Period: 1 Oct. 1985 - 1 Oct. 1995
Assumes Unlimited Pumping Capacity
Channel Capacity = 600 cfs
3117 Days Pump Rate @ or less than 5 cfs
COUNT
0
10
20
30
40
50
60
70
80
90
100
5
45
85
125
165
205
245
285
325
365
405
445
485
525
565
PUMPING RATE (cfs)

FIGURE 9

DEVILS LAKE, ND

PRE-PROJECT ELEV. VS. SULFATE CONC.

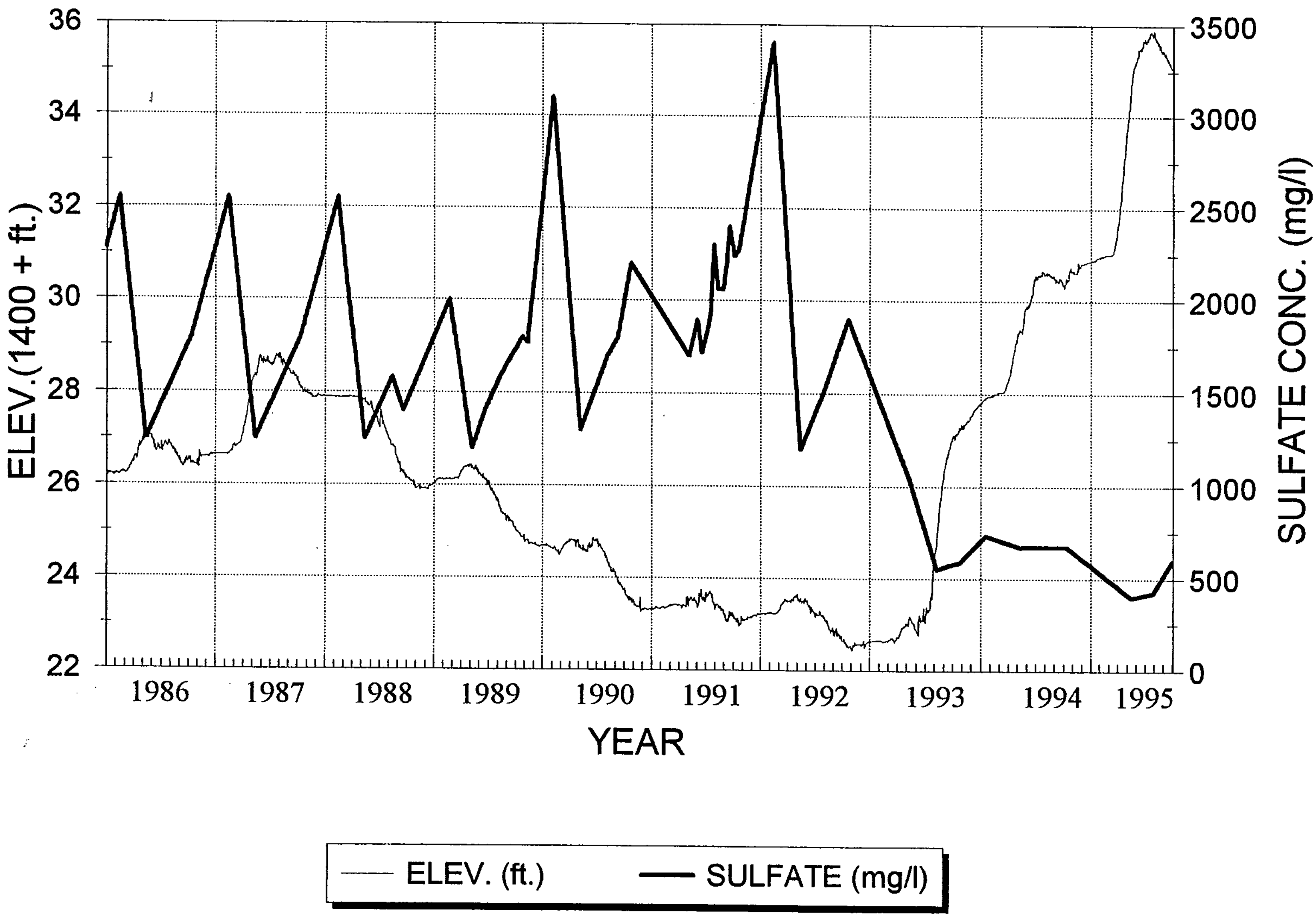


FIGURE 10

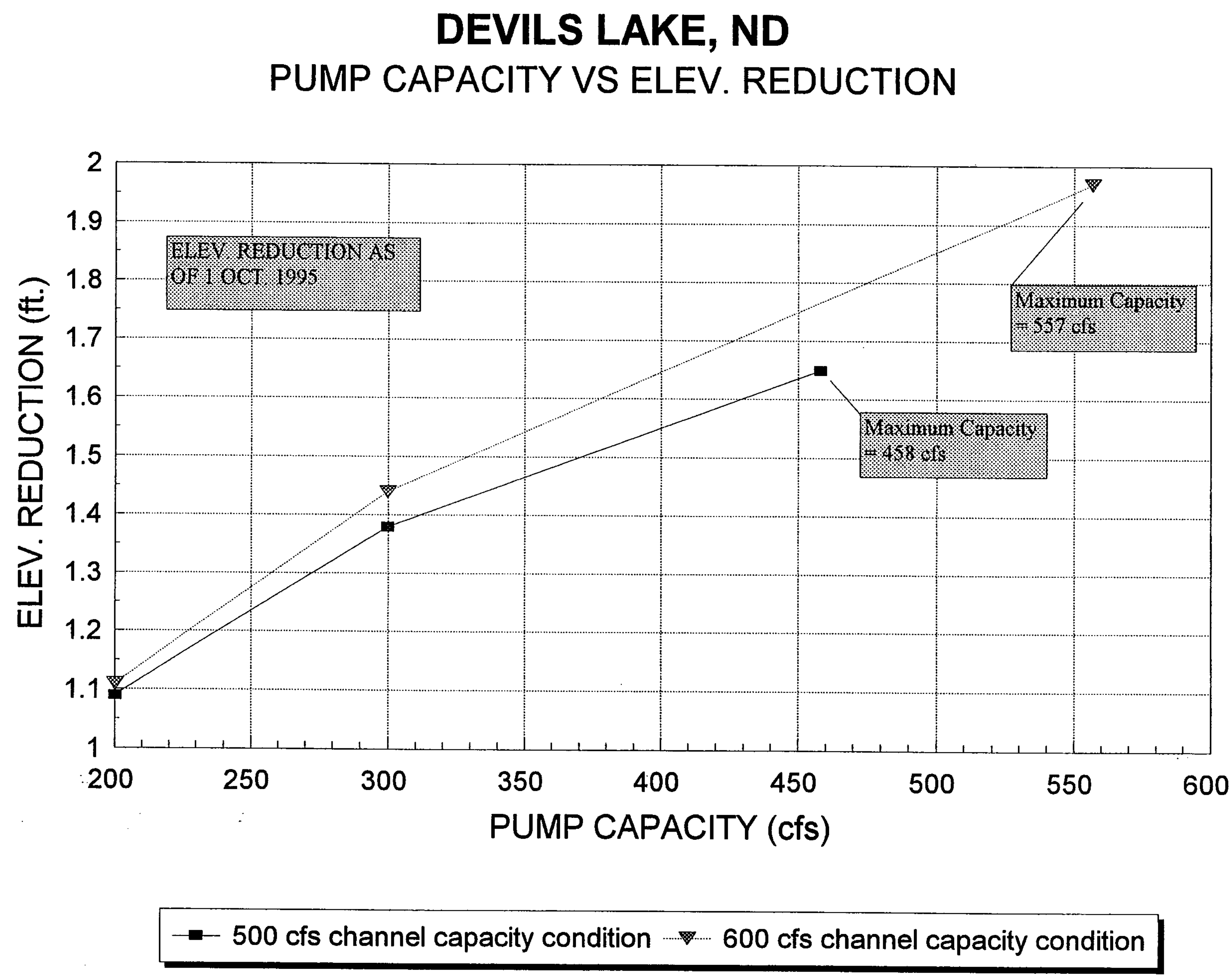

DEVILS LAKE, ND
PUMP CAPACITY VS ELEV. REDUCTION
ELEV. REDUCTION (ft.)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
200
250
300
350
400
450
500
550
600
PUMP CAPACITY (cfs)
ELEV. REDUCTION AS OF 1 OCT. 1995
Maximum Capacity = 557 cfs
Maximum Capacity = 458 cfs
500 cfs channel capacity condition
600 cfs channel capacity condition

FIGURE 11

DEVILS LAKE, ND
WITH AND WITHOUT PUMPING ELEV.

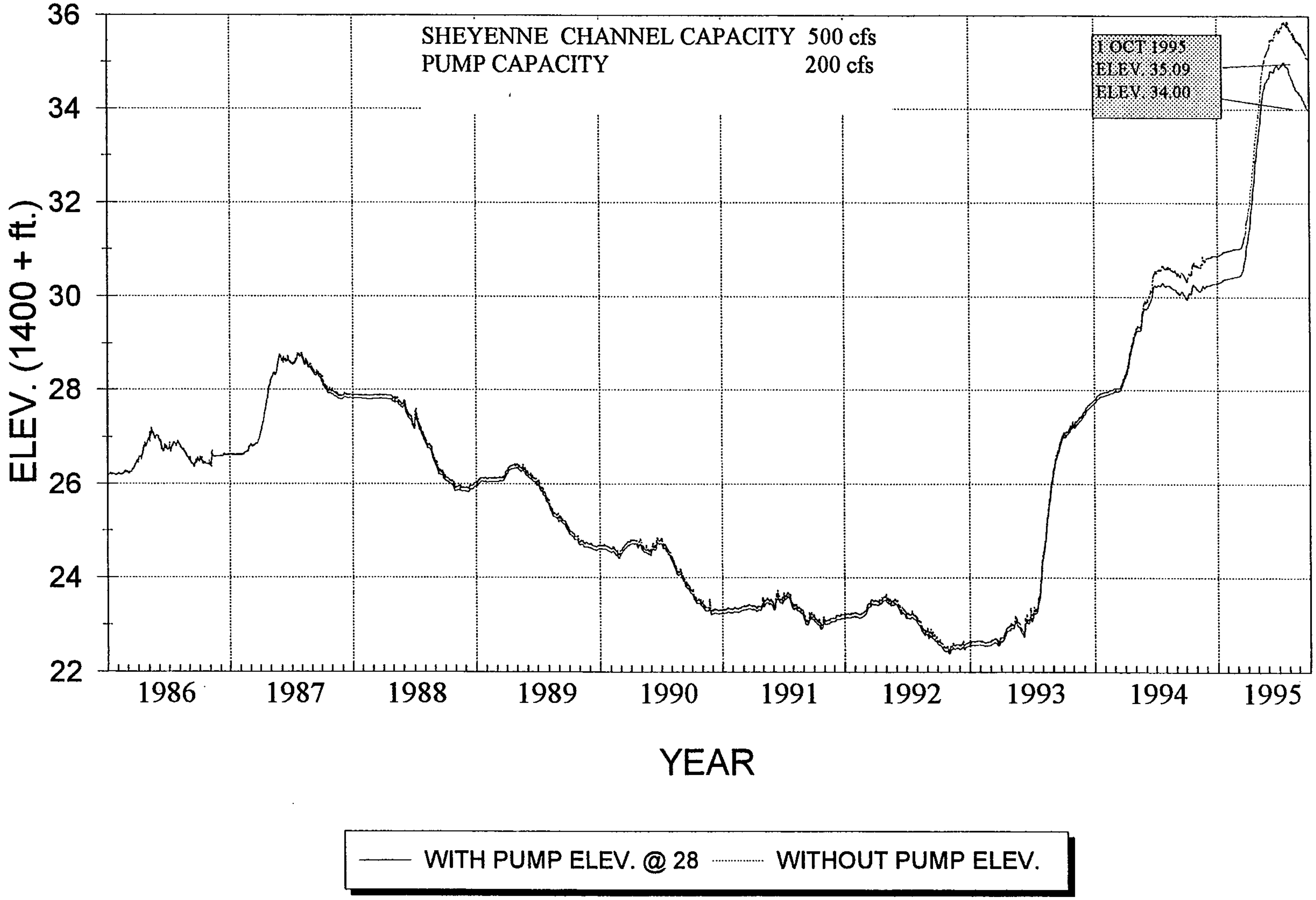
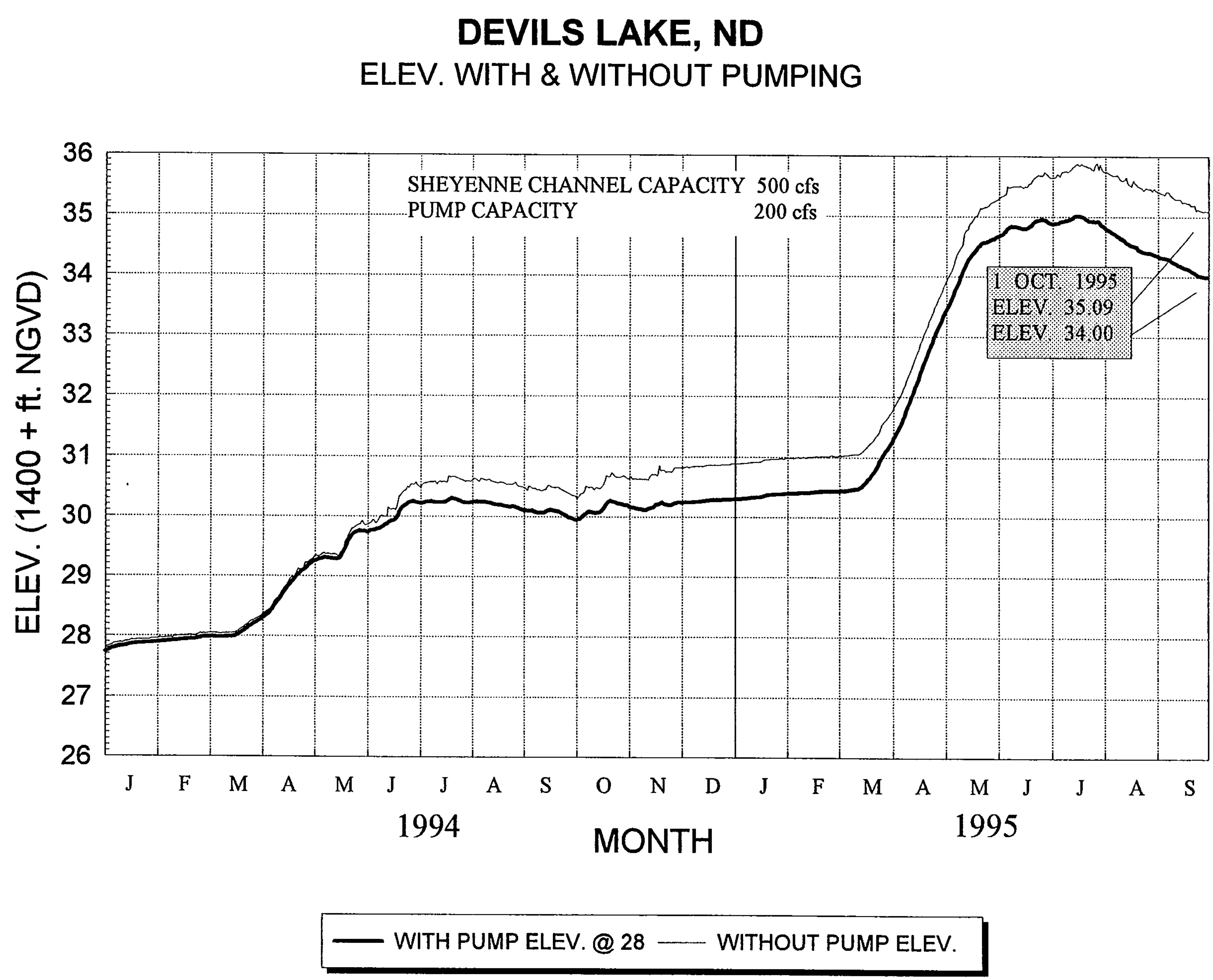


FIGURE 12



DEVILS LAKE, ND
ELEV. WITH & WITHOUT PUMPING
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 200 cfs
1 OCT. 1995
ELEV. 35.09
ELEV. 34.00
ELEV. (1400 + ft. NGVD)
36
35
34
33
32
31
30
29
28
27
26
J F M A M J J A S O N D J F M A M J J A S
1994
MONTH
1995
WITH PUMP ELEV. @ 28
WITHOUT PUMP ELEV.

FIGURE 12a

DEVILS LAKE, ND

WITH AND WITHOUT PUMPING ELEV.

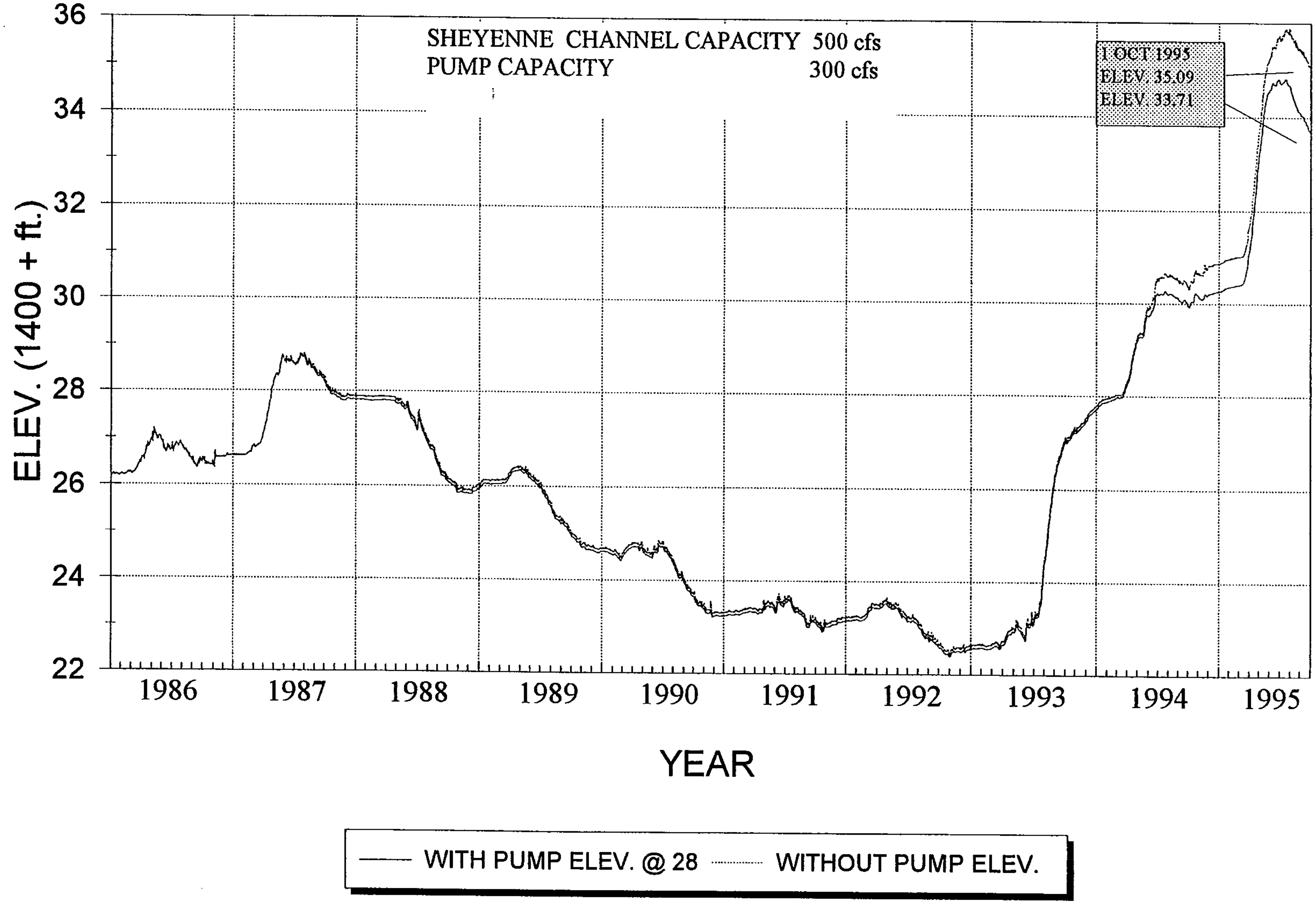


FIGURE 13

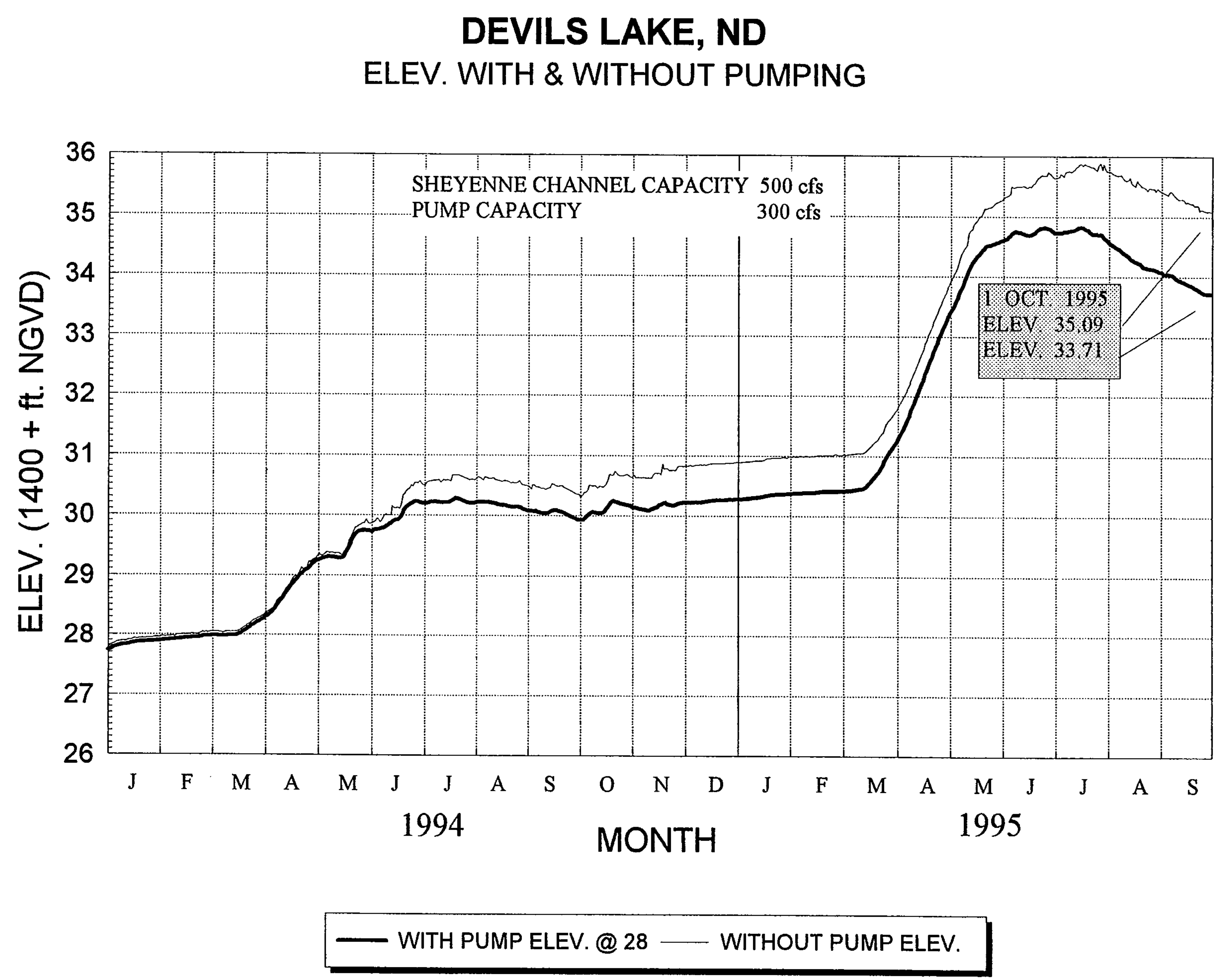
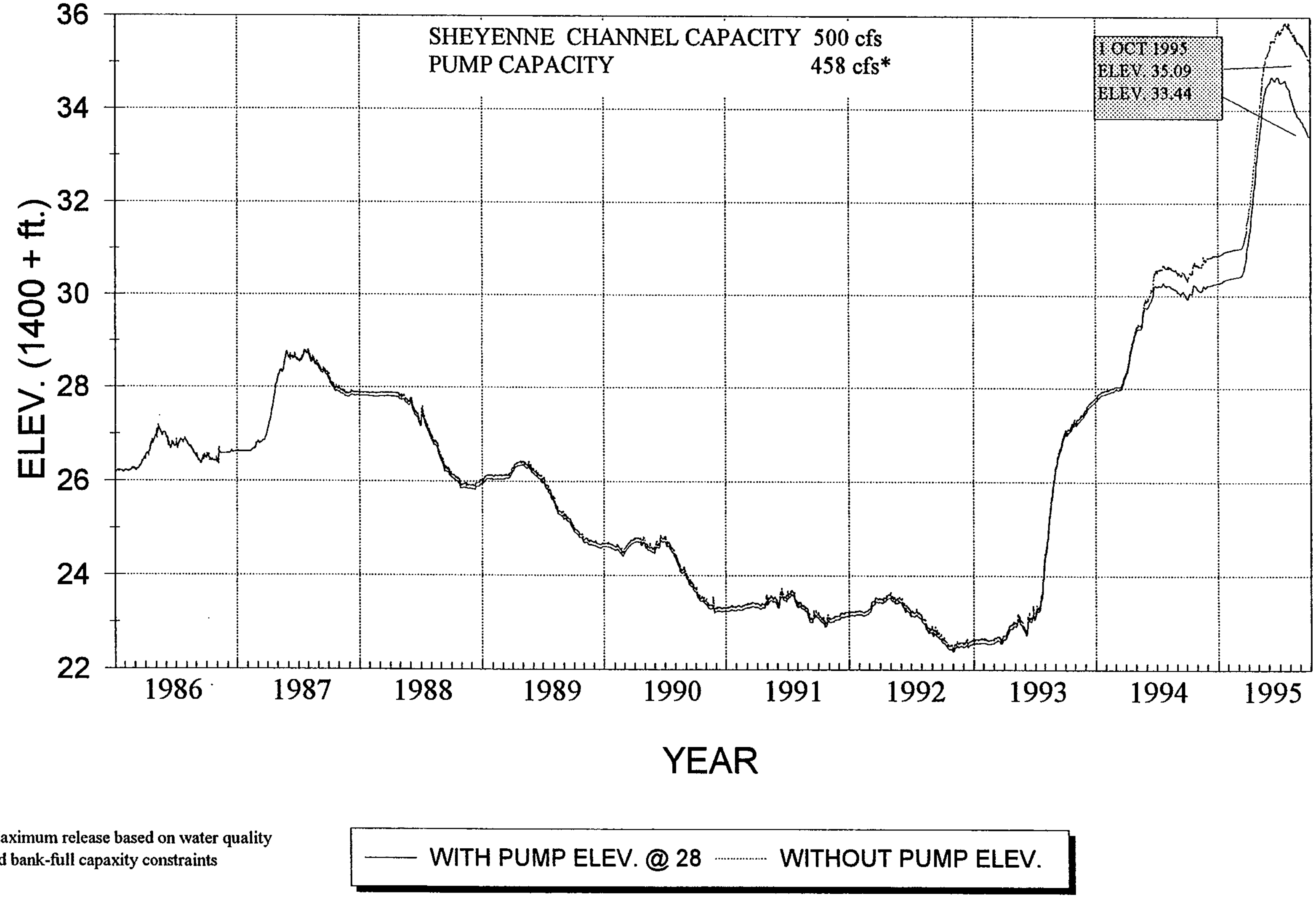

DEVILS LAKE, ND
ELEV. WITH & WITHOUT PUMPING
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 300 cfs
ELEV. (1400 + ft. NGVD)
36
35
34
33
32
31
30
29
28
27
26
1 OCT. 1995
ELEV. 35.09
ELEV. 33.71
J F M A M J J A S O N D J F M A M J J A S
1994
MONTH
1995
WITH PUMP ELEV. @ 28
WITHOUT PUMP ELEV.

FIGURE 13a

DEVILS LAKE, ND
WITH AND WITHOUT PUMPING ELEV.

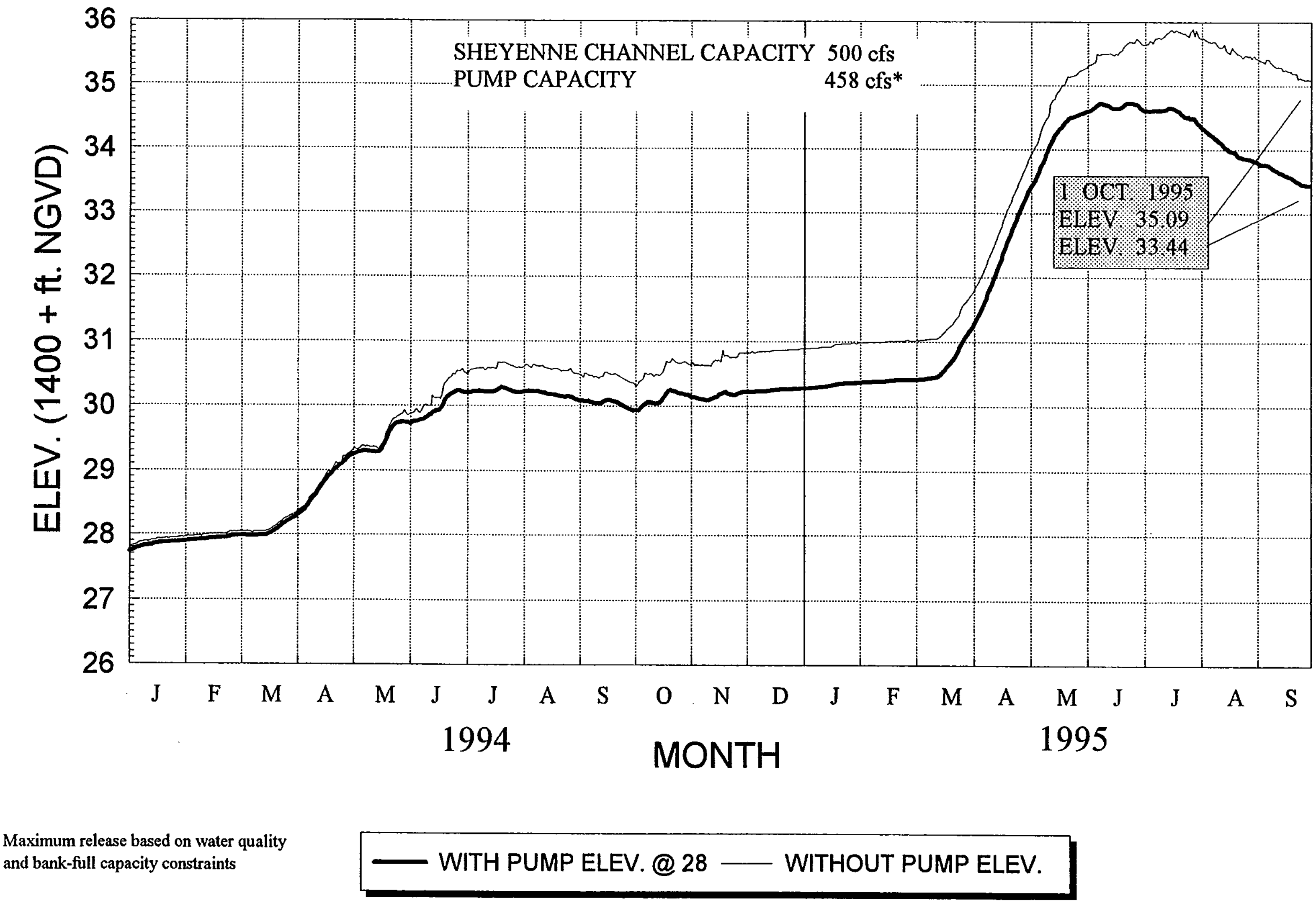


* Maximum release based on water quality and bank-full capaxity constraints

FIGURE 14

DEVILS LAKE, ND

ELEV. WITH & WITHOUT PUMPING



* Maximum release based on water quality and bank-full capacity constraints

FIGURE 14a

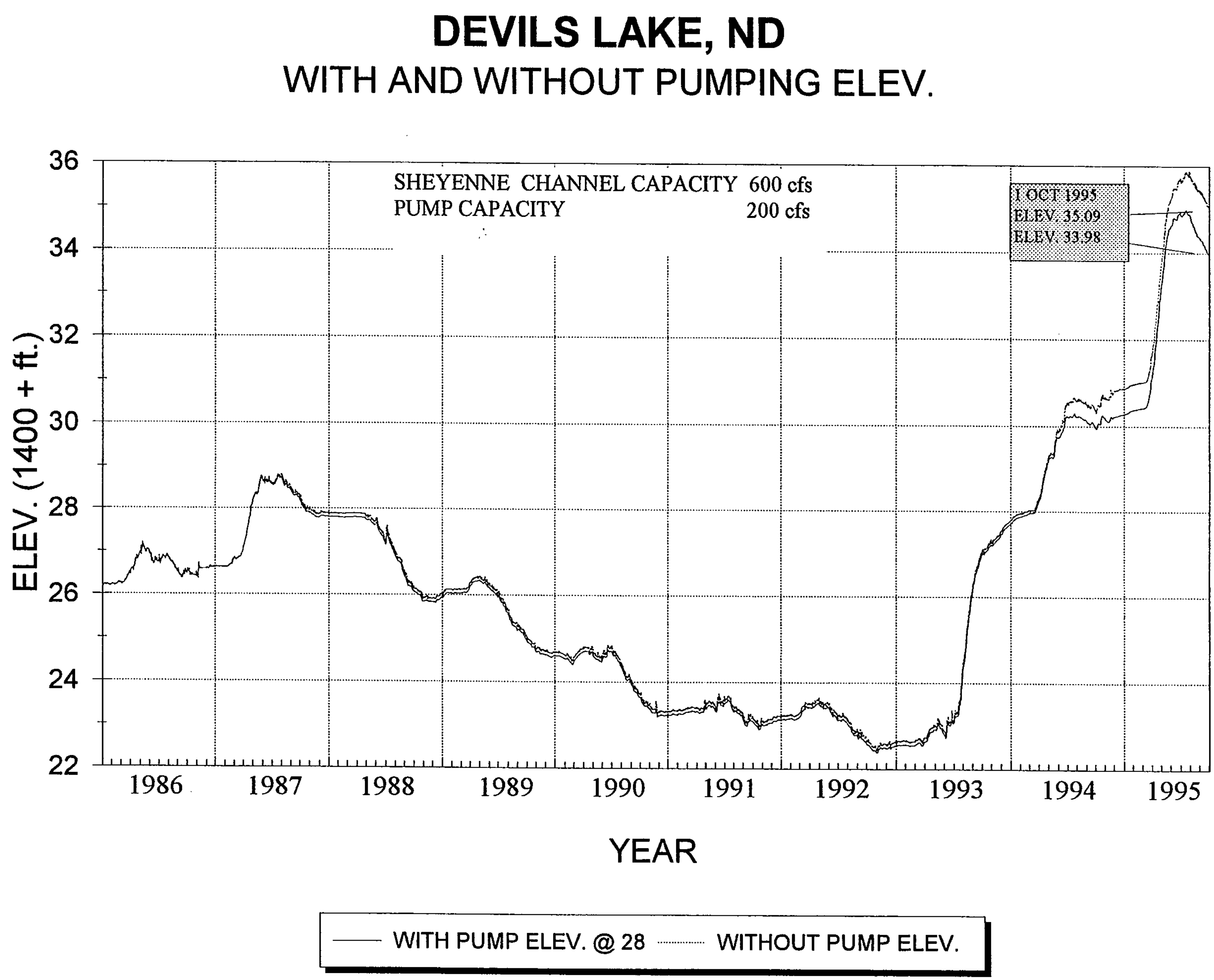

DEVILS LAKE, ND
WITH AND WITHOUT PUMPING ELEV.
SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 200 cfs
1 OCT 1995
ELEV. 35.09
ELEV. 33.98
ELEV. (1400 + ft.)
36
34
32
30
28
26
24
22
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
WITH PUMP ELEV. @ 28
WITHOUT PUMP ELEV.

FIGURE 15

DEVILS LAKE, ND

ELEV. WITH & WITHOUT PUMPING

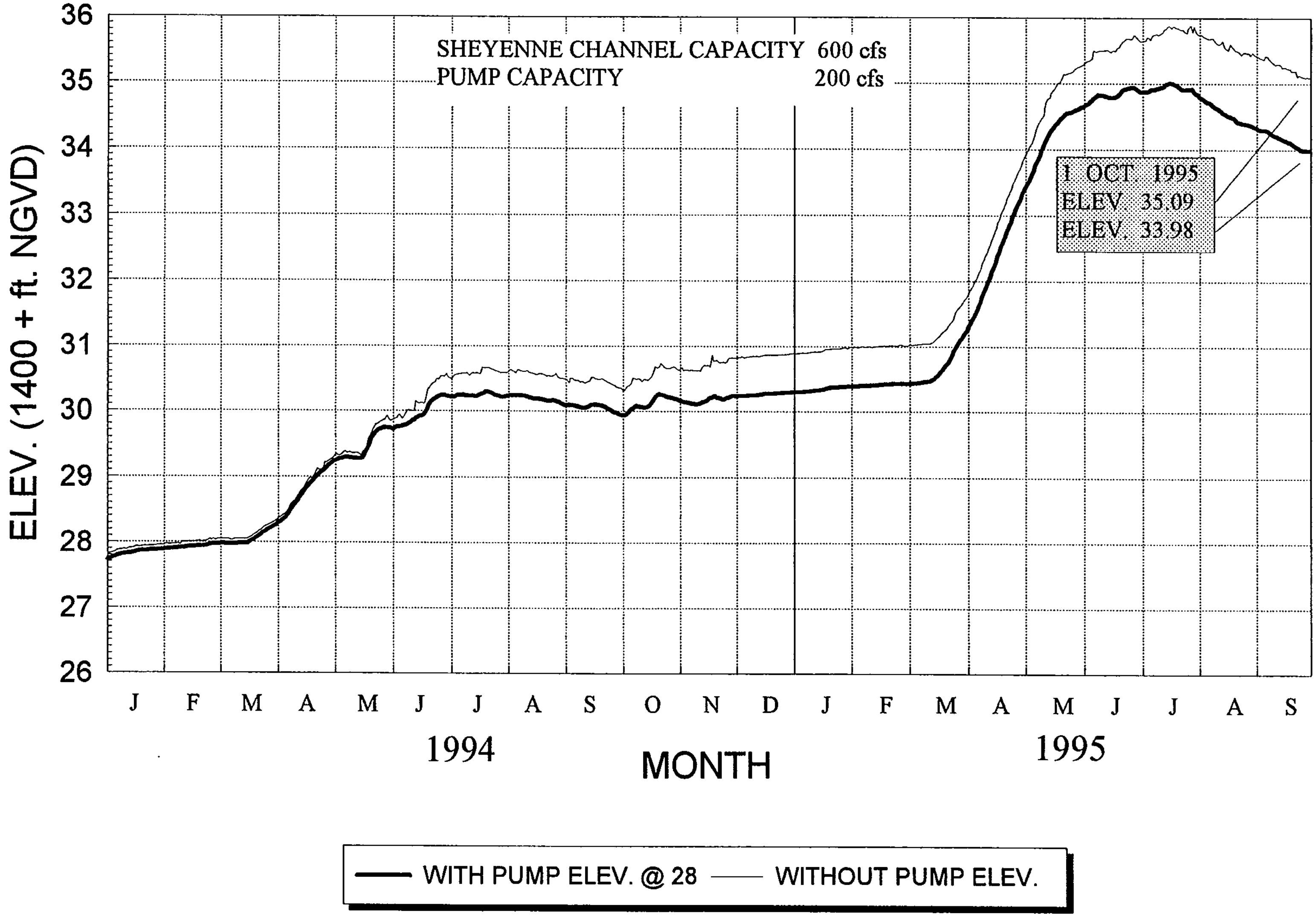


FIGURE 15a

DEVILS LAKE, ND
WITH AND WITHOUT PUMPING ELEV.

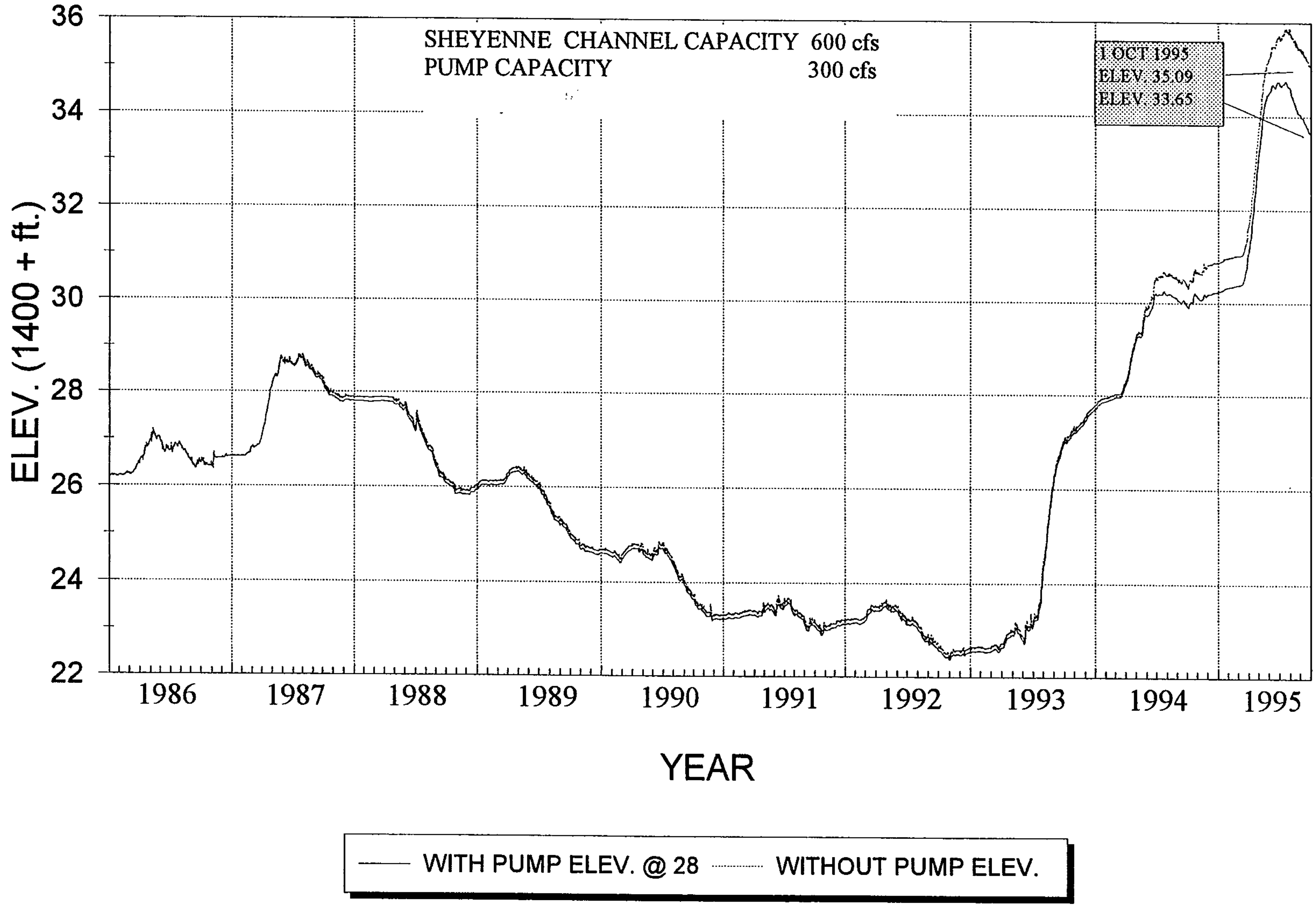


FIGURE 16

DEVILS LAKE, ND
ELEV. WITH & WITHOUT PUMPING

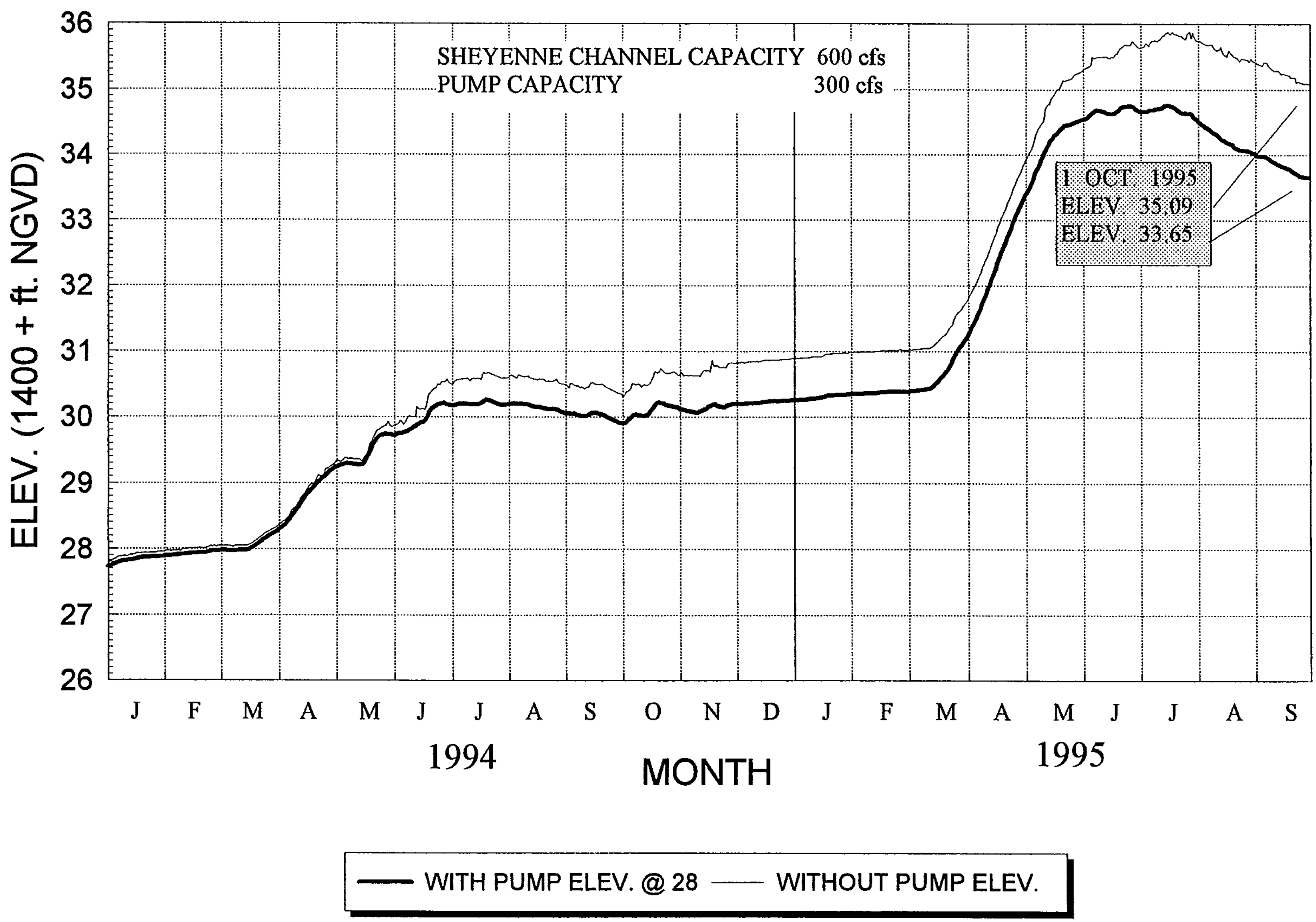
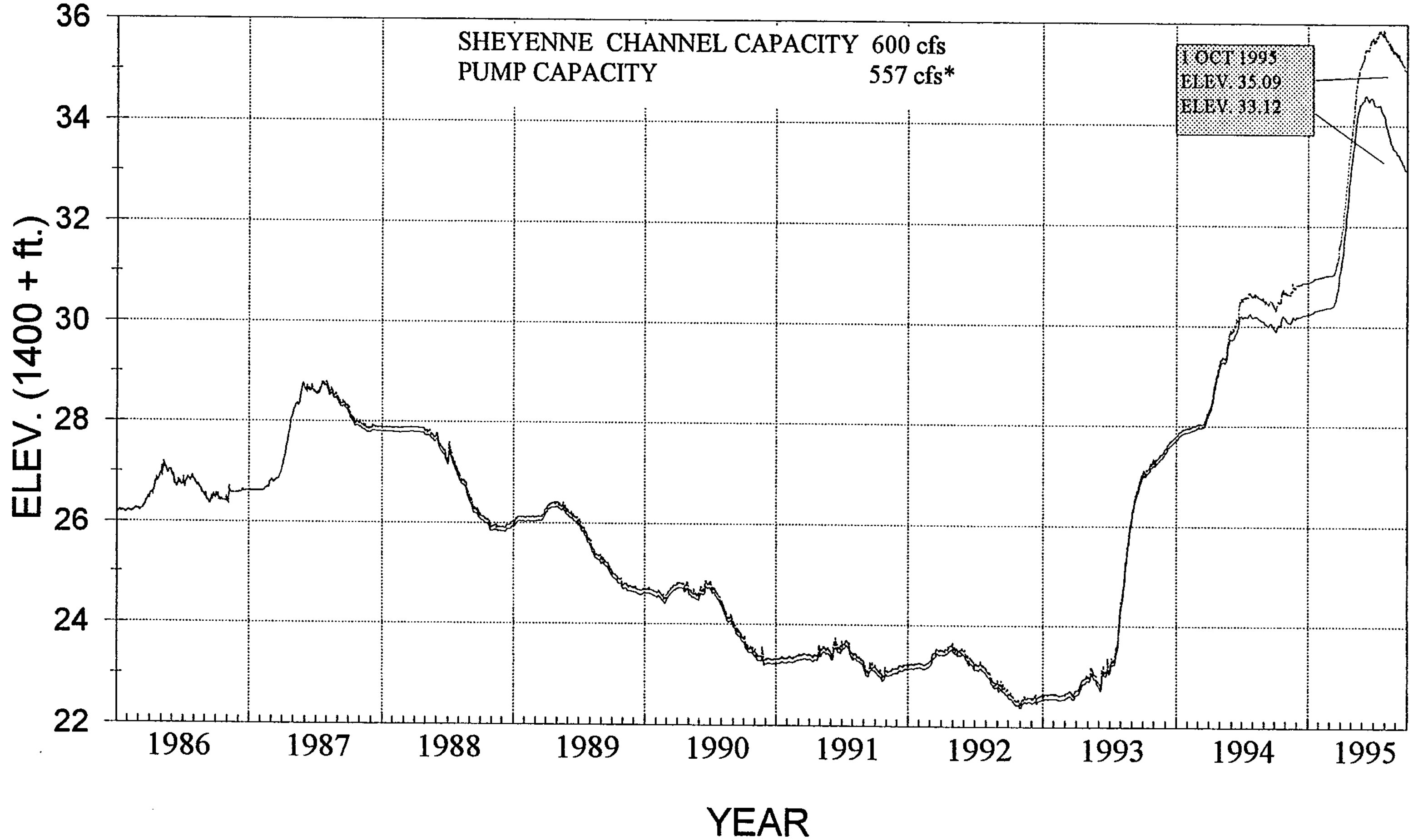


FIGURE 16a

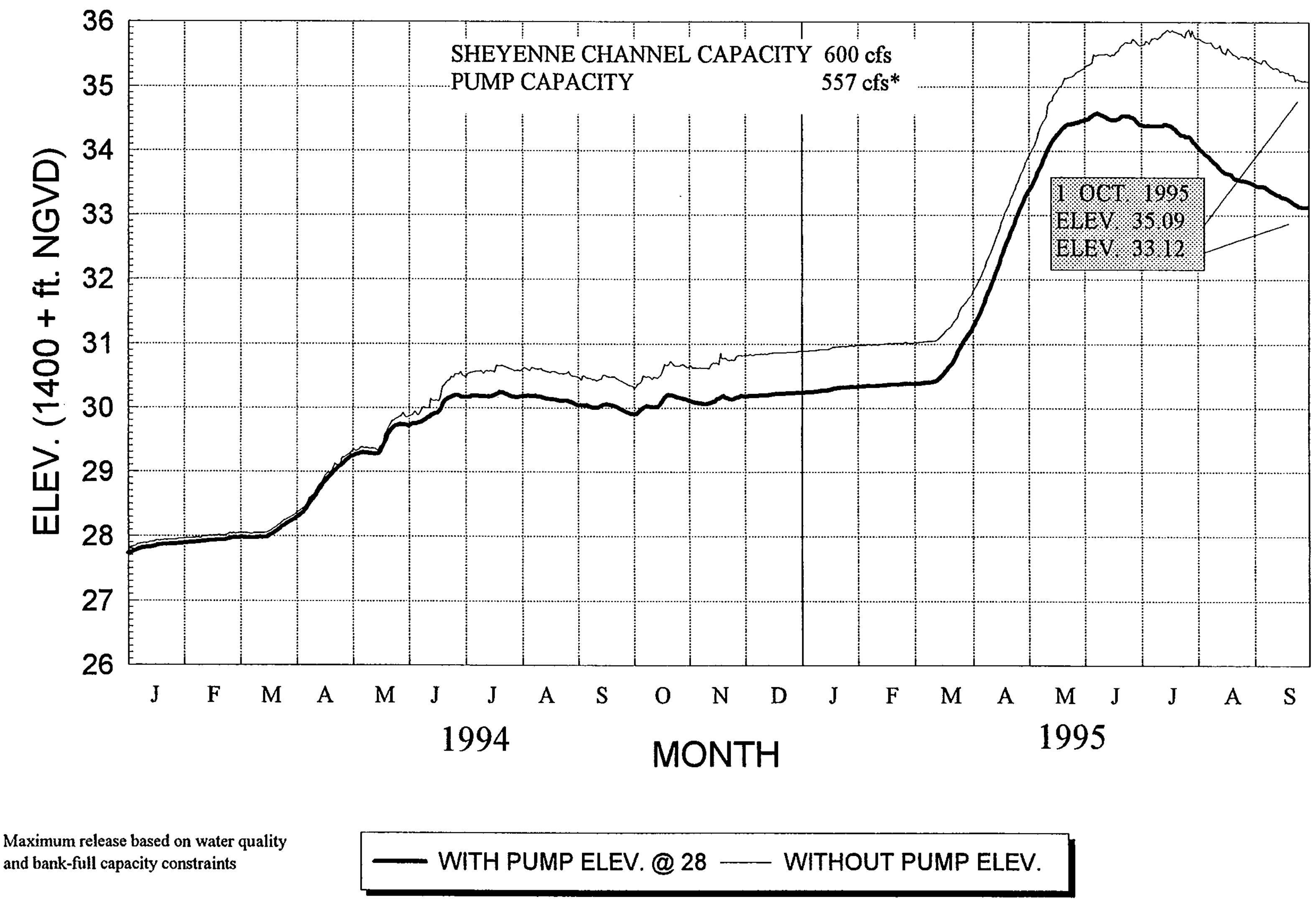
DEVILS LAKE, ND
WITH AND WITHOUT PUMPING ELEV.



* Maximum release based on water quality and bank-full capacity constraints

FIGURE 17

DEVILS LAKE, ND
ELEV. WITH & WITHOUT PUMPING



* Maximum release based on water quality and bank-full capacity constraints

FIGURE 17a

DEVILS LAKE, ND

PUMPED OUTFLOW (CFS)

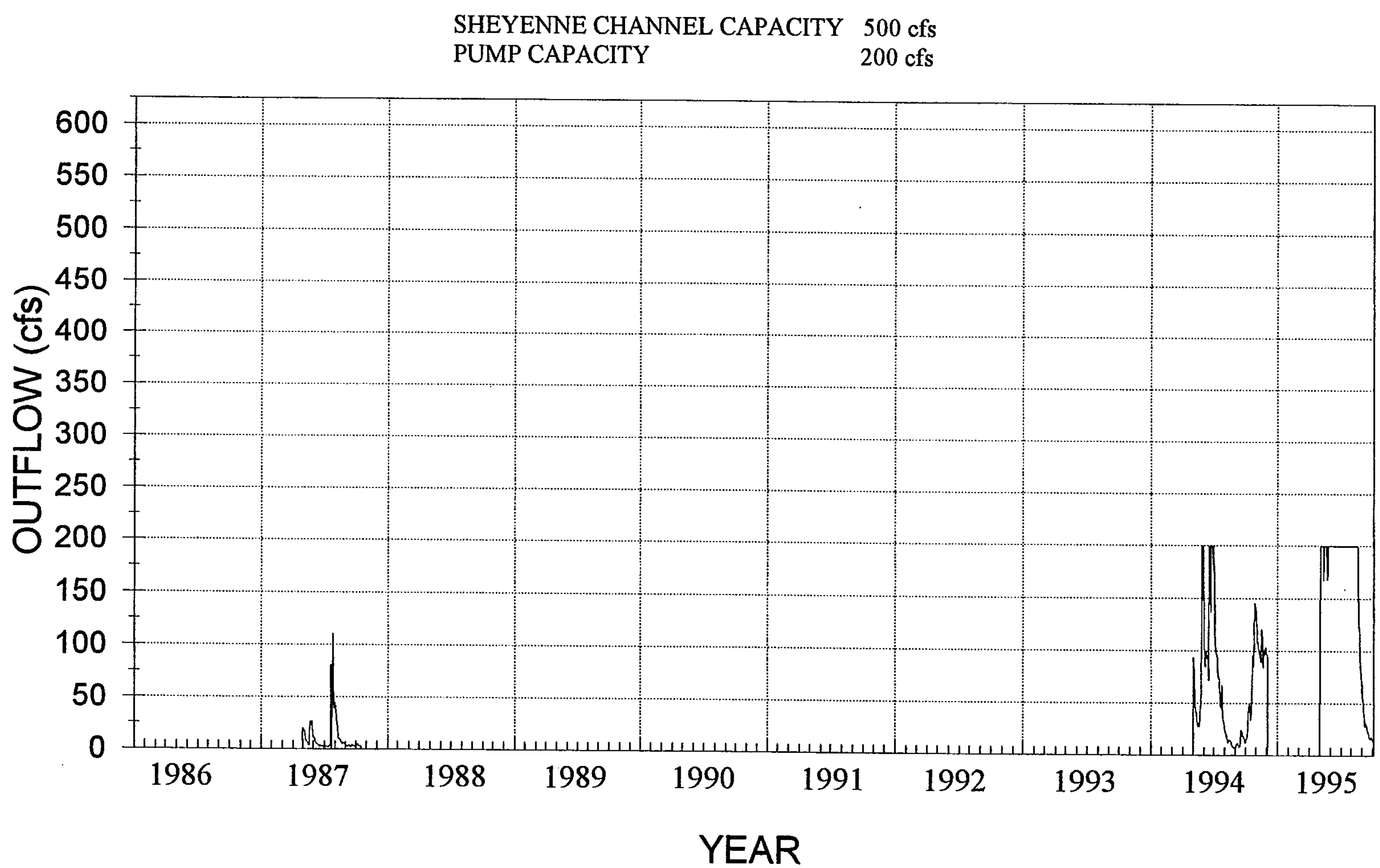


FIGURE 18

DEVILS LAKE, ND

PUMPED OUTFLOW (CFS)

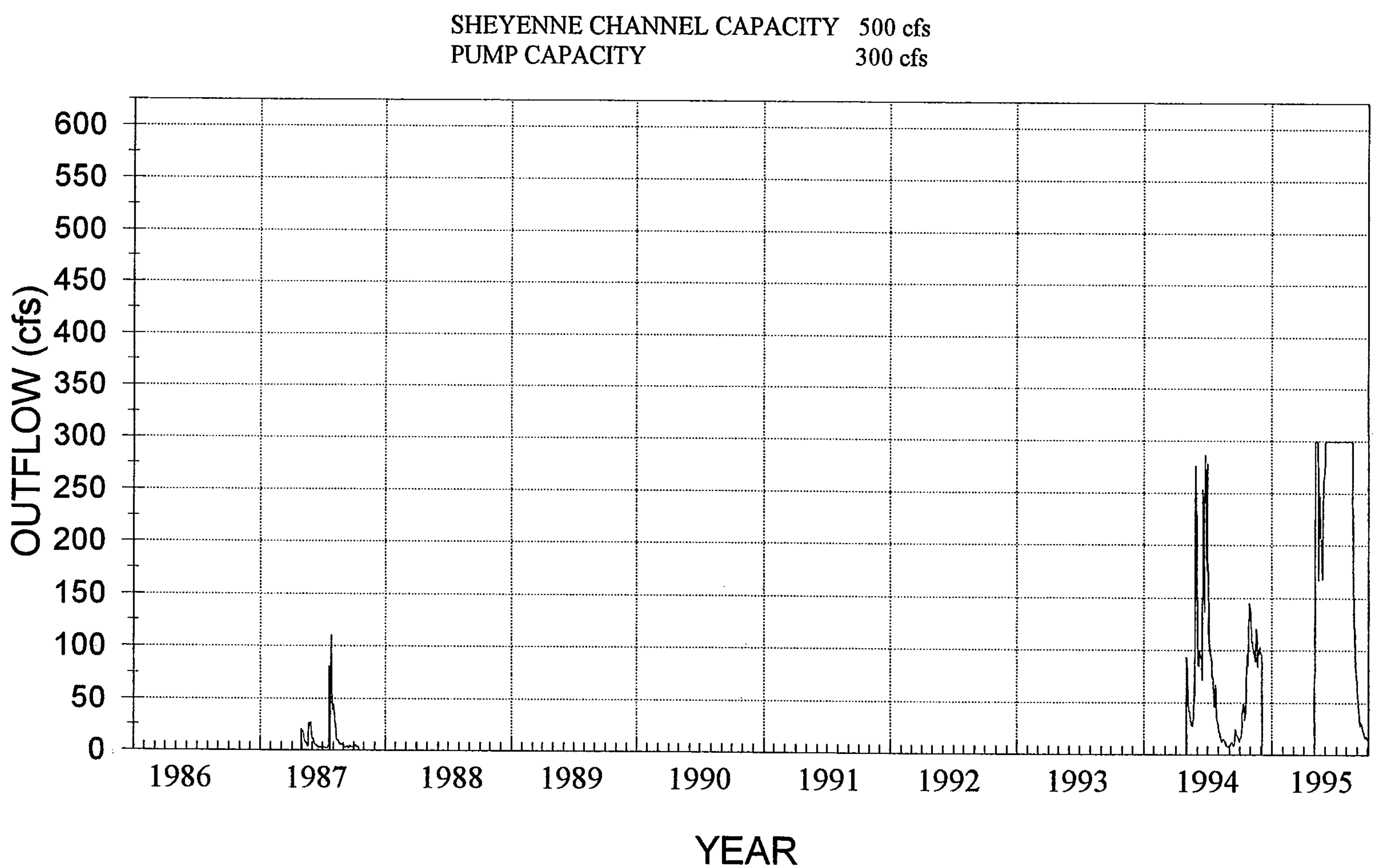
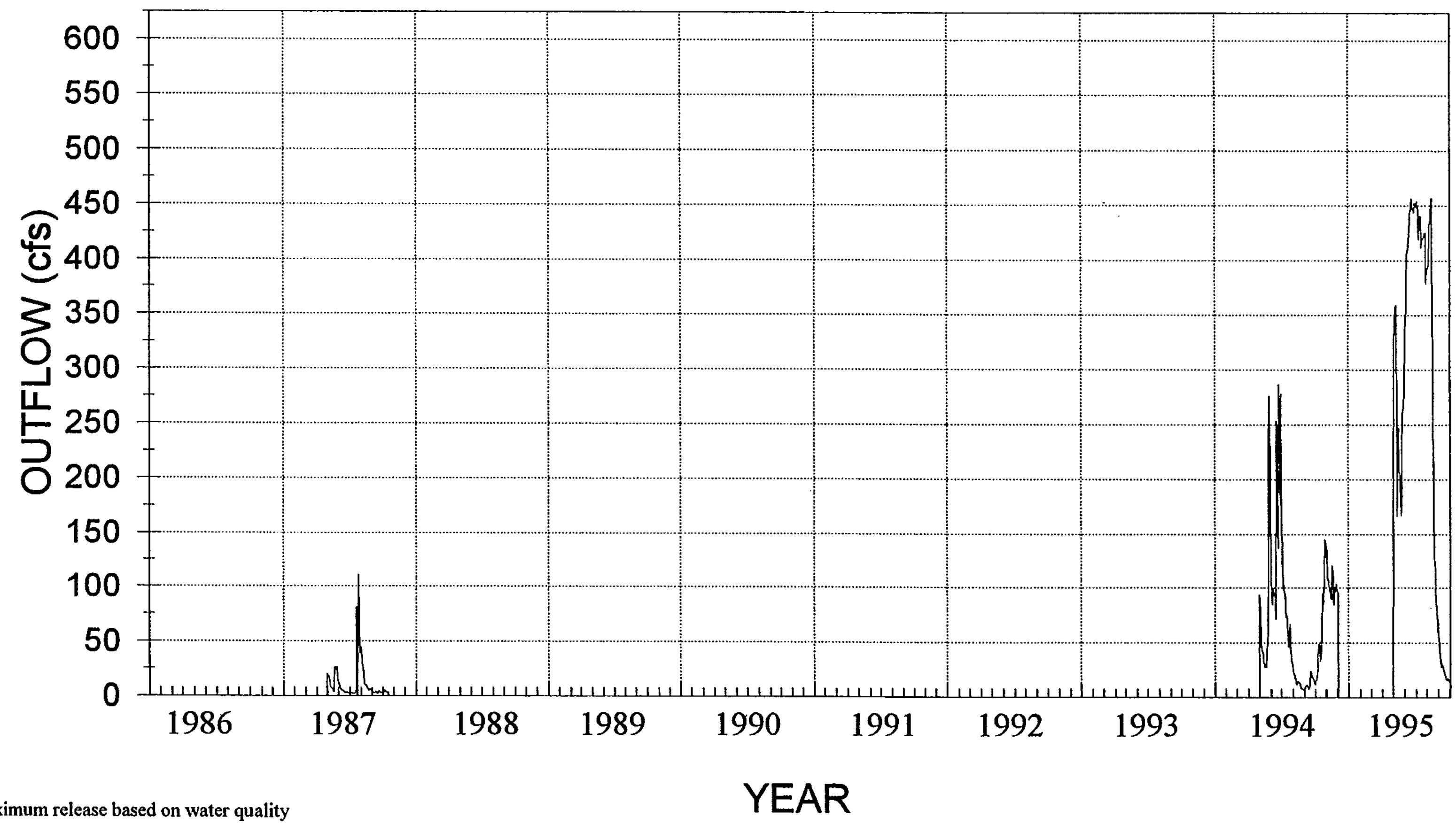


FIGURE 19

DEVILS LAKE, ND
PUMPED OUTFLOW (CFS)

SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 458 cfs*



* Maximum release based on water quality and bank-full capacity constraints

FIGURE 20

DEVILS LAKE, ND
PUMPED OUTFLOW (CFS)

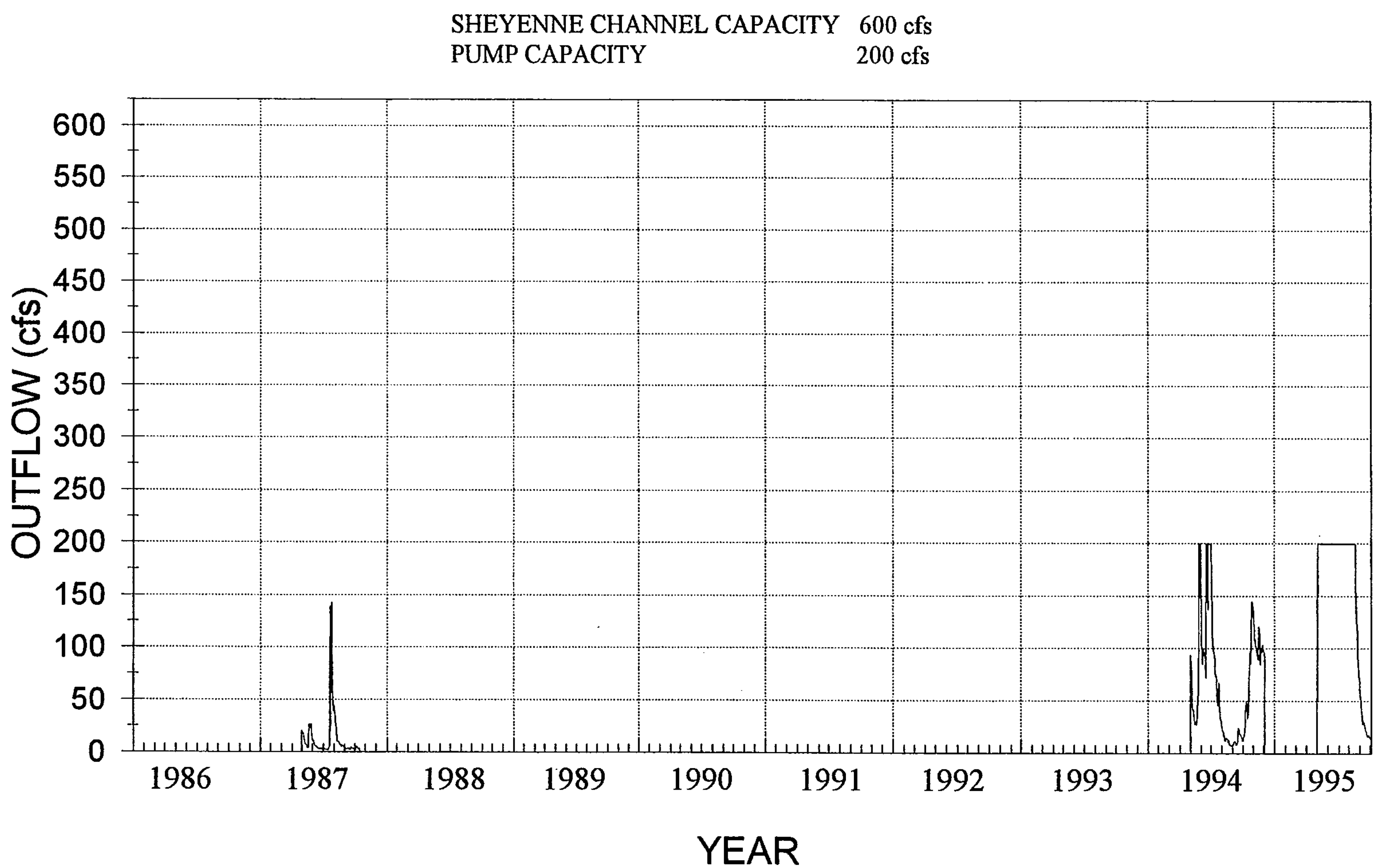


FIGURE 21

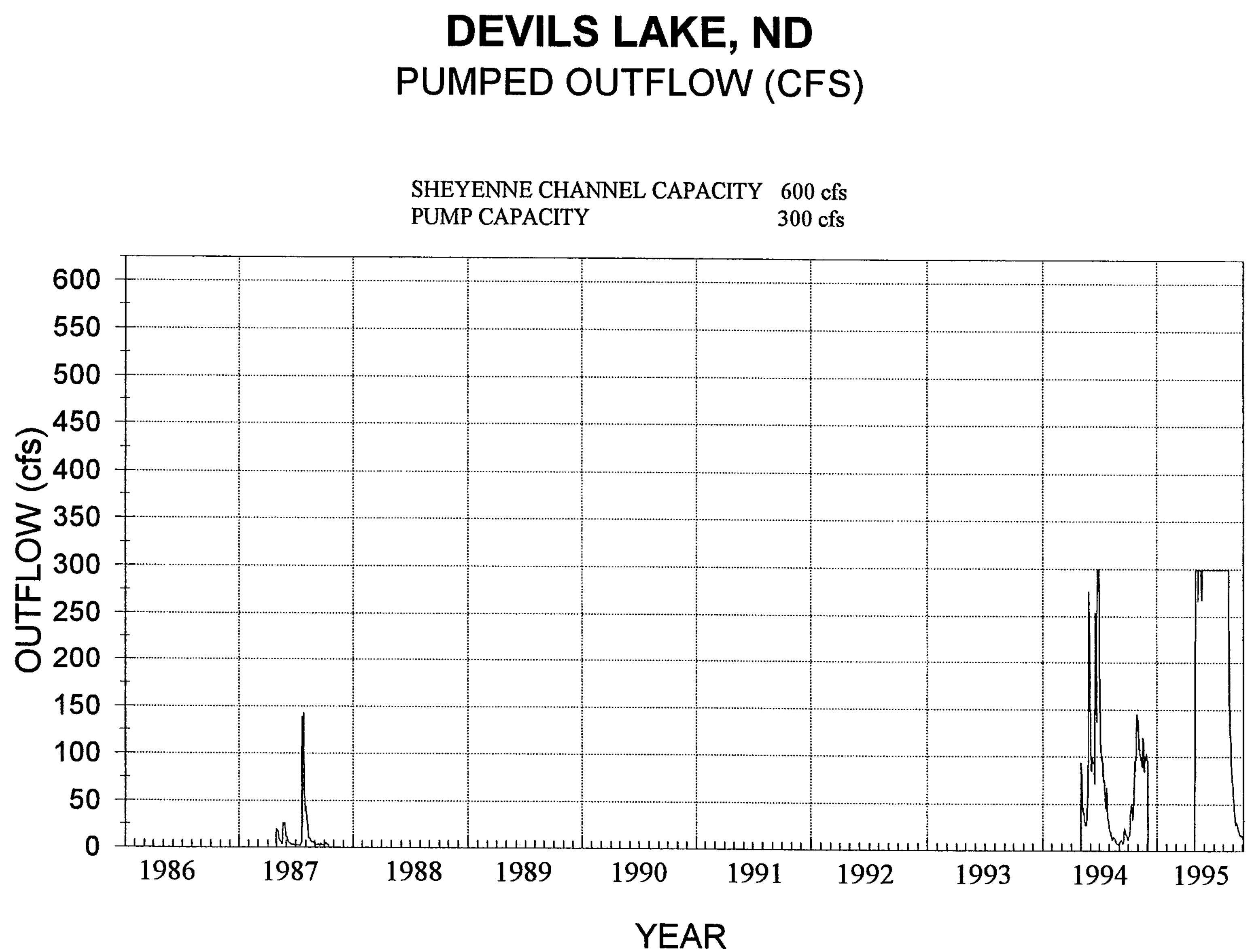
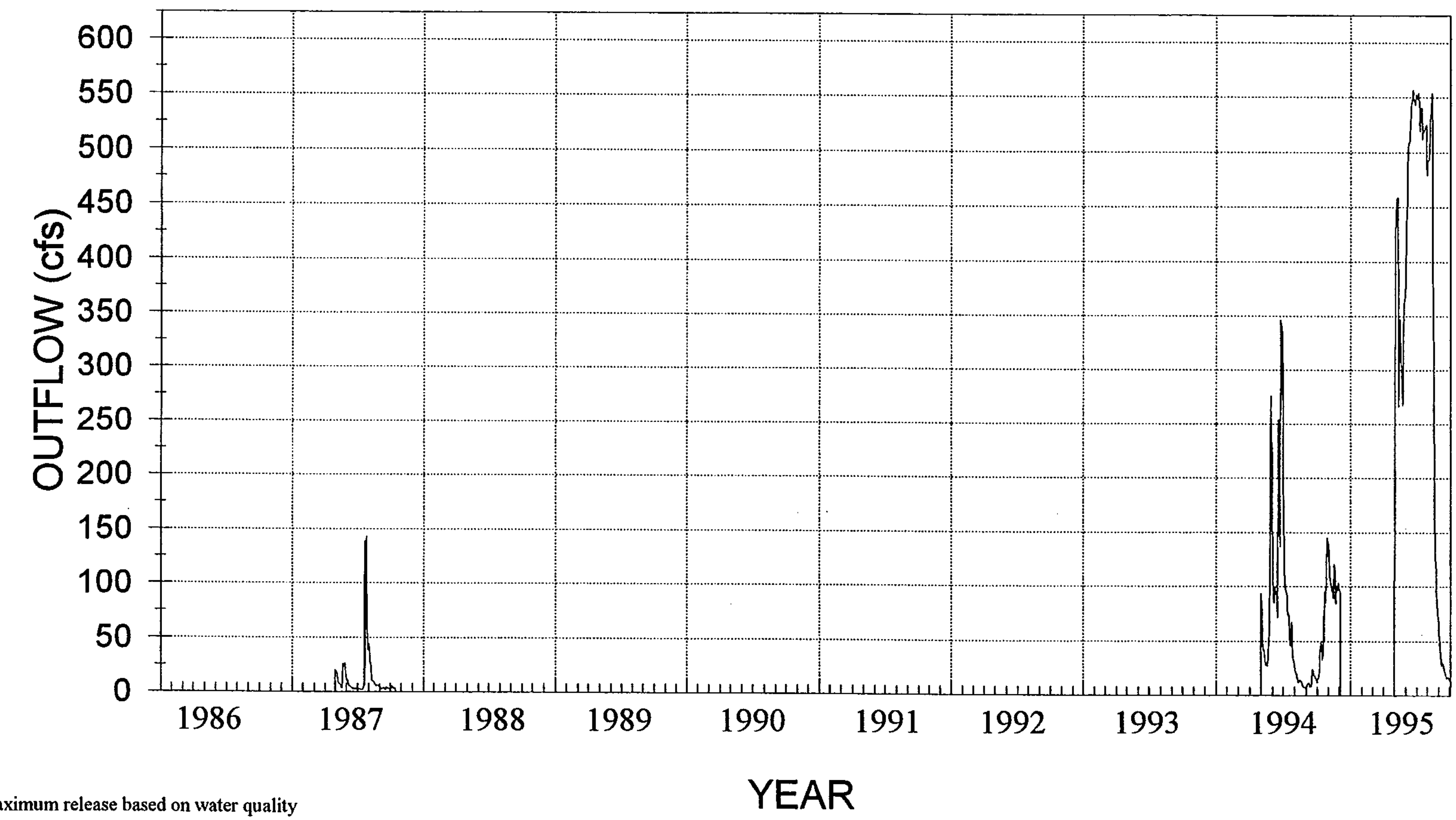

DEVILS LAKE, ND
PUMPED OUTFLOW (CFS)
SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 300 cfs
OUTFLOW (cfs)
600
550
500
450
400
350
300
250
200
150
100
50
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR

FIGURE 22

DEVILS LAKE, ND
PUMPED OUTFLOW (CFS)

SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 557 cfs*



* Maximum release based on water quality and bank-full capacity constraints

FIGURE 23

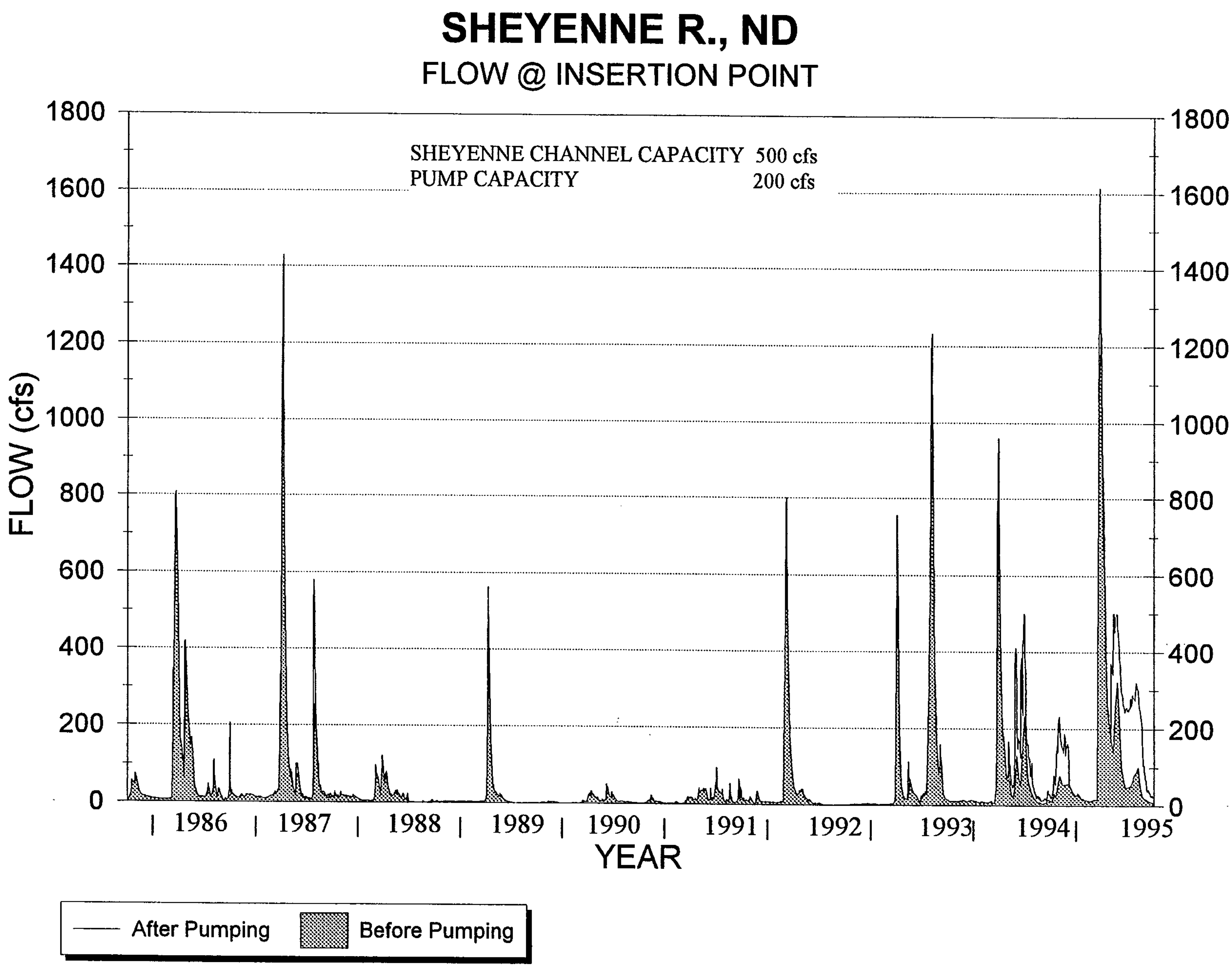

SHEYENNE R., ND
FLOW @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 200 cfs
FLOW (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping

FIGURE 24

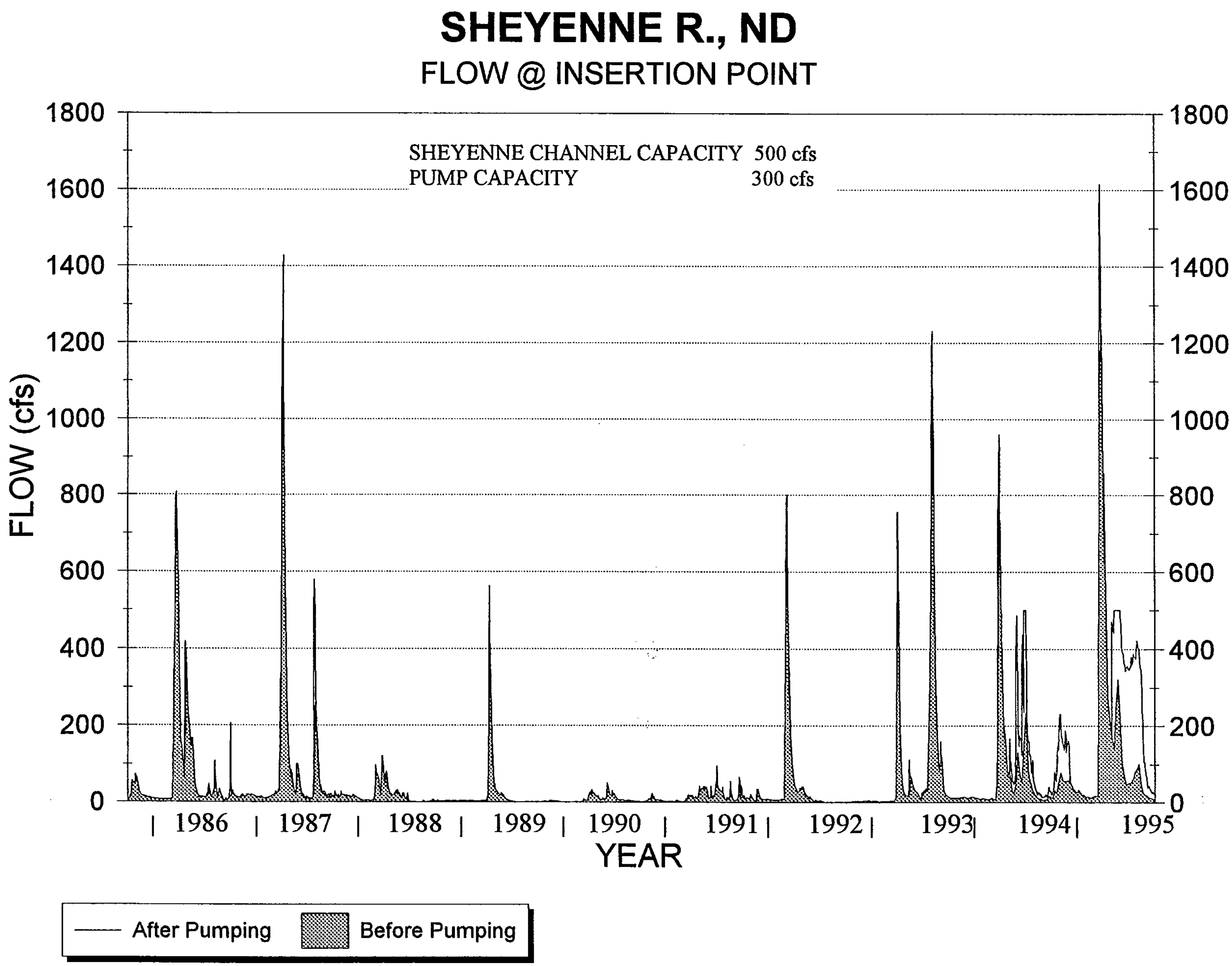

SHEYENNE R., ND
FLOW @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 300 cfs
FLOW (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping

FIGURE 25

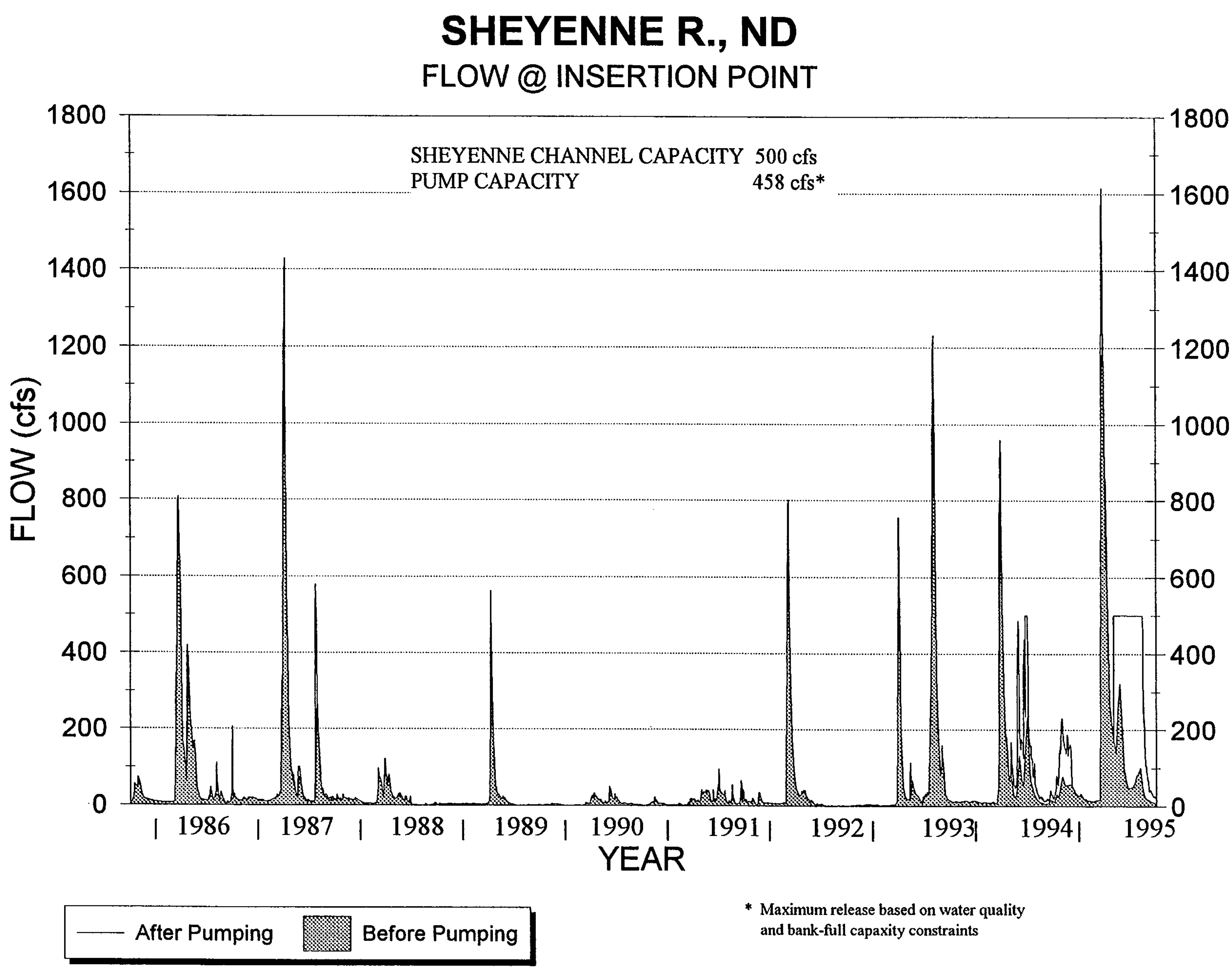

SHEYENNE R., ND
FLOW @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 458 cfs*
FLOW (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping
* Maximum release based on water quality and bank-full capacity constraints

FIGURE 26

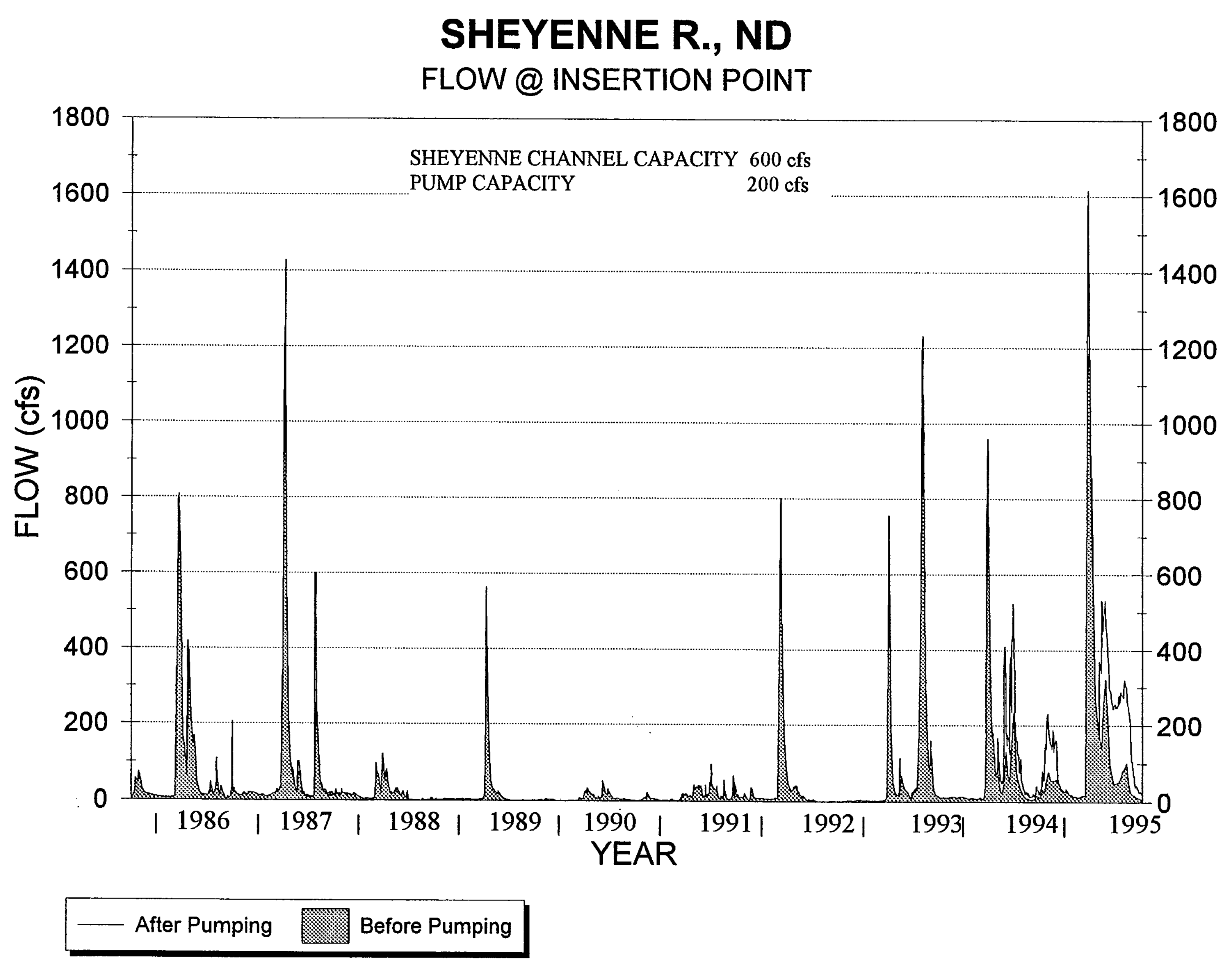
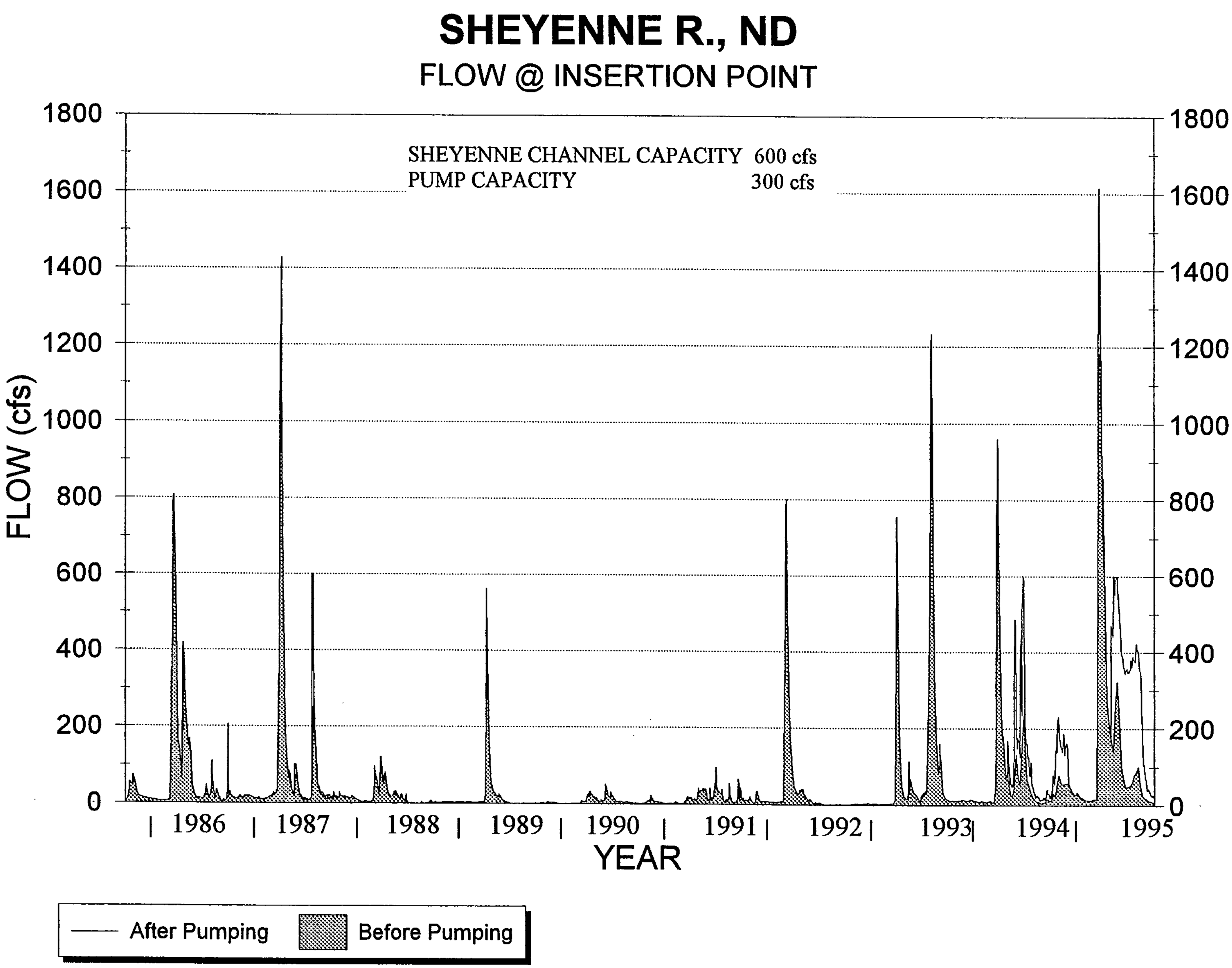

SHEYENNE R., ND
FLOW @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 200 cfs
FLOW (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping

FIGURE 27



SHEYENNE R., ND
FLOW @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 300 cfs
FLOW (cfs)
1800
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping

FIGURE 28

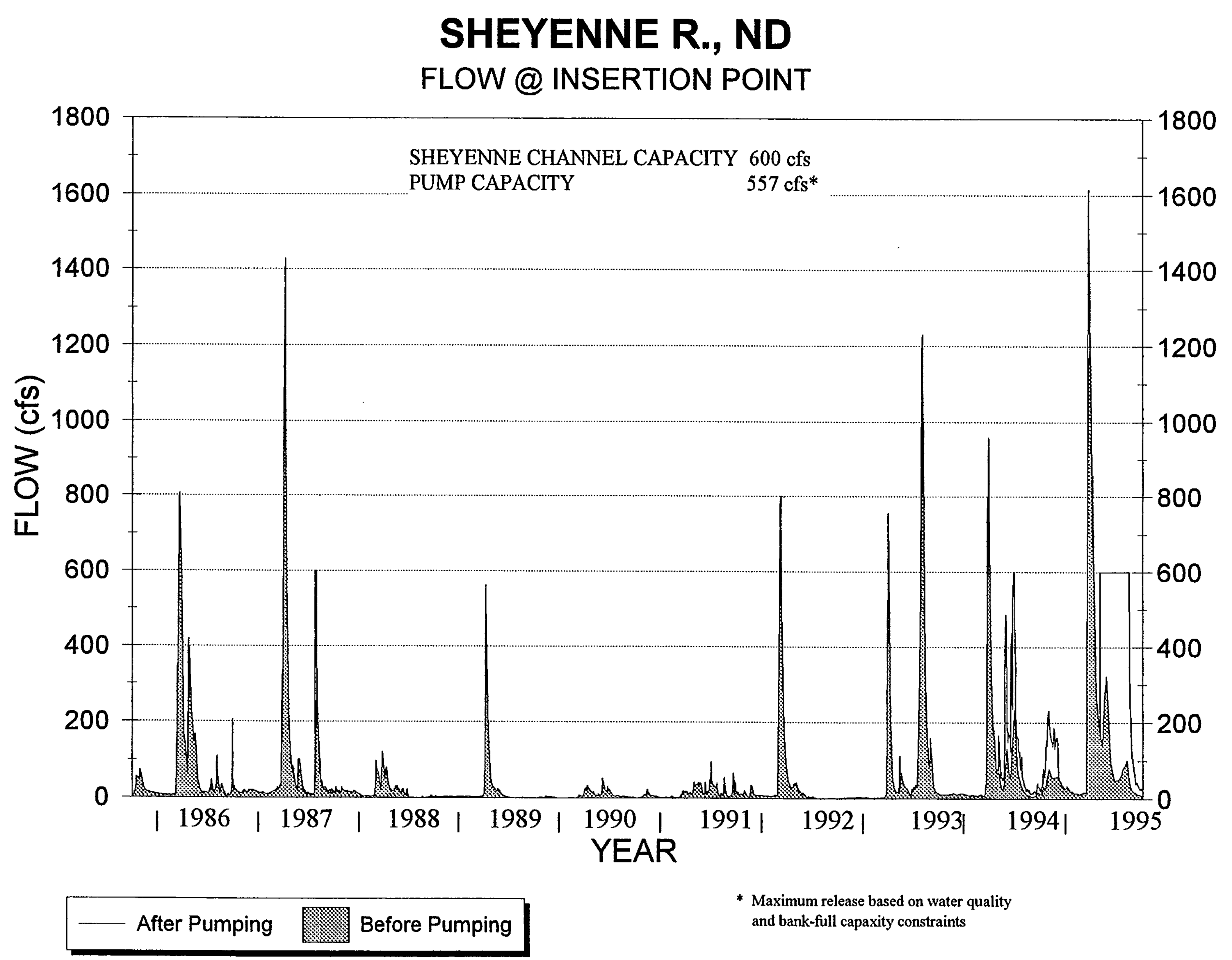

SHEYENNE R., ND
FLOW @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 557 cfs*
FLOW (cfs)
0
200
400
600
800
1000
1200
1400
1600
1800
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping
* Maximum release based on water quality
and bank-full capaxity constraints

FIGURE 29

SHEYENNE R. , ND

SULFATE CONC. @ INSERTION POINT

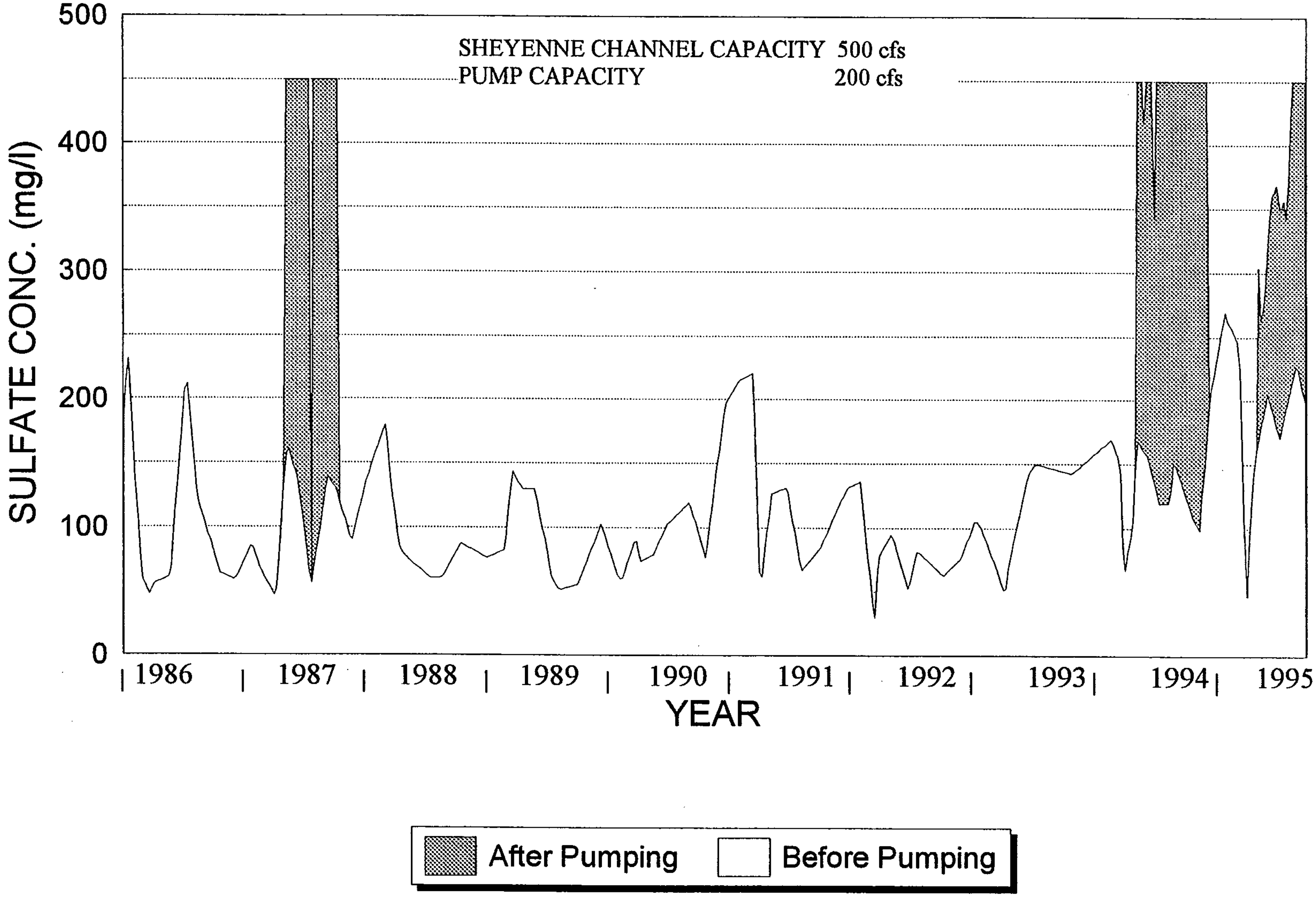


FIGURE 30

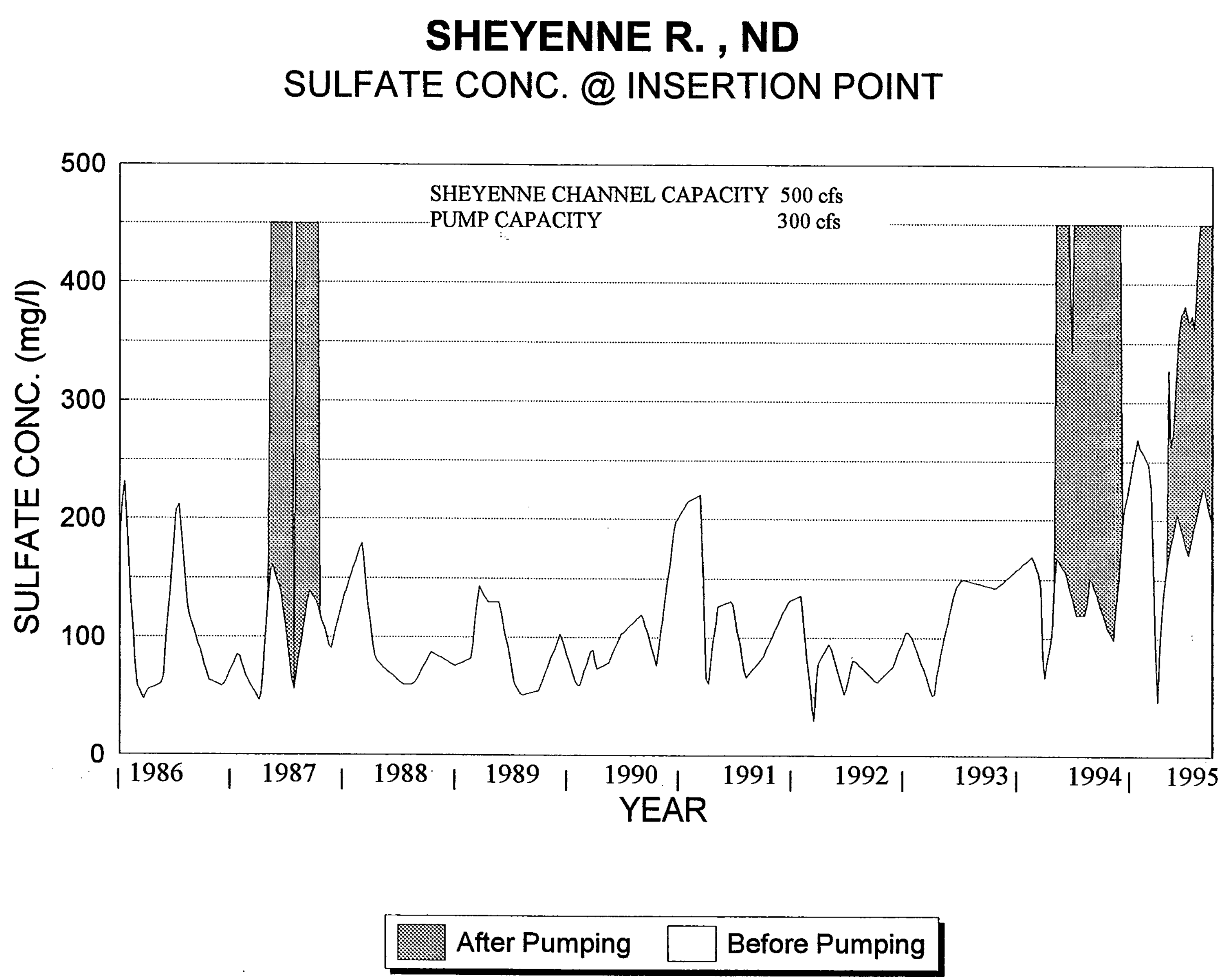
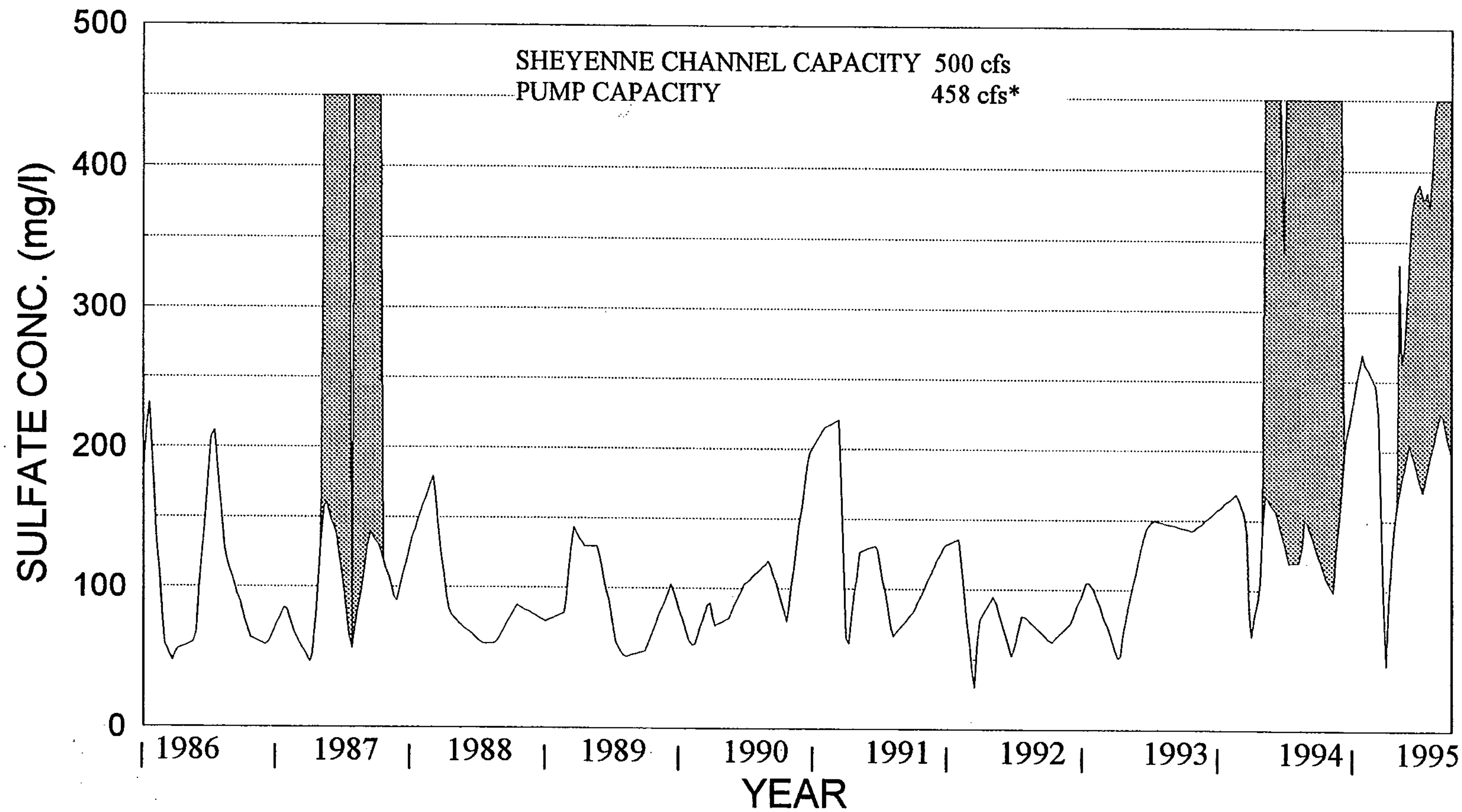

SHEYENNE R. , ND
SULFATE CONC. @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping

FIGURE 31

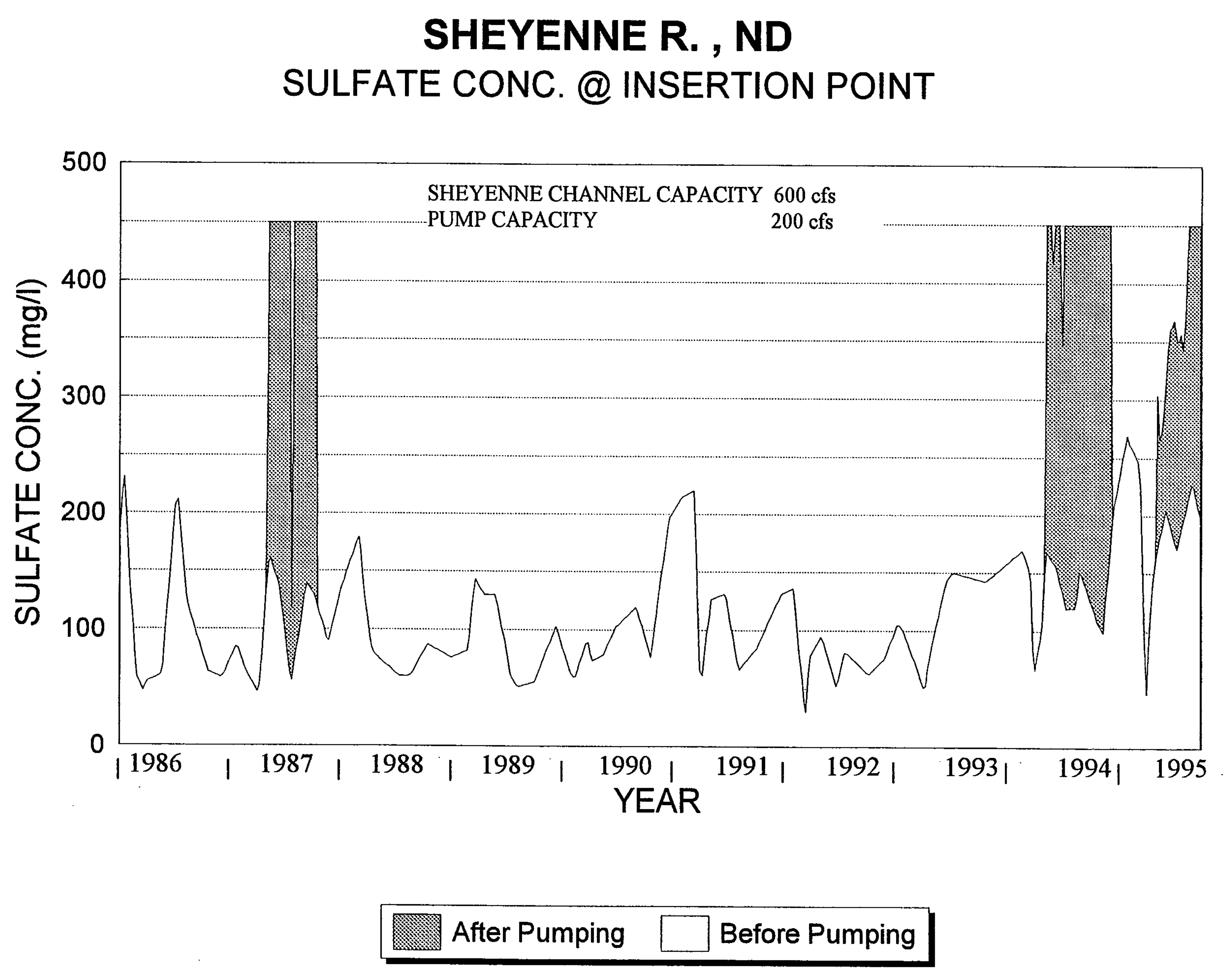
SHEYENNE R. , ND

SULFATE CONC. @ INSERTION POINT



* Maximum release based on water quality and bank-full capaxity constraints

FIGURE 32



SHEYENNE R. , ND
SULFATE CONC. @ INSERTION POINT
SHEYENNE CHANNEL CAPACITY 600 cfs
PUMP CAPACITY 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
After Pumping
Before Pumping

FIGURE 33

SHEYENNE R. , ND
SULFATE CONC. @ INSERTION POINT

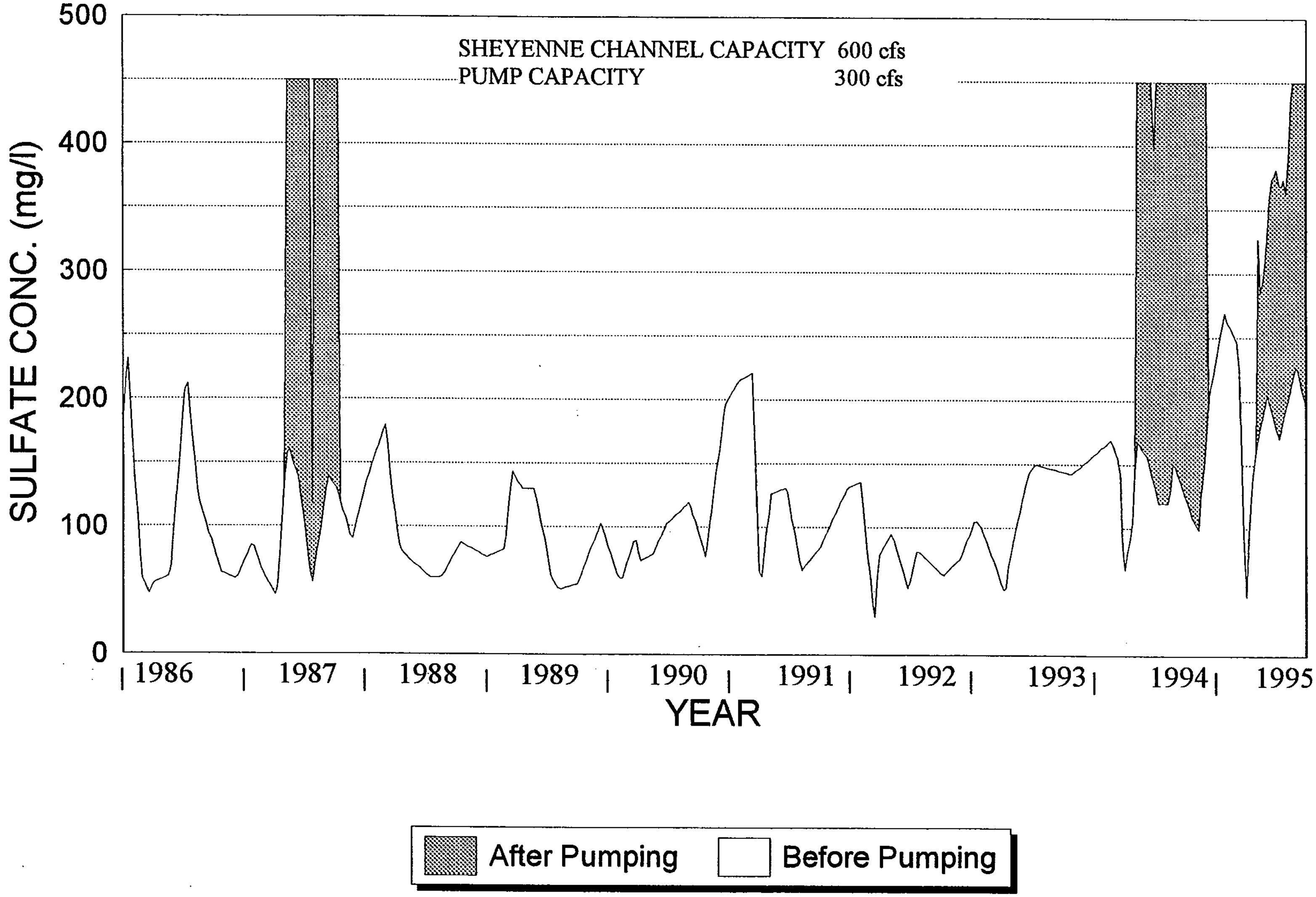
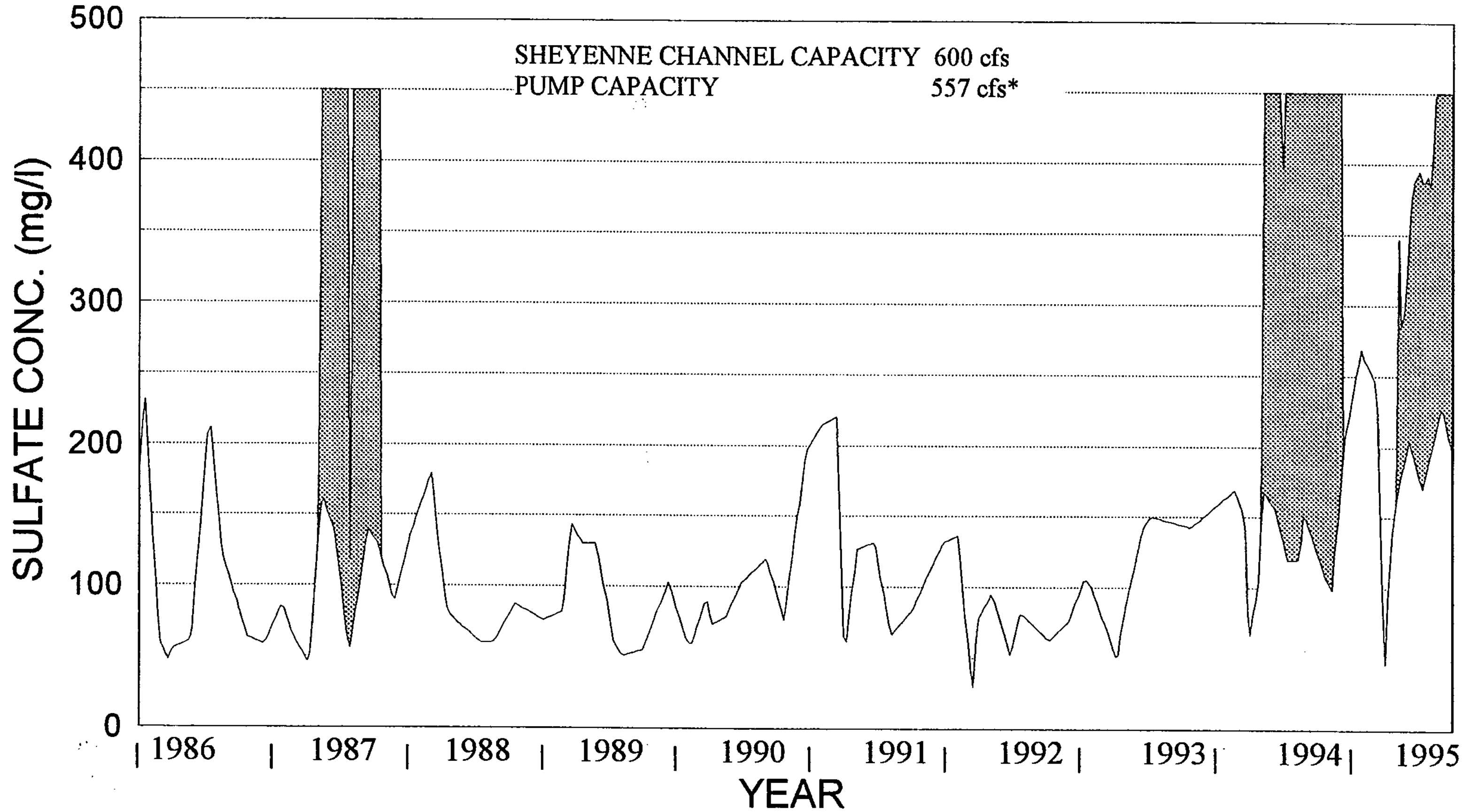


FIGURE 34

SHEYENNE R. , ND

SULFATE CONC. @ INSERTION POINT



* Maximum release based on water quality and bank-full capaxity constraints

FIGURE 35

DEVILS LAKE, ND; BIG COULEE & WEST BAY
WITH AND WITHOUT PUMPING ELEV.

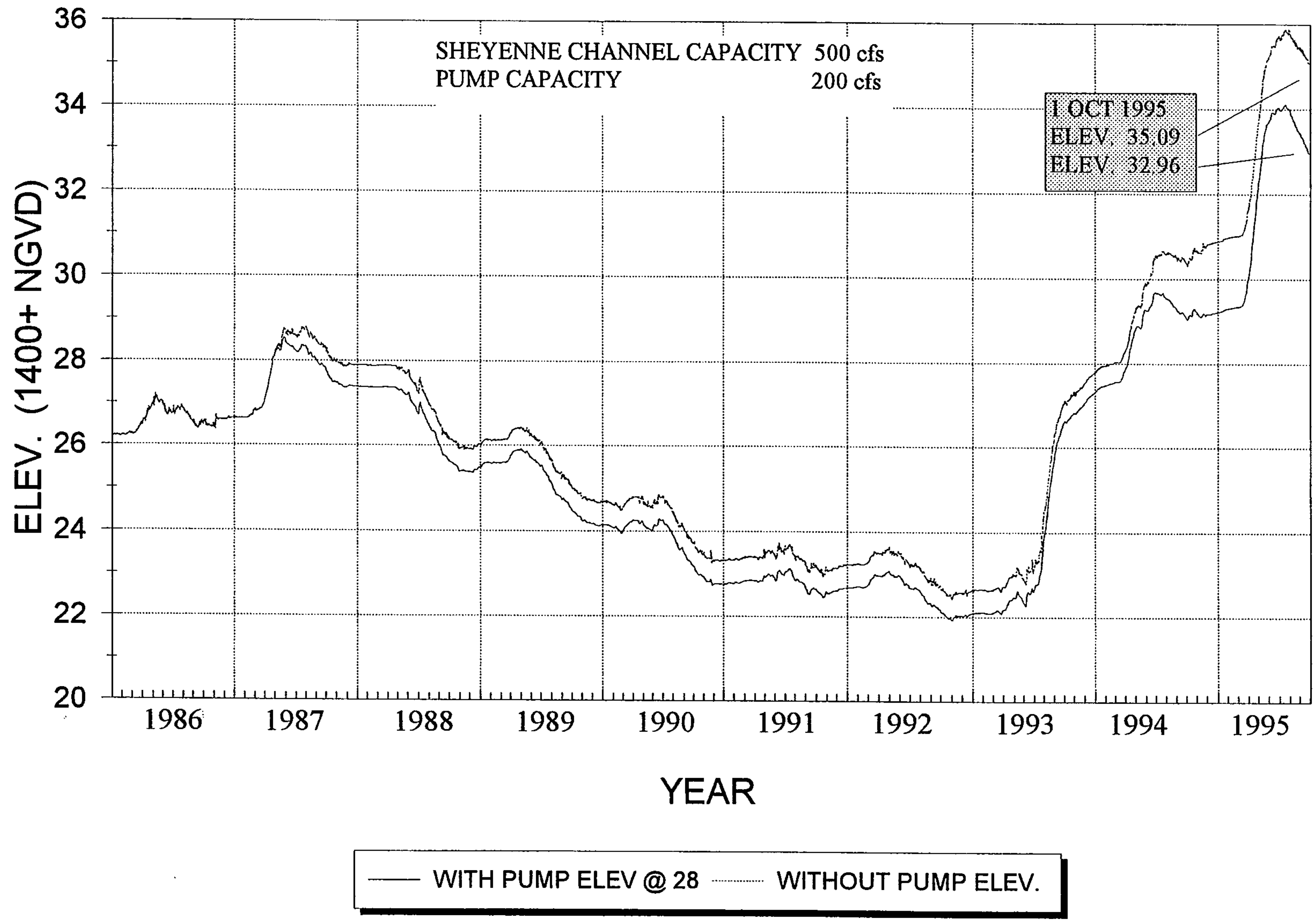


FIGURE 36

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

WATER QUALITY IMPACTS APPENDIX

WATER QUALITY IMPACTS APPENDIX

SULFATE MODELING

The water quality of Devils Lake differs considerably from that of the Sheyenne River and Red River of the North most notably with respect to its higher salinity and the relative proportion of the major ions. On the Sheyenne River and the Red River of the North, the principal cations are calcium and magnesium, and the principal anion is bicarbonate, with less than 25 percent of total dissolved solids (TDS) composed of sulfate. In Devils Lake, the principal cation is sodium and the principal anion is sulfate. About 50 percent of TDS in Devils Lake is sulfate.

This analysis of downstream effects from operation of an emergency outlet from Devils Lake deals primarily with sulfate because it is the most restrictive parameter with numerical water quality standards (450 mg/l for the Sheyenne River, 250 mg/l for the Red River). As long as the sulfate standard is met, the numerical standards for sodium, chloride, and other parameters would probably be met. There is no numerical standard for TDS applicable to the Sheyenne River. It is expected that during the feasibility study other, probably non-numerical, water quality criteria will be identified and addressed to protect or mitigate for impacts affecting designated uses of the receiving waters. It is also possible, if not likely, that a water quality parameter such as TDS or chloride, with numerical standards applicable to the Red River, could prove to be more restrictive than sulfate on the Sheyenne River.

The model, SHYREDWQ, is a LOTUS spreadsheet that computes the mass balance of flow and sulfate load, producing time and concentration plots for nine locations downstream of the outlet's confluence with the Sheyenne River. The concentrations are computed for each location by combining the respective upstream flow and concentration with local contributing flow and concentration. Local flows are the difference between the upstream and downstream stations for each specific reach. Local concentrations were similarly determined using long-term monitoring data. All flow inputs are quarter monthly mean values computed from daily USGS flow records. Local concentration values were computed from mean monthly values based on long-term averages or, in some cases, were estimated using professional judgment. The quarter monthly time interval permits the use of different travel time assumptions between stream reaches. The model predicts sulfate concentrations at Warwick, Cooperstown, Baldhill Dam, Lisbon, Kindred, and West Fargo on the Sheyenne River and at Halstad, Grand Forks, and Emerson on the Red River of the North.

The model was run for the period 1 October 1985 through 30 September 1995 using output from the Devils Lake pumping model (see the EFFECTIVENESS APPENDIX). Those daily values were combined with daily flow and sulfate concentrations of the Sheyenne River at Warwick to determine a modified flow and sulfate record at Warwick. The modified record represents different operational scenarios of the Devils Lake outlet project. The daily record was reduced, by averaging, to a quarter monthly record for continued routing downstream. Allowance for travel time between Warwick and Cooperstown (1 quarter month) was accomplished by shifting spreadsheet columns. Quarter-month lags were also used between Lake Ashtabula and Lisbon, Kindred and West Fargo, Halstad and Grand Forks, and Grand Forks and Emerson. Baldhill Dam was assumed to pass all marginal (pumping) inflow without delay.

MODEL RESULTS: 200-cfs outlet capacity / 500-cfs channel capacity

Figures 1 - 3 illustrate downstream effects from Devils Lake outlet operation during the historic period October 1985 - September 1995 if it had operated with the following restrictions:

Devils Lake trigger elevation: 1428
Design peak outlet capacity: 200 cfs
Sheyenne River bank-full channel capacity: 500 cfs
No pumping from 1 December through 30 April

During that period, pumping would have been allowed during three events -- 1987, 1994, and 1995. Figure 1 at Warwick shows that pumping was limited most of the time by the 450 mg/l in-stream sulfate standard during the first two pumping events. The plots peak slightly below 450 mg/l because there is a small amount of local inflow diluting the combined river/outlet flow between the point of discharge and the Warwick gage. Extended periods of sulfate limitation produce flat tops on the peaks. Deviations from flat tops were caused by 5 days of pumping reduction due to an interval when channel capacity was the constraint. The abrupt ascending and descending limbs were due to the 1 May start-up and 30 November cutoff of operation. Note that sulfate concentration at Warwick was increased by 200 to 300 mg/l above baseline (ambient conditions) during much of the duration of all three events.

Figure 1 at Cooperstown shows the sulfate concentration was attenuated more than at Warwick by the additional local flow entering the Sheyenne River between the two locations. The effect of the pumping did not persist for more than a week beyond the pumping cutoff date.

Figure 1 at Baldhill Dam/Valley City shows the concentration was attenuated significantly by mixing with Lake Ashtabula and local contributing flow, including Baldhill Creek. The effect persisted for several years after pumping cutoff because storage in Lake Ashtabula was large compared to runoff during the drought years of 1987 through 1991. In contrast, Lake Ashtabula freshened rapidly after the 1994 pumping period because high inflows at that time "flushed" the lake out.

Figure 2 shows that water quality of the lower Sheyenne River is largely determined by storage in Lake Ashtabula. Sulfate concentrations at Lisbon, Kindred, and West Fargo are only slightly more attenuated than at Baldhill Dam. Much of the effect of the 1987 pumping was realized in 1988 with a 20-percent increase over baseline sulfate levels.

Figure 3 shows that the effects of the first two pumping periods were relatively minor on the Red River of the North. During the 1995 pumping period, however, the sulfate concentration increased by about 28 percent over baseline at Halstad and by about 20 percent over baseline at Grand Forks and Emerson. The Red River of the North's numerical standards and international objectives for sulfate were not exceeded during any of the operational periods. It is possible, however, that communities using the river for water supply might have incurred higher treatment costs due to increased sulfate and other water quality parameters from outlet operation.

MODEL RESULTS: 300-cfs outlet capacity / 500-cfs channel capacity

Figures 4 - 6 describe the case with design peak pumping capacity of 300 cfs and 500-cfs bank-full capacity. During the 1987 pumping period, the additional pumping capacity (above the 200-cfs case) was essentially unused because the sulfate constraint was already reached with the lesser discharge.

During the 1994 pumping period, the additional pumping capacity was used so infrequently that the difference in downstream effects is negligible.

By the 1995 pumping period, Devils Lake had freshened enough that pumping was limited more often by pumping capacity and bank-full capacity than by water quality. A slight difference can be seen during the 1995 operating period because pumping at rates greater than 200 cfs was allowed much of the time. The effect at Halstad is a 31-percent increase over the baseline sulfate condition. The effect at Grand Forks and Emerson was a 25-percent increase.

MODEL RESULTS: 557-cfs outlet capacity / 600-cfs channel capacity

This case represented the most liberal use of the outlet that was analyzed. Although outlet capacity theoretically was not limited in this particular analysis, bank-full and sulfate constraints restricted the maximum calculated outflow during the 10-year simulation to 557 cfs.

During the 1987 pumping period, the additional channel capacity allowed additional pumping for only 4 days in July. Figures 7 - 9 show that the marginal water quality effect compared to the 200-cfs/500-cfs case was negligible.

During the 1994 pumping period, additional pumping was allowed on 17 days. On 13 of those days, pumping was limited by water quality before channel capacity was reached. The marginal water quality effect was again negligible.

During the 1995 pumping period, considerably more pumping was allowed because, with the freshening lake water, outlet operation avoided the sulfate constraint and, therefore, could take advantage of the additional channel capacity and pumping capacity. The marginal effect is especially noticeable at Red River locations (compare Figures 3 and 9). The effect at Halstad is a 40-percent increase over the baseline sulfate condition. Increases at Grand Forks and Emerson are 35 and 31 percent, respectively.

MODEL RESULTS: 200-cfs outlet capacity / 500-cfs channel capacity / tapping Big Coulee water

Sensitivity tests were also run to assess the relative effectiveness of an outlet tapping a fresher source of discharge water. These tests used the same constraints -- a trigger elevation of 1428, 200-cfs peak pumping capacity, 7-month pumping window, 500-cfs bank-full capacity in the river, and 450-mg/l sulfate standard in the river.

Scenario A assumed that Big Coulee water could be pumped to the Sheyenne River before mixing with Devils Lake water. Because the sulfate concentration in Big Coulee water is below the river's sulfate standard, coulee water could be pumped without running into the water quality constraint until either the design pumping capacity or bank-full capacity was reached, with excess coulee inflow bypassed into the West Bay. This scenario produced a with-project lake elevation on 30 September 1995 of 1433.53, a drawdown of 1.56 feet from the without-project elevation.

Under Scenario B, when coulee inflows decreased to the point that there would be additional pumping or bank-full capacity, West Bay water would be added to the outlet flow until the total discharge matched the design peak pumping capacity or until the mix of coulee, West Bay, and river water reached either the 500-cfs bank-full capacity or 450-mg/l sulfate standard. Because the sulfate concentration of coulee and river water was similar, tapping the coulee had the same effect as having more river flow with which to dilute West Bay discharges; this allowed the outlet to release even more West Bay water. Scenario B increased the drawdown to a calculated 2.13 feet.

Figures 10 - 12 (corresponding to Scenario B) show significant differences from Figures 1 - 3. Because of the higher volume of discharge made possible by tapping Big Coulee inflows, peak sulfate concentrations with Scenario B exceed those drawing just on West Bay water. For example, Figure 10 at Warwick shows higher peak sulfate concentrations than Figure 1 because local inflows have a reduced dilution effect with Scenario B's larger volume of discharge. Similarly, Figure 10 at Baldhill Dam shows higher sulfate levels in mid-1987 under Scenario B because the dilution impact from Lake Ashtabula's storage is reduced with the higher volume of inflow at the 450-mg/l sulfate limit.

Figure 10 at Warwick also shows that, in 1987, Scenario B's larger discharge drew Devils Lake below the trigger elevation faster than in Figure 1, resulting in an earlier shutdown of operation.

In addition, Figure 10 shows that, in 1987, 1994, and 1995, the sulfate level at all locations peaks later than in Figure 1 because, under Scenario B, outlet operation early in the year taps the fresher Big Coulee water rather than the higher sulfate West Bay water. This effect is particularly pronounced in early 1994 and 1995 and is noticeable at all downstream locations.

CONCLUSIONS

The 10-year pumping model describes the way a real-time water control operating plan would work to achieve optimal effectiveness within the confines of several restrictive criteria. The plan would assert nearly absolute control over effects at a point immediately downstream of the outlet if real-time data are available. However, effects are less controllable downstream of the control point because operational control would depend on increasingly unpredictable "future" data.

The 10-year water quality effects model shows effects that, for the most part, are not controllable at the pumping site. During the 1987 pumping period, for example, the operators would not have known that a 5-year drought would follow and, as a result, that the effects of 6 months of outlet operation would persist in Lake Ashtabula and be felt downstream of the reservoir for many years. The model appears to confirm that meeting the 450 mg/l sulfate objective at Warwick adequately protects against excursions of sulfate standards downstream, including the more restrictive 250 mg/l standard for the Red River of the North.

Sulfate concentrations under the existing conditions are well enough below the standard that the predicted 20- to 40-percent increase does not significantly encroach upon it. The increased sulfate concentration implies, however, that there would be a corresponding increase in TDS.

Figures 13 - 17 show recorded baseline sulfate and TDS concentrations vis-a-vis the respective standards at locations along the Sheyenne and Red Rivers. Note that ambient sulfate concentrations stay below the respective standard at all locations. However, baseline TDS on the Red River can exceed the 500-mg/l TDS standard and matching objective at the International Border. Although there is no standard for TDS on the Sheyenne River, Figure 13 shows baseline TDS values at Cooperstown frequently are above 600 mg/l, reflecting runoff from the Northern Glaciated Plains ecoregion. The water quality of the Red River at Fargo (above the confluence with the Sheyenne River) is largely determined by runoff from the Ottertail River watershed, characterized by the North Central Hardwood Forest ecoregion; consequently, Figure 14 shows that TDS in the Red River at Fargo rarely exceeds the 500-mg/l TDS standard.

The Sheyenne River's introduction of high TDS water into the Red River is reflected in Figure 15 at Halstad where TDS exceeds the standard a significant percentage of the time. Water quality at Grand Forks (Figure 16) shows the effects of the Red Lake River introducing a large volume of low TDS water from the Northern Minnesota Wetlands ecoregion and low TDS inflows from the Red River Valley ecoregions, which greatly reduces the incidence of TDS exceeding the standard. However, an influx of high TDS waters from tributaries north of Grand Forks (e.g., the Forrest, Tongue, Park, and Pembina Rivers, which originate from near surface bedrock aquifers) results in significant exceedences of the TDS standard.

Because, at certain locations along the Red River, baseline TDS exceeds the standard at times, and assuming that TDS levels increase proportionately to the model's predicted sulfate increases from outlet operation, it is reasonable to conclude that frequency, duration, and magnitude of TDS exceedences of the standard and international objective could occur with outlet operation.

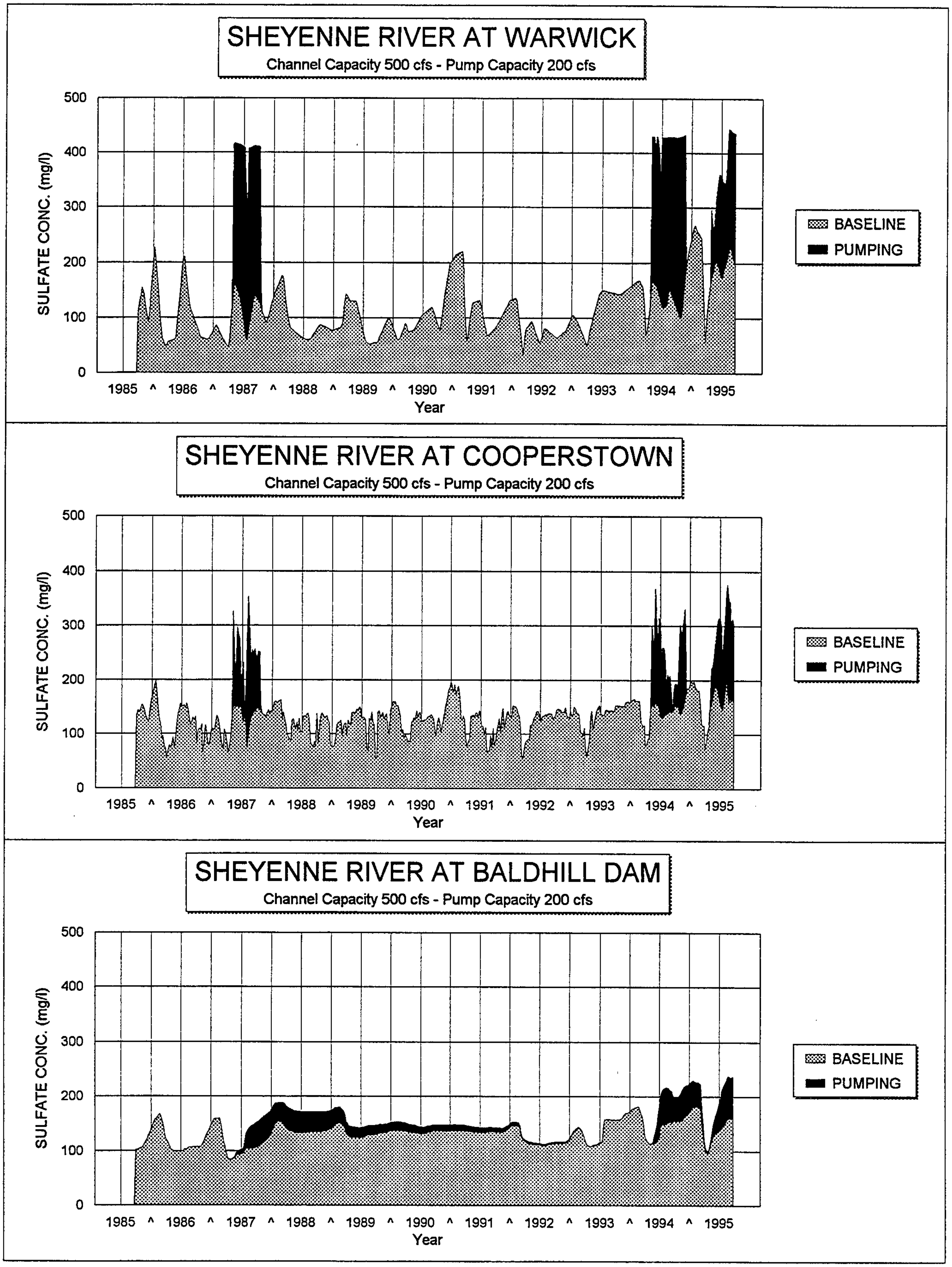

SHEYENNE RIVER AT WARWICK
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT COOPERSTOWN
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT BALDHILL DAM
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 1

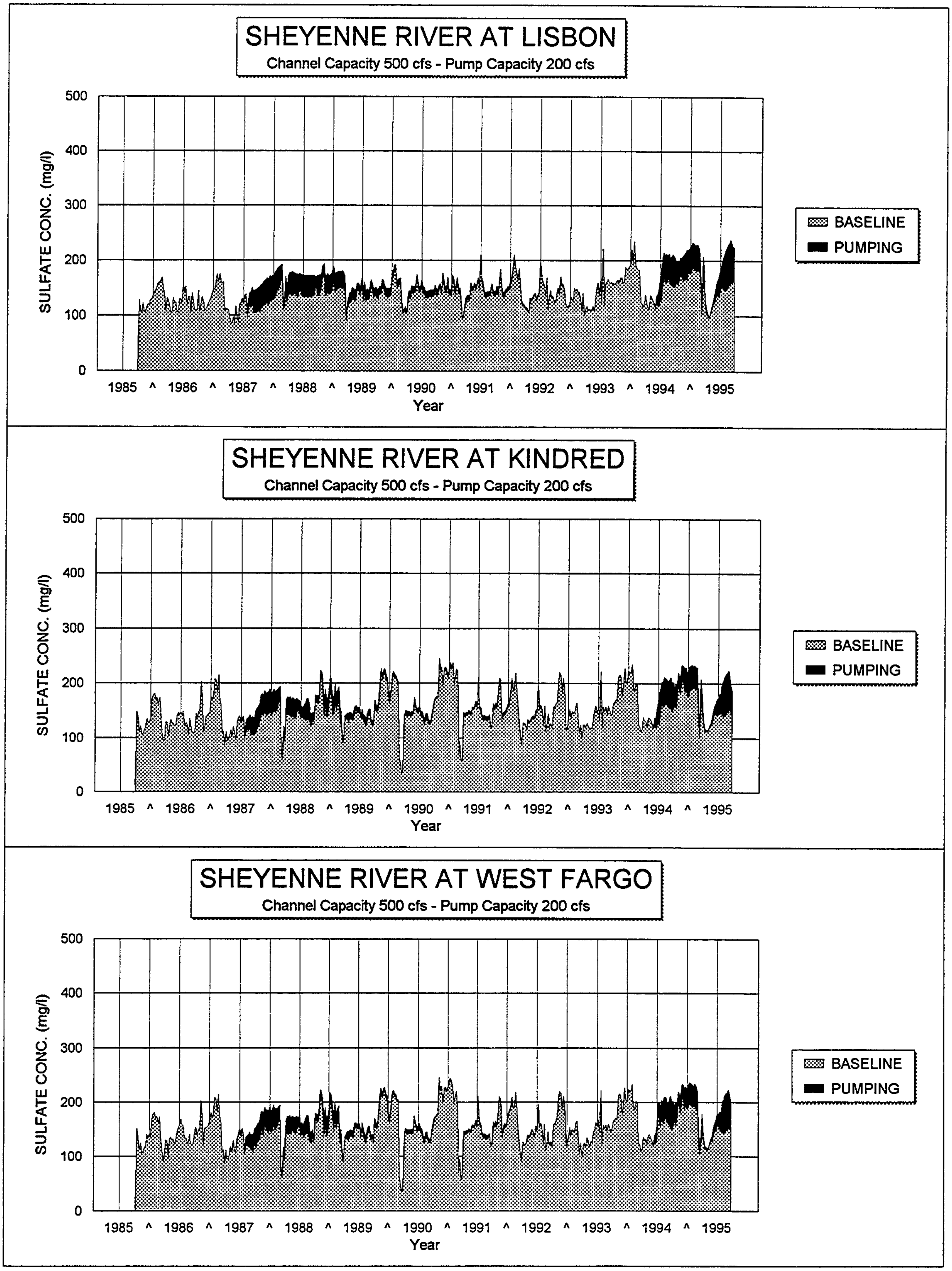

SHEYENNE RIVER AT LISBON
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT KINDRED
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT WEST FARGO
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 2

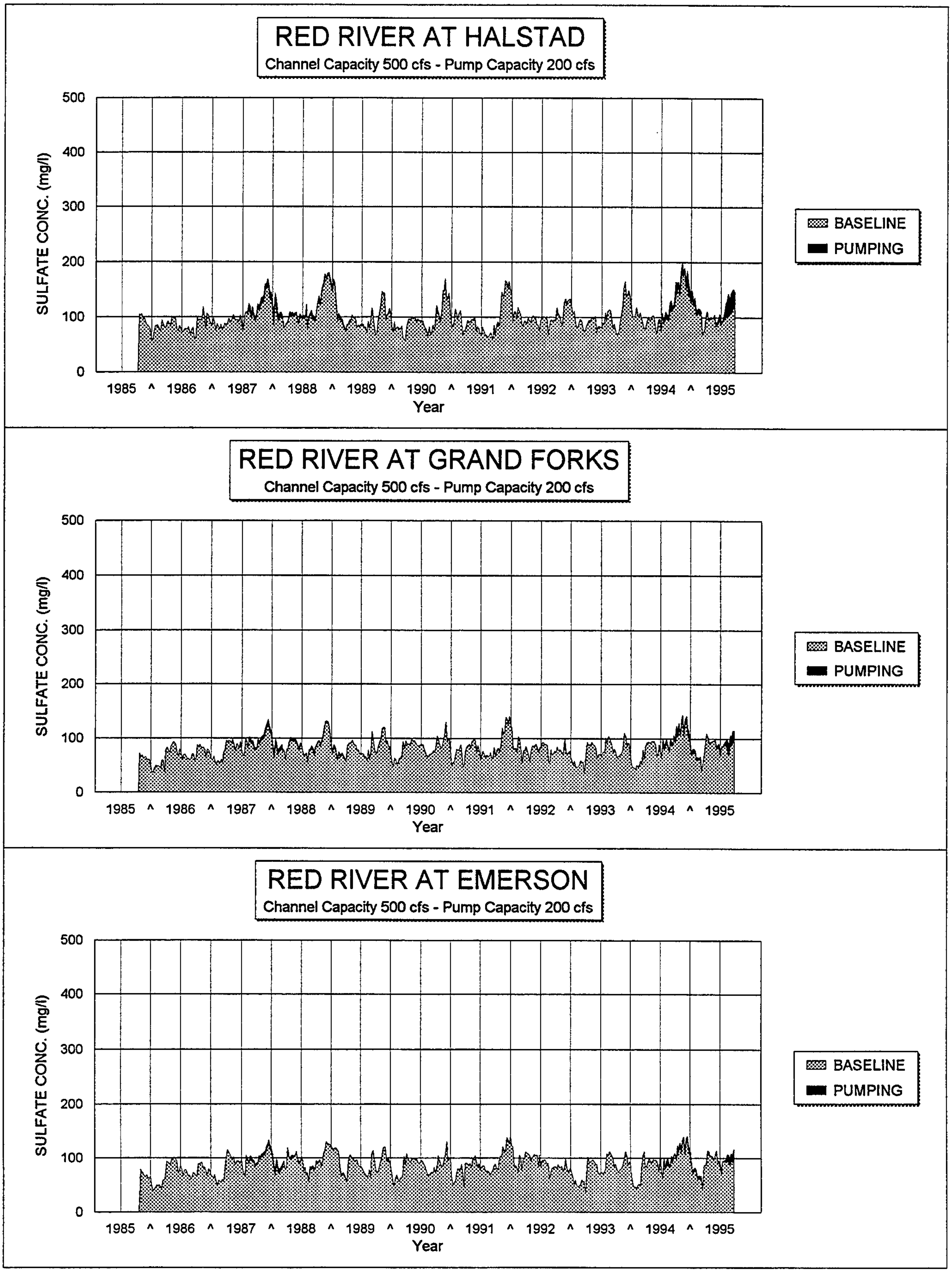
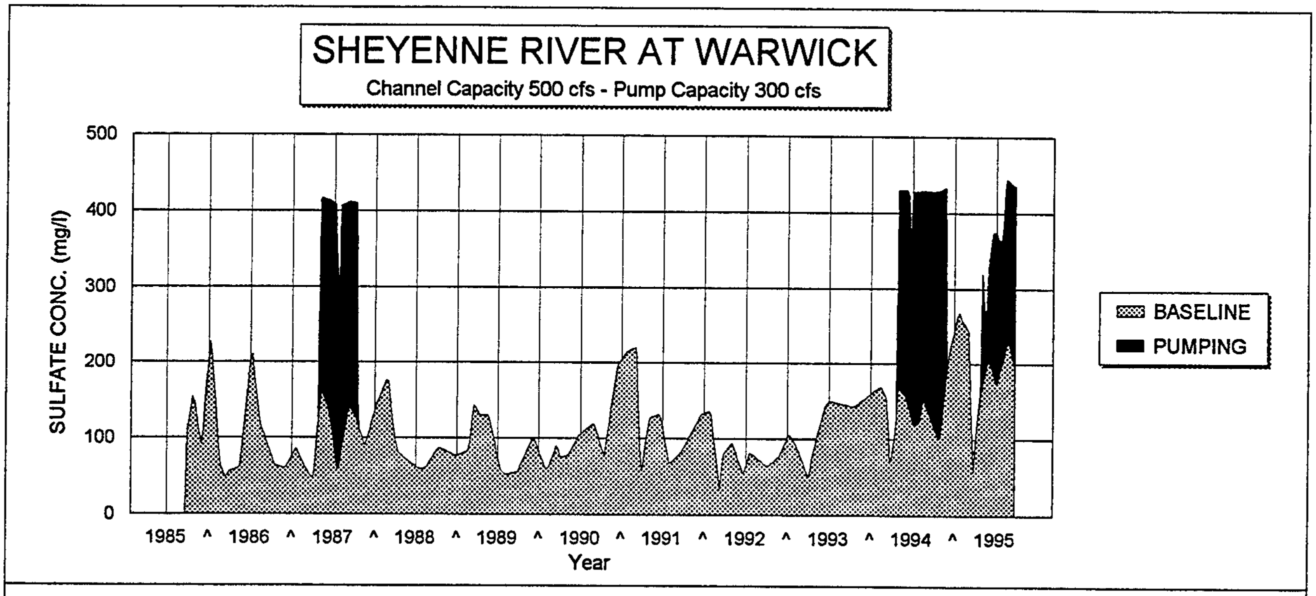
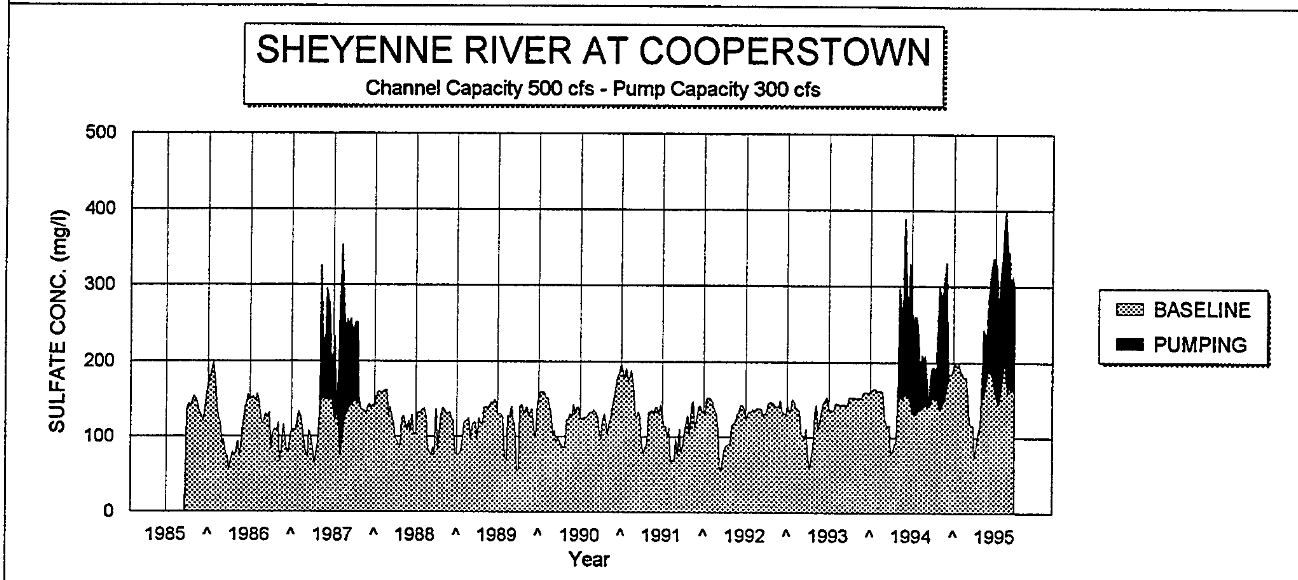

RED RIVER AT HALSTAD
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
RED RIVER AT GRAND FORKS
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
RED RIVER AT EMERSON
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 3


SHEYENNE RIVER AT WARWICK
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING


SHEYENNE RIVER AT COOPERSTOWN
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

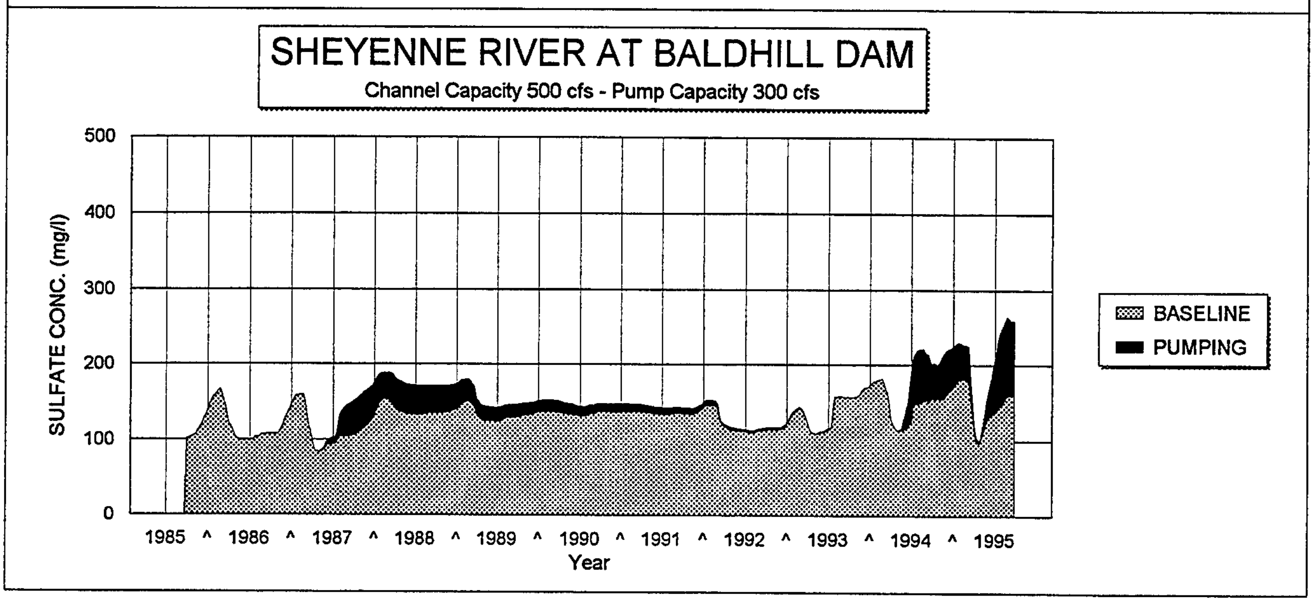
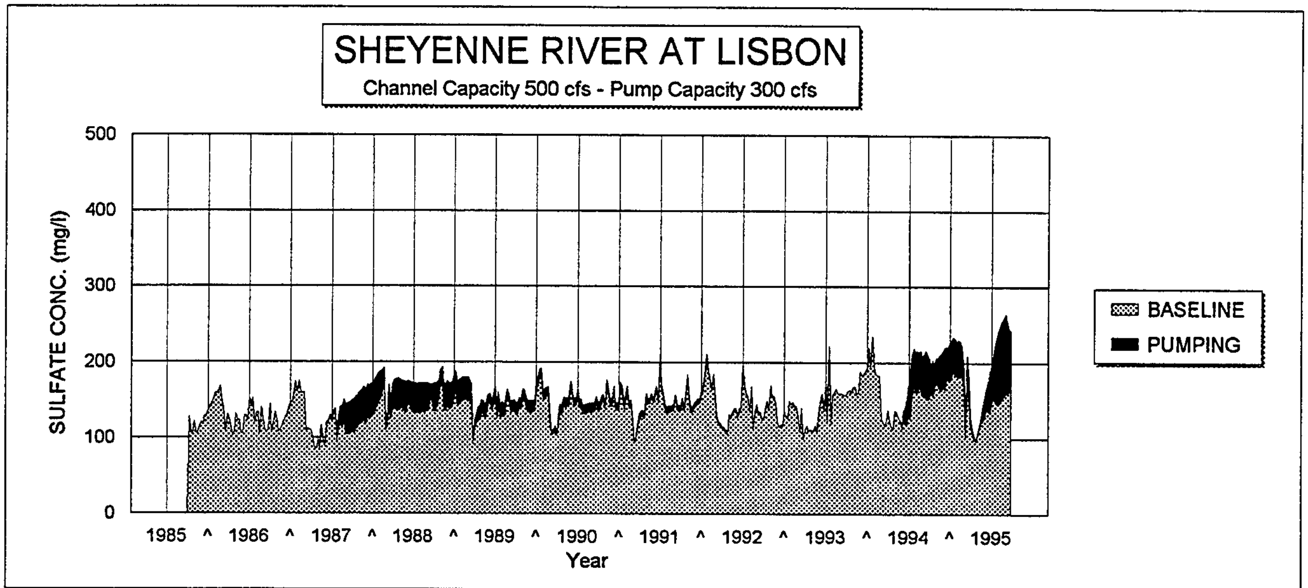
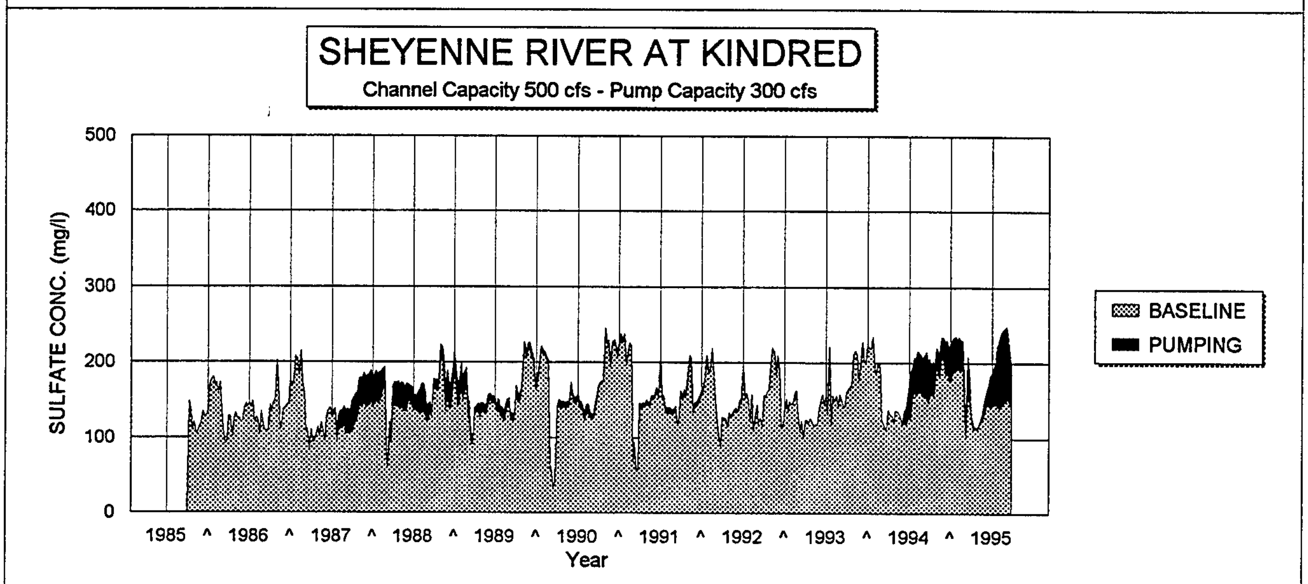

SHEYENNE RIVER AT BALDHILL DAM
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 4


SHEYENNE RIVER AT LISBON
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING


SHEYENNE RIVER AT KINDRED
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

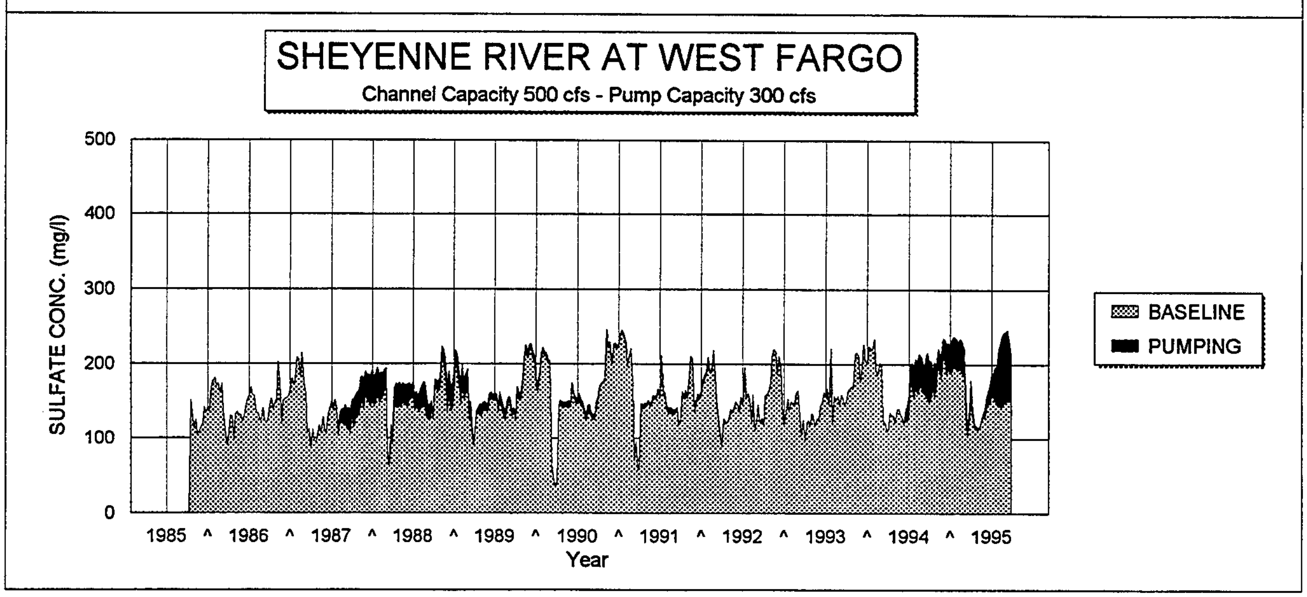

SHEYENNE RIVER AT WEST FARGO
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 5

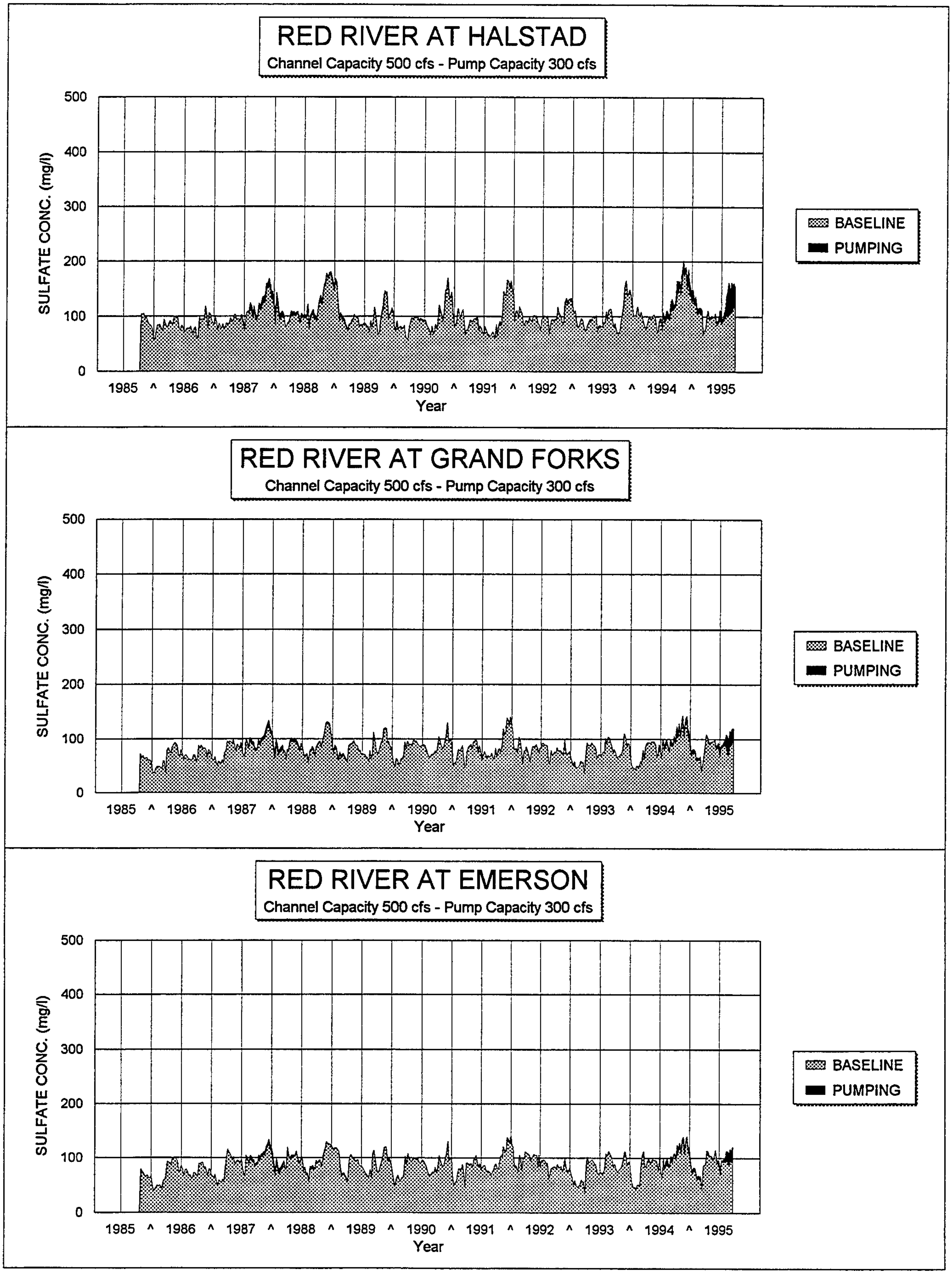

RED RIVER AT HALSTAD
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
RED RIVER AT GRAND FORKS
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
RED RIVER AT EMERSON
Channel Capacity 500 cfs - Pump Capacity 300 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 6

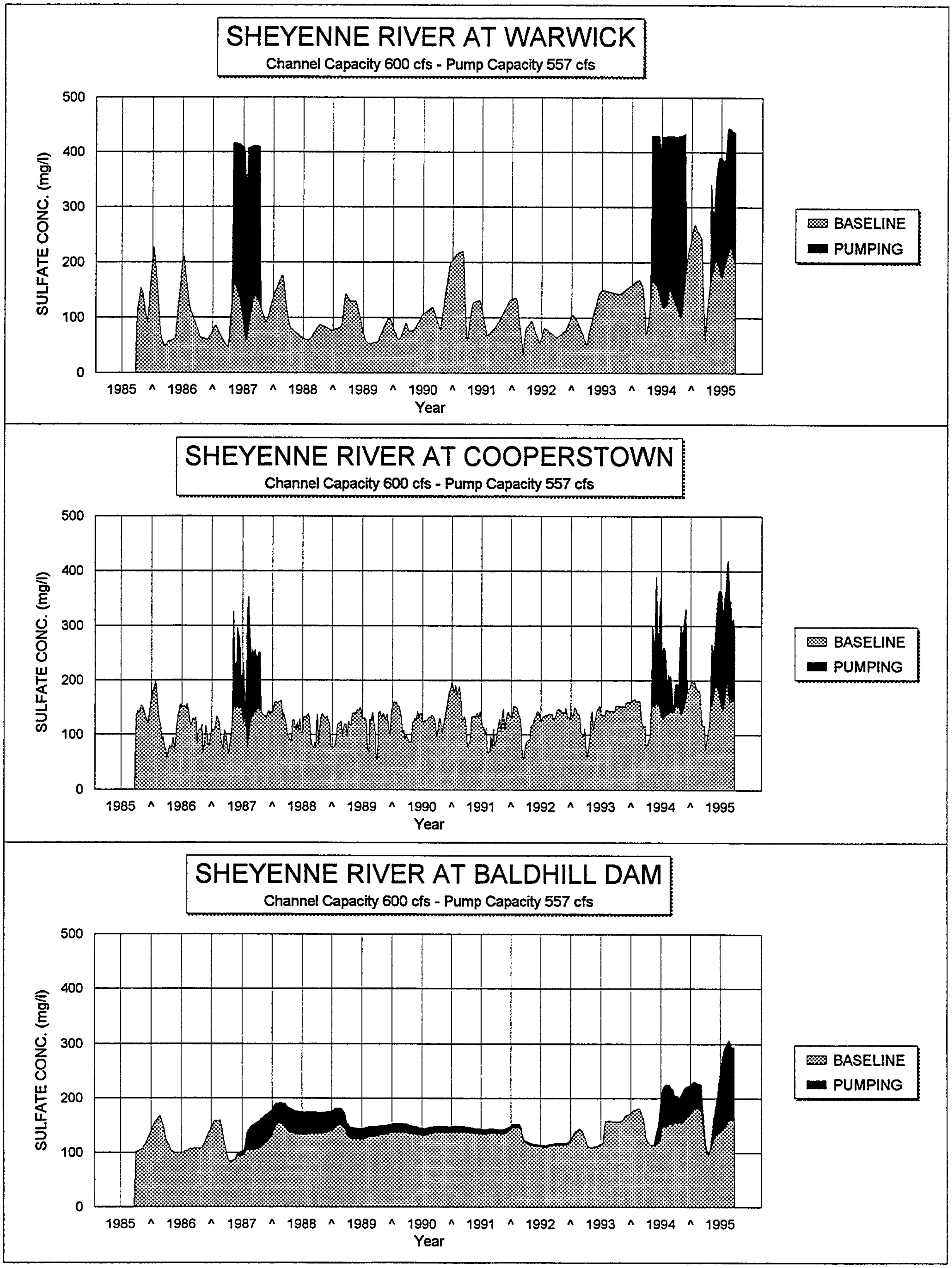
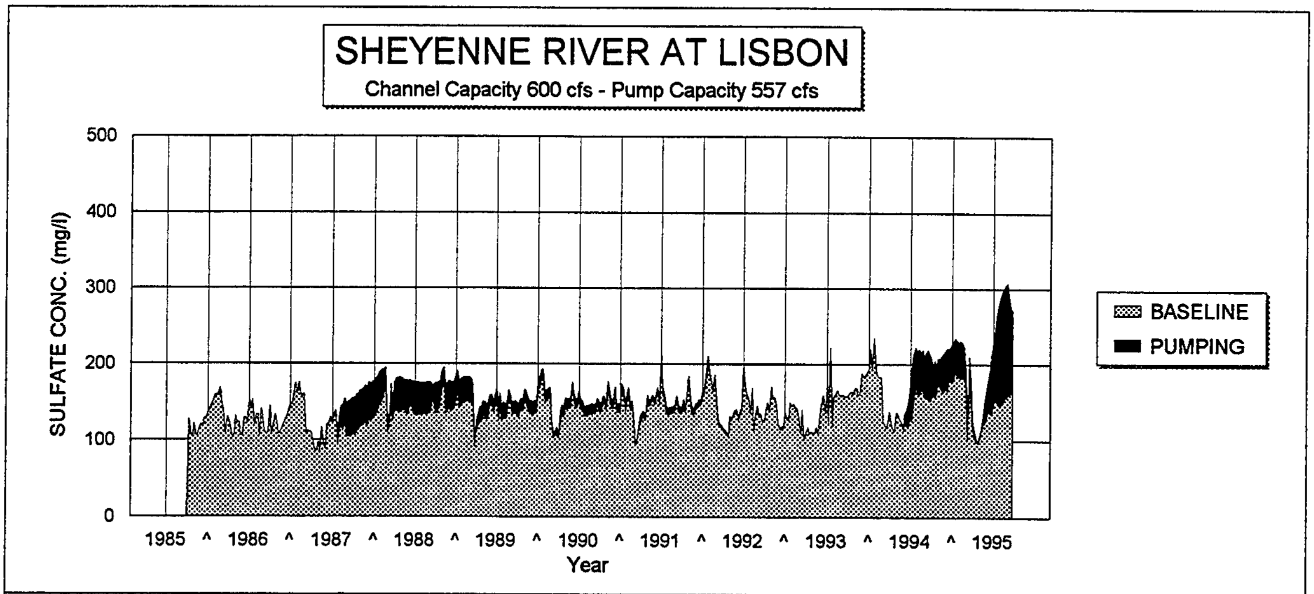
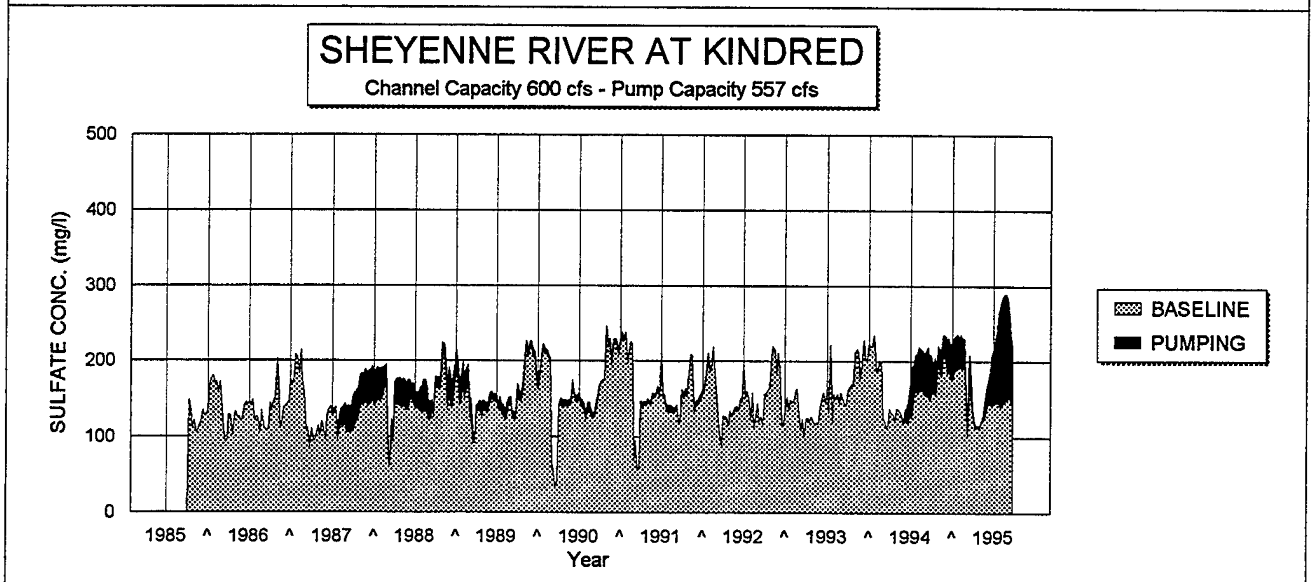

SHEYENNE RIVER AT WARWICK
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT COOPERSTOWN
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT BALDHILL DAM
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 7


SHEYENNE RIVER AT LISBON
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING


SHEYENNE RIVER AT KINDRED
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

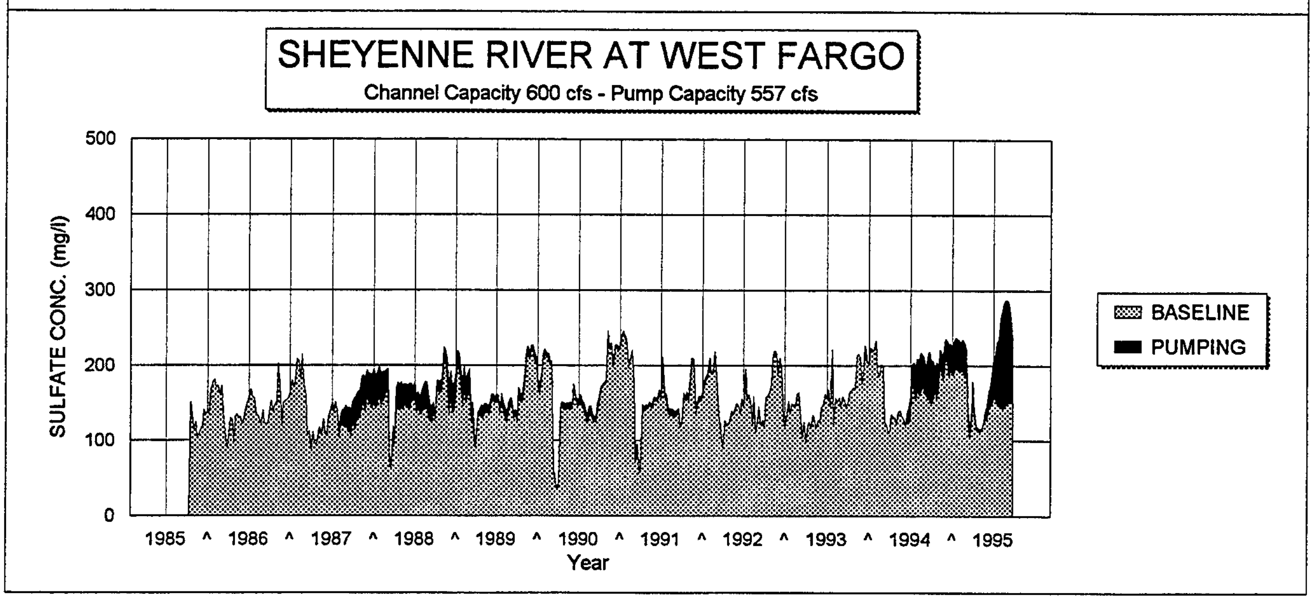

SHEYENNE RIVER AT WEST FARGO
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 8

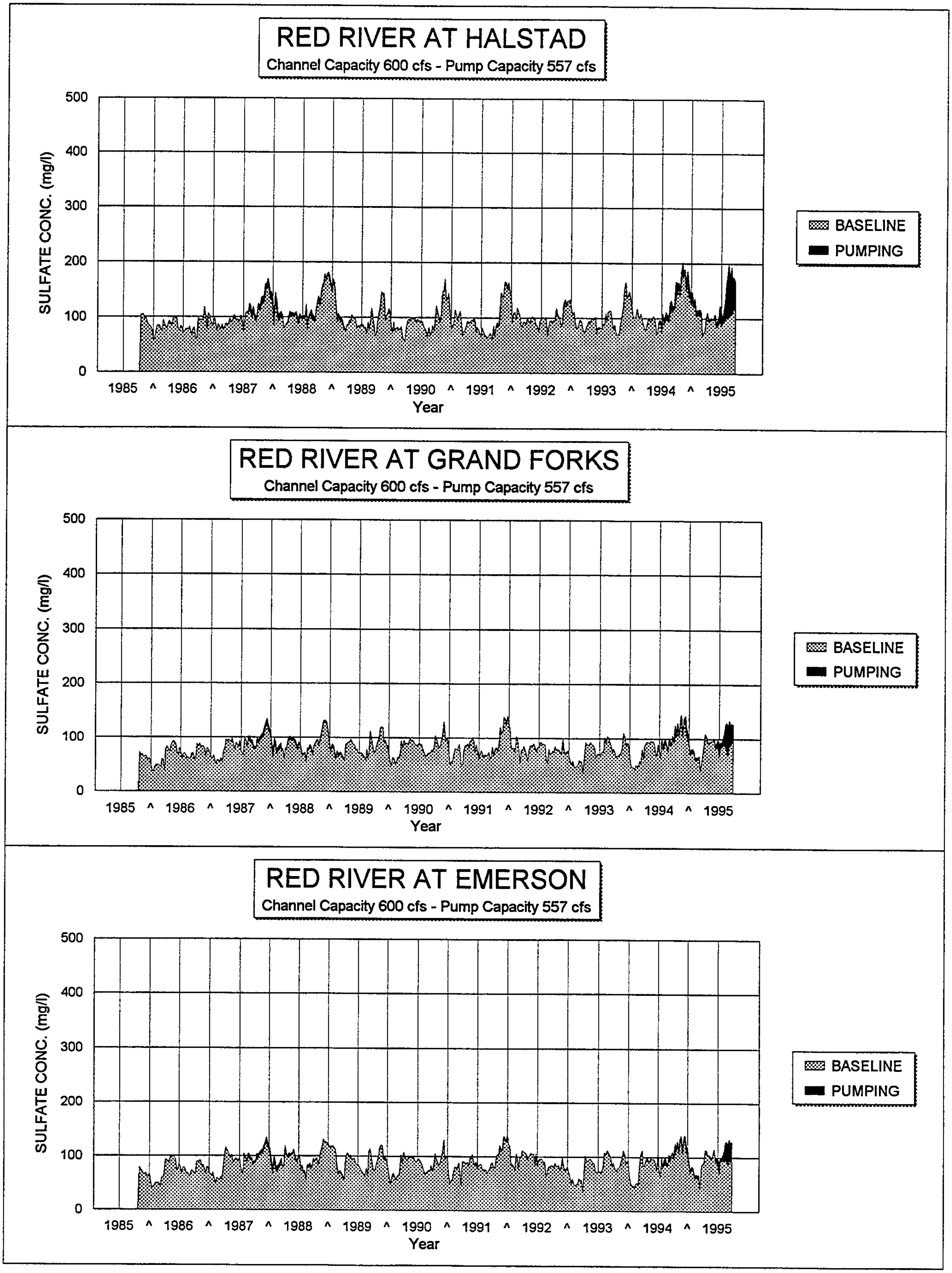

RED RIVER AT HALSTAD
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
RED RIVER AT GRAND FORKS
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
RED RIVER AT EMERSON
Channel Capacity 600 cfs - Pump Capacity 557 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 9

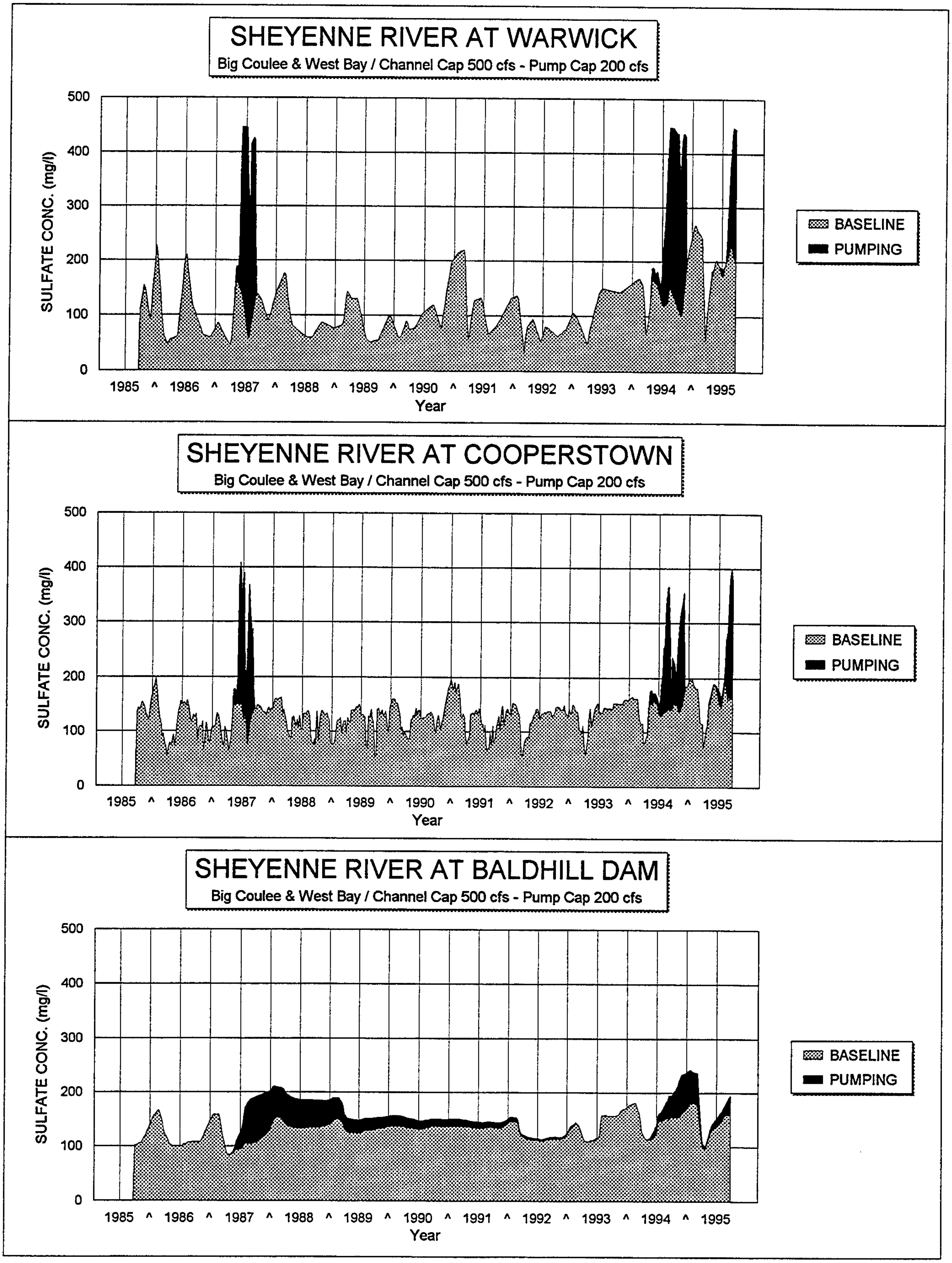
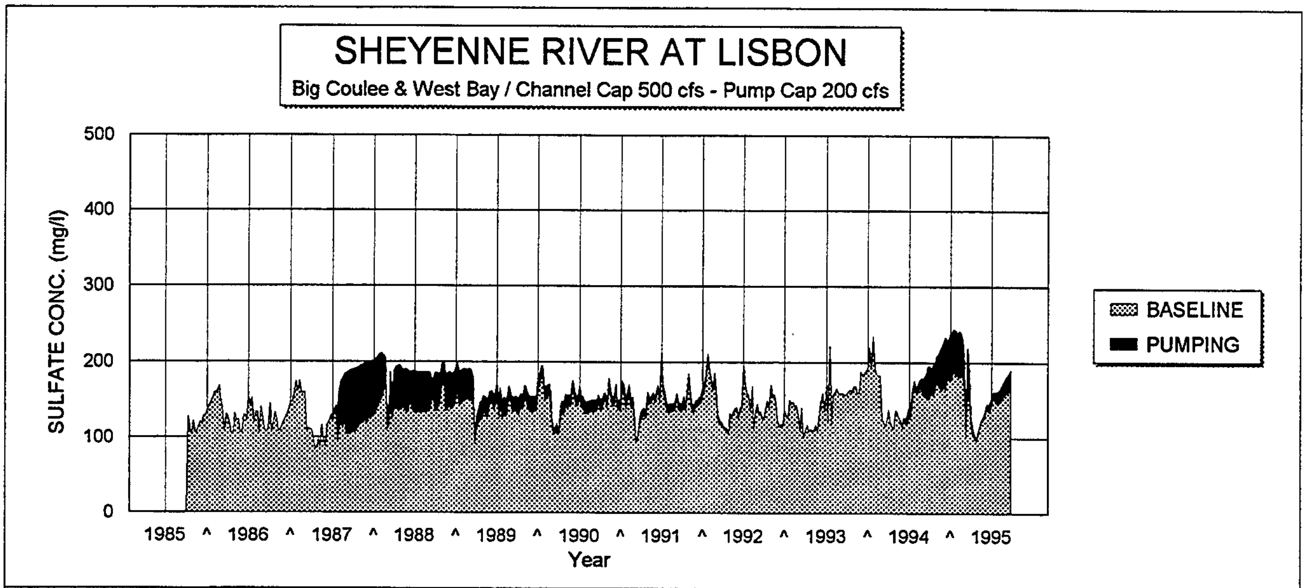
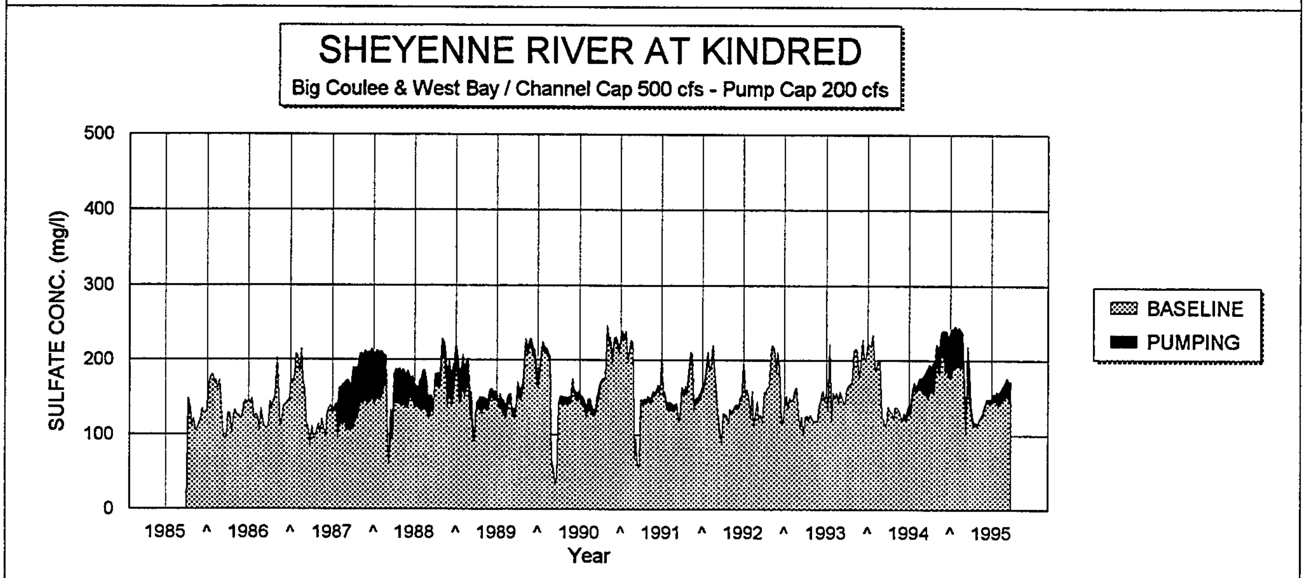

SHEYENNE RIVER AT WARWICK
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT COOPERSTOWN
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING
SHEYENNE RIVER AT BALDHILL DAM
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

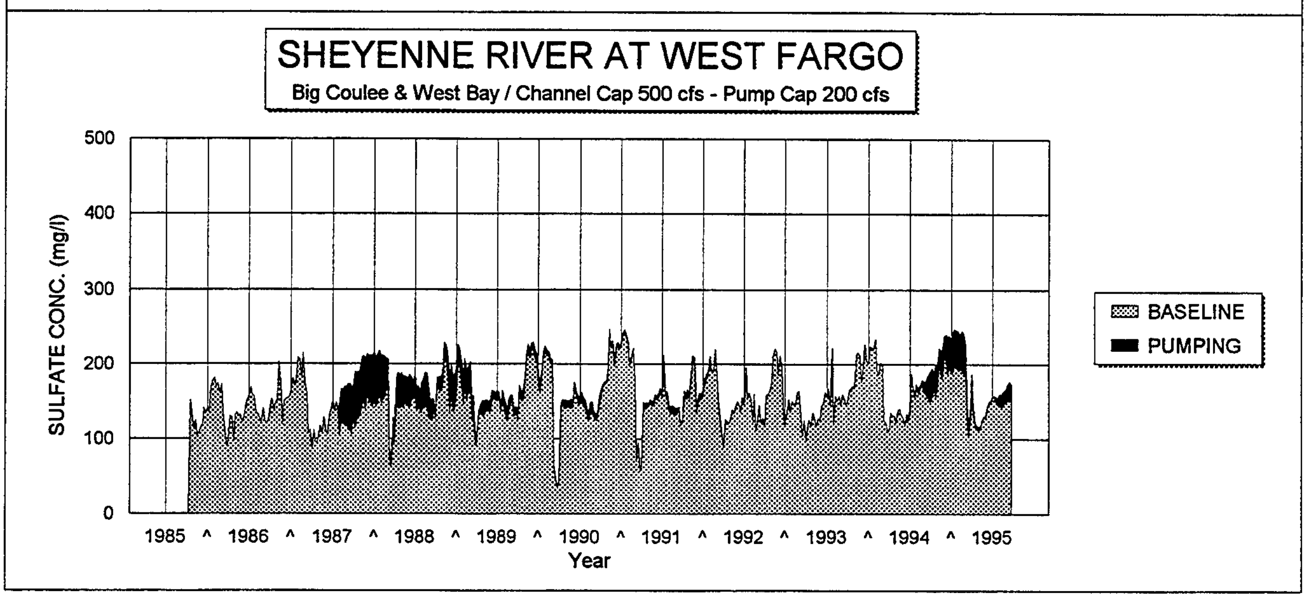
Figure 10



SHEYENNE RIVER AT LISBON
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

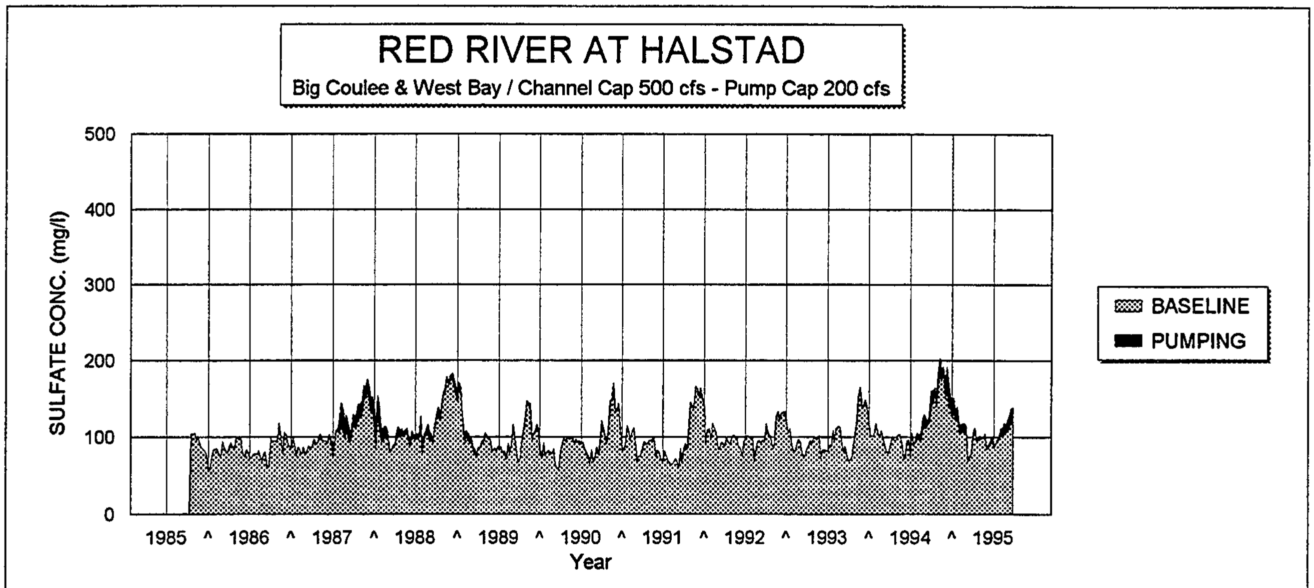


SHEYENNE RIVER AT KINDRED
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

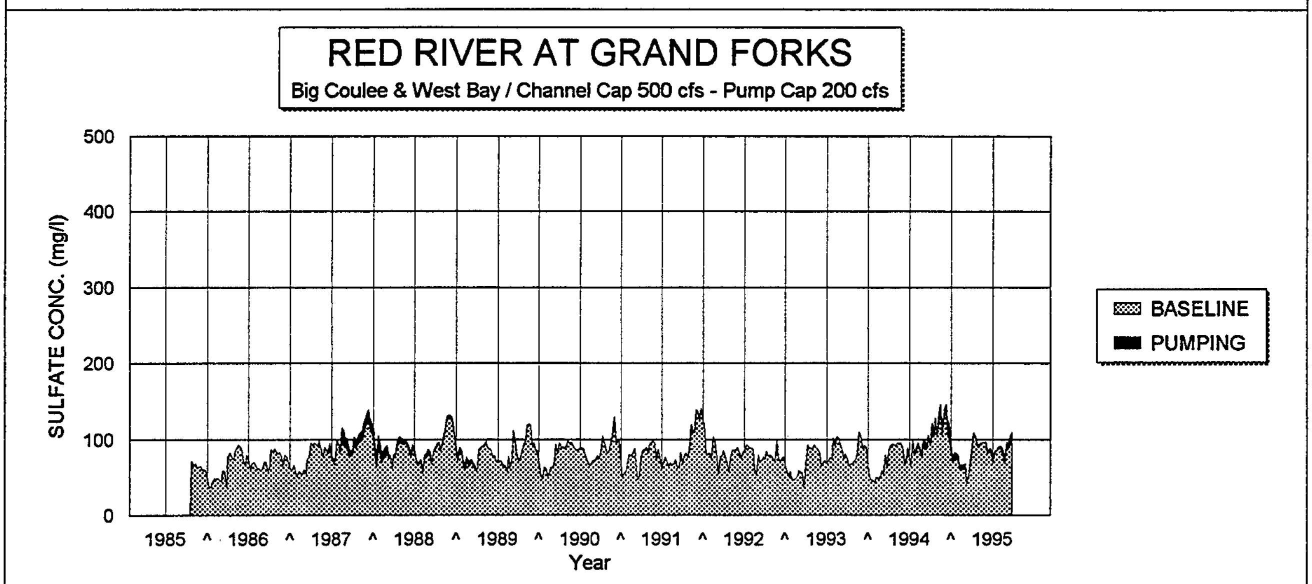


SHEYENNE RIVER AT WEST FARGO
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

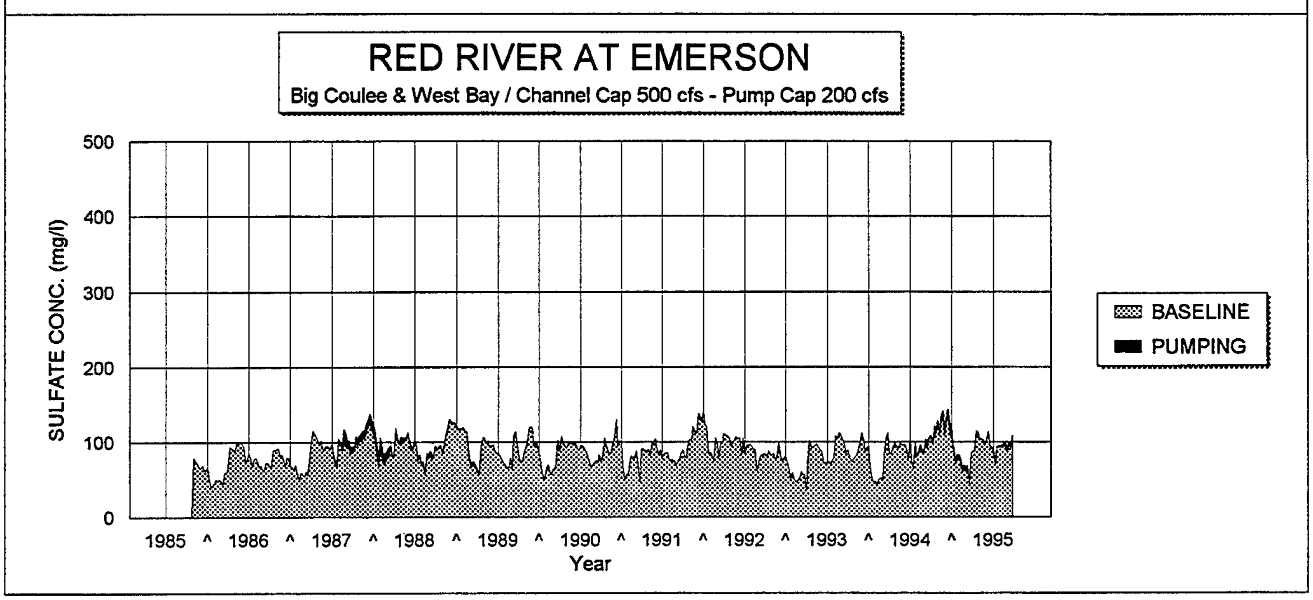
Figure 11



RED RIVER AT HALSTAD
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING



RED RIVER AT GRAND FORKS
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING



RED RIVER AT EMERSON
Big Coulee & West Bay / Channel Cap 500 cfs - Pump Cap 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985 ^ 1986 ^ 1987 ^ 1988 ^ 1989 ^ 1990 ^ 1991 ^ 1992 ^ 1993 ^ 1994 ^ 1995
Year
BASELINE
PUMPING

Figure 12

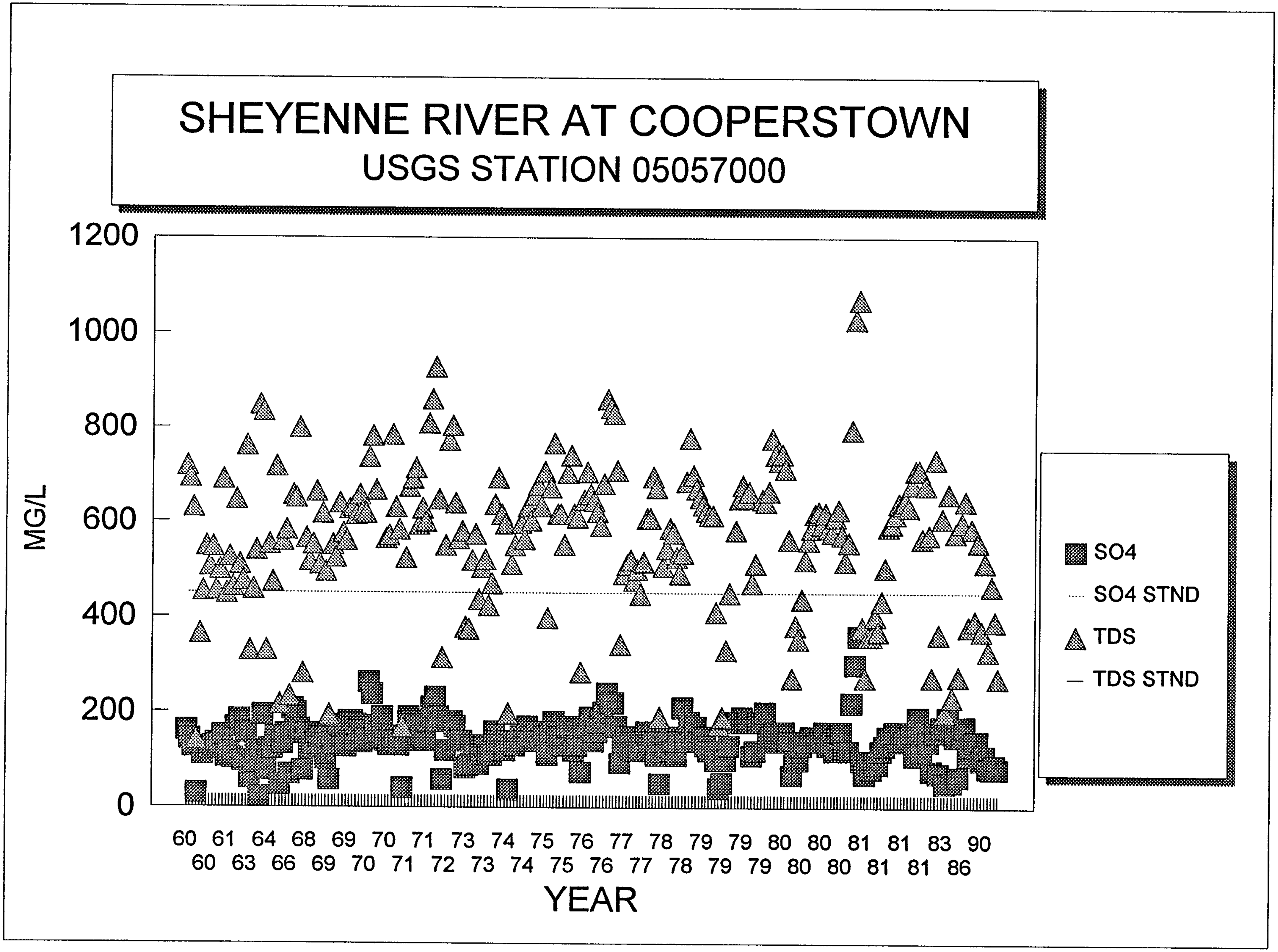

SHEYENNE RIVER AT COOPERSTOWN
USGS STATION 05057000
MG/L
1200
1000
800
600
400
200
0
60 61 64 68 69 70 71 73 74 75 76 77 78 79 79 80 80 81 81 83 90
60 63 66 69 70 71 72 73 74 75 76 77 78 79 79 80 80 81 81 86
YEAR
SO4
SO4 STND
TDS
TDS STND

Figure 13

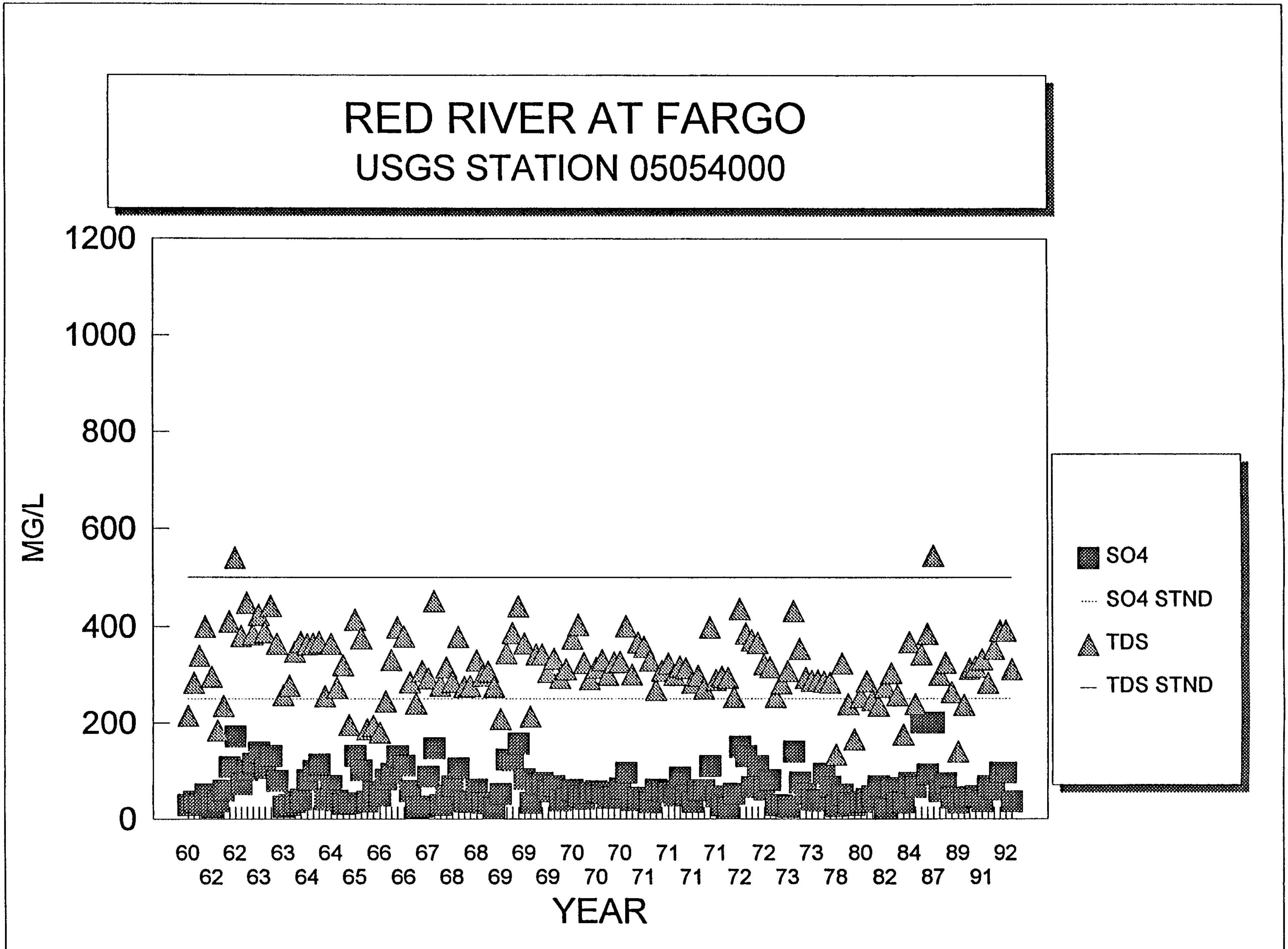

RED RIVER AT FARGO
USGS STATION 05054000
MG/L
1200
1000
800
600
400
200
0
60 62 63 64 66 67 68 69 70 70 71 71 72 73 80 84 89 92
62 63 64 65 66 68 69 69 70 71 71 72 73 78 82 87 91
YEAR
SO4
SO4 STND
TDS
TDS STND

Figure 14

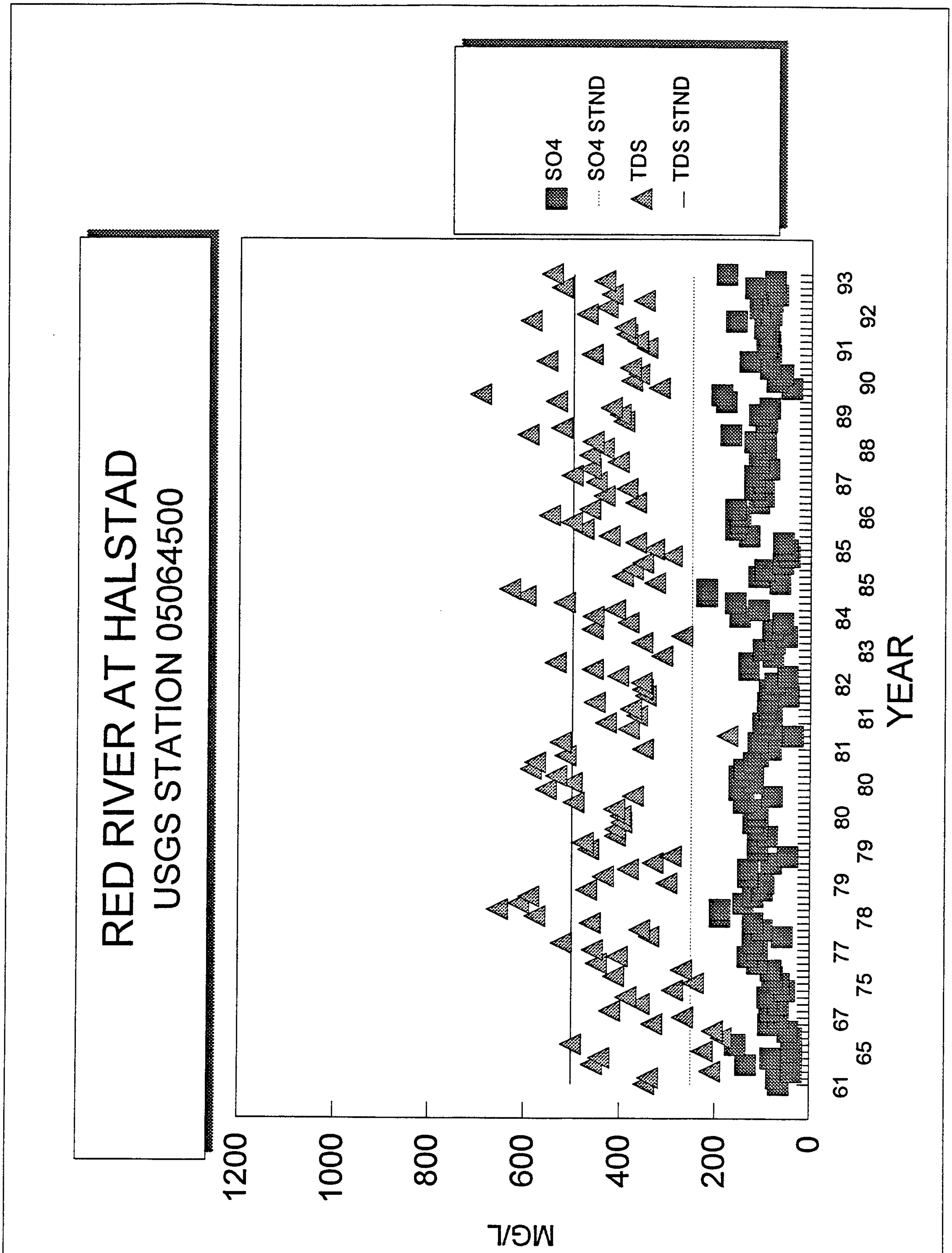

RED RIVER AT HALSTAD
USGS STATION 05064500
MG/L
0
200
400
600
800
1000
1200
YEAR
61
65
67
75
77
78
79
79
80
80
81
81
82
83
84
85
85
86
87
88
89
90
91
92
93
SO4
SO4 STND
TDS
TDS STND

Figure 15

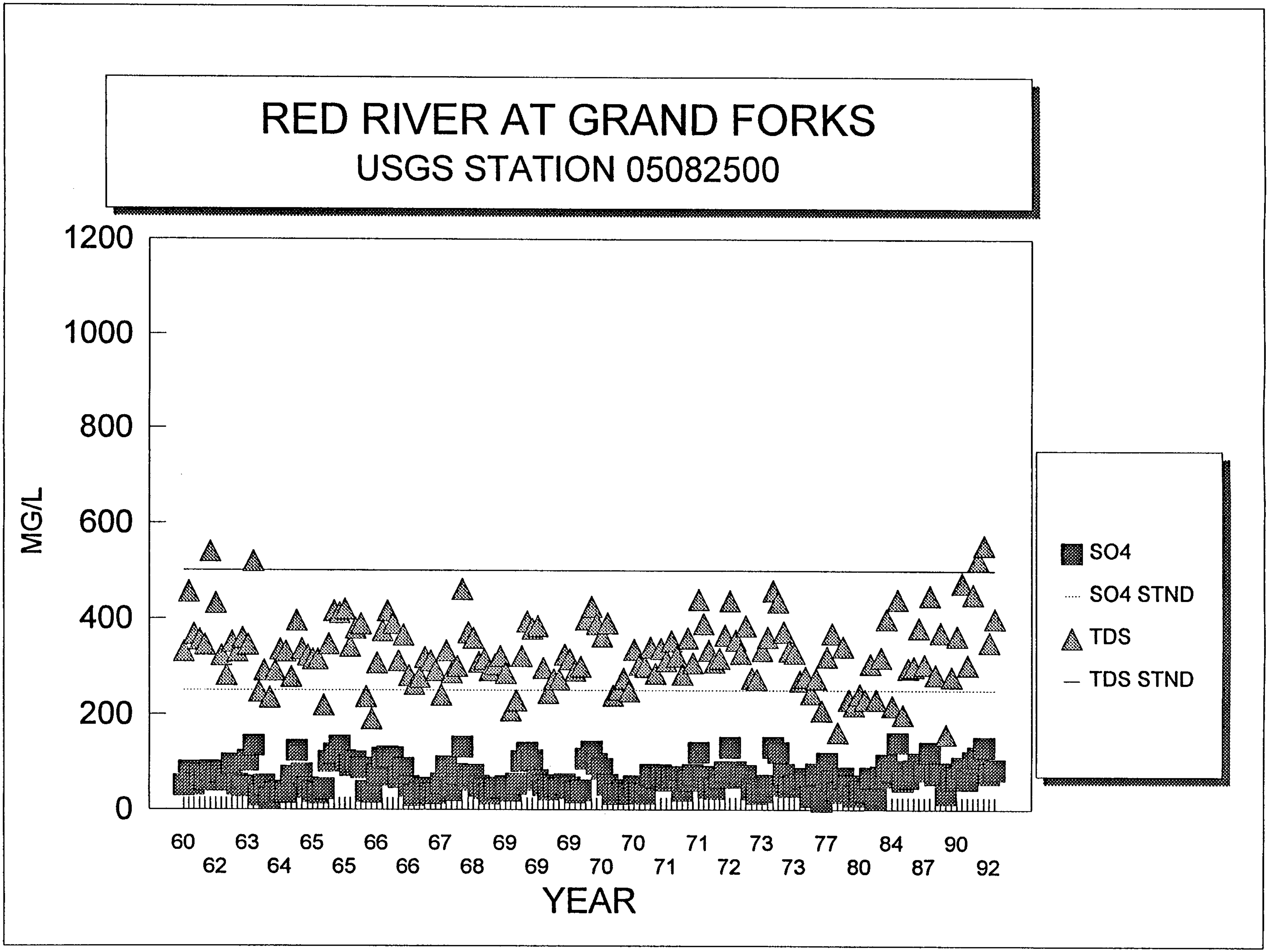

RED RIVER AT GRAND FORKS
USGS STATION 05082500
MG/L
1200
1000
800
600
400
200
0
60 62 63 64 65 65 66 66 67 68 69 69 69 70 70 71 71 72 73 73 77 80 84 87 90 92
YEAR
SO4
SO4 STND
TDS
TDS STND

Figure 16

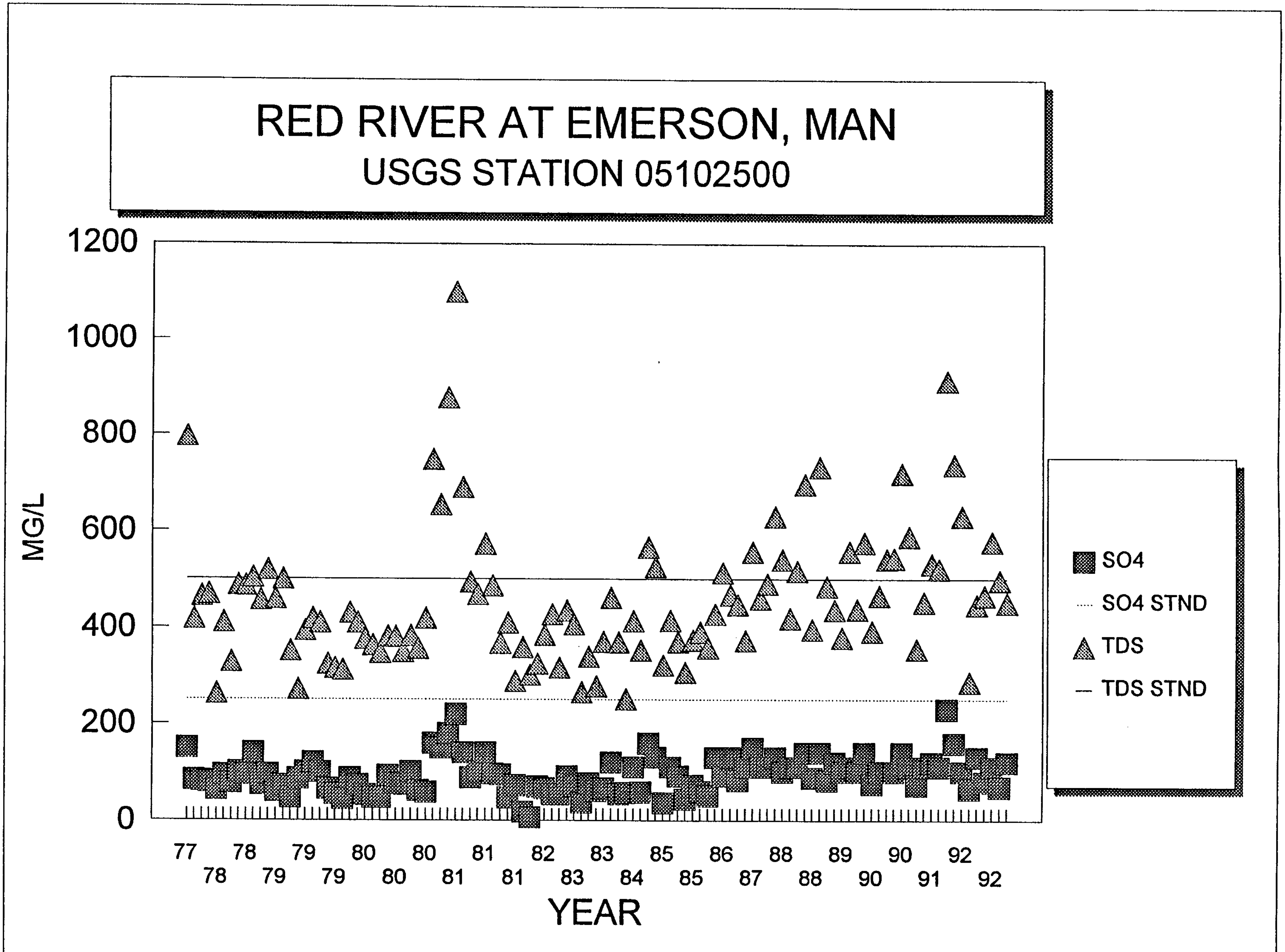

RED RIVER AT EMERSON, MAN
USGS STATION 05102500
MG/L
1200
1000
800
600
400
200
0
77 78 78 79 79 79 80 80 80 81 81 81 82 83 83 84 85 85 86 87 88 88 89 90 90 91 92 92
YEAR
SO4
SO4 STND
TDS
TDS STND

Figure 17

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

ENVIRONMENTAL RESOURCES APPENDIX

ENVIRONMENTAL RESOURCES APPENDIX

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ENVIRONMENTAL RESOURCES APPENDIX

INTRODUCTION

This evaluation is based on preliminary data and information obtained from the following COE reports -- "General Reevaluation and Environmental Impact Statement for Flood Control and Related Purposes, Sheyenne River, North Dakota," dated August 1982, "Devils Lake Basin, North Dakota, Integrated Draft Feasibility Report and Environmental Impact Statement," dated April 1988, and "Devils Lake Basin, North Dakota, Reconnaissance Report," dated February 1992.

This appendix addresses only the Twin Lakes outlet proposal and does not consider any alternatives. The evaluation primarily addresses potential effects on natural and cultural resources. The discussion identifies areas of concern and potential impact areas. A brief presentation of broader environmental concerns is presented under the Significant Resources and Issues of Concern discussion at the end of this appendix.

EXISTING CONDITIONS

Although the area potentially affected by this study includes a vast area including Devils Lake, the Sheyenne River, Red River of the North, Minnesota, and Canada, the description of the existing and future conditions will be restricted to the Devils Lake basin, the Twin Lakes outlet route, the Sheyenne River, and the Red River of the North. These are the areas that would be most directly impacted by construction activities or operation of the project. The Devils Lake basin has been extensively studied for various reasons. Much information is available on the existing conditions and probable future conditions under various scenarios. Some of this information is pertinent to the existing study.

Natural Resources

Land Use

The land use in the Devils Lake basin is primarily cultivated agriculture with cropland accounting for approximately 70 percent of the total area. Other land use categories and their percent occurrence in the basin are; grassland - 9.5 percent, woodlands - 3 percent, wetlands - 8 percent, and urban - 2.5 percent.

Although the Devils Lake basin and surrounding area is predominantly agricultural, natural vegetation provides significant wildlife habitat. Approximately 75 percent of the original grassland and wetland habitat has been converted to agricultural uses. The remaining woodlands, wetlands, and grasslands provide important habitat for the upland wildlife and waterfowl in the basin.

North Dakota has the smallest percentage of woodlands of all fifty States. The Devils Lake area represents one of the three most important remaining areas of natural woodlands in North Dakota. There are about 43,000 acres of forest land in the Devils Lake basin, less than 4 percent of which is in public ownership. Woodlands are extremely significant habitats for wildlife, are important for wildlife oriented recreation, and are of exceptional aesthetic value.

The Devils Lake basin has one of the highest concentrations of prairie wetlands in the Northern Great Plains. These wetlands range from numerous large lakes to thousands of small, shallow potholes or marshes. Wetland drainage is still continuing and is reducing the amount of prime waterfowl habitat. Representatives of the native grasslands are still likely to be found in the areas occupied by the range and pasture land use category; however, they are undoubtedly small in areal extent. These two major habitat types are very productive for wildlife. There is a need to protect, conserve, and enhance, where possible, these sensitive ecosystems.

Land use around the lake is quite different from that of the rest of the basin. While agriculture is an important land use at all elevations, it is not the predominant use at lower elevations. Below elevation 1445, land use around Devils Lake is dominated by grasslands.

Land use along the Twin Lakes outlet route is basically undeveloped and consists of a mixture of lakes, wetlands, grassland, pasture, agriculture, and scattered residential. There are about 900 acres of U.S. Fish and Wildlife Service (USFWS) easements located along and adjacent to the Twin Lakes outlet route.

Along the Sheyenne River, from its confluence with the proposed outlet to its confluence with the Red River, land use is a mixture of agricultural land, grassland, woodland, and urban. With the exception of the Sheyenne Delta area, woodlands are confined primarily to a narrow corridor along the river. Primary tree species include bur oak, basswood, American elm, aspen, and cottonwood. Cropland is the predominant land use adjacent to this river corridor. Major urban areas along the Sheyenne River include Valley City, Lisbon, and West Fargo, and a number of smaller communities.

Wildlife

Waterfowl use of the basin is significant. The major use of the main Devils Lake chain is by ducks, mostly mallard, gadwall, and scaup, whereas the upstream lakes are used mostly by migrating geese. The use of the lakes and ponds varies with water levels. West Stump Lake has been an important staging area for migrating waterfowl. Large numbers of waterfowl, especially canvasback ducks and tundra swans, use West Stump Lake as a staging area. These species are likely attracted to the lake because of the extensive, shallow-water beds of sago pondweed and lack of human disturbance. The western part of Stump Lake has a long history as a breeding or staging area for waterfowl and colonial birds. Of particular importance is the large number of canvasback ducks, over 26,000, that used the area in 1985. This number represented 7.8 percent of the continental population in that year and is likely the largest number of canvasbacks ever recorded on a single water body in North Dakota. The use of the lake varies with water levels. The periodic dry periods are not totally undesirable because it allows the lake to lose some of its salt through wind erosion.

Wildlife species common to the area include white-tailed deer, red fox, squirrel, mink, raccoon, cottontail, rabbit, beaver, and muskrat. Avian species include wood duck, sharp-tailed grouse, mourning dove and raptors, such as the great-horned owl and red-tailed hawk. Wooded areas provide excellent habitat for songbirds and migratory habitat for numerous passerine species.

Four Federally-listed threatened or endangered species of birds may occur in the project area. They are the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), and piping plover (*Charadrius melodus*). Most of these species are seen on a migratory basis. Although the piping plover has been recorded in the basin historically, no recent sightings have been recorded. Potential piping plover habitat is located around Devils Lake and at the Stump Lakes.

Fisheries

<u>**Devils Lake**</u>: The Devils Lake fishery adds significantly to the economic base

of the area. To a large extent the area has become dependent on the fishery and the tourism it attracts. Recreational tourism based on fishing and hunting is a multi-million dollar business in the basin.

When the Devils Lake area was first settled by Europeans the lake had a substantial fishery, particularly for northern pike. The fish were taken indiscriminately and carloads of fish were shipped to the east. In 1889, after the lake had declined nearly 10 feet in ten years, the northern pike disappeared from the lake. In subsequent years the remaining species, fathead minnows and brook stickleback, declined as the lake levels diminished even further.

The present day fishery of Devils Lake is comprised of several species of fish which were stocked in the lake or migrated from the upstream lakes to the main lake as it became fresher. These are brook stickleback, fathead minnow, black bullhead and white sucker. Since the mid-1970s, the State has stocked a variety of game species of which the following are currently present: Yellow perch, northern pike, walleye, white bass, and black crappie (see Table 1).

Devils Lake is dominated by game fish species and does not contain any species that are not present in the Red River drainage, with the possible exception of the striped bass. Stripped bass were originally introduced into Devils Lake in 1977 as fingerlings. None have been stocked since that time. Recent evaluations have concluded that suitable conditions for stripped bass reproduction do not exist in Devils Lake. An intensive netting program in 1995 to capture any potential bass remaining from original stock resulted in no stripped bass being captured. Recent studies have also concluded that the stripped bass has not hybridized with the white bass.

Reproduction in Devils Lake is restricted by TDS concentrations and is limited primarily to the fresher western end of the lake. Habitat requirements of organisms may vary with different life stages. Among fish, the larval stage is less tolerant than the adult stage to elevated TDS concentrations. This is true of many of the species in Devils Lake, the Sheyenne River, Lake Ashtabula, and the Red River. Spawning appears to be controlled by TDS concentrations in Devils Lake. There are no fish in East Stump Lake. Fathead minnows and brook stickleback are present in West Stump Lake when water levels are adequate. Spawning may be aided by fresh water seeps in West Stump Lake. In addition, yellow perch, white suckers, northern pike, and walleye are found in the main lake chain. It appears that they may only reproduce in the Main and West Bays where TDS concentrations are below 2000 ppm (mg/l).

<u>**Twin Lakes Outlet Route**</u>: Several small, shallow lakes are located along the proposed outlet route, the most notable of which is Twin Lakes. These lakes do not support any substantial fishery and are susceptible to winter kill.

<u>**Sheyenne River**</u>: The Sheyenne River has a diverse fish population, with over 50 species of the approximately 80 species recorded in the entire Red River drainage area in Minnesota and North Dakota, and yet the Sheyenne River basin is only 24 percent of the Red River basin. The Sheyenne River has twice as many species of fish as the other Red River tributaries. The large number and diversity of fish species in the Sheyenne River result from the variety of habitats and substrates present. The many spring-fed streams in the Sheyenne River Delta area may provide unique clean-water conditions required for certain fish. The presence of the blacknose and rosyface shiners and other species is a good indication that the springs are functioning as refuge areas. Dams along the river present partial barriers to upstream movement of fish, especially during low flow periods. Carp are not found in the Sheyenne River above Baldhill Dam.

<u>**Lake Ashtabula**</u>: Lake Ashtabula contains a significant fishery and attracts many anglers from eastern North Dakota. The lake is stocked by the State, and

some natural reproduction occurs, especially in the upper reaches and in rocky areas. TDS concentrations do not restrict reproduction.

Lake Ashtabula is a long, narrow reservoir created by the Baldhill Dam on the Sheyenne River. Fish species collected from or planted in, the lake are common shiner, fathead minnow, blacknose dace, creek chub, white sucker, black bullhead, brook stickleback, white bass, orange spotted sunfish, bluegill, black crappie, Iowa darter, and yellow perch. It is a valuable fishery which depends, at least in part, on natural reproduction in the upper pool of the lake. Planting of several game species also takes place.

Lake Ashtabula provides a significant fishery for this portion of North Dakota. Stocking is an important factor, while some natural reproduction occurs in the upper end of the lake. The Valley City National Fish Hatchery is located about 12 miles below Lake Ashtabula. Part of the hatchery, including fifteen rearing ponds, is located immediately downstream of Baldhill Dam. The Sheyenne River and Lake Ashtabula are used as water sources for hatchery operations. Lake Ashtabula and the National Fish Hatchery are expected to continue to be an important part of the fishery in North Dakota.

Red River: The Red River is a significant fishery resource. The river and its tributaries provides habitat for a number of aquatic species. The lower reaches of the Red River have been identified as being one of the best trophy catfish fisheries in the nation. Other species of importance are walleye, northern pike, and bass. The river provides important regional fishing opportunities in an area of limited water resources.

Cultural Resources

Previous Surveys and Known Cultural Resources Sites

The earliest archeological field work involving lands along the Twin Lakes outlet route was a reconnaissance of two unspecified areas along the "Devils Lake Lateral" by Smithsonian Institution River Basin Surveys archaeologists J. J. Bauxar and Paul Cooper in September 1946 in connection with the U.S. Bureau of Reclamation's Garrison Diversion Project (ref. Cooper and Wedel, 1947, Preliminary Appraisal of the Archeological and Paleontological Resources of the Devils Lake Project, North Dakota). One of the two unspecified areas checked must have included at least part of the uplands overlooking the Sheyenne River in Section 29, Township 151 North, Range 65 West, as Cooper recorded prehistoric cultural material scatter site 32BE6 in this location. No cultural resources were apparently found or recorded in the other unspecified reconnaissance area.

In 1966, SIRBS archeologist Oscar Mallory conducted a preliminary survey of lands along the Devils Lake shoreline and the Sheyenne River where Garrison Diversion Project features were proposed. Prehistoric cultural material scatter site 32BE6 is also mentioned in this report (ref. Mallory, 1966, An Appraisal of the Archaeological Resources of the Garrison Diversion Project, North Dakota).

The University of North Dakota conducted a survey of alignments of the New Rockford Canal and four branch canals as well as nineteen proposed recreation areas on Devils Lake and Stump Lake for the Bureau of Reclamation in 1974 and 1975 (ref. Schneider, Good, and Schweigert, 1977, Cultural Resources Inventory of Portions of the Central North Dakota Section, Garrison Diversion Unit, North Dakota, 1975 Field Season). The canal alignments and recreation areas checked for archeological resources did not include any portion of the currently proposed Twin Lakes outlet route. However, the associated historic overview and architectural survey conducted in 1975 and 1976 did cover parts of the Twin Lakes route in Township 152 North, Range 66 West along Devils Lake and in Township 151 North, Range 65 West along the Sheyenne River (ref.

Schweigert, 1977, Historic Sites Cultural Resources Inventory in the Devils Lake Region, Central North Dakota Section, Garrison Diversion Unit, North Dakota). The Nash Railroad Tower (site 32BE430) was recorded at elevation 1445 feet in Section 16, Township 152 North, Range 66 West. It is west of the presently proposed Twin Lakes channel alignment. This historic sites inventory report also contains an historical overview of the Devils Lake region, especially the area between the Devils Lake-Stump Lake complex and the Sheyenne River.

One hundred twenty (120) acres of outwash channel bottom and adjacent slopes and uplands and 50 acres of the river terrace where the proposed Twin Lakes outlet route intersects with the Sheyenne River have been previously surveyed for the presence of cultural resources sites. This fieldwork was conducted in 1986 and 1987 by Larson-Tibesar Associates under contract with the St. Paul District, U.S. Army Corps of Engineers (COE), in connection with a COE flood control study for providing an outlet channel from the Devils Lake-Stump Lake complex and/or additional storage in six lakes north of Devils Lake (ref. Floodman, 1989, Final Report of an Archaeological Inventory of Portions of the Devils Lake Basin, Benson, Eddy, Nelson, and Ramsey Counties, North Dakota). An isolated white chert core (IF#3) was found in a cultivated field overlooking the two lakes in Section 4, Township 151 North, Range 66 West. Prehistoric cultural material scatter site 32BE6 was noted as being in the uplands overlooking the river terrace where the channel enters the Sheyenne River. The Nash Railroad Tower site (32BE430) was indicated as being to the west of the proposed Twin Lakes outlet channel.

According to a 1976 Devils Lake Basin Study, the Benson County atlases for 1910 and 1929 indicate that there were (are?) rural schools in Sections 9 and 27, Township 152 North, Range 66 West (refs. Standard Atlas of Benson County, North Dakota, 1910, George A. Ogle & Co., Chicago and Standard Atlas of Benson County, North Dakota, 1929, Brock & Co., Chicago).

Other pre-1950 buildings and structures potentially in the area of effect of the proposed Twin Lakes outlet route are depicted on the U.S.G.S. 7.5' Crow Hill (1951, PR 1975) and 7.5' Sheyenne (1950, PR 1986) topographic quadrangle maps and the U.S.G.S. 15' Oberon (1950) topographic quadrangle. These include buildings and farmsteads in Sections 16, 21, 22, and 33, Township 152 North, Range 66 West; the Plainview School No. 2 in Section 3, Township 151 North, Range 66 West; and a farmstead in Section 30, Township 151 North, Range 65 West. A well and a spring in Section 29, Township 151 North, Range 65 West are located within the channel bottom just above its confluence with the Sheyenne River Valley.

As of June 15, 1996, there are no known National Register of Historic Places listed or eligible sites in the sections through which the proposed Twin Lakes emergency outlet channel passes. However, none of the known sites along this outlet route have had their National Register eligibility evaluated and most of the route has never been surveyed for cultural resources nor had its traditional cultural properties inventoried.

ENVIRONMENTAL EFFECTS

A preliminary evaluation of the effects associated with the construction of an outlet for Devils Lake along the Twin Lakes alignment is presented below. This evaluation is based on a review of existing information. Not all of the impacts can be identified until detailed field surveys and studies are conducted.

The following assumptions were made in performing this analysis:

- Operation of the outlet would be on an emergency basis and would be restricted to this single event. Any subsequent operations of the outlet would require additional environmental evaluation.

o The outlet would be operated in such a manner so as to meet water quality standards on the Sheyenne River and Red River.

o The outlet would be operated in such manner so as to not aggravate flood conditions on the Sheyenne River or Red River.

o Operation of the outlet would not require a change in the operation plan of Baldhill Dam.

o There are no appreciable fishery resources in the lakes along the outlet alignment.

o Based on limited studies, there is a low potential for biota transfer associated with the emergency operation of an outlet for Devils Lake.

o Impacts associated with construction and operation of an outlet would generally occur in three areas -- Devils Lake, along the outlet route, and areas downstream of the outlet.

o The emergency operation of the outlet would have a limited effect on the maximum water surface elevation in Devils Lake.

This preliminary determination of habitat types affected by the proposed outlet channel is based on two data sources -- data generated in 1984 by interpretation of satellite imagery was used to identify woodlands and grasslands affected, and National Wetlands Inventory data were used to identify wetlands that would be affected. Precise determinations of the acres of woodlands, grasslands, and wetlands affected by the outlet channel would require more detailed studies.

Natural Resources

Effects on Woodlands, Grasslands, Wetlands

Devils Lake: The effect on habitat types around Devils Lake would be minimal. While the outlet would result in slightly lower lake levels, it appears that, over the long term and from the perspective of environmental impacts, lake levels would not be appreciably different from conditions that would occur if the outlet were not built. The main effect would be to slightly shift the timing and duration of inundation that may occur. The maximum level to which the lake will eventually rise may be slightly lowered. By preventing Devils Lake from raising as high as would have occurred under natural conditions, some terrestrial habitat is protected from inundation while some open water habitat is prevented from being created.

Twin Lakes Outlet Route: Construction and operation of the outlet channel would result in the loss of woodland, wetland, and grassland. In addition, indirect impacts could occur to lakes and wetlands adjacent to the channel, due to changes in TDS concentrations, groundwater levels, and drainage.

The effects on wetlands along the outlet route is based on National Wetland Inventory data delineated in the late 1970s and early 1980s. The channel alignment was placed over the digitized NWI data bases, and the acres of wetlands affected were determined (Figure 1). The proposed alignment would affect a total of 770 acres of wetlands. Approximately 622 acres would be affected by water quality changes associated with the operation of the outlet. Approximately 470 acres of the wetlands affected by water quality changes are lakes that are located along the alignment. Approximately 150 acres of wetlands would be affected by construction activities. The majority of the these wetlands are located along the channel inlet at Devils Lake (30 acres) and along the lower reaches of the outlet channel above its confluence with the Sheyenne River (120 acres).

The wetlands along the lower reaches of the outlet channel would be reduced in extent after construction as they would be confined to the new channel. Once emergency operation of the outlet ceased, it likely that this portion of the channel would drain and any wetlands along this portion of the alignment would be lost.

The lakes and wetlands located along the outlet route are mostly freshwater systems. The TDS levels of these systems would be increased as a result of outlet operation. It is possible that the change in TDS levels would result in a change in vegetation composition present in these marshes and lakes. Once operation of the outlet ceases, TDS levels in these aquatic systems would change again. These fluctuating changes in water quality and water levels would likely result in an overall decline in aquatic vegetation density and extent.

There are a number of wetland easements located along the outlet route. These areas must be mitigated in accordance with the Refuge Administration Act.

Approximately 50 acres of woodlands would be affected by construction and operation of the outlet channel. While some woodlands would be directly affected by construction, it appears that the majority of the effects would come from prolonged inundation with operation of the outlet.

Approximately 150 acres of grasslands would be affected with the proposed outlet. About 50 percent of the effects would be a direct result of construction activities, while the remaining effects would result from prolonged inundation.

Along Sheyenne River: Although not quantified at this time, operation of the outlet has the potential to have effects on the riparian woodlands along the Sheyenne River. Increased flows may result in a change in groundwater levels along the river, which may result in subtle changes in vegetative composition. These changes may reduce the habitat value of these important riparian areas for wildlife. The extent and significance of these changes could not determined at this time.

Lake Ashtabula: It is assumed that the operating level of Lake Ashtabula would not be affected by the outlet from Devils Lake. Therefore, direct effects of water level changes and groundwater are not anticipated. The operation of the outlet may, over time, have an effect on water quality and TDS levels. This could affect vegetation along the shoreline and aquatic vegetation, both in extent and species composition.

Effects on Wildlife

Devils Lake: As noted earlier, construction of an outlet may have some effect on the maximum elevation to which the Devils Lake will rise, which may prevent inundation of some terrestrial habitat around Devils Lake. There would probably be no noticeable effect on wildlife in the area.

Twin Lakes Outlet Route: Construction and operation of the outlet would most likely result in displacement and loss of some wildlife. Some changes in the species of birds that use the wetlands may occur due to changes in habitat conditions. There could be some benefits to wildlife along the channel route by providing a source of water during operation. There might be short-term displacements and losses during construction; however, there would probably be no noticeable long-term effect on wildlife.

Sheyenne River: As noted earlier, operation of the outlet may result in changes in vegetation composition and abundance along the riparian corridor. Subtle changes in species composition or abundance may occur along the Sheyenne River in response to those changes in habitat condition. The extent and significance of these changes cannot be determined at this time.

Threatened and Endangered Species: The bald eagle, peregrine falcon, and whopping crane migrate through the study area but do not nest there. The proposed emergency outlet would not have any significant adverse effects on these species. The piping plover has nested in the basin historically but has not been recorded since before 1972. Surveys were conducted in 1986 and 1987, but no plovers were observed. No critical habitat has been designated in the project area.

Effects on Fisheries

Devils Lake: Operation of the outlet may affect the timing or duration of fluctuating water levels and effects that will occur without the outlet in place. However, it appears that there would be no appreciable change in water quality in Devils Lake and, therefore, no appreciable effect on the existing fisheries resource.

The Twin Lakes emergency outlet would discharge water from the Minnewaukan Flats-West Bay area. However, with a one-time operation, potentially spanning several years, TDS concentrations of the various portions of the lake are likely to be essentially the same as if no project had been put into place. Reproduction of fish is likely to be maintained in the main part of the lake; East Bay would continue to support adult fish but not reproduction; East Devils Lake TDS concentrations are expected to remain at or near stressful levels for fish; West Stump Lake would continue to support only saline-tolerant fish species; and East Stump Lake would contain only the organisms tolerant of its high salinity.

Twin Lakes Outlet Route: Operation of the outlet could have adverse effects on any fisheries that are present in the existing chain of lakes along the outlet route. Changes in water quality conditions, aquatic vegetation compositions, and water depths could affect the suitability of the lakes for some species. Once operation of the outlet ceases, conditions would change again, affecting species that became established in response to conditions prevalent during operation. The overall, long-term effect may be a decline in the limited fisheries present in these lakes.

Sheyenne River: Operation of the emergency outlet would appreciably increase TDS levels, especially sulfates, in the Sheyenne River (see Water Quality Effects Appendix). The potential effects of the increased flows and decreased water quality include effects on the resident fish in the river, on spawning fish below the Cooperstown Dam, on spawning or resident fish in Lake Ashtabula, on the fish hatchery below the reservoir, and downstream of the reservoir in the Sheyenne and Red Rivers.

While the projected flows would remain in the channel banks, erosion may increase due to prolonged higher flows. Higher flows may provide some benefits to species using the river because under current conditions flows in the Upper Sheyenne River become very low during the summer. Higher flows may affect the suitability of some areas on the river as spawning habitat.

Although the outlet would be operated to meet water quality standards, the end result would be extended periods where TDS levels, especially sulfates, are at or near the upper limit. Prolonged elevated TDS concentrations in the Sheyenne River may have adverse effects on the fishery resource, especially during the sensitive larval stage of fish development. The length of this stage and the limiting TDS concentration is not specifically known for the various fish species in the watershed. It is assumed that the fish would be vulnerable until the formation of all adult characteristics and that this would occur within 1 month after hatching. Spawning may take place in some reaches as late as August. Therefore, the effects of elevated TDS concentrations on reproduction and development may extend as late as September.

The change in water quality and flow could also affect reproduction and development of other aquatic organisms, such as aquatic insects, in the Sheyenne River. The long-term effect could be changes in aquatic invertebrate species composition and abundance along the Sheyenne River.

Lake Ashtabula: A preliminary evaluation indicates that operation of the emergency outlet would have a minimal effect on the fishery resource in Lake Ashtabula. Water quality changes may result in subtle changes in aquatic vegetation, benthic and nektonic species composition and abundance, which may eventually be reflected in the composition and abundance of the fishery resource. More detailed studies would be required to fully quantify these effects.

Immediately downstream of the Baldhill Dam, there are rearing ponds for the Federal fish hatchery which raises fish for stocking in Federally-controlled and State waters. Water for the ponds is obtained Lake Ashtabula. The main hatchery, located about 12 miles downstream from Lake Ashtabula, obtains its water from the Sheyenne River. Both facilities would be vulnerable to adverse water quality effects of a Devils Lake outlet. Prolonged, elevated TDS levels may be more of a critical concern with respect to the hatchery operations than for the rearing ponds.

Red River: There would be an increase in TDS concentrations in the Red River with the operation of an outlet from Devils Lake. The TDS standard for the Red River is 500 ppm (mg/l). This standard is currently exceeded under natural conditions at various times of the year. Operation of the outlet could change the timing, duration, and frequency of occurrence of such events. The fishery on the Red River appears fairly tolerant of poor and fluctuating water quality conditions. Therefore, it is anticipated that the operation of the proposed outlet would have minimal effects on the fishery resource in the Red River.

Biota Transfer

Biota transfer from Devils Lake to Red River drainage basin has been repeatedly identified as a concern in past studies. A recent evaluation of the operation of an emergency outlet for Devils Lake with respect to biota transfer identified no impacts, potential threats, or areas of concern for the following existing biota: Fish, macrophytes, algae, pathogens, and invertebrates. A slight potential for increased phosphorus loading was identified. The change in phosphorus loading could affect the algal community in Lake Winnipeg. The evaluation also identified that, while unlikely, it was not impossible that unique pathogens for pike, walleye, and perch could be introduced to the receiving water through fish escaping from Devils Lake via the outlet.

Mercury

The bioaccumulation of mercury is also a potential problem in Devils Lake, the Sheyenne River, and the Red River. There have been mercury advisories in all three areas in the past. The mercury advisory in Devils Lake was probably due to the inundation of organic material that had not been flooded for many years, and the subsequent methylation of mercury. Operation of an outlet could increase the potential for increasing mercury in the aquatic system downstream of the outlet. The likelihood that operation of the outlet would result in a measurable increase in mercury levels in downstream aquatic systems is considered to be slight. This is a potential effect that would require more detailed evaluation.

Cultural Resources

Potential for Additional Cultural Resources Sites

In 1985, the Corps Waterways Experiment Station conducted a geomorphological study of the Devils Lake area in connection with a St. Paul District, COE, feasibility study for flood reduction and related purposes at Devils Lake (ref. Larson, 1986, Geomorphological Study of the Devils Lake Area, North Dakota). This study concentrated on seven alternative outlet channel alignments from the Devils Lake-Stump Lake complex to the Sheyenne River, but included an overview of the entire Devils Lake basin. The two highest strandlines around Devils Lake are at 1445 and 1453 above mean sea level. The strandline at 1453 occurs at the base of a wave-cut bench which encircles both Devils Lake and Stump Lake and is related to the natural outlet from Stump Lake to the Sheyenne River. The strandline at 1445 is associated with the outlet at the eastern end of Devils Lake where flows pass along a meltwater channel to Stump Lake.

The proposed Twin Lakes outlet alignment follows the Crow Hill glacial meltwater channel which flows through the North Viking Moraine located south of Devils Lake. Geomorphic landforms along the Twin Lakes outlet alignment include lake bed, outwash channel, end moraine, stagnation moraine, outwash deposits, river terrace, and river floodplain alluvium. According to this study, the uplands and terraces along the Sheyenne River have the highest potential for archeological sites (e.g., 32BE6). Other landforms with high potential for archeological sites include point bar (inside loop) deposits ib the Sheyenne River floodplain; lakeshores, especially those areas adjacent to natural inlets and outlets; ancient beach ridges and back beach areas; uplands adjacent to the glacial outwash channels south of Devils Lake; eskers; kames; peninsulas; and islands. Areas of low archeological potential include lakebeds; the wet, marshy bottoms of outwash channels; and uplands away from lakeshores and river valleys, except for around any small, shallow lakes. Sites in north-south outwash channels, such as the Twin Lakes outwash channel, would be buried by up to six feet of aeolian deposits. Sites on the uplands will be at or near the surface.

The 1986-1987 Larson-Tibesar Associates survey found little significant correlation between specific landforms and archeological site locations; however, they acknowledge that this may be due to the small amount of acreage surveyed. The majority of prehistoric archeological sites found in their sample survey areas occurred on terminal moraine, which is the commonest geomorphic landform in the area. The bottoms of outwash channels and lacustrine deposits at Devils Lake have few sites. Most archeological sites around Devils Lake occur above 1450, which parallels the 1453 beach strandline surrounding both Devils Lake and Stump Lake. The uplands overlooking the outwash channels contain a variety of archeological sites and isolated artifacts (e.g., IF#3). Archeological site types which are known from the Devils Lake vicinity include mounds, stone circles or tipi rings, cultural material scatters, rock cairns, a fortified village, a bison jump, a 3-foot-by-2.5-foot rock ring, and a petroform (rock outline). Mounds occur on terminal moraine, outwash plain, lacustrine, ground moraine, and esker landforms. Cultural material scatters occur on terminal moraine, outwash plain, alluvium, and lacustrine landforms. Stone circles occur on terminal moraine and outwash plain landforms. Rock cairns, the rock ring, and the bison jump occur on terminal moraine. The fortified village occurs on Sheyenne River alluvium, and the petroform occurs on lacustrine deposits at Devils Lake. A traditional Hidatsa village site occurs on terminal moraine and lacustrine deposits on Grahams Island.

Potential Impacts to Cultural Resources Sites

Devils Lake: Any prehistoric or historic archeological site, architectural sites, or traditional cultural properties located below 1436 have already been directly affected by inundation and/or erosion as a result of the recent rise in the level of Devils Lake. Based on past surveys, archeological sites tend to be located at and above 1450, which is associated with the 1453 beach strandline encircling the entire Devils Lake-Stump Lake complex of lakes. Few prehistoric archeological sites have been found or are expected on the lakebed below 1450. Historic sites and standing structures are a different matter. Lake levels were sufficiently high between 1883 to 1910, the period of initial settlement, that steamboats operated on Devils Lake. After 1910, however, the lake level became too low for such boat traffic. It continued to drop until 1940, then began to rise until the present high water level. Around Devils Lake, any prehistoric or historic archeological sites, architectural sites, or traditioanl cultural properties located up to 5 feet above the lake's eventual high water elevation may be subject to damage from inundation, wave action and erosion. Construction of an outlet may have some effect on the maximum elevation to which Devils Lake will rise. This may prevent inundation or damage to some cultural resources sites or traditional cultural properties located around Devils Lake.

Twin Lakes Outlet Route: Several of the known archeological and architectural sites located along the proposed Twin Lakes emergency outlet alignment may be directly affected by construction of the outlet. These include building(s) on the raised area surrounded by marsh in Section 21, Township 152 North, Range 66 West, and the well and spring in the channel bottom in Section 29, Township 151 North, Range 65 West. Other pre-1950 buildings, farmsteads and rural schools are within the area of potential effect. Because most of the Twin Lakes emergency outlet route has not been surveyed for cultural resources, it is unknown how many other archeological and architectural sites are located in the outlet route's construction and operation area. As of June 15, 1996, there are no known National Register of Historic Places listed or eligible sites along the Twin Lakes emergency outlet route. Traditional cultural properties along this route have yet to be inventoried, so potential effects to this type of cultural property are unknown.

Sheyenne River: Portions of the Sheyenne River have been surveyed for cultural resources. Archeological sites have been found on the floodplain, river terraces, and edges of the uplands overlooking the river valley. Sites in these areas will be affected to the extent that discharge from the emergency outlet will increase erosion along the river channel.

MITIGATION

Natural Resources

A preliminary evaluation indicates that the construction and operation of an emergency outlet from Devils Lake would require the development and implementation of a mitigation plan to compensate for unavoidable losses. An estimate of potential mitigation needs and costs is presented below.

Along the Outlet Route

The most direct effects would be associated with the construction of the outlet channel. As noted earlier, approximately 150 acres of wetlands, 75 acres of grasslands, and 10 acres of woodlands would be directly affected by the construction of the outlet. An additional 620 acres of wetlands, 75 acres of grasslands, and 40 acres would woodlands along the outlet route would be affected by operation of the outlet. Assuming in-kind mitigation would be required for any acreages affected by construction and operation of the outlet, full compensation would be required for a total of approximately 770 acres of wetlands, 150 acres of grasslands, and 50 acres of woodlands.

Several approaches for compensating for losses associated with the outlet are possible. They include management of project lands, acquisition of separable lands, or a combination of the two. Management of project lands could include operation of the structures to maintain and manage created wetlands after emergency operation of the outlet ceases, grassed channel plantings, or woodland plantings. It is assumed that the real estate interest acquired for the majority of project lands would be temporary and flowage easements and would not be fenced. Therefore, most project lands would have little management opportunity for reducing compensation requirements.

Acquisition and management of separable lands could also be used as an approach for compensating for unavoidable losses. A preliminary analysis indicated that suitable opportunities for acquisition or restoration of these habitat types exist in the project area. A 2-for-1 ratio for replacement was used for this preliminary evaluation. More detailed studies may indicate that a higher or lower replacement ratio would be required for certain habitat types.

Precise cost estimates for fish and wildlife compensation features associated with the construction and operation of the outlet are not possible without more detailed studies to identify actual losses associated with construction, existing habitat quality in the project area, the potential for improving the quality of existing habitat through management, and the availability and suitability of separable lands. However, a general guideline that can be used to calculate the acquisition/establishment cost of replacement habitat is on a 2-for-1 basis. In reality, the amount of lands required may be somewhat less; but the estimated cost will usually reflect the management costs of acquired lands as well. For this evaluation, an acquisition cost of $500 per acre was used. This cost may appear excessive at first, given that appraised values for wetlands, grasslands, and woodlands in the area range from $200 to $400 per acre. However, suitable mitigation lands would most likely be located on or immediately adjacent to productive farmland or pasture land. It is unlikely that such lands could be bought in isolation, but rather would require acquisition of some portion of adjacent lands. It is felt that the higher cost per acre is a more accurate estimate at this time of what the actual acquisition costs may be.

Successful implementation of mitigation features would most likely require that the separable lands be fenced. Based on an estimate of 2000 acres of mitigation lands, an estimated fencing cost of $24,000 was used for this evaluation.

Mitigation costs for impacts to wetlands, woodlands, and grasslands along the outlet alignment are estimated to be $1,576,000. A summary of the estimate is provide in Table 2.

Devils Lake and Receiving Waters

Many of the effects associated with the operation of the outlet can not be readily quantified. Many of the potential effects involve subtle long-term changes to existing ecosystems and may not be readily noticeable or quantifiable without extensive monitoring programs. Extensive monitoring programs for Devils Lake and along the Sheyenne River should be designed and initiated prior to operation of the outlet. Potential monitoring programs include long-term water quality monitoring once operation is initiated; groundwater monitoring; establishment of vegetation survey transects along the Sheyenne River riparian corridor to monitor vegetation changes; and establishment of long-term survey stations to assess aquatic ecosystem changes, including channel morphology, fish surveys, benthic/nektonic surveys, and mussel surveys. The extent and cost of these programs was not identified at this time.

Some measures may be required to ensure that the hatchery operations on the Sheyenne River are not adversely affected. Such measures may include water treatment facilities or alternate water sources. Costs for these measures were not estimated at this time.

Table 2: Estimated Cost for Mitigation for Effects along Outlet Alignment

ITEM	HABITAT LOST (acres)	UNIT	UNIT COST	QUANTITY	COST
Wetland	770	acres	$500	1540	$ 770,000
Woodland	50	acres	$500	100	50,000
Grassland	150	acres	$500	300	150,000
Acquisition cost					97,000
Contingencies (50%)					485,000
Subtotal					$1,552,000
Fencing		mile	$3000	8	$24,000
TOTAL					$1,576,000

Mitigation Policies

Current COE mitigation policy provides guidance for the development of mitigation plans. This guidance would be used in developing a final mitigation plan for the proposed outlet. The general guidance is summarized below.

a. Habitat-Based Evaluation - The evaluation procedure used to determine mitigation needs is to be habitat-based. The evaluations and compensation plan for Devils Lake would be based on habitat delineations, acreage determinations, and an evaluation of the quality of the habitat affected. The North Dakota Game and Fish Department and the USFWS have indicated in past studies that they want to use 1-for-1 restoration for mitigation, similar to that approved for the Garrison Diversion Unit.

b. Incremental Analysis - The most cost-effective features for mitigating impacts should be given priority consideration; that is, the value of the last increment of losses prevented should exceed the added costs of the last increment of mitigation. An incremental analysis would have to be conducted to identify the most cost-effective measures to offset unavoidable impacts associated with construction and operation of the outlet.

c. Project Lands - Mitigation measures should be provided on project lands to the extent practicable and justifiable. Impacts may be minimized to the extent possible through control structures to maintain existing conditions, drop structures to create wetland habitat, and plantings in the channel to restore habitat. This would depend on the land acquisition policy used, including amount of land acquired and if it is fee title or easement.

d. Contiguous Lands - To the extent practicable, mitigation measures should be contiguous to the areas where impacts occur. The impacts occur primarily along the outlet route. The goal would be compensate for losses where they occur. However, the actual location of compensation areas would depend on the availability of lands. Potential compensation areas have not been identified.

e. Use of Public Lands - Policy allows for the management of public lands for mitigation purposes. No opportunities to provide mitigation through management of public lands have been identified during past studies.

f. Beneficial Effects - The extent to which the beneficial fish and wildlife actions associated with the project offset adverse impacts should be assessed before considering separable measures. Beneficial effects associated with the outlet need to be quantified to the extent possible and considered in the development of any final mitigation plans.

g. Consideration of Separable Measures - Separable measures should be evaluated when adverse effects exceed the beneficial impacts associated with the project. It is likely the proposed action would require the acquisition and management of separable lands to provide full compensation of unavoidable losses associated with construction and operation of an outlet from Devils Lake.

h. In-Kind Mitigation - To the extent practicable, losses in a given habitat type will be offset by mitigation measures which replace or raise the value of the same type of habitat. The habitat types lost include woodland, wetland, and grassland. Out-of-kind mitigation was not considered at this time.

A summary of the current status of mitigation needs for the emergency outlet is shown in Table 3.

Table 3: Mitigation Needs for Devils Lake Emergency Outlet

EVALUATION AREA	HABITAT AREA LOST OR AFFECTED	MITIGATION ACTION	TOTAL COST
Twin Lakes outlet route	970 acres	Acquisition and management	$1,576,000[a]
Devils Lake	Cannot be determined at this time	Monitoring	Cannot be determined at this time
Sheyenne River / Red River of the North	Cannot be determined at this time	Monitoring	Cannot be determined at this time

[a] Mitigation estimate based on acquisition of replacement habitat on a 2-for-1 basis.

Cultural Resources

If any cultural resources sites or traditional cultural properties found along the Twin Lakes emergency outlet route are evaluated as being eligible for listing on the National Register of Historic Places and cannot be avoided, potential impacts to that site or property will have to be mitigated through some combination of formal excavation, archival research, oral histories, Historic American Building Survey/Historic American Engineering Record (HABS/HAER) recordation, and/or replacement plantings of traditionally used plants.

FUTURE STUDIES

Due to the preliminary nature of the design and uncertainty as to the effects of construction and operation of the outlet, more detailed information is required to fully identify the effects of an emergency outlet from Devils Lake. Ideally, mitigation features should be implemented concurrently with construction. However, should it be directed that the project be constructed prior to the completion of needed studies, detailed monitoring programs should be developed in order to quantify the effects of construction and operation of the outlet, and appropriate mitigation features designed and implemented in a timely manner. Extensive and long-term studies would be required to fully identify effects to Devils Lake and downstream that could occur with operation of an outlet. Studies would be required in the areas of water quality, groundwater, aquatic resources, lake levels, terrestrial habitat, social acceptability, cultural resources, downstream water quality, recreation, etc. The types and scopes of needed studies would be developed in coordination with other Federal, State, and local agencies.

Natural Resources

The following studies would be required to complete a more detailed evaluation of the potential effects along the outlet:

o An updated and more detailed delineation of the amounts and types of habitat along the outlet alignment.

o Completion of a Habitat Evaluation Procedure (HEP) study to determine existing habitat quality, project effects on existing habitat quality, and mitigation needs.

o Detailed mitigation planning would involve a tiered approach to minimize the need to acquire separable lands. A summary of the mitigation and compensation approaches to be considered during detailed design studies is presented below.

a. Avoid impacts. Impacts may be avoided by such measures as shifting alignment, eliminating channel excavation where possible, or proposing control structures on wetlands or lakes to maintain optimum conditions.

b. Minimize impacts. The impacts could be minimized by alternatives to water delivery methods, such as construction of a pipeline instead of an open channel. Water level control and drop structures could be used to maintain water levels, reduce erosion, and minimize the loss of habitat. Impacts might be reduced if, instead of drawing the pools down under non-operating conditions, the levels in the pools would be retained at the operating level. In addition, water levels would not be modified along the routes until the project is actually needed.

c. Rectify impacts. Using drop structures to create wetland areas could be considered as a measure to reduce some of the losses. Also grassed channels may compensate for some of the losses incurred by the project.

d. Reduce impact over time. The impacts of the project may be reduced by maintaining non-operating water levels in some wetlands at the same level as currently exists. Devils Lake water could be used to maintain operating and non-operating water levels along the routes.

e. Compensation. Compensation plans to provide for in-kind replacement for losses due to construction and operation of the outlet should be developed and implemented at the same time as the construction loss occurs. Due to the unpredictability of lake level fluctuations, the creation of wetlands of a different type from those lost and the inability to predict if and when woodland benefits could be expected, the area around Devils Lake would be excluded from the compensation analysis. Various compensation plans should be considered to minimize acquisition of separable land, maximize compensation opportunities adjacent to project lands or at existing Federal refuge areas, and optimize restoration of habitat.

o Identification of the extent of groundwater effects, both water quality and elevations, that could occur with the operation of the outlet would be required to identify the potential effects on habitat adjacent to outlet channel and the Sheyenne River.

Traditional Cultural Properties

Coordination has been initiated with the Spirit Lake Nation regarding the presence of traditional cultural properties along the proposed Twin Lakes emergency outlet route and in the vicinities of the Devils Lake shoreline and along the Sheyenne River. Because of their historical associations with the Devils Lake region, the Hidatsa will also be consulted regarding traditional cultural properties in the project vicinity. The Hidatsa are currently part of the Three Affiliated Tribes and, along with the Mandan and Arikara, are located on the Fort Berthold Reservation on the Missouri River in the New Town vicinity.

Cultural Resources Surveys

A 100-percent cultural resources survey of the Twin Lakes emergency outlet route would need to be conducted prior to the start of outlet channel and related pumped storage construction. Any prehistoric and historic archeological sites and all buildings and structures older than 50 years which are located within the proposed project area will need to have their National Register of Historic Places eligibility evaluated. Impacts to those National Register of Historic Places eligible sites which cannot be avoided will have to be mitigated. This work will be coordinated with the North Dakota State Historic Preservation Officer.

SIGNIFICANT RESOURCES AND ISSUES OF CONCERN

Construction of the emergency outlet may be viewed as the first step in implementing features required for the stabilization of Devils Lake. Proceeding with construction of an outlet on an emergency basis will most likely generate considerable public and agency controversy in both the U.S. and Canada. Implementation of this feature would require the preparation of an Environmental Impact Statement (EIS).

Numerous studies have been completed in the Devils Lake basin. Significant resources and concerns have been identified during these studies. Many of the issues/concerns remain items that would need to be addressed should construction of the outlet proceed. The following is a preliminary list of potential significant environmental resources that have been identified on the basis of public interest, law, and/or technical criteria. The purpose of this list is to point out some of the significant concerns in the area and the need for future studies. The major area of concern is the Devils Lake basin and areas that would receive outlet water from the basin.

Woodlands

Although the Devils Lake basin is heavily wooded compared to other areas of the State, woodlands are still only 3 percent of the land use in the basin. Large continuous woodlands are located around Main and East Bays and East Devils Lake. Scattered woodlands are located in the coulees and around wetlands and lakes along the outlet route. The woodlands provide important cover and reproduction habitat for many species including white-tailed deer, owl, grouse, and songbirds.

Wetlands

Wetland habitat in the basin varies from small temporary type 1 wetlands to large permanent open-water lakes. Along the outlet alignment, pothole wetlands are located adjacent to the channel alignment, whereas large, deep type 5 wetlands are found both on the channel alignment and on the bays and lakes of the Devils Lake chain. These areas provide habitat for waterfowl, water quality benefits, and flood damage reduction.

Grasslands

The grassland areas are important for upland wildlife such as fox and grouse and also for their interspersion with wetland complexes. Grasslands are found mainly in the southern part of the basin and are an important habitat found along the channel alignment.

Threatened and Endangered Species

Four Federally-listed threatened or endangered species of birds may occur in the project area. They are the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), and piping plover (*Charadrius melodus*). Most of these species are seen on a migratory basis. Although the piping plover has been recorded in the basin historically, no recent sightings have been recorded. Potential piping plover habitat is located in areas around Devils Lake and at the Stump Lakes.

Management Areas

State and Federal game management areas, refuges, and easements are found throughout the project area. Kirk's State Wildlife Management Area is located at East Devils Lake, and numerous Waterfowl Production Areas and Wetland Easement lands are located throughout the basin.

Natural Areas

There are a number of designated and inventoried natural areas in the project area. For example, the Sweetwater Lake complex is a nesting and migration area for many bird species. These areas have been identified as having important wildlife, aesthetic, vegetation, or scientific value. These areas are rather uncommon or have characteristics unique to the region.

Fishery

The fishery of Devils Lake is highly valued and is an important economic resource. Ice fishing routinely draws large numbers of anglers from Canada, Minnesota, and Wisconsin. Game species are, by far, dominant from West Bay to East Devils Lake. Reproduction appears to be limited to the west end of the lake due to water quality. The lakes in the southern and northern parts of the basin have limited fishery potential due to their shallow depth. The upper reaches of the Sheyenne River do have some fishery value and are used by local fishermen. Lake Ashtabula is a valuable fishery and is important to the surrounding recreation. Both Devils Lake and Lake Ashtabula are stocked by the ND Game and Fish Department. The Red River of the North is a significant fishery. Trophy catfish are found along the lower reaches of the Red River.

Rough Fish Introduction

The introduction of rough fish into the Devils Lake system would have a extremely detrimental effect on fish habitat. The Baldhill and Cooperstown Dams prevent the upstream movement of fish in the Sheyenne River. Carp, for example, are not known to be above Baldhill Dam. The final outlet design and operation plan should be evaluated to ensure that it does not provide for the movement of fish from the Sheyenne River to Devils Lake.

Biota Transfer

Presently there is no major connection between major basins. The Sheyenne and Red River basins are not connected to the Devils Lake basin, which is a closed basin at lake levels below approximately 1455. There presently does not appear to be any species in the Devils Lake basin which are not found in the Hudson Bay drainage.

Cultural

Archaeological studies in the basin have found a number of significant sites and suggest that there are probably a large number of sites that have yet to be recorded. Future opportunities include the identification of these unknown sites and the preservation and study of the recorded areas.

Tribal Trust Resources

The Twin Lakes alignment is located primarily on the Devils Lake Sioux Reservation. Future studies need to identify tribal concerns along the outlet route and ensure compliance with Native American treaty obligations.

Water Quality

The recreation and fishery resources of the area are dependent on water quality. The primary area of concern and study was the main Devils Lake chain, Lake Ashtabula, and the Sheyenne River for TDS and sulfate concentrations. Nutrient inflow also increases growth of algae and detracts from the recreational experience. The water quality of the basin and receiving waters is a concern of many agencies. The methylation of mercury is also a concern in the Devils Lake basin and receiving waters. There have been mercury advisories in the past concerning fish consumption.

Recreation

Public and private recreation facilities located around the lake offer a range of services from full service campgrounds to boat launch facilities. These areas have modified their services in reaction to the fluctuating lake levels. Other activities in the basin include hunting, fishing, boating, sightseeing, biking, snowmobiling, and picnicking.

Public Health and Safety

Public health and safety considerations in the Devils Lake basin related to lake level include flooding of emergency routes, water quality, sewage, and vectors.

Productive and Fiscal Capacity

Currently, the City of Devils Lake is a stable agricultural support and rural center that has suffered less than many similar communities from the weak agricultural economy. This is partly due to the diversified economy and tax base, which includes significant manufacturing, educational, and recreational activities.

Community Cohesion

The Devils Lake region has several issues related to water resources management that are sources of conflict. Some of these issues are drainage of prairie potholes for farmland, mitigation, ownership of the lake bed, and management of the Devils Lake fishery. Relations between the city, rural areas, State and Federal agencies, and the Spirit Lake Nation are frequently strained.

Effects at the International Boundary

The operation of an outlet from Devils Lake has the potential to result in effects at the International Border. Recent evaluations have indicated that the operation of an outlet from Devils Lake may have minimal effects at the border. However, the need for additional studies to adequately evaluate effects at the border were identified and include:

a. More extensive water quality monitoring in Devils Lake.

b. Identification of the rate, transport and storage mechanisms of phosphorus and nitrogen in the Sheyenne River, Lake Ashtabula, and Red River of the North.

c. Travel time from Devils Lake to Emerson, including routing and residence time in Lake Ashtabula.

d. Water quality monitoring that identifies water quality characteristics at the border.

e. Determine if algal toxins are present in Minnewaukan Flats Bay of Devils Lake and quantify concentrations.

f. Continue striped bass sampling in Devils Lake.

g. Further review and research as to endemic pathogens present in both Hudson Bay and Missouri River basins.

Identified Downstream Concerns

During the preparation of the COE's "Devils Lake, North Dakota, Contingency Plan," issued 15 February 1996, downstream concerns were identified via letters, faxes, and verbal statements at public meetings held in Lisbon and Valley City, ND, on 31 January 1996. Downstream concerns include the following:

a. Environmental
- An altered flow regime (in particular, long-term bank-full flow) might adversely affect the aquatic community
- ... increase groundwater levels adjacent to the river, thereby changing floodplain vegetation
- ... alter adjacent land use.
- Will the added salinity and possibility of mercury and other heavy metals affect the river's fishery?
- Will the added drainage area increase phosphate runoff, hence, algal

blooms?

b. Flooding

- A bank-full river during outlet operation poses a threat of downstream flooding from coincidental thunderstorm events. Throttling back the outlet when a major runoff event is anticipated would not help because an outlet release can take 2 or more weeks travel time to reach the RRN.
- Would higher river flows from outlet operation affect the regulatory floodplain (hence, change Flood Insurance Rate Maps)?
- Would higher winter or spring flows increase the frequency or severity of ice jams and cause more flooding?
- Who would pay for induced damages from higher water downstream?
- ... if Valley City has to raise its dikes?
- ... for relocations of structures flooded more frequently due to higher river stages?
- Should the Lisbon emergency dike system be upgraded because of the higher river flows?

c. Erosion

- Would higher river flows increase riverbank erosion?
- Downstream residents contend that, before the Baldhill Dam was built, spring flood flows passed before the riverbanks thawed; therefore, erosion was minimal. Today, water stored by Baldhill operation to lower the peak stage has to be released over a longer duration of high flows, which increases erosion. Would added flow from a DL outlet worsen the situation?
- Increased erosion could result in loss of Woodland Period Native American cultural resource sites and of riverbank trees.

d. Farming

- Farmers adjacent to the Sheyenne River are concerned that outlet operation will increase river flow and, in turn, raise the water table and affect farming operations. Some farmers contend that operation of the Baldhill Dam already keeps the river high too long and prevents normal drainage of farmland; they feel that outlet operation would exacerbate those problems. Farmers in the Sheyenne delta area miles from the river assert that, because of the porous soils, they already are experiencing problems with a higher than normal water table from prolonged high river stages. Would added flow from a DL outlet worsen the situation?
- Farmers owning land on both sides of the river rely on low-flow crossings to get stock and equipment across. Would outlet operation increase river levels and interfere with or prevent crossing?
- Would WQ impacts from outlet operation affect the river's suitability for stock watering?

e. Roads and bridges

- Would downstream roads and bridges suffer damages from higher river flows?

f. Community water supply

- Will WQ changes (TDS, heavy metals, etc.) affect the Valley City water supply?

g. Other

- Wintertime operation of the outlet could weaken the river's ice cover and pose a threat to snowmobilers and other recreational users of the river corridor. Weakened ice also could prevent use of the ice cover for clearing and snagging operations.
- Will WQ effects have adverse impacts on Lake Ashtabula recreation?

SOCIAL IMPACT ASSESSMENT

A social impact assessment will be required as part of the EIS, whether an EIS is done in conjunction with the Devils Lake Feasibility Study or independently for the emergency outlet alone. Past studies have indicated that the proposed emergency outlet is the type of alternative that will affect a number of social and economic parameters, including recreation, public health and safety, community growth and development, and community cohesion and controversy. The proposed outlet would also have some effect on flood damage reduction, transportation, aesthetics, and land use. Social impacts will be directly related to project design and performance, as well as resultant environmental effects, such as fishery and water quality impacts.

Effects will be distinguished for at least three geographically distinct populations -- persons living in immediate proximity to Devils Lake, persons living along the outlet route, and persons living downstream of the outlet's confluence with the Sheyenne River. Concerns and effects will be different among these groups, and they will be analyzed accordingly. Techniques used to gather information on effects could include mail and telephone surveys, institutional analyses, focus groups, public meetings, and other forms of public involvement. Issues will range in scope from the individual's level (e.g., stress and uncertainty related to flooding), to upstream/downstream concerns between groups, to the international level (WQ and biota transfer issues involving Canada).

DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

COST ESTIMATE APPENDIX

COST ESTIMATE APPENDIX

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COST ESTIMATE APPENDIX

1 GENERAL. This appendix contains the project cost estimate prepared for the construction of the Devils Lake Emergency Outlet Plan at Devils Lake, North Dakota. The estimate has been prepared using historic cost data. Results are presented on a spread sheet showing costs and contingencies. This write-up is prepared to explain cost relationships and development of the contingencies. Guidance for preparation of this appendix was obtained from ER 1110-2-1150, Engineering and Design for Civil Works Projects, and ER 1110-2-1302, Civil Works Cost Engineering. The estimate is in the Civil Works Breakdown Structure format as directed by ER 1110-2-1302.

2 PRICE LEVEL. Estimated costs are based on June 1996 price levels. Estimated prices on the Total Project Cost Summary Sheet are rounded to the nearest $1,000.

3 PROJECT DESCRIPTION.

3.1 GENERAL. The purpose of the project is to provide an outlet for Devils Lake. Water from Devils Lake will be pumped by a series of three pump stations. Each pump station pumps water to a pond created by an earth embankment. After the third pump station, the water is ponded until it reaches the elevation of the discharge channel where it flows by gravity to the Sheyenne River.

3.2 EARTH EMBANKMENTS. The costs for the earth embankments are included in Account Code 04 DAMS. Typical features of the embankments include a toe drain, relief wells with pumps, random and impervious fill materials, topsoil and seed, and stone protection. Also included are costs to construct access roads to the areas from existing roadways. At the completion of construction, it is assumed that these access roads will be final graded and surfaced with aggregate. Slurry trenches, backfilled with a bentonite slurry, will be constructed where necessary. A reinforced concrete overflow spillway will be constructed in the middle embankment to prevent an overtopping failure from inflow due to interior drainage. The overflow spillway includes a steel sheet pile wall to cut off seepage and an underdrain system. These two features, the slurry trench and the overflow spillway, add significant cost to the earth embankments.

3.3 CHANNELS. The costs for the channel work are included in Account Code 09, CHANNELS AND CANALS. Channel excavation is required for the channels to the pump stations and for the gravity flow channel to the Sheyenne River. Costs include the construction of sand drains and relief wells. The channel to the pump stations will cross several roadways and costs have been included to construct box culverts through these roadways. In some cases, the roadways will be raised to allow room for the box culverts. The gravity flow channel to the Sheyenne River will contain gabion drop structures to prevent erosion.

3.4 PUMP STATIONS. The costs for the pump stations, including the electrical and mechanical work, are included in Account Code 13, PUMPING PLANT. It is assumed that the three pump stations are identical. Pump station costs include the cost of the pump stations and the inlet boxes. The structures are founded on timber piles and the inlet boxes contain a sheet pile wall for scour protection. Included in the costs for the pump stations is all the equipment costs and the cost to bring electrical power to each site for the operation of the lights and ventilation equipment.

3.5 OTHER PROJECT COSTS. The estimate includes costs for Account Code 30, PLANNING, ENGINEERING AND DESIGN and for Account Code 31, CONSTRUCTION MANAGEMENT. Costs for these features are estimated as a percentage of the construction cost. Costs for Account Code 01, LANDS AND DAMAGES have been determined by the Real Estate office.

4 CONSTRUCTION METHODS.

4.1 CONSTRUCTION TECHNIQUES. Construction will be done using conventional construction techniques. It is assumed that the work would be under the control of one prime contractor with several sub contractors. Subcontracted work would include the work associated with the concrete, electrical service and equipment, mechanical equipment and construction of the slurry trench.

4.2 TEMPORARY FEATURES. The project includes several temporary features of work to facilitate construction such as drains and relief wells for the excavation of the channels. The contractor will develop additional temporary features of work to facilitate the various methods of construction actually used.

4.3 CONSTRUCTION SEQUENCE. At this time, restrictions on the sequence of construction have not been identified. The Contractor will determine the sequence of construction based on his methods of operation, equipment available, and other factors. However, it seems likely that generally the channel work will be completed prior to the embankment work and the embankment work will be completed prior to the pump station work.

4.4 CONSTRUCTION DURATION. The duration of the construction is dependent on the number and sizes of the crews doing the work. A preliminary analysis indicates that two construction seasons, from May through October would be adequate to complete the work. A more detailed analysis would be necessary to determine the effects of requiring that the work be completed in one construction season.

5 COST RELATIONSHIPS

5.1 UNIT COSTS. Unit costs have been developed by very preliminary analysis and historical data. Due to the very limited design, no attempt was made to distinguish costs for similar items of work such as for 12 inch riprap and 18 inch riprap. Unit costs for concrete are divided into horizontal, vertical and overhead and columns concrete to reflect the associated forming costs however no distinction is made in the cost for concrete for the various structures.

5.2 MOBILIZATION AND DEMOBILIZATION. Mobilization and demobilization are calculated to be 2 percent of the construction cost. In addition, a separate mobilization was added for the pile driving as a function of the length of piles driven.

6 CONTINGENCIES.

6.1 GENERAL. Very little actual design was done for the preparation of this concept report. In addition, design data such as surface and subsurface information is very limited. To account for this in the cost estimate, contingencies are higher than what might be expected for a base line estimate where the costs are based on an actual design and the design is based on field data. The costs with contingencies are not intended to establish an upper limit estimate on the cost of the project. Rather, the contingencies are meant to establish what a reasonable cost for the project could be.

6.2 CONTINGENCY VALUES. Contingency costs are based on a percentage of the construction cost. Contingencies are included to cover uncertainties in unit pricing, unanticipated items of work, and quantities. Generally contingencies are based on:

a. 5 to 10 percent for unit pricing

b. 10 to 25 percent for unanticipated work

c. 10 to 20 percent for quantities

6.3 EARTHWORK. All earthwork items have a large contingency because of the uncertainties in field data (e.g., available topography was 10-foot contours from USGS quadrangle maps), sources of materials, groundwater conditions, and disposal areas. Contingencies are generally set at 45 percent.

6.4 STRUCTURAL. The structural items of work have less uncertainties than for the earthwork. The members have been sized or determined based on similar structures. The unit costs are based on recent historical data. Therefore, contingencies are generally set at 35 percent.

6.5 MECHANICAL AND ELECTRICAL. The quantities for these items is unlikely to change for this plan. Prices are based on recent historical data. Therefore, uncertainties are relatively less. Contingencies for these items of work are set at 25 percent.

6.6 PLANNING, ENGINEERING, AND DESIGN. Costs are based on a percentage of the estimated construction cost plus contingencies. Contingencies are set at 10 percent.

6.7 CONSTRUCTION MANAGEMENT. Costs are based on a percentage of the estimated construction cost plus contingencies. Contingencies are set at 10 percent.

7. COST SENSITIVITY TO OPTIONS

7.1 DIESEL POWER VERSUS ELECTRICAL POWER. An alternate to using diesel motors to drive the pumps is to use electric motors to drive the pumps. Operation and maintenance costs for diesel and electric motor driven pumps are discussed in the MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX.

7.1.1 The relative advantages of diesel and electrical power from a cost perspective include the following:

a. Diesel power has a lower first cost: Electrical power would require approximately 8 miles of transmission line to a new substation at Pump Station #1. The new substation would provide 4,160-volt service to all three pump stations via an estimated 10 miles of distribution feeder to Pump Stations #2 and #3. All three pump stations would be metered from the substation. In addition, a motor control center would be required at each pump station. The estimated cost for providing electrical service and a motor control center is $317,000 per pump station.

b. Electrical power possibly has lower OM&R costs: The MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX assumed a 7-month operational scenario -- 2⅓ months each at full, three-fourths, and one-half capacity -- to estimate operating costs of $320,000 and $450,000 for electrical and diesel power, respectively. However, the operating cost for electrical power could be higher than the diesel estimate if the power company imposed a demand charge on electrical service.

7.2 OUTLET CAPACITY: 200 cfs VERSUS 300 cfs. While testing the sensitivity of effectiveness to assumptions of the river's bank-full capacity and Devils Lake sulfate concentration, it became apparent that a larger bank-full capacity and the diluted sulfate concentrations at the high lake stages made larger outlet capacities practicable. Therefore, EOP costs were also estimated for an outlet capacity of 300 cfs. This option was evaluated for diesel-driven pumps only.

7.2.1 Features affected by the larger capacity include the following:

a. Pump capacity would be increased from 50-cfs to 75-cfs each. This requires a 42-inch pump and pipelines versus the original 30-inch size. The diesel motors would be increased to 300 hp from the original 200 hp at Pump Stations #1 and #2 and 225 hp at Pump Station #3. Other pump station features that would be affected include (1) the inlet sluice gates would be increased from 6 ft x 6 ft to 7 ft x 7 ft and (2) the capacity of the fuel tanks would be increased from 10,000 gallons to 15,000 gallons. In addition, the bottom width of the outlet channel and gabion drop structures would be increased from the original 30 feet to 50 feet. Fuel consumption was assumed to increase proportionately with the larger pumps, i.e., to 15 gallons/hour per engine at full load.

b. Features that would not be affected include the intake channel, dams, pump station structures, pools, and road crossings/box culverts.

7.3 COST ESTIMATE SUMMARY. The table below summarizes estimated first costs and annual OM&R costs for the basic 200-cfs diesel-powered design, the 200-cfs electrical-powered design, and the 300-cfs diesel-powered design.

OPTION	FIRST COST[a]	OM&R		
		Operating[b] (7-month scenario)	Operating[c] (100,000 ac-ft)	Downtime[d]
200-cfs / diesel power	$21,463,000	$660,000	$1,060,000	$210,000
200-cfs / electrical power	$22,398,000	$540,000	$860,000	$220,000
300-cfs / diesel power	$24,041,000	$920,000	$980,000	$240,000

[a] Includes PED, construction, construction management, real estate, and contingencies.
[b] Assumes OM&R operation 7 months per year, 2⅓ months each at full, three-quarter, and half capacity. OM&R cost estimates are developed in the MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX.
[c] OM&R to pump out 100,000 ac-ft.
[d] M&R assuming full-year downtime.

8 ATTACHMENTS

8.1 COST ESTIMATE SUMMARY SHEETS

a) 200-cfs capacity, diesel-driven pumps

b) 200-cfs capacity, electric motor-driven pumps

c) 300-cfs capacity, diesel-driven pumps

COST ESTIMATE SUMMARY SHEETS

200-cfs capacity, diesel-driven pumps

DEVILS LAKE EMERGENCY OUTLET PLAN, CONCEPT DESIGN **** TOTAL PROJECT COST SUMMARIES ****

PROJECT: DEVILS LAKE EMERGENCY OUTLET PLAN 200 CFS, DIESEL PUMPS PREPARED BY: GARY SMITH , CENCS-ED-C
LOCATION: DEVILS LAKE, NORTH DAKOTA
DATE PREPARED: 12 JULY 1996 REVISED REVIEWED AND APPROVED BY: ALLEN L. GEISEN , CHIEF, ED-C

ACCOUNT NUMBER	ITEM DESCRIPTION	ESTIMATED COST($) (EPD)	CONTINGENCY AMOUNT($)	%	TOTAL EST COST (EPD)	OMB INFLATION TO XX/XX %	OMB INFLATION TO XX/XX AMOUNT	MID POINT OF FEATURE	OMB (%) INFLATION (+/-)	INFLATED COST AMOUNT ($)	INFLATED CONTG. AMT. ($)	FULLY FUNDED COST
04---	DAMS	2,528,000	1,547,000	61%	4,075,000							
09---	CHANNELS AND CANALS	3,551,000	1,703,000	48%	5,254,000							
13---	PUMPING PLANT	4,623,000	1,383,000	30%	6,006,000							
	ENVIRONMENTAL MITIGATION	1,091,000	485,000	44%	1,576,000							
	TOTAL CONSTRUCTION COSTS =====>	11,793,000	5,118,000	43%	16,911,000							
01---	LANDS AND DAMAGES	251,000	42,000	17%	293,000							
30---	PLANNING, ENGINEERING AND DESIGN	2,875,000	287,000	10%	3,162,000							
31---	CONSTRUCTION MANAGEMENT	997,000	100,000	10%	1,097,000							
	TOTAL PROJECT COSTS ======>	15,916,000	5,547,000		21,463,000							

NOTES:
1. UNIT PRICES ARE AT JUNE 1996 PRICE LEVELS UNLESS NOTED OTHERWISE.
2. ASSUME THAT ENVIRONMENTAL MITIGATION REQUIRES NO ADDITIONAL CONSTRUCTION MANAGEMENT.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
01.-.-.-	LANDS AND DAMAGES							
	ALL COSTS COMBINED	JOB	1	251000.00	251,000	42,000	16.7%	2,3,4

SUBTOTAL CONSTRUCTION COSTS		$251,000	
SUBTOTAL CONTINGENCIES	16.7%		$42,000
TOTAL 01. LANDS AND DAMAGES			$293,000

REASONS FOR CONTINGENCIES:

1. NOT APPLICABLE
2. UNKNOWN DUE TO LEGAL COSTS.
3. UNKNOWNS DUE TO LAND PRICES.
4. UNKNOWNS DUE TO QUANTITIES.

NOTES:

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
04.--.--.--	DAMS							
04.01.--.--	MAIN DAM							
04.01.01.--	MOBILIZATION, DEMOB AND PREP. WORK	JOB						
04.01.01.--	MOBILIZATION, DEMOBILIZATION	JOB	1	39,773.73	39,774	39,774	100.0%	1,2,3,4
04.01.01.--	ACCESS ROADS	JOB	1	500,000.00	500,000	500,000	100.0%	1,2,3,4
04.01.02.--	DRAINAGE							
04.01.02.02	SITEWORK							
04.01.02.02	TOE DRAIN	LF	1,260	15.00	18,900	8,505	45.0%	1,2,3,4
04.01.02.02	F&O RISERS	EA	10	55.00	550	248	45.0%	1,2,3,4
04.01.02.02	RELIEF WELLS W/ PUMPS	EA	4	3,000.00	12,000	5,400	45.0%	1,2,3,4
04.01.42.--	EARTH AND ROCKFILL DAMS							
04.01.42.02	SITE WORK							
04.01.42.02	RANDOM FILL	CY	19,013	5.00	95,065	42,779	45.0%	1,2,3,4
04.01.42.02	IMPERVIOUS FILL	CY	18,464	6.20	114,477	51,515	45.0%	1,2,3,4
04.01.42.02	TOE AND SAND DRAIN	CY	5,376	26.20	140,851	63,383	45.0%	1,2,3,4
04.01.42.02	TOPSOIL	CY	2,507	9.50	23,817	10,717	45.0%	1,2,3,4
04.01.42.02	SEED	AC	1.55	1,250.00	1,943	874	45.0%	1,2,3,4
04.01.42.02	6" BEDDING	CY	780	27.50	21,450	9,653	45.0%	1,2,3,4
04.01.42.02	9" BEDDING	CY	129	27.50	3,548	1,596	45.0%	1,2,3,4
04.01.42.02	12" RIPRAP	CY	1,599	50.00	79,950	35,978	45.0%	1,2,3,4
04.01.42.02	18" RIPRAP	CY	255	50.00	12,750	5,738	45.0%	1,2,3,4
04.01.42.02	12" STRIPPING	CY	2,110	1.53	3,228	1,453	45.0%	1,2,3,4
04.01.42.02	EXCAVATION	CY	10,495	5.07	53,210	23,944	45.0%	1,2,3,4
04.01.42.02	SLURRY TRENCH, CONCRETE BACKFILLED	CY	6,000	55.00	330,000	330,000	100.0%	1,2,3,4
04.01.42.02	ACCESS ROADWAY AGGREGATE SURFACE	JB	1	200,000.00	200,000	90,000	45.0%	1,2,3,4
04.02.--.--	SPILLWAY							
04.02.10.--	EARTHWORK FOR STRUCTURES							
04.02.10.02	EXCAVATION	CY	650	5.07	3,296	1,483	45.0%	1,2,3,4
04.02.12.--	SEEPAGE CONTROL							
04.02.12.02	SHEET PILE							
04.02.12.02	PZ22	SF	11,400	20.00	228,000	79,800	35.0%	1,2,3,4
04.02.12.02	6" DRAINS, PVC	LF	460	15.00	6,900	2,415	35.0%	1,2,3,4
04.02.12.02	BEDDING	CY	305	27.50	8,388	2,936	35.0%	1,2,3,4
04.02.20.--	OUTLET CHANNEL							
04.02.20.02	EXCAVATION	CY	3,800	5.07	19,266	8,670	45.0%	1,2,3,4
04.02.20.02	60" RIPRAP	CY	3,000	50.00	150,000	67,500	45.0%	1,2,3,4
04.02.20.02	12" BEDDING	CY	600	27.50	16,500	7,425	45.0%	1,2,3,4
04.02.51.--	CONCRETE OVERFLOW SECTION							
04.02.51.03	CONCRETE							
04.02.51.03	HORIZONTAL	CY	1,150	300.00	345,000	120,750	35.0%	1,2,3,4
04.02.51.03	VERTICAL	CY	95	400.00	38,000	13,300	35.0%	1,2,3,4
04.02.51.03	REINFORCING	LBS	112,000	0.55	61,600	21,560	35.0%	1,2,3,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	SUBTOTAL CONSTRUCTION COSTS				$2,528,460			
	SUBTOTAL CONTINGENCIES		61.2%			$1,547,394		
	TOTAL 04. DAMS					$4,075,854		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. NOT APPLICABLE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
09.--.--.--	CHANNELS AND CANALS							
09.01.--.--	CHANNELS							
09.01.01.--	MOB, DEMOB AND PREPATORY WORK							
09.01.01.--	MOB AND DEMOB	JOB	1	69,627	69,627	69,627	100.0%	1,2,3,4
09.01.01.--	SAND DRAINS	CY	1,500	26.20	39,300	17,685	45.0%	1,2,3,4
09.01.01.--	DEWATERING WELLS	EA	120	525.00	63,000	28,350	45.0%	1,2,3,4
09.01.15.--	MECHANICAL EXCAVATION							
09.01.15.02	SITEWORK							
09.01.15.02	STRIPPING	CY	165,588	1.53	253,350	114,007	45.0%	1,2,3,4
09.01.15.02	EXCAVATION (DRY)	CY	566,364	1.25	707,954	318,579	45.0%	1,2,3,4
09.01.15.02	EXCAVATION (WET)	CY	566,364	1.70	962,818	433,268	45.0%	1,2,3,4
09.01.15.02	12" TOPSOIL	CY	165,588	2.00	331,176	149,029	45.0%	1,2,3,4
09.01.15.02	SEED	AC	102	500.00	51,246	23,061	45.0%	1,2,3,4
09.01.99.--	ASSOCIATED GENERAL ITEMS							
09.01.99.02	GABION STRUCTURES							
09.01.99.02	GROUT	SY	247	200.00	49,400	22,230	45.0%	1,2,3,4
09.01.99.02	FILTER FABRIC	SY	5,643	3.00	16,929	7,618	45.0%	1,2,3,4
09.01.99.02	3'GABION BASKETS	CY	684	95.00	64,980	29,241	45.0%	1,2,3,4
09.01.99.02	1' GABION BASKETS	CY	1,425	105.00	149,625	67,331	45.0%	1,2,3,4
09.01.99.02	6" GABION BASKETS	CY	152	90.00	13,680	6,156	45.0%	1,2,3,4
09.01.99.02	CULVERTS							
09.01.99.02	EXCAVATION	CY	1,000	2.00	2,000	900	45.0%	1,2,3,4
09.01.99.02	BEDDING MATERIAL	CY	330	27.50	9,075	4,084	45.0%	1,2,3,4
09.01.99.02	BACKFILL-STRUCTURAL	CY	8,500	3.00	25,500	11,475	45.0%	1,2,3,4
09.01.99.02	CULVERT							
09.01.99.02	CONCRETE	CY	640	600.00	384,000	134,400	35.0%	1,2,3,4
09.01.99.02	REINFORCING	LBS	90,000	0.55	49,500	17,325	35.0%	1,2,3,4
09.01.99.02	ROADRAISE	CY	15,400	7.00	107,800	48,510	45.0%	1,2,3,4
09.01.99.02	EROSION STRUCTURE AT SHEYENNE RIVER	JB	1	200,000.00	200,000	200,000	100.0%	1,2,3,4

SUBTOTAL CONSTRUCTION COSTS		$3,550,960	
SUBTOTAL CONTINGENCIES	48.0%		$1,702,877
TOTAL 09. CHANNELS AND CANALS			$5,253,837

REASONS FOR CONTINGENCIES

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. NOT APPLICABLE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
13.--.--.--	PUMPING PLANT							
13.00.--.--	PUMPING PLANT							
13.00.01.--	MOB, DEMOB AND PREPATORY WORK	LS	1	91,000.00	91,000	91,000	100.0%	1,2,3,4
13.00.03.--	CARE AND DIVERSION OF WATER							
13.00.03.10	COFFERDAM INCLOSURE	EA	3	50,000.00	150,000	67,500	45.0%	1,2,3,4
13.00.10.--	EARTHWORK							
13.00.10.10	EXCAVATION	CY	1,330	1.20	1,596	718	45.0%	1,2,3,4
13.00.10.20	BACKFILL	CY	80	3.00	240	108	45.0%	1,2,3,4
13.00.74.--	STRUCTURE							
13.00.74.01	FOUNDATION							
13.00.74.01	SHEET PILE							
13.00.74.01	PZ-22	SF	5,450	20.00	109,000	38,150	35.0%	1,2,3,4
13.00.74.01	BEARING PILES							
13.00.74.01	MOB/DEMOB	JOB	1	15,444	15,444	15,444	100.0%	1,2,3,4
13.00.74.01	TIMBER 12" DIA	LF	11,880	14.00	166,320	58,212	35.0%	1,2,3,4
13.00.74.03	CONCRETE							
13.00.74.03	CONCRETE							
13.00.74.03	HORIZONTAL	CY	500	300.00	150,000	52,500	35.0%	1,2,3,4
13.00.74.03	VERTICAL	CY	1,115	400.00	446,000	156,100	35.0%	1,2,3,4
13.00.74.03	OVERHEAD/COLUMNS	CY	160	500.00	80,000	28,000	35.0%	1,2,3,4
13.00.74.03	REINFORCING	LBS	212,900	0.55	117,095	40,983	35.0%	1,2,3,4
13.00.74.05	METALS							
13.00.74.05	RAILING	LF	380	33.00	12,540	4,389	35.0%	1,2,3,4
13.00.74.05	GRATING	SF	1,000	25.00	25,000	8,750	35.0%	1,2,3,4
13.00.74.05	TRASH SCREENS	LBS	14,000	1.20	16,800	5,880	35.0%	1,2,3,4
13.00.74.05	CRANE BEAMS	LBS	31,000	1.20	37,200	13,020	35.0%	1,2,3,4
13.00.74.05	LADDERS, 26' LONG	EA	12	650.00	7,800	2,730	35.0%	1,2,3,4
13.00.74.05	TREAD PLATE	SF	510	7.00	3,570	1,250	35.0%	1,2,3,4
13.00.74.07	MISCELLANEOUS							
13.00.74.07	PREFABRICATED WALKWAY	SF	630	45.00	28,350	7,088	25.0%	1,2,3,4
13.00.74.07	54" DIA BIT COATED CMP	LF	600	120.00	72,000	18,000	25.0%	1,2,3,4
13.00.74.07	BUILDING	EA	3	66,000.00	198,000	49,500	25.0%	1,2,3,4
13.00.76.00	MACHINERY AND APPURTENANCES							
13.00.76.15	COMBINATION CANAL/FLAP GATES	EA	12	5,000.00	60,000	15,000	25.0%	1,2,3,4
13.00.76.15	SLUICE GATES, 6' X 6'	EA	12	25,000.00	300,000	75,000	25.0%	1,2,3,4
13.00.76.15	VERTICAL PROPELLER PUMPS (1 & 2)	EA	8	85,000.00	680,000	170,000	25.0%	1,2,3,4
13.00.76.15	VERTICAL PROPELLER PUMPS (3)	EA	4	110,000.00	440,000	110,000	25.0%	1,2,3,4
13.00.76.15	DIESEL ENGINES	EA	12	40,000.00	480,000	120,000	25.0%	1,2,3,4
13.00.76.15	RIGHT ANGLE GEAR DRIVES	EA	12	15,000.00	180,000	45,000	25.0%	1,2,3,4
13.00.76.15	FUEL OIL FURNACE	EA	3	3,000.00	9,000	2,250	25.0%	1,2,3,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
13.00.76.15	POWER ROOF VENTILATORS	EA	6	2,500.00	15,000	3,750	25.0%	1,2,3,4
13.00.76.15	MANUAL CHAIN HOIST AND TROLLY	EA	3	10,000.00	30,000	7,500	25.0%	1,2,3,4
13.00.76.15	FUEL OIL STORAGE TANKS	EA	3	50,000.00	150,000	37,500	25.0%	1,2,3,4
13.00.76.15	DAY TANKS	EA	15	7,000.00	105,000	26,250	25.0%	1,2,3,4
13.00.76.15	30" DIP DISCHARGE PIPEING	LF	1,200	100.00	120,000	30,000	25.0%	1,2,3,4
13.00.76.16	MOB, DEMOB AND SITEWORK	EA	3	1,300.00	3,900	975	25.0%	1,2,3,4
13.00.76.16	ELECTRICAL SERVICE	EA	3	36,000.00	108,000	27,000	25.0%	1,2,3,4
13.00.76.15	GENERATOR FOR EMERG BACKUP	EA	3	22,440.00	67,320	16,830	25.0%	1,2,3,4
13.00.76.15	ELECTRICAL SERVICE EQUIPMENT	EA	3	10,922.00	32,766	8,192	25.0%	1,2,3,4
13.00.76.15	TELEMETRY AND CONTROL SYSTEM	EA	3	19,000.00	57,000	14,250	25.0%	1,2,3,4
13.00.76.15	LIGHTING FIXTURES AND CIRCUITS	EA	3	11,469.00	34,407	8,602	25.0%	1,2,3,4
13.00.76.15	ALL OTHER ELECTRICAL	EA	3	7,517.00	22,551	5,638	25.0%	1,2,3,4

SUBTOTAL CONSTRUCTION COSTS		$4,622,899	
SUBTOTAL CONTINGENCIES	29.9%		$1,383,057
TOTAL 13. PUMPING PLANT			$6,005,956

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	ENVIRONMENTAL MITIGATION							
	LAND							
	WETLAND	ACRE	1,540	500.00	770,000	385,000	50.0%	
	WOODLAND	ACRE	100	500.00	50,000	25,000	50.0%	
	GRASSLAND	ACRE	300	500.00	150,000	75,000	50.0%	
	ACQUISITION COST	JOB	1	97,000.00	97,000	0	0.0%	
	FENCE	MILE	8	3,000.00	24,000	0	0.0%	
	SUBTOTAL CONSTRUCTION COSTS				$1,091,000			
	SUBTOTAL CONTINGENCIES		44.5%			$485,000		
	TOTAL ENVIRONMENTAL MITIGATION					$1,576,000		

NOTES

1. MITIGATION ESTIMATE BASED ON ACQUISITION OF EXISTING HABITAT AT A RATIO OF 2 FOR 1.
2. CONTINGENCY BASED ON PRELIMINARY DATA AND EVALUATION.
3. COST PER ACRE UNIT COMPENSATED (970 ACRES) = $1,626.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	JOB	1	2874870.00	2,874,870	287,487	10.0%	1
30.B.-.-	ENGINEERING AND DESIGN PRIOR TO XX/XX							
30.B.4.-	DESIGN BY DISTRICT	JOB						
30.C.-.-	LOCAL COOPERATIVE AGREEMENT							
30.C.B.-	FINAL LCA/FINANCIAL PLAN	JOB						
30.C.1.-	LCA NEGOTIATIONS	JOB						
30.C.2.-	TRAN. PROJECT TO SPONSOR	JOB						
30.D.-.-	ENVI. & REG. ACTIVITIES							
30.D.2.-	401 CERTIFICATION	JOB						
30.F.C.-	FEASIBILITY STUDY	JOB						
30.F.B.-	DESIGN MEMORANDUM	JOB						
30.H.-.-	PLANS AND SPECIFICATIONS							
30.H.B.-	FINAL DESIGN (IN-HOUSE)	JOB						
30.J.-.-	ENG. DURING CONSTRUCTION							
30.J.9.-	ALL OTHER ENGINEERING	JOB						
30.N.-.-	CONSTR. & SUPPLY ACTIVITY							
30.N.9.-	PREP. BIDDING DOCUMENTS	JOB						
30.P.-.-	PROJECT MANAGEMENT							
30.P.9.-	PROJECT MANAGER DURING P&S	JOB						
30.P.9.-	PROJECT MANAGER DURING CONSTRUCTION	JOB						

SUBTOTAL CONSTRUCTION COSTS		$2,874,870	
SUBTOTAL CONTINGENCIES	10.0%		$287,487
TOTAL 30. PLANNING, ENGINEERING AND DESIGN			$3,162,357

REASONS FOR CONTINGENCIES

1. NOT APPLICABLE
2. UNKNOWNS DUE TO MANHOURS REQUIRED.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
31.-.-.-	CONSTRUCTION MANAGEMENT (S&I)	LS	1	996775.00	996,775	99,678	10.0%	1
31.A.-.-	CONST. MGMT (S&I) PRIOR TO XX/XX	LS						
31.B.-.-	CONTRACT ADMINISTRATION							
31.B.1.-	PRE-AWARD ACTIVITIES	LS						
31.B.2.-	AWARD ACTIVITIES	LS						
31.B.3.-	REV AND APPROV OF CONTRACT PMTS	LS						
31.B.4.-	CONTRACT MODIFICATIONS	LS						
31.B.5.-	PROGRESS AND COMPLETION REPORTS	LS						
31.B.9.-	ALL OTHER ACTIVITIES	LS						
31.C.-.-	BENCH MARKS AND BASELINES	LS						
31.D.-.-	REVIEW OF SHOP DRAWINGS	LS						
31.E.-.-	INSPECTION AND QUALITY ASSURANCE							
	SCHEDULE COMPLIANCE	LS						
	COMPLIANCE SAMPLING AND TESTING	LS						
	QUANTITY SURVEYS	LS						
	ALL OTHER ACTIVITIES	LS						
31.F.-.-	PROJECT OFFICE OPERATIONS	LS						
31.G.-.-	DAMAGES ASSESSED CONTRACTORS	LS						
31.H.-.-	CONTRACTOR INITIATED CLAIMS & LITIGATIO	LS						
31.J.-.-	GOVERNMENT INITIATED CLAIMS & LITIGATIO	LS						
31.P.-.-	PROJECT MANAGEMENT	LS						

SUBTOTAL CONSTRUCTION COSTS		$996,775	
SUBTOTAL CONTINGENCIES	10.0%		$99,678
TOTAL 31. CONSTRUCTION MANAGEMENT (S&I)			$1,096,453

REASONS FOR CONTINGENCIES

1. UNCERTAINTIES DUE TO MANHOURS REQUIRED

COST ESTIMATE SUMMARY SHEETS

200-cfs capacity, electric motor-driven pumps

DEVILS LAKE EMERGENCY OUTLET PLAN, CONCEPT DESIGN **** TOTAL PROJECT COST SUMMARIES ****

PROJECT: DEVILS LAKE EMERGENCY OUTLET PLAN 200 CFS, ELECTRIC MOTOR DRIVEN PUMPS PREPARED BY: GARY SMITH , CENCS-ED-C
LOCATION: DEVILS LAKE, NORTH DAKOTA
DATE PREPARED: 12 JULY 1996 REVISED REVIEWED AND APPROVED BY: ALLEN L. GEISEN , CHIEF, ED-C

ACCOUNT NUMBER	ITEM DESCRIPTION	ESTIMATED COST($) (EPD)	CONTINGENCY AMOUNT($)	%	TOTAL EST COST (EPD)	OMB INFLATION TO XX/XX %	OMB INFLATION TO XX/XX AMOUNT	MID POINT OF FEATURE	OMB (%) INFLATION (+/-)	INFLATED COST AMOUNT ($)	INFLATED CONTG. AMT. ($)	FULLY FUNDED COST
04---	DAMS	2,528,000	1,547,000	61%	4,075,000							
09---	CHANNELS AND CANALS	3,551,000	1,703,000	48%	5,254,000							
13---	PUMPING PLANT	5,213,000	1,536,000	29%	6,749,000							
	ENVIRONMENTAL MITIGATION	1,091,000	485,000	44%	1,576,000							
	TOTAL CONSTRUCTION COSTS =====>	12,383,000	5,271,000	43%	17,654,000							
01---	LANDS AND DAMAGES	251,000	42,000	17%	293,000							
30---	PLANNING, ENGINEERING AND DESIGN	3,001,000	300,000	10%	3,301,000							
31---	CONSTRUCTION MANAGEMENT	1,045,000	105,000	10%	1,150,000							
	TOTAL PROJECT COSTS ======>	16,680,000	5,718,000		22,398,000							

NOTES:
1. UNIT PRICES ARE AT JUNE 1996 PRICE LEVELS UNLESS NOTED OTHERWISE.
2. ASSUME THAT ENVIRONMENTAL MITIGATION REQUIRES NO ADDITIONAL CONSTRUCTION MANAGEMENT.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
01.-.-.-	LANDS AND DAMAGES							
	ALL COSTS COMBINED	JOB	1	251000.00	251,000	42,000	16.7%	2,3,4

SUBTOTAL CONSTRUCTION COSTS		$251,000	
SUBTOTAL CONTINGENCIES	16.7%		$42,000
TOTAL 01. LANDS AND DAMAGES			$293,000

REASONS FOR CONTINGENCIES:

1. NOT APPLICABLE
2. UNKNOWN DUE TO LEGAL COSTS.
3. UNKNOWNS DUE TO LAND PRICES.
4. UNKNOWNS DUE TO QUANTITIES.

NOTES:

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
04.--.--.--	DAMS							
04.01.--.--	MAIN DAM							
04.01.01.--	MOBILIZATION, DEMOB AND PREP. WORK	JOB						
04.01.01.--	MOBILIZATION, DEMOBILIZATION	JOB	1	39,773.73	39,774	39,774	100.0%	1,2,3,4
04.01.01.--	ACCESS ROADS	JOB	1	500,000.00	500,000	500,000	100.0%	1,2,3,4
04.01.02.--	DRAINAGE							
04.01.02.02	SITEWORK							
04.01.02.02	TOE DRAIN	LF	1,260	15.00	18,900	8,505	45.0%	1,2,3,4
04.01.02.02	F&O RISERS	EA	10	55.00	550	248	45.0%	1,2,3,4
04.01.02.02	RELIEF WELLS W/ PUMPS	EA	4	3,000.00	12,000	5,400	45.0%	1,2,3,4
04.01.42.--	EARTH AND ROCKFILL DAMS							
04.01.42.02	SITE WORK							
04.01.42.02	RANDOM FILL	CY	19,013	5.00	95,065	42,779	45.0%	1,2,3,4
04.01.42.02	IMPERVIOUS FILL	CY	18,464	6.20	114,477	51,515	45.0%	1,2,3,4
04.01.42.02	TOE AND SAND DRAIN	CY	5,376	26.20	140,851	63,383	45.0%	1,2,3,4
04.01.42.02	TOPSOIL	CY	2,507	9.50	23,817	10,717	45.0%	1,2,3,4
04.01.42.02	SEED	AC	1.55	1,250.00	1,943	874	45.0%	1,2,3,4
04.01.42.02	6" BEDDING	CY	780	27.50	21,450	9,653	45.0%	1,2,3,4
04.01.42.02	9" BEDDING	CY	129	27.50	3,548	1,596	45.0%	1,2,3,4
04.01.42.02	12" RIPRAP	CY	1,599	50.00	79,950	35,978	45.0%	1,2,3,4
04.01.42.02	18" RIPRAP	CY	255	50.00	12,750	5,738	45.0%	1,2,3,4
04.01.42.02	12" STRIPPING	CY	2,110	1.53	3,228	1,453	45.0%	1,2,3,4
04.01.42.02	EXCAVATION	CY	10,495	5.07	53,210	23,944	45.0%	1,2,3,4
04.01.42.02	SLURRY TRENCH, CONCRETE BACKFILLED	CY	6,000	55.00	330,000	330,000	100.0%	1,2,3,4
04.01.42.02	ACCESS ROADWAY AGGREGATE SURFACE	JB	1	200,000.00	200,000	90,000	45.0%	1,2,3,4
04.02.--.--	SPILLWAY							
04.02.10.--	EARTHWORK FOR STRUCTURES							
04.02.10.02	EXCAVATION	CY	650	5.07	3,296	1,483	45.0%	1,2,3,4
04.02.12.--	SEEPAGE CONTROL							
04.02.12.02	SHEET PILE							
04.02.12.02	PZ22	SF	11,400	20.00	228,000	79,800	35.0%	1,2,3,4
04.02.12.02	6" DRAINS, PVC	LF	460	15.00	6,900	2,415	35.0%	1,2,3,4
04.02.12.02	BEDDING	CY	305	27.50	8,388	2,936	35.0%	1,2,3,4
04.02.20.--	OUTLET CHANNEL							
04.02.20.02	EXCAVATION	CY	3,800	5.07	19,266	8,670	45.0%	1,2,3,4
04.02.20.02	60 " RIPRAP	CY	3,000	50.00	150,000	67,500	45.0%	1,2,3,4
04.02.20.02	12" BEDDING	CY	600	27.50	16,500	7,425	45.0%	1,2,3,4
04.02.51.--	CONCRETE OVERFLOW SECTION							
04.02.51.03	CONCRETE							
04.02.51.03	HORIZONTAL	CY	1,150	300.00	345,000	120,750	35.0%	1,2,3,4
04.02.51.03	VERTICAL	CY	95	400.00	38,000	13,300	35.0%	1,2,3,4
04.02.51.03	REINFORCING	LBS	112,000	0.55	61,600	21,560	35.0%	1,2,3,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	SUBTOTAL CONSTRUCTION COSTS				$2,528,460			
	SUBTOTAL CONTINGENCIES		61.2%			$1,547,394		
	TOTAL 04. DAMS					$4,075,854		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. NOT APPLICABLE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
09.--.--.--	CHANNELS AND CANALS							
09.01.--.--	CHANNELS							
09.01.01.--	MOB, DEMOB AND PREPATORY WORK							
09.01.01.--	MOB AND DEMOB	JOB	1	69,627	69,627	69,627	100.0%	1,2,3,4
09.01.01.--	SAND DRAINS	CY	1,500	26.20	39,300	17,685	45.0%	1,2,3,4
09.01.01.--	DEWATERING WELLS	EA	120	525.00	63,000	28,350	45.0%	1,2,3,4
09.01.15.--	MECHANICAL EXCAVATION							
09.01.15.02	SITEWORK							
09.01.15.02	STRIPPING	CY	165,588	1.53	253,350	114,007	45.0%	1,2,3,4
09.01.15.02	EXCAVATION (DRY)	CY	566,364	1.25	707,954	318,579	45.0%	1,2,3,4
09.01.15.02	EXCAVATION (WET)	CY	566,364	1.70	962,818	433,268	45.0%	1,2,3,4
09.01.15.02	12" TOPSOIL	CY	165,588	2.00	331,176	149,029	45.0%	1,2,3,4
09.01.15.02	SEED	AC	102	500.00	51,246	23,061	45.0%	1,2,3,4
09.01.99.--	ASSOCIATED GENERAL ITEMS							
09.01.99.02	GABION STRUCTURES							
09.01.99.02	GROUT	SY	247	200.00	49,400	22,230	45.0%	1,2,3,4
09.01.99.02	FILTER FABRIC	SY	5,643	3.00	16,929	7,618	45.0%	1,2,3,4
09.01.99.02	3'GABION BASKETS	CY	684	95.00	64,980	29,241	45.0%	1,2,3,4
09.01.99.02	1' GABION BASKETS	CY	1,425	105.00	149,625	67,331	45.0%	1,2,3,4
09.01.99.02	6" GABION BASKETS	CY	152	90.00	13,680	6,156	45.0%	1,2,3,4
09.01.99.02	CULVERTS							
09.01.99.02	EXCAVATION	CY	1,000	2.00	2,000	900	45.0%	1,2,3,4
09.01.99.02	BEDDING MATERIAL	CY	330	27.50	9,075	4,084	45.0%	1,2,3,4
09.01.99.02	BACKFILL-STRUCTURAL	CY	8,500	3.00	25,500	11,475	45.0%	1,2,3,4
09.01.99.02	CULVERT							
09.01.99.02	CONCRETE	CY	640	600.00	384,000	134,400	35.0%	1,2,3,4
09.01.99.02	REINFORCING	LBS	90,000	0.55	49,500	17,325	35.0%	1,2,3,4
09.01.99.02	ROAD RAISE	CY	15,400	7.00	107,800	48,510	45.0%	1,2,3,4
09.01.99.02	EROSION STRUCTURE AT SHEYENNE RIVER	JB	1	200,000.00	200,000	200,000	100.0%	1,2,3,4

SUBTOTAL CONSTRUCTION COSTS		$3,550,960	
SUBTOTAL CONTINGENCIES	48.0%		$1,702,877
TOTAL 09. CHANNELS AND CANALS			$5,253,837

REASONS FOR CONTINGENCIES

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. NOT APPLICABLE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
13.--.--.--	PUMPING PLANT							
13.00.--.--	PUMPING PLANT							
13.00.01.--	MOB, DEMOB AND PREPATORY WORK	LS	1	102,000.00	102,000	102,000	100.0%	1,2,3,4
13.00.03.--	CARE AND DIVERSION OF WATER							
13.00.03.10	COFFERDAM INCLOSURE	EA	3	50,000.00	150,000	67,500	45.0%	1,2,3,4
13.00.10.--	EARTHWORK							
13.00.10.10	EXCAVATION	CY	1,330	1.20	1,596	718	45.0%	1,2,3,4
13.00.10.20	BACKFILL	CY	80	3.00	240	108	45.0%	1,2,3,4
13.00.74.--	STRUCTURE							
13.00.74.01	FOUNDATION							
13.00.74.01	SHEET PILE							
13.00.74.01	PZ-22	SF	5,450	20.00	109,000	38,150	35.0%	1,2,3,4
13.00.74.01	BEARING PILES							
13.00.74.01	MOB/DEMOB	JOB	1	15,444	15,444	15,444	100.0%	1,2,3,4
13.00.74.01	TIMBER 12" DIA	LF	11,880	14.00	166,320	58,212	35.0%	1,2,3,4
13.00.74.03	CONCRETE							
13.00.74.03	CONCRETE							
13.00.74.03	HORIZONTAL	CY	465	300.00	139,500	48,825	35.0%	1,2,3,4
13.00.74.03	VERTICAL	CY	1,075	400.00	430,000	150,500	35.0%	1,2,3,4
13.00.74.03	OVERHEAD/COLUMNS	CY	160	500.00	80,000	28,000	35.0%	1,2,3,4
13.00.74.03	REINFORCING	LBS	203,900	0.55	112,145	39,251	35.0%	1,2,3,4
13.00.74.05	METALS							
13.00.74.05	RAILING	LF	380	33.00	12,540	4,389	35.0%	1,2,3,4
13.00.74.05	GRATING	SF	1,000	25.00	25,000	8,750	35.0%	1,2,3,4
13.00.74.05	TRASH SCREENS	LBS	14,000	1.20	16,800	5,880	35.0%	1,2,3,4
13.00.74.05	CRANE BEAMS	LBS	31,000	1.20	37,200	13,020	35.0%	1,2,3,4
13.00.74.05	LADDERS, 26' LONG	EA	12	650.00	7,800	2,730	35.0%	1,2,3,4
13.00.74.05	TREAD PLATE	SF	510	7.00	3,570	1,250	35.0%	1,2,3,4
13.00.74.07	MISCELLANEOUS							
13.00.74.07	PREFABRICATED WALKWAY	SF	630	45.00	28,350	7,088	25.0%	1,2,3,4
13.00.74.07	54" DIA BIT COATED CMP	LF	600	120.00	72,000	18,000	25.0%	1,2,3,4
13.00.74.07	BUILDING	EA	3	66,000.00	198,000	49,500	25.0%	1,2,3,4
13.00.76.00	MACHINERY AND APPURTENANCES							
13.00.76.15	COMBINATION CANAL/FLAP GATES	EA	12	5,000.00	60,000	15,000	25.0%	1,2,3,4
13.00.76.15	SLUICE GATES, 6' X 6'	EA	12	25,000.00	300,000	75,000	25.0%	1,2,3,4
13.00.76.15	VERTICAL PROPELLER PUMPS (1 & 2)	EA	8	85,000.00	680,000	170,000	25.0%	1,2,3,4
13.00.76.15	VERTICAL PROPELLER PUMPS (3)	EA	4	110,000.00	440,000	110,000	25.0%	1,2,3,4
13.00.76.15	ELECTRIC MOTORS	EA	12	55,000.00	660,000	165,000	25.0%	1,2,3,4
13.00.76.15	DIESEL ENGINES	EA	0	40,000.00				
13.00.76.15	RIGHT ANGLE GEAR DRIVES	EA	0	15,000.00				

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
13.00.76.15	FUEL OIL FURNACE	EA	3	3,000.00	9,000	2,250	25.0%	1,2,3,4
13.00.76.15	POWER ROOF VENTILATORS	EA	6	2,500.00	15,000	3,750	25.0%	1,2,3,4
13.00.76.15	MANUAL CHAIN HOIST AND TROLLY	EA	3	10,000.00	30,000	7,500	25.0%	1,2,3,4
13.00.76.15	FUEL OIL STORAGE TANKS	EA	0	50,000.00				
13.00.76.15	DAY TANKS	EA	0	7,000.00				
13.00.76.15	30" DIP DISCHARGE PIPEING	LF	1,200	100.00	120,000	30,000	25.0%	1,2,3,4
13.00.76.16	MOB, DEMOB AND SITEWORK	EA	3	1,300.00	3,900	975	25.0%	1,2,3,4
13.00.76.16	ELECTRICAL SERVICE	EA	3	167,000.00	501,000	125,250	25.0%	1,2,3,4
13.00.76.15	GENERATOR FOR EMERG BACKUP	EA	3	22,440.00	67,320	16,830	25.0%	1,2,3,4
13.00.76.15	ELECTRICAL SERVICE EQUIPMENT	EA	3	168,452.00	505,356	126,339	25.0%	1,2,3,4
13.00.76.15	TELEMETRY AND CONTROL SYSTEM	EA	3	19,000.00	57,000	14,250	25.0%	1,2,3,4
13.00.76.15	LIGHTING FIXTURES AND CIRCUITS	EA	3	11,469.00	34,407	8,602	25.0%	1,2,3,4
13.00.76.15	ALL OTHER ELECTRICAL	EA	3	7,517.00	22,551	5,638	25.0%	1,2,3,4

SUBTOTAL CONSTRUCTION COSTS		$5,213,039	
SUBTOTAL CONTINGENCIES	29.5%		$1,535,697
TOTAL 13. PUMPING PLANT			$6,748,736

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	ENVIRONMENTAL MITIGATION							
	LAND							
	WETLAND	ACRE	1,540	500.00	770,000	385,000	50.0%	
	WOODLAND	ACRE	100	500.00	50,000	25,000	50.0%	
	GRASSLAND	ACRE	300	500.00	150,000	75,000	50.0%	
	ACQUISITION COST	JOB	1	97,000.00	97,000	0	0.0%	
	FENCE	MILE	8	3,000	24,000	0	0.0%	
	SUBTOTAL CONSTRUCTION COSTS				$1,091,000			
	SUBTOTAL CONTINGENCIES		44.5%			$485,000		
	TOTAL ENVIRONMENTAL MITIGATION					$1,576,000		

NOTES

1. MITIGATION ESTIMATE BASED ON ACQUISITION OF EXISTING HABITAT AT A RATIO OF 2 FOR 1.
2. CONTINGENCY BASED ON PRELIMINARY DATA AND EVALUATION.
3. COST PER ACRE UNIT COMPENSATED (970 ACRES) = $1,626.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	JOB	1	3001180.00	3,001,180	300,118	10.0%	1
30.B.-.-	ENGINEERING AND DESIGN PRIOR TO 5/96							
30.B.4.-	DESIGN BY DISTRICT	JOB						
30.C.-.-	LOCAL COOPERATIVE AGREEMENT							
30.C.B.-	FINAL LCA/FINANCIAL PLAN	JOB						
30.C.1.-	LCA NEGOTIATIONS	JOB						
30.C.2.-	TRAN. PROJECT TO SPONSOR	JOB						
30.D.-.-	ENVI. & REG. ACTIVITIES							
30.D.2.-	401 CERTIFICATION	JOB						
30.F.C.-	FEASIBILITY STUDY	JOB						
30.F.B.-	DESIGN MEMORANDUM	JOB						
30.H.-.-	PLANS AND SPECIFICATIONS							
30.H.B.-	FINAL DESIGN (IN-HOUSE)	JOB						
30.J.-.-	ENG. DURING CONSTRUCTION							
30.J.9.-	ALL OTHER ENGINEERING	JOB						
30.N.-.-	CONSTR. & SUPPLY ACTIVITY							
30.N.9.-	PREP. BIDDING DOCUMENTS	JOB						
30.P.-.-	PROJECT MANAGEMENT							
30.P.9.-	PROJECT MANAGER DURING P&S	JOB						
30.P.9.-	PROJECT MANAGER DURING CONSTRUCTION	JOB						

SUBTOTAL CONSTRUCTION COSTS		$3,001,180	
SUBTOTAL CONTINGENCIES	10.0%		$300,118
TOTAL 30. PLANNING, ENGINEERING AND DESIGN			$3,301,298

REASONS FOR CONTINGENCIES

1. NOT APPLICABLE
2. UNKNOWNS DUE TO MANHOURS REQUIRED.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
31.-.-.-	CONSTRUCTION MANAGEMENT (S&I)	LS	1	1045070.00	1,045,070	104,507	10.0%	1
31.A.-.-	CONST. MGMT (S&I) PRIOR TO ___________	LS						
31.B.-.-	CONTRACT ADMINISTRATION							
31.B.1.-	PRE-AWARD ACTIVITIES	LS						
31.B.2.-	AWARD ACTIVITIES	LS						
31.B.3.-	REV AND APPROV OF CONTRACT PMTS	LS						
31.B.4.-	CONTRACT MODIFICATIONS	LS						
31.B.5.-	PROGRESS AND COMPLETION REPORTS	LS						
31.B.9.-	ALL OTHER ACTIVITIES	LS						
31.C.-.-	BENCH MARKS AND BASELINES	LS						
31.D.-.-	REVIEW OF SHOP DRAWINGS	LS						
31.E.-.-	INSPECTION AND QUALITY ASSURANCE							
	SCHEDULE COMPLIANCE	LS						
	COMPLIANCE SAMPLING AND TESTING	LS						
	QUANTITY SURVEYS	LS						
	ALL OTHER ACTIVITIES	LS						
31.F.-.-	PROJECT OFFICE OPERATIONS	LS						
31.G.-.-	DAMAGES ASSESSED CONTRACTORS	LS						
31.H.-.-	CONTRACTOR INITIATED CLAIMS & LITIGATIOLS							
31.J.-.-	GOVERNMENT INITIATED CLAIMS & LITIGATIOLS							
31.P.-.-	PROJECT MANAGEMENT	LS						

SUBTOTAL CONSTRUCTION COSTS		$1,045,070	
SUBTOTAL CONTINGENCIES	10.0%		$104,507
TOTAL 31. CONSTRUCTION MANAGEMENT (S&I)			$1,149,577

REASONS FOR CONTINGENCIES

1. UNCERTAINTIES DUE TO MANHOURS REQUIRED

COST ESTIMATE SUMMARY SHEETS

300-cfs capacity, diesel-driven pumps

DEVILS LAKE EMERGENCY OUTLET PLAN, CONCEPT DESIGN **** TOTAL PROJECT COST SUMMARIES ****

PROJECT: DEVILS LAKE EMERGENCY OUTLET PLAN 300 CFS, DIESEL PUMPS PREPARED BY: GARY SMITH , CENCS-ED-C
LOCATION: DEVILS LAKE, NORTH DAKOTA
DATE PREPARED: 12 JULY 1996 REVISED REVIEWED AND APPROVED BY: ALLEN L. GEISEN , CHIEF, ED-C

ACCOUNT NUMBER	ITEM DESCRIPTION	ESTIMATED COST($) (EPD)	CONTINGENCY AMOUNT($)	%	TOTAL EST COST (EPD)	OMB INFLATION TO XX/XX %	AMOUNT	MID POINT OF FEATURE	OMB (%) INFLATION (+/-)	INFLATED COST AMOUNT ($)	INFLATED CONTG. AMT. ($)	FULLY FUNDED COST
04---	DAMS	2,528,000	1,547,000	61%	4,075,000							
09---	CHANNELS AND CANALS	4,049,000	1,933,000	48%	5,982,000							
13---	PUMPING PLANT	5,668,000	1,659,000	29%	7,327,000							
	ENVIRONMENTAL MITIGATION	1,091,000	485,000	44%	1,576,000							
	TOTAL CONSTRUCTION COSTS =====>	13,336,000	5,624,000	42%	18,960,000							
01---	LANDS AND DAMAGES	251,000	42,000	17%	293,000							
30---	PLANNING, ENGINEERING AND DESIGN	3,223,000	322,000	10%	3,545,000							
31---	CONSTRUCTION MANAGEMENT	1,130,000	113,000	10%	1,243,000							
	TOTAL PROJECT COSTS ======>	17,940,000	6,101,000		24,041,000							

NOTES:
1. UNIT PRICES ARE AT JUNE 1996 PRICE LEVELS UNLESS NOTED OTHERWISE.
2. ASSUME THAT ENVIRONMENTAL MITIGATION REQUIRES NO ADDITIONAL CONSTRUCTION MANAGEMENT.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
01.-.-.-	LANDS AND DAMAGES							
	ALL COSTS COMBINED	JOB	1	251000.00	251,000	42,000	16.7%	2,3,4

SUBTOTAL CONSTRUCTION COSTS		$251,000	
SUBTOTAL CONTINGENCIES	16.7%		$42,000
TOTAL 01. LANDS AND DAMAGES			$293,000

REASONS FOR CONTINGENCIES:

1. NOT APPLICABLE
2. UNKNOWN DUE TO LEGAL COSTS.
3. UNKNOWNS DUE TO LAND PRICES.
4. UNKNOWNS DUE TO QUANTITIES.

NOTES:

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
04.--.--.--	DAMS							
04.01.--.--	MAIN DAM							
04.01.01.--	MOBILIZATION, DEMOB AND PREP. WORK	JOB						
04.01.01.--	MOBILIZATION, DEMOBILIZATION	JOB	1	39,773.73	39,774	39,774	100.0%	1,2,3,4
04.01.01.--	ACCESS ROADS	JOB	1	500,000.00	500,000	500,000	100.0%	1,2,3,4
04.01.02.--	DRAINAGE							
04.01.02.02	SITEWORK							
04.01.02.02	TOE DRAIN	LF	1,260	15.00	18,900	8,505	45.0%	1,2,3,4
04.01.02.02	F&O RISERS	EA	10	55.00	550	248	45.0%	1,2,3,4
04.01.02.02	RELIEF WELLS W/ PUMPS	EA	4	3,000.00	12,000	5,400	45.0%	1,2,3,4
04.01.42.--	EARTH AND ROCKFILL DAMS							
04.01.42.02	SITE WORK							
04.01.42.02	RANDOM FILL	CY	19,013	5.00	95,065	42,779	45.0%	1,2,3,4
04.01.42.02	IMPERVIOUS FILL	CY	18,464	6.20	114,477	51,515	45.0%	1,2,3,4
04.01.42.02	TOE AND SAND DRAIN	CY	5,376	26.20	140,851	63,383	45.0%	1,2,3,4
04.01.42.02	TOPSOIL	CY	2,507	9.50	23,817	10,717	45.0%	1,2,3,4
04.01.42.02	SEED	AC	1.55	1,250.00	1,943	874	45.0%	1,2,3,4
04.01.42.02	6" BEDDING	CY	780	27.50	21,450	9,653	45.0%	1,2,3,4
04.01.42.02	9" BEDDING	CY	129	27.50	3,548	1,596	45.0%	1,2,3,4
04.01.42.02	12" RIPRAP	CY	1,599	50.00	79,950	35,978	45.0%	1,2,3,4
04.01.42.02	18" RIPRAP	CY	255	50.00	12,750	5,738	45.0%	1,2,3,4
04.01.42.02	12" STRIPPING	CY	2,110	1.53	3,228	1,453	45.0%	1,2,3,4
04.01.42.02	EXCAVATION	CY	10,495	5.07	53,210	23,944	45.0%	1,2,3,4
04.01.42.02	SLURRY TRENCH, CONCRETE BACKFILLED	CY	6,000	55.00	330,000	330,000	100.0%	1,2,3,4
04.01.42.02	ACCESS ROADWAY AGGREGATE SURFACE	JB	1	200,000.00	200,000	90,000	45.0%	1,2,3,4
04.02.--.--	SPILLWAY							
04.02.10.--	EARTHWORK FOR STRUCTURES							
04.02.10.02	EXCAVATION	CY	650	5.07	3,296	1,483	45.0%	1,2,3,4
04.02.12.--	SEEPAGE CONTROL							
04.02.12.02	SHEET PILE							
04.02.12.02	PZ22	SF	11,400	20.00	228,000	79,800	35.0%	1,2,3,4
04.02.12.02	6" DRAINS, PVC	LF	460	15.00	6,900	2,415	35.0%	1,2,3,4
04.02.12.02	BEDDING	CY	305	27.50	8,388	2,936	35.0%	1,2,3,4
04.02.20.--	OUTLET CHANNEL							
04.02.20.02	EXCAVATION	CY	3,800	5.07	19,266	8,670	45.0%	1,2,3,4
04.02.20.02	60" RIPRAP	CY	3,000	50.00	150,000	67,500	45.0%	1,2,3,4
04.02.20.02	12" BEDDING	CY	600	27.50	16,500	7,425	45.0%	1,2,3,4
04.02.51.--	CONCRETE OVERFLOW SECTION							
04.02.51.03	CONCRETE							
04.02.51.03	HORIZONTAL	CY	1,150	300.00	345,000	120,750	35.0%	1,2,3,4
04.02.51.03	VERTICAL	CY	95	400.00	38,000	13,300	35.0%	1,2,3,4
04.02.51.03	REINFORCING	LBS	112,000	0.55	61,600	21,560	35.0%	1,2,3,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	SUBTOTAL CONSTRUCTION COSTS				$2,528,460			
	SUBTOTAL CONTINGENCIES		61.2%			$1,547,394		
	TOTAL 04. DAMS					$4,075,854		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. NOT APPLICABLE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
09.--.--.--	CHANNELS AND CANALS							
09.01.--.--	CHANNELS							
09.01.01.--	MOB, DEMOB AND PREPATORY WORK							
09.01.01.--	MOB AND DEMOB	JOB	1	79,399	79,399	79,399	100.0%	1,2,3,4
09.01.01.--	SAND DRAINS	CY	1,500	26.20	39,300	17,685	45.0%	1,2,3,4
09.01.01.--	DEWATERING WELLS	EA	120	525.00	63,000	28,350	45.0%	1,2,3,4
09.01.15.--	MECHANICAL EXCAVATION							
09.01.15.02	SITEWORK							
09.01.15.02	STRIPPING	CY	194,751	1.53	297,969	134,086	45.0%	1,2,3,4
09.01.15.02	EXCAVATION (DRY)	CY	661,777	1.25	827,221	372,250	45.0%	1,2,3,4
09.01.15.02	EXCAVATION (WET)	CY	661,777	1.70	1,125,021	506,259	45.0%	1,2,3,4
09.01.15.02	12" TOPSOIL	CY	194,751	2.00	389,502	175,276	45.0%	1,2,3,4
09.01.15.02	SEED	AC	121	500.00	60,357	27,161	45.0%	1,2,3,4
09.01.99.--	ASSOCIATED GENERAL ITEMS							
09.01.99.02	GABION STRUCTURES							
09.01.99.02	GROUT	SY	371	200.00	74,100	33,345	45.0%	1,2,3,4
09.01.99.02	FILTER FABRIC	SY	7,315	3.00	21,945	9,875	45.0%	1,2,3,4
09.01.99.02	3'GABION BASKETS	CY	817	95.00	77,615	34,927	45.0%	1,2,3,4
09.01.99.02	1' GABION BASKETS	CY	1,862	105.00	195,510	87,980	45.0%	1,2,3,4
09.01.99.02	6" GABION BASKETS	CY	228	90.00	20,520	9,234	45.0%	1,2,3,4
09.01.99.02	CULVERTS							
09.01.99.02	EXCAVATION	CY	1,000	2.00	2,000	900	45.0%	1,2,3,4
09.01.99.02	BEDDING MATERIAL	CY	330	27.50	9,075	4,084	45.0%	1,2,3,4
09.01.99.02	BACKFILL-STRUCTURAL	CY	8,500	3.00	25,500	11,475	45.0%	1,2,3,4
09.01.99.02	CULVERT							
09.01.99.02	CONCRETE	CY	640	600.00	384,000	134,400	35.0%	1,2,3,4
09.01.99.02	REINFORCING	LBS	90,000	0.55	49,500	17,325	35.0%	1,2,3,4
09.01.99.02	ROAD RAISE	CY	15,400	7.00	107,800	48,510	45.0%	1,2,3,4
09.01.99.02	EROSION STRUCTURE AT SHEYENNE RIVER	JB	1	200,000.00	200,000	200,000	100.0%	1,2,3,4

SUBTOTAL CONSTRUCTION COSTS		$4,049,334	
SUBTOTAL CONTINGENCIES	47.7%		$1,932,519
TOTAL 09. CHANNELS AND CANALS			$5,981,853

REASONS FOR CONTINGENCIES

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. NOT APPLICABLE

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
13.--.--.--	PUMPING PLANT							
13.00.--.--	PUMPING PLANT							
13.00.01.--	MOB, DEMOB AND PREPATORY WORK	LS	1	111,000.00	111,000	111,000	100.0%	1,2,3,4
13.00.03.--	CARE AND DIVERSION OF WATER							
13.00.03.10	COFFERDAM INCLOSURE	EA	3	50,000.00	150,000	67,500	45.0%	1,2,3,4
13.00.10.--	EARTHWORK							
13.00.10.10	EXCAVATION	CY	1,330	1.20	1,596	718	45.0%	1,2,3,4
13.00.10.20	BACKFILL	CY	80	3.00	240	108	45.0%	1,2,3,4
13.00.74.--	STRUCTURE							
13.00.74.01	FOUNDATION							
13.00.74.01	SHEET PILE							
13.00.74.01	PZ-22	SF	5,450	20.00	109,000	38,150	35.0%	1,2,3,4
13.00.74.01	BEARING PILES							
13.00.74.01	MOB/DEMOB	JOB	1	15,444	15,444	15,444	100.0%	1,2,3,4
13.00.74.01	TIMBER 12" DIA	LF	11,880	14.00	166,320	58,212	35.0%	1,2,3,4
13.00.74.03	CONCRETE							
13.00.74.03	CONCRETE							
13.00.74.03	HORIZONTAL	CY	500	300.00	150,000	52,500	35.0%	1,2,3,4
13.00.74.03	VERTICAL	CY	1,115	400.00	446,000	156,100	35.0%	1,2,3,4
13.00.74.03	OVERHEAD/COLUMNS	CY	160	500.00	80,000	28,000	35.0%	1,2,3,4
13.00.74.03	REINFORCING	LBS	212,900	0.55	117,095	40,983	35.0%	1,2,3,4
13.00.74.05	METALS							
13.00.74.05	RAILING	LF	380	33.00	12,540	4,389	35.0%	1,2,3,4
13.00.74.05	GRATING	SF	1,000	25.00	25,000	8,750	35.0%	1,2,3,4
13.00.74.05	TRASH SCREENS	LBS	14,000	1.20	16,800	5,880	35.0%	1,2,3,4
13.00.74.05	CRANE BEAMS	LBS	31,000	1.20	37,200	13,020	35.0%	1,2,3,4
13.00.74.05	LADDERS, 26' LONG	EA	12	650.00	7,800	2,730	35.0%	1,2,3,4
13.00.74.05	TREAD PLATE	SF	510	7.00	3,570	1,250	35.0%	1,2,3,4
13.00.74.07	MISCELLANEOUS							
13.00.74.07	PREFABRICATED WALKWAY	SF	630	45.00	28,350	7,088	25.0%	1,2,3,4
13.00.74.07	54" DIA BIT COATED CMP	LF	600	120.00	72,000	18,000	25.0%	1,2,3,4
13.00.74.07	BUILDING	EA	3	66,000.00	198,000	49,500	25.0%	1,2,3,4
13.00.76.00	MACHINERY AND APPURTENANCES							
13.00.76.15	COMBINATION CANAL/FLAP GATES	EA	12	5,000.00	60,000	15,000	25.0%	1,2,3,4
13.00.76.15	SLUICE GATES, 7' X 7'	EA	12	35,000.00	420,000	105,000	25.0%	1,2,3,4
13.00.76.15	VERT PROPELLER PUMPS (1&2) 75 CFS EA	EA	8	127,500.00	1,020,000	255,000	25.0%	1,2,3,4
13.00.76.15	VERT PROPELLER PUMPS (3) 75 CFS EA	EA	4	165,000.00	660,000	165,000	25.0%	1,2,3,4
13.00.76.15	DIESEL ENGINES, 300 HP	EA	12	60,000.00	720,000	180,000	25.0%	1,2,3,4
13.00.76.15	RIGHT ANGLE GEAR DRIVES	EA	12	15,000.00	180,000	45,000	25.0%	1,2,3,4
13.00.76.15	FUEL OIL FURNACE	EA	3	3,000.00	9,000	2,250	25.0%	1,2,3,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
13.00.76.15	POWER ROOF VENTILATORS	EA	6	2,500.00	15,000	3,750	25.0%	1,2,3,4
13.00.76.15	MANUAL CHAIN HOIST AND TROLLY	EA	3	10,000.00	30,000	7,500	25.0%	1,2,3,4
13.00.76.15	FUEL OIL STORAGE TANKS, 15,000 GAL	EA	3	75,000.00	225,000	56,250	25.0%	1,2,3,4
13.00.76.15	DAY TANKS	EA	15	7,000.00	105,000	26,250	25.0%	1,2,3,4
13.00.76.15	42" DIP DISCHARGE PIPEING	LF	1,200	125.00	150,000	37,500	25.0%	1,2,3,4
13.00.76.16	MOB, DEMOB AND SITEWORK	EA	3	1,300.00	3,900	975	25.0%	1,2,3,4
13.00.76.16	ELECTRICAL SERVICE	EA	3	36,000.00	108,000	27,000	25.0%	1,2,3,4
13.00.76.15	GENERATOR FOR EMERG BACKUP	EA	3	22,440.00	67,320	16,830	25.0%	1,2,3,4
13.00.76.15	ELECTRICAL SERVICE EQUIPMENT	EA	3	10,922.00	32,766	8,192	25.0%	1,2,3,4
13.00.76.15	TELEMETRY AND CONTROL SYSTEM	EA	3	19,000.00	57,000	14,250	25.0%	1,2,3,4
13.00.76.15	LIGHTING FIXTURES AND CIRCUITS	EA	3	11,469.00	34,407	8,602	25.0%	1,2,3,4
13.00.76.15	ALL OTHER ELECTRICAL	EA	3	7,517.00	22,551	5,638	25.0%	1,2,3,4

SUBTOTAL CONSTRUCTION COSTS		$5,667,899	
SUBTOTAL CONTINGENCIES	29.3%		$1,659,307
TOTAL 13. PUMPING PLANT			$7,327,206

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	ENVIRONMENTAL MITIGATION							
	LAND							
	WETLAND	ACRE	1,540	500.00	770,000	385,000	50.0%	
	WOODLAND	ACRE	100	500.00	50,000	25,000	50.0%	
	GRASSLAND	ACRE	300	500.00	150,000	75,000	50.0%	
	ACQUISITION COST	JOB	1	97,000.00	97,000	0	0.0%	
	FENCE	MILE	8	3,000.00	24,000	0	0.0%	
	SUBTOTAL CONSTRUCTION COSTS				$1,091,000			
	SUBTOTAL CONTINGENCIES		10.0%			$485,000		
	TOTAL ENVIRONMENTAL MITIGATION					$1,576,000		

REASONS FOR CONTINGENCIES

1. MITIGATION ESTIMATE BASED ON ACQUISITION OF EXISTING HABITAT AT A RATIO OF 2 FOR 1.
2. CONTINGENCY BASED ON PRELIMINARY DATA AND EVALUATION.
3. COST PER ACRE UNIT COMPENSATED (970 ACRES) = $1,626.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
30.-.-.-	PLANNING, ENGINEERING AND DESIGN	JOB	1	3223200.00	3,223,200	322,320	10.0%	1
30.B.-.-	ENGINEERING AND DESIGN PRIOR TO 5/96							
30.B.4.-	DESIGN BY DISTRICT	JOB						
30.C.-.-	LOCAL COOPERATIVE AGREEMENT							
30.C.B.-	FINAL LCA/FINANCIAL PLAN	JOB						
30.C.1.-	LCA NEGOTIATIONS	JOB						
30.C.2.-	TRAN. PROJECT TO SPONSOR	JOB						
30.D.-.-	ENVI. & REG. ACTIVITIES							
30.D.2.-	401 CERTIFICATION	JOB						
30.F.C.-	FEASIBILITY STUDY	JOB						
30.F.B.-	DESIGN MEMORANDUM	JOB						
30.H.-.-	PLANS AND SPECIFICATIONS							
30.H.B.-	FINAL DESIGN (IN-HOUSE)	JOB						
30.J.-.-	ENG. DURING CONSTRUCTION							
30.J.9.-	ALL OTHER ENGINEERING	JOB						
30.N.-.-	CONSTR. & SUPPLY ACTIVITY							
30.N.9.-	PREP. BIDDING DOCUMENTS	JOB						
30.P.-.-	PROJECT MANAGEMENT							
30.P.9.-	PROJECT MANAGER DURING P&S	JOB						
30.P.9.-	PROJECT MANAGER DURING CONSTRUCTION	JOB						

SUBTOTAL CONSTRUCTION COSTS		$3,223,200	
SUBTOTAL CONTINGENCIES	10.0%		$322,320
TOTAL 30. PLANNING, ENGINEERING AND DESIGN			$3,545,520

REASONS FOR CONTINGENCIES

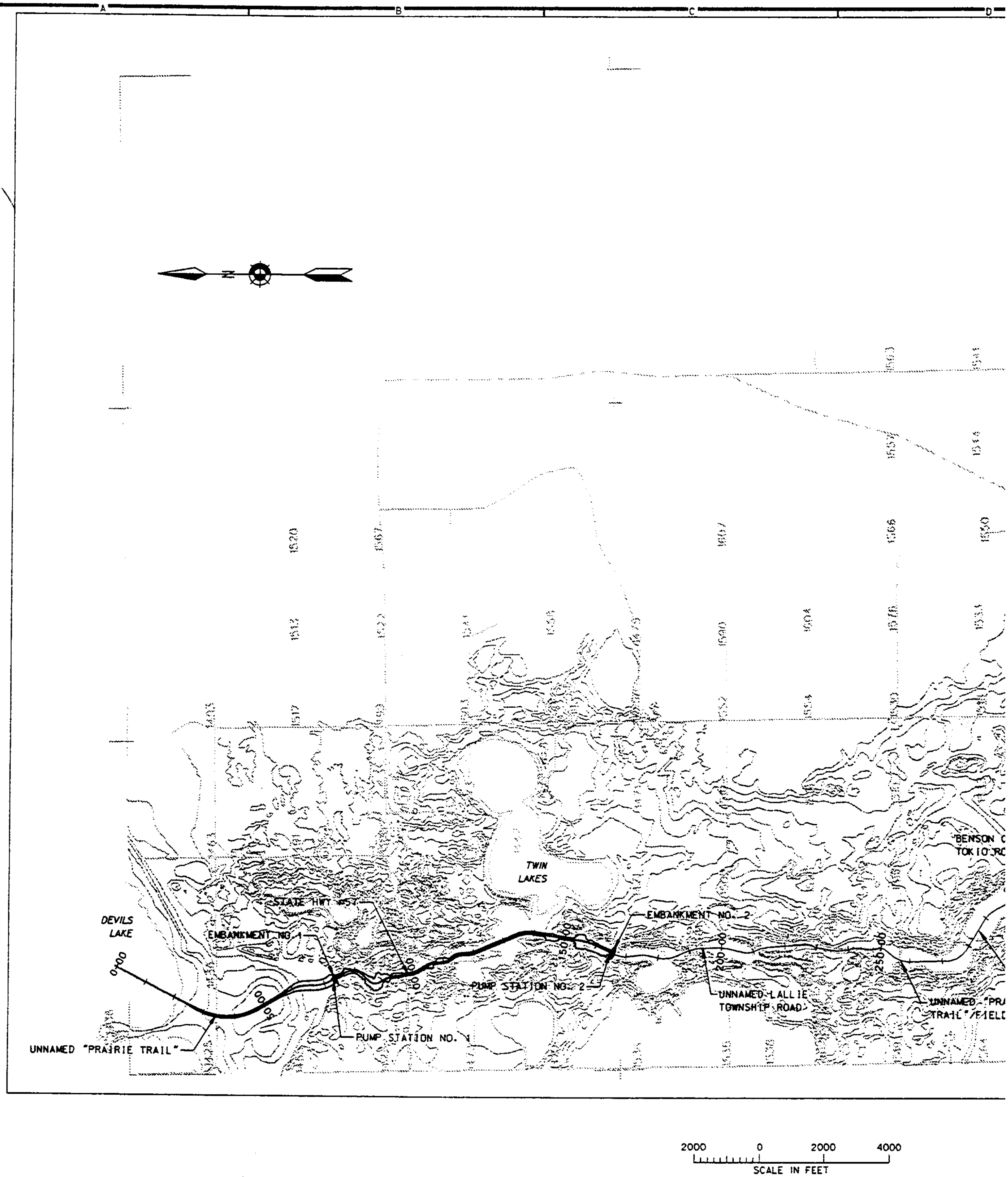
1. NOT APPLICABLE
2. UNKNOWNS DUE TO MANHOURS REQUIRED.

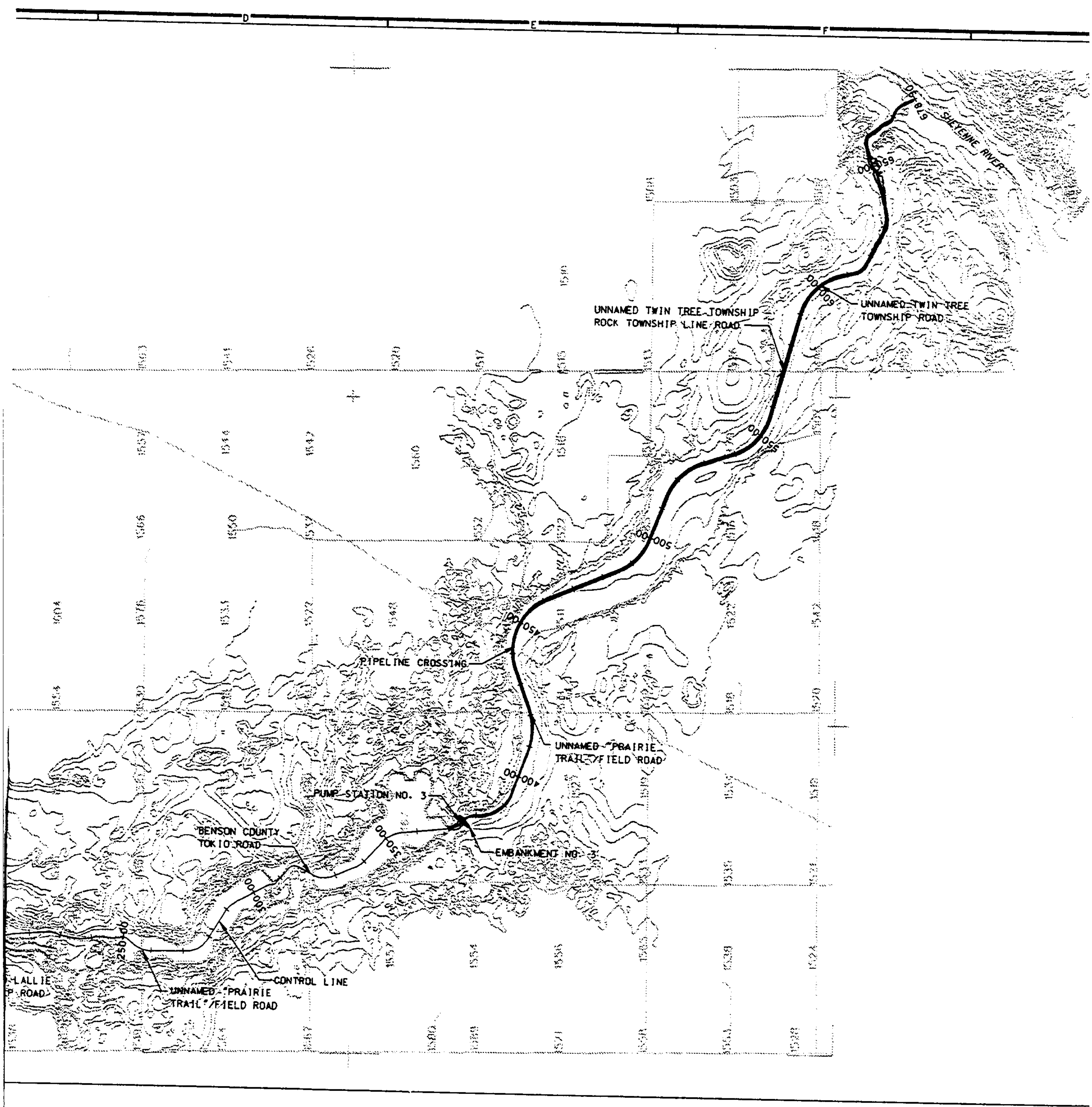
ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
31.-.-.-	CONSTRUCTION MANAGEMENT (S&I)	LS	1	1129960.00	1,129,960	112,996	10.0%	1
31.A.-.-	CONST. MGMT (S&I) PRIOR TO ____________	LS						
31.B.-.-	CONTRACT ADMINISTRATION							
31.B.1.-	PRE-AWARD ACTIVITIES	LS						
31.B.2.-	AWARD ACTIVITIES	LS						
31.B.3.-	REV AND APPROV OF CONTRACT PMTS	LS						
31.B.4.-	CONTRACT MODIFICATIONS	LS						
31.B.5.-	PROGRESS AND COMPLETION REPORTS	LS						
31.B.9.-	ALL OTHER ACTIVITIES	LS						
31.C.-.-	BENCH MARKS AND BASELINES	LS						
31.D.-.-	REVIEW OF SHOP DRAWINGS	LS						
31.E.-.-	INSPECTION AND QUALITY ASSURANCE							
	SCHEDULE COMPLIANCE	LS						
	COMPLIANCE SAMPLING AND TESTING	LS						
	QUANTITY SURVEYS	LS						
	ALL OTHER ACTIVITIES	LS						
31.F.-.-	PROJECT OFFICE OPERATIONS	LS						
31.G.-.-	DAMAGES ASSESSED CONTRACTORS	LS						
31.H.-.-	CONTRACTOR INITIATED CLAIMS & LITIGATIO	LS						
31.J.-.-	GOVERNMENT INITIATED CLAIMS & LITIGATIO	LS						
31.P.-.-	PROJECT MANAGEMENT	LS						

SUBTOTAL CONSTRUCTION COSTS		$1,129,960	
SUBTOTAL CONTINGENCIES	10.0%		$112,996
TOTAL 31. CONSTRUCTION MANAGEMENT (S&I)			$1,242,956

REASONS FOR CONTINGENCIES

1. UNCERTAINTIES DUE TO MANHOURS REQUIRED


DEVILS
LAKE
TWIN
LAKES
STATE HWY #57
EMBANKMENT NO. 1
EMBANKMENT NO. 2
PUMP STATION NO. 1
PUMP STATION NO. 2
UNNAMED "PRAIRIE TRAIL"
UNNAMED LALLIE
TOWNSHIP ROAD
2000 0 2000 4000
SCALE IN FEET



2000 4000
SCALE IN FEET

SYMBOL	DESCRIPTION

DEPARTME...
ST. PAUL DIST...
ST. ...

AE APPROVING OFFICIAL:

CONCEPT DESIG...
DEVILS LAKE EMERGENCY ...
GENERAL INVESTIGATIONS - SHEYE...
DEVILS LAKE DEVILS...
FLOOD CONTR...
PLAN

PE-O DESIGNED: GVF/PDM
CHECKED:
DRAWN: CAS
PE-H DESIGNED: PMF/DJR
CHECKED:
DATE: JUNE 1996

CAD FILE NAME: DV05R002.DGN
SOL. NO:
DRAWING NU...
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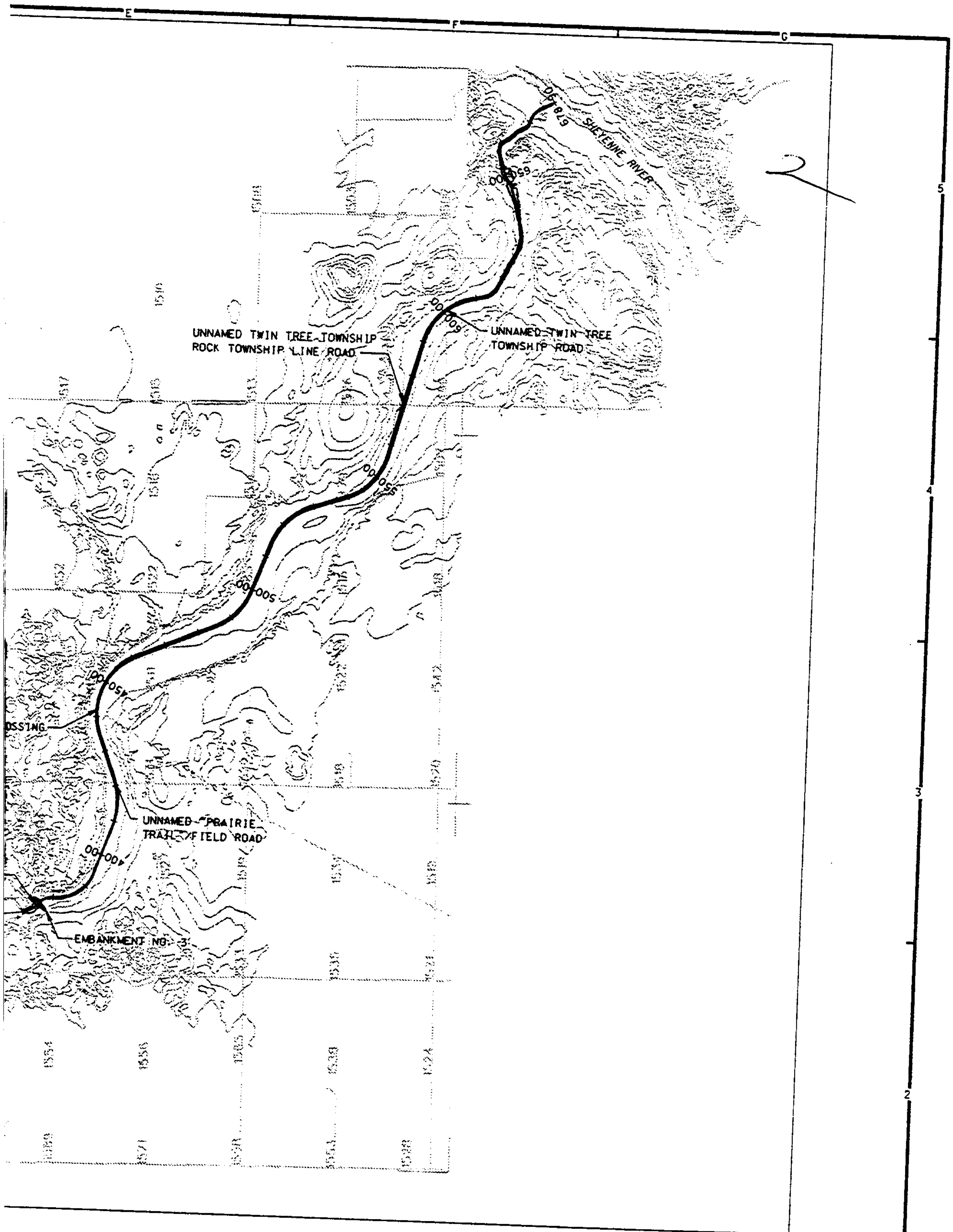


SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

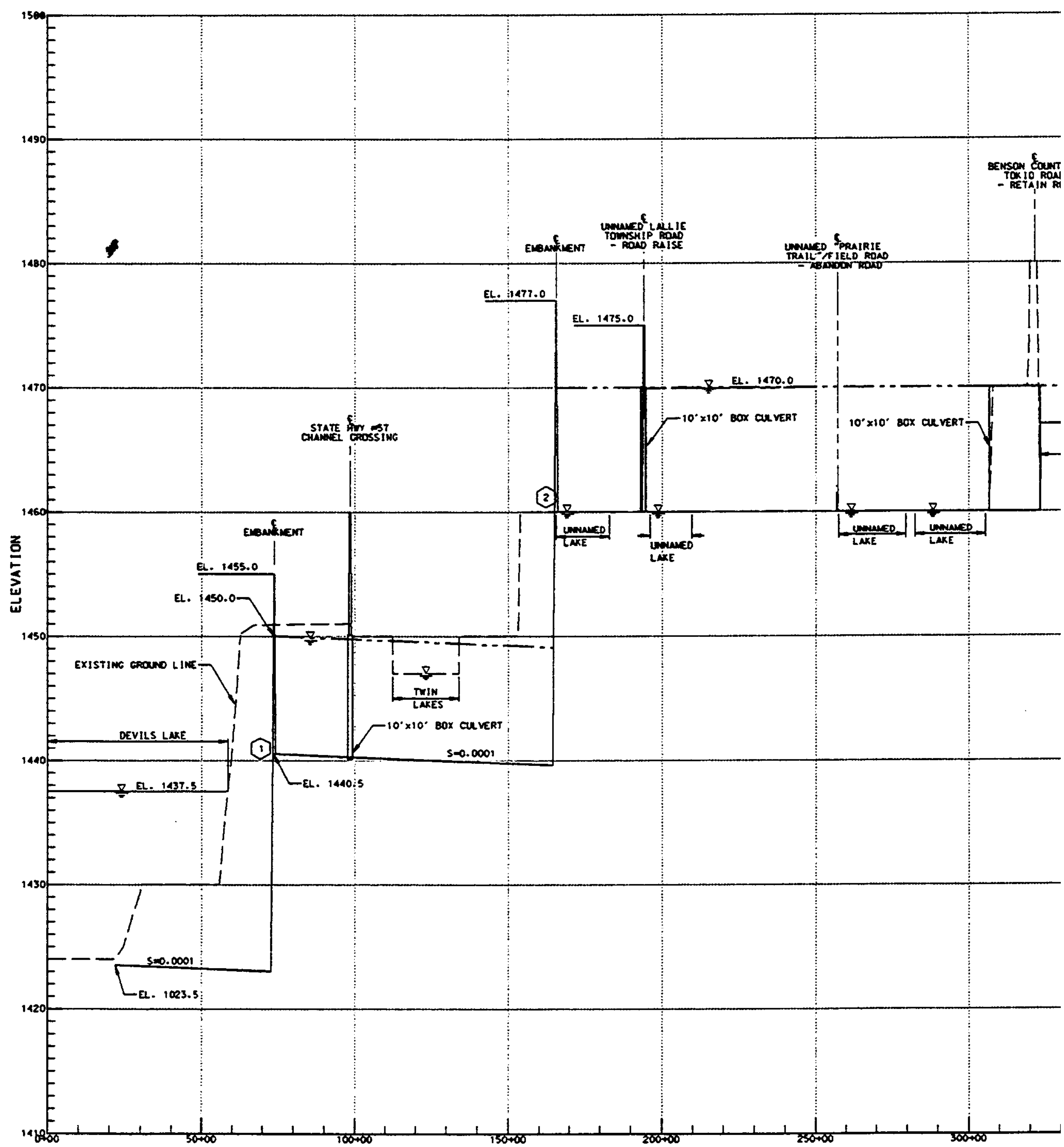
PE-D DESIGNED: GVF/PDM
CHECKED:
DRAWN: CAS

PE-H DESIGNED: PMF/DJR
CHECKED:

DATE: JUNE 1996

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
PLAN

CAD FILE NAME: DV05R002.DGN
SOL. NO:
DRAWING NUMBER: PLATE 1
SHT C-1
OF



N ENG
HYD
HYDR
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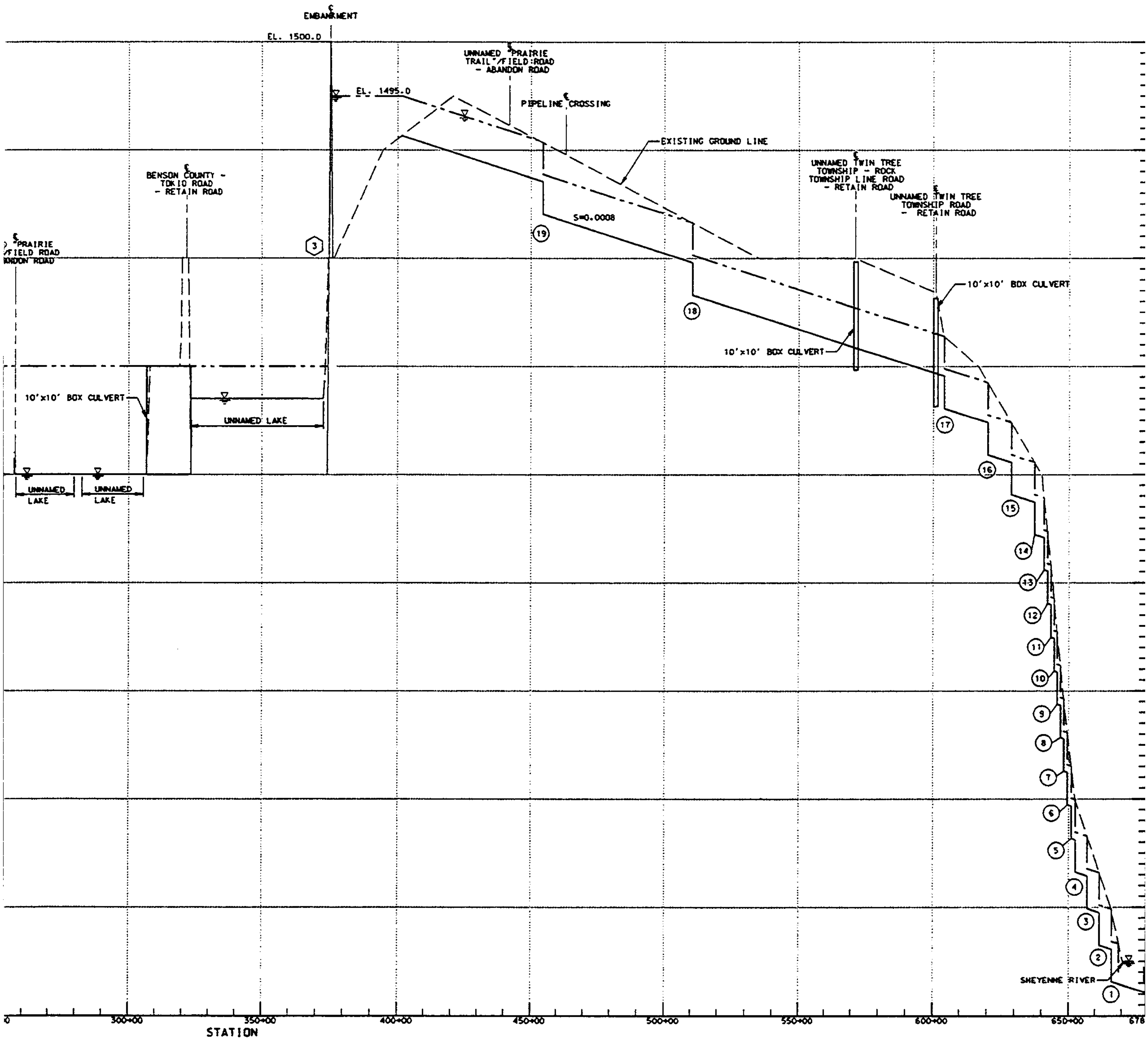
MEA



LEGEND

(1) GABION STRUCTURE

⬡1 PUMP STATION

▽ WATER SURFACE

NOTE: LAKE ELEVATIONS ARE ESTIMATED FROM USGS QUADRANGLE MAP DATED 1951 (REVISED 1975).

SYMBOL	DESCRIPTION

DEPART...
ST. PAUL DI...
ST...

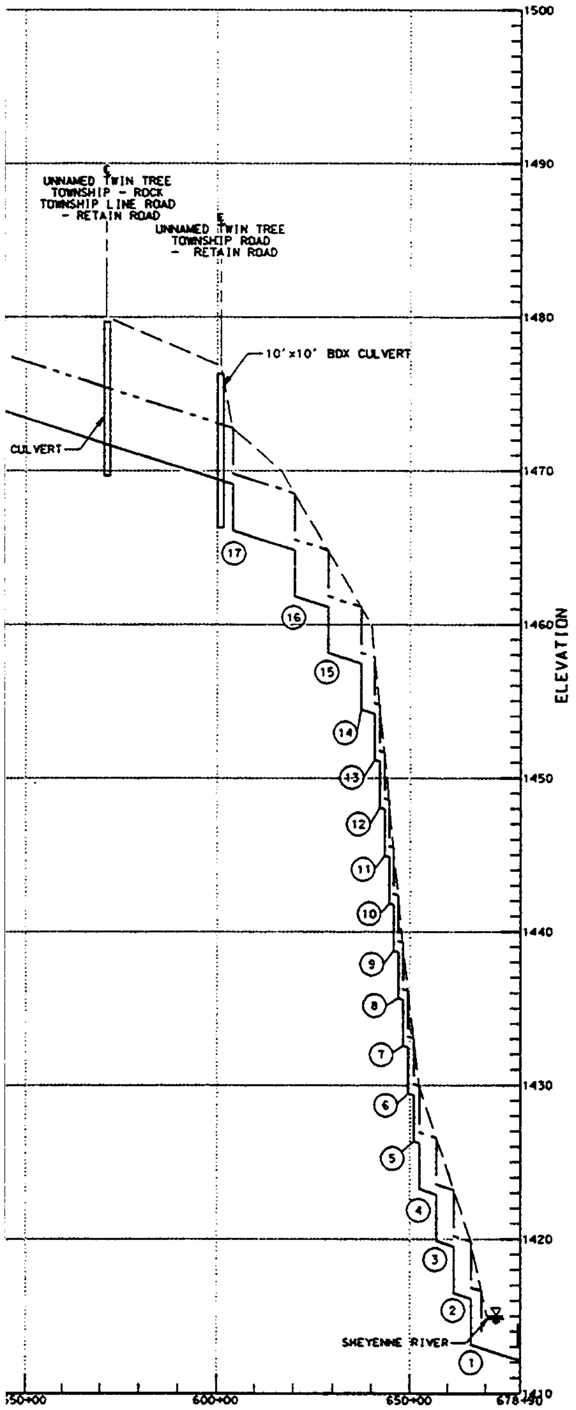
AE APPROVING OFFICIAL:

CONCEPT DES...
DEVILS LAKE EMERGENC...
GENERAL INVESTIGATIONS - SHE...
DEVILS LAKE DEVI...
FLOOD CON...
PROFILE

PE-D	DESIGNED: GVF/PDM
	CHECKED:
	DRAWN: CAS
PE-H	DESIGNED: PMF/DJR
	CHECKED:
DATE: JUNE 1996	

CAD FILE NAME: DV05R003.DGN | DRAWING ...

SOL. NO:



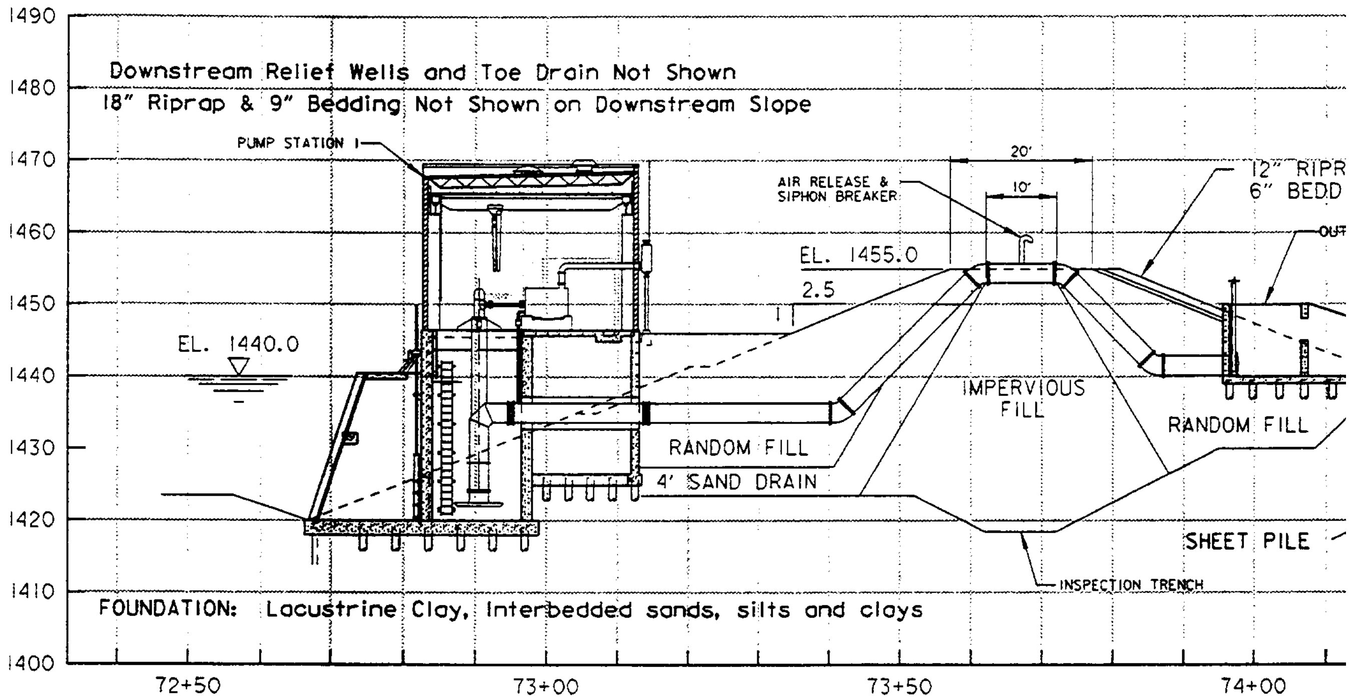
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

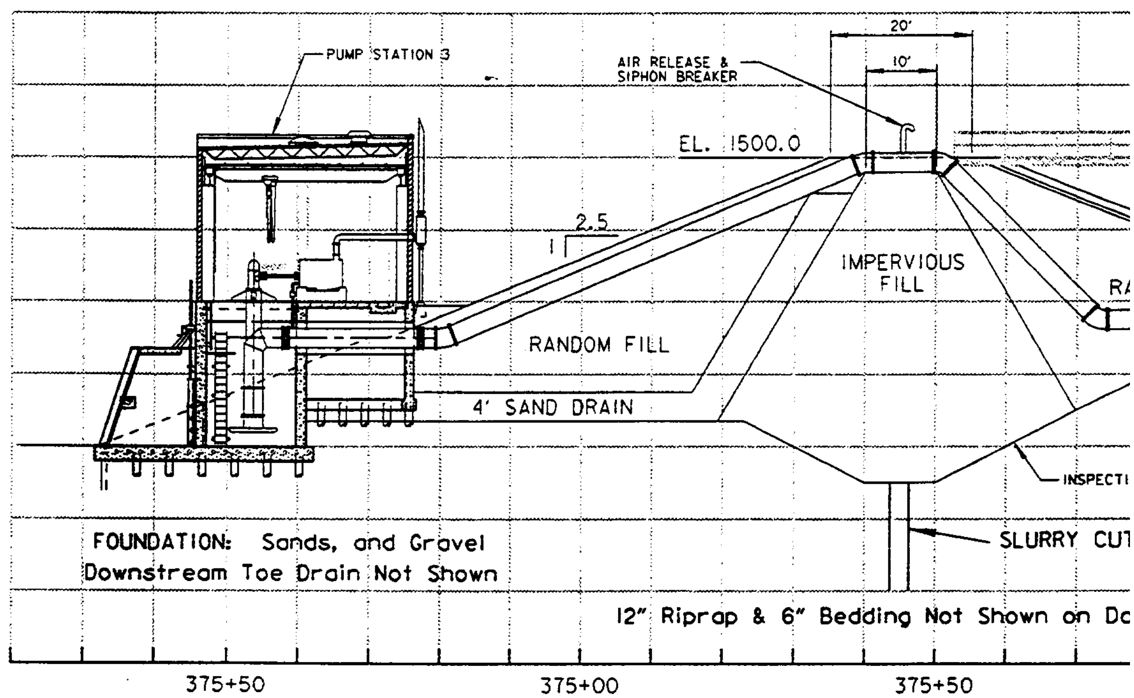
AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
PROFILE

PE-D: DESIGNED: GVF/PDM; CHECKED:; DRAWN: CAS
PE-H: DESIGNED: PMF/DJR; CHECKED:
DATE: JUNE 1996
CAD FILE NAME: DV05R003.DGN
SOL. NO:
DRAWING NUMBER: PLATE 2
SHT C-4 OF



DAM (EMBANKMENT) NUMBER 1



DAM (EMBANKMENT) NUMBER 3

ENG
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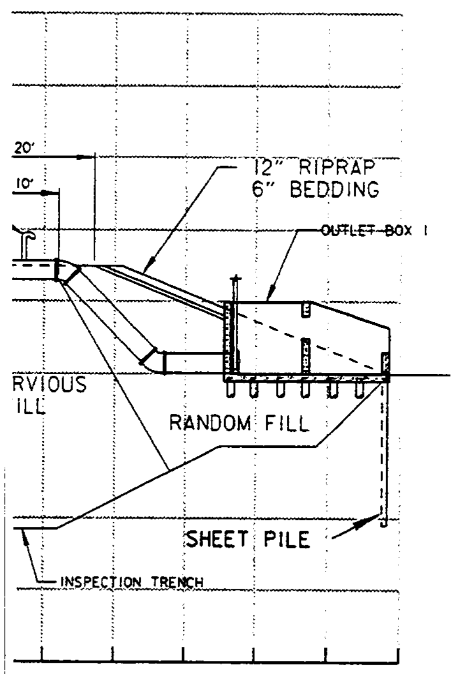
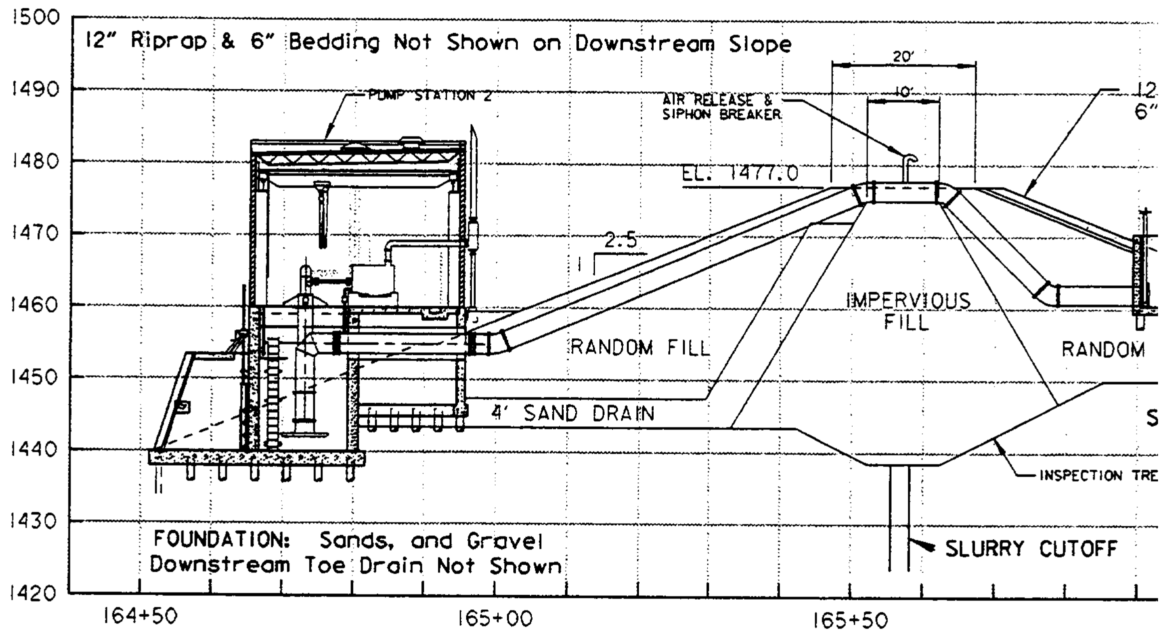
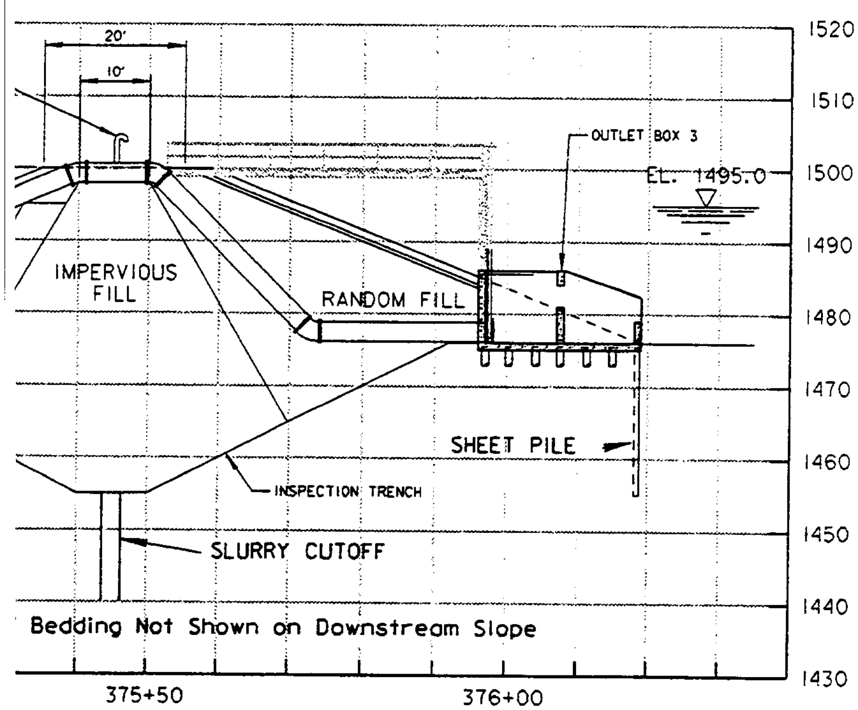
HYDR
GEOTECH
S ENG
EA





DAM (EMBANKMENT) NUMBER 2



NUMBER 3

NOTES:

1. TIMBER PILES 40 FEET IN LENGTH ARE AS
2. THE SAND DRAIN VARIES WITH GROUND SUR WITH A 2' MIN. THICKNESS
3. THE TOE DRAIN HAS A 4' TOP WIDTH WITH PERFORATED PVC PIPE DRAINING INTO THE
4. EMERGENCY SPILLWAY FOR DAM *2 IS NOT

SYMBOL	DESCRIPTION

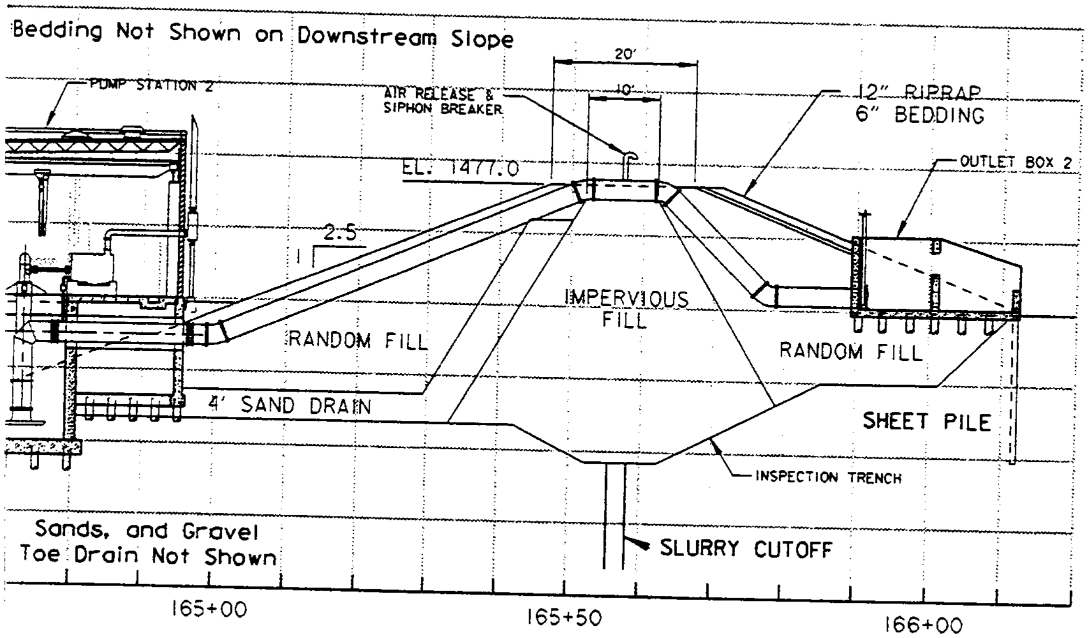
DEPA
ST. PAU

AE APPROVING OFFICIAL:

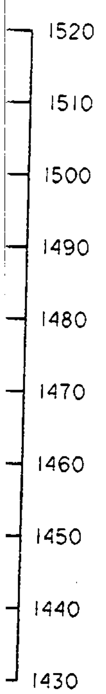
CONCEPT
DEVILS LAKE EMERGE
GENERAL INVESTIGATIONS -
DEVILS LAKE D
FLOOD C
EMBANKMENT CR
AT CENTERLINE

PE-D DESIGNED:
CHECKED:
DRAWN: LKT
PE-H DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-15-96

CAD FILE NAME: GEOXSEC.DGN
DRAW
SOL. NO:



DAM (EMBANKMENT) NUMBER 2



NOTES:

1. TIMBER PILES 40 FEET IN LENGTH ARE ASSUMED
2. THE SAND DRAIN VARIES WITH GROUND SURFACE WITH A 2' MIN. THICKNESS
3. THE TOE DRAIN HAS A 4' TOP WIDTH WITH 8" PERFORATED PVC PIPE DRAINING INTO THE PUMP STATIONS
4. EMERGENCY SPILLWAY FOR DAM *2 IS NOT SHOWN

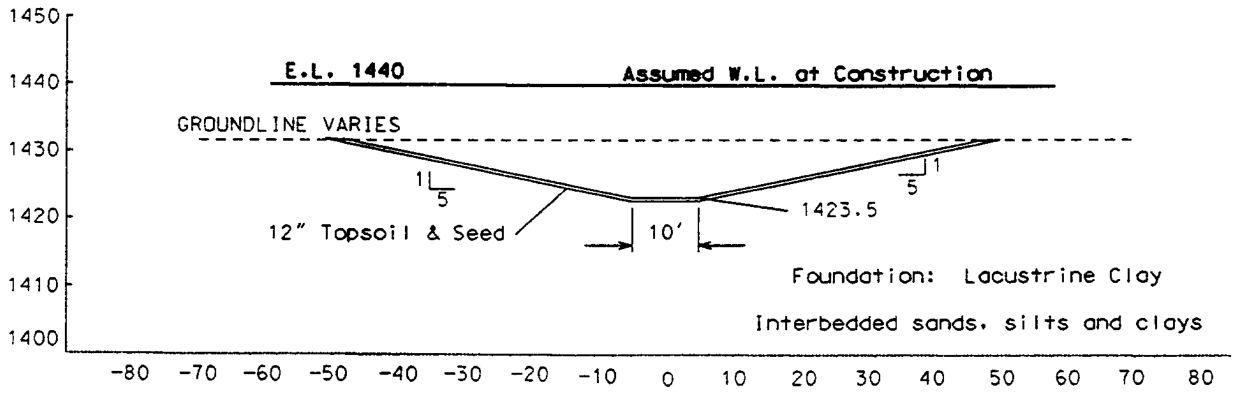
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

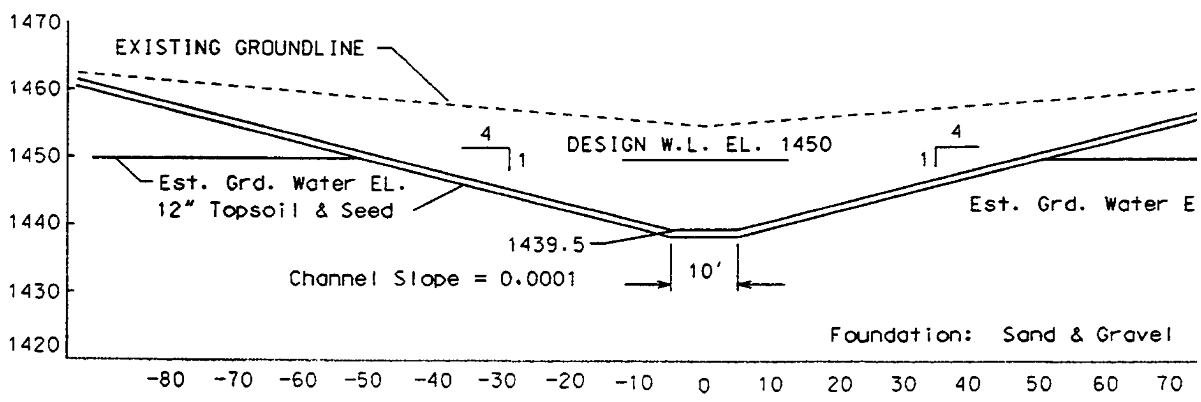
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
EMBANKMENT CROSS SECTION
AT CENTERLINE OF CHANNEL

PE-D: DESIGNED: / CHECKED: / DRAWN: LKT
PE-H: DESIGNED: PMF / CHECKED: XXX/XXX
DATE: 07-15-96
CAD FILE NAME: GEOXSEC.DGN
SOL. NO:
DRAWING NUMBER: PLATE 5
SHT 8 OF 11



TYPICAL INLET CHANNEL SECTION
STATION 0+00 THRU 73+00

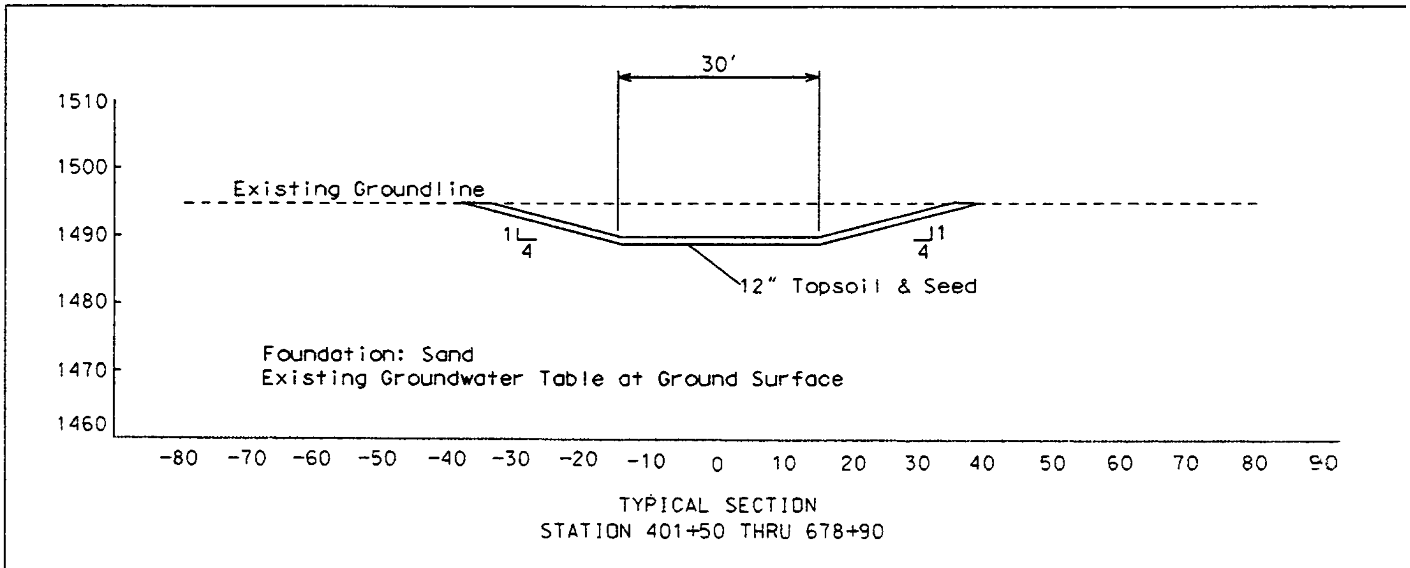
Note: Topsoil & Seed Placed After Lake Level is Drawn Down



TYPICAL SECTION
STATION 74+00 (+/-) THRU 164+60 (+/-)
CHANNEL BETWEEN EMBK. 1 & 2

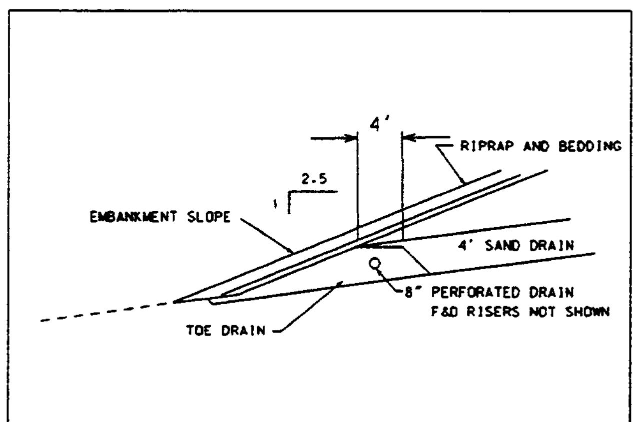
Note: Topsoil & Seed Placed After Lake Level is Drawn Down

G ENG
YD
HYDR
GEOTECH
S ENG
EA

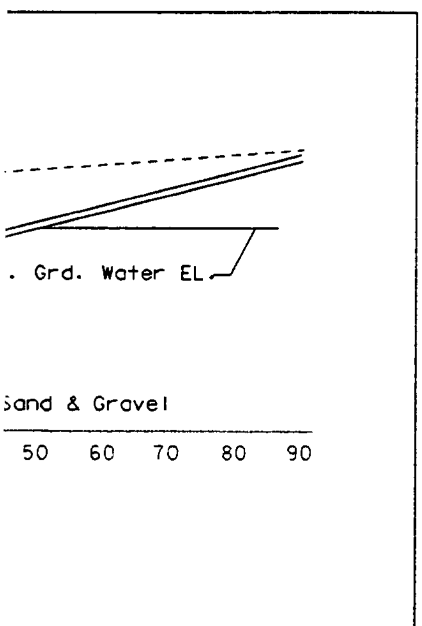


TYPICAL SECTION
STATION 401+50 THRU 678+90

Note: Topsoil & Seed Placed After Lake Level is Drawn Down



Toe Drain Typical Section For All Embankments



SYMBOL	DESCRIPTION

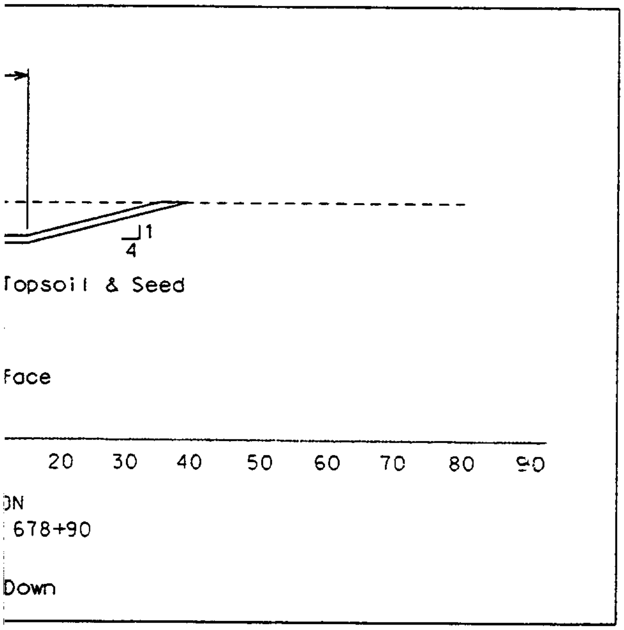
DEPARTMENT OF TH
ST. PAUL DISTRICT, CORPS
ST. PAUL, MINNES

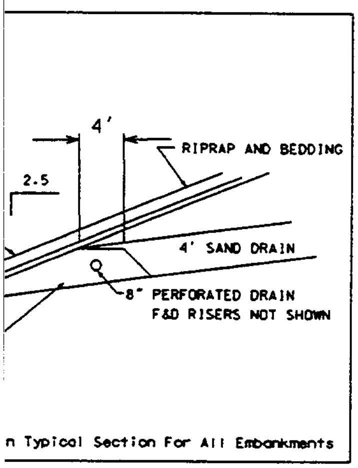
AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET P
GENERAL INVESTIGATIONS - SHEYENNE RIVER
DEVILS LAKE DEVILS LAKE, NC
FLOOD CONTROL
CHANNELS AND TOE DRAIN

PE-D	DESIGNED:	
	CHECKED:	
	DRAWN:	PDM
PE-H	DESIGNED:	PMF
	CHECKED:	
DATE:		

CAD FILE NAME:
SOL. NO:
DRAWING NUMBER: PLATE 6





SYMBOL	DESCRIPTION	DATE	APPROVAL

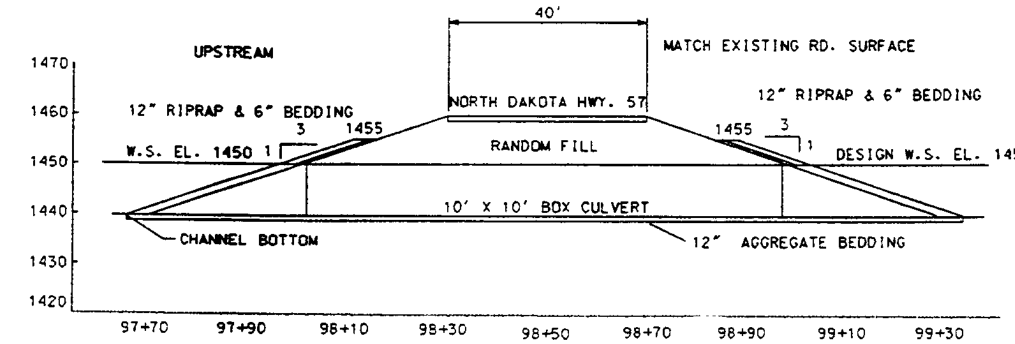
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

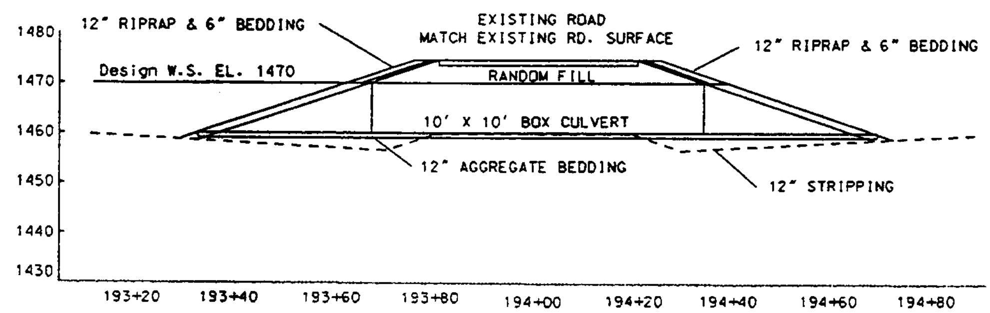
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
CHANNELS AND TOE DRAIN

PE-D: DESIGNED: / CHECKED: / DRAWN: PDM
PE-H: DESIGNED: PMF / CHECKED:
DATE:

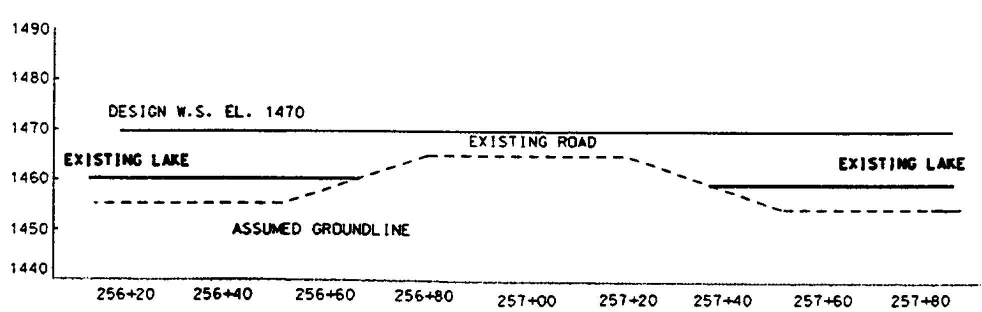
CAD FILE NAME:
SOL. NO:
DRAWING NUMBER: PLATE 6
SHT
OF



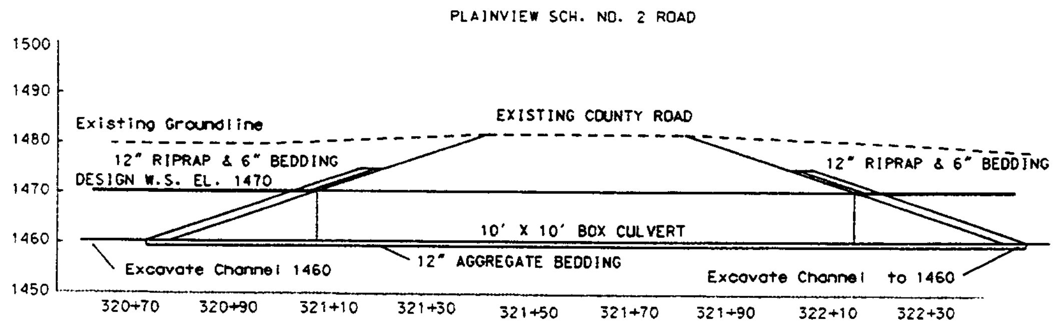
TYPICAL ROAD SECTION
HIGHWAY 57 (ASSUMED SIDE SLOPES)



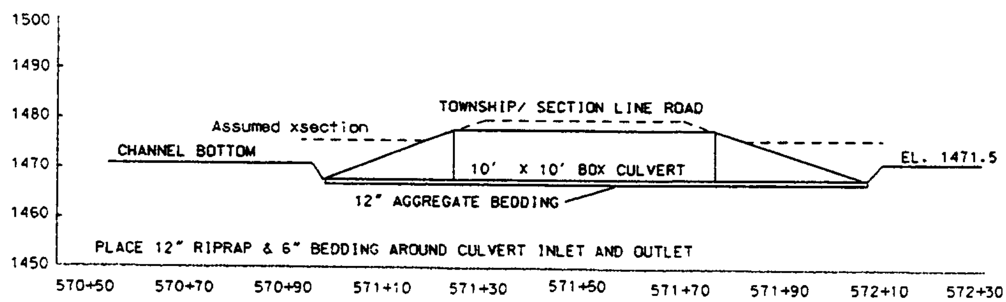
TYPICAL SECTION
SECTION LINE ROAD (ASSUMED SIDE SLOPES)
ROAD TO BE RAISED TO 1475



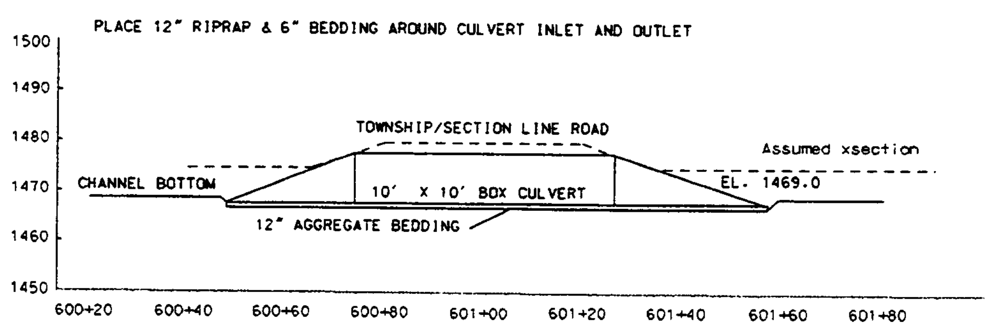
TYPICAL ROAD SECTION
SECTION LINE ROAD (ASSUMED SIDE SLOPES)
ROAD TO BE ABANDONED



TYPICAL ROAD SECTION
PLAINVIEW SCH. NO. 2 ROAD



TYPICAL ROAD SECTION
STATION 571+50



TYPICAL ROAD SECTION
STATION 601+00

NOTES:

1. Section Line Road Located at Station 390+00 is Abandoned.
2. Section Line Road Located at Station 35+00 is Already Abandoned.

SYMBOL	DESCRIPTION	DATE	APPROVAL

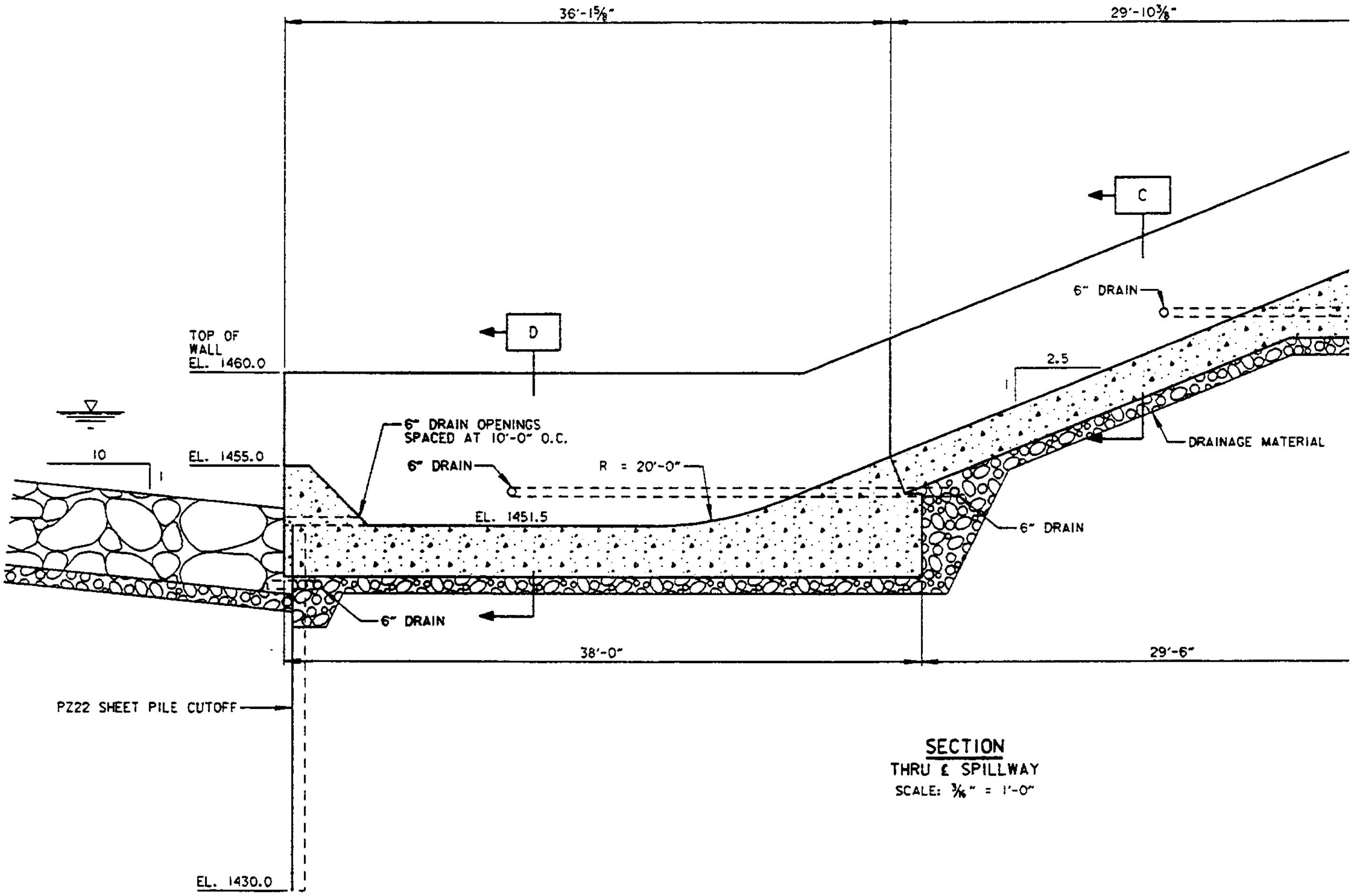
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

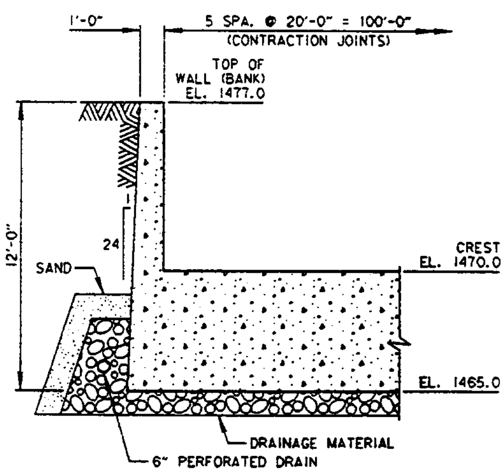
PE-D	DESIGNED:	
PE-D	CHECKED:	
PE-D	DRAWN:	PDM
PE-H	DESIGNED:	PMF
PE-H	CHECKED:	XXX/XXX
	DATE:	

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
ROAD CROSSINGS

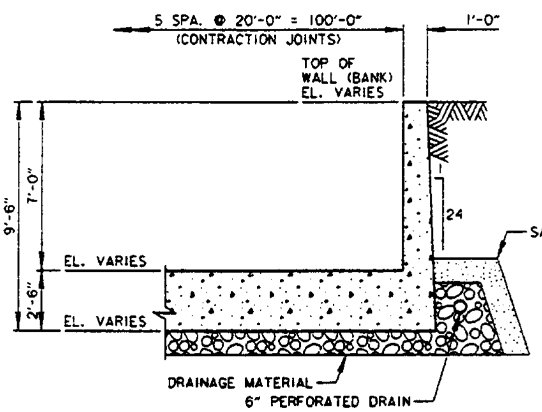
CAD FILE NAME:	DRAWING NUMBER: PLATE 7	SHT
SOL. NO:		OF



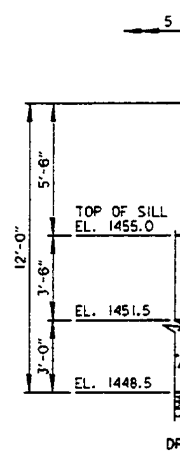
SECTION
THRU ℄ SPILLWAY
SCALE: 3/16" = 1'-0"



SECTION
SPILLWAY CREST
SCALE: 1/4"=1'-0"
B

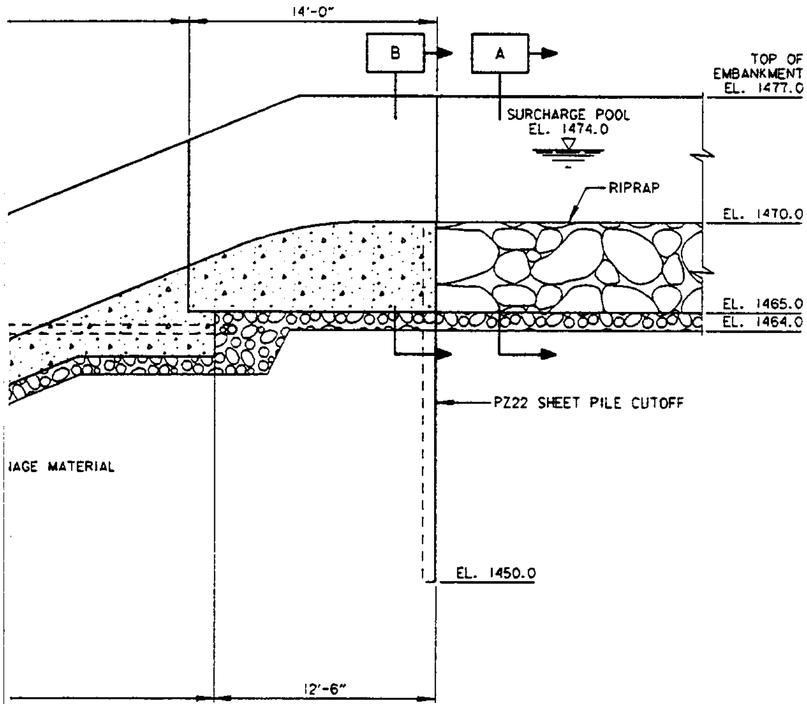


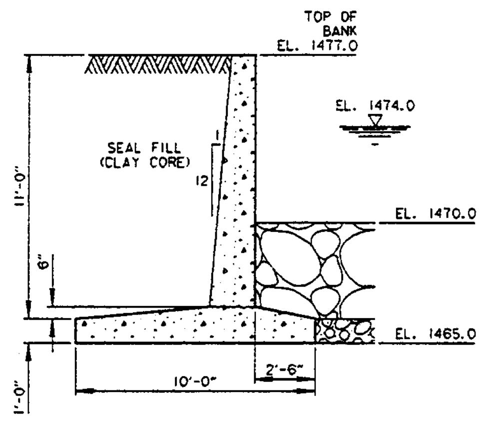
SECTION
FLUME
SCALE: 1/4"=1'-0"
C



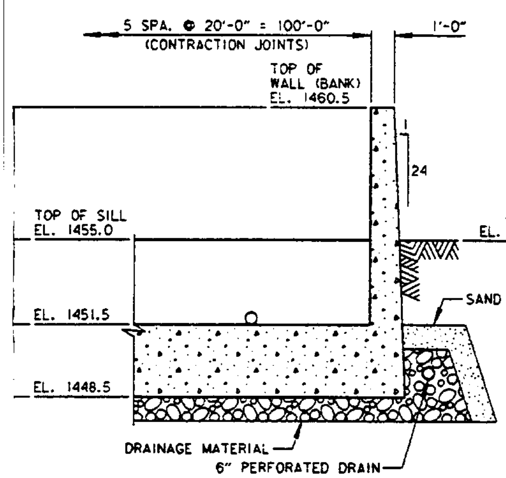
SECTION
STILLING BA
SCALE: 1/4"=1'-

ENG
HYD
HYDR
GEOTECH
ENG
EA





SECTION A
EMBANKMENT RETAINING WALL
SCALE: 1/4"=1'-0"



SECTION D
STILLING BASIN
SCALE: 1/4"=1'-0"

1 0 4 8
SCALE: 1/4" = 1'-0"

1 0 4 8 12
SCALE: 3/16" = 1'-0"

SYMBOL	DESCRIPTION	DATE

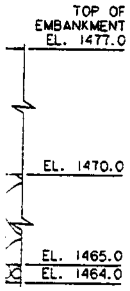
DEPARTMENT OF THE ARM
ST. PAUL DISTRICT, CORPS OF ENGI
ST. PAUL, MINNESOTA

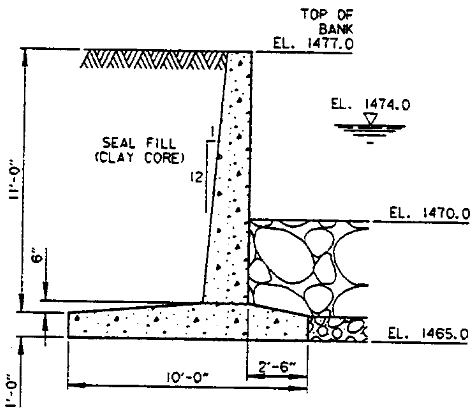
AE APPROVING OFFICIAL:

PE-D DESIGNED: BGS
CHECKED: DMT
DRAWN: LKT
PE-H DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-09-96

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH [
FLOOD CONTROL
EMBANKMENT SPILLWAY
SECTIONS

CAD FILE NAME: DV05RS06.DGN
SOL. NO:
DRAWING NUMBER: PLATE 8





SECTION A

EMBANKMENT RETAINING WALL

SCALE: 1/4"=1'-0"

0 4 8
SCALE: 1/4" = 1'-0"

4 8 12
SCALE: 3/16" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

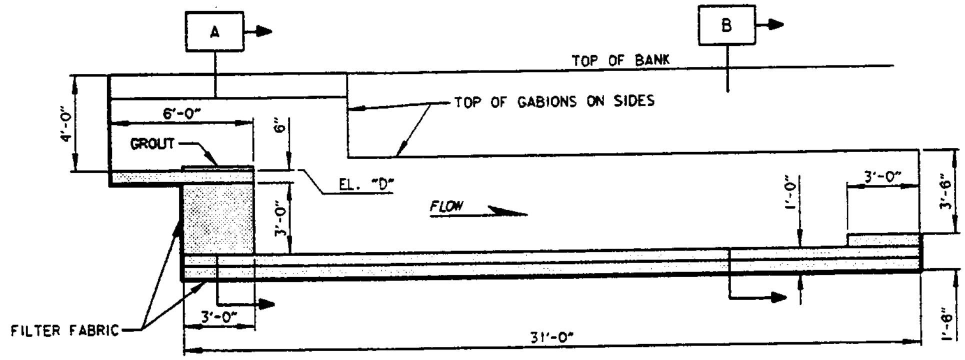
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

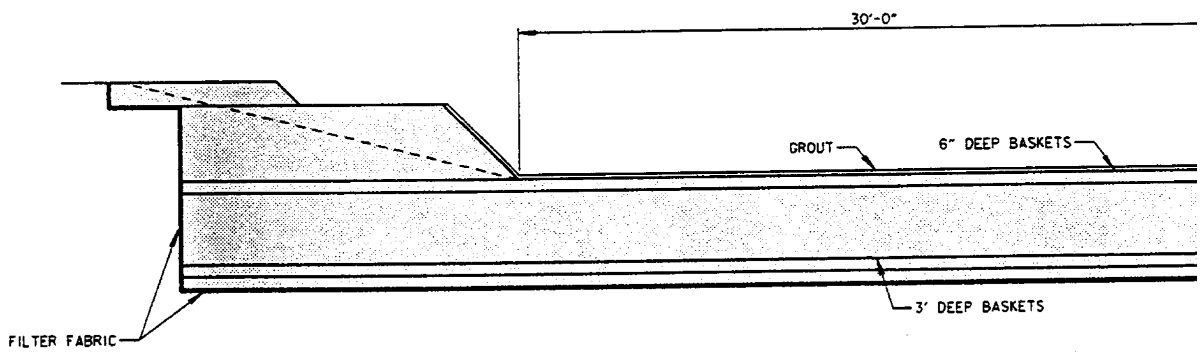
PE-D: DESIGNED: BGS; CHECKED: DMT; DRAWN: LKT
PE-H: DESIGNED: PMF; CHECKED: XXX/XXX
DATE: 07-09-96

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
EMBANKMENT SPILLWAY
SECTIONS

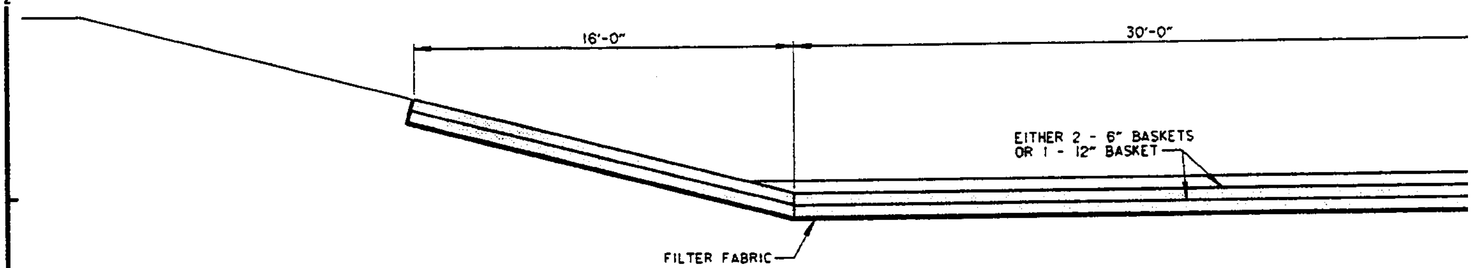
CAD FILE NAME: DV05RS06.DGN
SOL. NO:
DRAWING NUMBER: PLATE 8
SHT 8 OF 8



PROFILE
TYPICAL GABION DROP STRUCTURE
SCALE: 1/4" = 1'-0"



SECTION A
GABION DROP STRUCTURE
SCALE: 1/4"=1'-0"



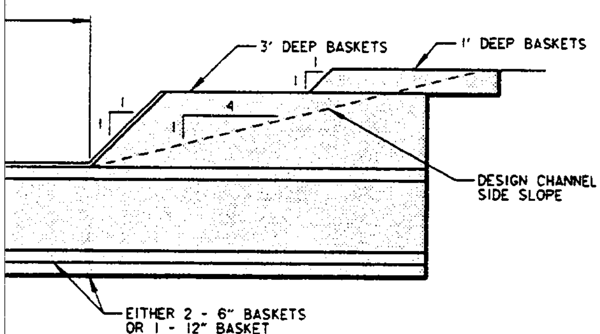
SECTION B
GABION DROP STRUCTURE
SCALE: 1/4"=1'-0"

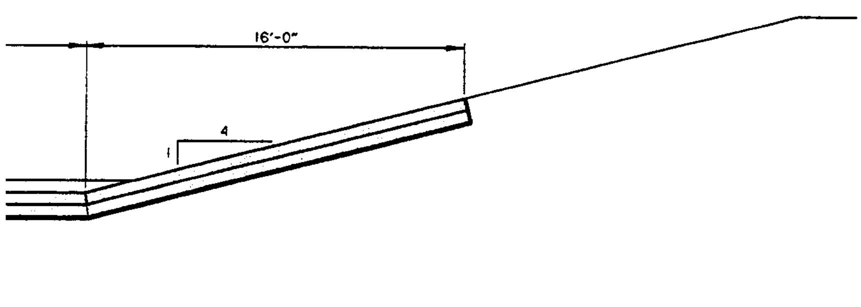
GE ENG
HYD
HYDR
GEOTECH
ST ENG
A

2

3

STATION	ELEVATION D	NOTES
666+13.08	1416.13	
661+55.91	1419.49	
657+00.74	1422.86	
652+45.58	1426.22	
650+98.53	1429.34	
649+58.81	1432.45	
648+19.09	1435.56	
646+96.03	1438.66	
645+78.14	1441.76	
644+60.24	1444.85	
643+42.35	1447.95	
642+07.30	1451.05	
640+78.20	1454.16	
637+25.32	1457.44	
628+72.06	1461.12	
620+18.80	1464.80	
604+10.36	1469.09	
510+53.00	1479.58	
454+56.04	1487.05	





SCALE: 1/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
GABION DROP STRUCTURES
TYPICAL PROFILE & SECTION

PE-D: DESIGNED: PDM; CHECKED: BGS; DRAWN: LKT
PE-H: DESIGNED: PMF; CHECKED: XXX/XXX
DATE: 07-09-96
CAD FILE NAME: DV05RS05.DGN
SOL. NO:
DRAWING NUMBER: PLATE 9
SHT 7 OF 8

3

STATION	ELEVATION D	NOTES
666+13.08	1416.13	
661+55.91	1419.49	
657+00.74	1422.86	
652+45.58	1426.22	
650+98.53	1429.34	
649+58.81	1432.45	
648+19.09	1435.56	
646+96.03	1438.66	
645+78.14	1441.76	
644+60.24	1444.85	
643+42.35	1447.95	
642+07.30	1451.05	
640+78.20	1454.16	
637+25.32	1457.44	
628+72.06	1461.12	
620+18.80	1464.80	
604+10.36	1469.09	
510+53.00	1479.58	
454+56.04	1487.05	

4 8

/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

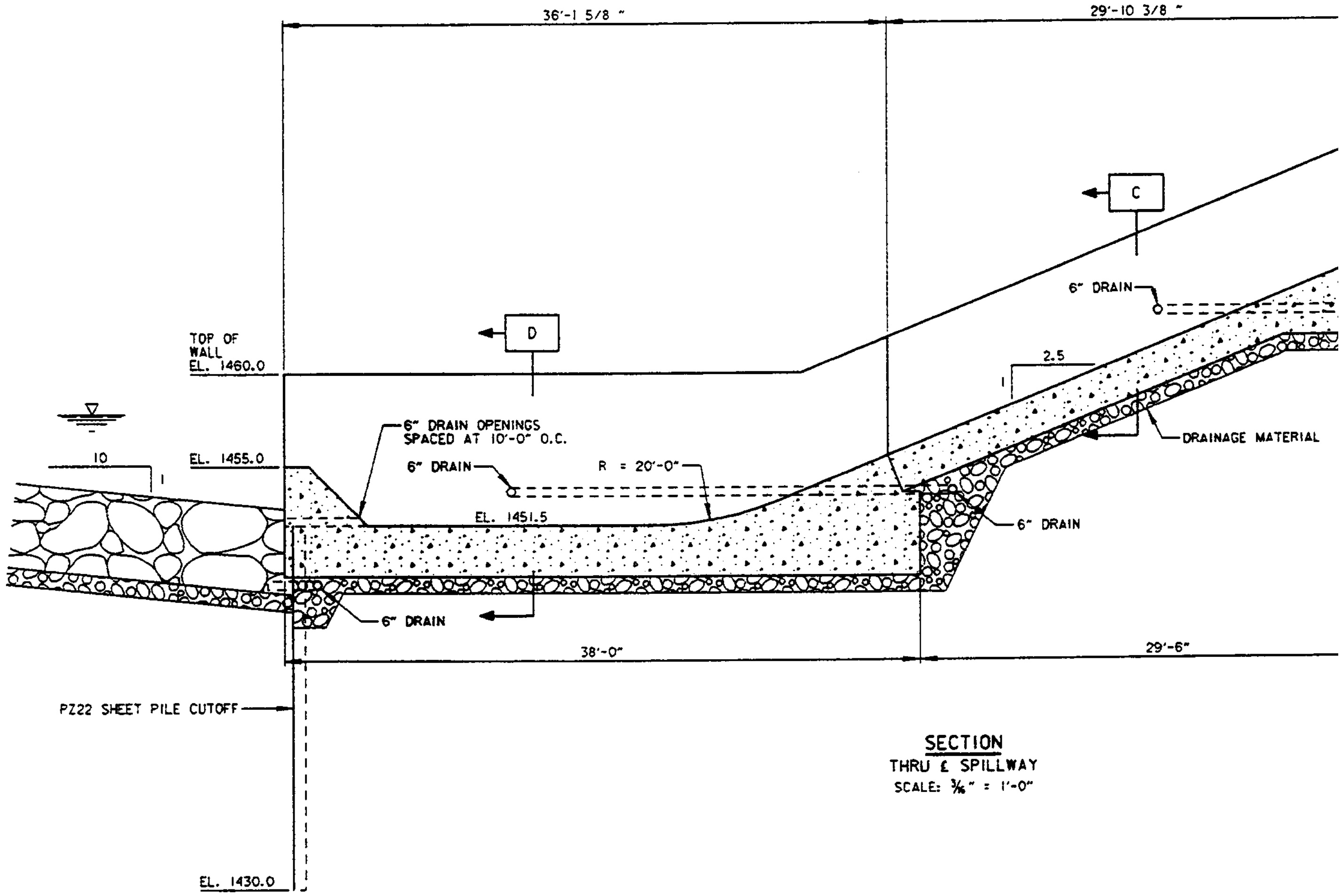
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

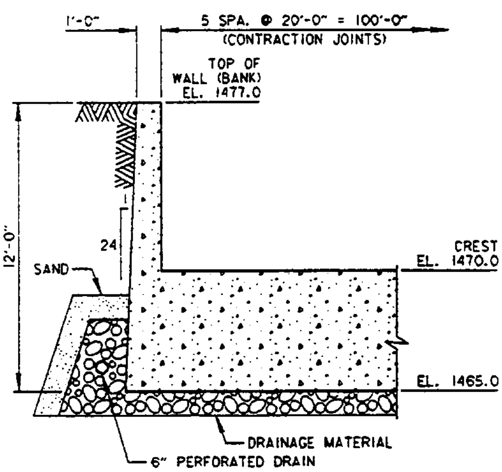
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
GABION DROP STRUCTURES
TYPICAL PROFILE & SECTION

PE-D: DESIGNED: PDM; CHECKED: BGS; DRAWN: LKT
PE-H: DESIGNED: PMF; CHECKED: XXX/XXX
DATE: 07-09-96

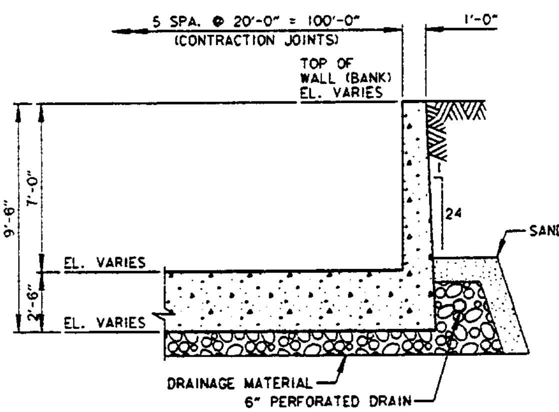
CAD FILE NAME: DV05RS05.DGN
SOL. NO:
DRAWING NUMBER: PLATE 9
SHT 7 OF 8



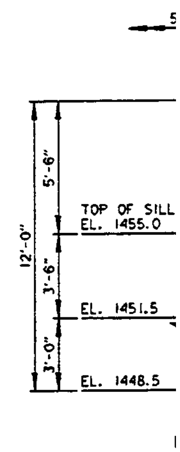
SECTION
THRU ℄ SPILLWAY
SCALE: 3/16" = 1'-0"



SECTION B
SPILLWAY CREST
SCALE: 1/4"=1'-0"

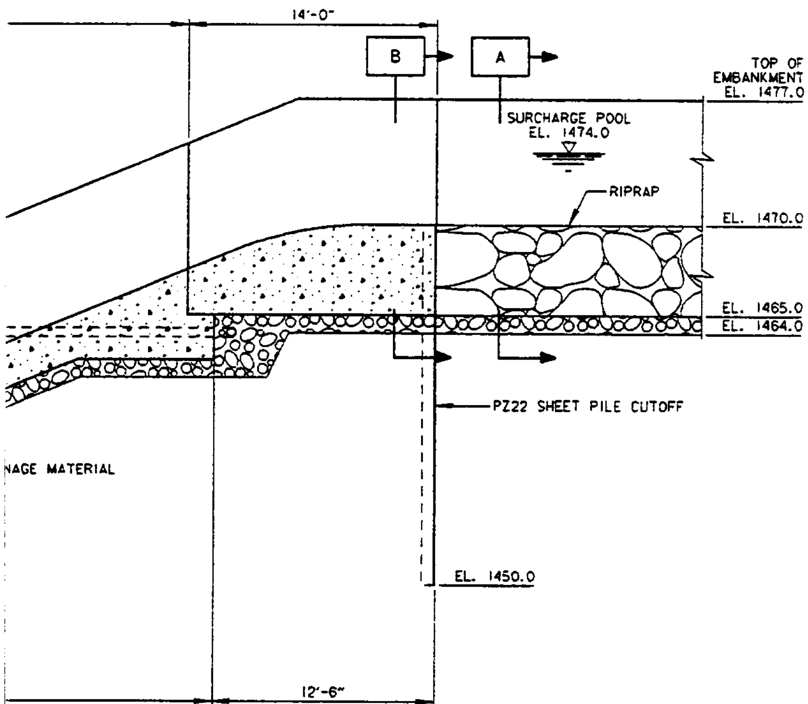


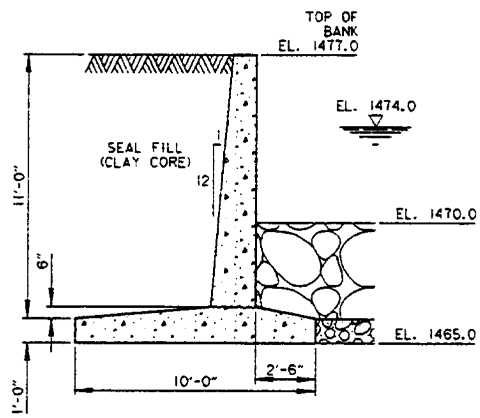
SECTION C
FLUME
SCALE: 1/4"=1'-0"



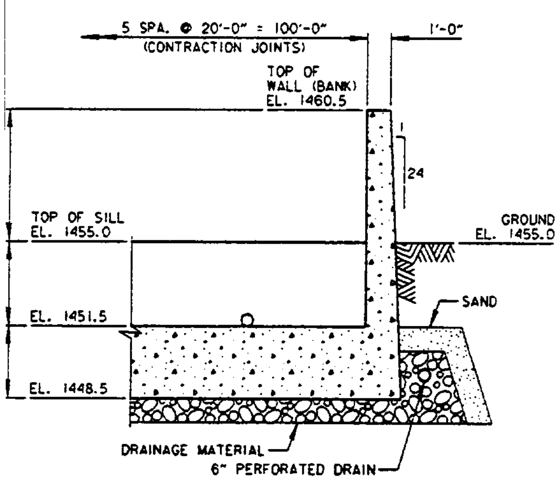
SECTION
STILLING B
SCALE: 1/4"=

G ENG
HYD
HYDR
GEOTECH
S ENG
A





SECTION A
EMBANKMENT RETAINING WALL
SCALE: 1/4"=1'-0"



SECTION D
STILLING BASIN
SCALE: 1/4"=1'-0"

SCALE: 1/4" = 1'-0"

SCALE: 3/16" = 1'-0"

SYMBOL	DESCRIPTION	DATE

DEPARTMENT OF THE ARM
ST. PAUL DISTRICT, CORPS OF ENGI
ST. PAUL, MINNESOTA

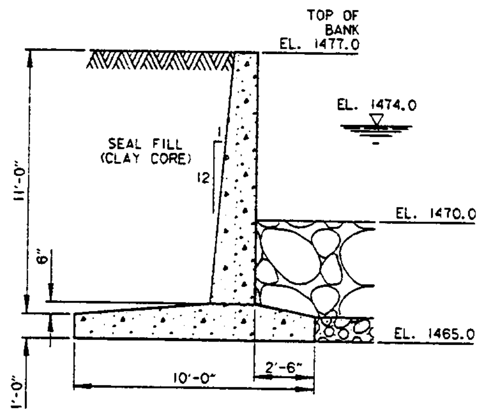
AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH D
FLOOD CONTROL
EMBANKMENT SPILLWAY
SECTIONS

PE-D DESIGNED:	BGS
PE-D CHECKED:	DMT
PE-D DRAWN:	LKT
PE-H DESIGNED:	PMF
PE-H CHECKED:	XXX/XXX
DATE:	07-09-96

CAD FILE NAME: DVO5RSO6.DGN
SOL. NO:
DRAWING NUMBER: PLATE 1

3



SECTION A
EMBANKMENT RETAINING WALL
SCALE: 1/4"=1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

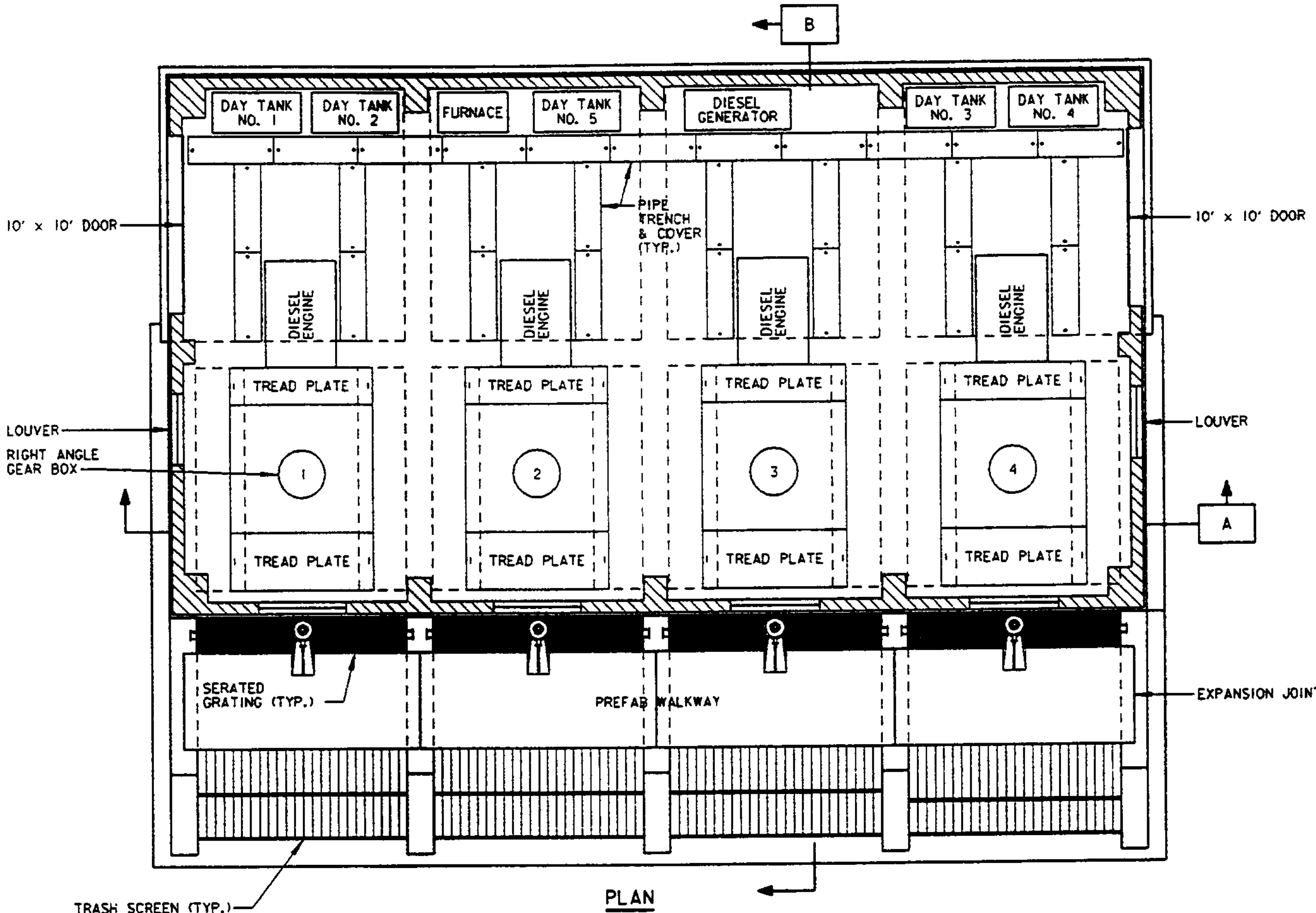
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

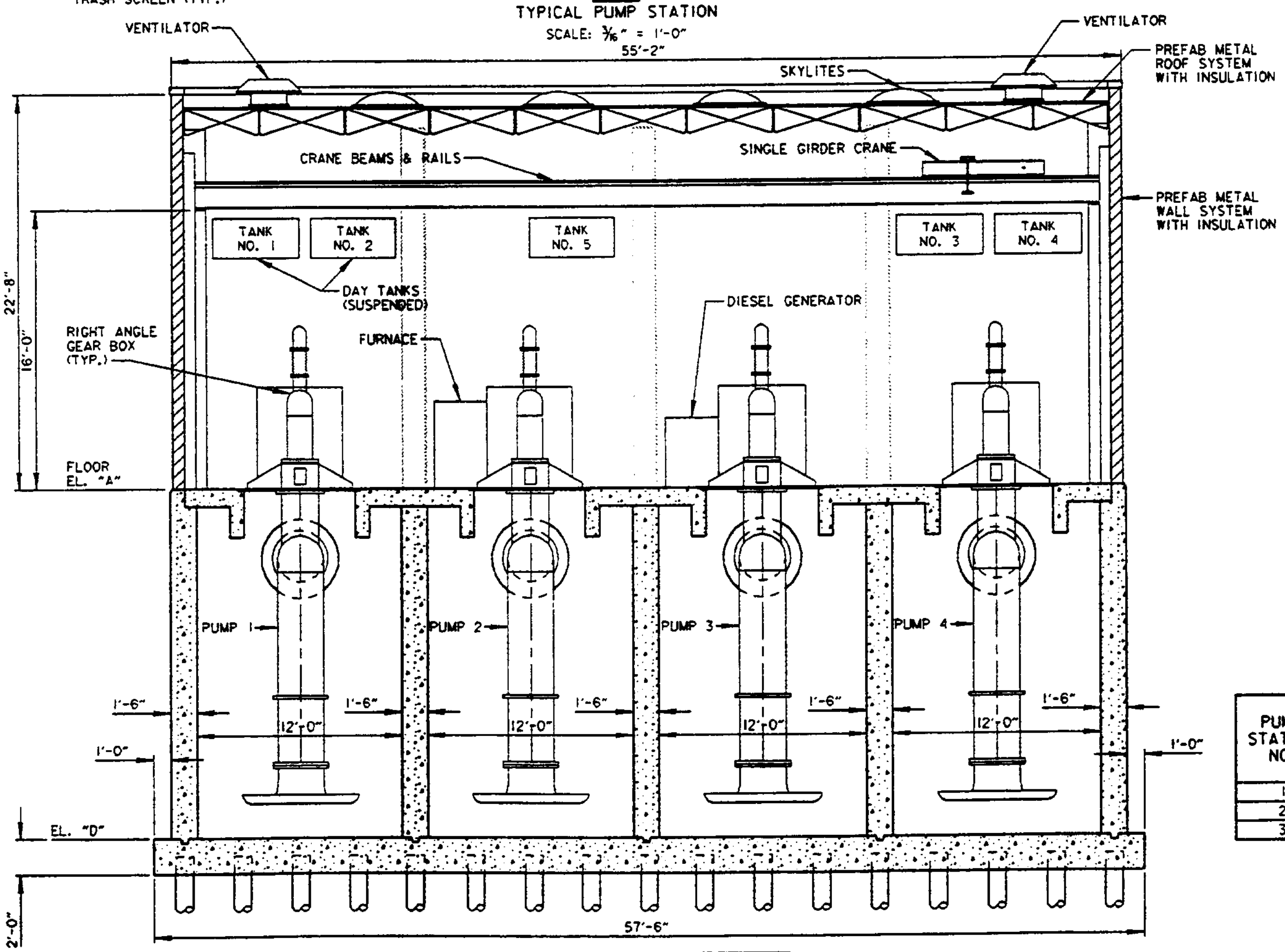
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
EMBANKMENT SPILLWAY
SECTIONS

PE-0 DESIGNED:	BGS
CHECKED:	DMT
DRAWN:	LKT
PE-H DESIGNED:	PMF
CHECKED:	XXX/XXX
DATE:	07-09-96

CAD FILE NAME: DV05RS06.DGN
SOL. NO:
DRAWING NUMBER: PLATE 1
SHT 8 OF 8



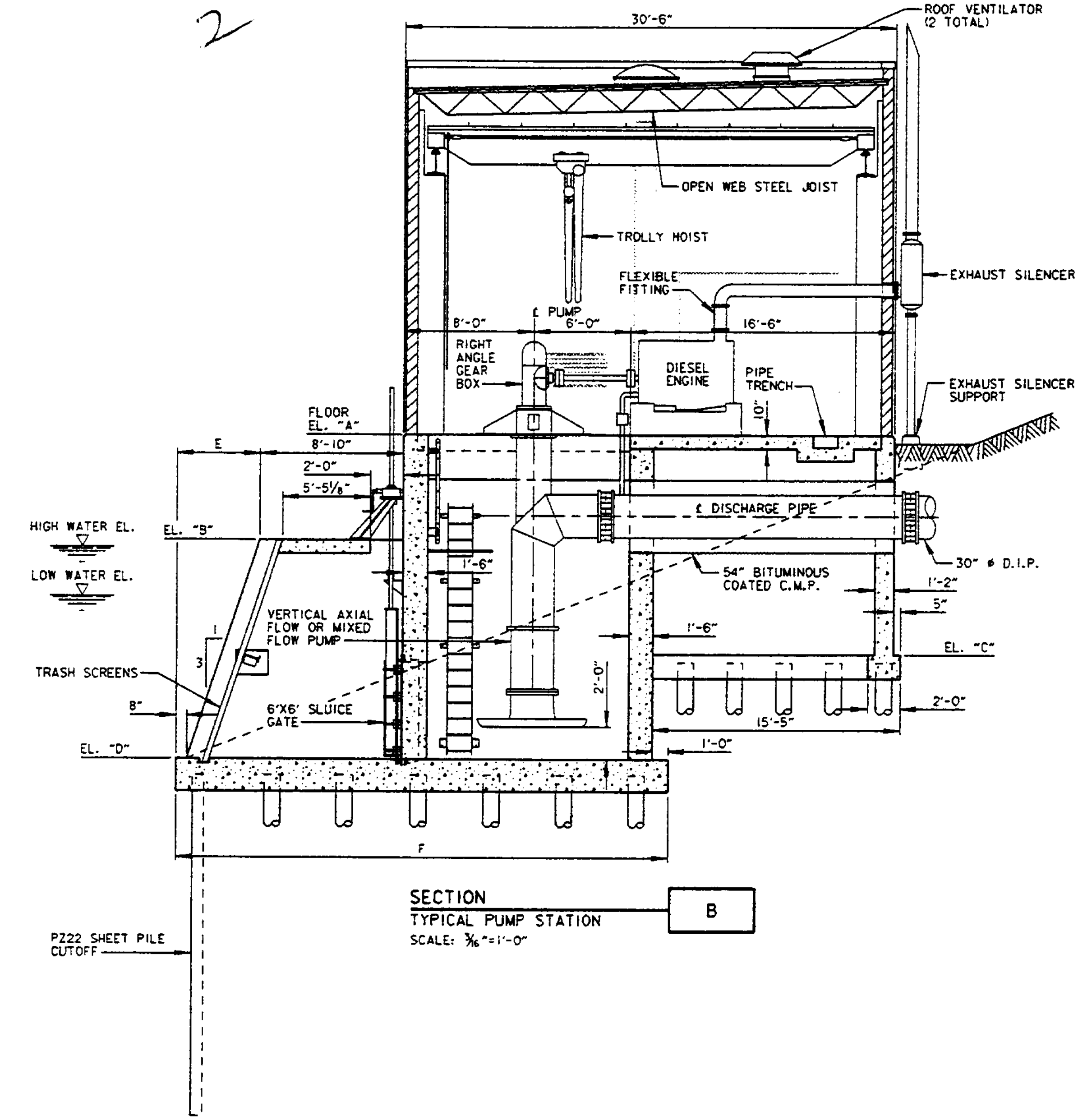
PLAN
TYPICAL PUMP STATION
SCALE: 3/16" = 1'-0"



SECTION
TYPICAL PUMP STATION
SCALE: 3/16"=1'-0"
A

GI ENG
HYD
HYDR
GEOTECH
ST ENG
A

PUMP STATION NO.
1
2
3



SECTION
TYPICAL PUMP STATION
SCALE: 3/16"=1'-0"

B

NOTES:

1. DAY TANKS 1 THROUGH 4 ARE FOR SUPPLYING FUEL TO DIESEL ENGINES 1 THROUGH 4.
2. DAY TANK 5 IS FOR THE FURNACE.
3. THE DAY TANK FOR THE GENERATOR IS SKID MOUNTED.

PUMP STATION NO.	STATION	ELEVATIONS							DIMENSIONS	
		A	B	C	D	℄ DISCHARGE PIPE	LOW WATER	HIGH WATER	E	F
1	73+67	1446.5	1440.5	1426.5	1420.0	1435.0	1428.0	1440.0	7'-4"	32'-8"
2	165+57	1460.0	1453.5	1446.5	1440.0	1455.0	1450.0	1453.0	5'-2"	30'-6"
3	375+45	1480.0	1473.5	1466.5	1460.0	1475.0	1470.0	1473.0	5'-2"	30'-6"

0 4 8 12
SCALE: 3/16" = 1'-0"

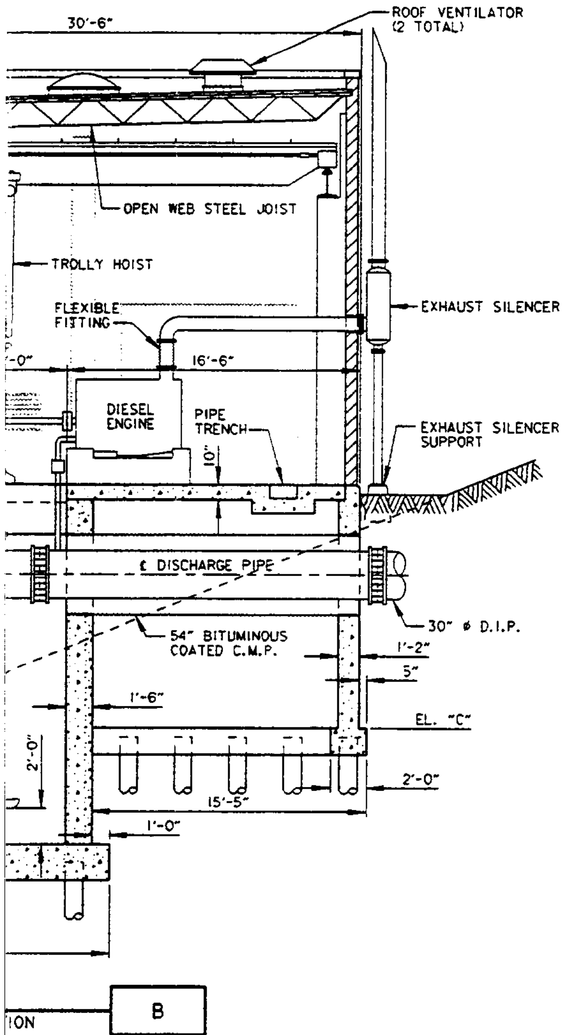
SYMBOL	DESCRIPTION	DATE

DEPARTMENT OF THE AR
ST. PAUL DISTRICT, CORPS OF ENG
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH
FLOOD CONTROL
PUMP STATION
PLAN, SECTIONS & TABLE

PE-D DESIGNED: BGS/TMP
CHECKED: DMT
DRAWN: LKT
PE-H DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-12-96
CAD FILE NAME: DV05RS01.DGN
SOL. NO:
DRAWING NUMBER: PLATE 2



3

NOTES:

1. DAY TANKS 1 THROUGH 4 ARE FOR SUPPLYING FUEL TO DIESEL ENGINES 1 THROUGH 4.
2. DAY TANK 5 IS FOR THE FURNACE.
3. THE DAY TANK FOR THE GENERATOR IS SKID MOUNTED.

DIMENSIONS	
E	F
7'-4"	32'-8"
5'-2"	30'-6"
5'-2"	30'-6"

8 12
= 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

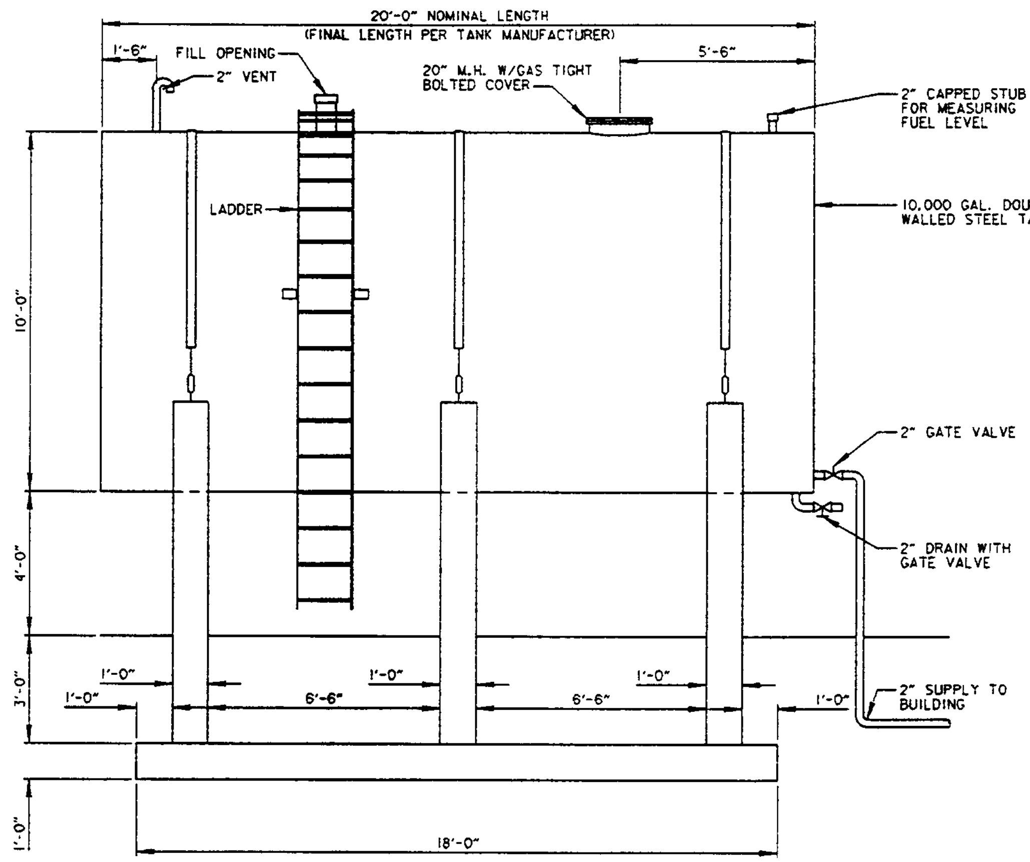
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
PUMP STATION
PLAN, SECTIONS & TABLE

PE-D DESIGNED: BGS/TMP
CHECKED: DMT
DRAWN: LKT
PE-H DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-12-96

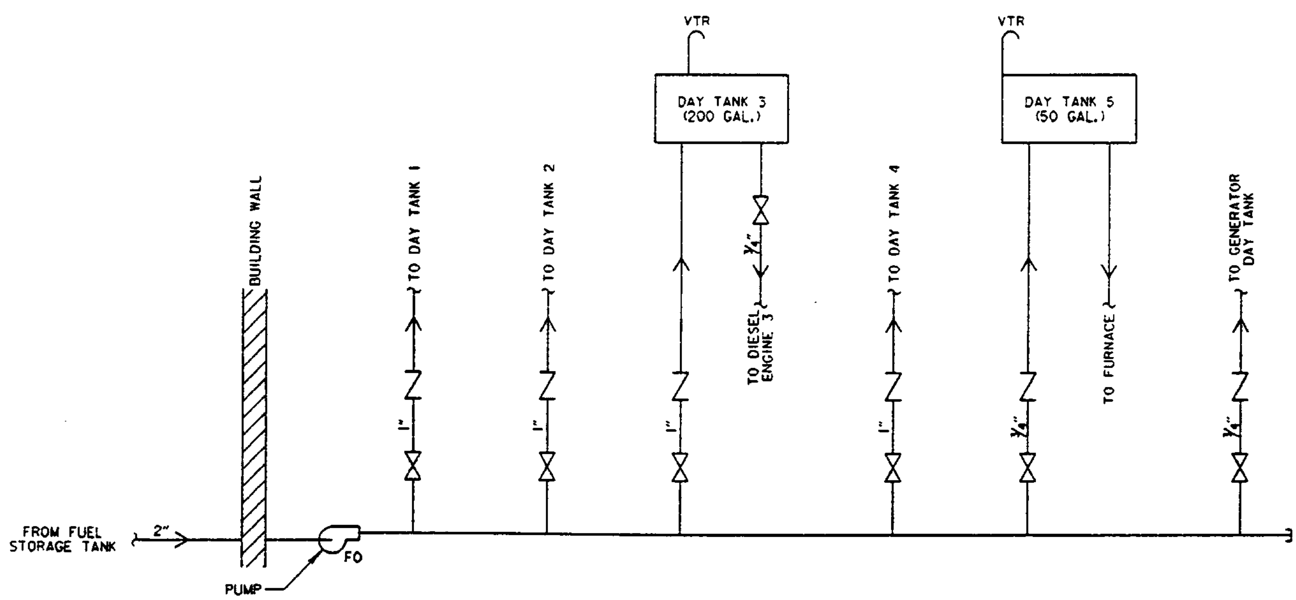
CAD FILE NAME: DV05RS01.DGN
SOL. NO:
DRAWING NUMBER: PLATE 2
SHT 1 OF 8



SIDE ELEVATION

FUEL TANK

SCALE: 3/8" = 1'-0"



FUEL OIL SYSTEM SCHEMATIC

GI ENG

HYD

HYDR

GEOTECH

ST ENG

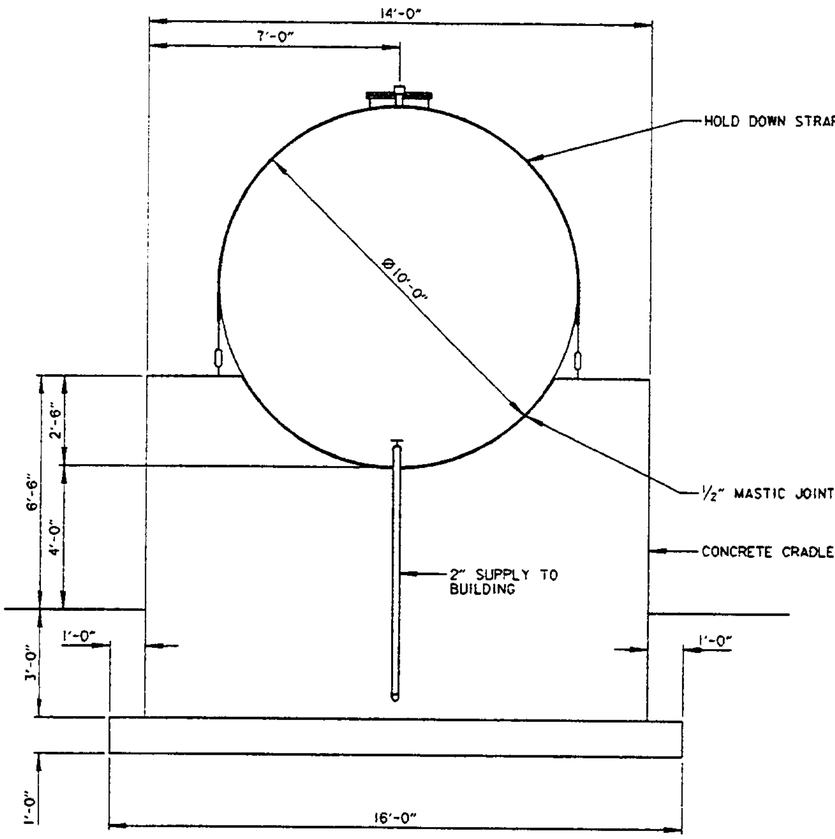
A

6'-6"

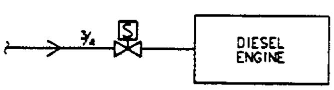
3'-0"

1'-0"

2

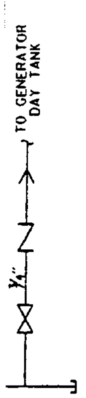


END ELEVATION
FUEL TANK
SCALE: 3/8" = 1'-0"



NOTE:
SOLENOID VALVE & DIESEL ENGINE TO BE INTERLOCKED.

DIESEL ENGINE
FUEL LINE SCHEMATIC

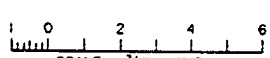


NOTES:

1. DAY TANKS 1, 2, 3, AND 4 ARE SIMILAR.

LEGEND:

- GATE VALVE
- CHECK VALVE
- SOLENOID VALVE
- VTR — VENT THROUGH ROOF



SCALE: 3/8" = 1'-0"

SYMBOL	DESCRIPTION	DATE

DEPARTMENT OF THE AR
ST. PAUL DISTRICT, CORPS OF EN
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

PE-0 DESIGNED: TMP	
CHECKED:	
DRAWN: LKT	
PE-H DESIGNED: PMF	
CHECKED: XXX/XXX	CAD FILE NAME: DV05RM01.DGN
DATE: 07-09-96	SOL. NO:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASI
DEVILS LAKE — DEVILS LAKE, NORTH
FLOOD CONTROL
FUEL OIL SYSTEM
ELEVATIONS & SCHEMATICS

DRAWING NUMBER:
PLATE 3

F G

3

5

RAPS

INT

DLE

4

3

2

NOTES:

1. DAY TANKS 1, 2, 3, AND 4 ARE SIMILAR.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
FUEL OIL SYSTEM
ELEVATIONS & SCHEMATICS

PE-D: DESIGNED: TMP; CHECKED: ; DRAWN: LKT
PE-H: DESIGNED: PMF; CHECKED: XXX/XXX
DATE: 07-09-96

CAD FILE NAME: DV05RM01.DGN
SOL. NO:
DRAWING NUMBER: PLATE 3
SHT 2 OF 8

GE ENG

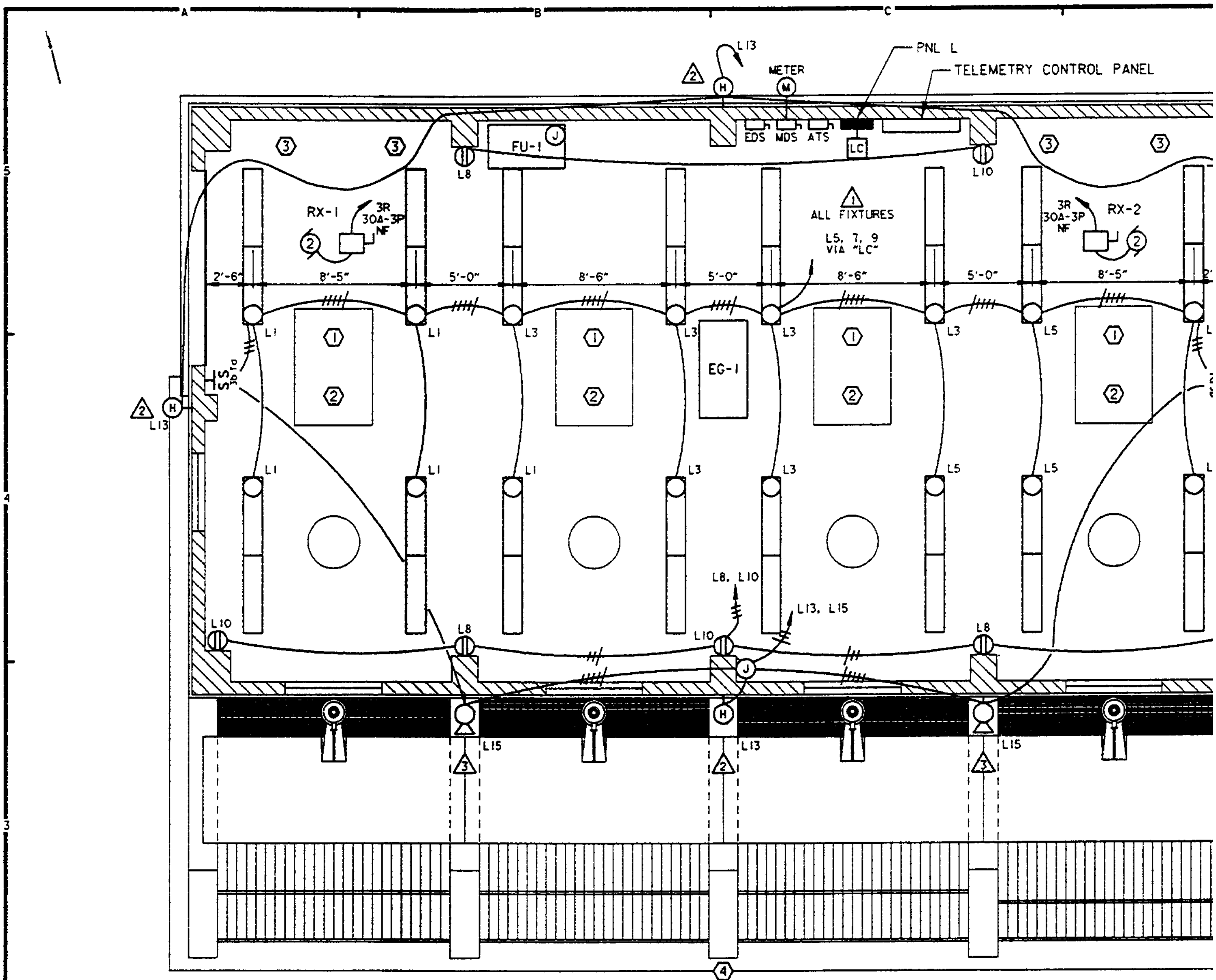
HYD

HYDR

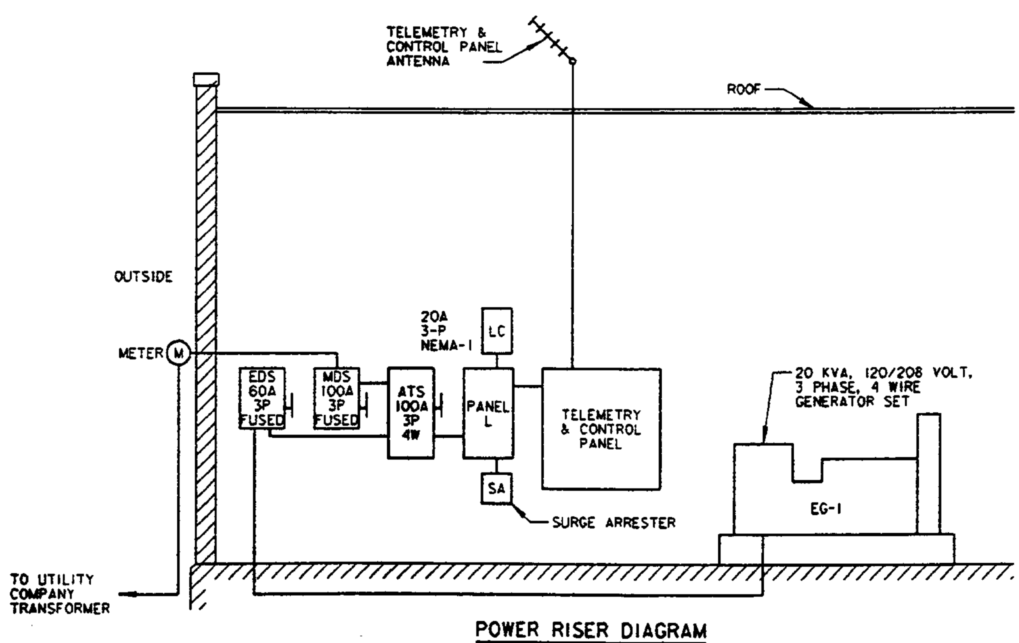
GEOTECH

ST ENG

A



PLAN
ELECTRICAL LAYOUT
SCALE: ¼" = 1'-0"



POWER RISER DIAGRAM
SCALE: NONE

SYMBOLS:

INDUSTRIAL

WALL MOUN

WALL MOUN

RECEPTACL

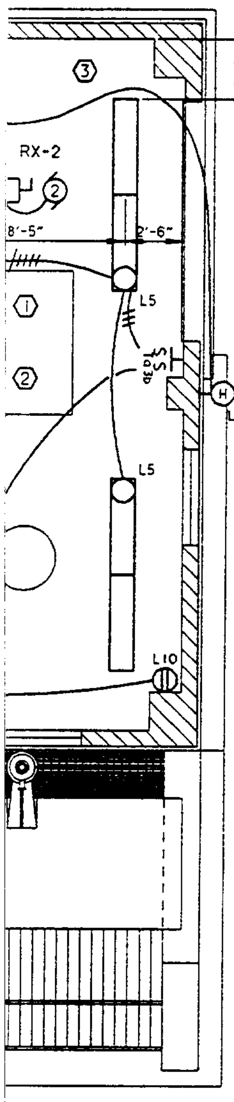
FIXTURE M

L1 CIRCUIT NU

MOTOR (2 =

DISCONNECT
F = FU
NF= NO
30A-3P
3R = NE
1 = NEM

PANEL



PANEL L								
KT. NO.	DESCRIPTION	LOAD	BRKR	PHASE	BRKR	LOAD	DESCRIPTION	KT. NO.
1	ROOM EXHAUSTER, RX-1	985	20-3P	-A-----	20-3P	985	ROOM EXHAUSTER, RX-2	2
3		985		---B---		985		4
5		985		-----C-		985		6
7	LIGHTS, TYPE 1	1173	15-3P	-A-----	20-1P	1200	RECEPTACLES	8
9		1173		---B---	20-1P	1200	RECEPTACLES	10
11		1173		-----C-	20-1P	2300	FURNACE, FU-1	12
13	EXTERIOR LIGHTS	325	15-1P	-A-----	20-1P	1200	TELEMETRY & CONTROL PNL	14
15	EXTERIOR FLOOD LIGHTS	1000	15-1P	---B---	20-1P	1200	SPARE	16
17	BATTERY CHARGERS	1200	15-1P	-----C-	20-1P	1200	SPARE	18
19	BATTERY CHARGERS	800	15-1P	-A-----			SPACE	20
21	SPACE			---B---			SPACE	22
23	SPACE			-----C-			SPACE	24
25	SPACE			-A-----			SPACE	26
27	SPACE			---B---			SPACE	28
29	SPACE			-----C-			SPACE	30

PANEL DATA:
MAINS & GND BUS:
MAINS: M.L.O. 125 AMPS
INT. CAP.: 22,000
MOUNTING: SURFACE
REMARKS: NEMA 1 PANEL

LOCATION: OPERATING ROOM
BRANCH DEV.: BOLT-ON BREAKERS

EQUIPMENT SCHEDULE											
MARK	EQUIPMENT	LOCATION (ROOM)	RATINGS			WIRING			PANEL		REMARK NUMBER
			K.W.	HP.	VOLT	PH.	NO.	SIZE	NO.	CKT.	
RX-1	ROOF EXHAUSTER	OPER. RM.		2	208	3	3	12			1, 2
RX-2	ROOF EXHAUSTER	OPER. RM.		2	208	3	3	12			1, 2
FU-1	FURNACE	OPER. RM.		1	208	1	2	12			1, 2
1	GENERATOR BATTERY CHARGER	OPER. RM.	600		120	1	2	14			1, 3
2	SHUTDOWN ALARM, DIESEL ENG.	OPER. RM.			24	1	2	14			4
3	DAY TANK PUMPS	OPER. RM.		0.25	24	1	2	10			5, 7
4	LEVEL SENSOR	GAUGEWELL			24	3	2	14			6

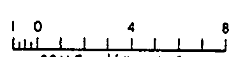
REMARKS:
1. REFER TO PANEL "L" SCHEDULE FOR CIRCUIT NUMBER.
2. THERMOSTATICALLY CONTROLLED.
3. LOCATED ON DIESEL PUMP MOTOR BASE FRAME.
4. ALARM CONTACTS CONNECTED TO PUMP CONTROL AND TELEMETRY PANEL.
5. CONNECTED TO OPERATE FROM INDIVIDUAL 24 VOLT D.C. ELECTRICAL SYSTEM, EACH DIESEL ENGINE.
6. ANALOG SIGNAL FROM POND GAUGE STATION TO PUMP CONTROL AND TELEMETRY PANEL.
7. STRANDED CONDUCTORS.

LIGHTING FIXTURE SCHEDULE							
FIXTURE MARK	DET. NO. 40-06-04		LAMP			FIXTURE VOLTAGE	REMARK NUMBER
	TYPE	SHEET NO.	TYPE	NO.	WATTS		
1	230-A1	36	F32T8	2	32	120	1, 2
2	501-A	56	50W-HPS	1	50	120	3, 4, 5
3	508-B	61	TUNG-HAL	1	500	120	5

REMARKS:
1. CEILING MOUNTED 20 FT ABOVE FINISHED FLOOR.
2. SWITCHED BY 3-POLE, 30 AMP ELECTRICALLY HELD LIGHTING CONTACTOR, LC-1.
3. WALL MOUNTED 15 FT ABOVE FINISHED FLOOR.
4. PHOTO-CONTROLLED. LOCATED PHOTOCELL BEHIND PARAPET.
5. VANDEL-RESISTANT LENS OR LENS INSERT.

INDUSTRIAL FLUORESCENT LIGHT FIXTURE
WALL MOUNTED LIGHT FIXTURE (H = H.I.P.)
WALL MOUNTED FLOOD LIGHT
RECEPTACLE, NEMA
FIXTURE MARK
CIRCUIT NUMBER
MOTOR (2 = HORSE POWER
DISCONNECT SWITCH:
F = FUSED
NF= NON-FUSED
30A-3P = 30 AMP, 3 POLES
3R = NEMA 3R
1 = NEMA 1 ENCLOSURE

LC — LIGHTING CONTACTOR
LIGHTING PANEL
S_3 — LIGHT SWITCH, 3 = 3 WAY, T = TOGGLE
EQUIPMENT MARK
J — JUNCTION BOX
ATS — AUTOMATIC TRANSFER SWITCH
EDS — EMERGENCY DISCONNECT SWITCH
MDS — MAIN DISCONNECT SWITCH



SYMBOL	DESCRIPTION	DATE

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGIN
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DA
FLOOD CONTROL
TYPICAL PUMP STATION
ELECTRICAL PLAN, DIAGRAM & SCHEDULES

PE-D: DESIGNED: BDN; CHECKED:; DRAWN: LKT
PE-H: DESIGNED: PMF; CHECKED: XXX/XXX
DATE: 07-09-96
CAD FILE NAME: DVO5REO1.DGN
SOL. NO:
DRAWING NUMBER: PLATE 4

RKR	LOAD	DESCRIPTION	KT. NO.
	985		2
)-3P	985	ROOM EXHAUSTER, RX-2	4
	985		6
)-1P	1200	RECEPTACLES	8
)-1P	1200	RECEPTACLES	10
)-1P	2300	FURNACE, FU-1	12
)-1P	1200	TELEMETRY & CONTROL PNL	14
)-1P	1200	SPARE	16
)-1P	1200	SPARE	18
		SPACE	20
		SPACE	22
		SPACE	24
		SPACE	26
		SPACE	28
		SPACE	30

ATION: OPERATING ROOM
NCH DEV.: BOLT-ON BREAKERS

)ULE

	WIRING			PANEL		REMARK NUMBER
VOLT	PH.	NO.	SIZE	NO.	CKT.	
208	3	3	12			1, 2
208	3	3	12			1, 2
208	1	2	12			1, 2
120	1	2	14			1, 3
24	1	2	14			4
24	1	2	10			5, 7
24	3	2	14			6

PANEL.
AL SYSTEM, EACH DIESEL ENGINE.
ID TELEMETRY PANEL.

TTS	FIXTURE VOLTAGE	REMARK NUMBER
2	120	1, 2
0	120	3, 4, 5
00	120	5

ACTOR, LC-1.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

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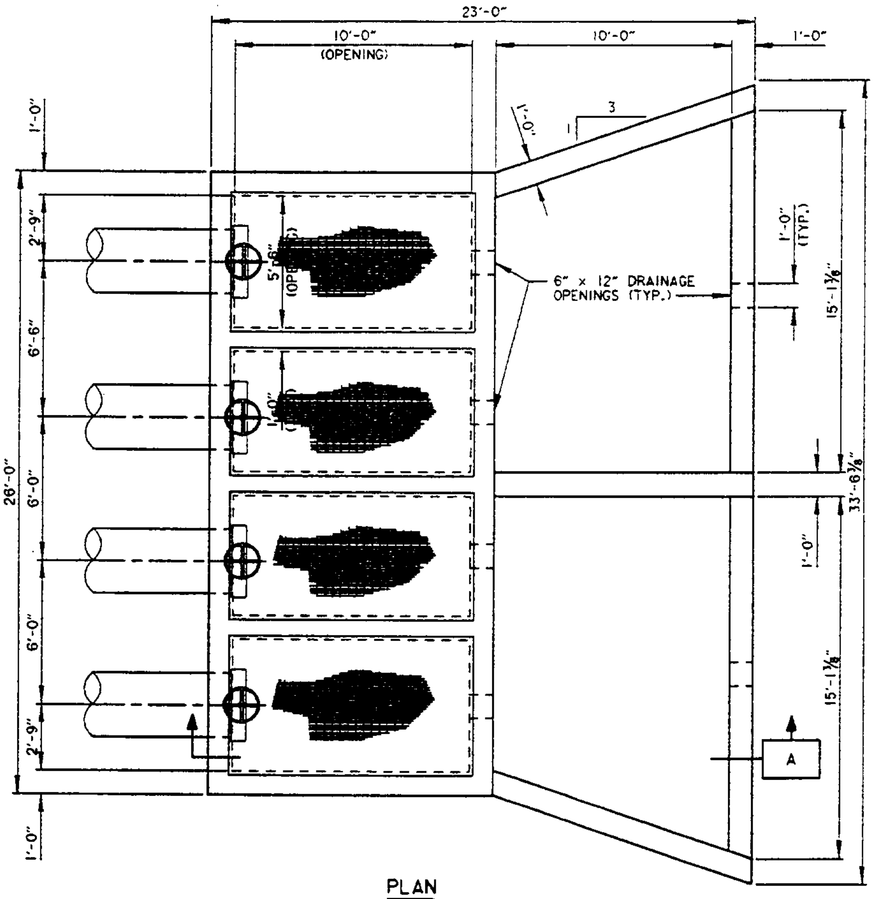
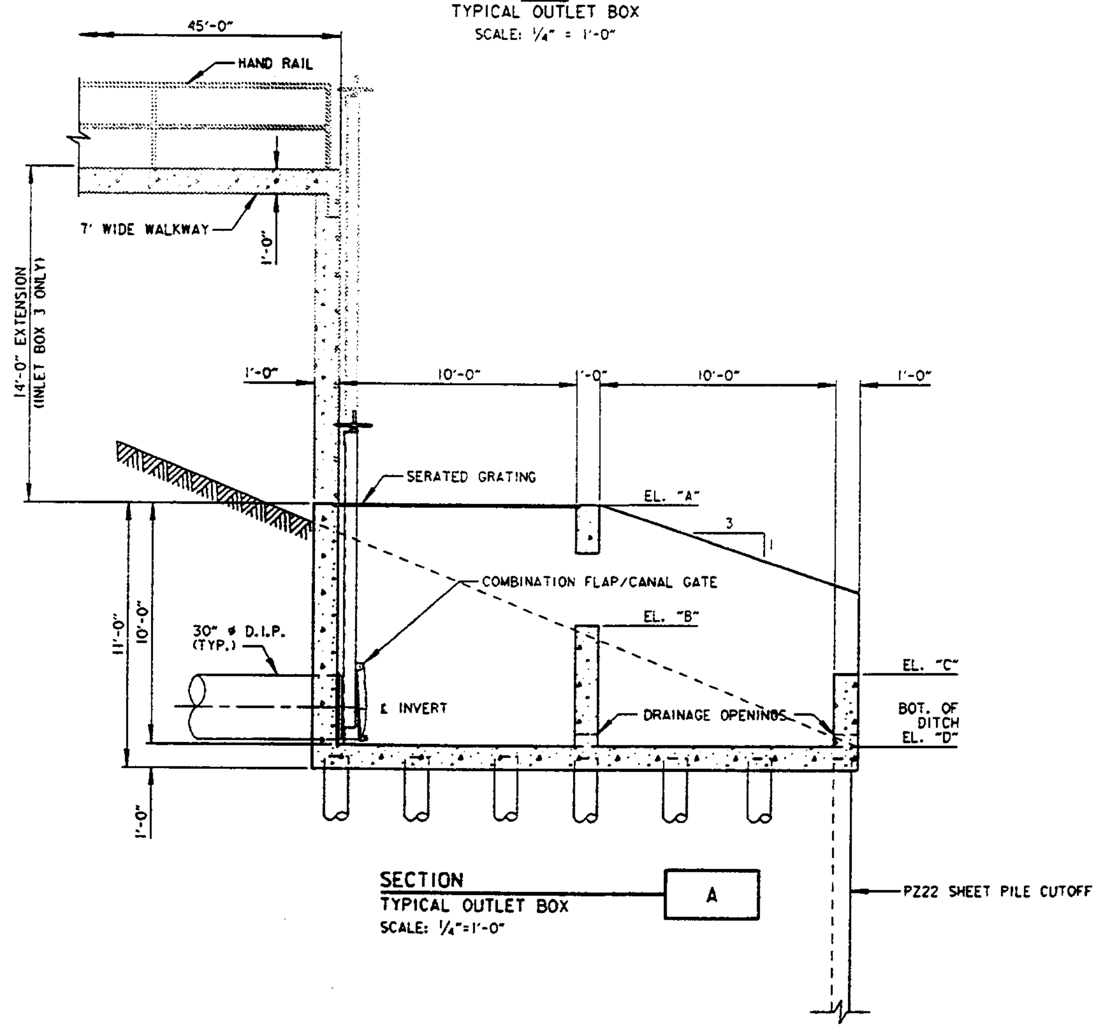
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
TYPICAL PUMP STATION
ELECTRICAL PLAN, DIAGRAM & SCHEDULES

PE-D: DESIGNED: BDN / CHECKED: / DRAWN: LKT
PE-H: DESIGNED: PMF / CHECKED: XXX/XXX
DATE: 07-09-96
CAD FILE NAME: DV05RE01.DGN
SOL. NO:
DRAWING NUMBER: PLATE 4
SHT 3 OF 8



PLAN
TYPICAL OUTLET BOX
SCALE: 1/4" = 1'-0"



SECTION
TYPICAL OUTLET BOX
SCALE: 1/4"=1'-0"

OUTLET BOX NO.	S
1	
2	
3	

2

'LET OX O.	STATION	ELEVATIONS					NOTES
		A	B	C	D (DITCH BOT.)	℄ INVERT	
1	73+67	1450.0	1445.0	1443.0	1440.0	1441.5±	
2	165+57	1465.0	1460.0	1458.0	1455.0	1456.5±	
3	375+45	1486.0	1481.0	1479.0	1476.0	1477.5±	

1 0 4 8

SCALE: 1/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

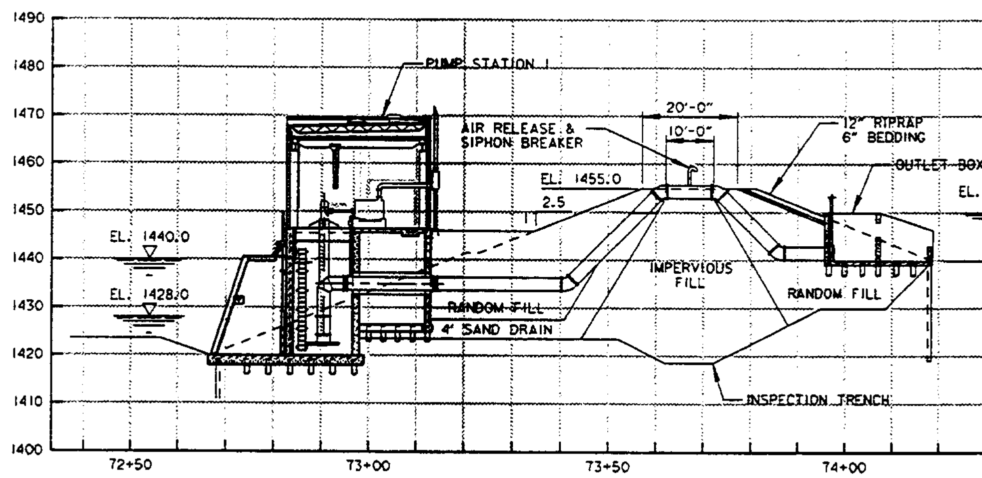
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

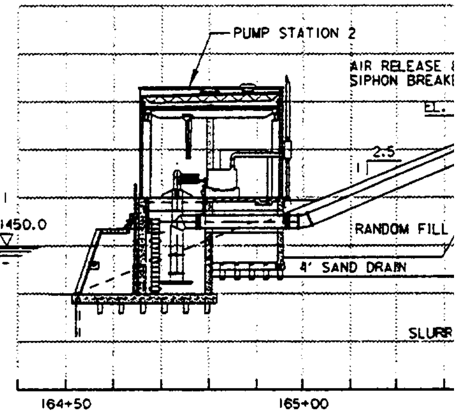
AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
OUTLET BOX
PLAN AND SECTION

PE-D: DESIGNED: BGS; CHECKED: DMT; DRAWN: LKT
PE-H: DESIGNED: PMF; CHECKED: XXX/XXX
DATE: 07-12-96

CAD FILE NAME: DV05RS02.DGN
SOL. NO:
DRAWING NUMBER: PLATE 5
SHT 4 OF 8





G ENG

HYD

HYDR

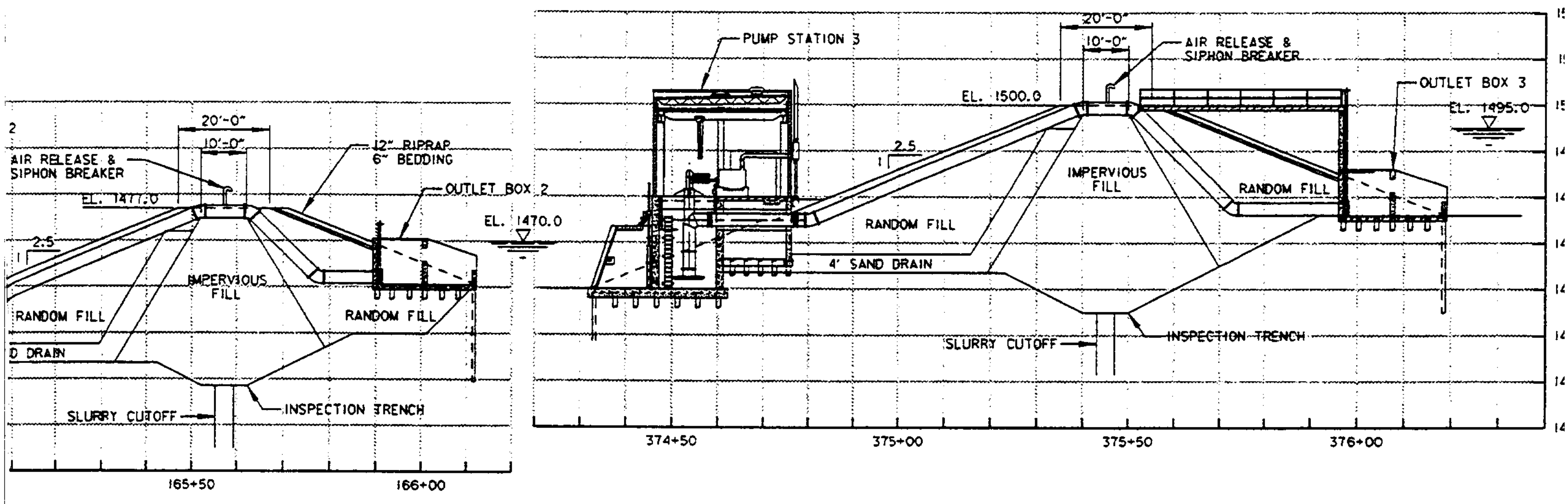
GEOTECH

S ENG

:A

2

3



SYMBOL	DESCRIPTION	DATE	APPR

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

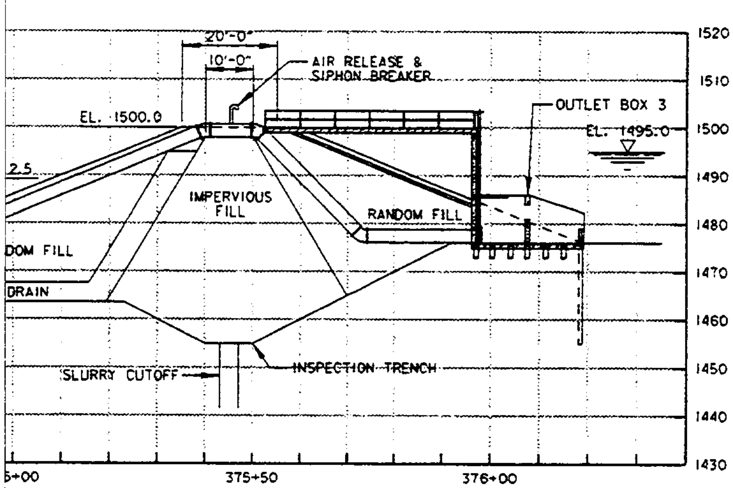
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKO
FLOOD CONTROL
PIPE PROFILE

PE-D	DESIGNED:	BGS
PE-D	CHECKED:	DMT
PE-D	DRAWN:	LKT
PE-H	DESIGNED:	PMF
PE-H	CHECKED:	XXX/XXX

DATE: 07-15-96

CAD FILE NAME: DVO5RSO3.DGN
SOL. NO:
DRAWING NUMBER: PLATE 6
SHT
OF

3



SYMBOL	DESCRIPTION	DATE	APPROVAL

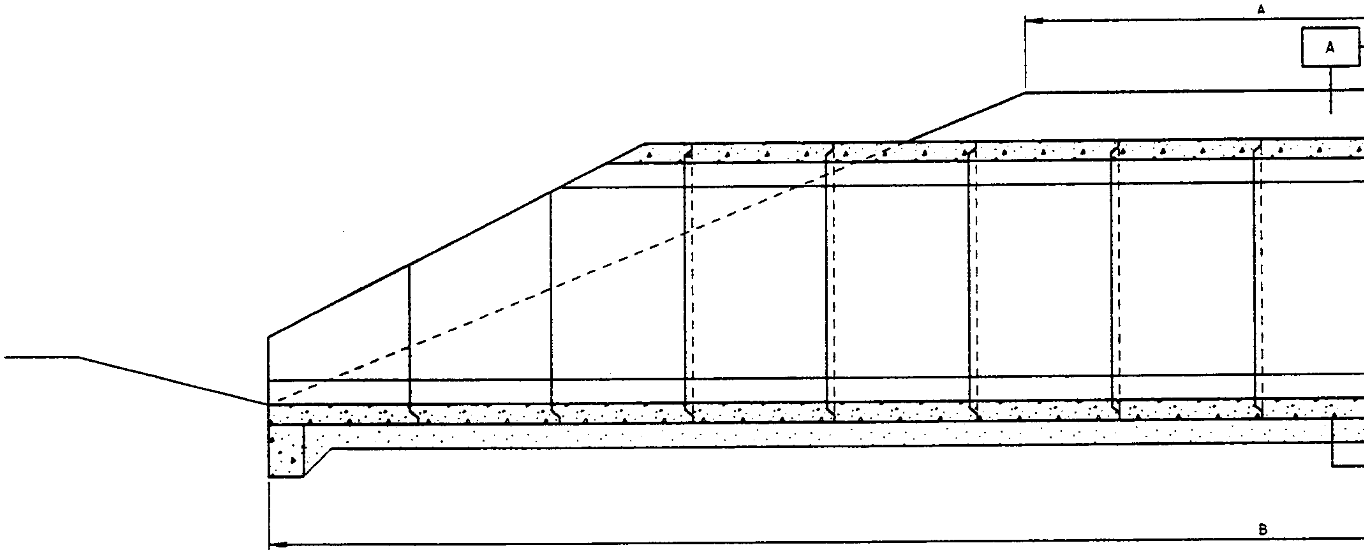
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

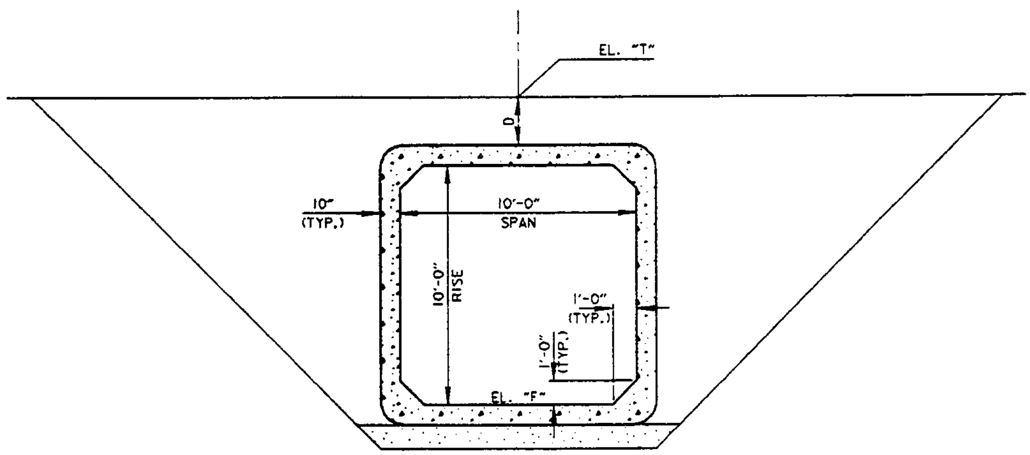
CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
PIPE PROFILE

PE-D DESIGNED: BGS
CHECKED: DMT
DRAWN: LKT
PE-H DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-15-96

CAD FILE NAME: DV05RS03.DGN
SOL. NO:
DRAWING NUMBER: PLATE 6
SHT 5 OF 8



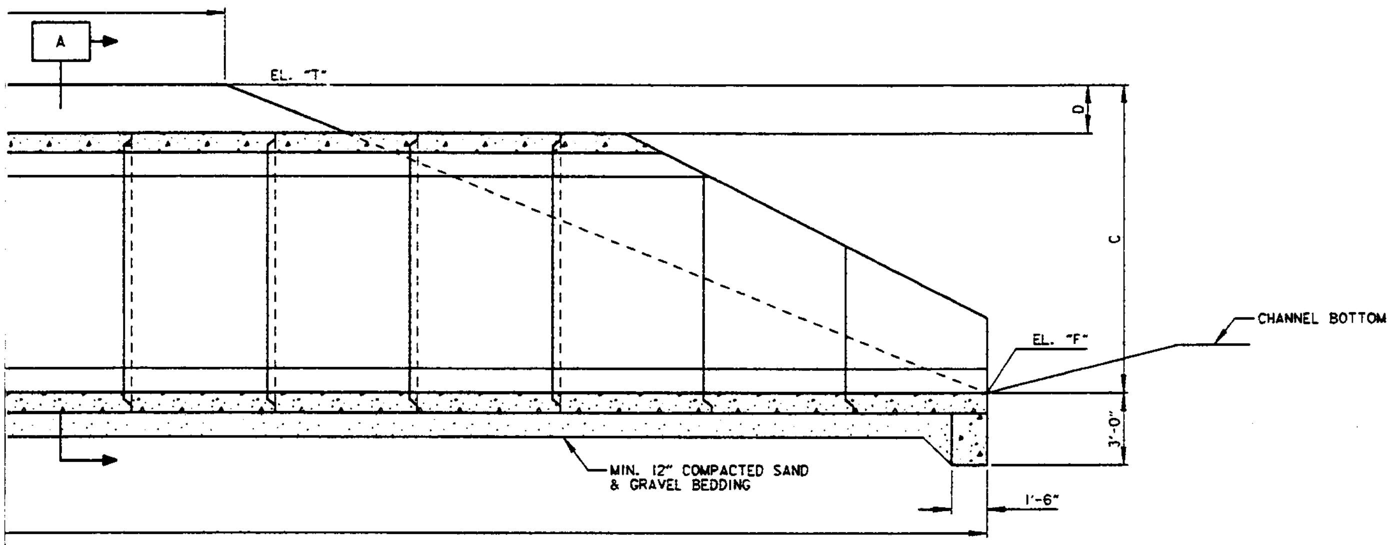
PROFILE
THRU ℄ BOX CULVERT
SCALE: 1/4" = 1'-0"



SECTION | A |
TYPICAL BOX CULVERT
SCALE: 1/4"=1'-0"

BOX CULVERT NO.	LOCATION	STATION	DIMENSIONS A	DIMENSIONS B	DIMENSIONS C	DIMENSIONS D	ELEVATIONS (FEET) F	ELEVATIONS (FEET) T	ELEVATIONS (FEET) CHANNEL BOTTOM	ELEVATIONS (FEET) WATER SURFAC
1	HIGHWAY 57	97+00	40'-0"	160'-0"	20'-0"	9'-2"	1440.0	1460.0	1440.0	1450
2		191+00	49'-6"	169'-6"	20'-0"	9'-2"	1455.0	1475.0	1455.0	1470
3	PLAINVIEW SCHOOL	321+60	40'-0"	172'-0"	22'-0"	11'-2"	1460.0	1482.0	1460.0	1470
4		571+57	40'-0"	117'-0"	12'-10"	2'-0"	1467.2	1480.0	1471.5	
5		601+06	40'-0"	117'-0"	12'-10"	2'-0"	1467.2	1480.0	1469.0	

GI ENG
HYD
HYDR
GEOTECH
ST ENG
A



LE
CULVERT
= 1'-0"

WATER SURFACE	NOTES
1450	
1470	
1470	

SYMBOL	DESCRIPTION	DATE	APPRO

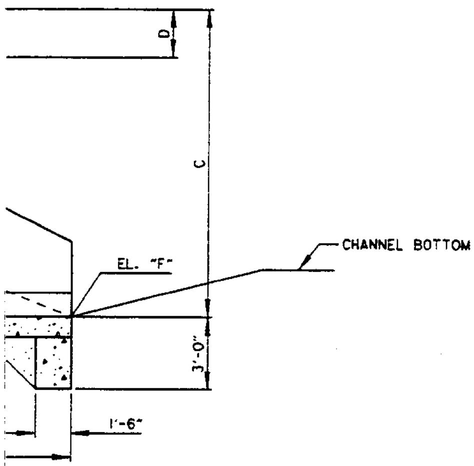
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

PE-D DESIGNED: BGS
CHECKED: DMT
DRAWN: LKT
PE-H DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-09-96

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOT
FLOOD CONTROL
BOX CULVERT
TYPICAL PROFILE & SECTION

CAD FILE NAME: DV05RS04.DGN
SOL. NO:
DRAWING NUMBER: PLATE 7
SHT 6
OF 8



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

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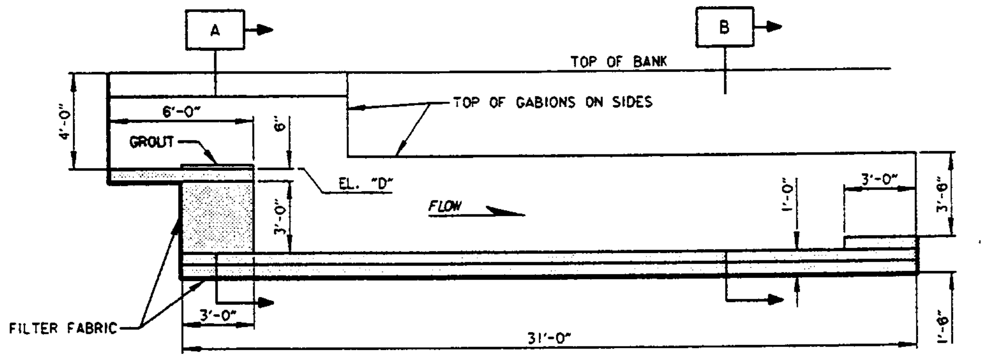
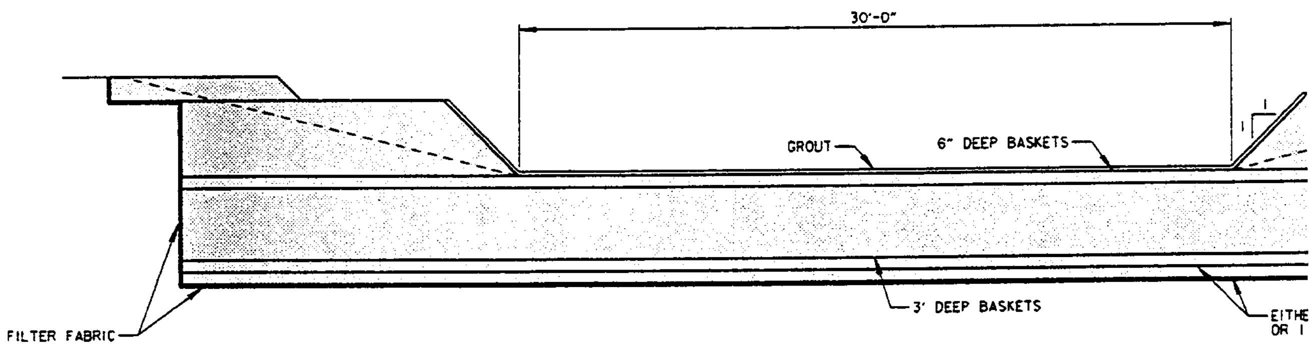
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
BOX CULVERT
TYPICAL PROFILE & SECTION

PE-D	DESIGNED:	BGS
PE-D	CHECKED:	DMT
PE-D	DRAWN:	LKT
PE-H	DESIGNED:	PMF
PE-H	CHECKED:	XXX/XXX
DATE: 07-09-96		

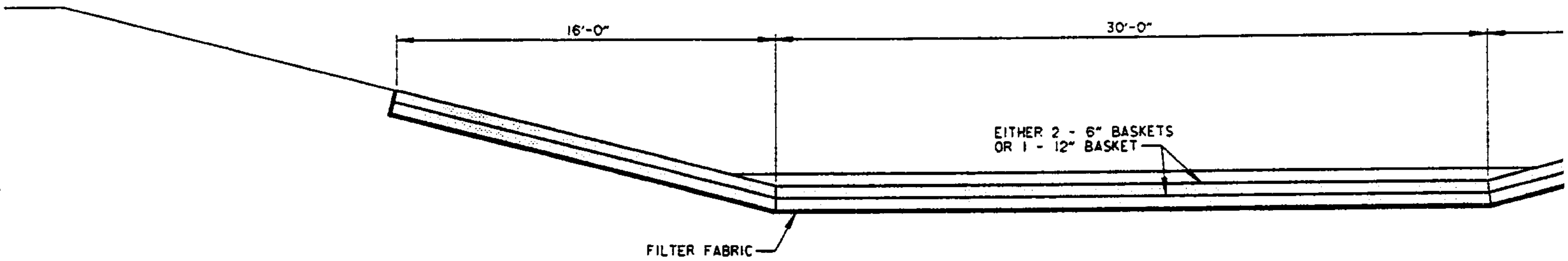
CAD FILE NAME: DV05RS04.DGN
SOL. NO:
DRAWING NUMBER: PLATE 7
SHT 6 OF 8



PROFILE
TYPICAL GABION DROP STRUCTURE
SCALE: 1/4" = 1'-0"

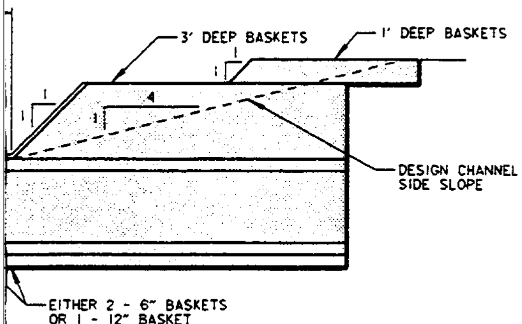


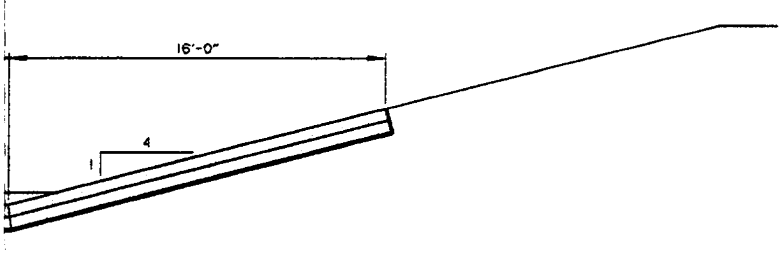
SECTION A
GABION DROP STRUCTURE
SCALE: 1/4"=1'-0"



SECTION B
GABION DROP STRUCTURE
SCALE: 1/4"=1'-0"

STATION	ELEVATION D	NOTES
666+13.08	1416.13	
661+55.91	1419.49	
657+00.74	1422.86	
652+45.58	1426.22	
650+98.53	1429.34	
649+58.81	1432.45	
648+19.09	1435.56	
646+96.03	1438.66	
645+78.14	1441.76	
644+60.24	1444.85	
643+42.35	1447.95	
642+07.30	1451.05	
640+78.20	1454.16	
637+25.32	1457.44	
628+72.06	1461.12	
620+18.80	1464.80	
604+10.36	1469.09	
510+53.00	1479.58	
454+56.04	1487.05	





SCALE: 1/4" = 1'-0"

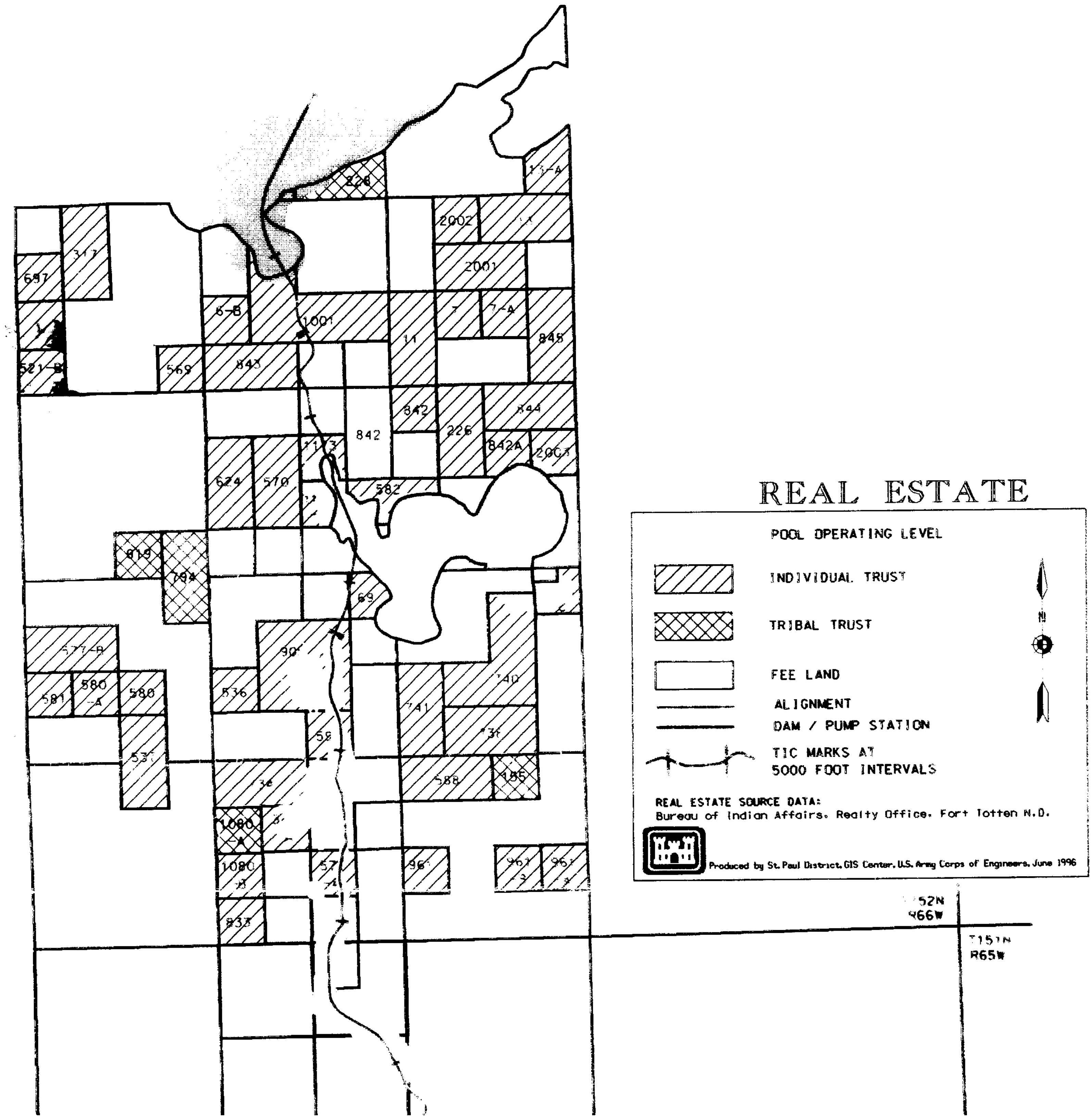
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
GABION DROP STRUCTURES
TYPICAL PROFILE & SECTION

PE-D DESIGNED: PDM CHECKED: BGS DRAWN: LKT
PE-H DESIGNED: PMF CHECKED: XXX/XXX
DATE: 07-09-96
CAD FILE NAME: DV05RS05.DGN
SOL. NO:
DRAWING NUMBER: PLATE 8
SHT 7 OF 8


REAL ESTATE
POOL OPERATING LEVEL
INDIVIDUAL TRUST
TRIBAL TRUST
FEE LAND
ALIGNMENT
DAM / PUMP STATION
TIC MARKS AT
5000 FOOT INTERVALS
REAL ESTATE SOURCE DATA:
Bureau of Indian Affairs, Realty Office, Fort Totten N.D.
Produced by St. Paul District, GIS Center, U.S. Army Corps of Engineers, June 1996
R66W
T151N
R65W
697
6-B
1001
845
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842A
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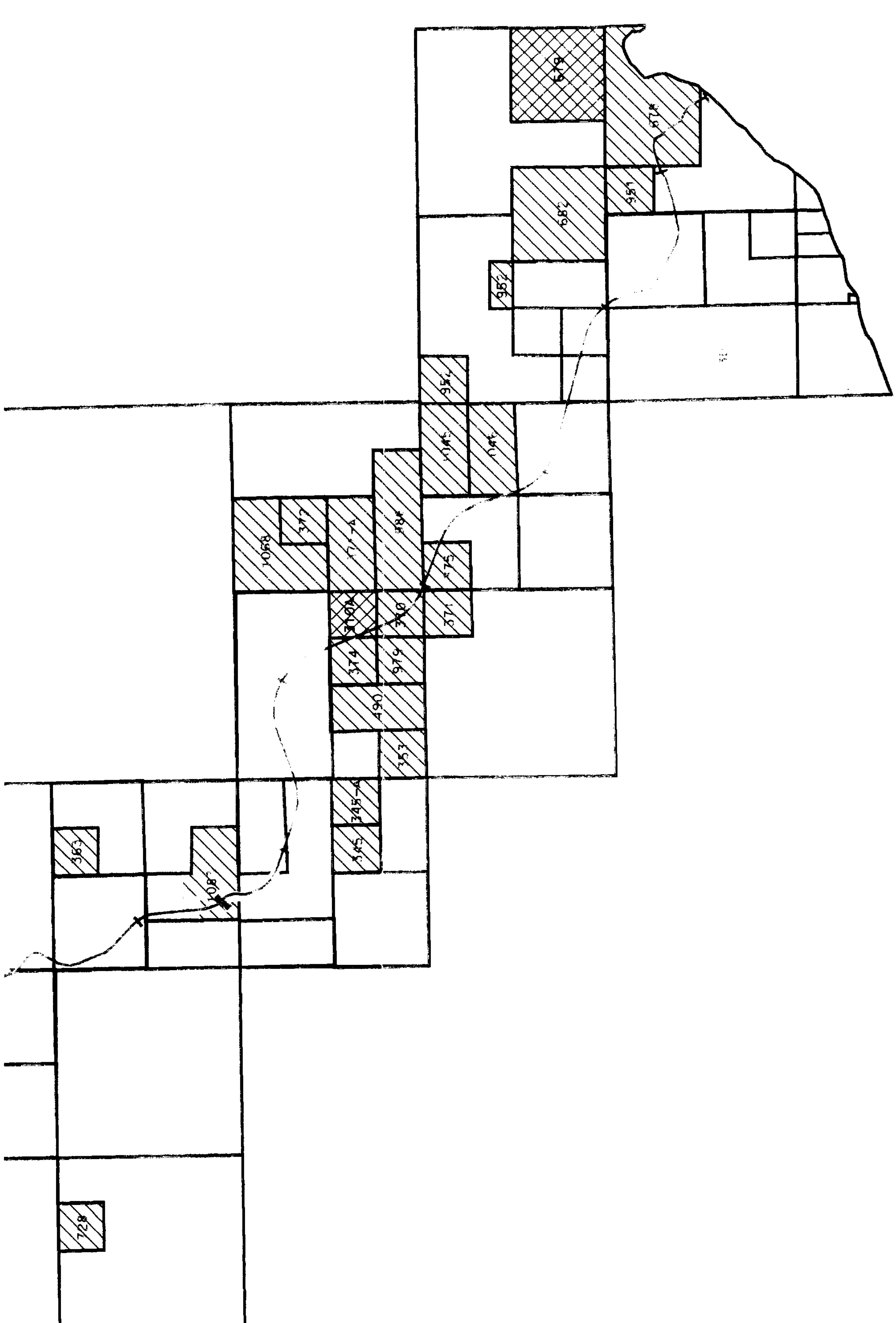
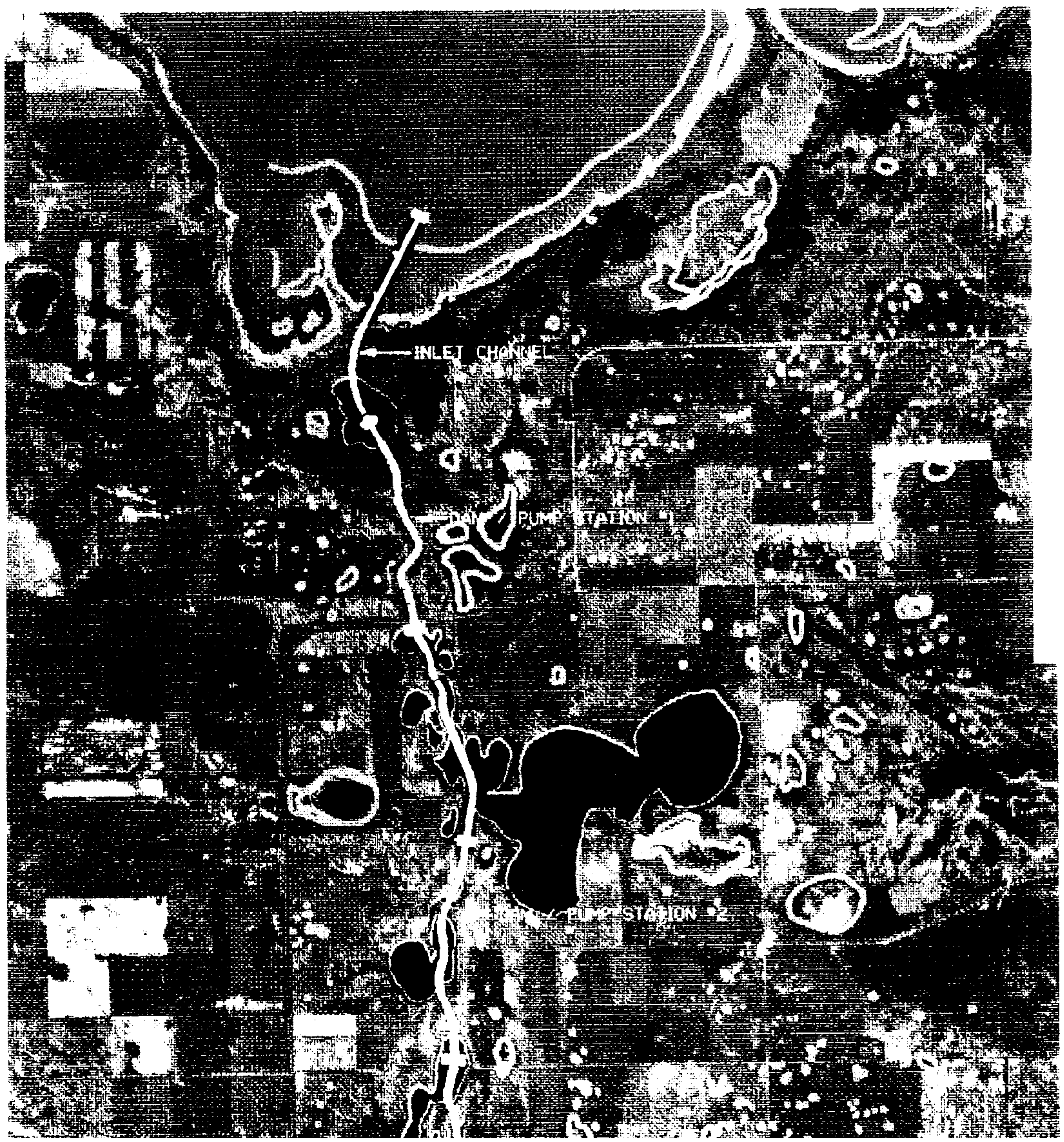


Figure 13

NWI WETLAND IMPACTS



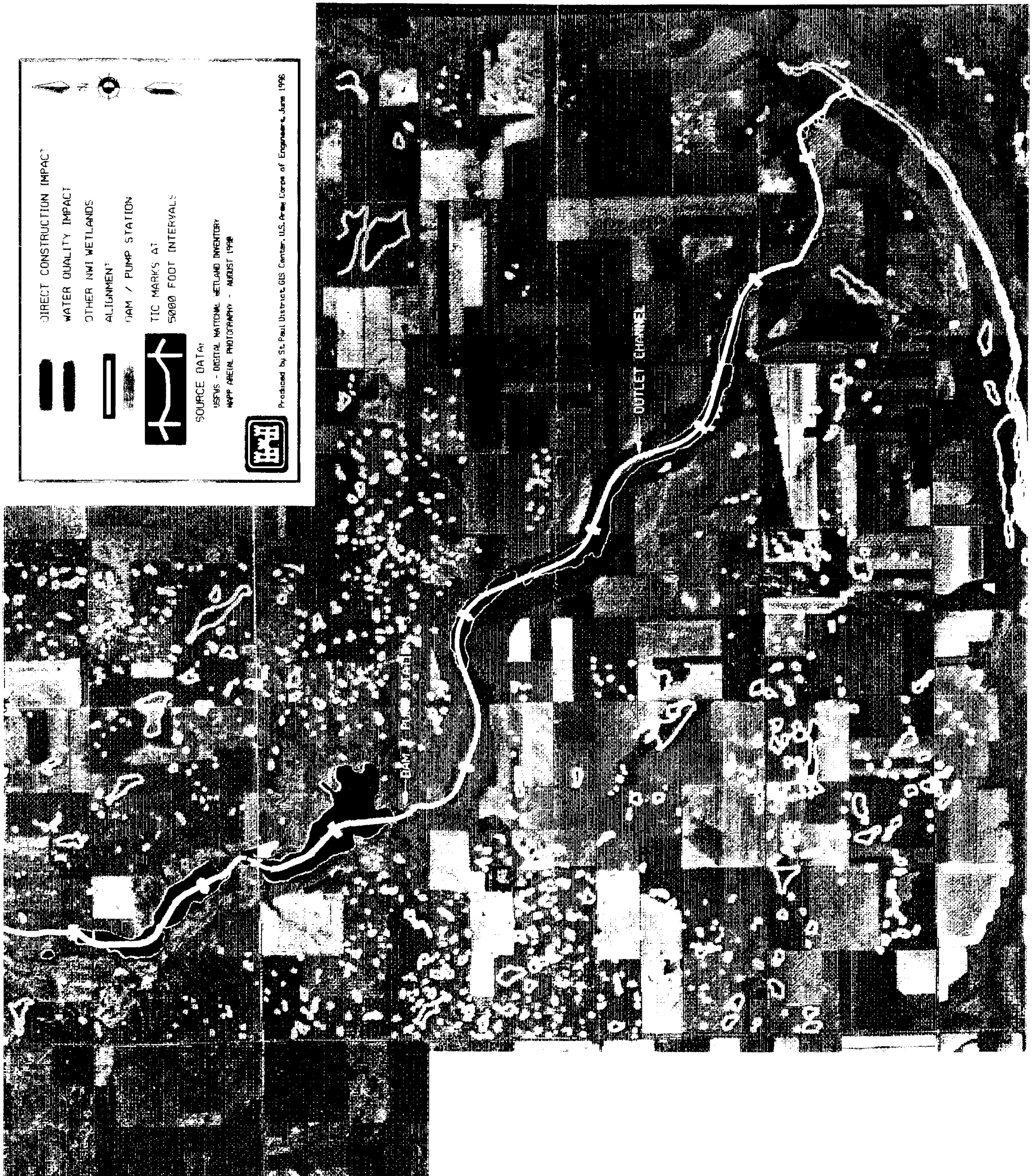

DIRECT CONSTRUCTION IMPACT
WATER QUALITY IMPACT
OTHER NWI WETLANDS
ALIGNMENT
DAM / PUMP STATION
TIC MARKS AT
5000 FOOT INTERVALS
SOURCE DATA:
USFWS - DIGITAL NATIONAL WETLAND INVENTORY
NAPP AREIAL PHOTOGRAPHY - AUGUST 1990
Produced by St. Paul District GIS Center, U.S. Army Corps of Engineers, June 1996
OUTLET CHANNEL
DAM & PUMP STATION

Figure 1