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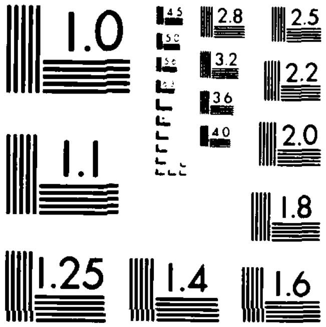

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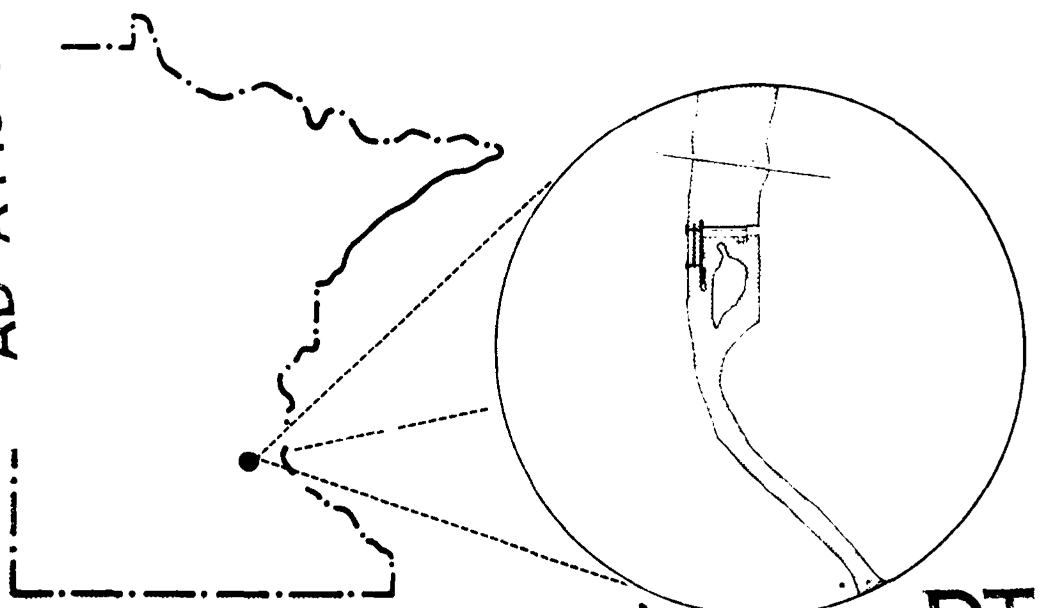
US Army Corps
of Engineers
North Pacific Division

LOCK AND DAM NO. 1 HYDROPOWER STUDY

Mississippi River at Minneapolis-St. Paul, Minn.



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HYDROELECTRICITY
MISSISSIPPI RIVER

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report determines the feasibility of adding hydropower generation to the lock and dam number 1 project, located on the Mississippi River in St. Paul, Minnesota. The existing project consists of a concrete Ambursen-type spillway section, two navigation locks on the right side of the river and an existing 14.4 megawatt hydro plant on the left side. The Corps owns and operates the dam and locks, while the Ford Motor Company owns and operates the hydro plant. This study shows that an additional powerplant can be

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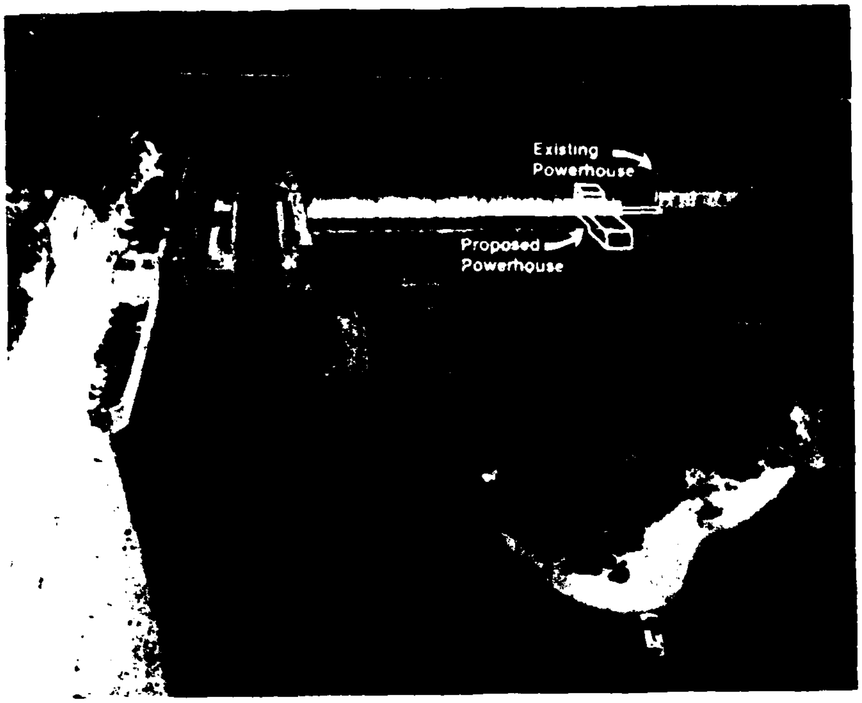
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) built at the project that will more fully utilize the existing river flows. Four alternative powerplant locations were investigated. The selected powerplant will be 7.2 megawatt, single tubular unit, constructed at the spillway located near the existing powerplant. The new powerplant will produce 21.5 million Kwh of annual generation. The total investment cost will be 11.5 million dollars. The project is economically feasibile with a benefit cost ration of 1.12. The annual production cost will be 48 mills per kwH.



LOCK AND DAM NO. 1

Mississippi River at St. Paul

Site of Proposed Hydroelectric Plant Addition

HYDROPOWER STUDY
LOCK AND DAM #1 PROJECT
ST. PAUL, MINNESOTA

A Technical Report
for
Feasibility Study

Prepared for St. Paul District
Corps of Engineers as an
Element of their Feasibility Study

Hydroelectric Design Center
North Pacific Division
Corps of Engineers
Portland, Oregon

October 1984

LOCK AND DAM #1 PROJECT
ST. PAUL, MINNESOTA

BASIC PROJECT DATA

General Data

Normal Forebay Elevation	725.1
Minimum Forebay Elevation	724.0
Normal Minimum Tailwater	687.2
Spillway Crest Length	574 feet
Spillway Crest Elevation	723.1
Crest Elevation With Flashboards	725.1
Maximum Flood Flow (1965)	91,000 cfs
Median Flow	5,200 cfs
Minimum Flow (1976)	529 cfs

Proposed Powerhouse

Project Installed Capacity	7.2 MW
Number of Units	one
Type of Turbine	Tubular
Type of Generator	Synchronous
Runner Diameter	142 inches
Speed	144 rpm
Unit Centerline Elevation	682.00
Project Design Head	35 feet
Turbine Design Flow	1200 to 3050 cfs
Annual Plant Factor	34%
Average Annual Energy	21,450 MWh

Economic Data

Total NED Investment Cost	$11,470,000
Annual Cost	$1,024,000
Power Production Cost	48 mills/kwh
Annual Net Benefit	$127,000
B/C Ratio	1.12

SUMMARY

This report, prepared by North Pacific Division, Corps of Engineers, determines the feasibility of adding hydropower generation to the Lock and Dam Number 1 project, located on the Mississippi River in St. Paul, Minnesota.

The existing project consists of a concrete Ambursen-type spillway section, two navigation locks on the right side of the river and an existing 14.4 megawatt hydro plant on the left side. The Corps owns and operates the dam and locks, while the Ford Motor Company owns and operates the hydro plant.

This study shows that an additional powerplant can be built at the project that will more fully utilize the existing river flows. Four alternative powerplant locations were investigated. The selected powerplant will be a 7.2 megawatt, single tubular unit, constructed at the spillway located near the existing powerplant. The new powerplant will produce 21.5 million Kwh of annual generation. The total investment cost will be 11.5 million dollars. The project is economically feasible with a benefit cost ratio of 1.12. The annual production cost will be 48 mills per Kwh.

The generation can be used in the existed power marketing area. Construction of this plant will preclude construction of an increment of thermal generation in the system.

SEE ADDENDUM ECONOMIC SUMMARY UPDATE, 1984 COST LEVELS

ADDENDUM
ECONOMIC SUMMARY UPDATE
(Oct 1984 cost levels)

The analysis presented in this report is based on October 1983 cost levels and 8 1/8 percent interest rates. Subsequent to these findings the Federal Energy Regulatory Commission provided alternative power values based on October 1984 cost levels and 8 3/8 percent interest.

Project costs for the 7.2 megawatt selected plant size were then indexed to the 1984 levels, and a revised economic analysis was made. Recent experiences with similar project cost updates have shown it unnecessary to rescope the total project. Because project costs and benefits for the range of plant sizes increase in the same magnitude, the point of maximm net-benefit (optimum project size) will not change significantly on the scoping curve. Therefore, the scoping analysis presented in this report is valid; only the cost and economic data for the selected plan are updated.

Economic Data:

Plant Size	7.2 MW
Annual Energy	21,450 MWh
Power Values 1/	$210.60/Kw & 38.2 mills/Kwh
Total Construction Cost	$ 8,136,000
Total NED Investment Cost	$11,696,000
Annual Cost	$ 1,076,000
Annual Benefit	$1,325,000
Annual Net Benefit	249,000
B/C Ratio	1.23

Comparison of the updated economic data with the original data shows that the 1984 price levels produce a more favorable project than the 1983 levels. For the 12 month period the project annual benefits increased more than the project annual costs. The annual net benefit increased from $127,000 to $249,000 and the B/C ratio increased from 1.12 to 1.23.

1/ From FERC letter 8 August 1984

HYDROPOWER STUDY
FEASIBILITY LEVEL

LOCK AND DAM #1 PROJECT

ST. PAUL, MINNESOTA

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SECTION 5 - PROJECT COST AND SCHEDULE

SECTION 6 - ECONOMIC

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SECTION 1 - GENERAL

1.01 Purpose and Authority. This report presents the results of an investigation for the economic feasibility of developing additional hydroelectric power at Lock and Dam Number 1 on the Mississippi River at St. Paul, Minnesota.

St. Paul District, Corps of Engineers, conducted the study under authority contained in the House Committee on Public Works resolution dated 11 December 1969. Funds were made available by the District to the Corps' North Pacific Division for preparation of this feasibility level technical report on hydropower.

1.02 Scope of Study. Lock and Dam No. 1 is an existing inland navigation project located on the Upper Mississippi River between Minneapolis and St. Paul. This report assesses the potential of adding hydropower to the project. An existing powerplant at the site utilizes only a portion of the total available streamflows in the river. This study investigates the potential of constructing a second powerplant at the site that will develop flows beyond that now required to run the existing plant. Powerplant costs were developed from manufacturers' information for the turbine-generators and from current cost experiences for similar related equipment and structures. Using a series of annual costs and annual benefits, a net benefit analysis produced a selected plant size.

SECTION 2 - EXISTING FACILITIES

2.01 General. Lock and Dam #1 is located on the Mississippi River at mile 847.6 above the mouth of the Ohio River between the cities of St. Paul and Minneapolis, Minnesota (see Figure 2-1). The project consists of a 152 foot-long hydroplant adjacent to the left bank and a 574 foot-long crest- length Ambursen-type spillway dam, surmounted by 2 foot-high automatic release flashboards. The dam is equipped with eight sluiceways (only three sluiceways are operated and maintained at the present time) and twin 56 by 400 feet navigation locks. The hydroplant houses four Francis-type turbines having a total rated capacity of 14.4 MW. This powerplant was completed and placed in operation in 1924.

2.02 Project Operations. The existing powerplant is presently owned and operated by the Ford Motor Company under FERC Licence No. 362. The plant operates in a run-of-river mode because the primary purpose of the project is navigation. Under present conditions, the dam maintains a normal head of about 38 feet during the navigation season and about 36 feet during the winter season. The total rated hydraulic capacity of the existing units is 6670 cubic feet per second. The average annual energy production is 87.0 million KWH. About 40 percent of the project generation is consumed by the Ford Automative Plant and the Corps' operated locks. The FERC license specifies the existing terms of power supplied to the Corps of Engineer's lock operations. Power not used by the Ford Motor Company or the Corps is transmitted to Northern States Power Company.

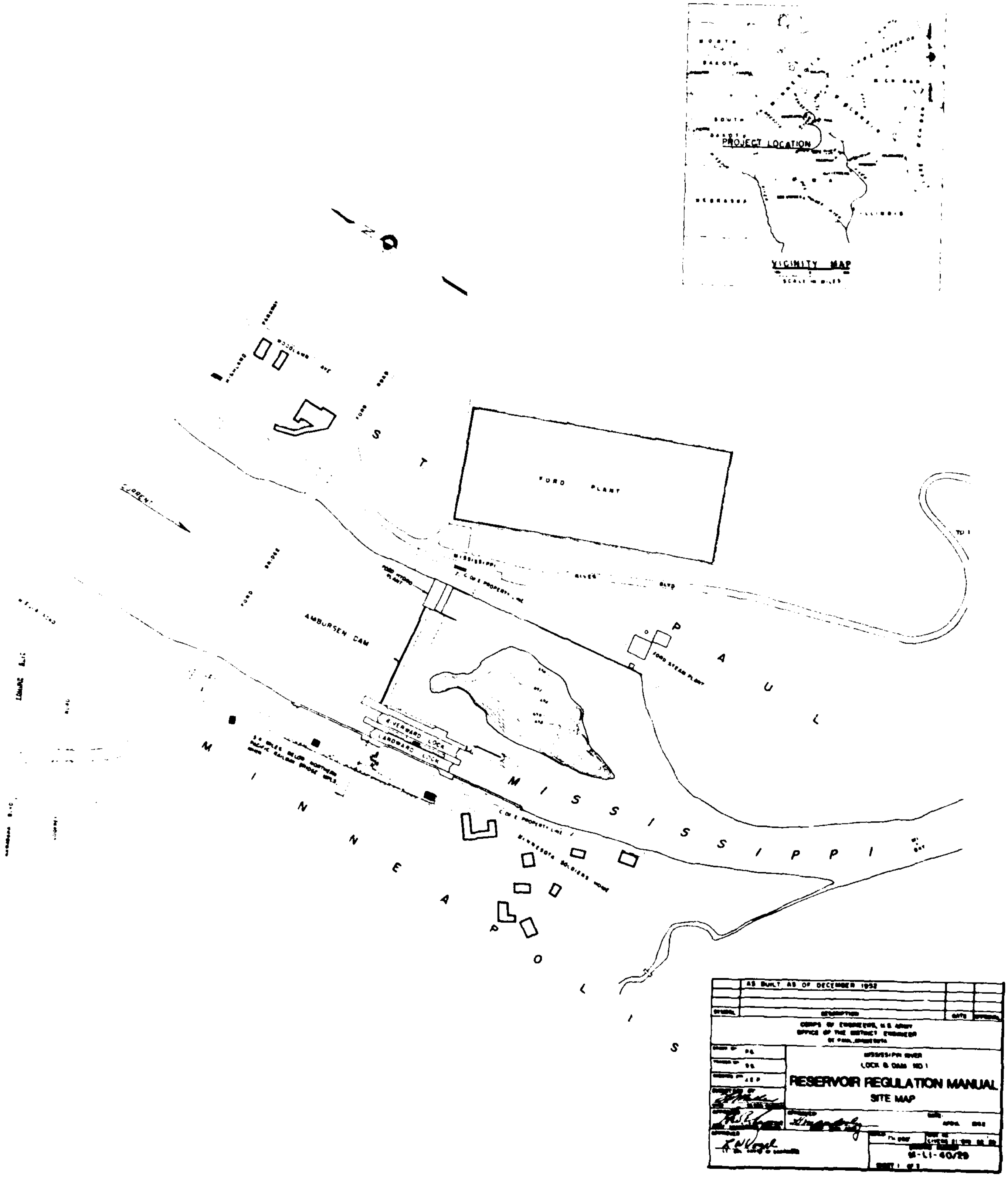

PROJECT LOCATION
VICINITY MAP
FORD PLANT
AMBURSEN DAM
RIVERWARD LOCK
LANDWARD LOCK
ST PAUL
MISSISSIPPI
MINNEAPOLIS
AS BUILT AS OF DECEMBER 1952
MISSISSIPPI RIVER
LOCK & DAM NO 1
RESERVOIR REGULATION MANUAL
SITE MAP

Figure 2-1

SECTION 3 - HYDROLOGY AND POWER CAPABILITY

3.01 Hydrologic Analysis. The flow available for hydropower at Lock and Dam No. 1 was estimated from 50 years of data from the gage at Anoka, Minnesota (USGS 05-2885). The gage is 17.3 miles upstream of the project and there are no major tributaries between the two. The total drainage area adjustment was estimated to be 3.1 percent, based on the differences in areas and estimating the inflows and depletions in the Minneapolis, St. Paul area. This difference was accounted for in analyzing the average daily flow data through the project. There have been no major diversions or additions to the streamflow at the project and none are anticipated. For this reason the 50 years of historical data corrected for drainage area adjustment was considered appropriate for the estimation of the future operation of the powerplants.

3.02 Existing Power. Since the existing plant already utilizes part of the available streamflow, a basic assumption of this study was that any additional generation would come from flows in excess of the existing plant's hydraulic capacity. Thus, the new plant will operate only after the existing plant was operating at full capability. Close operating coordination between the existing plant and the new plant will be needed. This coordination will be especially important in the transition phase from low streamflows, when only the old plant will operate, to higher flows when both the old and the new plants will operate. This situation is discussed further in paragraph 4, Section 6.07.

The hydraulic capacity of the existing plant was derived from known generation output and actual daily flows. By simulating the existing conditions, the hydraulic capacities were established after estimating several overall plant efficiencies. NPD's Power Duration Plot Program (described in Section 3.03) was used to estimate the energy output of the plant. These values are listed in Table 3-1.

+ TABLE 3-1

EXISTING PLANT DATA [1]

Annual Energy	Overally Efficiency	Annual Plant Factor	Plant Capacity	Hydraulic Capacity
87,000,000 kwh	81%	75%	13.2 MW	5400 cfs

The values listed above were calculated using average daily conditions. Certain values such as plant capacity and hydraulic capacity are slightly less than those published by the plant owner, the Ford Motor Company (described in Section 2). For example their published 14.4 MW of installed capacity and 6,670 cfs of hydraulic capacity is attainable only under the most favorable operating conditions. For this study the values shown in Table 3-1 were used and are considered more representative of the current operation.

Figure 3-1 shows graphically the annual flow-duration curve for the project. The existing plant flows are shown on the graph along with the plant flows of the selected plant (also see Section 6.07 for scoping). Once the hydraulic capacity was established for the existing plant, that flow was deducted from the daily streamflows in all successive analyses.

---

1 Plant capacity and hydraulic capacity derived from other known conditions using NPD's DURAPLOT program.

3.03 Additional Power Potential. Several powerhouse sizes and alternative site locations were investigated. In addition, different types of generating units were studied. See Section 4.02 for more detailed descriptives of the alternative powerhouse site locations considered. Power development was initially investigated for four alternative powerhouse locations. Two of the alternatives were located on the left side of the existing powerhouse and two alternatives were located on the right side of the existing powerplant, within the spillway section. For all site investigations the generating heads and flows were the same; thus, the project benefits remained essentially the same, while the project costs varied with each alternative.

The power potential at each site was determined using NPD's Power Duration Plot Program (DURAPLOT). This computer program analyzes daily average flow, forebay and tailwater elevation data, and constraints associated with various sized power installations. For the flow and generating head ranges associated with specific turbine generator sizes, the program produces annual and monthly flow-duration curves and the corresponding power duration curves. Power is developed using the following equation:

$$\text{Average Power (kW)} = \frac{Q \times H \times e}{11.8}$$

where Q = average flow in cfs.
H = average net generating head in feet.
e = efficiency, assumed constant at 85% for bulb units and 84% for tubular units.

In this equation, daily project flows were computed by deducting flows equal to the existing plants' hydraulic capacity from the total flows as described earlier.

In applying the power equation forebay elevations were developed from daily historical data. The forebay elevations reflect the effect of flashboards, which are in place except during periods of high streamflow. Figure 3-2 shows the forebay rating curve used in this study. The tailwater elevation is affected by several conditions including the project flows and the downstream backwater effects. The backwater effects are a result of the general river configuration and the effect of the Minnesota River which has its confluence about 5 miles downstream from Lock and Dam No. 1. Recorded daily tailwater conditions vs the streamflow at the dam were analyzed. This data was then correlated with the Minnesota River flows near the confluence (see telephone log dated 21 December 1982 in Appendix D). An adjusted tailwater curve was developed from recorded data at the existing Ford hydro plant depicting total releases for both old and new plants. As discussed in Section 3.02, in all cases the existing plant was assumed to be operating at full capacity. The tailwater curve is shown in Figure 3-3. Net generating heads were determined by subtracting the daily tailwater elevations from the forebay elevations, then deducting an estimated head loss. A one-foot average head loss based on operating experiences with similar plants was assumed for all flow conditions. A head-duration curve was prepared and is shown in Figure 3-4. These curves were useful in establishing preliminary turbine operating limits for initial project scoping.

Table 3-2 summarizes the different generating plant sizes and their respective annual energy outputs and dependable capacities. This data was used to scope the project (see Section 6.07) and to determine the project benefits listed in Table 6-4.

Power duration curves were developed for all cases. An annual power duration curve for the selected plant (7.2 MW) is shown in Figure 3-5. Monthly flow-duration curves are shown in Appendix B and monthly power-duration curves are shown in Appendix C. The shaded area under the curve represents the total flow or energy generation that can be developed with the selected plant size; the unshaded area represents the potential not feasible for development.

TABLE 3-2

SUMMARY OF PLANT SIZES AND GENERATION

(used for project scoping)

Hydraulic Capacity (cfs)	Installed Capacity (MW)	Annual Energy (MWh)	Annual Plant Factor	Jul-Aug Energy (MWh)	Hydrologic Availability 1/	Dependable Capacity (MW) 2/
			1-Unit Tubular Plant			
1,650	3.9	13,110	38%	2,290	39%	1.5
2,200	5.1	16,600	37%	2,857	38%	1.9
3,050	7.2	21,450	34%	3,620	34%	2.4
			2-Unit Tubular Plant			
2,725	6.3	19,440	35%	3,310	35%	2.2
3,500	8.5	23,430	33%	3,920	31%	2.6
4,400	10.0	27,540	31%	4,540	31%	3.1
6,000	13.4	33,360	29%	5,380	27%	3.6
			3-Unit Tubular Plant			
4,545	10.2	27,970	31%	4,600	30%	3.1
5,500	12.3	31,620	29%	5,140	28%	3.5
6,500	14.4	34,890	28%	5,600	26%	3.8
7,360	16.0	36,910	27%	5,870	25%	3.9
			1-Unit Bulb Plant			
3,500	8.4	24,210	33%	8,420	32%	2.7
5,900	14.0	34,710	28%	5,630	27%	3.8
6,790	16.0	37,820	27%	6,080	26%	4.1
7,650	18.0	40,500	26%	6,450	24%	4.3
9,300	21.7	44,970	24%	7,060	22%	4.7
10,400	24.1	47,500	23%	7,390	21%	5.0

1/ Based on the July-August energy divided by the achievable capacity for those months.

2/ (Installed Capacity) x (Hydrologic Availability)

3.04 Dependable Capacity. The dependable capacity of a hydropower project is usually defined as the amount of capacity available in a month or period of time that is considered most critical from the standpoint of both loads and hydrologic conditions. As such it is intended to reflect hydrologic availability. Dependable capacity is frequently less than installed capacity because the amount available when needed may be reduced because of low flows or reduced heads due to reservoir drawdown or tailwater encroachment. Various techniques have been used to measure dependable capacity, but it is widely agreed that for large predominately thermal power systems, traditional procedures often understate the true value of dependable hydroelectric capacity to the system. Procedures have been recommended by IWR[1/] and these have been used in this report. For a small run-of-river hydro project operating in a large, predominantly thermal power system, hydrologic availability is simply the average plant factor during the period of peak power demand. Thus,

Dependable Capacity = Installed Capacity x Hydrologic Availability.

The power system in which the Lock and Dam No. 1 project operates in, experiences both a winter and a summer peak load period. The summer load for July and August was used for establishing peak load in this study. Also see Section 6.09 which compares summertime and wintertime peak load periods. In Section 6.06, the capacity benefit is determined using the above definition of dependable capacity.

1/ US Water Resources Council, Water and Energy Task Force, Evaluating Hydropower Benefits, December 1981. Section 6.1.

LOCK & DAM NO. 1
ANNUAL FLOW DURATION CURVE
USING DAILY DATA

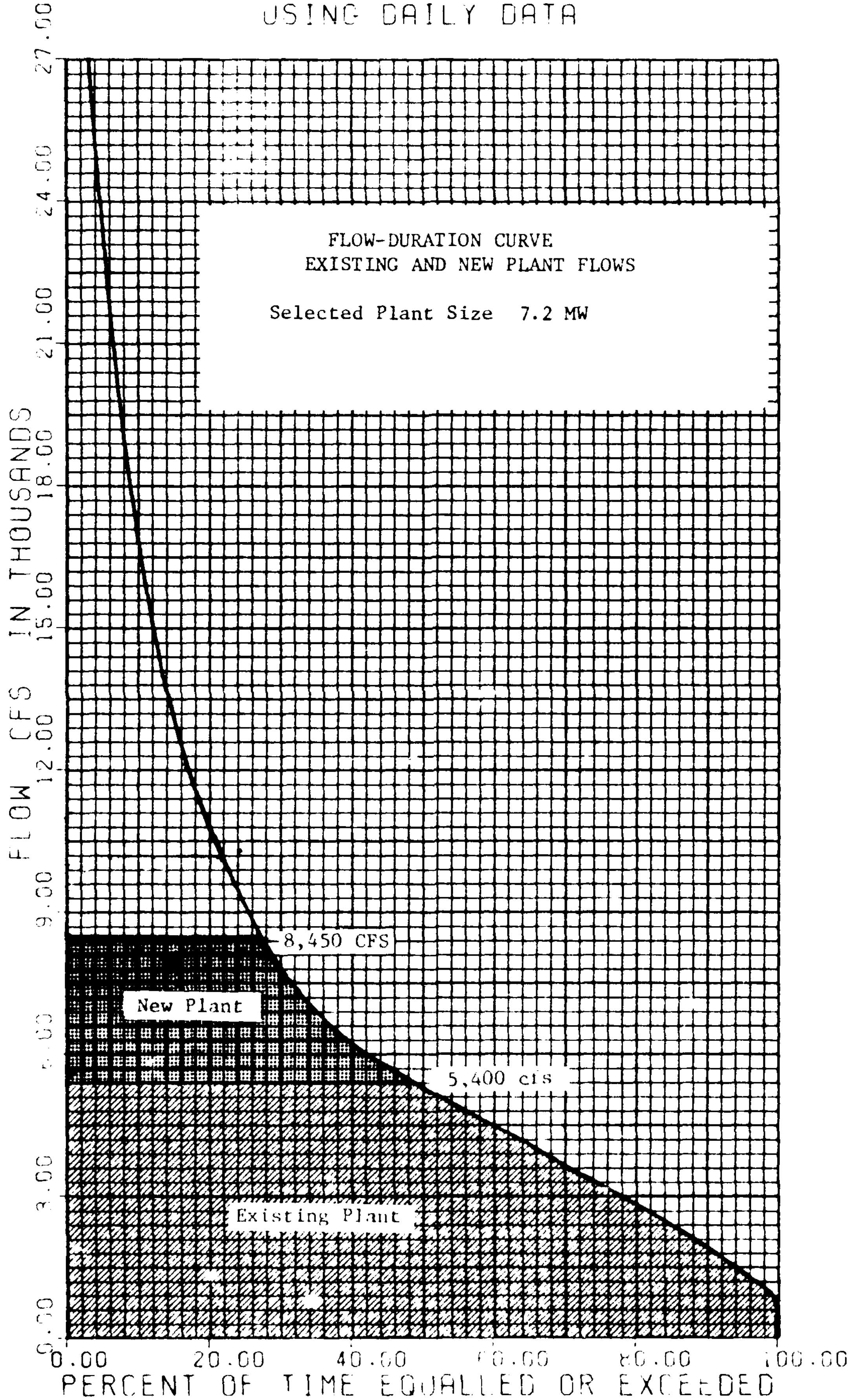


Figure 3-1

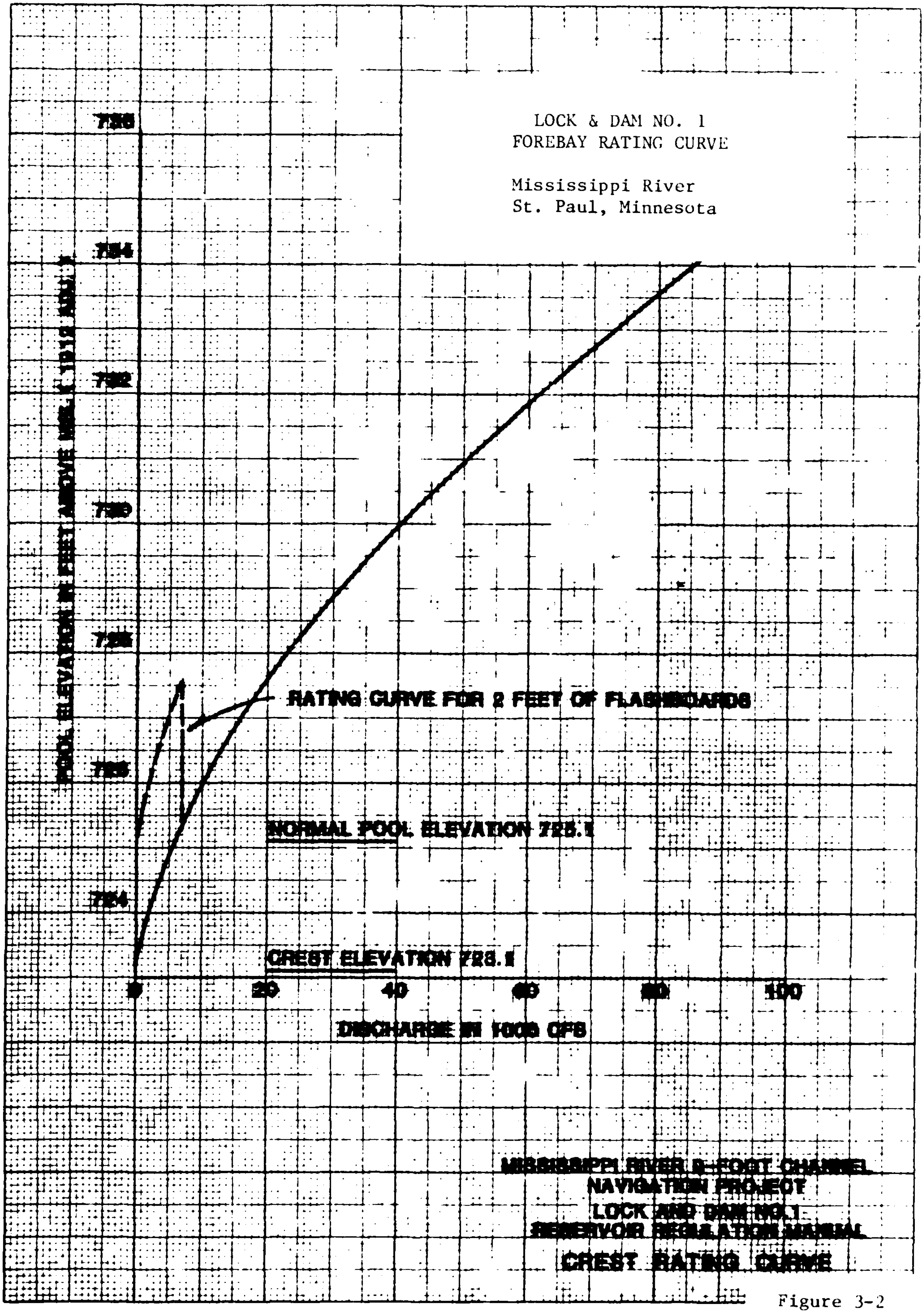
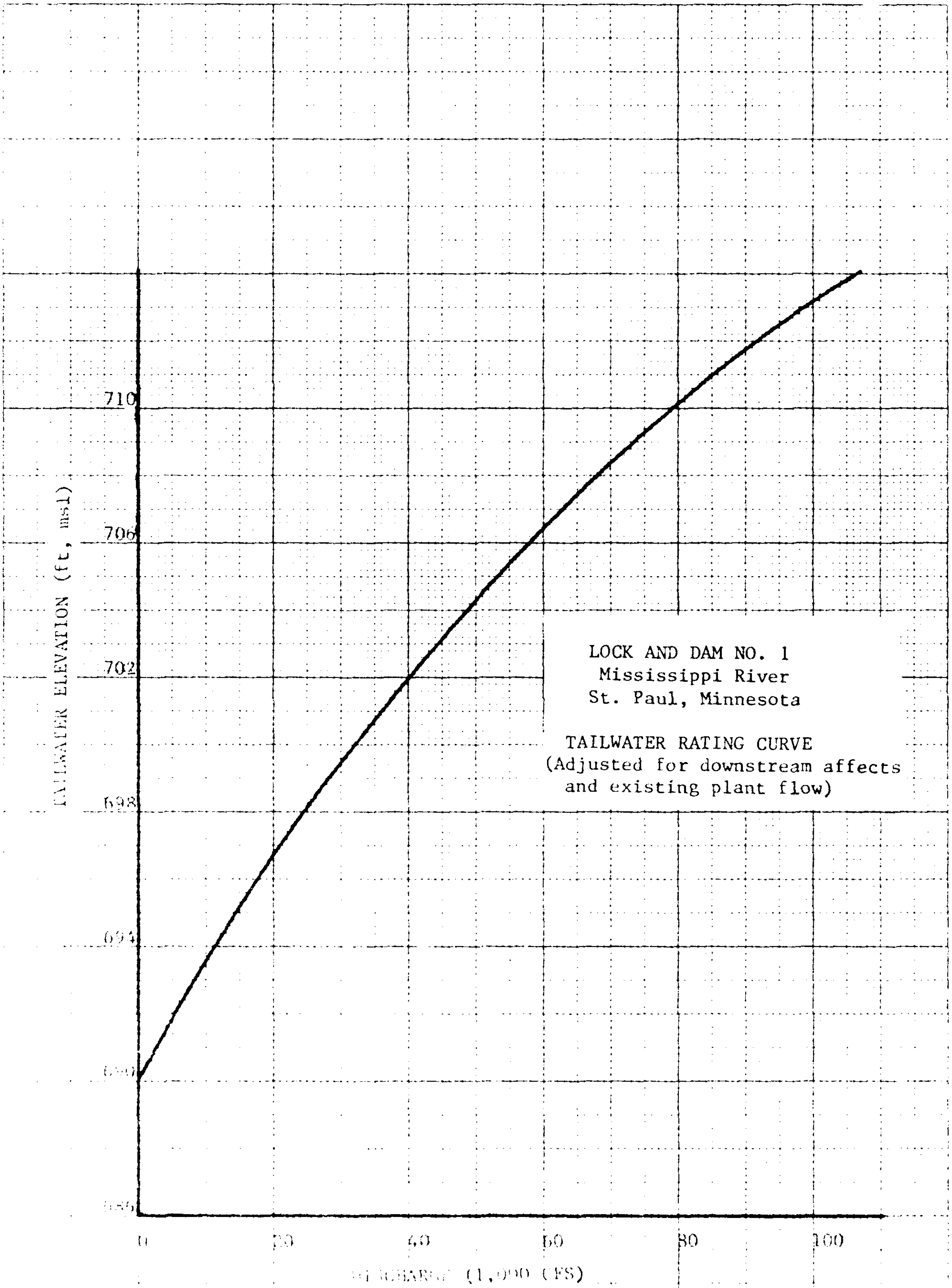

LOCK & DAM NO. 1
FOREBAY RATING CURVE
Mississippi River
St. Paul, Minnesota
RATING CURVE FOR 2 FEET OF FLASHBOARDS
NORMAL POOL ELEVATION
CREST ELEVATION
0
20
40
60
80
100
DISCHARGE IN 1000 CFS
MISSISSIPPI RIVER 9-FOOT CHANNEL
NAVIGATION PROJECT
LOCK AND DAM NO.1
RESERVOIR REGULATION MANUAL
CREST RATING CURVE

Figure 3-2



LOCK AND DAM NO. 1
Mississippi River
St. Paul, Minnesota

TAILWATER RATING CURVE
(Adjusted for downstream affects
and existing plant flow)

Figure 3-3

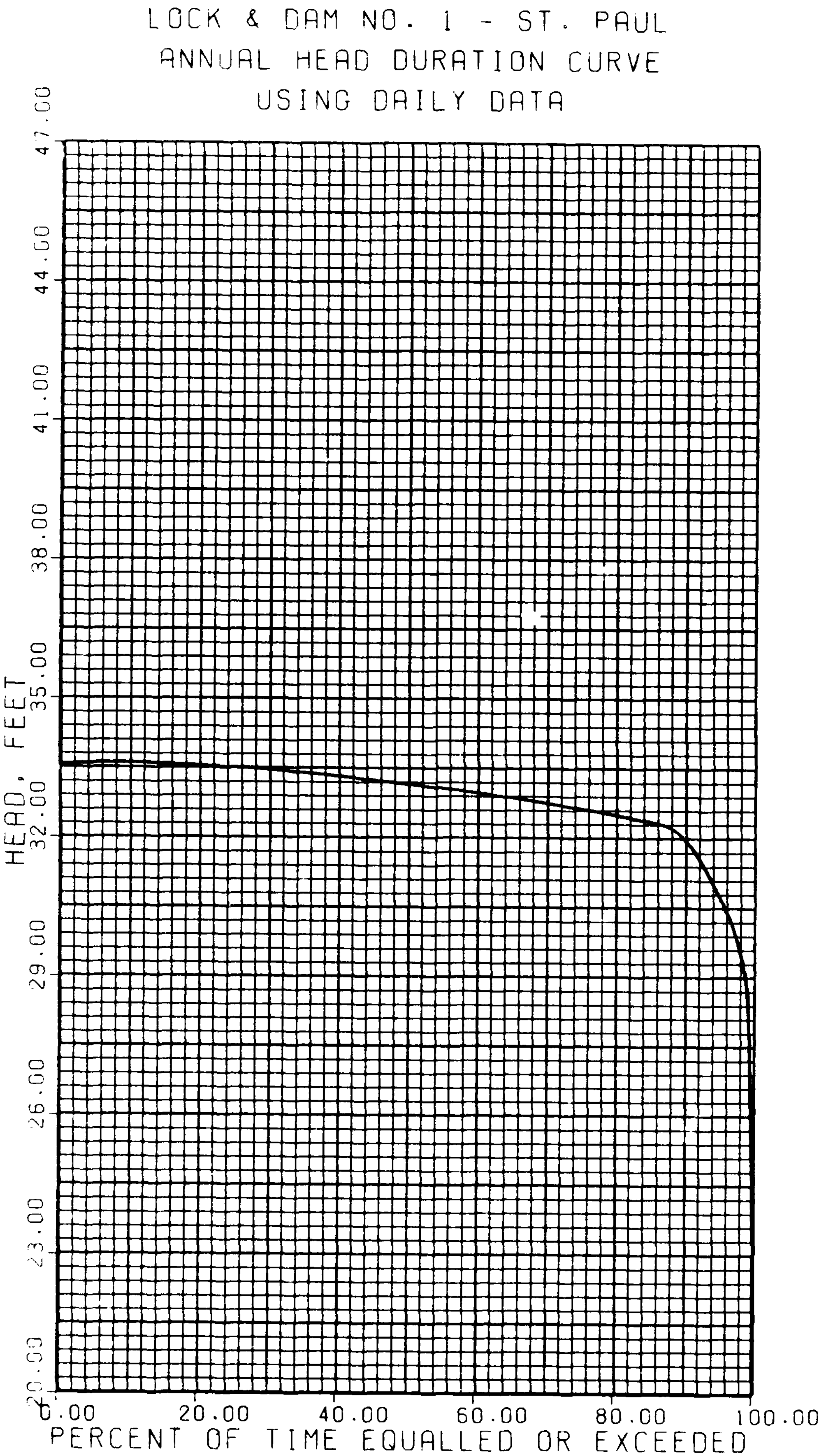
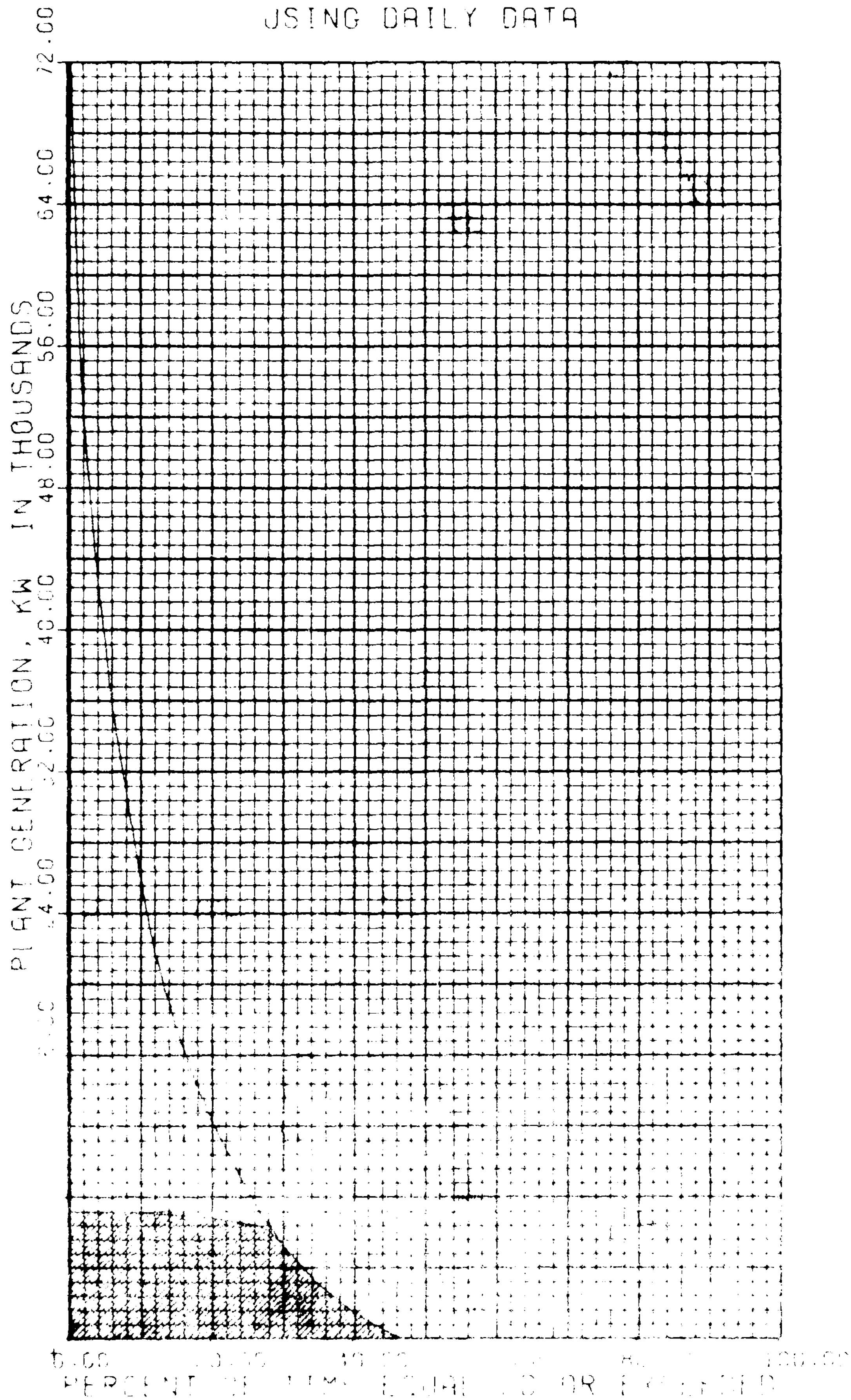

LOCK & DAM NO. 1 - ST. PAUL
ANNUAL HEAD DURATION CURVE
USING DAILY DATA
HEAD, FEET
47.00
44.00
41.00
38.00
35.00
32.00
29.00
26.00
23.00
20.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

Figure 3-4

LOCK & DAM NO. 1 - ST. PAUL
ANNUAL POWER DURATION CURVE
USING DAILY DATA



SECTION 4 - POWERHOUSE FEATURES

4.01 General Description of Selected Powerhouse. The proposed powerhouse is located at Site D, downstream of the existing spillway and 69 feet west from the existing Ford powerhouse. This allows the three existing operational sluiceways to remain in operation after construction and does not interfere with the Ford plant during construction. The structure will be of reinforced concrete, housing a single 3600 mm tube turbine. The centerline of the runner will be set at elevation 682.0, or 5 feet below minimum tailwater. The upstream water intake is positioned at the toe of the spillway monolith, with the invert at El. 693.6. The intake water passage will descend to the turbine on a slope which can be excavated without danger of undermining the spillway foundation.

Sections of two spillway monoliths will be modified to admit water to the intake. The spillway face slab and one pier will be removed, providing a water passage approximately 29 feet wide. Fill concrete will be placed to retain the existing river bed. The exposed piers of the remaining spillway will require structural investigation for lateral stability. An intake stoplog slot and trashrack will be provided within the intake structure.

Within the powerhouse, a 12.5' by 36' turbine pit having a floor elevation of 667.0 will contain an unwatering sump used to unwater the waterway. The wicket gate assembly, servomotors, and counterweight along with other miscellaneous mechanical equipment will be located within the turbine pit. Located just downstream will be a 20' x 30' control room and a 39' x 40' generator room at elevation 692 and 677.5, respectively. These rooms will contain the governor, switchgear, SCADA, excitation cubicle and appurtinent miscellaneous electrical equipment.

The main powerhouse, located at elevation 709.6, will be attached to the existing Ford plant's tailrace deck by an access bridge. This bridge will facilitate operation personnel and minor maintenance. Access required for the initial installation and maintenance of the major equipment will be by a barge mounted crane. A gantry crane will be provided and sized for all powerhouse lifts. As a secondary function, the gantry crane will be equipped with an auxiliary hoist, used for draft tube bulkhead installation and removal. An emergency gate will be located in the tailrace water passage.

4.02 Powerhouse Site Locations Considered. In this study, four powerhouse site locations were reviewed to maximize power production and are described in the following paragraphs. Site D was recommended as the best location for the powerhouse, subject to future geotechnical investigation, and is referred to as the selected site in this study. All sites were studied using (a) single bulb unit (b) multiple standardize tubular units and (c) one 3600 mm standard tubular turbine. These are described as follows:

Site A. Site A is located adjacent to the existing Ford plant, on the east bank (see plate 3). At elevation 735 the bank is 40 feet wide bounded by a steep sandstone bluff reaching to elevation 800. The sandstone bedrock is exposed to the surface throughout the entire site. A steep narrow road used mainly for personnel and minor equipment replacement traverses the left downstream bank, directly adjacent to the existing Ford plant, terminating at the powerhouse at elevation 735. The large amount of open excavation required at this site would make access difficult to the existing plant.

A single horizontal bulb-unit was selected for this site because of its narrow width, thus fully utilizing all available space within the site. The additional width required for larger capacity multiple tube unit plants eliminated them from the scope of this report. The base elevation of the foundation would slightly undermine the existing Ford plant, and could require special construction considerations during excavation. Two sheet-pile cell-wall cofferdams were used for diversion and care of water at the upstream and downstream ends of the project. The placement of these cells would interrupt the operation of two existing generating units charging the project with a cost associated to the loss of power production. The upstream and downstream retaining walls will be removed after construction, as required, to complete a clear and smooth flowing channel.

A single 3600 mm tube turbine was then investigated at this site. The powerplant was placed downstream of the existing Ford plant and access road. The intake would have a trashrack, intake gate and gate hoist. The draft tube would continue from the powerhouse discharging flow into the existing Ford plant's tailrace. Sheet pile cells would be used for the upstream and downstream cofferdams. Future studies could allow the use sheet piles braced against the existing concrete wall eliminating the use of sheet pile cells. This would lend to a savings in costs associated with the diversion and care of water and eliminate the cost associated to the loss of power generation at the existing Ford plant.

Site B. An underground powerhouse located within the sandstone bluff on the east bank was chosen as site B (see plate 4). Site B would reduce the problems of access during construction to the existing Ford Plant. Preliminary investigations indicate that the tunnel excavation in this area is relatively inexpensive; therefore, this alternative is considered to be a viable solution.

This site was fitted with a single horizontal bulb unit fed by a single intake tunnel. The additional excavation required for a multiple unit plant was considered excessive and therefore eliminated from further study. An intake portal equipped with a trashrack and an intake gate will be built behind the upstream retaining wall. This retaining wall will also act as a cofferdam in conjunction with a sheet pile cell wall and would be removed after the intake portal was completed. The cofferdams for Site B can placed so as to allow uninterrupted operation of the existing Ford plant. The bulb unit will be located within a lined tunnel connecting the intake and draft tube portals. An access chamber above the unit will be sized and equipped with cranes large enough to supply all required equipment to the underground powerhouse. The draft tube portal will be equipped with bulkheads, and will be located behind the downstream retaining wall. The retaining wall will be connected to the sheet pile cell wall, similar to the intake portal construction.

A single 3600 mm tube unit was also investigated at this site. This powerplant was placed in the same location as the larger bulb unit, utilizing the same intake and draft tube works. The tunnel and powerhouse size requirements were reduced to facilitate the smaller tube unit.

Site C. Site C, is located adjacent to the existing powerplant along the west side of the existing powerhouse (see plate 5). A precast Ambursen-type spillway dam and concrete apron occupies this area. The structure is on timber piles. The dam is constructed of reinforced concrete slabs spanning "A" shaped buttresses. Removal of the concrete slabs between two adjacent buttresses will provide sufficient space for the intake structure. The powerhouse will be located on the dam apron just downstream of the intake structure. Sandstone bedrock is at elevation 659 below a bed of alluvial fill. Eight 6 by 6 foot sluiceways are located in the spillway dam adjacent to the existing Ford plant; five of the sluiceways are currently plugged. The three sluiceways closest to the existing powerplant are used to assist control of the pool during normal operation and will be removed to make space for the new powerhouse. This will require opening three of the plugged sluiceways to retain the same control of the pool during normal operation.

Placement of the powerhouse at this site will reduce the capacity of the spillway by about 13%. This will increase the flood of record (1965) elevation by about one foot. There was minimal flood damage associated with the flood of record; therefore, this one foot rise should cause no harmful effects.

Three horizontal tube turbines were chosen for this site chiefly because the depth of excavation required is less for these units. The depth of excavation associated with locating a bulb unit within the spillway would require extensive sheet piling and pressurized grouting to insure a stable foundation under the existing spillway and apron. Access for large equipment during construction and for major repairs will be by barge-mounted crane. Smaller equipment will be transported down the road along the east bank, across the Ford plant's tailrace deck and into the powerhouse. Unlike Sites A and B, site C would not be accessible during the greater flooding conditions. The powerhouse was located slightly downstream from the dam in order to reduce the possibility of undermining the existing Ford plant. An upstream sheet pile cell cofferdam would tie into the spillway dam, reach across the front of the proposed powerhouse excavation and connect into the front of the existing Ford plant. The cofferdam would require that two of the existing four turbines be shut down for 18 months. The loss of existing power generation is reflected in the project economic evaluation. A downstream cofferdam would tie into the west downstream training wall, then extend across the new tailrace, and connect into the downstream lip of the spillway apron.

For comparison a single 3600 mm tube unit power plant was considered at this site. This plant is similar to the three unit plant in arrangement and orientation. The diversion and care of water for the one unit plant is subject to the same associated costs as the three unit plant.

Site D. Site D is located within the spillway, 69 feet west of the existing Ford plant (see plate 2). This site is similar to Site C with the exception that there is no loss of existing generation power at the Ford plant during construction. The upstream and downstream cofferdams would tie into the spillway adjacent to the existing plant. The depth of excavation associated with a bulb unit at this site requires costly protective measures as discussed in alternative Site C. Access for personnel and minor equipment maintenance would be provided by a bridge connecting the two tailrace decks together. Access for heavy equipment would be provided by a barge mounted crane.

Horizontal tube turbines were considered at Site D instead of bulb turbines to reduce the cost of excavation as discussed in prior sections. The powerhouse layout is similar to the tubular powerplant discussed in Site C.

4.03 Turbines. For the purposes of this study, a single full Kaplan (adjustable blade with wicket gates) "standardized" tubular horizontal shaft turbine was used for the selected powerhouse site. Initial investigations of the number and type of turbines (vertical, Kaplan, horizontal, bulb, "standardized" tubular) appropriate for this site indicated the greatest economic advantage for the turbine selected. The choice of a Kaplan tubular type turbine was based upon the relatively low heads and high discharges existing at this site. Economic analysis performed by NPD indicated that a single tubular turbine-generating unit would develop this site's potential.

The turbine would be rated to produce 10,150 HP at a net head of 33.0 feet. This corresponds to a generator output of 7.2 MW assuming a generator efficiency of 95%. The estimated runner diameter and speed of the turbine is 142 inches and 133 RPM, respectively. The actual speed, however, will be left to the discretion of the turbine-generator manufacturer. It is assumed the turbine will be connected to the generator through a speed increaser. The centerline elevation of the turbine is 682.00 fmsl. This elevation is based upon the estimated required submergence of the turbine for cavitation protection. Estimated turbine performance and overall operating net head and flow ranges are shown on Figure 4-1. These curves have been developed from existing manufacturer's data and indicate the approximate performance of the turbine selected for evaluation of this site. When further studies are made, all appropriate configurations and turbine types will be considered.

4.04 Generator. The generator portion of the tube turbine generator will be of the horizontal shaft, synchronous type, with a speed increaser between the shaft and the turbine. It will be rated at 7.2 MW

(8.0 MVA at 0.9 P.F.), 3-phase, 60 Hz, 13.8 kV, 900 RPM, with Class B insulation, 75 C temperature rise. A drip-proof housing will be provided with connections for out-going ducts. The exact mechanical arrangement will be determined by the turbine/generator supplier. The generator will be furnished with manufacturer's standard type exciter. This could be a "High Initial Response" bus-fed static excitation system or a direct connected brushless exciter.

4.05 Governor. The governor will be of the oil pressure, pilot operated, distributing valve, cabinet actuator type with speed and power responsive elements designed to regulate the speed and power by controlling the wicket gate and blade operation. Speed responsive elements will be controlled by a speed signal generator directly connected to the generator shaft. The governor will consist of a cabinet actuator equipped with the necessary indicating and control devices, and an oil pumping set consisting of a sump tank and two motor driven oil pumps, one or two pressure vessels as required, all necessary blade and gate servomotor piping and a speed signal generator. In addition, an automatic gate limit control system will be provided for positive limiting of the turbine gate opening and preventing the turbine from exceeding cavitation limits under varying head conditions.

4.06 Mechanical Equipment. H.V.A.C. Powerhouse cooling will be accomplished using outside air. Heating will be by electrical equipment heat loss and electric resistance back-up heater. Equipment will include an air handler, electric heater, louvers, ductwork and controls.

Cranes. A 20 ton gantry crane will be provided for minor installation and servicing. A barge-mounted crane will be used for heavier lifting. The gantry crane will also have a 20-ton auxiliary hoist for handling the draft tube emergency closure gate. An intake gantry will be provided to perform all trashraking and installation of intake stoplogs.

Piping. Raw water for unit cooling and turbine glands will be taken by gravity flow and strained. A small pump and filter will be required for gland water. One Governor air and two service air compressors will be provided. Unwatering and drainage will be handled by a dual pumping system and a common sump. Portable oil handling equipment and a pump for fire protection and deckwash will be provided. CO cylinders with automatic and manual releases will be provided for the generator fire protection. Potable water will be supplied by an existing potable water line. The waste from the toilet will be pumped to the existing sanitary system.

4.07 Generator Voltage System. The connection between the generator and breaker will be with non-segregated phase bus. The generator and station service breakers will be metal clad drawout type rated 500 MVA (nominal), 13.8 kV 1200 amps continuous. The breakers will be combined in a common switchgear lineup along with generator surge protection and instrument transformers.

4.08 Station Service. The station service power will be obtained via a tap between the generator breaker and the outgoing bus. The station service transformer will be adjacent to the generator switchgear lineup. Station service power distribution will be at 480 volts 3-phase and 120/240 volts single phase.

4.09 Connection to Load. 3-phase non-segregated phase bus will tie the plant to the existing 13.8 kV system in the Ford hydro plant. The bus will be connected to the powerhouses through a disconnect switch in the Ford hydro plant.

4.10 Control Equipment. A complete complement of generator and transformer protective relays, metering, synchronizing equipment and start-up and shut-down equipment will be located in a control switchboard near the unit. The control and protective scheme will be designed for attended manual start-up and loading, and will shut down automatically on a trouble condition. A single annunciation point will be wired to the lock control room to notify the operator of a trouble condition.

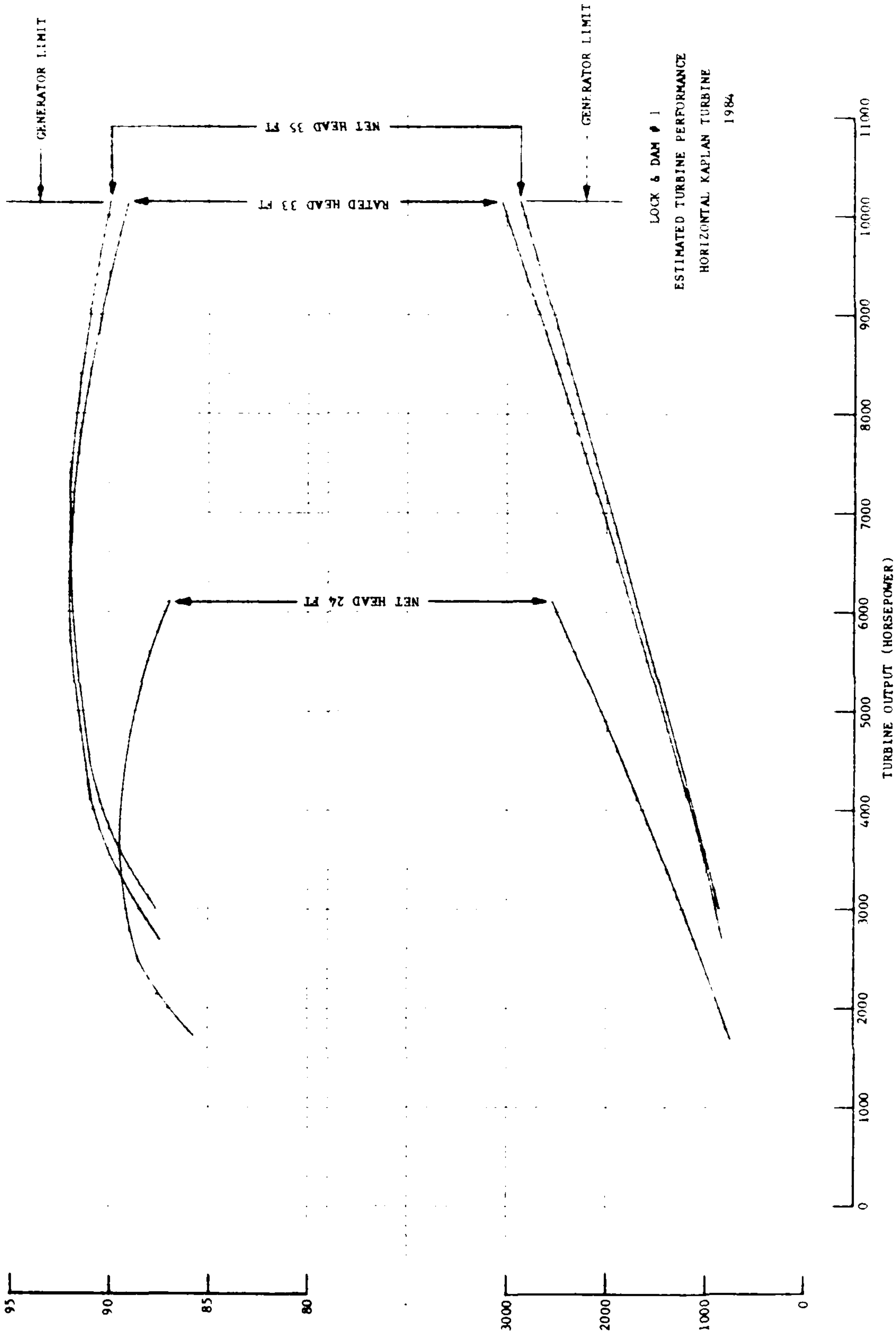

LOCK & DAM # 1
ESTIMATED TURBINE PERFORMANCE
HORIZONTAL KAPLAN TURBINE
1984
GENERATOR LIMIT
GENERATOR LIMIT
NET HEAD 35 FT
RATED HEAD 33 FT
NET HEAD 24 FT
TURBINE OUTPUT (HORSEPOWER)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
EFFICIENCY (PERCENT)
95
90
85
80
DISCHARGE (CFS)
3000
2000
1000
0

Figure 4-1

1 of 2

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DIVISION, N. P
PORTLAND, OREGON

DESIGNED BY J K J
DRAWN BY
CHECKED BY K
PREPARED

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA
GENERAL
ALTERNATIVE D
1 - TUBULAR UNIT
7.2 MW PLANT

APPROVED FOR DIV. ENGINEER DATE
SUBMITTED
SCALE AS SHOWN
SHEET PLATE 1

1/6

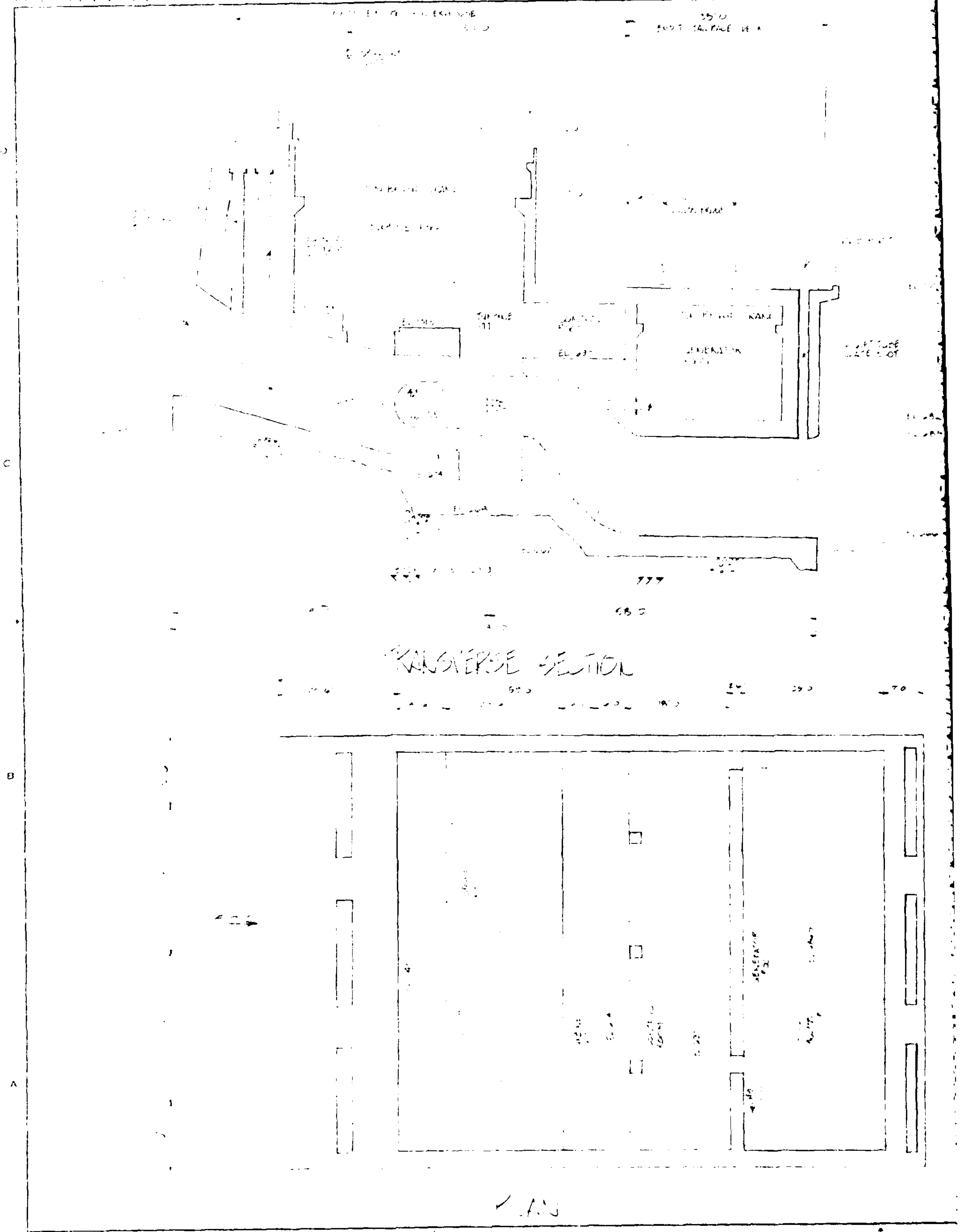
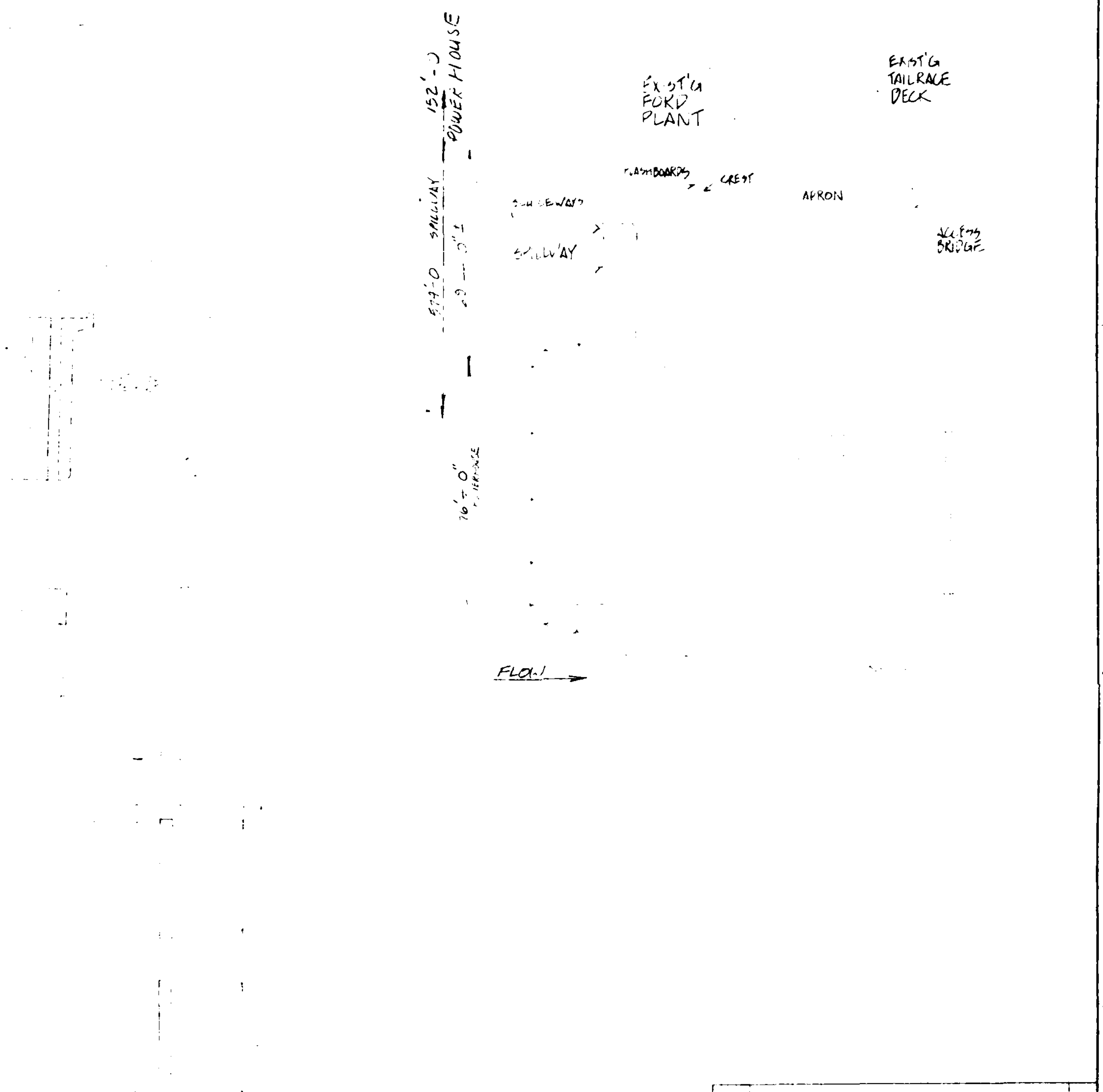


PLATE 2. 1 of 2



D

C

B

A

REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DIVISION, N. P.
PORTLAND, OREGON

DESIGNED BY JKJ
DRAWN BY
CHECKED BY KJL
PREPARED

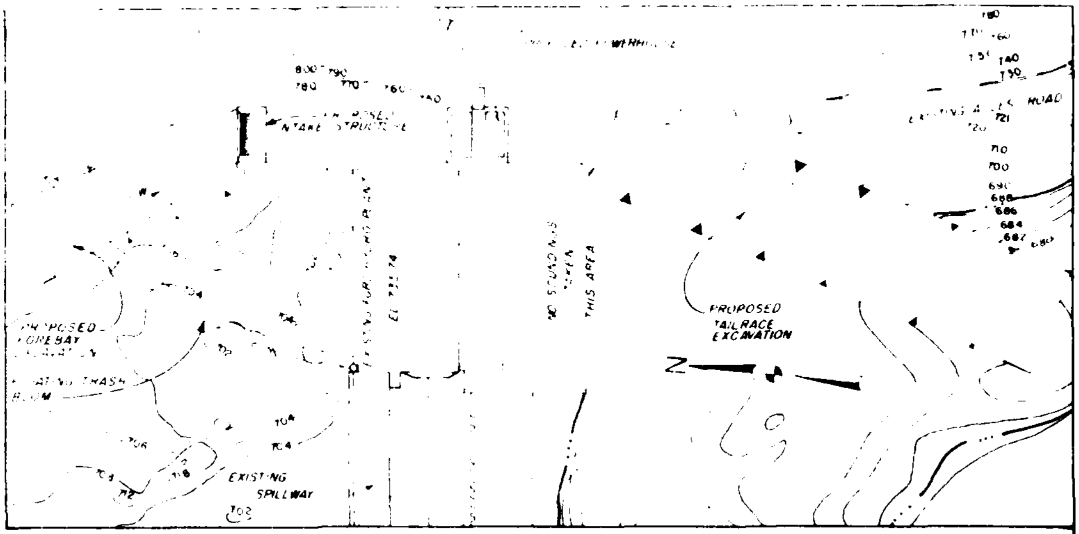
LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA
GENERAL
ALTERNATIVE D
3 TUBULAR UNITS
7.2 MW PLANT

APPROVED FOR DIV ENGINEER DATE
SUBMITTED
SCALE AS SHOWN
SHEET PLATE 2

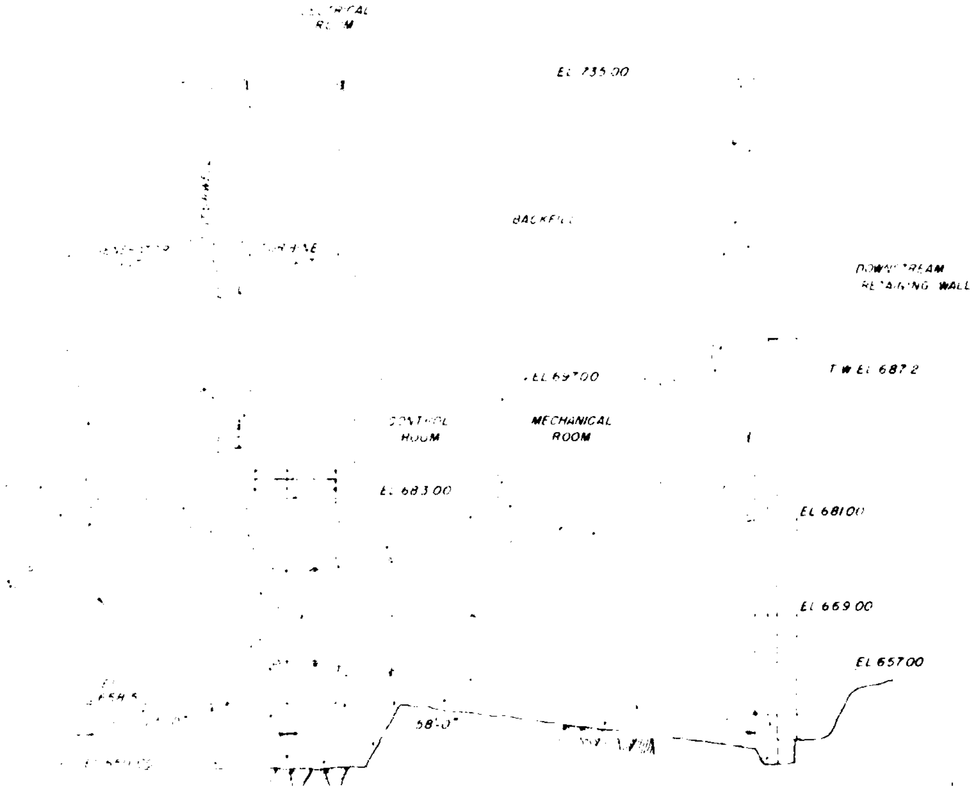
1/2

TRANSVERSE S

PLATE 3 4 1 of 2 3



SITE PLAN



TRANSVERSE SECTION

GRAPHIC SCALE

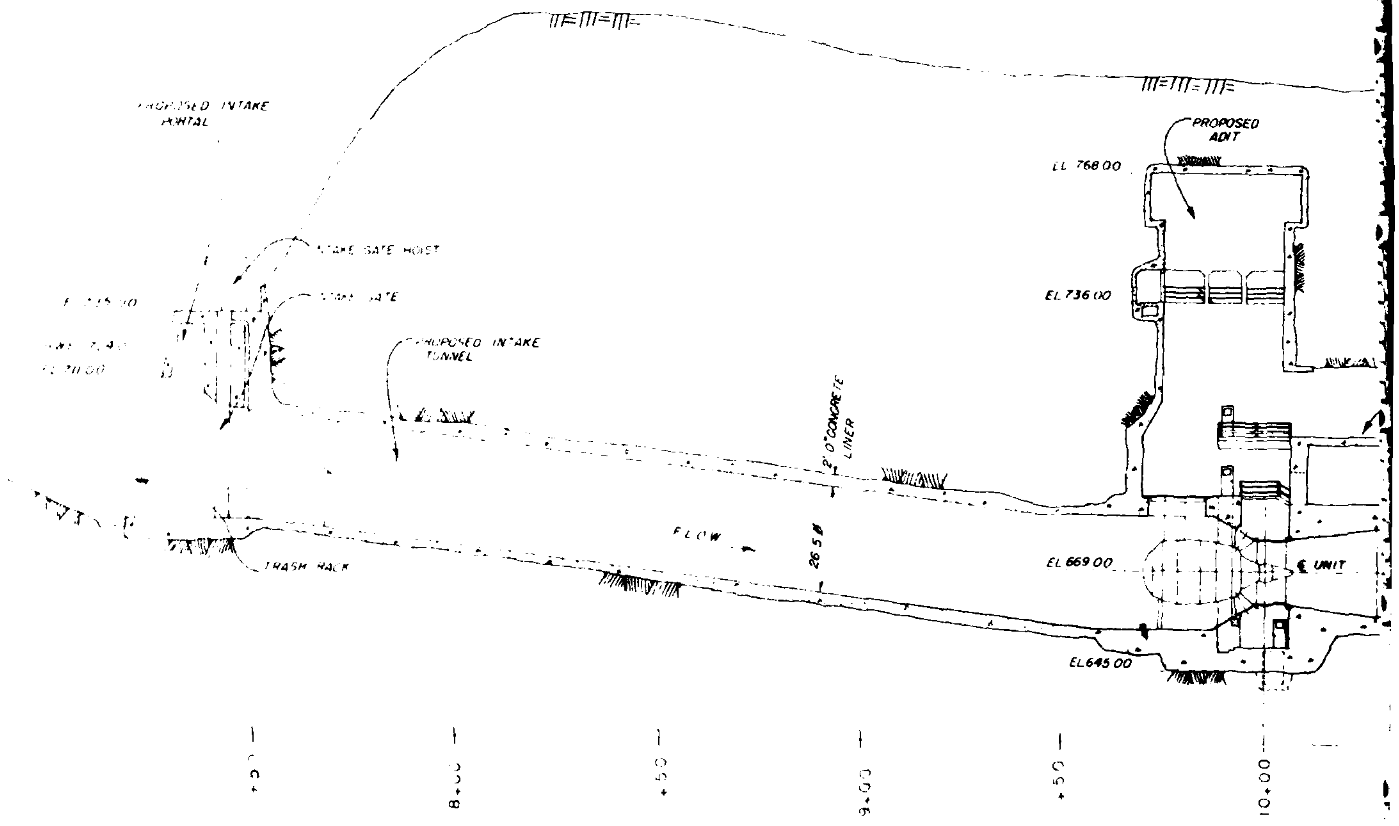
U.S. ARMY ENGINEER DIVISION, N.P.
PORTLAND, OREGON

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER ST. PAUL, MINNESOTA

GENERAL
ALTERNATIVE A
1-BULB UNIT
16.0 MW PLANT

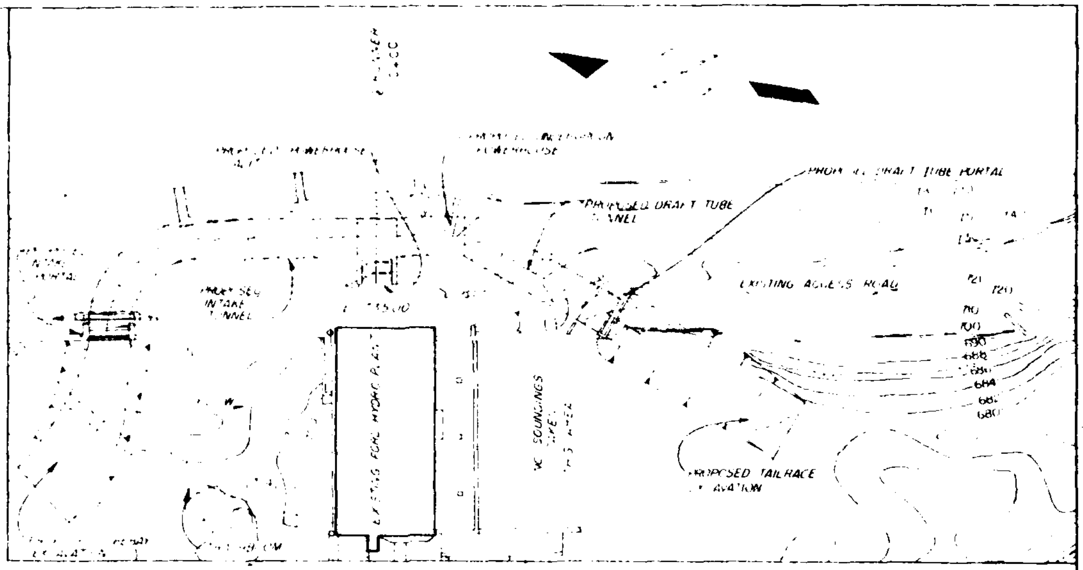
PLATE 3

[redacted]

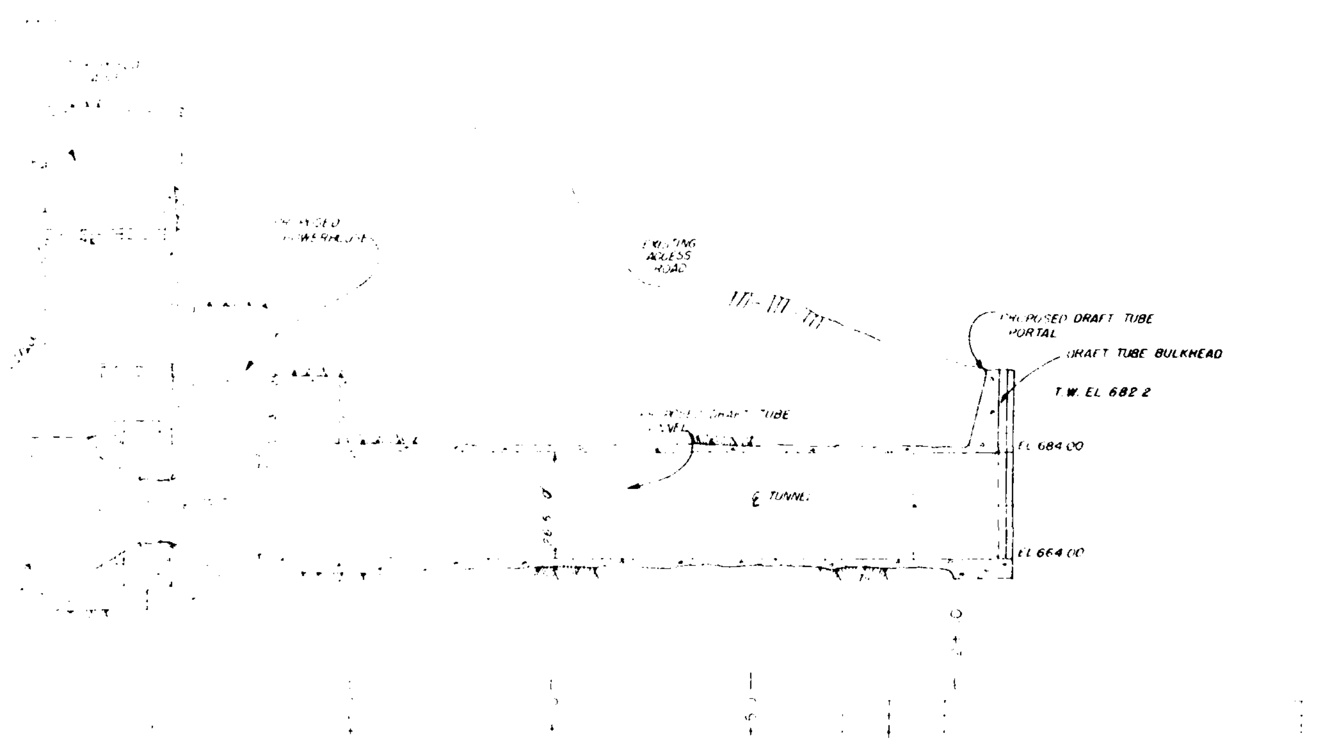


TUNNEL CROSS SECTI

SCALE: 1/16" = 1'-0"



SITE PLAN



GRAPHIC SCALE

U.S. ARMY ENGINEER DIVISION, N.P.

LOCK & DAM #1 PROJECT

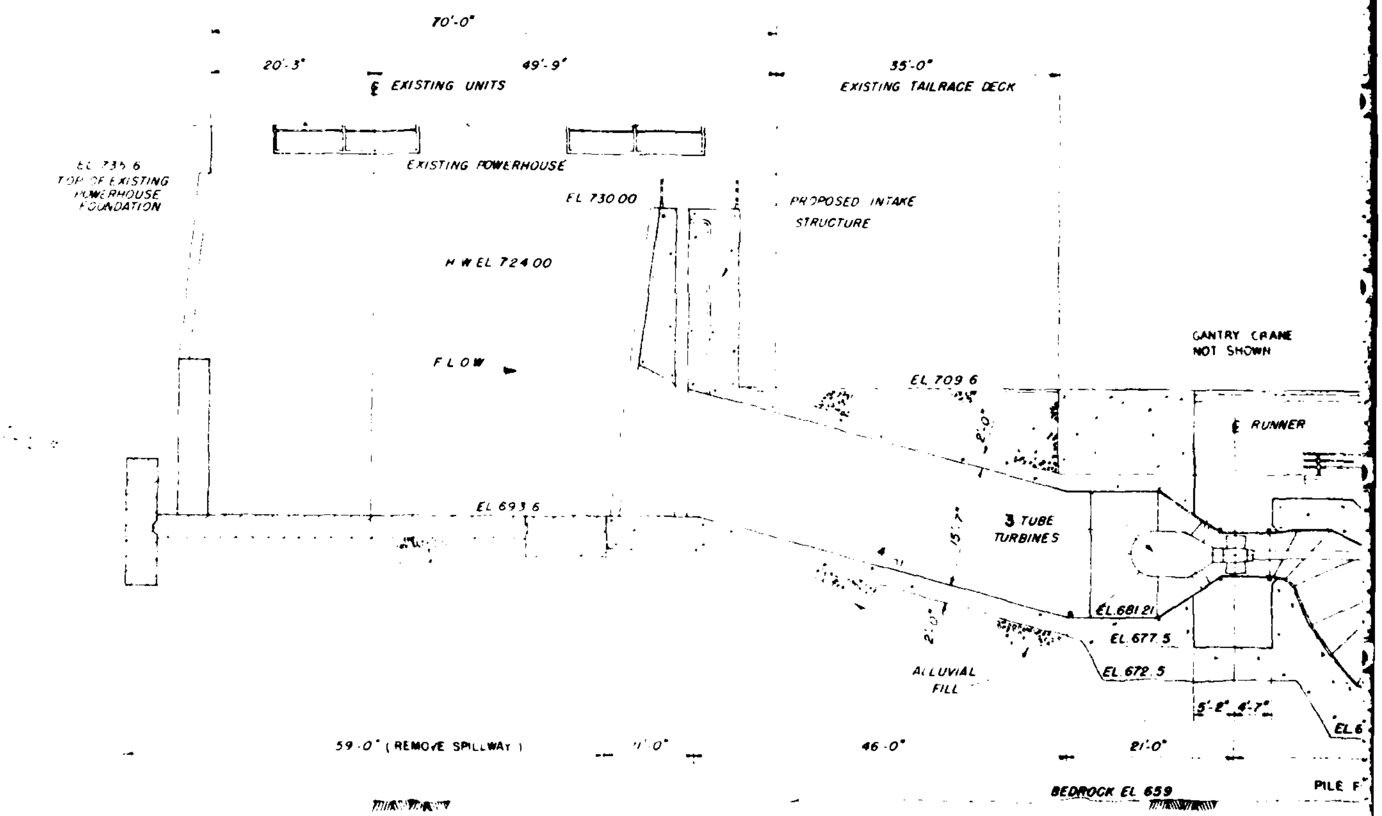
GENERAL

ALTERNATIVE B

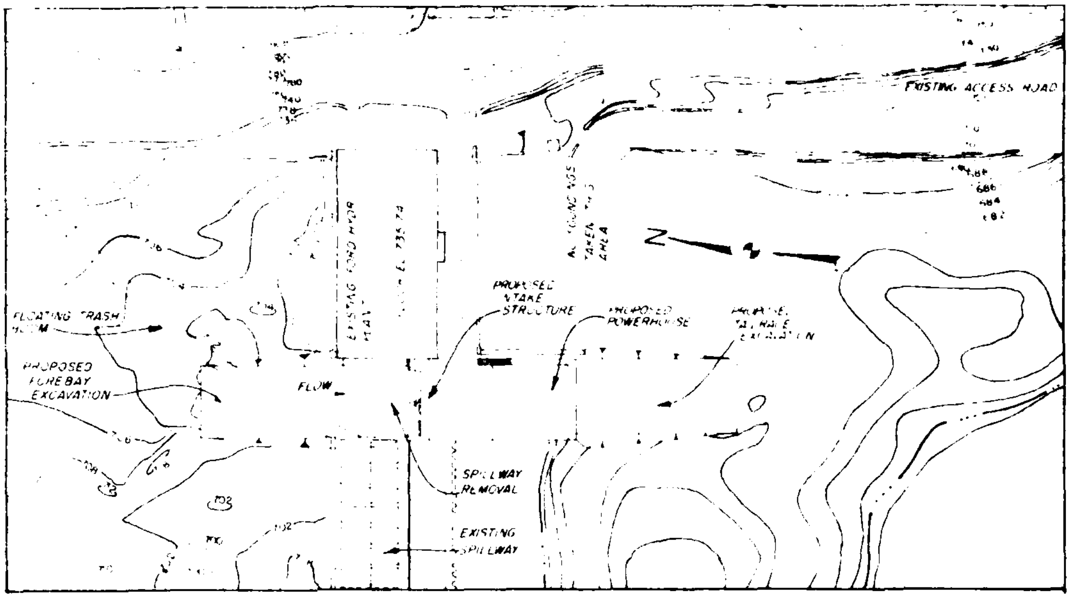
1-BULB UNIT

16.0 MW PLANT

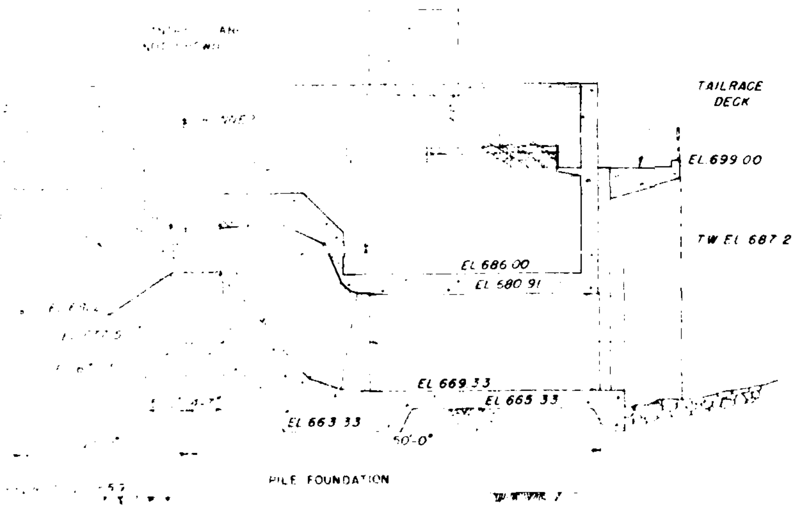
PLATE 4



TRANSVERSE SECTION



SITE PLAN



GRAPHIC SCALE

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, N.P.
PORTLAND, OREGON

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER ST. PAUL MINNESOTA

GENERAL
ALTERNATIVE C
3 TUBULAR UNITS
16.0 MW PLANT

SCALE AS SHOWN

PLATE 5

SECTION 5 - PROJECT COST AND SCHEDULE

5.01 Project Cost. An itemized cost estimate for the selected 7.2 MW plant, Site D, is shown below in Table 5-1. Comparison costs for Sites A, B and C are shown in Table 6-5. Unit costs for labor and materials are based on Oct 83 price levels. The excavation feature includes Diversion and Care of Water, both of which were computed by St. Paul District and shown in detail in Appendix A.

All cost features include materials and labor required to provide a complete job. The Total Project Cost is 8,012,000.00 and does not include any contingencies. Contingencies will be assessed at 15 percent for Turbine, Generator and Accessory Electrical Equipment; all other features are assessed at 20 percent, as shown on Table 6-2.

5.02 Design and Construction Schedule. The project design and construction schedule shown in Figure 5-1 is separated into two parts, the powerhouse design and construction contract and the turbine and generator design and construction contract. The powerhouse design and construction contract has a duration of 49 months. It is restricted by the turbine supply contract in 3 places. First, the construction contract is advertised after the turbine-generator contract is awarded. Second, the first stage concrete must be completed in order to set the embedded turbine parts. And finally, the second stage concrete must be completed in order to install the non-embedded turbine and generator parts. The total construction time, excluding design and review, is 28 months.

The turbine and generator design and construction contract has a duration of 47 months. The time required to supply embedded parts after awarding the turbine supply contract is 22 months. To supply the embedded parts after award of contract requires 22 months and the delivery of the non-embedded parts takes an additional 6 months. An additional 7 months is required to complete the powerhouse and test the turbine and generator before placing the unit on line. The total time of construction was measured from the award of the turbine & generator supply contract to the power-on-line, this was 35 months.

TABLE 5-1 COST ESTIMATE FOR 7.2 MW PLANT, ALTERNATIVE D.

PROJECT: LOCK AND DAM #1
PLANT CAPACITY: 7.2 MW
UNIT SIZE: 1-3600 mm Tube

PRICE LEVEL DATE: OCT 83
LOCATION: St. Paul
RIVER: Mississippi River

FEATURE	COST
1. POWERHOUSE	
1.1 Excavation 1/	
a. Powerhouse Placement	150,000
b. Downstream Channel	50,000
c. Cofferdams	400,000
d. Dewatering	600,000
1.2 Reinforced Concrete	1,500,000
1.3 Misc. Building Items	100,000
1.4 Bulkhead, Guides & Struct Steel	250,000
1.5 Architectural	50,000
1.6 Access Bridge	200,000
2. TURBINE AND GENERATOR	
2.1 Turbine & Generator	3,000,000
2.2 Excitation Equipment	------- 2/
2.3 Governor	------- 2/
2.4 Cooling System	20,000
3. ACCESSORY ELECTRICAL EQUIP.	
3.1 Switchgear, Breakers & Busses 3/	70,000
3.2 Station Service Unit	65,000
3.3 Control System	154,000
3.4 Misc. Electrical Systems	75,000
4. AUXILIARY SYSTEMS & EQUIP.	
4.1 Heating and Ventilating	8,000
4.2 Station, Brake & Governor Air	30,000
4.3 Unwatering & Drainage Systems	40,000
4.4 Gate Hoist, Draft Tube	100,000
4.5 Misc. Mechanical Systems	40,000
4.6 Gantry Crane, Tailrace	250,000
4.7 Trashraking & Stoplog Lifting Gantry	150,000
5. SWITCHYARD	
5.1 Power Transformer	
5.2 Disconnects & Elec. Equip.	10,000
6. SITE PREPARATION & SPECIAL ITEMS	
6.1 Mobilization & Preparation	700,000
TOTAL	8,012,000

1/ St. Paul District
2/ Included in 2.1 Turbines & Generators
3/ A portion of the switchgear is included in Feature 2.1 Turbines & Generator

LOCK & DAM #1 PROJECT

MISSISSIPPI RIVER, ST. PAUL, MINNESOTA

ALTERNATIVE D

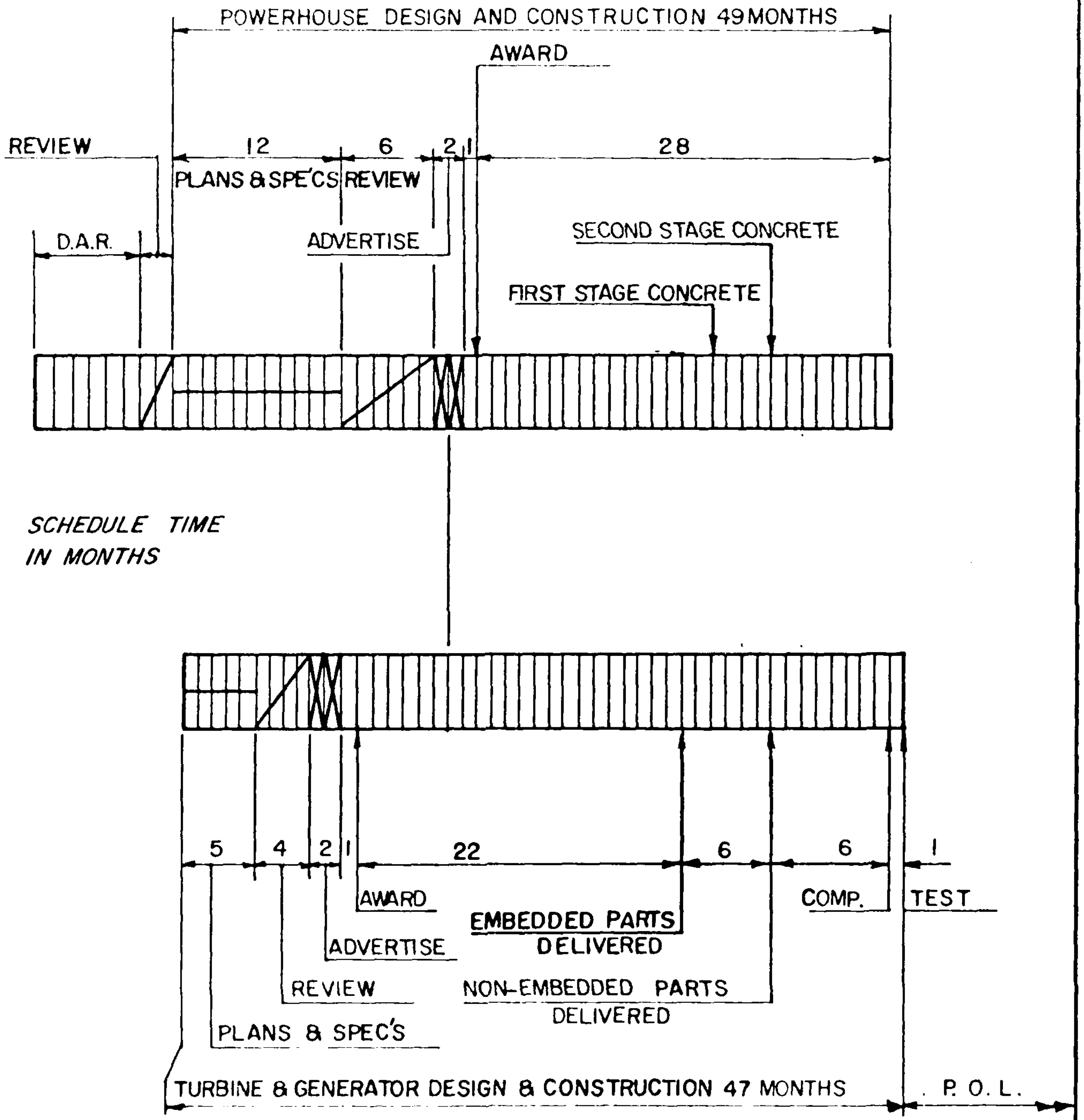


FIGURE 5-1 DESIGN AND CONSTRUCTION SCHEDULE

SECTION 6 - ECONOMICS

6.01 General. The purpose of this section is to estimate the economic value of the proposed power installation; the optimum size of the power plant will also be determined. Annual project costs for a range of plant sizes will be computed. The corresponding benefits based on power values provided by the Federal Energy Regulatory Commission (FERC) will also be determined. The power values are based on alternative development of a coal-fired thermal plant. A net-benefit analysis will then be made by comparing the annual cost to the annual benefits.

6.02 Cost Estimates. All cost levels in this report are based on October 1983 levels. Cost estimates were prepared for different sizes of generating plants that can utilize the available flows. For scoping it was found that construction costs varied nearly linearly with installed capacity. After the optimum plant size had been determined, a final, more refined cost estimate was developed for each site (also see Section 6.07 Scoping).

Initially, cost estimates were prepared for the four alternative powerhouse locations described in Section 4.02. Preliminary cost estimates were used in the scoping phases. Then when the selected plant was chosen, more detailed cost estimates were developed.

For the powerplant, engineering and design (E&D) cost of 6 percent and supervision and administration (S&A) costs of 6 percent were included. Because a large portion of the costs of the powerplant represents electrical and mechanical equipment purchased under supply contracts, E&D

and S&A costs represent a smaller portion of total project costs than for many other similar types of construction projects. To obtain the total investment cost, interest during construction was added based on a construction period of 37 months (see Section 5.02). Interest during construction (IDC) cost was compounded based on the estimated midpoints of yearly construction expenditures using a "rounded-off" 36 month period. Based on experiences with similar projects in North Pacific Division, the estimated yearly expenditures expressed as a percentage of the total cost for each site are as follows:

TABLE 6-1

TOTAL PROJECT EXPENDITURE PERCENTAGES

	Year 1	Year 2	Year 3
Powerplant Equipment 1/	60%	30%	10%
Items Exclusive 1/ of Powerplant Equip.	10%	70%	20%

1/ Items 2 and 3, Section 5.01
2/ Item 1, 4, 5 and 6, Section 5.01

6.03 Cost Adjustment for Inflation During Construction. Construction cost estimates for feasibility level reports are based largely on bids made by contractors on similar projects. Since contractors must cover all costs over the entire construction period, their bid estimates include an allowance for increases in the price of labor and material (inflation) over the entire construction period. Water Resources Council (WRC) NED benefits manual, 1/ states that a project's NED benefit and cost must be computed at a common point in time. The NED benefits for this report are based on October 1983 price levels; therefore, an adjustment was made to the project cost estimate to arrive at NED costs for the same price level. Procedures for making allowance in the cost estimate for inflation is specified in Engineering Manual 1110-2-1301, dated 15 April 1982. Based on the experience of North Pacific Division, a 6.1 percent total inflation rate adjustment was made to the project cost estimate. This inflation rate was computed from several completed powerhouse using an average length of construction of 24 months.

The process for making the appropriate inflation costs adjustment involves the following steps:

a. From the total project cost, deduct the cost of the turbines and generators and their contingency allowances. Cost estimates for supply contract items (i.e. turbines and generators) are point estimates with

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1/ Water Resources Council, Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C), December 14, 1979, Section 713.23.

inflation during construction provided for by escalating the contract payment at the time of delivery or partial payment.

b. An inflation adjustment is computed on the basis of an inflation rate of 6.1% compounded annually over the construction period.

c. The inflation adjustment is then subtracted from the total project cost. To this subtotal, engineering, design, supervision and administration--and interest during construction are added to derive the total investment cost (NED).

TABLE 6-2

INVESTMENT COST ($1,000)

Selected Plant Size 7.2 MW
(Single Tubular Unit)

	Powerplant Equipment 8/	Items Exclusive of Powerplant Equipment	Total
Subtotal 1/	$3,384	$4,628	$8,012
Contingencies 2/	508	926	
Subtotal	3,892	5,554	
Inflation Adjustment	0	- 501	
Subtotal	3,892	5,053	
EDS & A 4/	467	606	
Subtotal	4,359	5,659	
IDC 5/	744	658	
Real Estate Requirement 6/	0	50	
Total NED Invest. Cost 7/	$5,103	$ 6,367	$11,470

1/ Basic construction costs from Section 5.01.

2/ For powerplant equipment, use 15%; for items exclusive, use 20%.

3/ Adjustment for inflation during construction, items exclusive of powerplant equipment only; see Section 6.03.

4/ Engineering, design, supervision, and administration, 12%.

5/ Interest during construction, compounded from estimated yearly expenditures.

6/ For land rental, dredge materials and easement for construction.

7/ National Economic Development (NED) investment cost for scoping and economic excludes inflation during construction costs.

8/ Cost items 2 and 3 only from Section 5.01.

6.04 Annual Costs. The period of analysis for the projects is 100 years. The annual interest and amortization rate is 8 1/8 percent. Operation, and maintenance, costs are based on curves and procedures published in the Corps of Engineers' 1979 Hydropower Cost Estimating Manual 1/, adjusted to October 1983 price levels. These O&M costs, in-turn were increased by a factor of 1.5 to be comparable with procedures described in EM 1110-2-1701, Draft Jan 84, Section 8-5c. Replacement costs were computed based on actual items of expenditure, present worthed to their estimated economic life (from ER 37-2-10, change 23, 21 Sept 73, Chp 8, Appendix I), then amortized to the project life. It is assumed that operation of the plant will be automatic with manual start-up; however, personnel associated with the other project functions (navigation) could be called in on emergency conditions.

Table 6-3 summarizes annual costs for the selected plant size. The costs for all plant sizes considered are also shown in Tables 6-5(a) and 6-5(b) along with the corresponding annual benefits.

1/ Corps of Engineers, Hydropower Cost Estimating Manual, May 1979 (Rev. July 1981), pp. 46-49 (prepared by North Pacific Division for the Institute for Water Resources).

TABLE 6-3

ANNUAL COST ($1,000)

Selected Plant Size 7.2 MW

NED Investment Cost	$11,470
Annual Cost	
Interest & Amortization 1/	932
Operation & Maintenance 2/	86
Replacement 3/	6
Total	$ 1,024

1/ 8-1/8 percent and 100 years (I & A factor = 0.081283)
2/ See Section 6.04
3/ See Section 6.04

6.05 <u>Power Values.</u> Power benefits are based on avoided costs--the costs that would be incurred if the hydro project were not constructed. Hydropower project benefits are represented by the cost of the most likely alternative project, which would usually be a thermal generation plant. Hydro generation can displace thermal generation in two ways: (1) by displacing an increment of a new generating plant, or (2) by displacing the operation expenses of some existing power plants (energy displacement).

Discussions with FERC Chicago office indicated that generation from Lock and Dam No. 1 would be similar to the proposed generation at the St. Anthony Falls project and would most likely displace an increment of new coal-fired generation. Thus, the total power benefit will include both capacity and energy components, based on alternative coal-fired generation.

In their 11 October 1983 letter (Appendix D), FERC supplied unadjusted capacity and energy values based on 8-1/8 and 14 percent discount rates and at October 1983 prive levels. These values are shown below:

UNADJUSTED POWER VALUES
(provided by FERC)

	8-1/8 %	14% 1/
Capacity	$149.40/kw-yr	$259.20/kw-yr
Energy	18.9 mills/kwh-yr	18.9 mills/kwh-yr

1/ The effect of increased interest rates is described in Section 6.10.

6.06 Annual Benefits. Project annual benefits were computed for the series of plant sizes shown on Table 3-2. The energy benefit is the product of the annual energy output and the adjusted energy value. Likewise, the capacity benefit is the product of the dependable capacity and the adjusted capacity value. Therefore, the total annual benefit is the sum of the capacity and energy benefits.

Table 6-4 summarizes annual costs and benefits for plant sizes investigated for Site D. These costs and benefits are also shown graphically in Figure 6-1.

TABLE 6-4
ANNUAL COSTS AND BENEFITS
For Project Scoping -- Using Tubular Units
(October 1983 Price levels, $1,000)

Installed Capacity	3.9 MW	7.2 MW	8.5 MW	11.1 MW	12.3 MW	14.4 MW
Number of Units	1	1	2	2	3	3
<u>Generation</u>						
Dep. Capacity MW 1/	1.5	2.4	2.6	3.2	3.5	3.8
Annual Energy Mwh	13,110	21,450	23,430	29,250	31,620	34,890
Plant Factor 2/	38%	34%	31%	30%	29%	28%
<u>Costs</u>						
Annual Cost 3/	760	1,024	1,280	1,500	1,730	1,900
Production Cost 4/ (mills/kwh)	58	48	55	51	55	54
<u>Benefits</u>						
Annual Capacity 5/	305	488	529	651	712	773
Annual Energy 6/	405	663	724	904	977	1,078
Total Annual 7/	710	1,151	1,253	1,555	1,689	1,851
Net Benefits 8/	- 50	127	- 27	55	- 41	- 49
B/C Ratio 9/	0.93	1.12	0.98	1.04	0.98	0.97

1/ From Table 3-1
2/ (Annual Energy, MWh)/(Installed capacity, MW x 8760 hr)
3/ Annual Cost for selected plant from Table 6.3.
4/ (Annual Cost, $)/(Annual Energy, kwh x 1000 mills/$)
5/ (Dependable Capacity) x $203.31/kw-yr
6/ (Annual Energy) x $.0309/kwh
7/ (Annual Cap. Benefit) + (Annual Energy Benefit)
8/ (Annual Benefit) - (Annual Cost)
9/ (Annual Benefit)/(Annual Cost)

6.07 Scoping. The project was scoped using a net benefit analysis. Unit power values were used as described in the preceeding section. Table 6-4, lists the annual costs and the annual benefits for the range of plant sizes used in this analysis. Figure 6-1, shows graphically these costs and benefits. The optimum plant size was then selected based on the maximum net benefit shown on this curve.

Figure 6-1 shows costs and benefits for several different types of powerplants. The selected plant was based on using tubular type units. As described in Section 4, the maximum physical size of the tube type units was limited to a diameter of about 3600 mm. The cost curve on Figure 6-1 for the tube type units is a series of "steps". These steps are the points (7.2 MW and 11.0 MW) on the curve where the largest physical sizes for each plant that can be feasibly developed. The vertical portion of the curve (steps) represents the added cost of an additional unit but with no incremental gain in energy. The curve shows that the largest net-benefit is developed from the single-unit 7.2 Mw plant.

Also shown on Figure 6-1 are the cost curve and benefit curve for a single bulb-unit powerplant. It can be seen that the range of sizes for a bulb-unit is much larger than for a tube-unit. In the initial scoping phase of this project, using October 1982 levels for power values, a larger sized bulb unit plant (16 MW) was optimum and was economically feasible. Since adoption of October 1983 level power values, the bulb unit plant became economically infeasible. However, to provide a measure of comparison the bulb units are represented as supplemental curves on Figure 6-1. The optimum plant size was 16 MW using the original single bulb unit concept. Subsequently, as more detailed costs became available, the two alternative sites (A and D) near the spillway section of the project, a three-unit tubular plant configuration became more economical. These costs and benefits are included in Table 6-5(a) and (b) in Section 6.08.

As discussed in Section 3.02, it was assumed that operation of the new powerplant will be very closely coordinated with the operation of the older existing plant. This is especially important in the operational transition from moderately low flows, when only the old plant will operate, to medium and higher flows, when both new and old plants will be operating. For example, as the river flows increase from a low-flow state to a higher-flow state the new plant will begin to operate; to affect this the old plant will momentarily back down, thereby allowing enough flow to the new plant to permit it to operate at its minimum hydraulic discharge. Once the total river flows increased beyond these minimum transition flows, both old and new plants will then operate at their best efficiencies. This same situation will occur when the streamflows are in a regressive state. It is beyond the scope of this study, to fully evaluate this situation, but an operating agreement between all plant entities will be necessary to accommodate this operating transition. The agreement should be relatively easy to accomplish. For example, an equivalent amount of energy could be credited to the old plant to offset the loss of generation during these periods.

6.08 Comparison of Alternative Powerhouse Locations. Initially four alternative powerhouse locations were investigated. These powerhouse configurations are described in more detail in Section 4.02. Alternatives A and B are located on the left side of the existing powerhouse, while alternative C and D are located on the right side of the existing powerhouse, slightly downstream from the existing spillway (also see Plates 1, 3 and 4). The same head and flow characteristics were used for all of the alternatives.

To provide an economic base of comparison, scoping costs were developed and a net benefit analysis was made. Tables 6-5(a) and 6-5(b) lists the economic summary for the alternative locations based on the 7.2 MW selected plant size and a 16.0 MW plant. The 16.0 MW plant was used because it was the optimum size for a bulb unit. However, three-unit tubular plants were used for Sites C and D to develop the 16-megawatt capacity because of limitations on the foundation excavation. It can be seen from the cost curve (Figure 6-1) that costs for the single bulb unit plant are slightly higher than the 3-unit tubular plant.

TABLE 6-5(a)
ECONOMIC SUMMARY
ALTERNATE POWERHOUSE LOCATIONS
(x $1,000)

	Location A Left Abutment (Surface Powerhouse)		Location B Left Abutment (Underground Powerhouse)	
Physical Data				
Plant Size	16.0 MW	7.2 MW	16.0 MW	7.2 MW
No. Units	1	1	1	1
Type Units	Bulb	Tubular	Bulb	Tubular
Cost (x$1,000)				
Powerplant Equipment 2/	6,935	3,384	6,935	3,384
Items Exclusive 2/	9,012	4,893	10,101	6,240
Construction Cost	15,947	8,277	17,036	9,624
Contingencies 5/	2,842	1,487	3,060	1,756
Subtotal	18,789	9,764	20,096	11,380
Inflation Adjust. 6/	-1,704	- 639	-1,094	- 669
Subtotal	17,085	9,125	19,002	10,711
ED S, & A 7/	2,050	1,095	2,280	1,285
Subtotal	19,135	10,220	21,282	11,996
Loss of Existing Gen. 3/	1,526	1,526	21,282	0
Subtotal	20,660	11,746	21,282	11,996
IDC 8/	2,895	1,602	2,962	1,508
Investment Cost	23,555	13,348	24,243	13,504
Land Adjust.	50	50	50	50
Total Investment Cost	23,605	13,398	24,293	13,554
I&A 9/	1,919	1,089	1,975	1,102
O&M 10/	128	86	128	86
Replacement 11/	10	6	10	6
Total Annual Cost	2,057	1,181	2,113	1,194
Total Annual Benefit 12/	2,001	1,151	2,001	1,151
Net Benefit	- 56	- 30	-112	- 43
B/C Ratio	0.97	0.97	0.95	0.96

Footnotes: See next page

TABLE 6-5(b)
ECONOMIC SUMMARY
ALTERNATE POWERHOUSE LOCATIONS
(x $1,000)

	Location C Right Side Powerhouse (Adjacent)		Location D Right Side Powerhouse (Offset)	
Physical Data				
Plant Size	16.0 MW	7.2 MW	16.0 MW	7.2 MW 1/
No. Units	3	1	3	1
Type Units	Tubular	Tubular	Tubular	Tubular
Cost				
Powerplant Equipment 2/	7.982	3,384	8,037	3,384
Items Exclusive 2/	8.198	4.980	8.625	4.628
Construction Cost	16,180	8,364	16,662	8,012 4/
Contingencies 5/	2,837	1,504	2,931	1,434
Subtotal	19,017	9,868	19,593	9,446
Inflation Adjust. 6/	- 828	- 502	- 933	- 501
Subtotal	18,189	9,366	18,660	8,945
ED S, & A 7/	2.183	1.124	2.239	1.073
Subtotal	20,372	10,490	20,899	10,018
Loss of Existing Gen.	1,546	1,546	0	0
Subtotal	21,918	12,036	20,899	10,018
IDC 8/	2.547	1.684	2.995	1.402
Investment Cost	24,465	13,720	23,894	11,420
Land Adjust.	50	50	50	50
Total Investment Cost	24,515	13,770	23,944	11,470
I&A 9/	1.993	1,119	1,946	932
O&M 10/	128	86	128	86
Replacement 11/	13	6	13	6
Total Annual Cost	2,134	1,211	2,087	1,024
Total Annual Benefit 12/	1,950	1,151	1,950	1,151
Net Benefit	-184	- 60	-137	127
B/C Ratio	0.91	0.95	0.93	1.12

Footnotes: See next page

1/ Selected plant all cost data taken from Table 4-1.

2/ Alternative D from detailed cost Table 4-1, alternatives A B, and C proportioned from scoping costs.

3/ Alternative A and C cause partial shut-down of existing plant during construction. For loss of generation (disbenefits) see Appendix C.

4/ Total detailed construction cost of selected plant for alternative D (Table 4-1); for alternatives A, B and C scoping costs used.

5/ For alternative D, 15% of powerplant equipment items 2 and 3 (Table 4-1), 20% of items exclusived of powerplant equipment; for alternatives A, B and C contingencies proportioned accordingly.

6/ For alternative D from Table 6-1; for alternatives A, B and C proportioned.

7/ Engineering, design, supervision, and administration; use 12%.

8/ Interest during construction; for alternative D compound interest to midyear of construction (also see Section 6.02); alternatives A, B and C proportioned accordingly.

9/ Interest and amortization; 8-1/8 percent for 100 years.

10/ Operation and Maintenance, see Section 6.04.

11/ Replacement, see Section 6.04.

12/ See Section 6.06.

From Table 6-5(a) and 6-5(b) it can be seen that the one-unit tubular plant at Site D is the best site based on economics. Site D is also economically feasible for a two-unit, 11 megawatt development (see Figure 6-1); however, the net-benefit will be lower. Alternative locations A and C will cause loss of generation at the Ford plant during the construction phase. Alternative location B (underground) may create foundation problems; also the high cost of tunneling and evacuation make this location prohibitive. Alternate location D, by being offset 69 feet to the right of the Ford plant, will not cause any loss of generation during construction. The loss of generation during construction could be significant factor in the economic analysis. When additional design data becomes available, a two-unit larger capacity plant could become more desirable -- or one of the other alternatives could be selected.

6.09 Comparision: Summertime vs. Wintertime Dependable Capacity. As discussed earlier, project benefits were derived from the average annual energy and the dependable capacity of the plant.

The dependable capacity is based on the hydro project's performance in the months of peak power demand. While the region experiences both summer and winter peaks, the summer peak is somewhat higher at the present time, and it is expected to become more predominent as the region's air conditioning demand grows. For these reasons, FERC recommended that dependable capacity be based on project output in the months of July and August. However, to compare the two seasons, a sensitivity analysis was made to determine the impact of basing dependable capacity on the project's performance during the winter peak demand months of December and January. Table 6-6 shows the project benefits for the selected plant sizes for each site.

TABLE 6-6
ANNUAL BENEFIT COMPARISON
SUMMERTIME vs WINTERTIME PEAK, $1,000
(For selected 7.2 MW pl·.nt)

	July-August1/ Critical Months ($1,000)	December-January Critical Months ($1,000)
Energy Benefit	663	663
Dependable Capacity	2.4 MW	0.71 MW
Capacity Benefit	488	144
Total Benefit	1,151	807
Net Benefit	127	-217

1/ All values from Table 6-4.

Table 6-6 shows that the dependable capacity based on the winter months would be less than half that of the summer months. Further, if the capacity benefit is combined with the energy benefit, the total benefit would be reduced nearly one-third. The net benefits would be substantially reduced so that the project would be economically infeasible. Again, this comparison is only a sensitivity test to provide additional information for the marketability analysis. The appropriate critical load months for determining dependable capacity are July and August.

6.10 Comparison: Interest Rates and Periods of Economic Analysis. The economic analysis used in this study was based on the Federal Interest Rate of 8 1/8 percent and a project life of 100 years. To evaluate the effect at higher interest rates and shorter economic life, analyses were made at 14-percent and at a 50-year project life. Project economic value were developed and are presented in Table 6-7 below. These values are intended for sensitivty and are supplemental to the general economic analysis of the project. The values are listed only for the 7.2 megawatt select plant D. Also only two interest rates and two periods of economic analysis are used; the effect at other interest rates or economic periods may be determined by interpolation.

TABLE 6-7
COMPARISON: INTEREST RATES AND PERIODS OF ECONOMIC ANALYSIS
(for 7.2 MW selected size, Site D)

Interest Rate	Annual 1/ Cost ($1000)	Annual 1/ Benefit ($1000)	Net Benefit ($1000)	B/C Ratio
100-Yesr Period of Analysis				
8 1/8%	$1,024	$1,151	127	1.21
14%	1,850	1,505	- 345	0.81
50-Year Period of Analysis				
8 1/8%	$1,043	$1,151	108	1.10
14%	1,852	1,505	- 347	0.81

1/ Costs for 8 1/8% and 100-year life from Table 6-3; other costs developed from using appropriate interest rates and periods of analysis.

2/ Benefits for 8 1/8% from Table 6-4; Benefits for 14% based on adjusted power values Section 6.05.

6.11 Marketability. Generation from the project would appear to be marketable. Because the project is relatively small, a thorough marketing analysis is not required. Discussions with Chicago office of the Federal Energy Regulatory Commission indicate that the generation can be readily absorbed into the area power load. The region's electric load is supplied through the Mid-America Power Pool (MAPP). Of the many utilities that supply MAPP, there are several relatively large cooperative utilities who are preference customers and indicate need for future generation in their systems.1/ Preliminary discussions with DOE's office of Power Marketing and Coordination indicate that the generation can be marketed through DOE (see phone log dated 9 May 1983 in Appendix C). A formal marketability statement from DOE will be included in the feasibility report, confirming that the power from the recommended projects can be marketed and that costs can be repaid with interest in 50 years, as required by the 1944 Flood Control Act. Because the recommended project is smaller than 80 MW, the marketability statement will also serve to confirm the need for future generation.2/

Figure 6-3, shows the annual distribution of energy at the project. The figures show that the spring and early summer months produce the major portion of energy; however the summer to early winter months do produce a substantial amount of energy. Only during the peak winter months (Dec, Jan, Feb) would the energy production be substantially reduced.

1/ Department of Energy, Power Marketing: Great Lakes Area (Draft), January 1981, Chapter, III.

2/ Water Resources Counsel, Procedures for Evaluation of National Economic Development Benefits in Water Sources Planning (Level C), Section 713.601.

SECTION 7 - CONCLUSION

Additional power generation at Lock and Dam Number 1 on the Mississippi was analyzed using the existing project streamflows. The existing powerplant, built in 1924 by the Ford Motor Company, has been in operation continually since that time. The old plant has an installed capacity of 14.4 megawatts and operates at an annual plant factor about 75 percent. A basic assumption for the analysis in this report was that the new plant will not alter the existing plant's operation; therefore, the new plant will operate only during times when there is sufficient river flows for the existing plant to operate.

Four alternative powerhouse sites were investigated -- two on each side of the existing powerhouse. The selected plant is a single-unit tubular type located 69 feet to the right of the existing Ford plant within the spillway section. An access bridge is required to connect the new plant with the Ford plant. The selected plant size is 7.2 megawatts and the annual energy output is 21,450,000 kwh.

The total NED investment cost for the plant will be $11,470,000 while the annual cost will be $1,024,000. The project is economically feasible with a benefit-to-cost ratio of 1.12.

The generation will be marketable in the present power system. The power system is located in the Mid-American Power Pool (MAPP). Several large cooperatives utilities (preference customers) are members of MAPP.

While the project is relatively small, it can make a contribution to the regional power needs. As a measure of comparison the total project energy would produce the equivalent need for about 3,200 residential homes in the area.1/

1/ Based on U.S. Department of Energy Publication Statistics of Privately Owned Electrical Utilities in the United States - 1980 annual residential usage of 6,800 kwh.

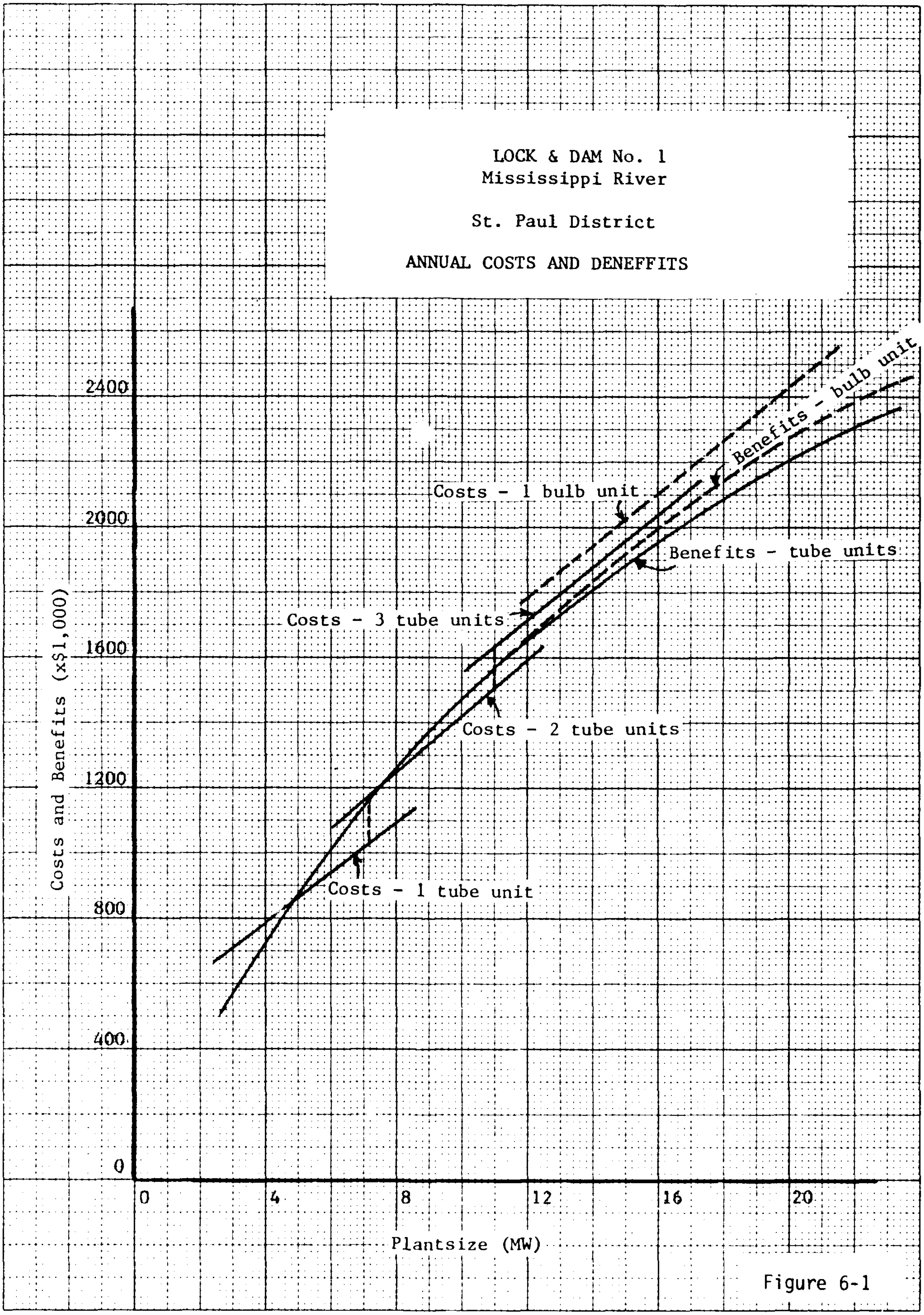

LOCK & DAM No. 1
Mississippi River
St. Paul District
ANNUAL COSTS AND DENEFFITS
Costs and Benefits (x$1,000)
Plantsize (MW)
Benefits - bulb unit
Costs - 1 bulb unit
Benefits - tube units
Costs - 3 tube units
Costs - 2 tube units
Costs - 1 tube unit
0
400
800
1200
1600
2000
2400
4
8
12
16
20

Figure 6-1

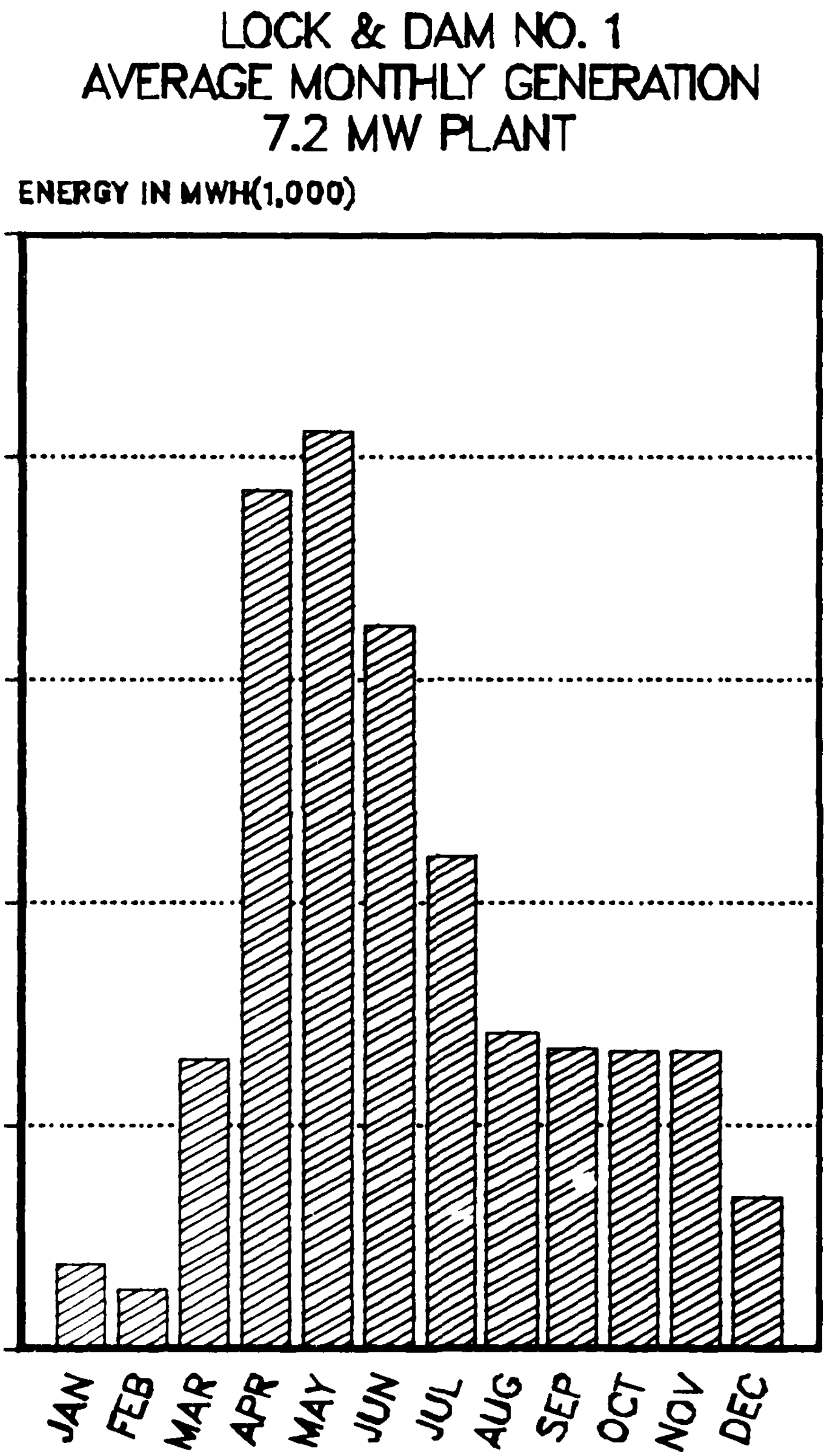

LOCK & DAM NO. 1
AVERAGE MONTHLY GENERATION
7.2 MW PLANT
ENERGY IN MWH(1,000)
5
4
3
2
1
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 6-2

APPENDIX A

DETAILED COST ESTIMATES FOR ITEMS EXCLUSIVE OF POWERPLANT

(prepared by St. Paul District)

COMPUTATION SHEET

St. Paul District | COMPUTATION [redacted] Hydropower L/D #1 | DATE Feb 83 | PAGE

PRICE LEVEL

COMPUTED BY PJW | CHECKED BY Plant "A" 20 MW | APPROVED BY Plant "B" 30 MW

	Unit	Quantity	Unit Cost	Total	Quantity	Unit Cost	Total
Upstream Channel							
Rock Excavation Cut	CY	6080	25.00	[illegible]	3840	25.00	96000
Rock Excav. (Tunnel)	CY	4960	100.00	496000	8850	100.00	885000
Riprap	CY	410	30.00	12300	240	30.00	7200
Gravel Filter	CY	310	10.00	3100	180	10.00	1800
4' Remove Exist Conc Wall	SF	3875	4.50	17,438	2100	4.50	9450
Install New Conc T.B. Wall	SF	4800	13.85	66,480	—	—	—
Powerhouse Excavation							
Cavern, Rock Excav	CY	8750	45.00	393750	9450	45.00	425250
Downstream Excavation							
Rock Excav. Open Cut	CY	9140	25.00	228500	9100	25.00	227500
Tunnel, Rock Excav.	CY	—	—	—	4870	100.00	487000
Riprap	CY	330	30.00	9900	440	30.00	13200
Filter	CY	250	10.00	2500	330	10.00	3300
Remove Exist Conc Wall	CY	3540	3.50	12,390	1680	3.50	5880
Install New Conc T.B. Wall	SF	6355	13.85	88,017	2160	13.85	29,916
Cofferdam							
Upstream 2 Sides	Ea	5	58,800	294000	3	58,800	176400
Downstream	Ea	7	44,000	308000	3	44,000	132000
Dewatering	Job	Sum	* * *	1,250,000	Job	* * *	1,250,000
Site Work							
Remove 5" Conc. Roadway	SF	2600	0.75	1950	900	0.75	675
Install 3" Bit. Roadway	SF	4200	0.80	3360	900	0.80	3360
Sub-Total				3,339,685			3,753,931
Contingencies (25%)				835,315			938,069
Total				4,175,000			4,692,000
Tunnel Liner	~~[illegible]~~/LF 5400/L						

NCD Form 15 2k Dec 79

COMPUTATION SHEET

NAME OF OFFICE	COMPUTATION	DATE	PAGE OF PAGES
St. Paul District	[redacted] Hydropower L/D #1	Feb 83	

SUBJECT

PRICE LEVEL: Current

COMPUTED BY: PJW

CHECKED BY: Plant "A"

APPROVED BY: Plant "B"

	Unit	Plant "A" Quantity	Plant "A" Unit Cost	Plant "A" Total	Plant "B" Quantity	Plant "B" Unit Cost	Plant "B" Total
Upstream Channel							
Rock Excavation (Open cut)	cy	3940	25.00	98,500	960	35.00	33,600
Rock Excavation (Tunnel)	cy	2740	100.00	274000	4870	100.00	487,000
4" Remove Exist Conc Wall	SF	3100	4.50	13,950	1240	4.50	5,580
New Concrete Tie Back Wall	SF	2690	13.85	37,257	—	—	—
Powerhouse Excavation:							
Cavern Rock Excavation	cy	6670	45.00	300,150	7370	45.00	331,650
Downstream Excavation							
Rock Excavation (open cut)	cy	3980	25.00	99,500	830	35.00	29,050
Rock Excavation (Tunnel)	cy	—	—	—	2700	35.00	94,500
Remove Exist Concrete Wall (3' thick)	SF	2065	3.50	7228	1050	3.50	3675
New Concrete Tie Back Wall	SF	2255	13.85	31,232	1350	13.85	18,698
Cofferdams							
Upstream Steel Pile cells	Ea.	4	58,800	235200	2	58800	117600
D.S. "	Ea	5	58800	294,000	2	58800	117600
Dewatering	Job	Sum	***	1,250,000	Job	***	1,250,000
Site Work							
Remove 5" Concrete Roadway	SF	2200	0.75	1650	600	0.75	450
New 3" Bit Roadway	SF	3800	0.80	3040	600	0.80	480
				2,645,707			2,489,885
Contingencies		25%		664,293			625,115
				3,310,000			3,115,000
Tunnel Liner 3900.00/LF							

NCS Form 22 Dec 75

COMPUTATION SHEET 7628

OF OFFICE St. Paul District	COMPUTATION Hydropower L/D #1	DATE Feb 83	PAGE OF PAGES	
SUBJECT	1-3600 MM tube Site A			
	≈ 7.2 MW	PRICE LEVEL Current		
COMPUTED BY PJ	CHECKED BY Plant "A"	APPROVED BY		

	Unit	Quantity	Unit Cost	Total	Quantity	Unit Cost	Total
Upstream Channel	101,200 "						
Rock Excavation	~~cy~~	~~3940~~	~~25.00~~	~~98,500~~	960	35.00	33,600
(Open cut)	cy	2000	25	50,000			
25x26 Rock Excavation (Tunnel)	cy	~~2740~~	~~100.00~~	~~274,000~~	4870	100.00	487,000
4' Remove Exist Conc Wall	~~SF~~	~~3100~~	~~4.50~~	~~13,950~~	1240	4.50	5580
New Concrete Tie Back	SF	660	4.50	3000			
Wall + Channel	~~SF~~	~~2690~~	~~13.85~~	~~37,257~~	—	—	—
		ITEMIZED		197,800			
Powerhouse Excavation:							
Common Rock Excavation	~~cy~~	~~6690~~	~~45.00~~	~~300,150~~	7370	45.00	331,650
Open Rock Excavation	cy	6114	25	152900			
Downstream Excavation							
Rock Excavation	cy	1666	25	41,600			
(open cut)	~~cy~~	~~3980~~	~~25.00~~	~~99,500~~	830	35.00	29050
Rock Excavation (Tunnel)	cy	—	—	—	2700	35.00	94,500
Remove Exist. Concrete							
Wall (3' thick)	SF	2065	3.50	7228	1050	3.50	3675
New Concrete Tie-Back							
Wall	SF	2255	13.85	31,232	1350	13.85	18,675
Cofferdams							
		2	58,800	117,600			
Upstream Sheet Pile Cells	Ea	~~4~~	~~58,800~~	~~235,200~~	2	58800	117,600
~~D.S. " " "~~	~~Ea~~	~~4~~	~~58,800~~	~~294,000~~	2	~~58800~~	117,600
Dewatering	Job	Sum	* * *	1,250,000	Job	* * *	1,250,000
D.S. Sheet Pile Cells	EA	4	36,000	144,000			
Site Work							
Remove 5" Concrete							
Roadway	SF	2200	0.75	1650	600	0.75	450
New 3" Bit. Roadway	SF	3800	0.80	3040	600	0.80	480
				1,955,000	←		
				~~2,645,707~~			2,489,585
Contingencies	~~25%~~			~~664,293~~			625,117
				~~3,310,000~~			3,115,000
~~Tunnel Liner~~	~~3900.00/LF~~						

NCS Form 15 22 Dec. 75

COMPUTATION SHEET

NAME OF OFFICE: St. Paul District

COMPUTATION:

DATE: May 83

PAGE:

SUBJECT: L/D #1 Hydropower (2nd Iteration)

PRICE LEVEL: May 83

COMPUTED BY: FTW

CHECKED BY:

APPROVED BY:

	UNIT	QUANT.	UNIT PRICE	TOTAL
Upstream Channel				
Rock Excavation (open cut)	CY	4680	25.00	117,000
Rock " (Tunnel)	CY	6090	100.00	609,000
Remove exist Conc. Wall	SF	3100	4.50	13,950
New Conc. Tie Back Wall	SF	960	23.00	22,080
Powerhouse Excavation				
Cavern Rock Excavation	CY	12000	45.00	540,000
Downstream Channel				
Rock Excavation (open cut)	CY	3230	25.00	80,750
" " (Tunnel)	CY	2300	100.00	230,000
New Concrete Tie Back Wall	SF	3200	14.00	44,800
Cofferdams				
Upstream - Sheet Pile Cells	Ea	5	60,000	300,000
Earth Cofferdam	CY	1840	7.00	12,880
Downstream Sheet Pile Cells	Ea	4	60,000	240,000
Earth Cofferdam	CY	2460	7.00	12320
Dewatering	Job	Sum		1,250,000
[illegible]				
[illegible] Gallery	SF	1440	1.00	1440
[illegible] Road	SF	240	8.00	1920
[illegible] Wall	SF	2400	14.00	33,600
Sub-Total				3,324,400
Contingencies				995,000
Total				3,980,000

[illegible] Tunnel × [illegible] 60 [illegible] 500,000/[illegible]

HQ Form [illegible] Dec 73

3,980,000

Background 27 Mar 84

Tunnel Liner

300' long tunnel

20 MW 5400 $/ft

Previous Method 2134 · 2 · 350 = 1,493,800

New Method 390 · 5400 = 2,106,000

Question

10 MW 3900 $/ft

Previous 2134 · 350 = 746,900

New 390' x 3900 $/' = $1,521,000

Question!

13.5 MW

@ rate = 3900\5400

= 4400 $/Foot

X 390' x 4400 = 1,716

Cost Estimate Revision

★

Total Cost of Tunnel Compairson, Distri

FEATURE	Quan	U. Cost	Total Cost	
Tunnel Liner	230	2650	609,500	Upstream
Cavern Excavation	12000	45	540,000	
Po. [illegible] Tunnel	6090	70	426,300	
"	140	2650	371,000	Downstre
"	3785	70	265,000	
			2,211,800	

179,006

2650

Liner 3000.00/foot

$\frac{28' \pi \cdot 2}{27} = 6.54$ cy/foot

$\frac{3000}{6.54} = \cancel{440}$ 400

$13.487 + (21.418 - 13.48$

$= \underline{16.26}$ mill

1.

17.5

1.

18.8

30.5' ϕ π [illegible]/4 = 730.6 SF

26.5' ϕ

$\frac{27{,}000}{730.6} = 225$

$\frac{7300}{[illegible]} = 270$

90.5 π 95 sf/foot

★ Total Cost of Tunnel Comparison, Geologist:

FEATURE	QUAN.	U. COST	TOTAL COST
Sidewall Treat	230	480.00	110,400.00
Shaft Removal	12,000	30.00	360,000.00
Horz. Removal	6090	10.00	60,900.00
Sidewall Treat	140	480.00	67,200.00
Horz. Removal	3785	10.00	37,900.00
			636,400.00

★ Total Cost of Tunnel Compairson, Cost Curve:

unit Cost
1980 w/Concrete Lining
3700 × (140 + 230) = 1,369,000
inflation increase (8%)
1369 000 $(1.08)^{3\,years}$ = 1,724,500.00

COMPUTATION SHEET

Name of Office	Computation	Date	Page
St. Paul District	Hydropower L/D #1	Feb 83	of pages

Subject: 10 / 1

Price Level: Current

Computed by: PJK — Checked by: Plant "A" — Approved by: Plant "B"

	Unit	Quantity	Unit Cost	Total	Quantity	Unit Cost	Total
Upstream Channel							
Rock Excavation (Open cut)	cy	3940	25.00	98,500	960	35.00	33,600
Rock Excavation (Tunnel)	cy	2740	100.00	274,000	4870	100.00	487,000
Remove Exist. Conc. Wall	SF	3100	4.50	13,950	1240	4.50	5,580
New Concrete Tie Back Wall	SF	2690	13.85	37,257	—	—	—
Powerhouse Excavation:							
Cavern Rock Excavation	cy	6670	45.10	300,150	7370	45.00	331,650
Downstream Excavation							
Rock Excavation (open cut)	cy	3980	25.00	99,500	830	35.00	29,050
Rock Excavation (Tunnel)	cy	—	—	—	2700	35.00	94,500
Remove Exist. Concrete Wall (3' thick)	SF	2065	3.50	7228	1050	3.50	3675
New Concrete Tie-Back Wall	SF	2255	13.85	31,232	1350	13.85	18,698
Cofferdams							
Upstream Sheet Pile Cells	Ea	4	58,800	235,200	2	58800	117,600
D.S. " " "	Ea	5	58,800	294,000	2	58800	117,600
Dewatering	Job	Sum	***	1,250,000	Job	***	1,250,000
Site Work							
Remove 5" Concrete Roadway	SF	2200	0.75	1650	600	0.75	450
New 3" Bit. Roadway	SF	3800	0.80	3040	600	0.80	480
				2,645,707			2,489,883
Contingencies	25%			664,293			625,117
				3,310,000			3,115,000
Tunnel Liner 3900/LF							

COMPUTATION SHEET

Red District | COMPUTATION [redacted] Hydropower L/D #1 | DATE Feb 83 | PAGE

PRICE LEVEL

COMPUTED BY FJw | CHECKED BY Plant "A" 20 MW | APPROVED BY Plant "B" 25 MW

	Unit	Quantity	Unit Cost	Total	Quantity	Unit Cost	Total
Upstream Channel							
Rock Excavation Open Cut	CY	6080	25.00	152000	3840	25.00	96000
Rock Excav. (Tunnel)	CY	4960	100.00	496000	8850	100.00	885000
Riprap	CY	410	30.00	12300	240	30.00	7200
Gravel Filter	CY	310	10.00	3100	180	10.00	1800
4' Remove Exist Conc Wall	SF	3875	4.50	17438	2100	4.50	9450
Install New Conc T.B. Wall	SF	4800	13.85	66480	—	—	—
Powerhouse Excavation							
Cavern Rock Excav	CY	8750	45.00	393750	9450	45.00	425250
Downstream Excavation							
Rock Excav. Open Cut	CY	9140	25.00	228500	9100	25.00	227500
Tunnel Rock Excav.	CY	—	—	—	4870	100.00	487000
Riprap	CY	330	30.00	9900	440	30.00	13200
Filter	CY	250	10.00	2500	330	10.00	3300
3' Remove Exist Conc Wall	CY	3540	3.50	12390	1680	3.50	5880
Install New Conc T.B. Wall	SF	6355	13.85	88017	2160	13.85	29916
Cofferdams							
Upstream Pile Cells	Ea	5	58,800	294000	3	58,800	176400
Downstream "	Ea	7	44,000	308000	3	44,000	132000
Dewatering	Job	Sum	**	1,250,000	Job	**	1,250,000
Site Work							
Remove 5" Conc. Roadway	SF	2600	0.75	1950	900	0.75	675
Install 2" Bit. Roadway	SF	4200	0.80	3360	900	0.80	3360
Sub-Total				3,339,685			3,753,931
Contingencies (25%)				835,315			938,069
Total				4,175,000			4,692,000

3,340,000

Tunnel Liner $400.00/LF

NCS Form 15 27 Dec 73

PAGE 1

COMPUTATION SHEET

NAME OF OFFICE: St. Paul District | COMPUTATION: [redacted] Hydropower L/D #1 | DATE: Feb 83 | PAGE: of PAGES

SUBJECT

PRICE LEVEL: [redacted] Current

COMPUTED BY: PJW | CHECKED: 10 MW | APPROVED: 20 MW

	Unit	Quantity	Unit Cost	Total	Quantity	Unit Cost	Total
Upstream Channel							
Earth Excavation	cy	980	4.00	3920.	1630	4.00	6520.
Riprap	cy	200	30.00	6000.	330	30.00	9900.
Gravel Filter	cy	150	10.00	1500.	250	10.00	2500.
Powerhouse Placement							
Dam Concrete Removal	cy	570	40.00	22800.	1190	40.00	47600.
Apron Concrete "	cy	570	40.00	22800.	1140	40.00	45600.
9" Dia Steel Piles (25')	LF	224	15.00	3360.	464	15.00	6960.
Braced Earth Excav.	cy	4540	12.00	54480.	9070	12.00	108840
6" Conc. Surfacing (Rmt)	SF	1390	30.00	41700.	1390	30.00	41,700.
Downstream Channel							
Earth Excavation	cy	2480	4.00	9920.	3710	4.00	14,840.
Riprap	cy	300	30.00	9000.	440	30.00	13200.
Sand Filter	cy	220	10.00	2200.	330	10.00	3300.
Cofferdams							
Upstream (Steel Pile Cell)	Ea	4	58810	235200.	7	58800	411,600.
Downstream (")	Ea	4	36,000	144000.	7	36,000	252000.
Dewatering	Sum	Job	***	1,200,000	Job	***	1,200,000.
Misc. (Remove plugs, 2 bulkheads, install gates plus oper. machinery, salvage machinery + gates 2 bays)	Sum	Job	***	300,000	Job	***	300,000.
			Sum	2,056,880			2,464,560
Contingencies		25%		513,120			615,440
Total			$	2,570,000			3,080,000

NCS Form 5 22 Dec 75

Steve Larson
St Paul District 8-725-7628

COMPUTATION SHEET

PAGE 1

NAME OF OFFICE: St. Paul District | COMPUTATION: Hydropower L/D #1 | DATE: Feb 83 | PAGE OF PAGES

SUBJECT

3-Tubes | PRICE LEVEL: Current

COMPUTED BY: PTur (JK) (NPD) | CHECKED: 10 MW | APPROVED BY: 14 MW

	Unit	Quantity	Unit Cost	Total	Quantity	Unit Cost	Total
Upstream Channel							
Earth Excavation	cy	920	4.00	3920.	1630	4.00	1520.
Riprap	cy	200	30.00	6000.	330	30.00	9900.
Gravel Filter	cy	150	10.00	1500.	250	10.00	2500.
Powerhouse Placement							
Dam Concrete Removal	cy	570	40.00	22800.	1140	40.00	45600.
Apron Concrete "	cy	570	40.00	22800.	1140	40.00	45600.
9" Dia Wood Piles (25')	LF	224	15.00	3360.	464	15.00	6960.
Braced Earth Excav.	cy	~~4540~~	12.00	~~54480~~	9070	12.00	~~[illegible]~~
6" Conc. Surfacing (Rmt)	SF	1390	30.00	41700.	1390	30.00	41,700.
		5448		65,376	7860		93,[illegible]
Downstream Channel							
Earth Excavation	cy	2480	4.00	9920.	3710	4.00	14,840.
Riprap	cy	300	30.00	9000.	440	30.00	13200.
Gravel Filter	cy	220	10.00	2200.	330	10.00	3300.
Cofferdams							
Upstream (Steel Pile Cell)	Ea	4	58800	235200.	7	58800	411,600.
Downstream (")	Ea	4	36,000	144000.	7	36000	252000.
Dewatering	Sum	Job	***	1,200,000	Job	***	1,200,000
~~Misc. (Remove plugs, 3 stoplogs, Install gates plus oper. machinery, Salvage machinery & gates in 3 bays)~~	~~Sum~~	~~Job~~	~~***~~		Job	***	
				~~2,056,880~~			~~2,[illegible]~~
~~Contingencies~~		~~25%~~		~~513,120~~			~~615,140~~
				1,768,000.00			2,149,320.00
Total				~~2,570,000~~			~~3,080,000~~

Width Raito:
10.0: 138 = 1.20
14.0: 86/100 = 0.86

NCS Form 15 22 Dec. 75

COMPUTATION SHEET COMPUTATION SHEET

NAME OF OFFICE: St. Paul District
COMPUTATION: Hydropower L/D Hydropower L/D
SUBJECT

2 - Tubes

COMPUTED BY: PTew / JKJ (NFO) | CHECKED | APPROVED

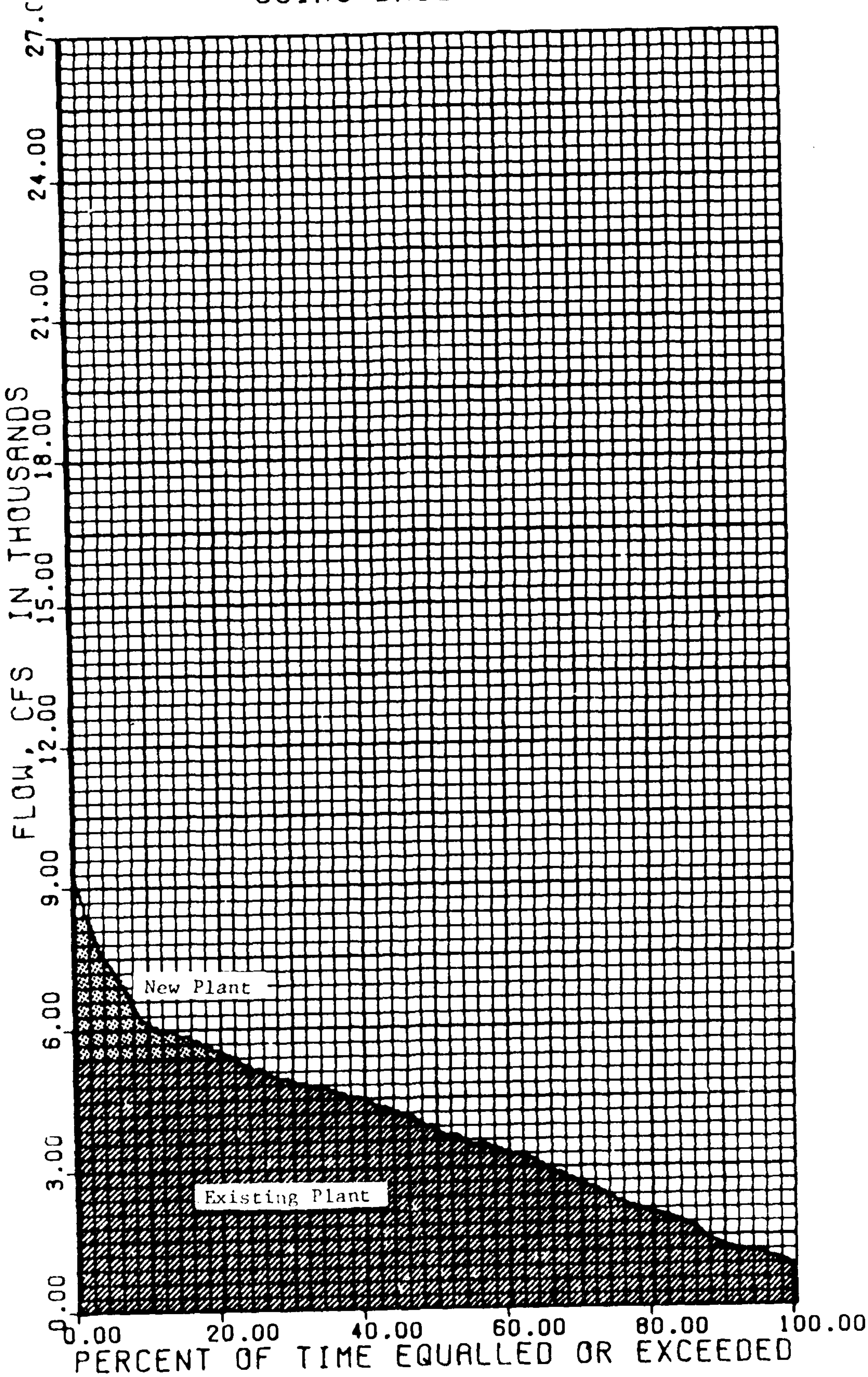
	Unit	6.2 MW Quantity	Unit Cost	Total	9.8 MW Quantity	Unit Cost	Total
Upstream Channel							
Earth Excavation	cy	980	4.00	3920	980	4.00	3920
Riprap	cy	200	30.00	6000	200	30.00	6000
Gravel Filler	cy	150	10.00	1500	150	10.00	1500
Penstock Placement							
Conc. Concrete Removal	cy	570	40.00	22800	570	40.00	22800
Apron Concrete	cy	570	40.00	22800	570	40.00	22800
Cut Sheet Piles	LF	224	15.00	3360	224	15.00	3360
Braced Earth Excav.	cy	~~4540~~	12.00	54480	~~4540~~	12.00	54480
Conc. Surrounding	SF	1390 / 3133	30.00	41700 / 37600	1390 / 3860	30.00	41700 / [illegible]
Downstream Channel							
Earth Excavation	cy	2480	4.00	9920	2480	4.00	9920
Riprap	cy	300	30.00	9000	300	30.00	9000
Gravel Filler	cy	220	10.00	2200	220	10.00	2200
Powerhouse							
[illegible] (Steel tile [illegible])	Ea	4	58800	235200	4	58800	235200
[illegible]	Ea	4	26,000	144000	4	26,000	144000
Generating	Sum	Job	***	1,200,000	Job	***	1,200,000
[illegible] (Remove plugs, 2 stoplogs, install gates plus oper. machinery, bridge machinery & gates on 2 bays)	Sum	Job	***		Job	***	
				~~2,050,880~~			~~2,050,880~~
~~Contingencies~~	25%			~~512,720~~ 25%			~~512,720~~
				1,114,000			1,[illegible]
Total				~~2,570,000~~			~~2,570,000~~

[illegible] .69
[illegible] 1.07

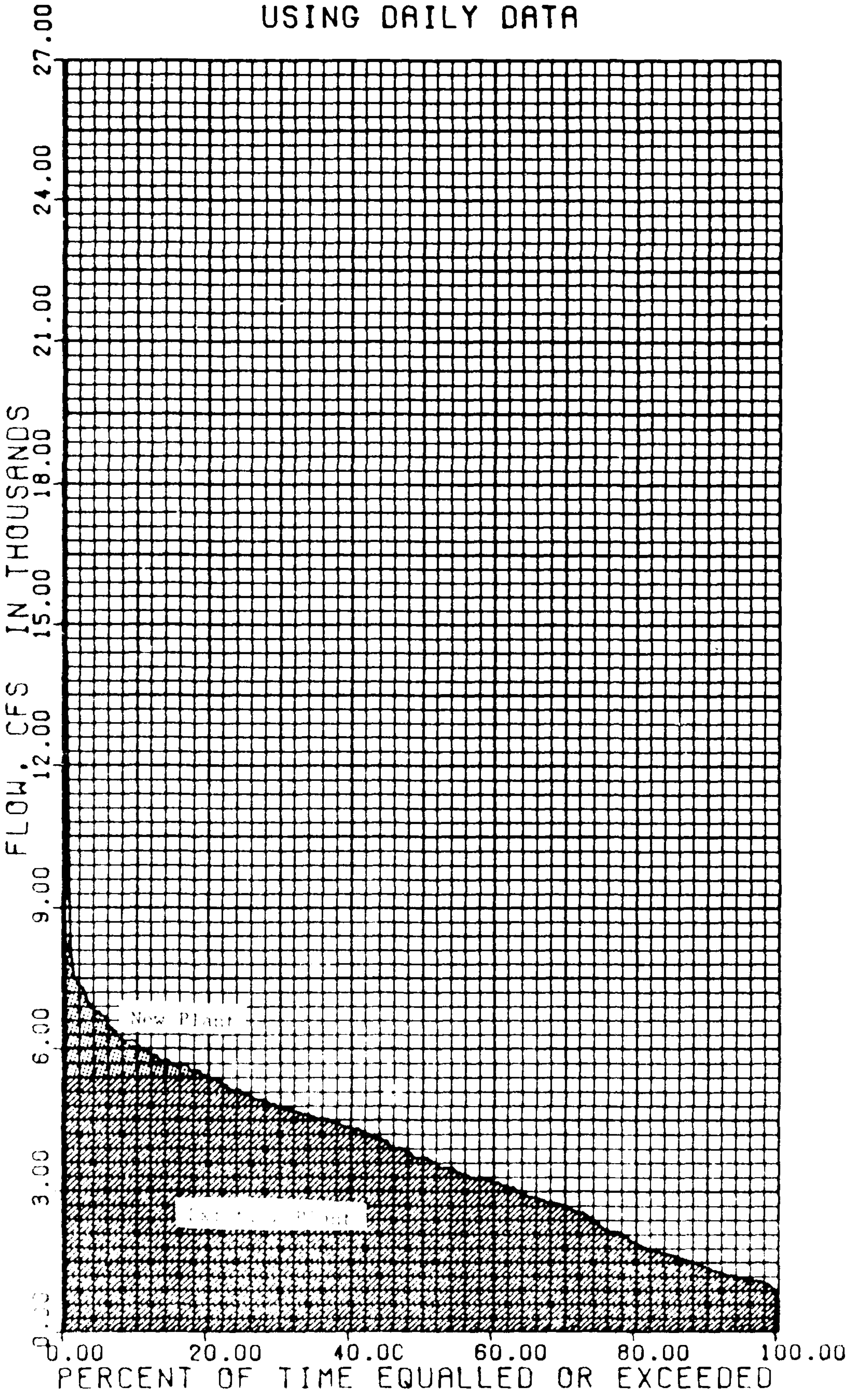
APPENDIX B

MONTHLY FLOW-DURATION CURVES

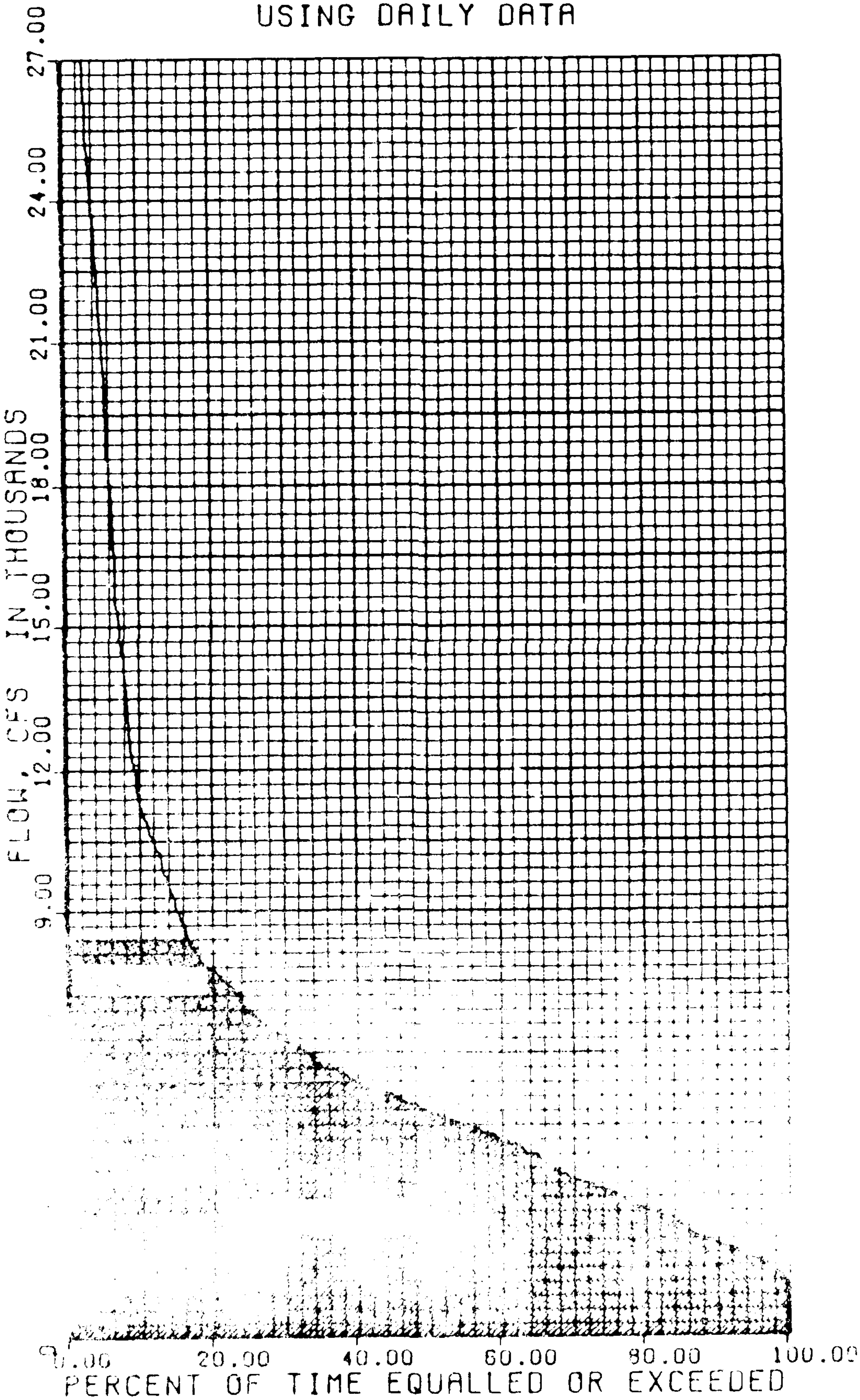
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR JAN
USING DAILY DATA



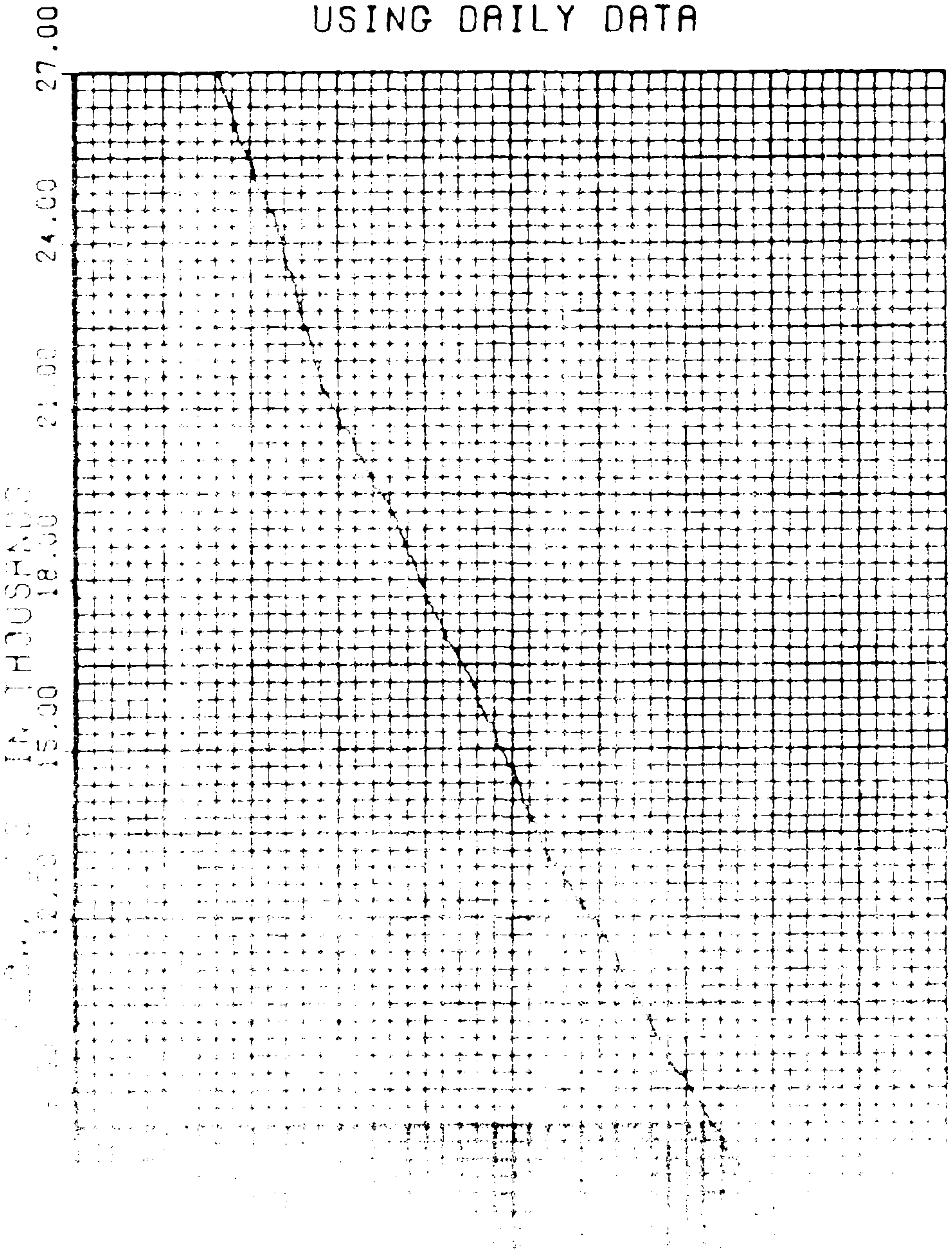
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR FEB
USING DAILY DATA



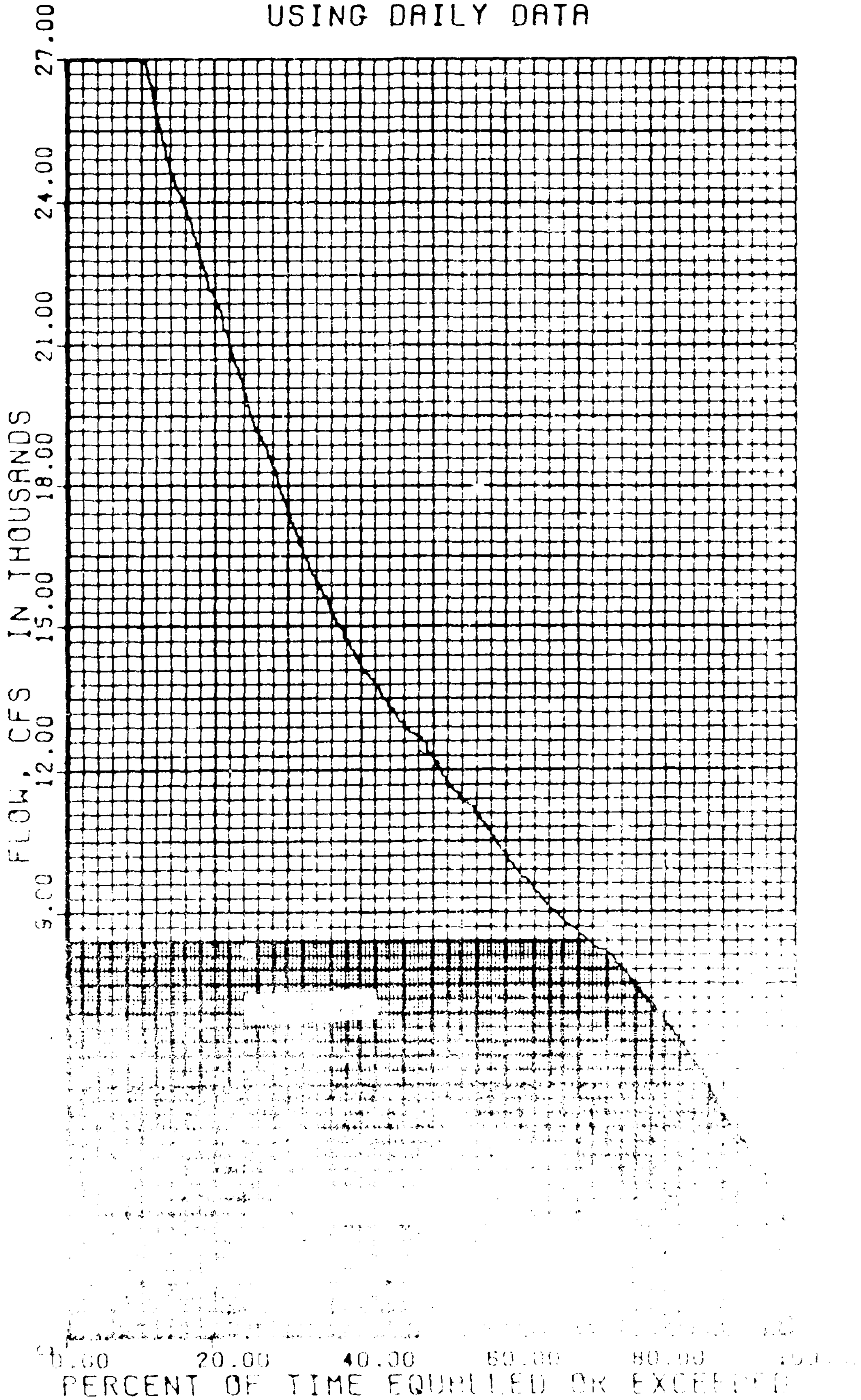
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR MAR
USING DAILY DATA



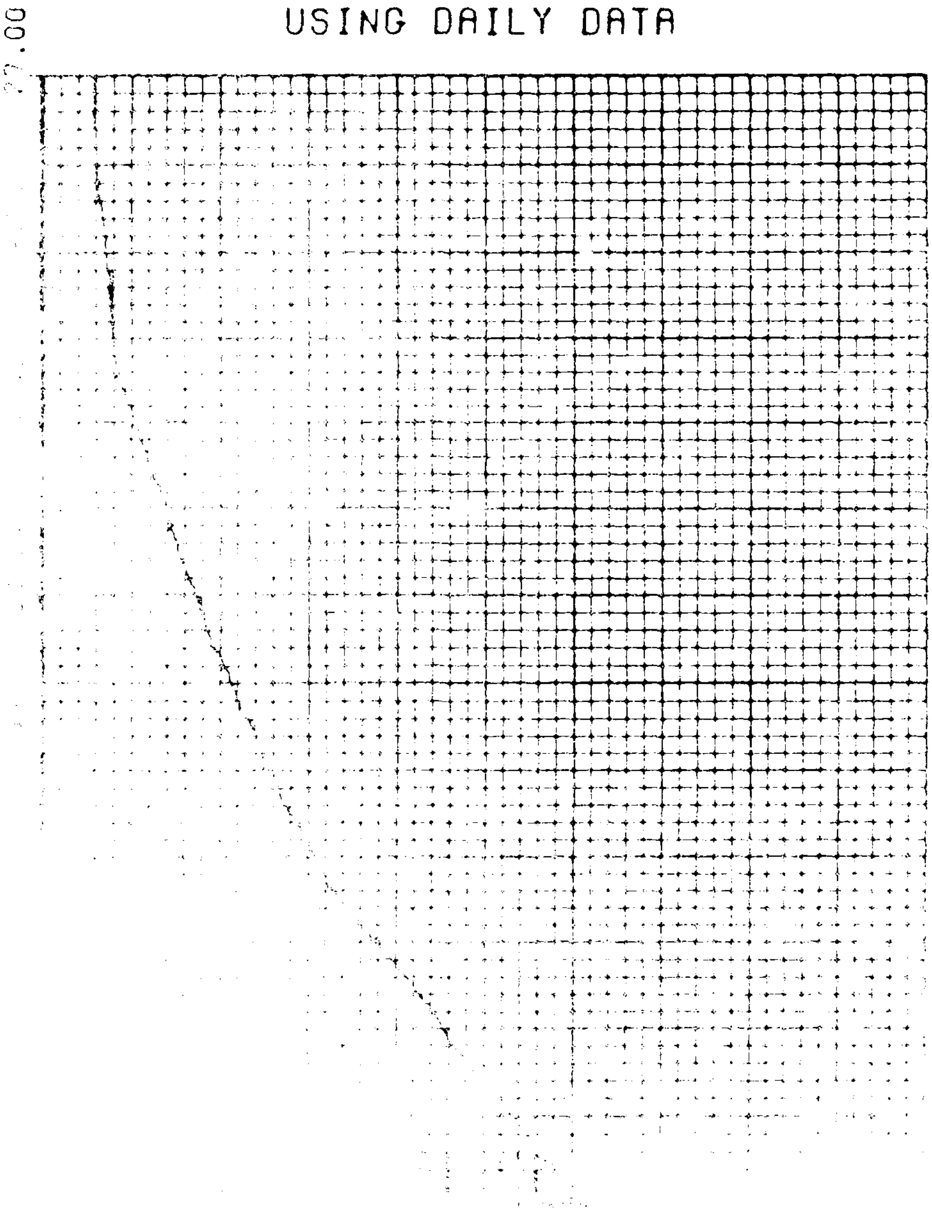
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR APR
USING DAILY DATA



LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR MAY
USING DAILY DATA



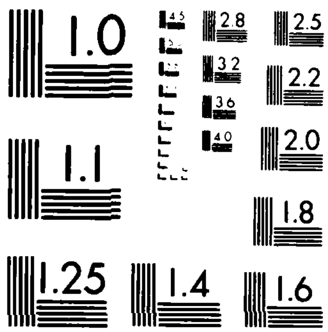
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR JUN
USING DAILY DATA



AD-A149 775 LOCK AND DAM NUMBER 1 HYDROPOWER STUDY MISSISSIPPI RIVER AT MINNEAPOLIS-ST PAUL MINNESOTA(U) CORPS OF ENGINEERS PORTLAND OREG NORTH PACIFIC DIV OCT 84 2/2

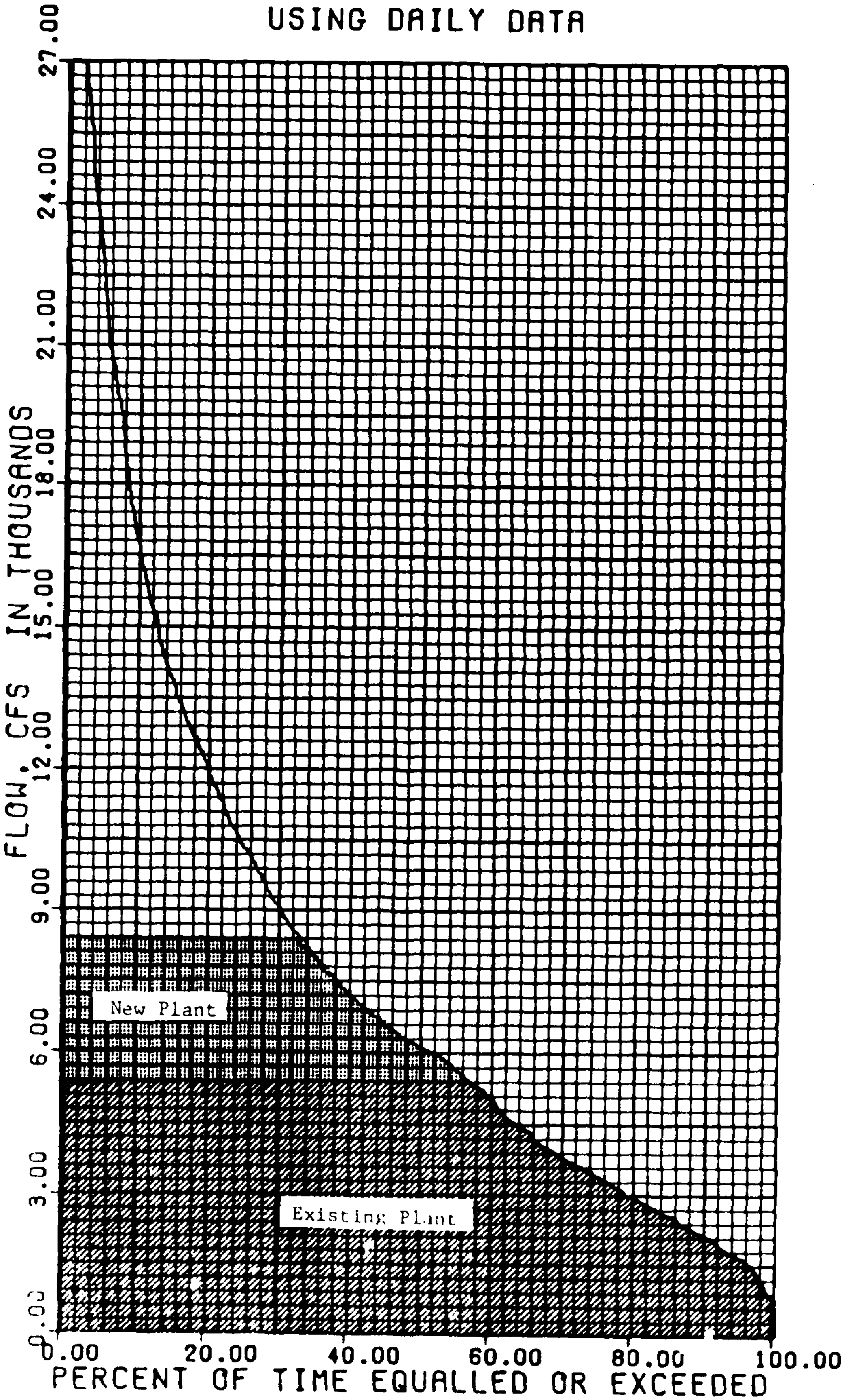
UNCLASSIFIED F/G 10/2 NL

END

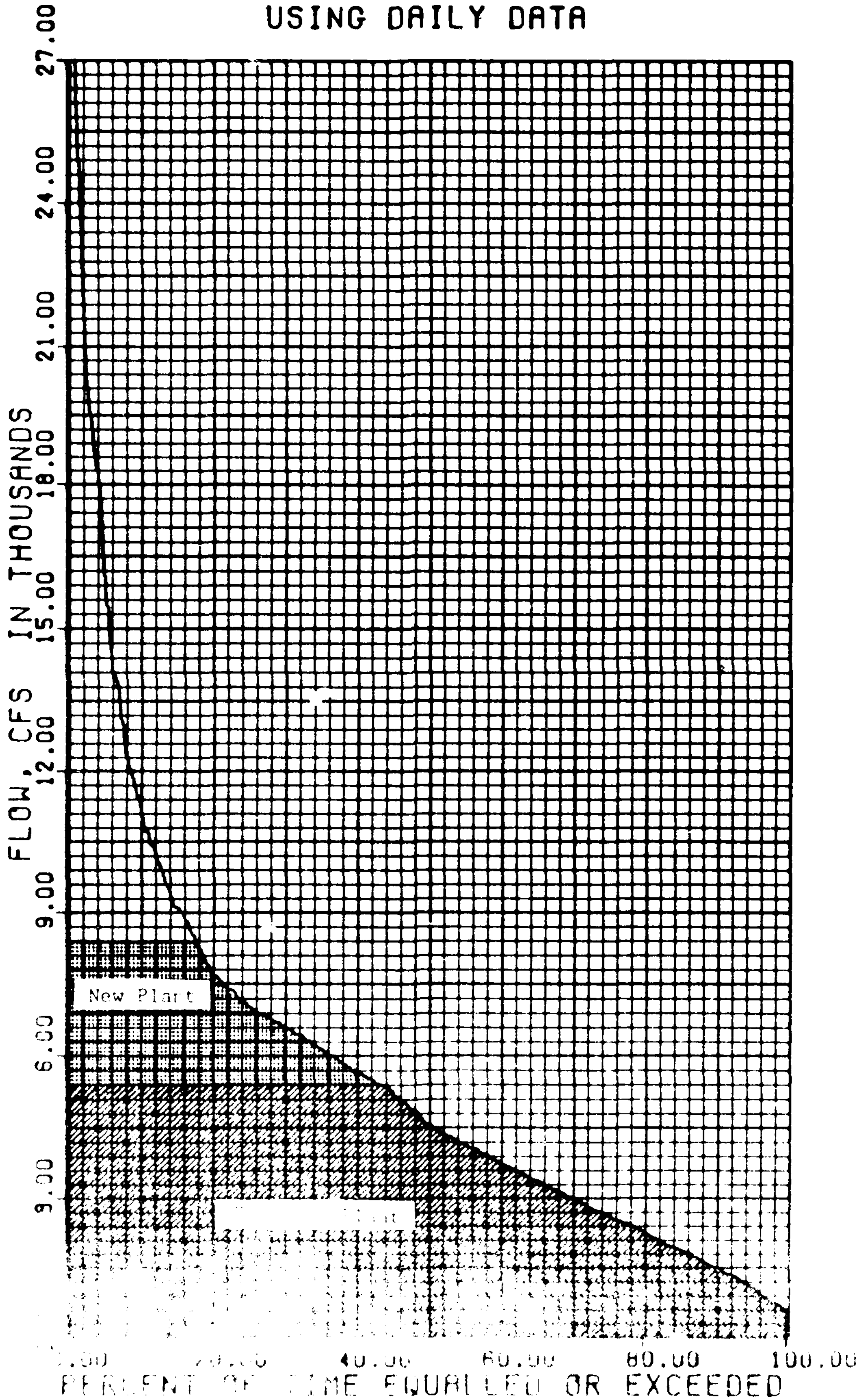


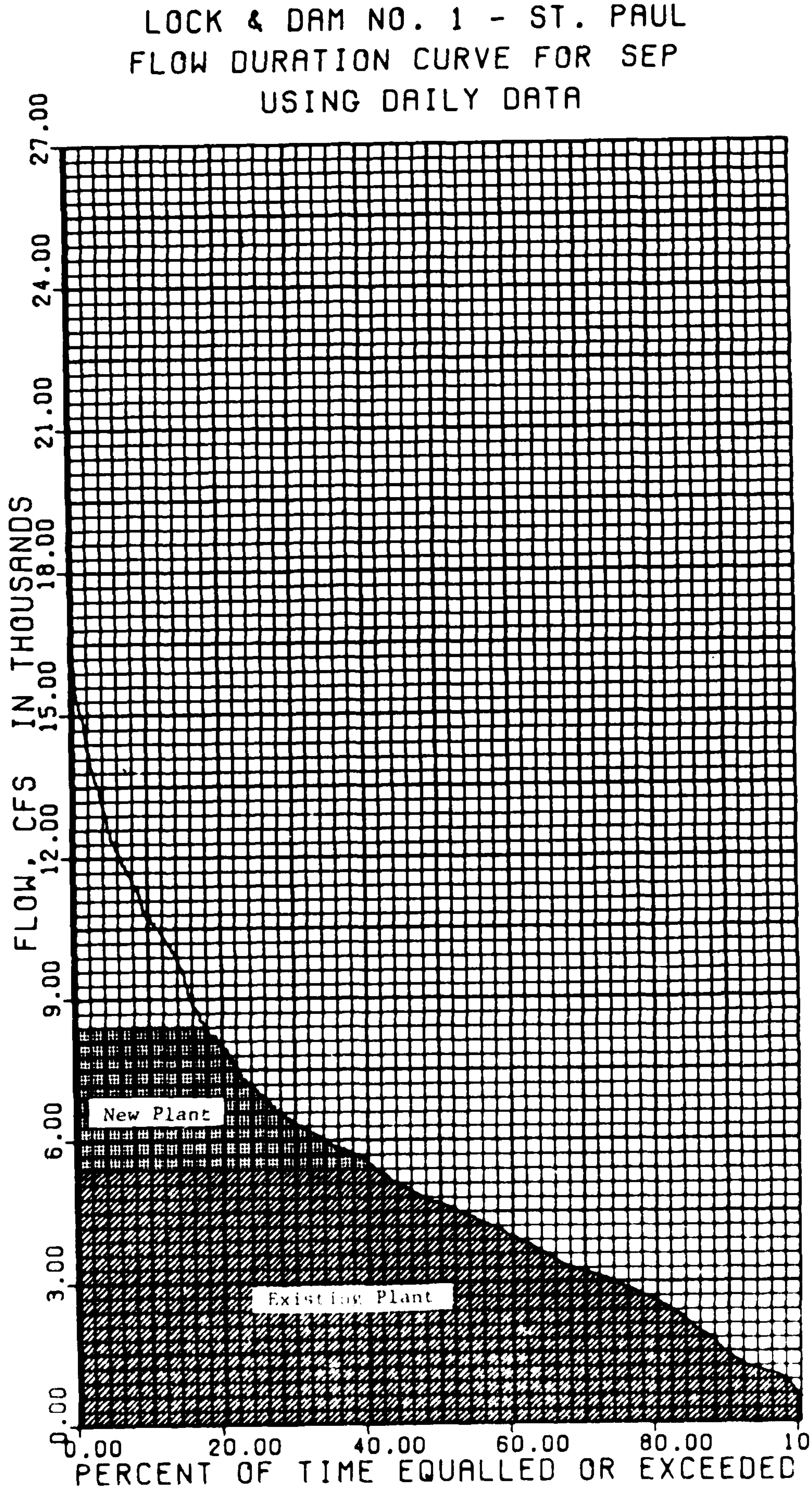
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR JUL
USING DAILY DATA

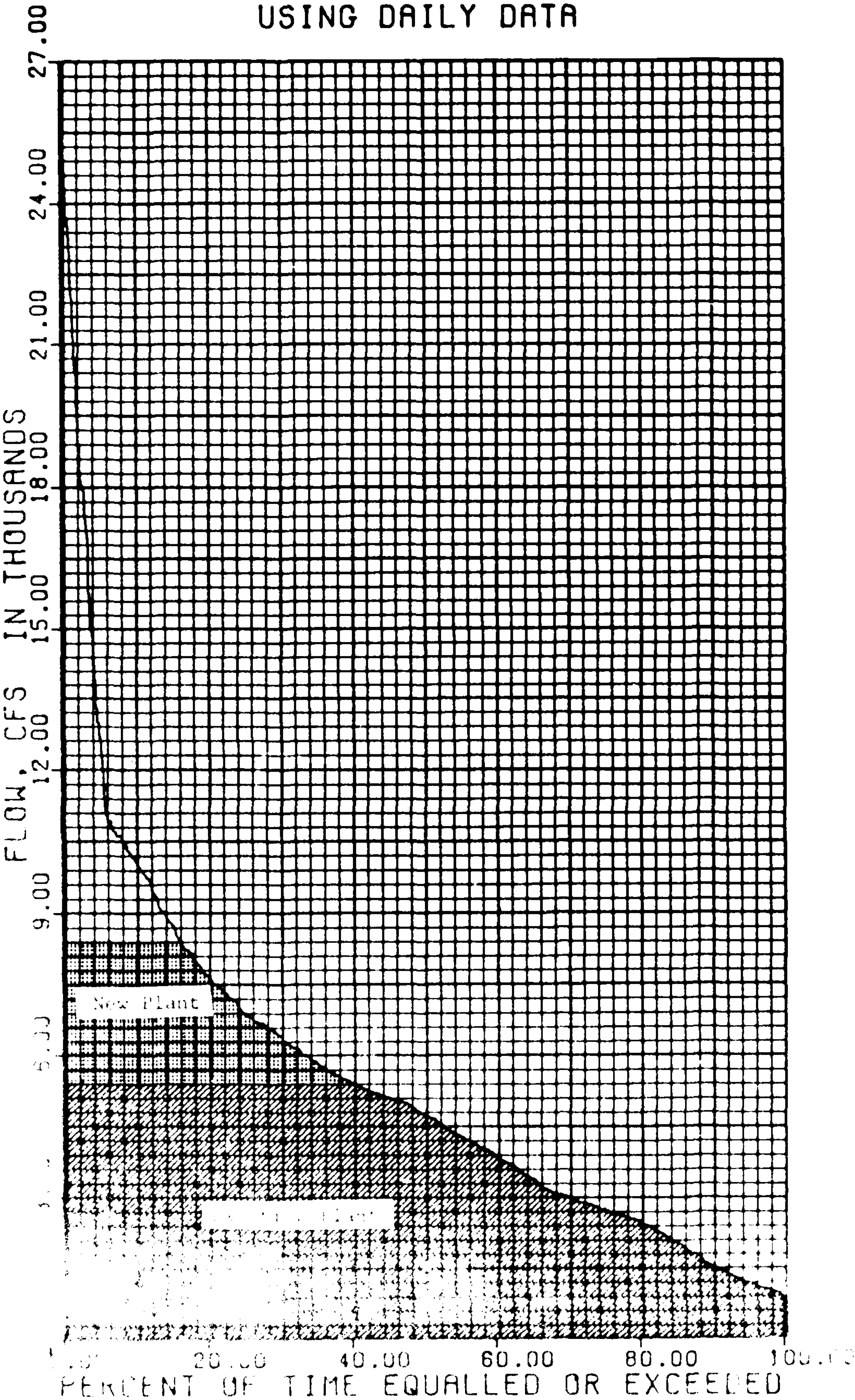


LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR AUG
USING DAILY DATA

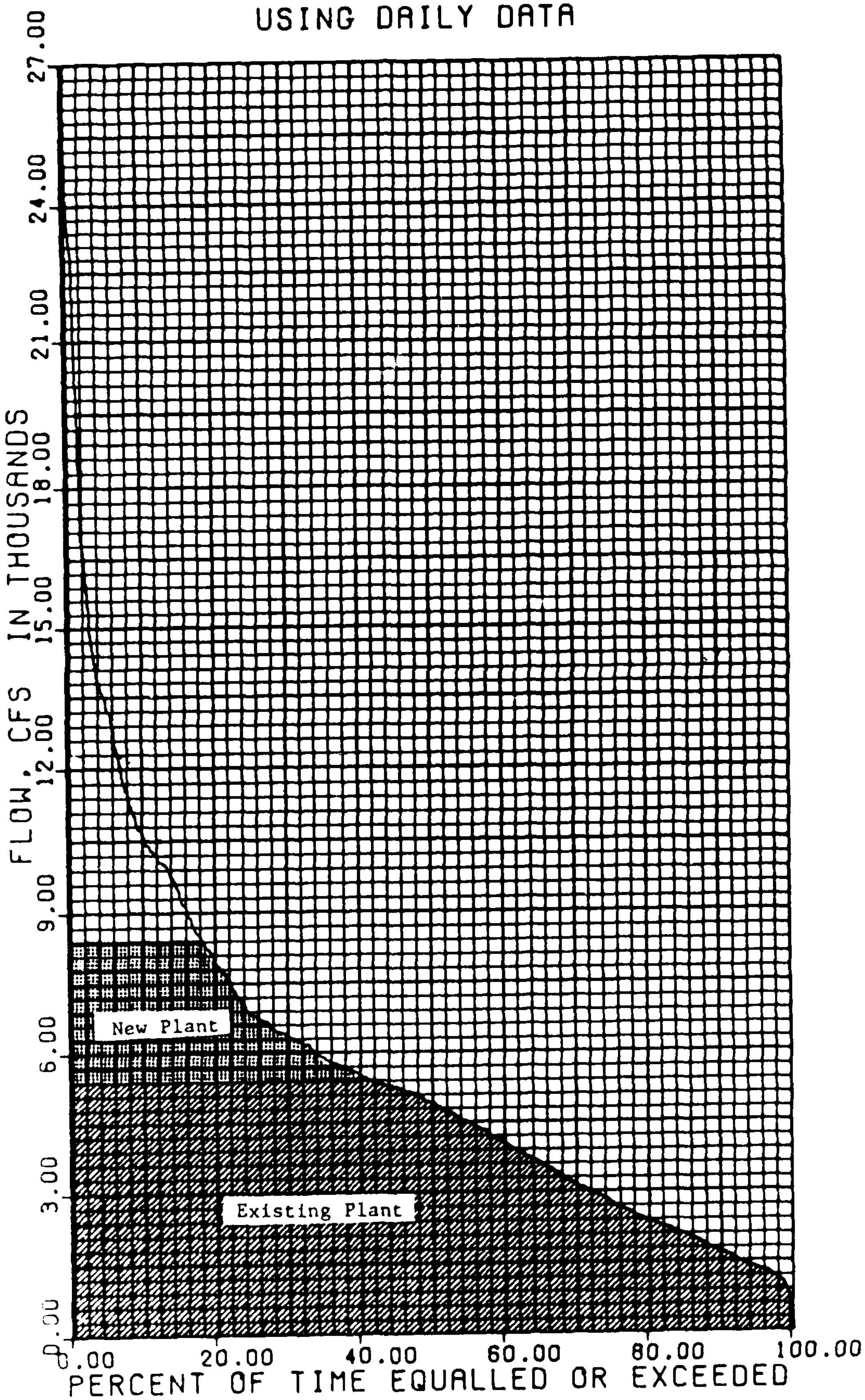



LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR SEP
USING DAILY DATA
FLOW, CFS IN THOUSANDS
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
New Plant
Existing Plant

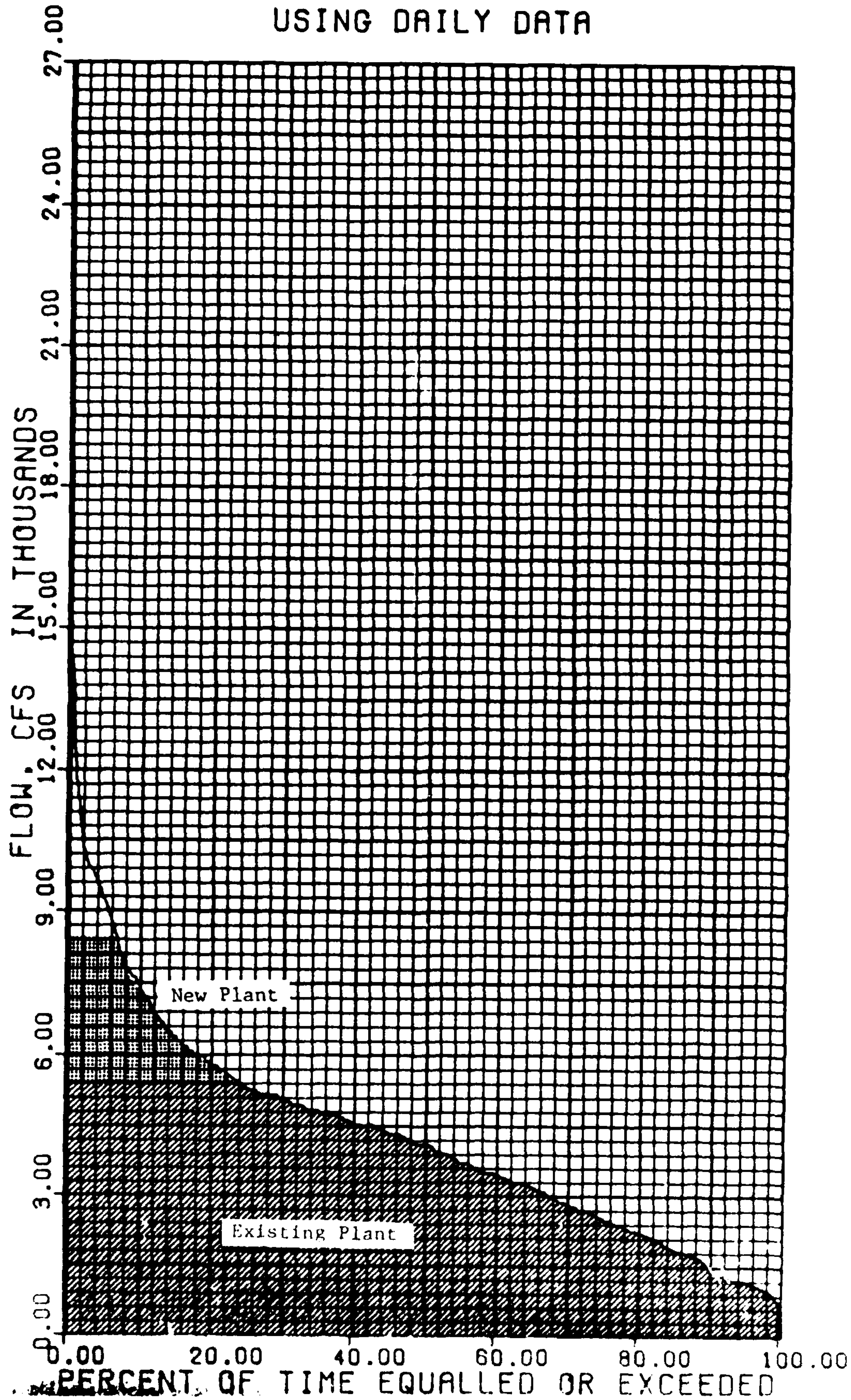
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR OCT
USING DAILY DATA



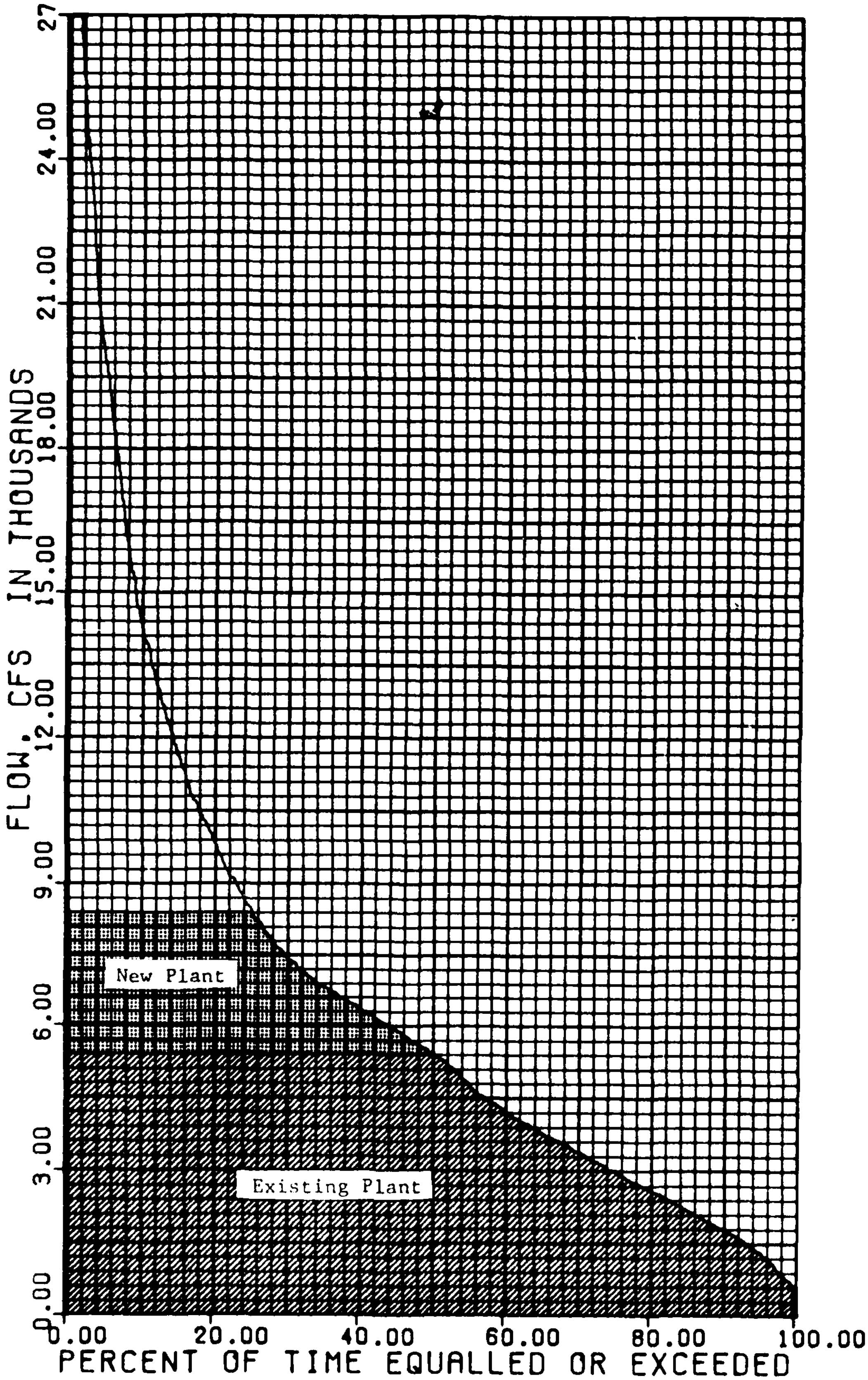
LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR NOV
USING DAILY DATA



LOCK & DAM NO. 1 - ST. PAUL
FLOW DURATION CURVE FOR DEC
USING DAILY DATA

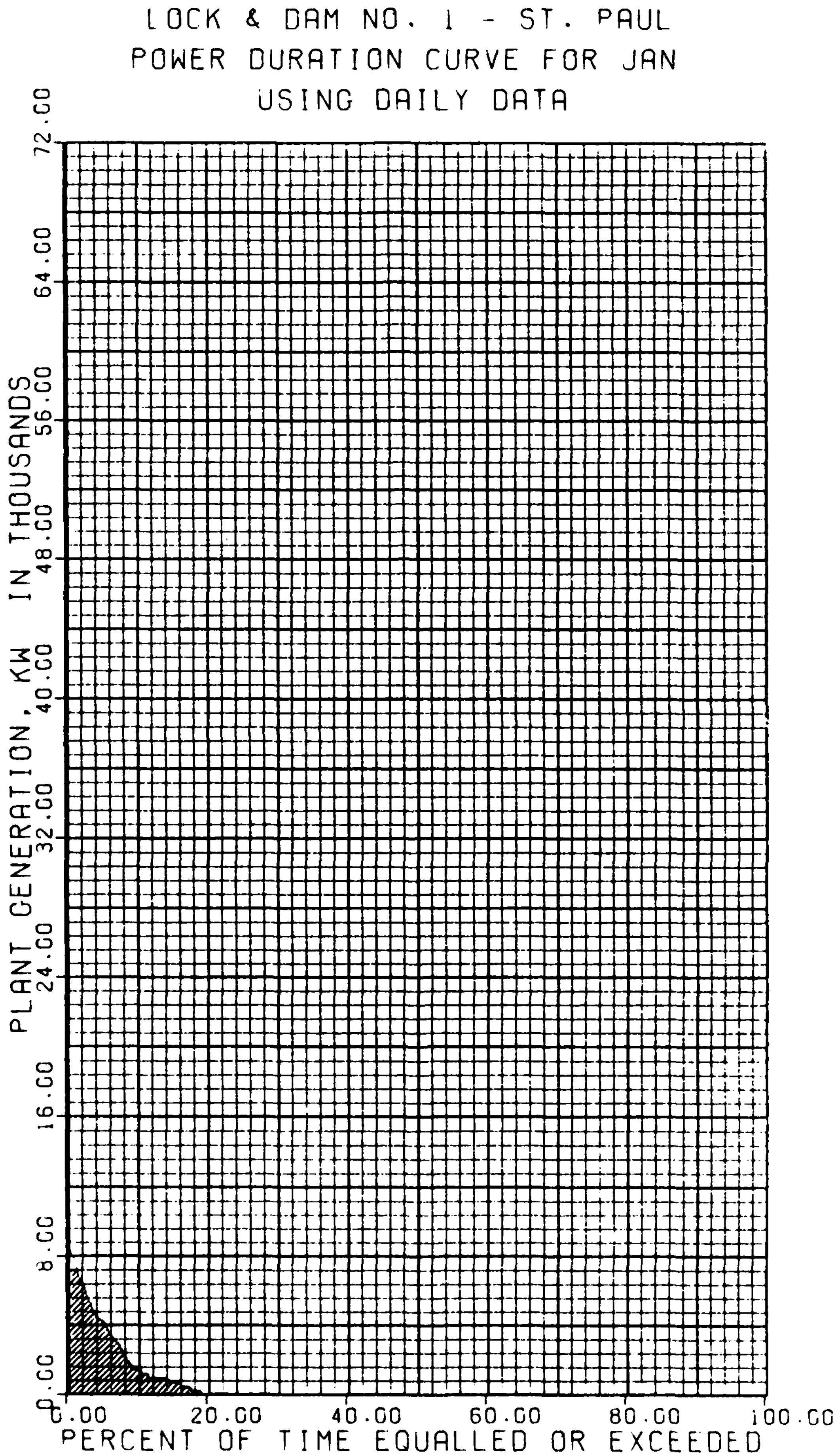


LOCK & DAM NO. 1 - ST. PAUL
COMBINED MONTHS FLOW DURATION CURVE
USING DAILY DATA

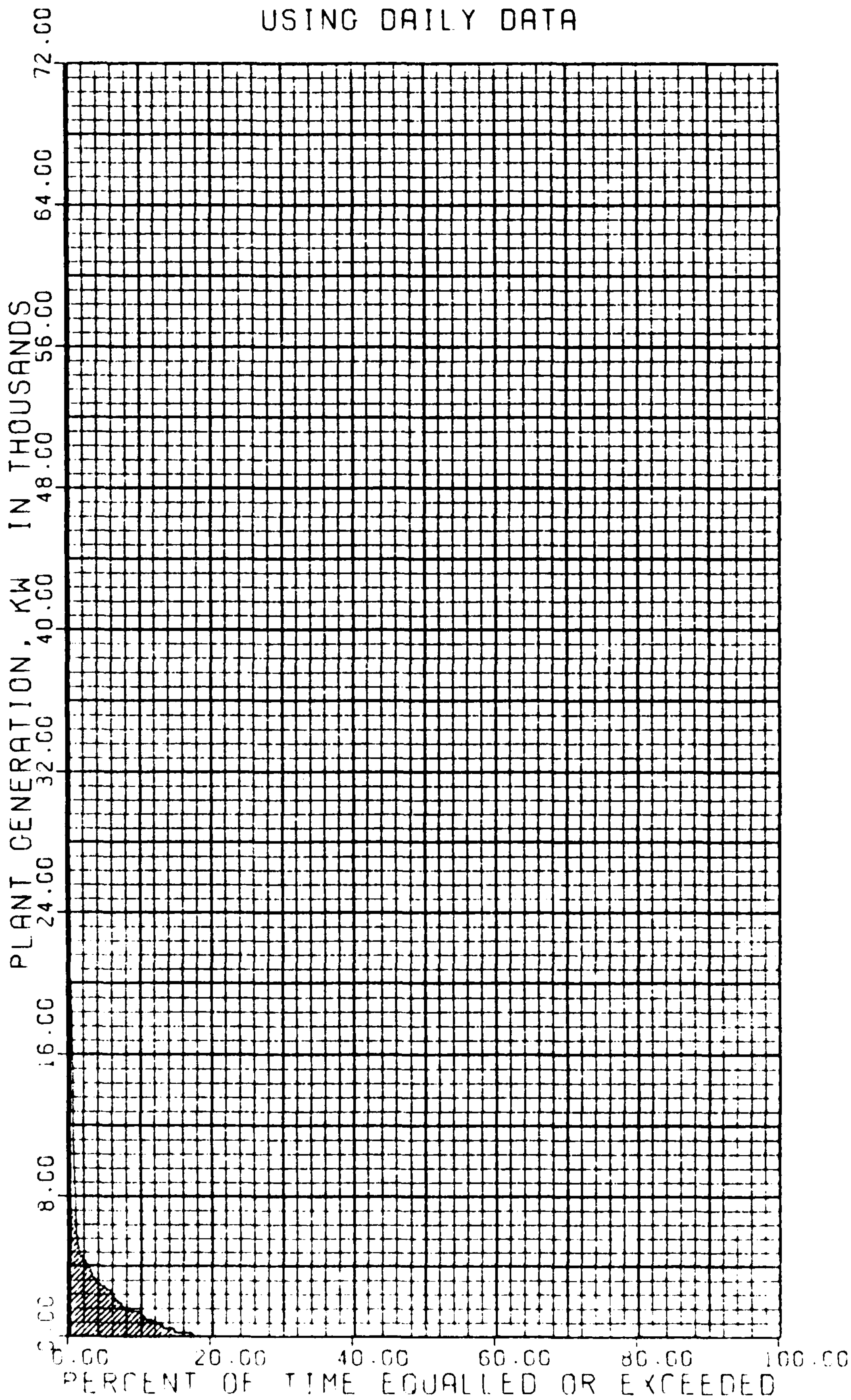


APPENDIX C

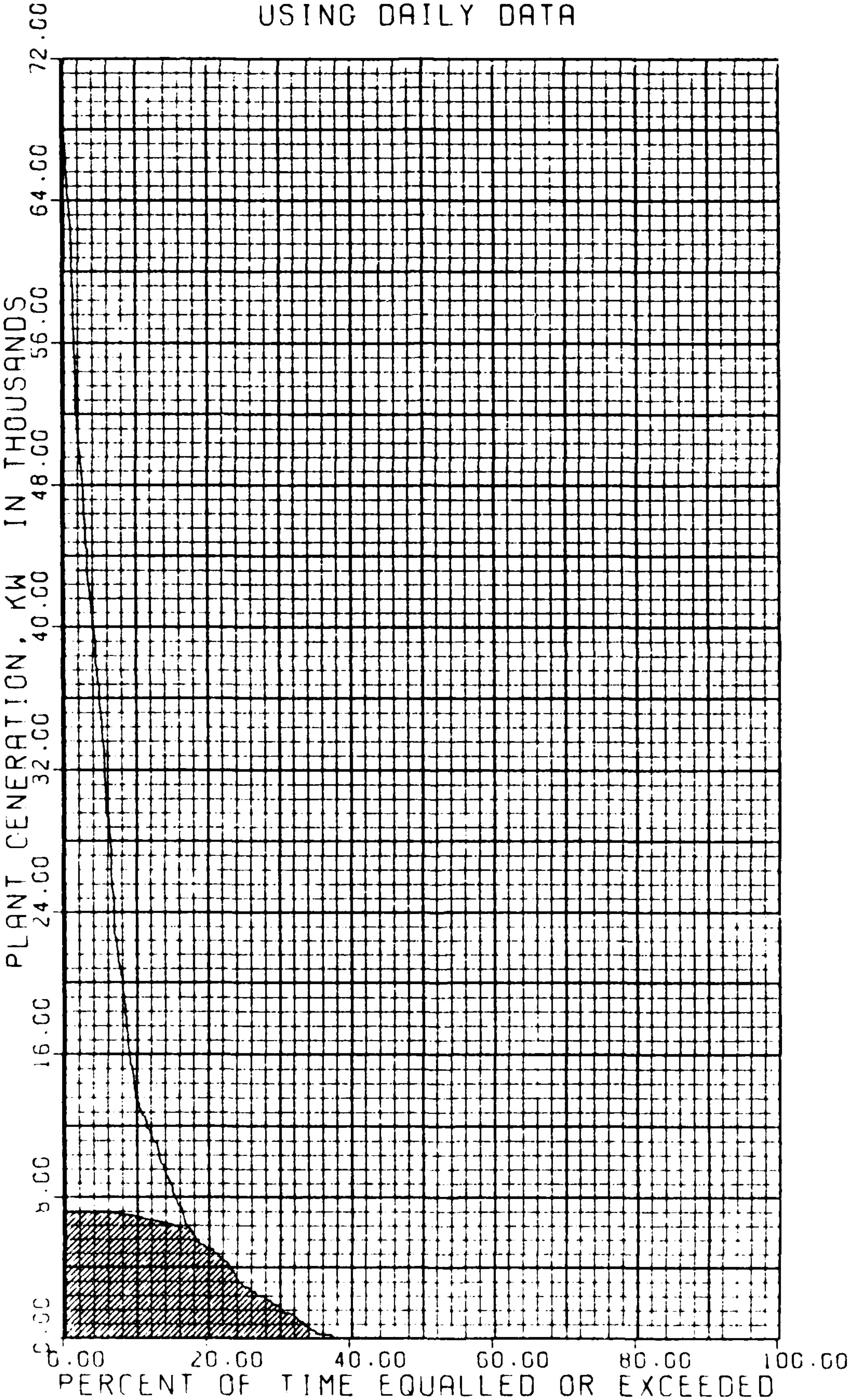
MONTHLY POWER-DURATION CURVES


LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR JAN
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
72.00
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

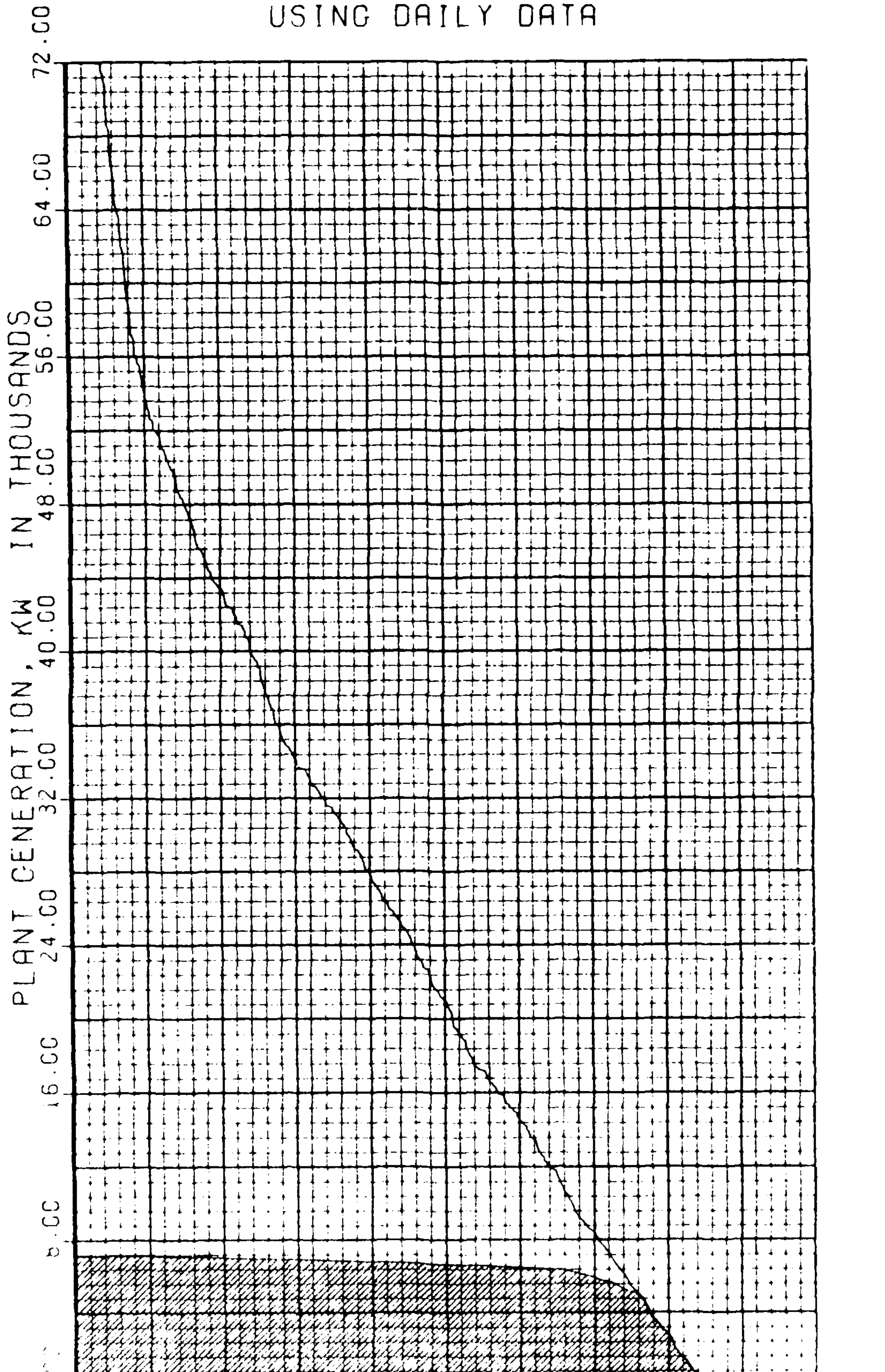
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR FEB
USING DAILY DATA



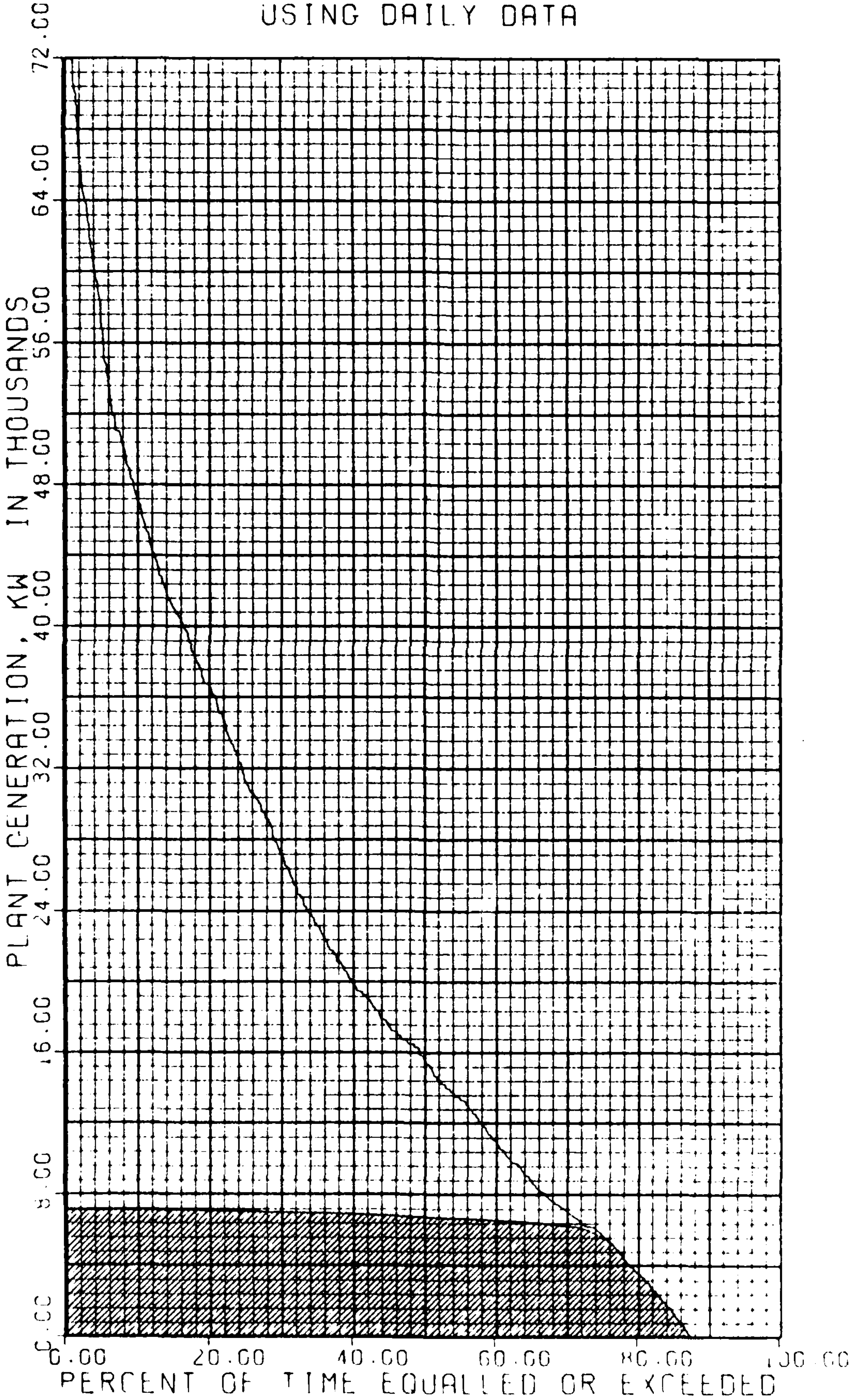
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR MAR
USING DAILY DATA



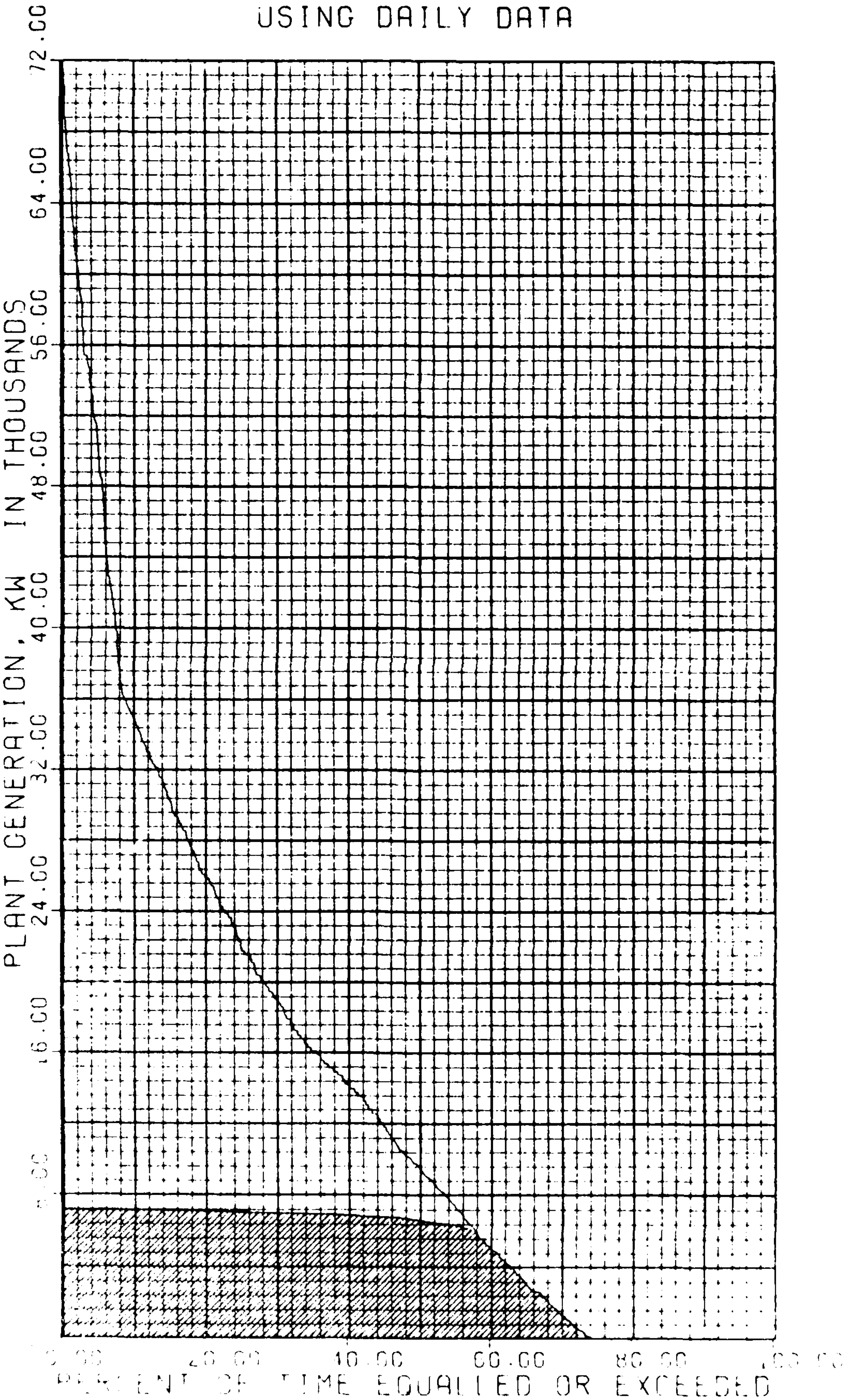
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR APR
USING DAILY DATA

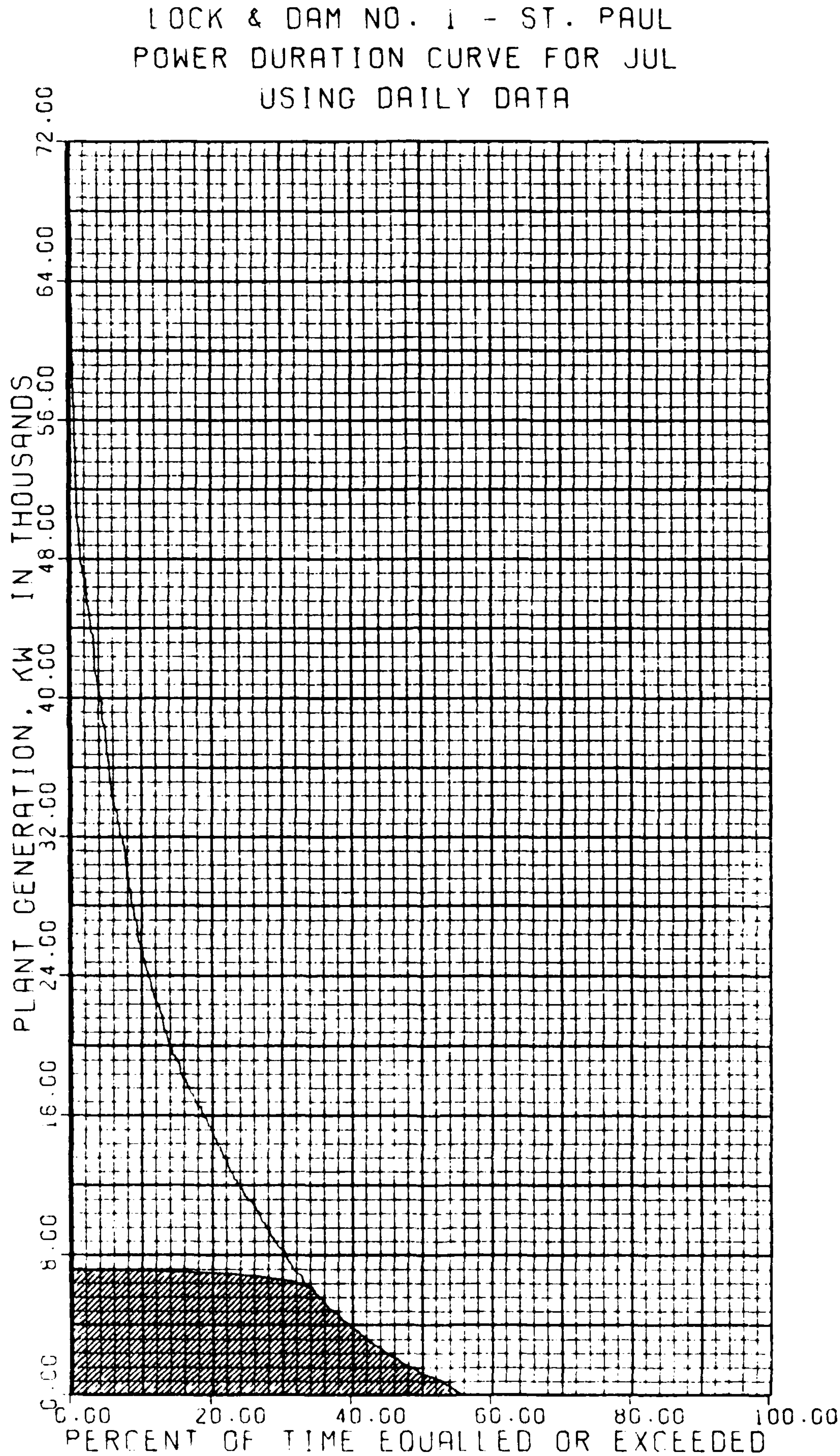


LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR MAY
USING DAILY DATA



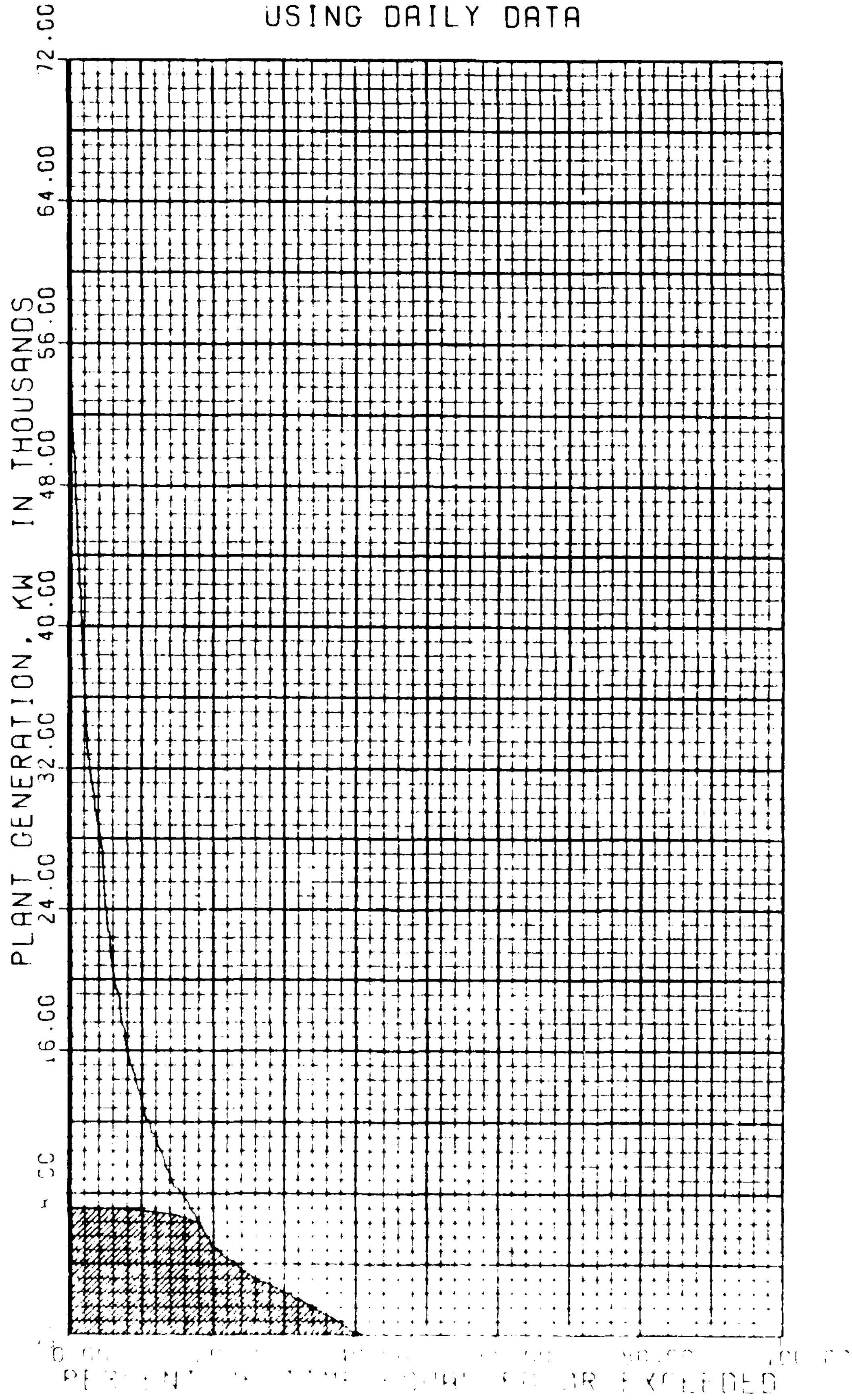
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR JUN
USING DAILY DATA



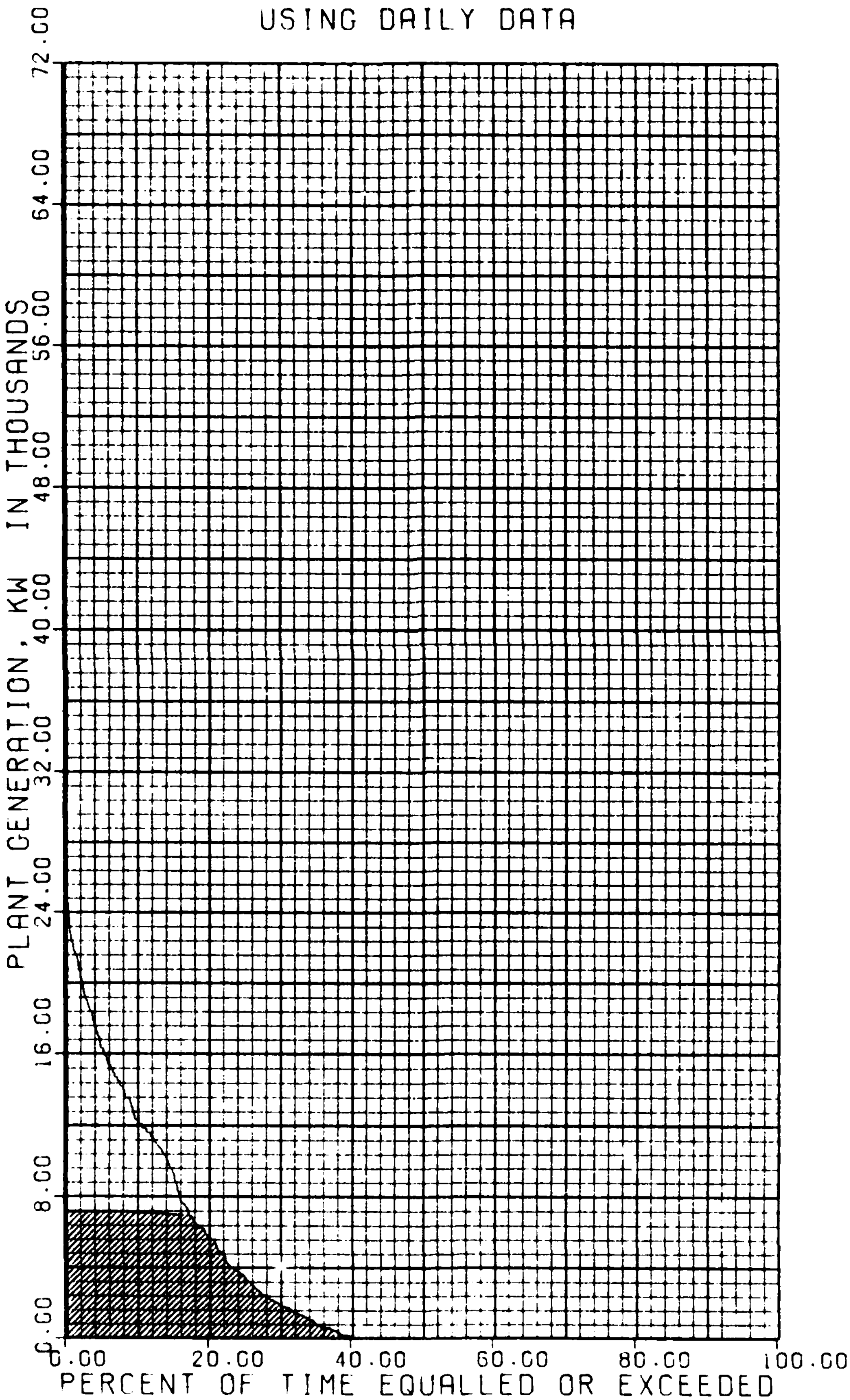


LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR JUL
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
0.00
8.00
16.00
24.00
32.00
40.00
48.00
56.00
64.00
72.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

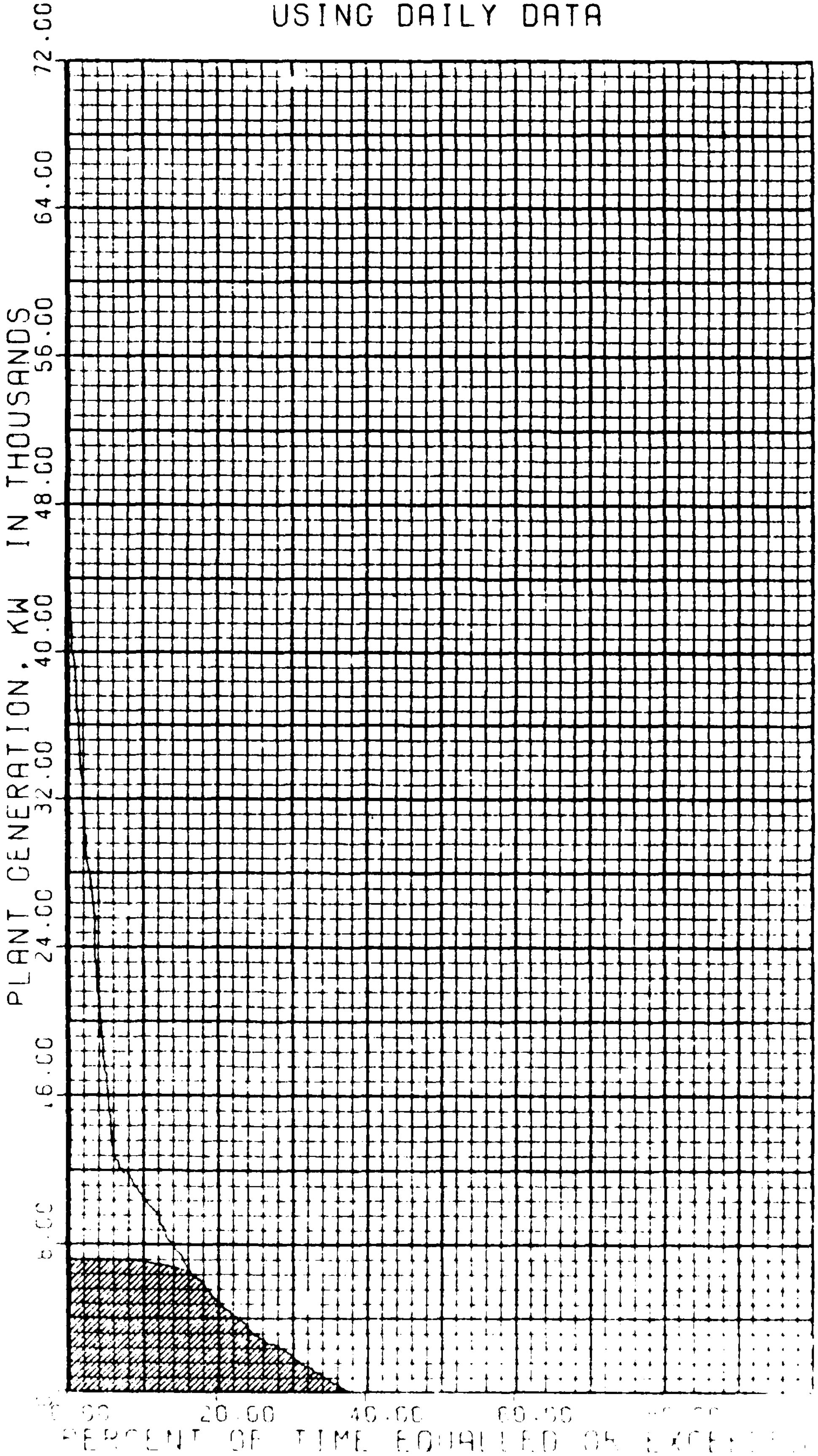
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR AUG
USING DAILY DATA



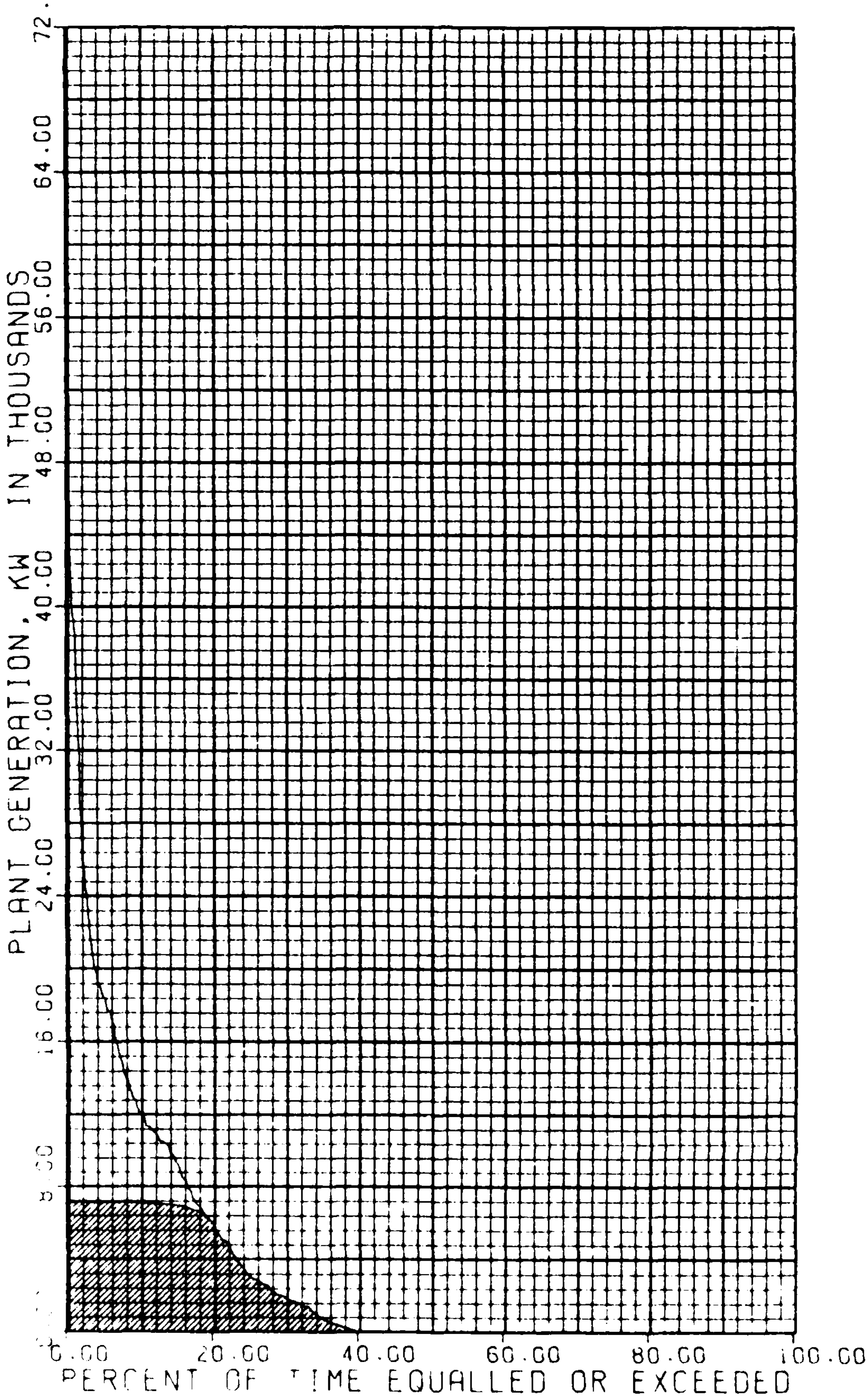
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR SEP
USING DAILY DATA



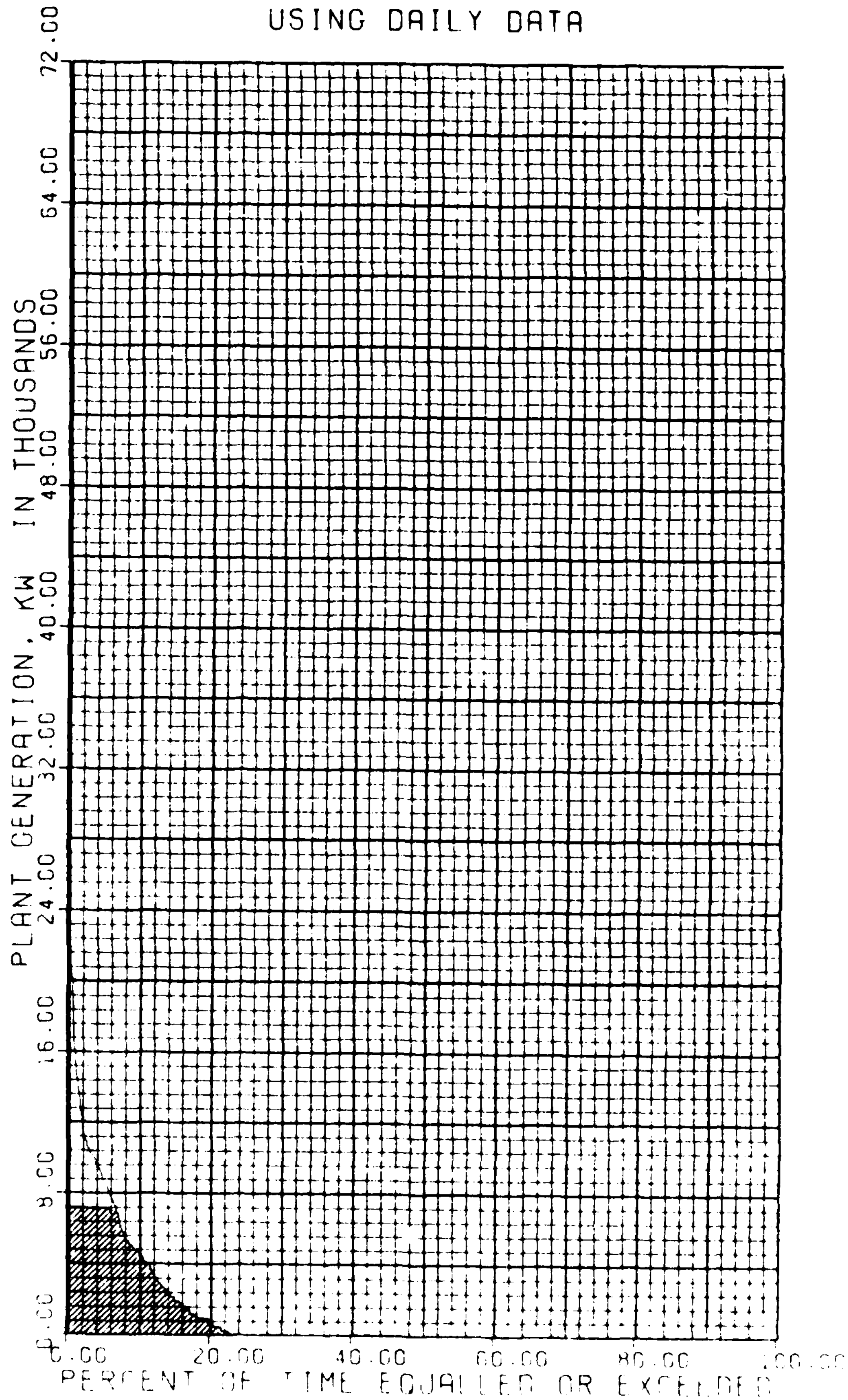
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR OCT
USING DAILY DATA



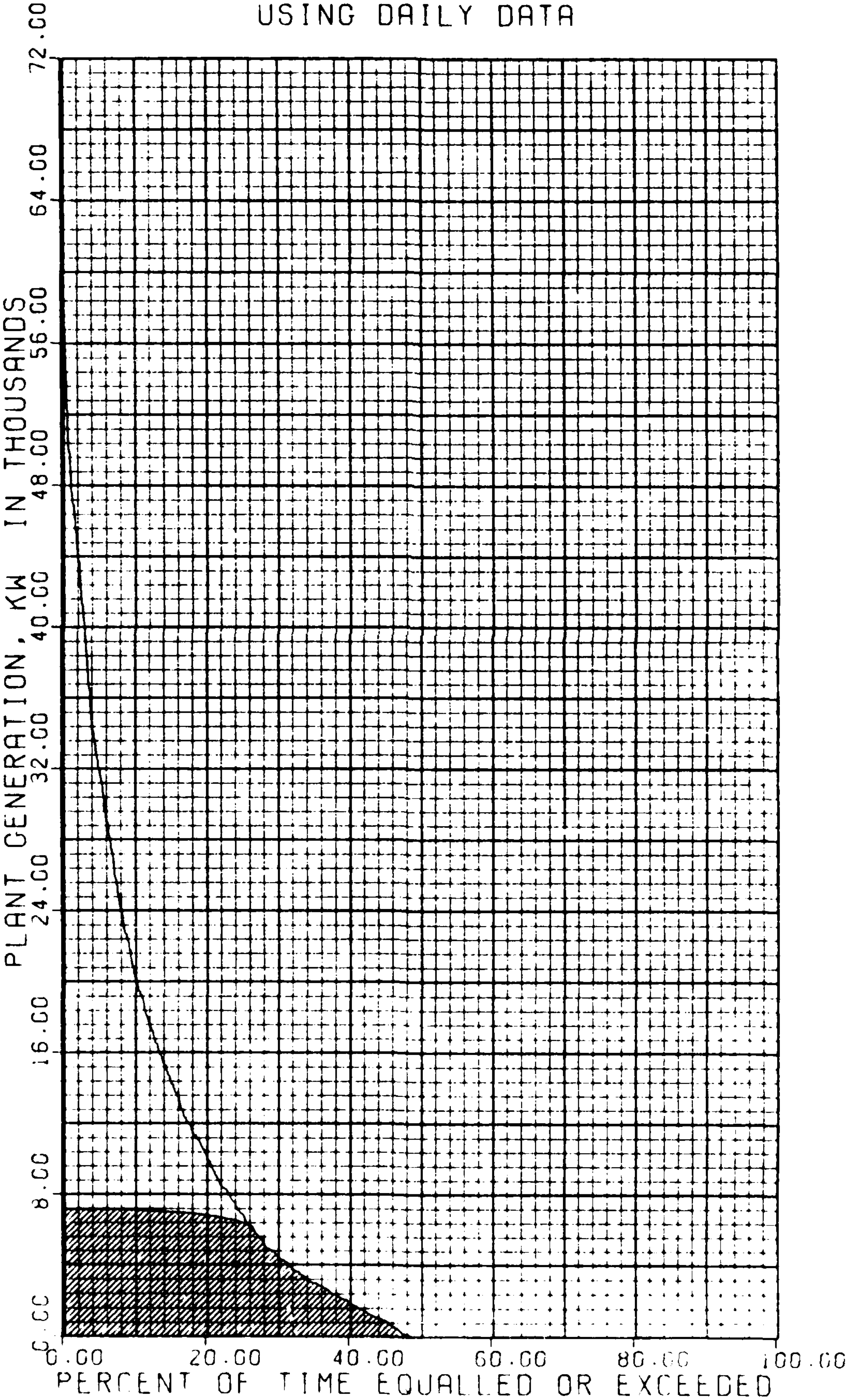
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR NOV
USING DAILY DATA



LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR DEC
USING DAILY DATA



LOCK & DAM NO. 1 - ST. PAUL
COMBINED MONTHS POWER DURATION CURVE
USING DAILY DATA



APPENDIX D

PERTINENT DATA AND CORRESPONDENCE

FEDERAL ENERGY REGULATORY COMMISSION
CHICAGO REGIONAL OFFICE
230 SOUTH DEARBORN STREET, ROOM 3130
CHICAGO, ILLINOIS 60604

October 11, 1983

Mr. Louis Kowalski
Chief, Planning Division
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Mr. Kowalski:

Your August 26, 1983 letter requests power values, developed at discount rates of 8.125 and 14.0 percent and based on October 1983 price levels, for Upper St. Anthony Falls, Lower St. Anthony Falls, and Lock and Dam No. 1.

Power values, based on a coal-fueled steam-electric plant as the most likely alternative to each of the above-proposed hydroelectric developments, are summarized on the attached table. These are "at market" values; no transmission line costs for the hydroelectric development have been included.

The energy values for the hydroelectric developments were determined by the difference in total system operating cost between a system utilizing the proposed hydro installation and one using an alternative steam-electric generating plant. System operating costs were simulated using the POWRSYM Version 48 production costing model.

Northern States Power Company was used as a "typical" system to measure the annual production cost differences between future operation with the added hydro capacity and its alternative. Operation of the system was simulated over a 30-year period based on load and energy requirements for the Northern States Power Company system.

If you have any questions regarding these power values, please contact Mr. David Simon of my staff at (FTS) 353-6701, and he will assist you.

Sincerely,

Lawrence F. Coffill

Lawrence F. Coffill, P.E.
Regional Engineer

Enclosure:
as stated

DOE/FERC/CRO
October 1093

Power Values at October 1983 Cost Levels

	Capacity Value 1/ ($/kW-yr)		Energy Value ($/mwh) Current	Escalated	
	@8.125%	@14.0%	-	@8.125%	@14.0%
St. Anthony Falls Upper Dam	201.10	348.80	24.5	31.4	31.2
Lower Dam	201.10	348.80	21.6	27.7	27.5
Lock and Dam 1	201.10	348.80	24.1	30.9	30.7

1/ These data do not include hydrologic availability.

Summary of input data:

Coal plant investment cost
@ 8.125% $1,370/kW
@ 14% $1,598/kW

Coal plant fuel cost - $1.74 per million Btu

Unadjusted Capacity Value
@ 8.125% $149.40 kW-yr
@ 14% $259.20 kW-yr.

Unadjusted Energy Value - $18.9/Mwh

Operating flexibility credit included in capacity values - 5 percent

Mechanical availability adjustment included in capacity values = $\frac{\text{Hydro Avail}}{\text{Coal Avail}} = \frac{0.985}{.76} = 1.296$

Plant on-line date 1990

Fuel escalation based on November 11, 1981 DOE projections

1980-1985	13.80%
1985-1990	2.00%
1990-2010	0.18%

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office

DATE: 9 May 1983

SUBJECT OF CONVERSATION

St. Anthony Falls Hydropower -- Marketability

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orval W. Bruton	NPDEN-WM-Power Section	FTS 423-3752
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**
Truman Price	Director Division of Water and Power Resources, DOE	FTS 633-8336

SUMMARY OF CONVERSATION:

1. A call was placed to Mr. Price to discuss marketing of the new generation at the St. Anthony Falls project.

2. Mr. Price said that the Corps' generated power could be marketed to any of the 800 public entities in the region. There is an apparent need for this type of relatively low cost generation in the region. Informally, he gave assurance that the power can be marketed through the Department of Energy. Appropriately, a formal request for a marketability statement will be made by St. Paul District, Corps of Engineers.

Orval W. Bruton

ORVAL W. BRUTON, P.E.
Power Section NPD

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office

DATE: 21 December 1982

SUBJECT OF CONVERSATION: Lock & Dam No. 1 Tailwater Elevation Data

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION

PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orv Bruton	NPDEN-WM-Power Section	FTS 423-3752

PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION
Gordon Heizman	St. Paul District	

SUMMARY OF CONVERSATION:

1. A call was placed to St. Paul District, Hydraulics Section so that corrections could be made to the existing tailwater-elevation curve shown in the Reservoir Regulation Manual, dated November 1979, Plate 6. Mr. Heizman said the tailwater curve published in the manual is in error and corrections should be made.

2. The tailwater elevation at Lock & Dam No. 1 is affected by the natural flow at the project and by some unrelated physical features downstream. The Minnesota River has its confluence with the Mississippi River about 5 miles below the dam and its backwater effects can influence Lock & Dam 1 tailwater. Also the general configuration of the Mississippi River and the pool conditions of Lock and Dam No. 2 can affect the tailwater of Lock and Dam No. 1.

3. There is no exact flow - tailwater relationship at the dam, but the Minnesota River confluence does have significant effect, it was,therefore, decided to compare different flows of the Mississippi and Minnesota Rivers with actual recorded tailwater elevations at Lock and Dam No. 1. The following is a sampling of data taken from river gages and recorded tailwater elevations.

RECORDED FLOW & TAILWATER DATA

(1) Flow, cfs Miss R.	(2) Flow, cfs Minn. R.	(3) T.W. Elev Lockside	(4) T.W. Elev Ford Plant	Diff. Col. 3&4
3,200	1,100	687.4	689.1	1.7
4,300	1,500	687.9	690.0	2.1
5,200	1,500	688.3	691.1	2.8
6,600	2,300	689.0	691.1	2.1
7,300	4,400	689.0	691.1	2.1
8,206	5,700	689.3	691.3	2.0
10,000	2,000	689.5	691.6	2.1
10,000	4,000	689.4	691.5	2.1
14,000	5,000	691.7	693.1	1.4
25,800	9,000	696.1	696.9	0.8
45,500	14,000	701.6	702.2	0.6

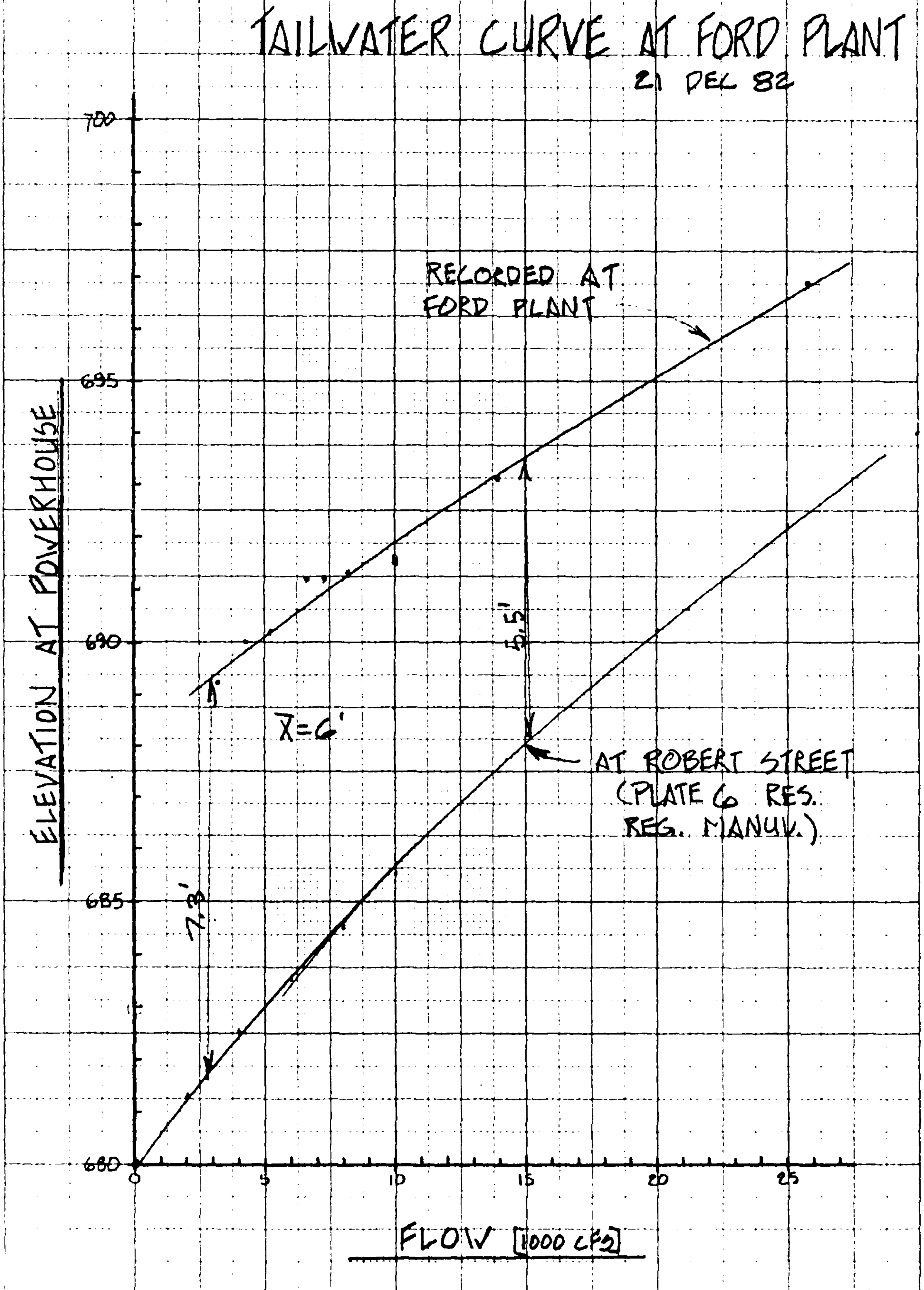
4. The flows of the Mississippi River (Col. 1) were plotted against the T.W. Elevation at the Ford Plant (Col. 4). This curve was then compared with the tailwater curve published in the Reservoir Regulation Manual, Plate 6, (attachment 1). From the data shown on the curves, it was decided to use a 6.0 foot constant correction to the tailwater curve data in the Reservoir Regulation Manual. This corrected data will be used to prepare a new tailwater rating curve for use in the Lock and Dam No. 1 hydropower studies.

Orv Bruton

Attachment
as

ORV BRUTON, P.E.
Hydropower Coordinator
North Pacific Division

L & D No 1 ST. PAUL



Attachment 1

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office

DATE: 14 December 1982

SUBJECT OF CONVERSATION: Upper Mississippi Critical Load Months -- St. Anthony Falls and L & D No. #1 Projects

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION

PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orv Bruton	NPDEN-WM-PWR	FTS 423-3752

PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION
Jim Kolak	FERC - Chicago Office	FTS 353-6701

SUMMARY OF CONVERSATION:

1. A call was placed to the Chicago Federal Energy Regulatory Commission Office to discuss the critical load months for the subject projects.

2. The area power load, currently served chiefly by Northern States Power, has two periods of critical demand:

   a) Summer months July - August
   b) Winter months December - January

3. Mr. Kolak said that his office uses only the two summer months (July-August) for their critical peak load determination. While the winter months also represent high demand months, they are not as critical as the summer months.

4. For St. Anthony Falls and Lock & Dam No. #1 studies, the two summer months will be used to determine dependable capacity.

Orv Bruton
Orv Bruton, P.E.
Study Coordinator

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15, the proponent agency is The Adjutant General's Office

DATE
24 November 1982

SUBJECT OF CONVERSATION
St. Anthony Falls Project and Lock & Dam No. #1 Project

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orv Bruton	NPDEN-WM-PWR	FTS 423-3752
PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION
Carl Stephen	St. Paul District	FTS 725-7472

SUMMARY OF CONVERSATION:

1. A call was placed to verify the use of the flashboards on the subject projects. Flashboards, two-feet high are used on the Upper Falls of St. Anthony project and on Lock and Dam 1 project. These flashboards are manually raised every year after the spring runoff and the flashboards go down as the river flow and ice flows increase in early spring. The flashboards automatically drop by shear-pin failure when the flow reaches a certain point (see regulation manual). In certain low flow years the flashboards do not go down at all -- while in other years (such as 1982) they go down as early as October.

2. For the hydropower studies at both projects assume the following:

Flashboards Up	1 July - 28 February
Flashboards Down	1 March - 30 June

3. Power Section will modify the Duraplot program to reflect the 2-foot increase in generating head for the months shown above.

Orv Burton
ORV BURTON, P.E.
Study Coordinator

 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED
☆U S GPO 1981-0-765-042/1038

AGENDA

MEETING WITH NPD ON HYDROPOWER
LOCK AND DAM 1

Wednesday, 3 November 1982

Arrive MSP airport - RON

Thursday, 4 November 1982

8:30 a.m.	Meet with study manager at St. Paul District office - Room 1228
9:00 a.m.	Leave for L/D 1 via gov't. van
9:30-10:30 a.m.	Inspect L/D 1
10:30-11:30 a.m.	Inspect Ford Motor Company's hydroelectric plant at L/D 1
11:30-1:00	Lunch and return to District office
1:00-2:00 p.m.	Informal meeting with NCS hydro study managers
2:00-4:00 p.m.	Meet with District study team members (Room ~~633)~~ 229

Friday, 5 November 1982

NPD return to Portland, OR

Rec'd from
Ford Motor Co.
Plant — on field visit
83

FORD MOTOR COMPANY

TWIN CITIES HYDRO ELECTRIC POWER PLANT

The plant was constructed in 1924 by the Ford Motor Company at a cost of $1.5 million.

The building ia 160' long x 74' wide and is 51' high. The four Westinghouse generators installed in 1924 are still operational today. Each unit is a 72 pole, 4500 KVA generator that runs at 100 RPM and provides an equivalent 18,000 H.P. Each rotor ia aupported by a 32 inch Kingsbury bearing located under the exciter, totally emerged in a bath of turbine oil. The diameter of the generator shaft measures 16 inches. The rotor and auxiliaries weigh 58 tons.

The turbines are Willman-Seaver Morgan Francis reaction type units, set in a 10 foot 9 inch circle of wicker gates, Each turbine is rated for 4500 h.p. when the head water is 34 feet. Each turbine has a water rate of 1500 cubic feet per second at full load. The river flow varies from 4,000 to 25,000 cubic feet per second seasonally. During the winter season, when ice forms on the river, the water flow decreases to an average of 5,000 cubic feet per second.

Woodward governors control the mechanism, activated by 125 pounds of hydraulic oil pressure supplied by two motor driven oil pumps located in the basement adjacent to the oil resevoirs.

The generators produce 13,800 volts of current, which is transmitted by underground cable and transformed to 440-220 and 110 volt current for distribution. The total daily power output averages close to 250,000 KWH.

The Federal license under which Ford operates the Hydro facility requires that the generators run at full capacity as determined by the river flow. Ford furnishes the U.S.Government with all the electrical power required to heat, light and operate the Locks across the river free of charge. With the new facilities installed in the 1981-82 Lock rehabilitation project, power used by the government exceeds 500,000 KWH annually.

Approximately 50% of the power generated is consummed by the Ford Assembly Plant, which normally operates on a five day,sixteen hour per day production schedule. Any surplus power beyond that used by the government locks, the assembvly plant and the hydro plant itself, is transmitted to Northern States Power Company in St. Paul for re-distribution to general consumers in the area.

Ford is proud to be the largest non-utility producer of alternate energy in the state of Minnesota, and intends to continue its hydro operation as long as taxes and regulatory statutes are not excessively prohibitive to an economically sound operation.

DAM and LOCK #1

The locks and dam were constructed in 1912 by the Corp of Engineers at a cost of $3.9 million. The dam is 574 feet long with a fixed overflow spillway. There are 36 hinged flashboards attached to the top of the dam to increase the water head to 34 feet and to provide a 9 foot channel for river navigation. The flashboards are designed to tip and release water when the pressure becomes too heavy.

The pool created by the dam extends to the Northern Pacific Railway bridge located 5.4 miles up river.

The U.S. government spent $45 million during 1981-82 to refurbish the locks to ensure continued and more efficient navigational capabilities with improved water saftey equipment.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

NCSPD-PF

15 OCT 1982

SUBJECT: Use of Hydroelectric Design Center - Lock and Dam 1

Commander
U.S. Army Engineer Division, North Pacific
P.O. Box 2870
Portland, Oregon 97208

1. Reference: Telephone conversation between Mr. Orval Bruton, Chief, NPD Power Section, and Mr. Herb Nelson, NCS, study manager.

2. The St. Paul District is starting a hydroelectric feasibility study in fiscal year 1983 for lock and dam 1 on the Mississippi River between Minneapolis and St. Paul, Minnesota. We completed a reconnaissance study in September 1981 (copy inclosed) using standardized units. The reconnaissance study indicates economic feasibility for added development at the site, which already has generating capacity.

3. Lock and dam 1 is operated for both hydropower and navigation. The St. Paul District controls and operates the navigation locks on the right bank of the river, and the Ford Motor Company operates the existing power facilities on the left bank. The installed capacity is 14.4 megawatts. The present licensee (Ford) is not interested in further development of the site at this time. The existing powerplant is operated to be compatible with water surface elevations required for navigation. Any new development would also be subject to the same constraint. Inclosed are copies of the reservoir regulation manual and the annual flow-duration and head-flow curves.

4. During the reconnaissance study, two potential powerhouse sites were identified. We will analyze the potential for additional alternative sites when we receive study funding. However, it now appears that no significantly different locations are available at lock and dam 1. A preliminary review of ponding operation at St. Anthony Falls indicates that this type of operation would not be appropriate at lock and dam 1 and would be inconsistent with the navigation purpose of this project.

5. We are interested in using the services of the Hydroelectric Design Center in our feasibility studies for this site. We expect the Design Center could initially develop a technical report similar to the one being produced for St. Anthony Falls.

NCSPD-PF
SUBJECT: Use of Hydroelectric Design Center - Lock and Dam 1

6. When we receive study funding, we will transfer funds for further coordination and a possible trip to the site. The tentative schedule is as follows:

November 1982	Field trip to lock and dam 1
December 1982	Scope of work approved
1 March 1983	Technical report completed

7. If you have any comments or questions, please contact us.

Edward G. Rapp

3 Incl
as

EDWARD G. RAPP
Colonel, Corps of Engineers
Commanding

US Army Corps of Engineers
St. Paul District
Nelson 725-7579
FTS

MISSISSIPPI RIVER NAVIGATION DAMS - HYDROPOWER STUDY

LOCK AND DAM 1

PLAN C: If this plant is constructed directly adjacent to existing Ford Motor Company Plant, it is likely that one or two of four turbines would need to be shut down for 12 to 15 months.

$$\frac{2 \text{ turbines}}{4 \text{ turbines}} \times \frac{15 \text{ mos.}}{12 \text{ mos.}} \times \frac{82{,}400{,}000 \text{ kwh}}{\text{year}} \times \$.01 = \$515{,}000$$

This assumes that all interupted energy would have been sold by Ford Co. to Northern States Power Co. Actually, a large portion of it must be purchased by Ford to replace energy they need to operate thier truck assembly plant. Ford pays $.05/kwh for energy it buys from NSP and gets $.01/kwh for surplus energy it sells to NSP.

If you assume only half of this energy will need to be replaced at $.05/kwh, Ford's loss would be more like $1,546,000. This also applies to Plan/Site A.

$$\frac{2 \text{ turbines}}{4 \text{ turbines}} \times \frac{15 \text{ mos.}}{12 \text{ mos.}} \times \frac{1}{2} \times \frac{82{,}400{,}000 \text{ kwh}}{\text{year}} \times \$.05 = \$1{,}288{,}000$$

$$\frac{2}{4} \times \frac{15 \text{ mos.}}{12 \text{ mos.}} \times \frac{1}{2} \times \frac{82{,}400{,}000 \text{ kwh}}{\text{year}} \times \$.01 = \$258{,}000$$

Total $1,546,000

L/D 1 Mississippi River

PLAN A: would require shut down of 1 or 2 existing turbines at the Ford hydro plant for approximately 12 to 15 months. I'm not sure whether those disbenefits enter your economic evaluation for turbine selection. If they do, we will estimate them for you. (more exactly)

Dis-benefits Roughly:

$$\frac{\text{2 turbines stopped}}{\text{4 turbines installed}} \times \frac{\text{15 months}}{\text{12 months}} \times \underset{\text{Ave. An. Energy}}{82{,}400{,}000\ \text{Kwh}} \times \underset{\text{(what Ford gets)}}{\$.01}$$

$$= \$515{,}000$$

PLAN B is cheaper as far as costs outside the powerhouse and would not interupt operation of the existing plant.

Herb Nelson
8-725-7579 FTS
Plan Formulation Branch

END

FILMED

3-85

DTIC