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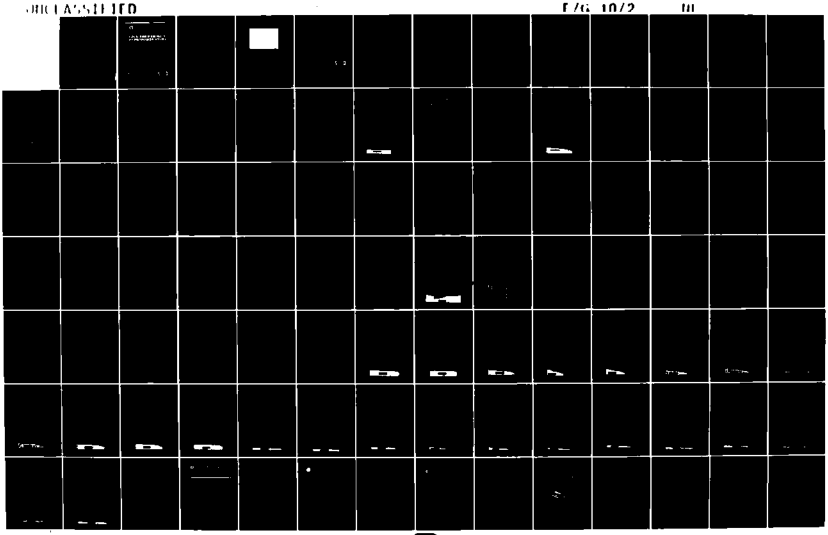

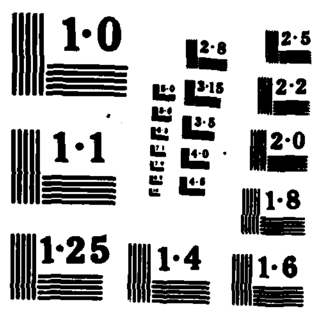
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US Army Corps
of Engineers
North Pacific Division

LOCK AND DAM NO. 8 HYDROPOWER STUDY

Mississippi River near
LaCrosse, Wis.

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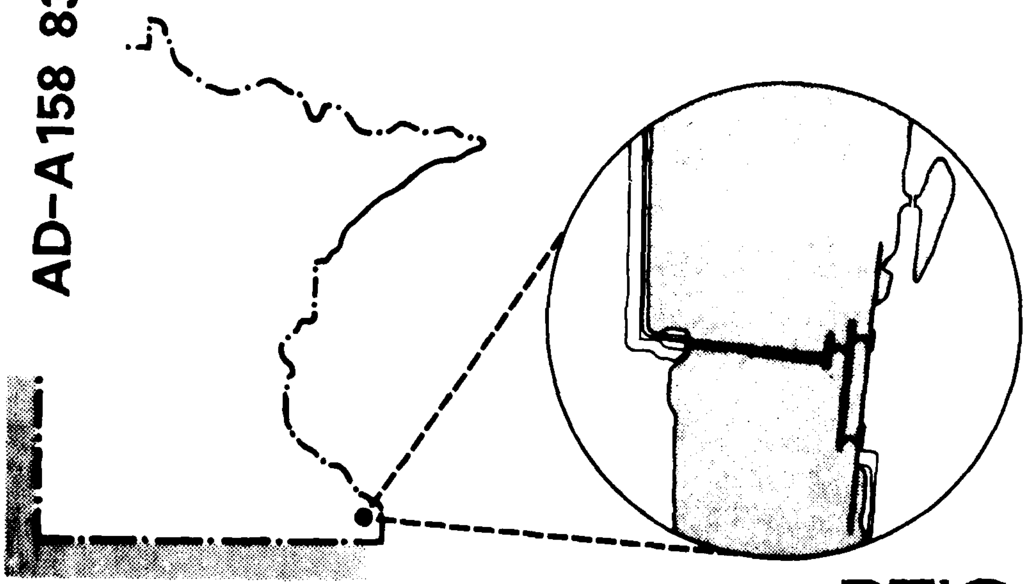

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HYDROPOWER
MISSISSIPPI RIVER

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

The purpose of this study is to determine the feasibility of constructing hydropower facilities at Lock and Dam no. 8, located on the Mississippi River, near La Crosse, Wisconsin. Several alternative powerhouse schemes were investigated. The 8.75 megawatt, 10-unit plant indicated in the 1981 reconnaissance is now considered economically infeasible. Two alternate developments using tubular generating units were selected for this new study. Because of the relatively low head, the powerhouse costs are proportionally high and project feasibility falls below unity.

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LOCK AND DAM NO. 8

Mississippi River near La Crosse, WI

Site of Proposed Hydroelectric Plant

HYDROPOWER STUDY
SUPPLEMENTAL REPORT
TO
1981 RECONNAISSANCE REPORT

Lock & Dam No. 8, Mississippi River
Near
La Crosse, Wisconsin

Prepared for
The St. Paul District
Corps of Engineers

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

January 1985

LAD8JJ.TW

BASIC PROJECT DATA

	Storage-Yard Alternative	Auxiliary Lock Alternative
General Data		
Project Installed Capacity	1.9 MW	4.8 MW
Number of Units	2	5
Type Turbine	Tubular	Tubular
Average Annual Energy	11,790 MWh	28,350 MWh
Annual Plant Factor	70%	69%
Normal Forebay Elevation	631.0 ft	631.0 ft
Normal Min. Tailwater Elev.	620.0 ft	620.0 ft
Gross Head	11.0 ft	11.0 ft
Average Flow	28,900 cfs	28,900 cfs
Plant Max Hyd. Capacity	2,800 cfs	7,000 cfs
Estimated Construction Time	3 yr	3 yr
Economic Data		
Total Investment Cost (NED)	$10,420,000	$21,200,000
Project Annual Cost	$ 1,003,000	$ 1,850,000
Net Benefit	- $260,000	- $10,000
Production Cost	85 mills/Kwh	65 mills/Kwh
Benefit-to-Cost	0.74	0.99

Summary

This study, prepared by North Pacific Division, Corps of Engineers is a supplemental report to a 1981 hydropower reconnaissance report published by St. Paul District Corps of Engineers. The purpose of this study is to determine the feasibility of contructing hydropower facilities at Lock and Dam No. 8, located on the Mississippi River, near La Crosse, Wisconsin.

The existing project was constructed by the Corps of Engineers in the mid-1930's and consists of a 900 foot long gated section with roller and tainter gates, a 110 foot by 600 foot navigation lock, a 110 foot wide auxiliary lock, and a long section of earthen dike.

Several alternative powerhouse schemes were investigated in this study. The 1981 reconnaissance report indicated an 8.75 megawatt, 10-unit plant to be economically feasible; however, an economic update using more detailed costs shows that development to be infeasible. Two alternate developments using tubular gnerating units were selected for this new study. A two-unit, 1.9 megawatt powerplant located on the right side of the river in the storage yard area would produce 11,790,000 Kwh of annual generation. The total investment cost would be $10.4 million dollars and the benefit-to-cost ratio would be 0.74. The second alternative would be a 4.8 megawatt, 5-unit powerhouse located in the auxiliary lock. The total investment cost would be $21.2 million dollars and the benefit-to-cost ratio would be 0.99. The annual production cost for the two alternatives would be 85 and 65 mills per Kwh respectively.

While project development is relatively costly, it does offer an opportunity to develop some otherwise wasted energy. Because of the relatively low head (average about 8-feet) the powerhouse costs are proportionally high and project feasibility falls below unity. The project should be restudied in the future when unit equipment costs become lower or alternative generation becomes more costly.

HYDROPOWER STUDY
SUPPLEMENTAL STUDY
TO
1981 RECONNAISSANCE REPORT

Lock & Dam No. 8, Mississippi River
La Crosse, Wisconsin

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

APPENDICES

SECTION 1 - GENERAL

1.01 Purpose and Authority. This report is an extension of the 1981 reconnaissance report for developing hydropower at Lock and Dam No. 8 on the Mississippi River near La Crosse, Wisconsin. St. Paul District Corps of Engineers prepared the 1981 reconnaissance report and are currently updating that study. The study authority is contained in the House Committee on Public Works resolution dated 11 December 1969. Funds were made available to North Pacific Division, Corps of Engineers by St. Paul District to prepare the supplemental report.

1.02 Scope of Study. This report assesses the feasibility of developing hydropower at Lock and Dam No. 8 on the Mississippi. This report updates St. Paul District's 1981 reconnaissance study. The study will be considered a supplemental study rather than a more detailed feasibility level study. The study investigates the possibility of constructing a powerplant that will utilize available flows at the site for power generation. Thus its operation will be considered run-of-river. Powerplant costs were developed from manufacturer's information for the turbine-generators and from current cost experiences from similar equipment and structures. Selected plant sizes were chosen from analyses of several different plant-sizes.

1.03 Description of Existing Project. Lock and Dam #8 is located on the Mississippi River at river mile 679.2 above the mouth of the Ohio River. The project consists of a main lock, 110 feet wide and 600 feet long, located on the left bank, or Wisconsin side of the river. Provisions for an auxiliary lock are provided for by an upper gate bay to the right of the main lock if future lockage needs arises. The dam section consists of 5 roller gates, 80 feet wide by 20 feet high and 10 tainter gates 35 feet wide by 15 feet high and a dike. An earth dike, 15,720 feet in length with a 20-foot wide roadway crest is located along the Minnesota side of the river. Along the dike are two fixed crest spillways totaling 2,275 feet in length. Figure 1-1 shows a plan layout of the project.

1.04 Findings of 1981 Reconnaissance Report. The 1981 reconnaissance report presented a preliminary evaluation for adding a 8.75 megawatt powerplant to the existing Lock and Dam. Table 1-1 lists pertinent data from the selected plan.

TABLE 1-1
1981 PROPOSED POWERPLANT
PERTINENT DATA

Total Capacity	8.75 MW
Number of Units	10
Type of Units	Tubular
Average Annual Energy	53,200 Mwh
Plant Factor	69%
Investment Cost	$28,174,000
Annual Cost	$ 2,186,000
Benefit-to-cost ratio	1.28

Costs for the selected plant were based on estimates prepared by St. Paul District, along with turbine and generator costs received from Allis-Chalmers. Costs were based on September 1981 price levels and the Federal interest rate of 7 3/8 percent. section 4.07 compares the plan with alternative investigations in this report.

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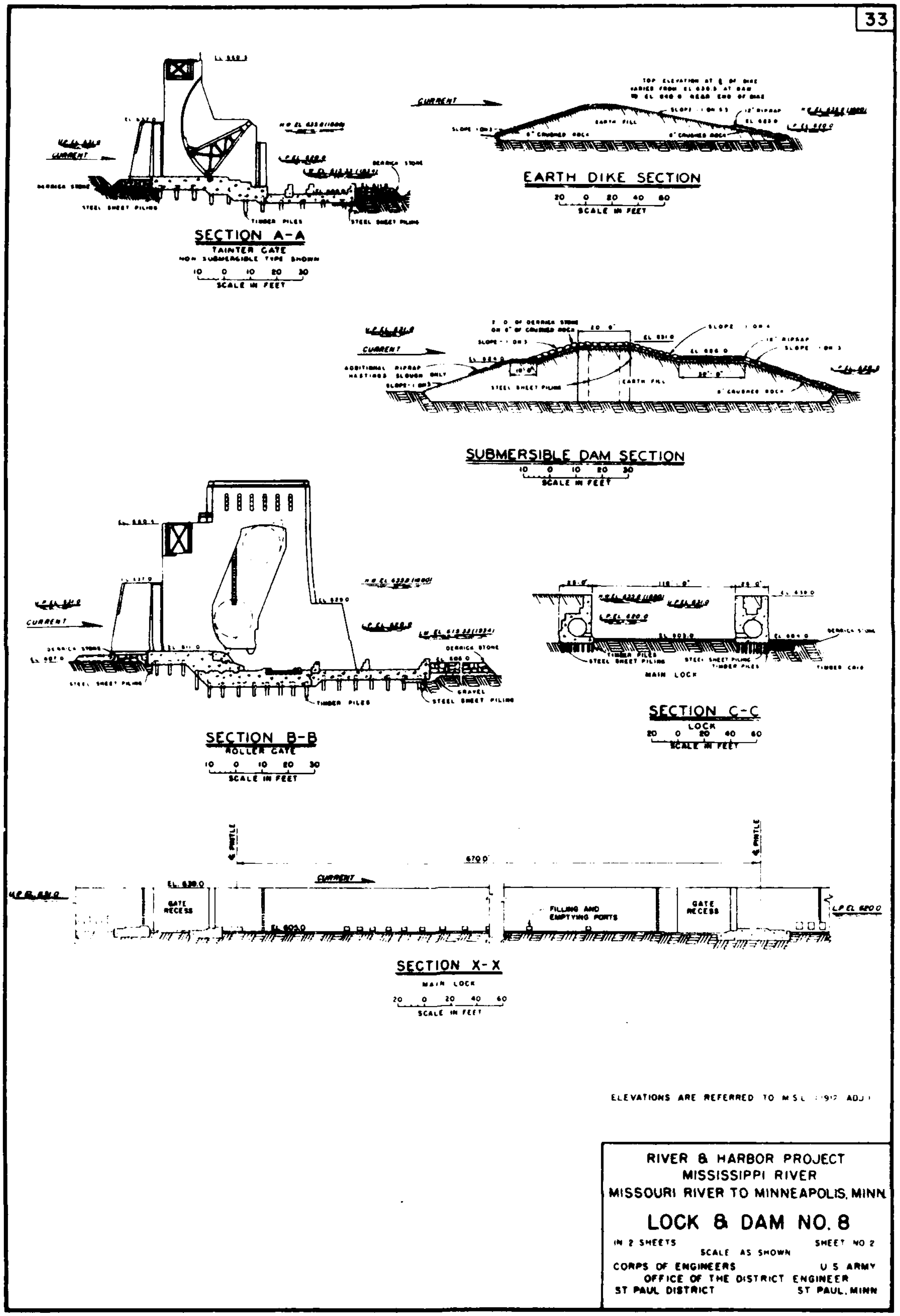
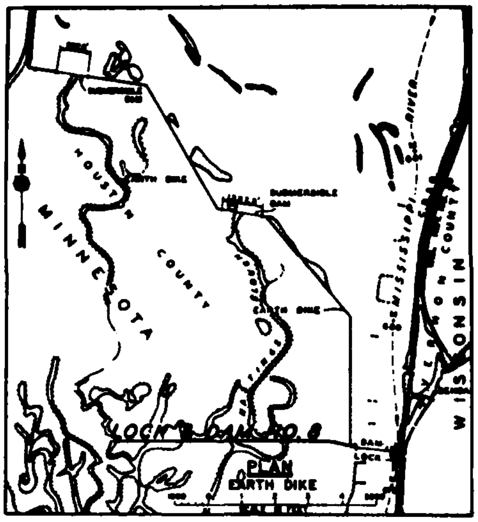
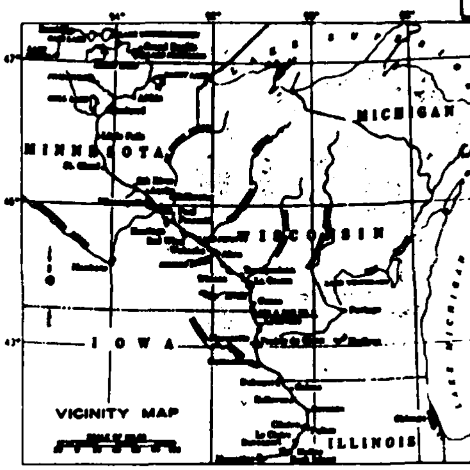
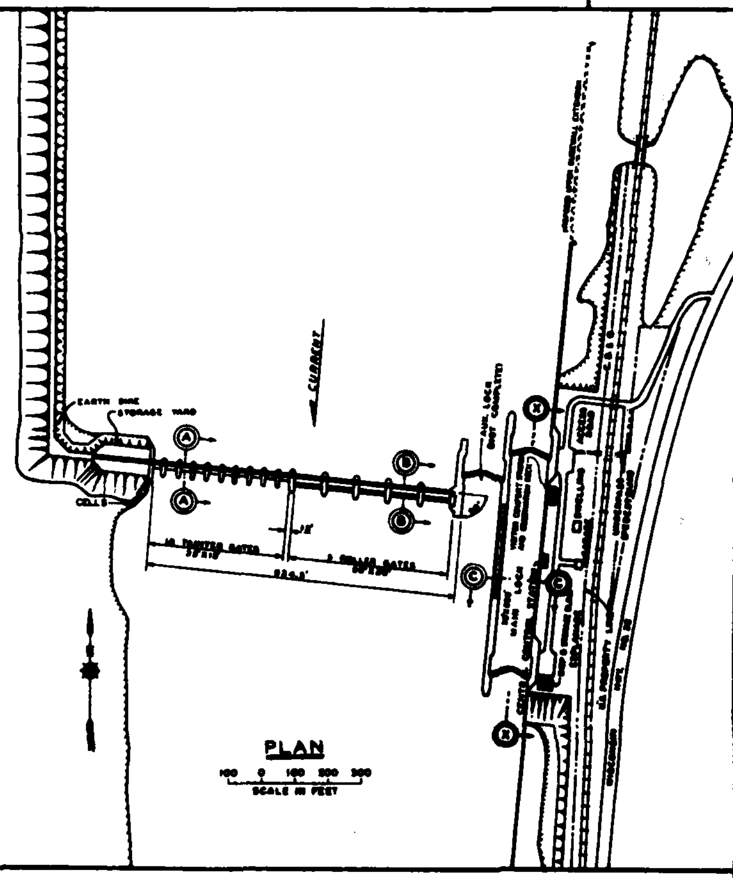


Figure 1-1a







TOTAL LENGTH OF EARTH DIKE - 15,720.0 FT
DEPTH ON UPPER GATE SILL - 22.0 FT (U.P. EL 631.0)
DEPTH ON LOWER GATE SILL - 14.0 FT (L.P. EL 620.0)
ELEVATION UPPER GATE SILL - 609.0
ELEVATION LOWER GATE SILL - 606.0

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCK & DAM NO. 8

IN 2 SHEETS SHEET NO. 1
SCALE AS SHOWN
CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.

Figure 1-1b

SECTION 2 - HYDROLOGY AND POWER CAPABILITIES

2.01 Hydrologic Analysis. Streamflow data for hydropower development was estimated from 50 years of daily gaged data at Winoa, Minnesota (USGS 05-3785). The gage is 46.5 miles upstream of Lock and Dam 8. The LaCrosse and Root Rivers are tributaries to the Mississippi River between the gage and Lock and Dam #8. An estimated drainage area adjustment factor of 9.4 percent was used to account for the drainage area differences and inflows and depletion between the gage and the hydropower site. The 50 year period of adjusted historical data was considered sufficient to evaluate the Lock and Dam #8 site for hydropower development. Figure 2-1 is an annual flow-duration curve developed from daily flows for the period of record. The shaded area represents the flows utilized for a 4.8 MW power plant (see below).

2.02 Power Potential. The power potential for the site was investigated at several alternate site locations. Several different powerhouse schemes and types of generating units were studied. See Section 3 for more detailed descriptions of the alternatives considered. 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 from 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 83% for bulb units and 81% for tubular units

The project has no significant pondage capability. Hence, the project operation is considered run-of-river, i.e., utilizing only existing streamflows for hydropower development.1/ The forebay elevation was considered constant at elevation 631.0. The tailwater elevation varies with streamflow. A tailwater rating curve (Figure 2-2) was used to establish daily tailwater elevations at varying flow conditions. Net generating heads were determined by subtracting the daily tailwater elevations from the corresponding forebay elevations, then deducting an estimated head loss. A one-foot average head loss was used for all power computations. This loss was based on operating experiences with similar plants and was assumed for all flow conditions. A net head-duration curve was prepared and is shown in Figure 2-3. This curve was useful in establishing preliminary turbine operating limits for initial project scoping.

1/ also see section 4.09 for additional discussion on effects of pondage.

Table 2-1 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 4) and to determined the project benefits listed in Table 4-1 .

Power-duration curves were developed based on daily flows: Figure 2-4 is the annual power duration curve. The shaded area under the curve represents the total flow or energy generation that can be developed with the selected plant sizes (also see Section 4.06 scoping); the unshaded area represents the potential not feasible for development. Monthly power-duration curves for the 1.9 MW and 4.8 MW selected plants are shown in Appendix A .

2.03 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 IWR1/ 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. 8 project operates experiences both a winter and summer peak load period. The summer load for July and August was used for establishing peak load in this study. The capacity benefits listed in Section 4 were 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.

TABLE 2-1

SUMMARY OF PLANT SIZES AND GENERATION
(used for project scoping)

Number of Units	Hydraulic Capacity (cfs)	Installed Capacity (MW)	Annual Energy (MWh)	Annual Plant Factor	Dependable Capacity (MW)
<u>Bulb Plant</u>					
1	9,800	6.4	39,500	71%	4.8
3	12,000	7.7	47,320	71%	5.7
3	14,100	8.8	53,590	70%	6.4
3	18,000	10.7	62,510	67%	7.5
3	24,000	13.3	71,030	61%	8.7
3	26,250	14.6	73,200	59%	9.0
3	27,500	15.5	79,690	59%	9.7
4	12,000	7.7	47,320	71%	5.7
4	16,000	9.8	53,370	62%	7.0
4	24,000	13.3	71,030	61%	8.7
4	32,000	15.2	77,110	58%	9.5
4	40,000	15.5	79,970	59%	9.9
<u>Tubular Plant</u>					
1	1,400	0.96	5,890	70%	0.7
2	2,800	1.9	11,770	70%	1.4
4	5,600	3.8	23,530	70%	2.8
5	7,000	4.8	29,420	70%	3.4
10	14,000	9.6	54,600	65%	6.3

LOCK & DAM #6

MISSISSIPPI RIVER

ANNUAL FLOW DURATION CURVE

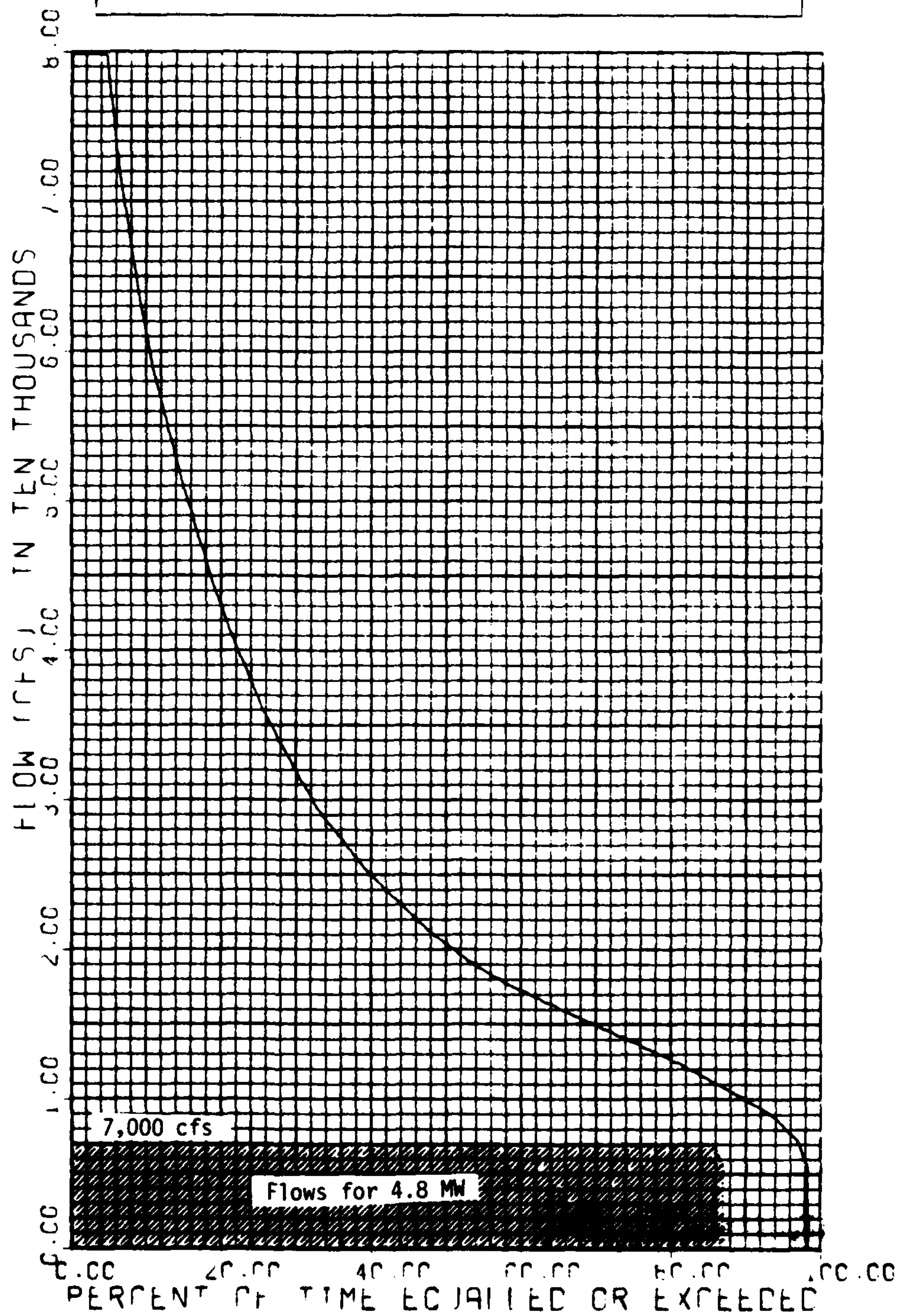
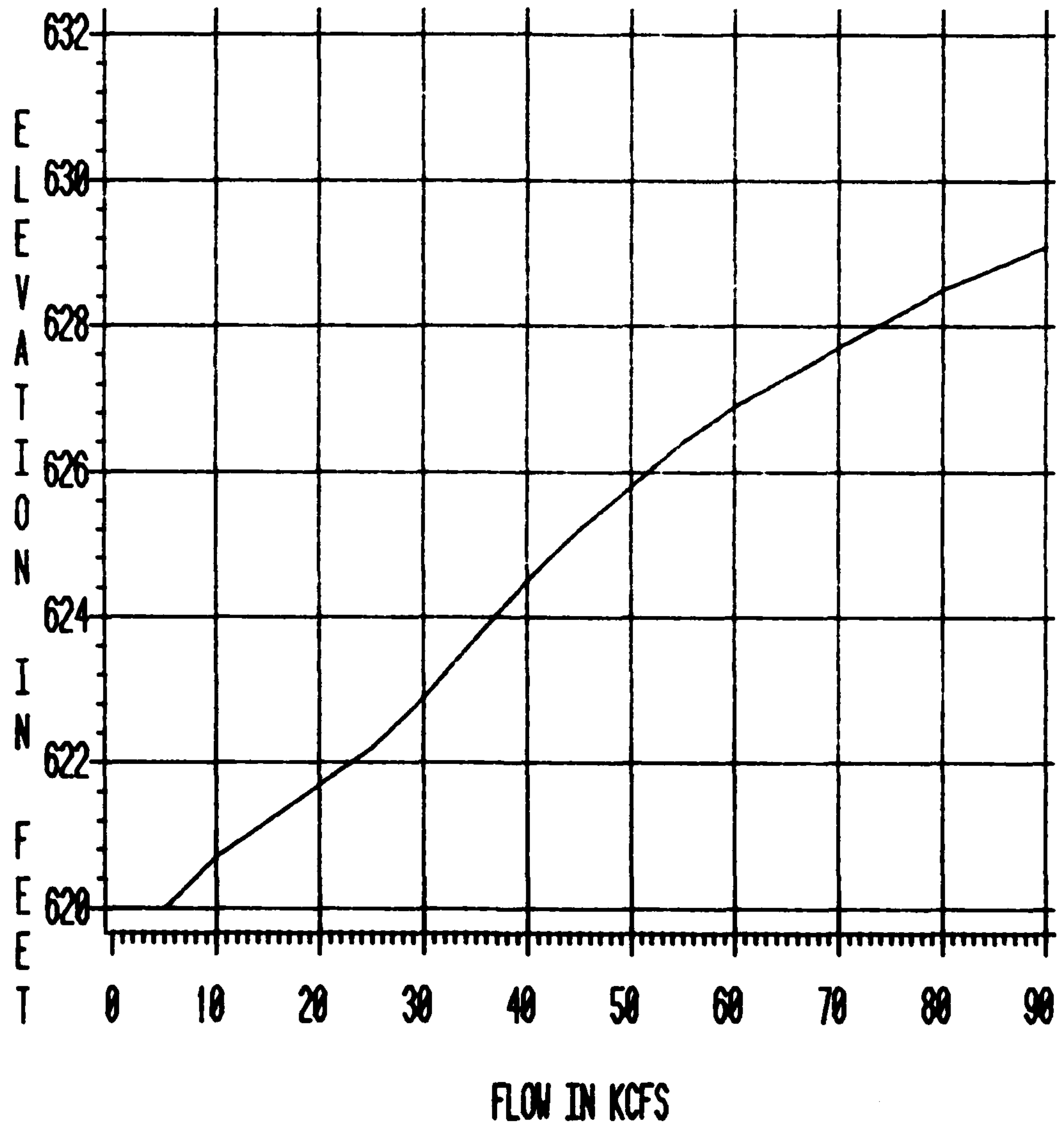


Figure 2-1

LOCK & DAM NO. 8

MISSISSIPPI RIVER - GENOA, WI

TAILWATER RATING CURVE



NPDEN-WM

Figure 2-2

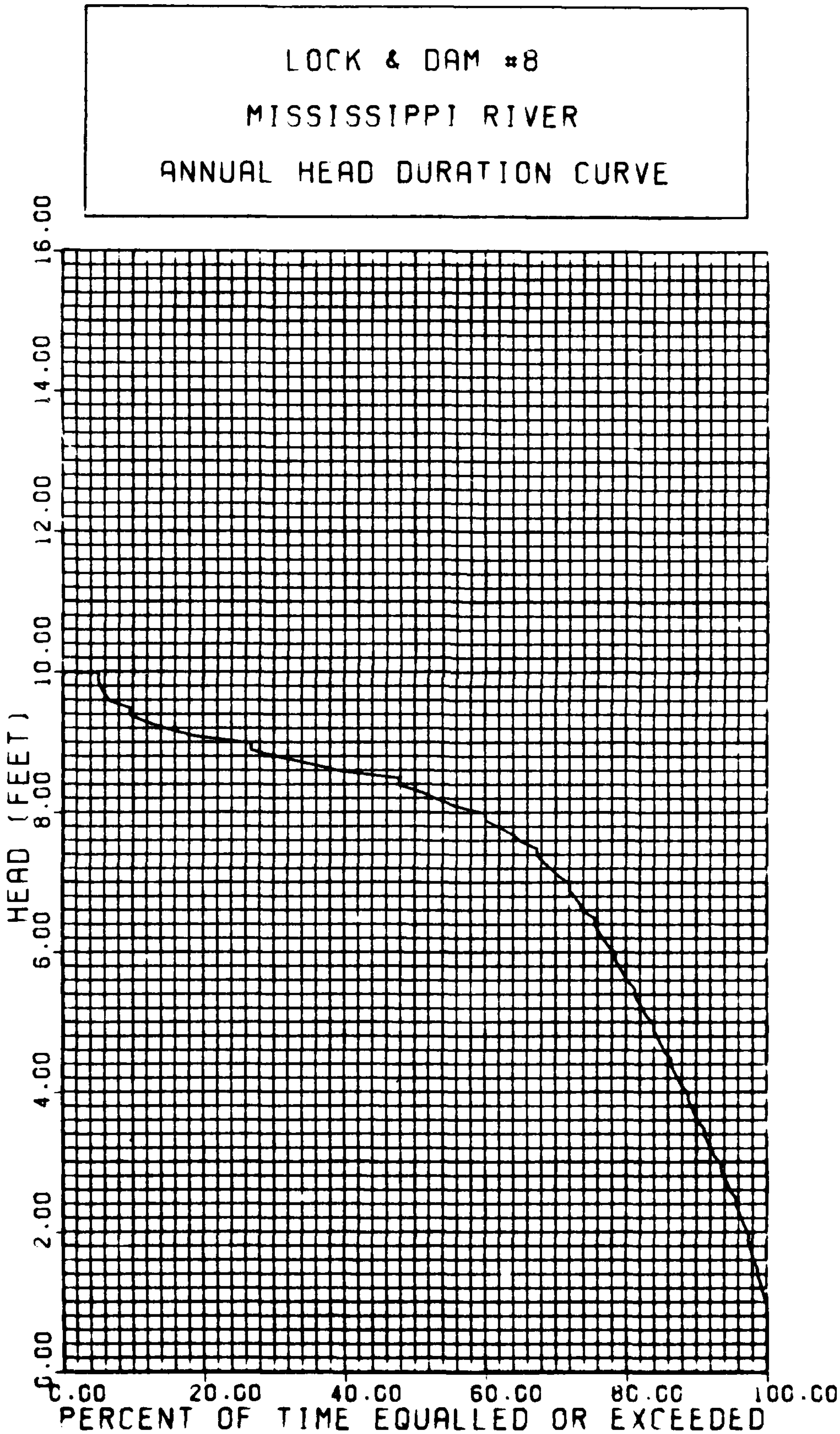
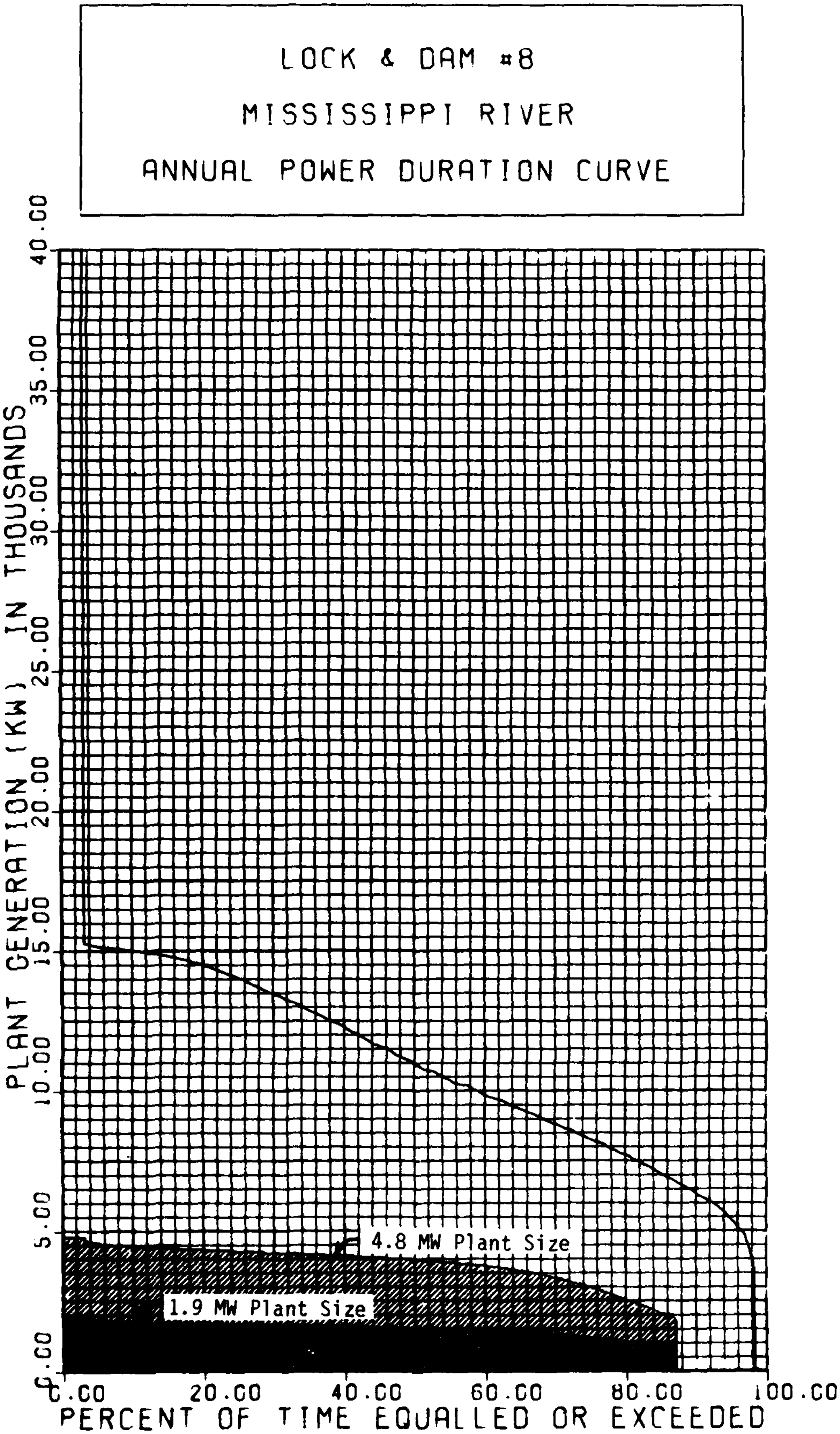

LOCK & DAM #8
MISSISSIPPI RIVER
ANNUAL HEAD DURATION CURVE
HEAD (FEET)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

Figure 2-3



LOCK & DAM #8
MISSISSIPPI RIVER
ANNUAL POWER DURATION CURVE
PLANT GENERATION (KW) IN THOUSANDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
4.8 MW Plant Size
1.9 MW Plant Size

Figure 2-4

SECTION 3 - POWERHOUSE FEATURES & PROJECT COSTS

3.01 Powerhouse Locations.

a. Storage Yard. Schemes 1, 2 and 4 site the powerhouse within the storage yard. The storage yard is 84 feet wide by 183 feet long with a crest elevation of 639.50. The crest which is paved with 10'-0" x 10'-0" x 8" thick concrete blocks must be restored to its original grade upon completion of construction. This would restrict the powerhouse to a location downstream of the storage yard or limit the structure to be constructed with the roof at ground level. From the spillway on the left side a service bridge extends across the yard a distance of 149'-3". Four piers founded on concrete piles support the bridge. Excavation for the powerhouse or conduits must pass between the piers. The capacity of the piles is sensitive to the depth of excavation, due to the increased unsupported length. Depending on the depth of excavation various levels of structural protection utilizing a balance of peripheral sheet piling, bracing and reduced service bridge loading would be required to assure their structural integrity during construction of powerhouse.

b. Earth Dike. The earth dike is located on the right side of the storage yard. The dike is 23 feet wide with a crest elevation of 639.50. The reduced width of the crest results in a cost savings from a reduction in excavation and the elimination of replacement of costly surfacing over the storage yard site. There is enough room on the right side of the end bridge pier to accommodate ten of the piplines described in Scheme 3 or a two unit powerhouse described in Schemes 1 and 2.

c. Auxiliary Navigational Lock. Located on the left bank are two navigational locks each 110 feet wide. The landward lock is operative whereas the waterward auxiliary lock was constructed with minimum provisions for future development. The powerhouse of Scheme 5 is shown located in the auxiliary lock. Civil costs would be greatly reduced since little additional excavation would be required and the work area could be easily closed and dewatered. However, model studies would be necessary to determine how the flows required for power generation would affect navigation. Also this would preclude its use as a future lock.

3.02 Scheme 1 Open Flume Turbine-Siphon. Scheme 1 maximizes the economical use of a 181" (3000 mm) diameter open flume turbine passing a rated flow of 1400 cfs at a rated head of 9.75 feet. Cost estimates were made for two and four unit plants having generating capacities of 1870 kW and 3740 kW, respectively.

A reinforced concrete intake structure equipped with trashracks and an intake gate will be constructed upstream of the storage yard, avoiding a reduction in storage yard capacity. Under the storage yard is a 15' x 26' wide intake conduit passing water into the powerhouse. The invert at the forebay is at elevation 611.00 rising to elevation 621.50 adjacent to the bridge piers. This rise in invert elevation will reduce the potential for undermining the pier pilings.

This scheme uses siphoning action to draw water up into the intake conduit and over the open flume weir plate which is set just above the upper pool elevation. This arrangement eliminates the need for a service gate because the turbine can be effectively dewatered by introducing air into the intake conduit and stopping the siphoning action. (See Plate 1)

The overall structure is 160 feet long by 78 feet and 173 feet wide for the two unit and four unit plants, respectively. Since the shaft is vertical the width of a superstructure necessary to house the generator and other equipment is only 34 feet compared to the 56 feet needed for the tubular units with a horizontal shaft used in Scheme 2. This could make the open flume arrangement more suitable for a less expensive light steel superstructure in the final design analysis. The units are located far enough downstream so the superstructure does not encroach on the storage yard. The draft tube cross section is 13 feet by 26 feet wide where it exits the powerhouse and the invert is at elevation 602.

3.03 Scheme 2 Tubular Turbine-Siphon. Scheme 2 utilizes tubular turbines passing a rated flow of 1400 cfs at a rated head of 9.75 feet. The cost estimates include a four and two unit powerhouse housing a total generating capacity of 1870 kW and 3740 kW, respectively.

A reinforced concrete intake structure and conduit similar to the one incorporated in scheme 1 will be used for this scheme. The intake conduit was elevated between the adjacent piers, as in scheme 1, to reduce the potential for undermining of the pile founded piers. Downstream of the piers the conduit invert drops to elevation 609.50 before entering the powerhouse. Since the conduit is above the elevation of the upper pool, vacuum pumps will be required to create a siphoning effect. One conduit cuts between each pair of piers and serves each turbine.

The powerhouse roof is set at grade and located downstream of the storage yard which in effect increases the storage yard area. The overall structure is 180 feet long and 89 feet wide for the two unit plant, and 180 feet by 179 feet for the four unit plant. A generator room will be provided to house electrical and mechanical equipment at elevation 616.00. Hatches will be required for equipment access. The draft tube exits the powerhouse at elevation 596.00 into the tailrace. A draft tube bulkhead will be required to unwater the unit.

3.04 Scheme 3 Mini-Bulb Turbine-Siphon. The unit used in scheme 3 is a standardized module consisting of an axial flow turbine, a speed increasing gear set, and a generator combined in a short section of a pipeline connecting the upper pool with lower pool. Each turbine has a runner throat diameter of 53 inches, operates with a rated flow of 138 c.f.s. at a rated head of 11 feet, and produces a generator output of 105 kW. An intake structure with trashracks and an outlet structure are required at the ends of the pipe line. The arrangement drawing (Plate 1) shows the pipeline laying on the side slopes of the dike and cutting through the embankment so that it has a minimum cover of 2 feet under the roadway. This arrangement minimizes excavation; however, a shorter pipeline could be attained by excavating into the side slopes. A detailed cost study would be required to determine the best profile. The cost estimate shown on Table 3-1 is based on 175 feet of pipe with excavation as described above. The top of the pipe would be at elevation 637 while upper pool is at elevation 631; thus, siphoning action will be required. A vacuum pump and air inlet valve will be required to start and stop the siphoning. The arrangement drawing shows only two pipelines. However, 10 of these units could be fitted within the dike and adjoining storage yard right of the last bridge pier if additional capacity is required.

3.05 Scheme 4 Tubular Turbine. The cost estimates for scheme 4 include a two and four unit powerhouse with the same turbines and generating capacities as those of scheme 2. However, the concrete quantity is less than half that of scheme 2. The intake leads directly into the powerhouse with no intervening conduit, thereby decreasing the overall length to 109 feet. Two units are placed between each set of piers decreasing the overall width to 56 feet for a two unit powerhouse and 102 feet for a four unit powerhouse. The intake establishes the depth of excavation between the piers to elevation 611.0. This is about ten feet deeper than the depth required for a conduit scheme. Pile capacity could be seriously reduced. The clear distance between adjacent piers is extremely minimal for the placement of the two 3-meter horizontal tubular units. The resulting draft tube widths and distances between unit centerlines are less than those recommended by turbine manufacturers. The arrangement drawing (Plate 3) shows some of the resulting problems such as narrow intermediate piers and tight clearances for construction and operation. The arrangement as shown would be generally unacceptable by Corps' standards.

3.06 Scheme 5 Tubular Turbine-Aux. Lock. Scheme 5 is located in the auxiliary lock. The 110 ft clear width of the lock will accommodate five 3-meter tubular units. Each is rated to produce 935 kW at a rated head of 9.75 ft. The total plant installed capacity is 4675 kW. The hydraulic discharge of the plant is approximately 7000 c.f.s. The intake is placed on the lock chamber floor at elev. 605.5. Excavation to elev. 593.5 is required downstream of the turbines for the draft tubes. The overall length of the powerhouse is 86 feet. A superstructure and bridge crane are included with the plant. Butterfly valves are located inside the powerhouse so they can be served by the bridge crane. The 20-ton bridge crane will be used for installation as well as maintenance of the equipment.

3.07 Project Costs. Unit costs for labor and materials were based on Jan. 84 price levels. These costs were subsequently indexed to October 1984 price levels for the economic analysis in Section 4.02. The excavation feature includes diversion and care of water, and was computed by St. Paul District. An itemized cost estimate is included in Table 3-1.

TABLE 3-1
CONSTRUCTION COSTS ($1,000)

HYDROPOWER STUDY
LOCK AND DAM #8
LACROSSE, WISCONSIN

Price Level Date: JAN 1984

FEATURE	Scheme 1		Scheme 2	
	2 Unit	4 Unit	2 Unit	4 Unit
1. POWERHOUSE				
1.1 Excavation	2405	2997	2312	2868
1.2 Reinforced Concrete	1227	2471	1526	3076
1.3 Misc. Building Items	40	80		
1.4 Bulkheads, Guides, Trashracks	165	326	585	1087
1.5 Architectural			48	96
2. TURBINES AND GENERATORS				
2.1 Turbines, Generators, Governors	1850	3640	2100	4150
2.2 Generator (if not incl. in 2.1)	248	496	248	496
2.3 Cooling System	12	20	12	20
3. ACCESSORY ELECTRICAL EQUIPMENT				
3.1 Switchgear, Breakers & Buses	230	417	230	417
3.2 Station Service Unit	40	65	40	65
3.3 Control System	235	395	235	395
3.4 Misc. Electrical Systems	85	176	170	376
4. AUXILIARY SYSTEMS & EQUIPMENT				
4.1 Heating and Ventilating	15	28	15	28
4.2 Station, Brake & Governor Air	8	12	8	12
4.3 Unwtering & Drainage Systems	20	26	20	26
4.4 Misc. Mechanical Systems	20	30	20	25
4.5 Bridge Crane			20	25
4.6 Draft Tube Gate Hoist			50	100
4.7 Trashrack Cleaning	150	150	150	150
4.8 Monorail Crane, Trailrace				
5. SWITCHYARD				
5.1 Power Transformer	57	1C7	57	107
5.2 Disconnects & Electrical Equipment	30	30	30	30
Sub-Total	6837	11466	7876	13554
CONTINGENCY	1266	2019	1413	2320
TOTAL	8103	13485	9289	15874

TABLE 3-1
CONSTRUCTION COSTS ($1,000)

HYDROPOWER STUDY
LOCK AND DAM #8 PROJECT
LACROSSE, WISCONSIN

Price Level Date:
Jan 1984

FEATURE	Scheme 3		Scheme 4		Scheme 5
	2 Unit	4 Unit	2 Unit	4 Unit	5 Unit
1. POWERHOUSE					
1.1 Excavation	140	174	2188	2492	1392
1.2 Reinforced Concrete	16	32	700	1351	1820
1.3 Misc. Building Items					100
1.4 Bulkheads, Guides, Trashracks	10	20	585	1087	650
1.5 Architectural			48	96	85
2. TURBINES AND GENERATORS					
2.1 Turbines & Generators, Governors	335	670	2100	4150	7150
2.2 Generator (if not incl in 2.1)			248	496	622
2.3 Cooling System			12	20	50
3. ACCESSORY ELECTRICAL EQUIPMENT					
3.1 Switchgear Breaker & Busses			230	417	570
3.2 Station SErvice Unit			40	65	85
3.3 Control System			235	395	474
3.4 Misc. Electric Systems			170	376	220
Total Accessory Elect Equip.	50	100			
4. AUXILIARY SYSTEMS & EQUIPMENT					
4.1 Heating and Ventilating			15	28	23
4.2 Station, Brake & Governor Air			8	12	42
4.3 Unwatering & Drainage Systems			20	26	95
4.4 Misc. Mechanical Systems			20	30	70
4.5 Bridge Crane			20	25	160
4.6 Draft Tube Gate Hoist			50	100	
4.7 Trashrack Cleaning			150	150	150
4.8 Monorail Crane, Tailrace					75
5. SWITCHYARD					
5.1 Power Transformer			57	107	80
5.2 Disconnects & Elect. Equipment			30	30	30
Sub-Total	551	996	6926	11453	13943
CONTINGENCY	97	167	1258	1967	2231
TOTAL	648	1163	8184	13420	16174

SECTION 4 - ECONOMICS

4.01 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.

4.02 Cost Estimates. All costs in this report are based on October 1984 levels. Cost estimates were prepared for different sizes of plants that could 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 (also see Section 4.06 Scoping).

The construction cost estimate was adjusted to account for inflation during construction in the estimate. The NED benefits for this report are based on October 1984 price levels. Therefore, an adjustment was made to the project cost estimate so that the NED costs would be at the same price level. Based on experiences within NPD an inflation adjustment of 6.7 percent compounded annually over the construction period was used. The adjustment was applied to all construction items except the turbines, generators, and control equipment which are themselves point estimates and have contractural agreements for escalating at future times.

For the powerplant, engineering and design (E&D) costs 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 35 months (see Section 3). Interest during construction (IDC) costs were 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 costs expressed as a percentage of the total cost for each site were as follows:

TABLE 4-1

PROJECT EXPENDITURE PERCENTAGES

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

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

Tables 4-2 and 4-3 show development of the NED 1/ Investment cost for the two selected plant sizes. Section 4.06 describes the optimization procedure used to select these plants.

1/ National Economic Development, used for project economics

TABLE 4-2

INVESTMENT COST ($1,000)

Selected Plant Size 1.9 MW
(2 Tubular Units)

	Items Exclusive of Powerplant Equipment	Powerplant Equipment 7/	Total
Subtotal 1/	$4,932	$3,092	$8,024
Contingencies 2/	986	464	
Subtotal	$5,918	$3,556	
Inflation Adjustment 3/	-533	0	
Subtotal	$5,385	$3,556	
EDS & A 4/	646	427	
Subtotal	$6,031	$3,983	
IDC 5/	724	702	
Total 6/ Invest. Cost	$6,754	$4,685	$11,439

1/ Basic construction costs from Table 3-1, Indexed to Oct 84 price levels
2/ For powerplant equipment, use 15%; for items exclusive, use 20%.
3/ Adjustment for inflation during construction, items exclusive of powerplant equipment only
4/ Engineering, design, supervision, and administration, 12%.
5/ Interest during construction, compounded from estimated yearly expenditures.
6/ National Economic Development (NED) investment cost for scoping and economic excludes inflation during construction costs.
7/ Cost items 2 and 3 only from Section 3 .

TABLE 4-3

INVESTMENT COST ($1,000)

Selected Plant Size 4.7 MW
(5-Tubular Units)

	Items Exclusive of Powerplant Equipment	Powerplant Equipment 7/	Total
Subtotal 1/	$5,321	$9,170	$14,491
Contingencies 2/	1,064	1,375	
Subtotal	$6,385	$10,545	
Inflation Adjustment 3/	-576	0	
Subtotal	$5,809	$10,545	
EDS & A 4/	697	1,264	
Subtotal	$6,506	11,810	
IDC 5/	781	2,082	
NED Invest. Cost 6/	$7,287	$13,892	$21,179

1/ Basic construction costs from Table 3-1, indexed to Oct 84 price levels.
2/ For powerplant equipment, use 15%; for items exclusive, use 20%.
3/ Adjustment for inflation during construction, items exclusive of powerplant equipment only
4/ Engineering, design, supervision, and administration, 12%.
5/ Interest during construction, compounded from estimated yearly expenditures.
6/ National Economic Development (NED) investment cost for scoping and economic excludes inflation during construction costs.
7/ Cost items 2 and 3 only from Section 3 .

4.03 Annual Costs. The period of analysis for the project is 100 years. The annual interest and amortization rate is 8 3/8 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 1984 price levels. These O&M costs, in-turn, were adjusted 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 was 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 4-4 summarizes annual costs for the selected plant sizes.

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 4-4

ANNUAL COST
FOR
SELECTED PLANTS ($1,000)

	1.9 MW Plant (2-Units)	4.7 MW Plant (4 Units)
NED Investment Cost	$11,439	$21,179
Annual Cost		
Interest & Amortization 1/	958	1,774
Operation & Maintenance 2/	41	71
Replacement 2/	4	6
Total	$1,003	$1,851

1/ 8-3/8 percent and 100 years (I&A factor = 0.08378)
2/ See Section 4.03

4.04 Power Values. 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 operating expenses of some existing power plants (energy displacement).

Discussion with FERC Chicago Office indicated that generation from Lock and Dam No. 8 would be similar to the proposed generation at the St. Anthony Falls project (located upstream) 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 8 August 1984 letter (Appendix D), FERC supplied capacity and energy values based on 8-3/8 percent discount rates and at October 1984 price levels for the St. Anthony Falls and Lock and Dam No. 1 projects. These power values will be applicable to the Lock and Dam No. 8 project.

An adjusted energy value was developed by FERC using DOE fuel escalation projections and a 1990 power-on-line date. The adjusted capacity value includes mechanical and thermal availabilities of 0.985 and 0.760 and an operating flexibility credit of 5 percent. The adjusted power values at 8-3/8 percent interest are $210.60/kw-yr for capacity and 38.2 mills/Kwh-yr for energy.

TABLE 4-5
ANNUAL BENEFITS ($1,000)
(October 1984 Price Levels, 8 3/8% Interest)

(1) Plant Size (MW)	(2) No.2 Type Units	(3) Hydr. Cap. (cfs)	(4) Annual Energy (MWh)	(5) Dep. Cap Jul-Aug (MW)	(6) Plant Factor %	(7) Energy Benefit $1,000 1/	(8) Capacity Benefit $1,000 2/	(9) Total Benefit $1,000 3/
6.4	1-bulb	9,750	39,510	4.8	71.2	1,509	1,011	2,520
7.7	3-bulbs	12,000	47,320	5.7	70.6	1,808	1,200	3,008
8.8	3-bulbs	14,100	53,590	6.4	69.7	2,047	1,350	3,395
10.7	3-bulbs	18,000	62,510	7.5	66.5	2,388	1,580	3,968
13.3	3-bulbs	24,000	71,030	8.7	61.0	2,713	1,832	4,545
14.0	3-bulbs	26,250	73,200	9.0	59.4	2,796	1,895	4,691
15.5	3-bulbs	27,500	79,690	9.7	58.7	3,044	2,043	5,087
7.7	4-bulbs	12,000	47,320	5.7	70.6	1,808	1,200	3,008
9.8	4-bulbs	16,000	58,370	7.0	68.2	2,230	1,474	3,704
13.3	4-bulbs	24,000	71,030	8.7	61.0	2,713	1,832	4,545
15.2	4-bulbs	32,000	77,110	9.5	57.7	2,946	2,001	4,947
15.5	4-bulbs	40,000	79,970	9.9	58.9	3,055	2,085	5,140
0.96	1-tube	1,400	5,890	0.7	70.2	225	147	372
1.9	2-tubes	2,800	11,790	1.39	70.0	450	293	743
3.8	4-tubes	5,600	23,530	2.8	70.2	899	590	1,489
4.8	5-tubes	7,000	29,420	3.4	69.9	1,124	716	1,840
9.6	10-tubes	1,400	54,600	6.3	65.1	2,086	1,327	3,413

1/(4)x 38.2 mills/Kwh
2/(5)x $210.60/Kw
3/(7)+ col(8)

4.05 Annual Benefits. Project annual benefits were prepared for the series of plant sizes shown on Table 2-1. 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 4-5 summarizes annual benefits for plant sizes investigated. These benefits along with annual costs are shown graphically on Figure 4-1.

4.06 Scoping. The project was scoped using a net benefit analysis. All price levels were at October 1984 and a Federal interest rate of 8 3/8 percent was used. Unit power values were used as described in the preceeding section. Table 4-5, lists the annual benefits for the range of plant sizes used in this analysis. A range of corresponding annual costs was also developed and are shown graphically along with the benefits on Figure 4-1. The optimum plant size was then selected based on the maximum net benefit shown on this curve. Table 4-6 shows annual costs, benefits, net-benefits, and benefit-to-cost ratios for the two selected optimum plant sizes. See section 5 for additional discussion on the optimum plant size.

Costs and benefits were developed for both bulb and tubular type powerhouses. It can be seen from Figure 4-1 that for plants less than about 6 MW, the tubular plants are more economical; conversely, for larger size plants the bulb type plant is more economical.

TABLE 4-6

PLANT AND ECONOMIC DATA FOR SELECTED PLANT SIZES

(Oct 1984 Price Levels)

Location	Right Storage Yard	Auxiliary Lock
Number Units	2 Tubular	5 Tubular
Installed Capacity	1.9 MW	4.8 MW
<u>Generation 1/</u>		
Annual Energy	11,790 Mwh	28,350 Mwh
Dependable Capacity	1.4 MW	3.4 MW
Plant Factor	70%	69%
<u>Costs</u>		
Investment Cost 2/	$10,420,000	$21,200,000
Annual Cost 3/	$ 1,003,000	$ 1,850,000
<u>Benefits 4/</u>		
Annual Capacity	$ 293,000	$ 716,000
Annual Energy	$ 450,000	$ 1,124,000
Total Annual	$ 743,000	$ 1,840,000
Net Benefit	- 260,000	- 10,000
B/C	0.74	0.99

1/ From Table 2-1
2/ From Tables 4-2 and 4-3
3/ From Table 4-4
4/ From Table 4-5

4.07 <u>Marketability</u>. Because of the relatively small size of the project and the level of study (supplemental to reconnaissance) it was unnecessary to conduct a marketing analysis. It should be noted, however, that contacts with the U.S.Department of Energy for similar types of projects in the region have indicated that generation of this type would be readily marketable (also see D.O.E letter 1 Nov 84 for Lock and Dam No.1). It will, therefore, be assumed that this project's generation can be absorbed into the existing energy system.

Figures 4-2 and 4-3 show the energy generation by months for the 1.9 MW and 4.9 MW selected plants. The figures show the generation pattern and can provide useful information for establishing marketing in the future. The figures shows graphically a relatively high energy capability in all months except the spring and early summer high runoff months when the rising tailwater curtails generation (April, June, July). The overall generating pattern appears to be compatible with the energy demand in the area.

4.08 Cost Comparison: 1981 Reconnaissance Report with 1984 Supplemental Study. To provide a measure of comparison for the selected plant published in the 1981 reconnaissance report, data is shown for a 10-unit tubular plant (Table 4-7). The first column lists data taken from the reconnaissance report at 1981 price levels, and the second column lists comparable date based on 1984 price levels. Table 4-7 shows the 1981 study to have a favorable project feasibility and a B/C ratio of 1.28. From the same table, the 1984 study, using a more detailed cost estimate, shows a B/C ratio cf 0.84. The slightly larger 1984 plant produces some additional generating benefits; however, these benefits are more than offset by the project cost increase over the 1981 plant cost.

TABLE 4-7

COST COMPARISON 1981 STUDY AND 1984 STUDY

Item	1981 Recon Report Selected Plant (Jan 81 price levels)	1984 Supplemental Comparable Plant (Oct 84 price levels)
Plant Size	8.75 MW	10.5 MW
No. Units	10 tubular	10 tubular
Annual Energy	46,600 Mwh	54,600 Mwh
Dependable Capacity	8.75 MW	6.4 MW
Plant Factor	61%	65%
Investment Cost	$28,174,000	$48,050,000
Annual Cost	$2,186,000	$4,100,000
Energy Value	41.4 mills/kwh	38.2 mills/kwh
Capacity Value	$100.00 kw	210.60 kw
Interest Rate	7 3/8%	8 3/8%
Energy Benefit	$1,929,000	$2,086,000
Capacity Benefit	$875,000	$1,348,000
Total Benefit	$2,804,000	$3,434,000
Net Benefit	$618,000	$ - 666,000
B/C	1.28	0.84

Several items in table 4-7 should be discussed further. Both the new study and the old reconnaissance study used a 10-unit tubular plant as a basis for comparison. The new study used slightly larger generating units (20% greater). Correspondingly the new study shows development of a greater project annual energy (17% greater).

New project costs in the supplemental study are considerably higher than those in the 1981 report (70% higher). This item has a major effect on the project economic feasibility. Some of the cost increase is due to normal inflation; however, some of the component costs have increased beyond that considered for normal inflation. For example, the turbine-generator costs are

$20.5 and $14.2 million respectively for the new and old studies (44% increase). Some of the costing procedures used could also account for the cost differences. For example, the new cost estimate used a 3-year period of construction interest while a 2-year period was used for the old study. Engineering, design, supervision, and administration costs of 12 percent were used for the new study, while only 6 percent was used in the old study. Generally, the project costs for the new study are in more detail and reflect a higher level of estimating standards and, therefore, result in higher items of cost than those used in the older reconnaissance level study.

Benefits for the project are based on current power values received from FERC. The values represent an increase in interest rate from 7 3/8 percent to 8 3/8 percent, and of most significance is the energy value that decreased from 41.4 mills per kwh to 38.2 mills per kwh. This reduction in alternative energy costs is representative of costs over the nation in the past two or three years -- as alternative fuel and energy costs have decreased appreciately. Because about two thirds of the total project benefits were derived from energy, this reduction in the unit energy value greatly reduced the total project benefits. Some additional benefits were gained by an increased capacity value, but not enough to offset those benefits lost by the reduction in energy benefits. It is also significant to note that the reconnaissance study used the full installed capacity for the dependable capacity component, whereas the new study used a reduced value based on the critical generation months for dependable capacity.

Summarizing the comparison, the supplemental study shows project costs to exceed the benefits for the 10-unit plant. The 1981 reconnaissance study showed an economically favorable project with a benefit-to-cost ratio of 1.28 for the same development. The decrease in economic value is the result of two significant changes: 1) The new project costs have increased greatly, chiefly because of a more detailed cost analysis and, 2) the new project benefits did not increase appreciately from 1981 levels to 1984 levels.

4.09 Effects of Pondage Operation on Project Economics. The power potential for Lock and Dam No. 8 was developed based on a run-of-river operation. All project economics were developed using unregulated historical flows. However, it should be recognized that a small amount of daily regulation could enhance the project economics significantly. It is beyond the scope of this study to analyze the full effects of regulation; however, the following example should indicate the magnitude of the economic effect on the project.

For example, using the 5-unit powerhouse, in times of low river flows(the critical summer months) some of the units would be shut down. If a small amount of daily pondage were available, the water could be ponded behind the dam and then released for short periods of peak power demand. These critical months without regulation currently produce a hydrologic availability of 71 percent. Thus, some additional generation could be developed for up to 29 percent of the time by increasing the flows through regulation. As a practical example assume that the flows during the critical period could be regulated so that half of the lost capacity could be recovered, then the dependable capacity would increase from 3.4 MW to 4.1 MW and the annual capacity benefit would be increased from $1,840,000 to $1,987,000. The net benefit would increase from -$10,000 to $137,000 annually and a favorable B/C ratio of 1.07 would be produced.

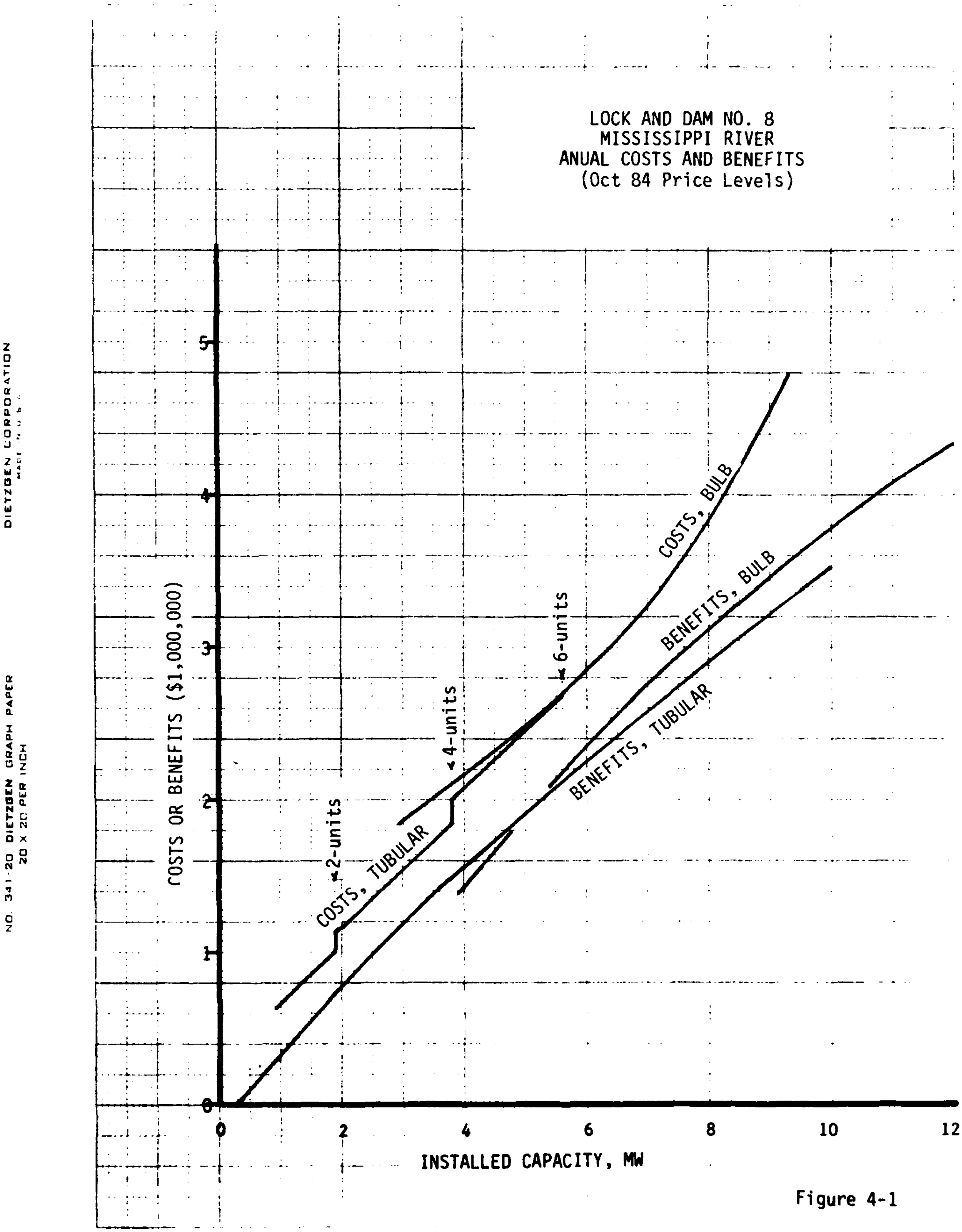

LOCK AND DAM NO. 8
MISSISSIPPI RIVER
ANUAL COSTS AND BENEFITS
(Oct 84 Price Levels)
COSTS OR BENEFITS ($1,000,000)
INSTALLED CAPACITY, MW
0
1
2
3
4
5
0
2
4
6
8
10
12
COSTS, BULB
BENEFITS, BULB
BENEFITS, TUBULAR
COSTS, TUBULAR
2-units
4-units
6-units
NO. 341-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH
DIETZGEN CORPORATION

Figure 4-1

LOCK & DAM #8

MISSISSIPPI RIVER

AVERAGE MONTHLY GENERATION

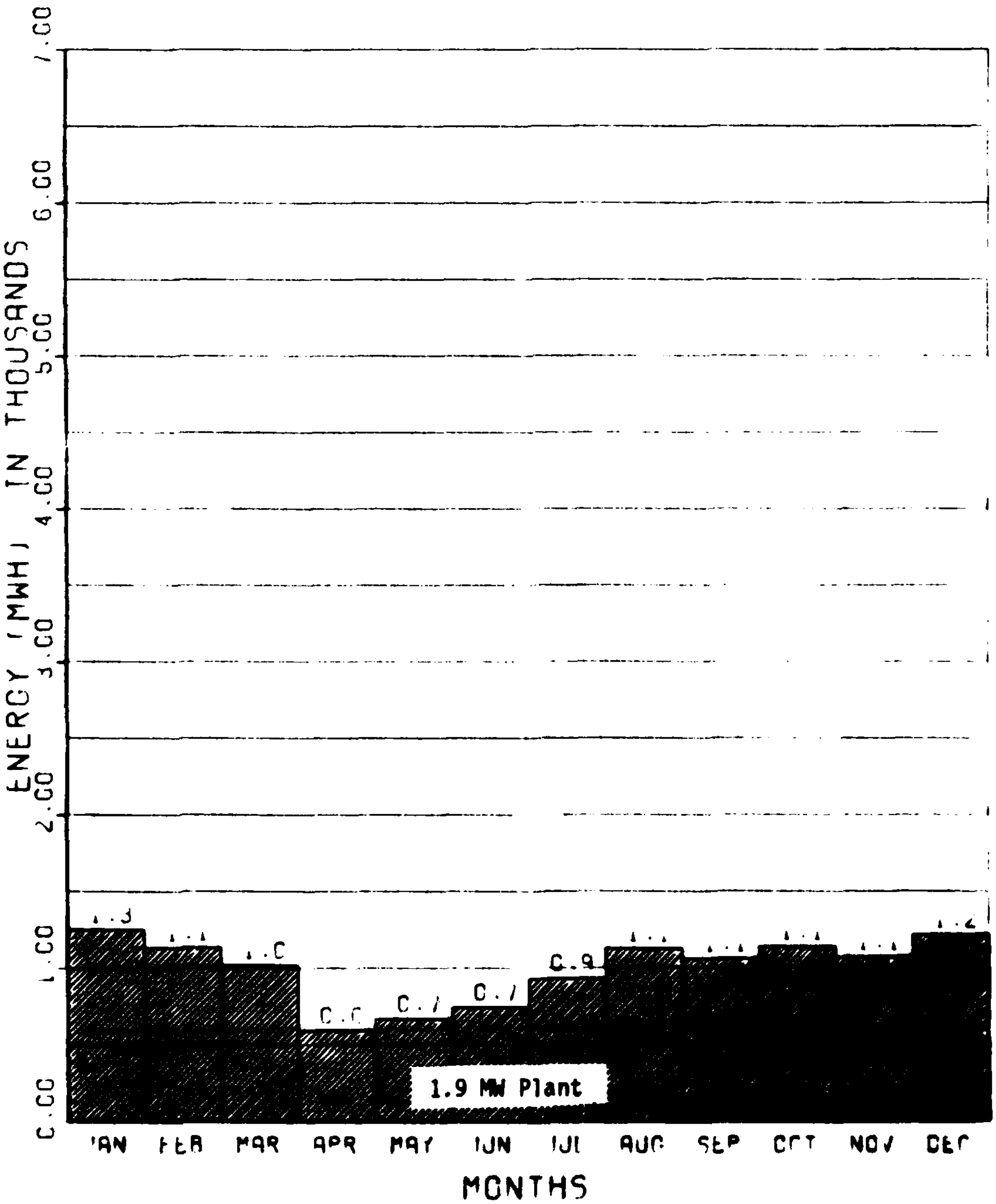


Figure 4-2

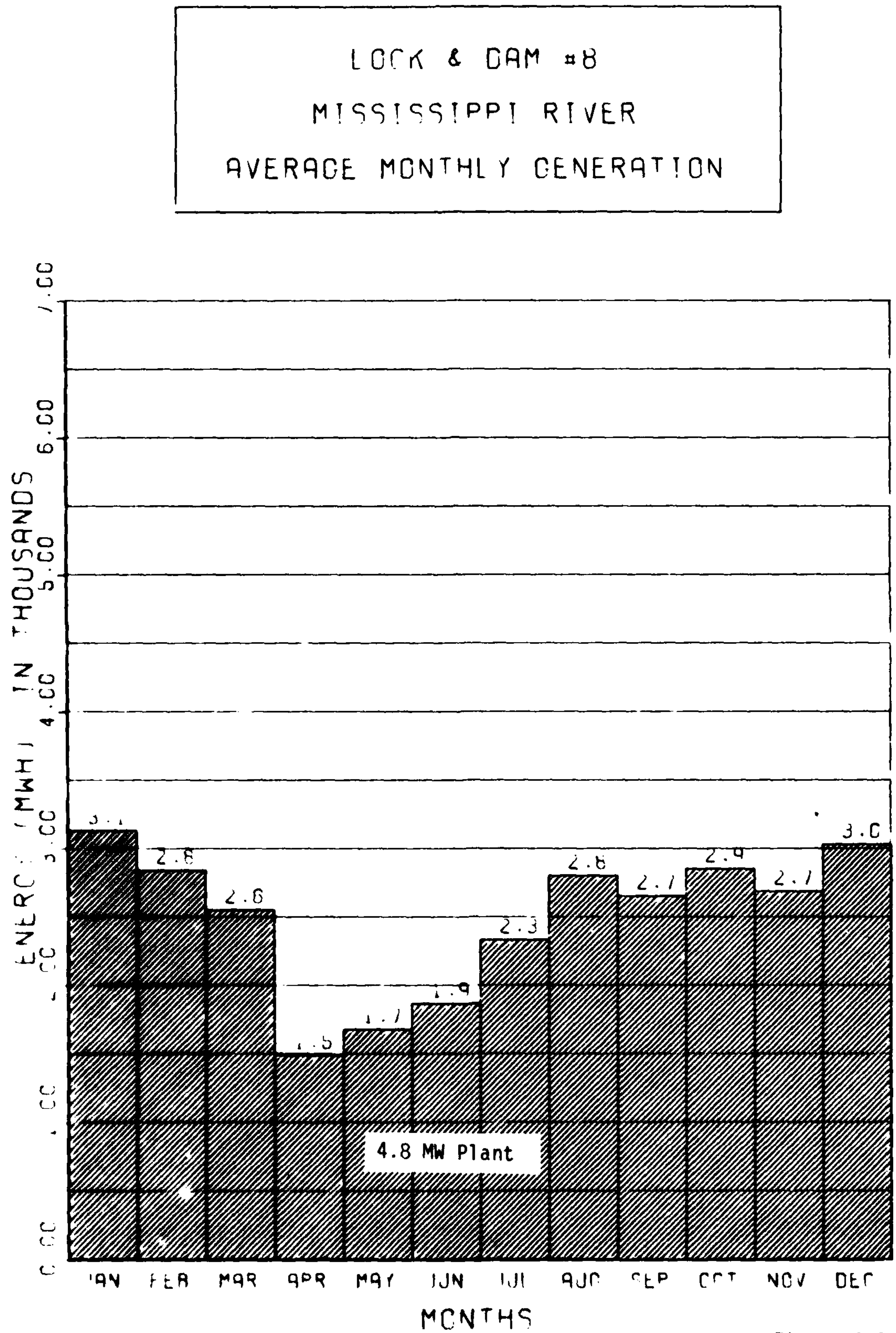
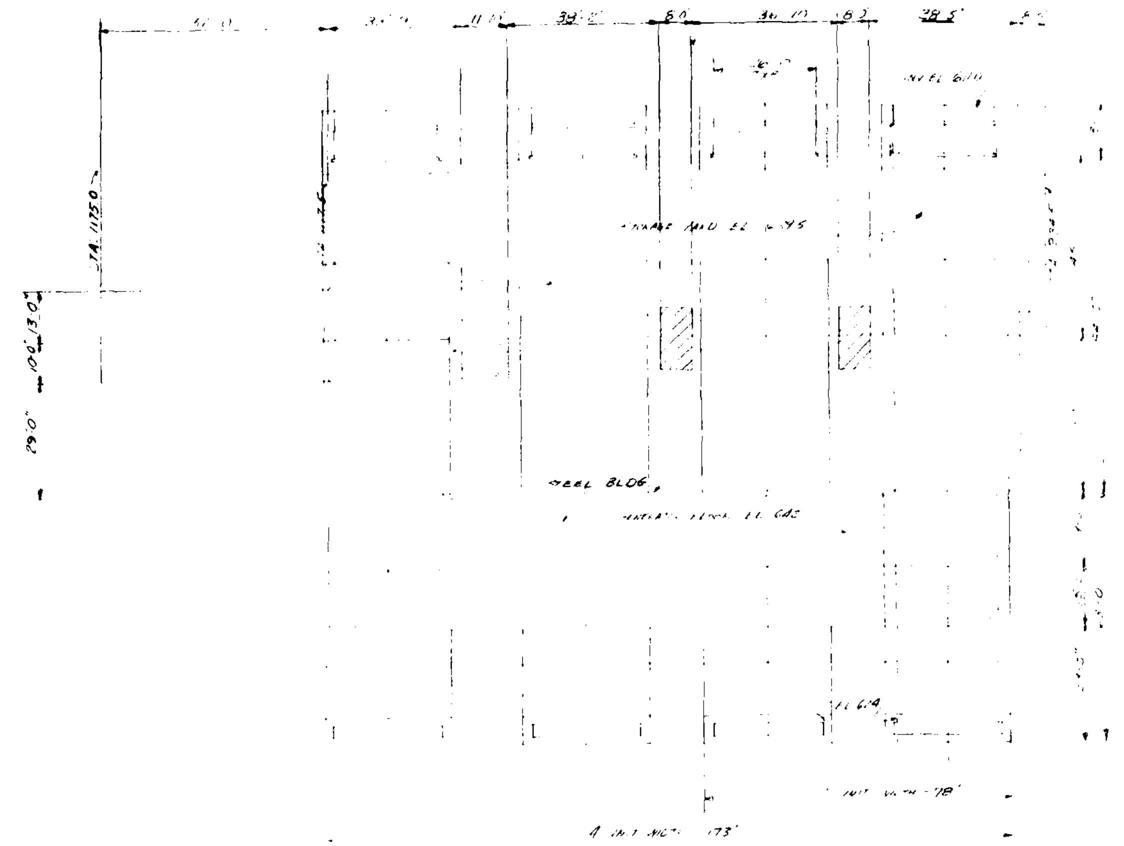
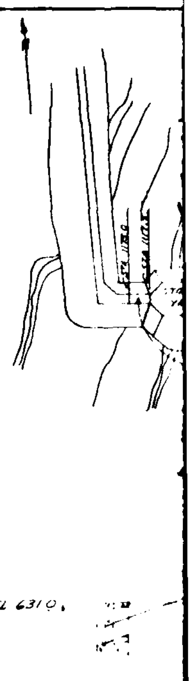

LOCK & DAM #8
MISSISSIPPI RIVER
AVERAGE MONTHLY GENERATION
ENERGY (MWH) IN THOUSANDS
7.00
6.00
5.00
4.00
3.00
2.8
2.6
1.5
1.7
1.9
2.3
2.8
2.7
2.9
2.7
3.0
4.8 MW Plant
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHS

Figure 4-3

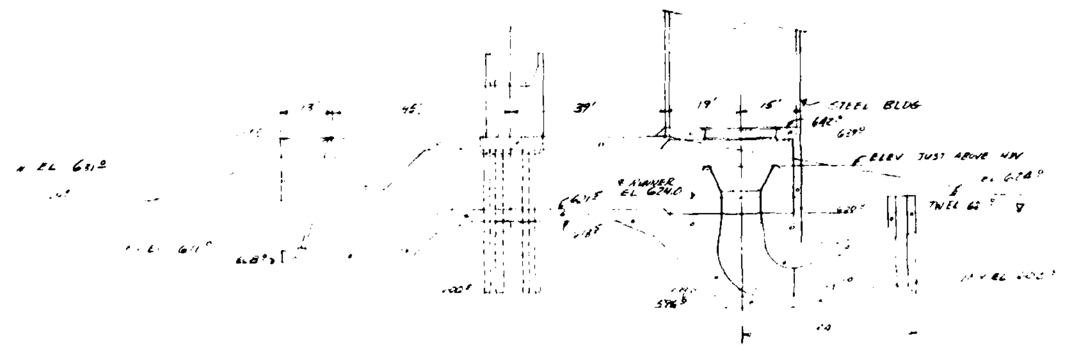




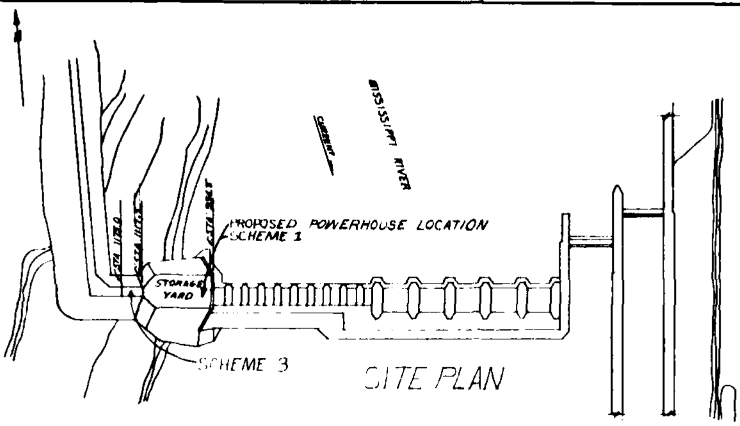
SCHEME I
PLAN- OPEN FLUME TURBINE - EL 642
STATION ARRANGEMENT
SCALE 1/16" = 1'-0"

PERTINENT DATA PER UNIT

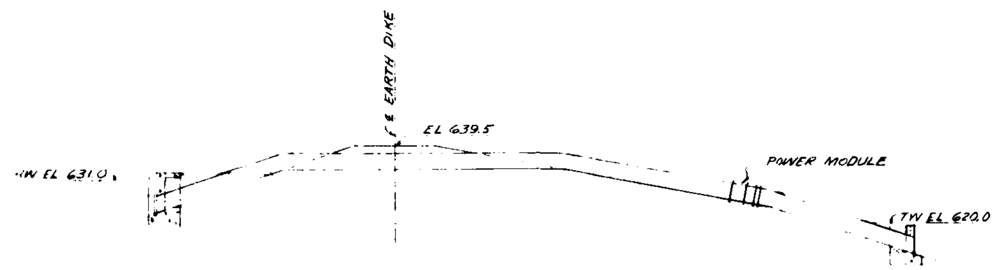
H RATED	9.75 FT
RUNNER THROAT DIA	3000 mm
Q	1400 TO 575 CFS
GENERATOR OUTPUT	935 KW



TRANSVERSE SECTION
SCALE 1/8" = 1'-0"



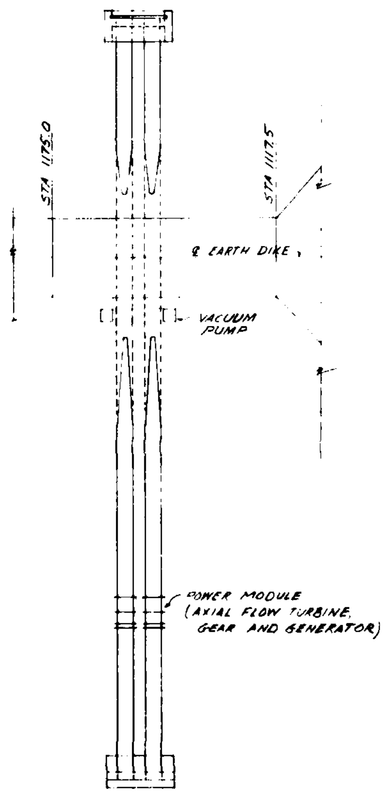
SITE PLAN



TRANSVERSE SECTION
SCALE $\frac{1}{16}$" = 1'-0

PERTINENT DATA PER UNIT
H RATED 11 FT
RUNNER THROAT DIA 1352 mm
Q 138 CFS
GENERATOR OUTPUT 105 KW

PERTINENT DATA PER UNIT
H RATED 9.75 FT
RUNNER THROAT DIA 3000 mm
Q 1400 TO 575 CFS
GENERATOR OUTPUT 935 KW



SCHEME 3
PLAN - BULB TURBINE
SIPHON ARRANGEMENT

REVISION	DATE	DESCRIPTION	BY

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

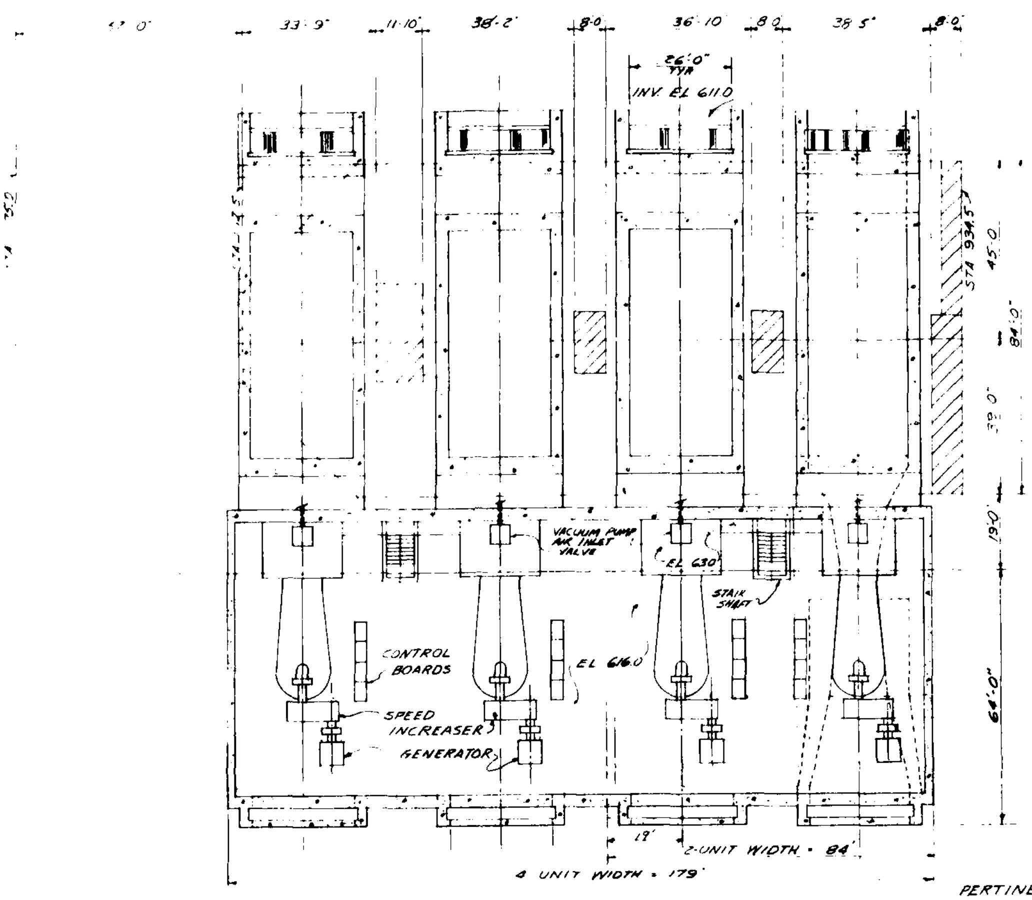
DESIGNED BY D.L.S.
DRAWN BY
CHECKED BY K.J.L.

LOCK AND DAM NO.8 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA
POWERHOUSE
PLAN AND SECTION

SCALE AS SHOWN

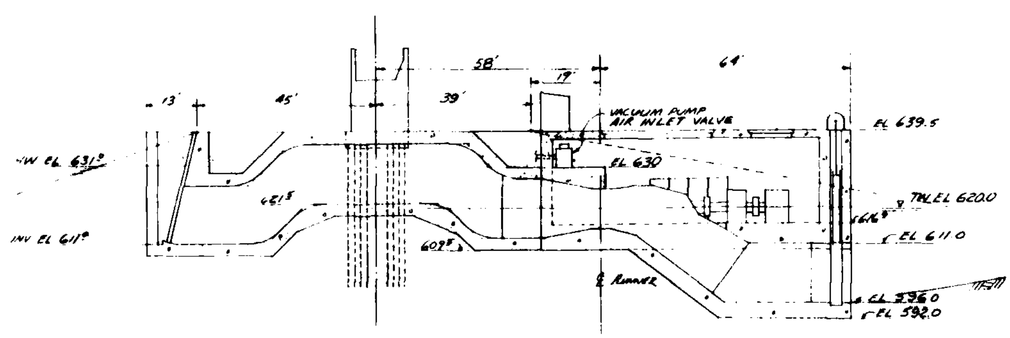
PLATE I

2



PLAN-TUBULAR TURBINE-EL 630
SYPHON ARRANGEMENT
SCALE 1/16" = 1'-0"

PERTINENT DATA PER UNIT
H RATED 9.75 FT
RUNNER THROAT DIA 3000 mm
Q 1400 TO 575 CFS
GENERATOR OUTPUT 935 KW

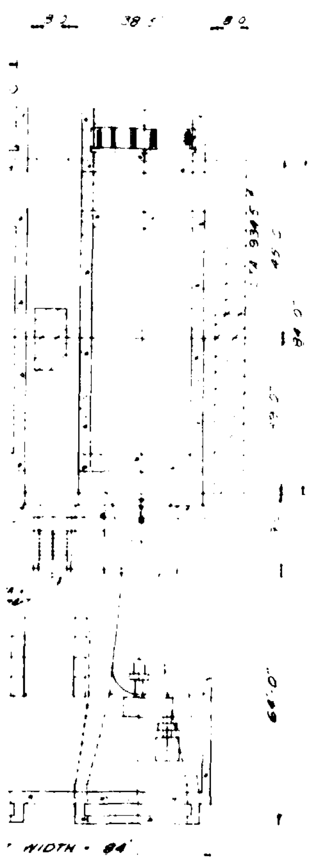


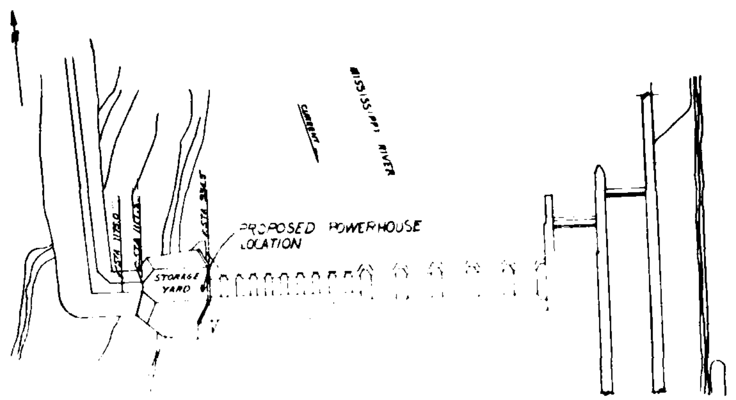
SCHEME 2

TRANSVERSE SECTION
SCALE 1/16" = 1'-0

E ENGINEERING WILL INCREASE YOUR PROFITS

U. S. ARMY





SITE PLAN

E - EL 630
MENT

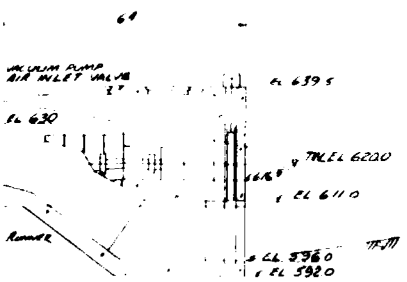
PERTINENT DATA PER UNIT

H RATED 9.75 FT

RUNNER
THROAT DIA 3000 mm

Q 1400 TO 575 CFS

GENERATOR
OUTPUT 935 KW



TION

REVISION	DATE	DESCRIPTION	BY

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

DESIGNED BY B.L.B.
DRAWN BY
CHECKED BY K.J.L.

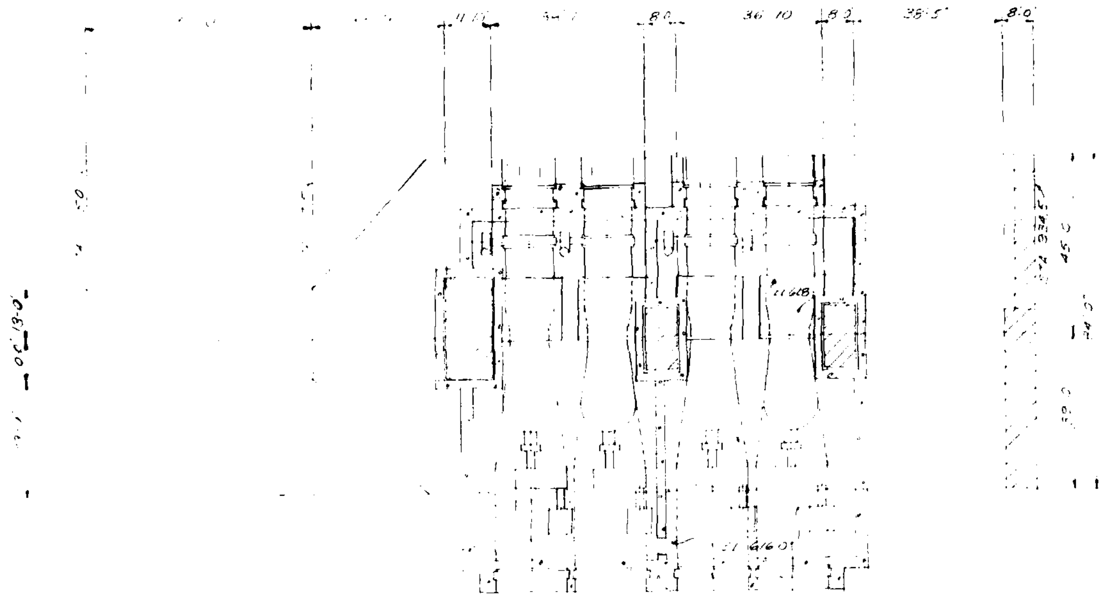
LOCK AND DAM NO.8 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA

POWERHOUSE
PLAN AND SECTION

SCALE AS SHOWN

PLATE 2

2



... TUBULAR TURBINE ... 628
SCALE 1/16" = 1'-0"

TRANSVERSE SECTION
SCALE 1/16" = 1'-0"

SCHEME 4

PERFORMANCE DATA PER UNIT

RATED HEAD	9.75 FT
RUNNER THROAT DIA	3000 mm.
Q	400 TO 575 CFS
GENERATOR OUTPUT	335 KW

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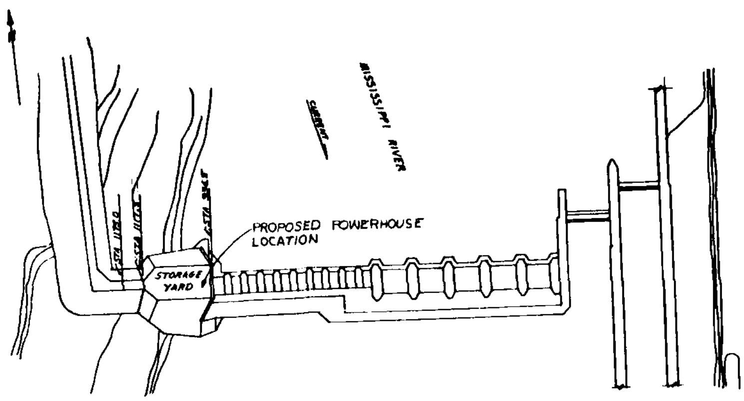
U. S. ARMY



SITE PLAN

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

LOCK AND DAM NO.6 PROJECT

MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA

POWERHOUSE

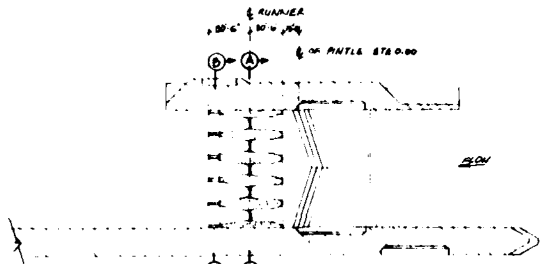
PLAN AND SECTION

DESIGNED BY S L S

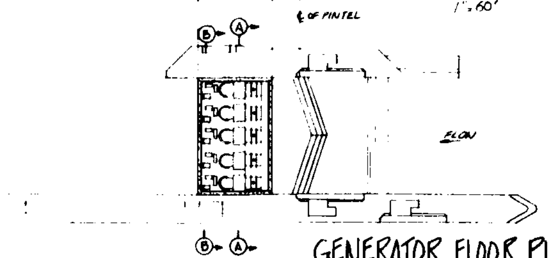
CHECKED BY K & L

SCALE AS SHOWN

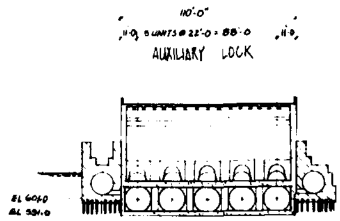
PLATE 3



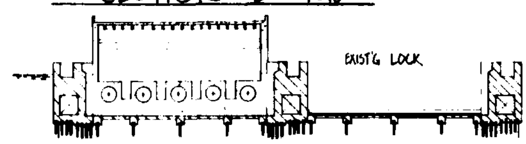
WATERWAY PLAN
1" = 60'



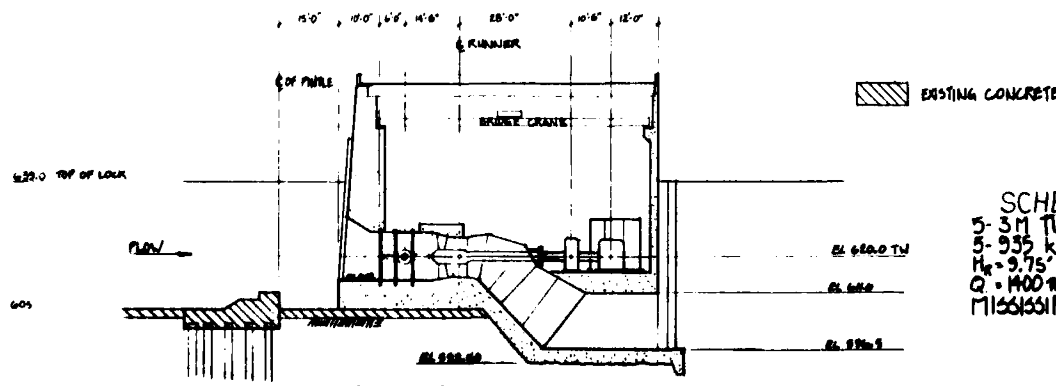
GENERATOR FLOOR PLAN
1"=60'



SECTION B 1"=40'



SECTION A 1"=40'

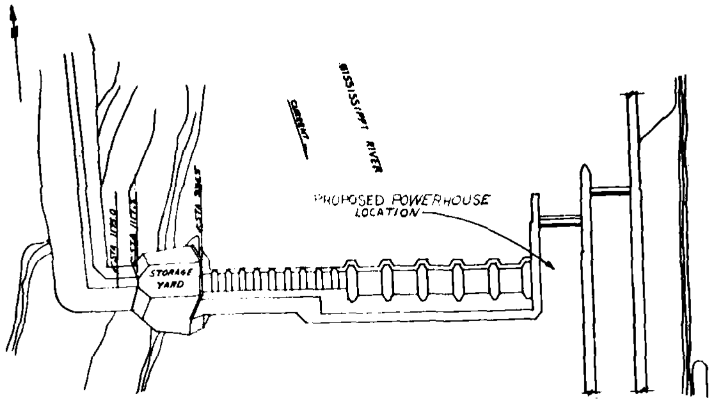


TRANSVERSE SECTION

SCHEME 5
5- 3 M TUBE TURBINES
5- 935 kW GENERATORS
H_R = 9.75'
Q = 1400 to 575 cfs
MISSISSIPPI RIVER

ENGINEERING WILL INCREASE YOUR PROFITS

U. S. ARMY



SITE PLAN

EXISTING CONCRETE

SCHEME 5
5- 3M TUBE TURBINES
5- 935 kW GENERATORS
H_R = 9.75'
Q = 1400 to 575 cfs
MISSISSIPPI RIVER

EL 620.0 TW

REVISION	DATE	DESCRIPTION	BY

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

DESIGNED BY B.L.B.
DRAWN BY
CHECKED BY K.J.L.

LOCK AND DAM NO. 8 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA
POWERHOUSE
PLAN AND SECTION

SCALE AS SHOWN

PLATE 4

2

SECTION 5 - CONCLUSION

Several different types and sizes of hydropower installations were investigated at Lock and Dam No. 8. This study shows it to be generally infeasible to install hydropower facilities at the project.

Plant optimization was based on a net-benefit analysis. Of several schemes investigated the tubular type powerhouses are best suited for the site conditions. The study presents two site configuration alternatives. One alternative would be located on the right side of the existing spillway in the storage yard area; the optimum size plant would be a two-unit 1.9 MW tubular plant that would develop 11,790,000 kwh of annual energy. The NED investment cost would be 10.4 million dollars and the annual cost would be 1.0 million dollars. The annual net-benefit would be -$260,000 while the benefit-to-cost ratio would be less than unity at 0.74.

The second alternative would be a 4.8 MW, 5-unit tubular plant located in the existing auxiliary lock; the plant would develop 28,350,000 kwh of annual energy. The NED investment cost would be 21.2 million dollars and the annual cost would be 1.85 million dollars. The 5-unit plant would have economic justification slightly below unity at 0.99. The near favorable B/C ratio suggests that further study may be justified.

The 5-unit, auxiliary lock powerhouse is clearly the best site from a standpoint of economics. However, this study does not address the subject of acquisition of the skeleton lock facility. The auxiliary lock was constructed over 40-years ago along with the initial lock and dam construction. At that time it was projected that two operating navigation locks would be needed in the future. If the auxiliary lock can be utilized for power, some cost savings can be realized and this alternative will become the best plan of development.

The power studies for the project were developed using a run-of-river operating mode. Nevertheless, with some regulation (daily pondage) the project benefits could be increased significantly. It was beyond the scope of this study to analyze the project regulation; however, Section 4.08 addresses this as an example.

The project generation would be marketable in a local power system. As a magnitude of comparison, the 5-unit plant would produce 28,350,000 kwh of annual generation, the energy equivalent of 3,500 residential homes in the area 1/.

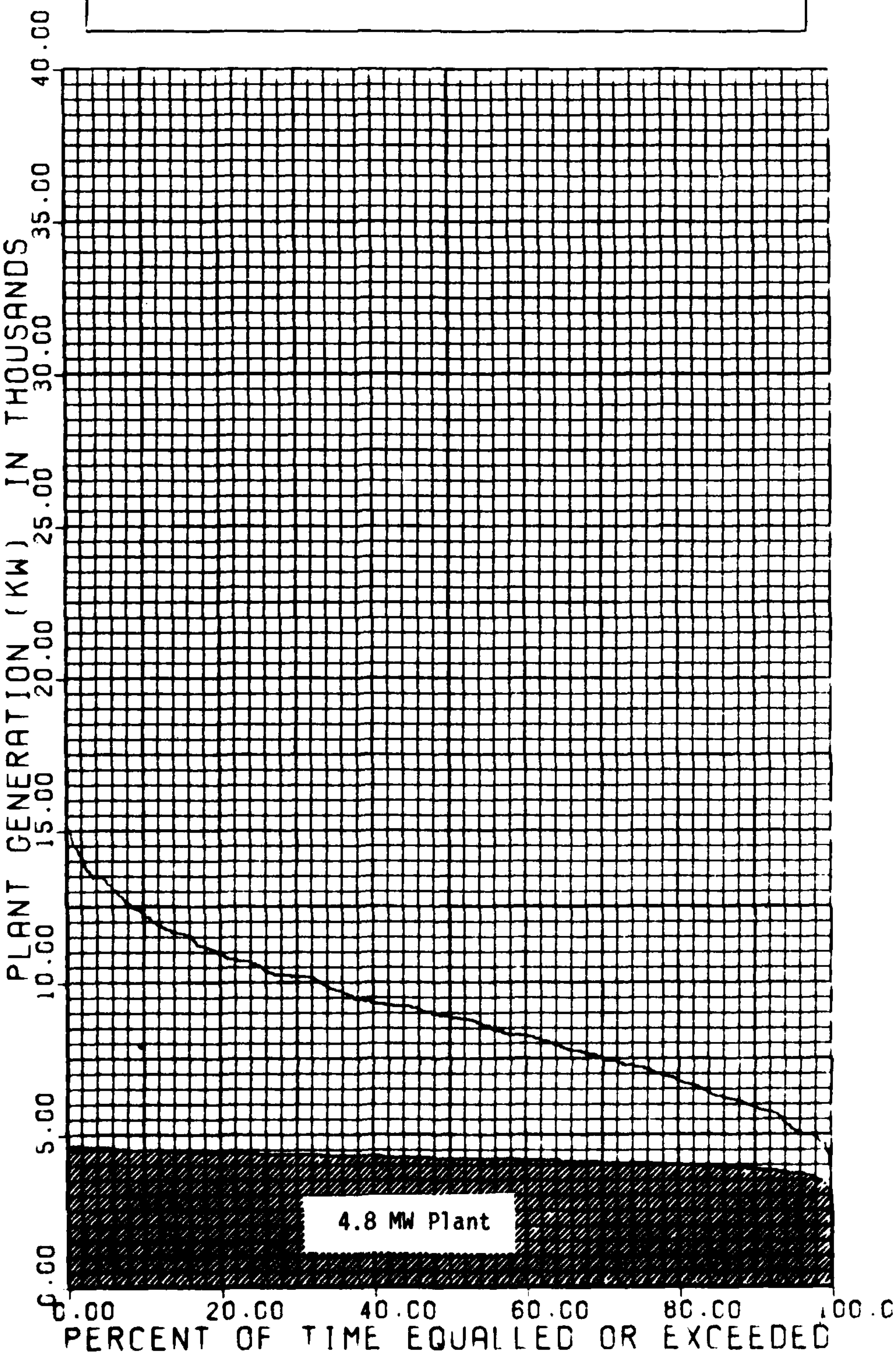
1/ Based on U.S. Department of Energy Publication "Statistics of Privately owned Electric Utilities in the U.S. - 1980", annual residential usage of 8,100 Kwh for the four-state area.

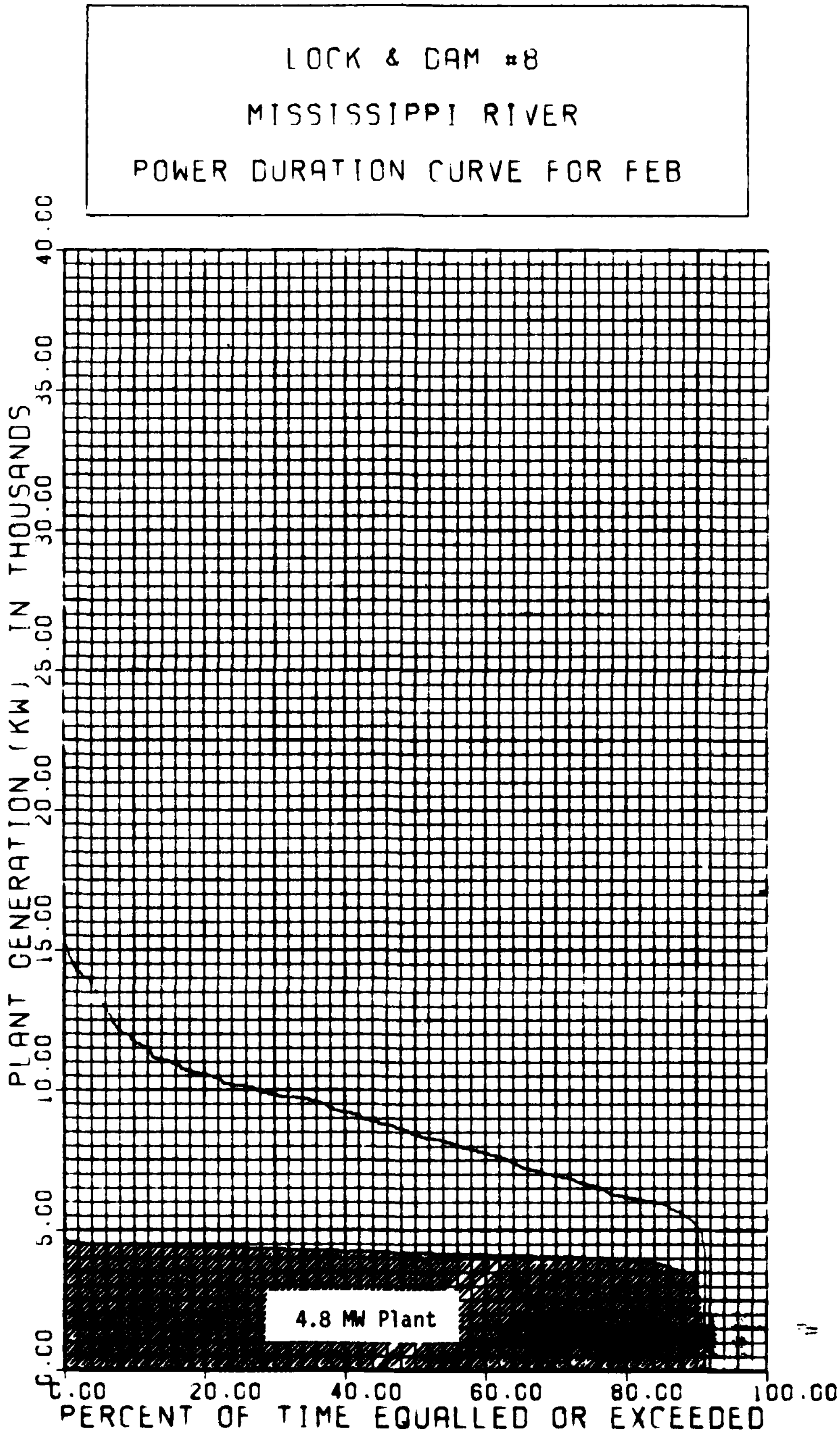
APPENDIX A
MONTHLY POWER-DURATION CURVES

LOCK & DAM #8

MISSISSIPPI RIVER

POWER DURATION CURVE FOR JAN

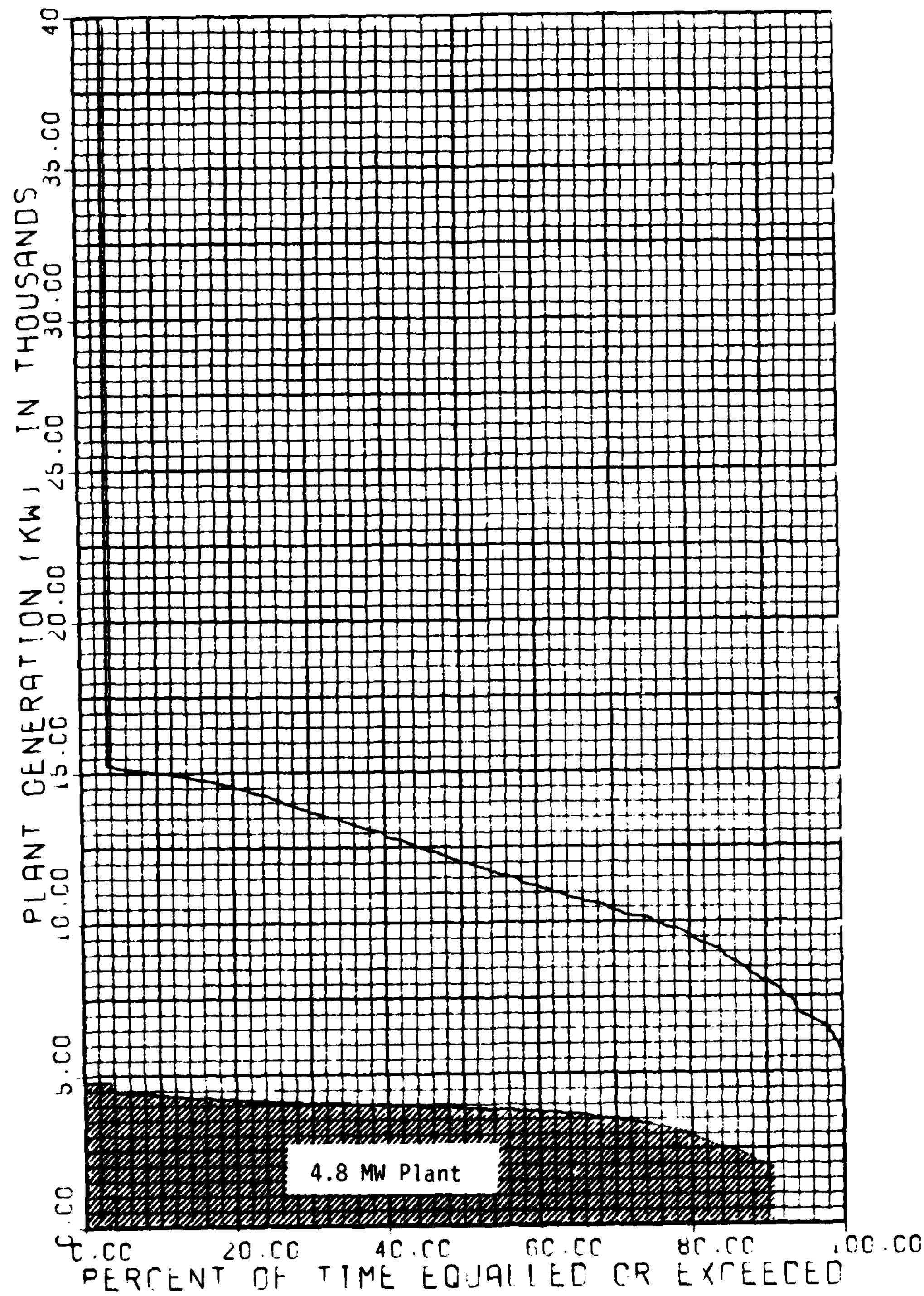


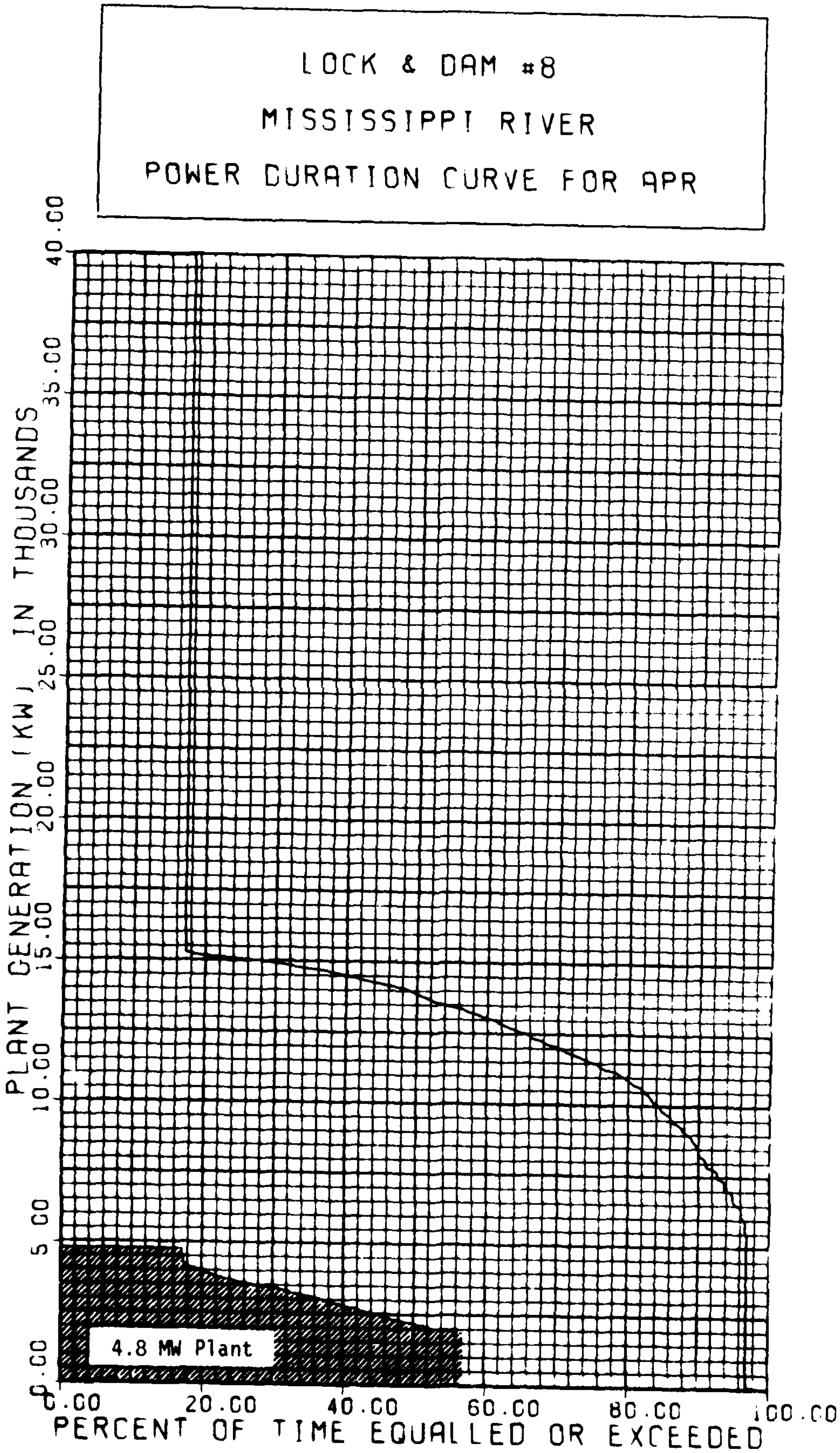

LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR FEB
PLANT GENERATION (KW) IN THOUSANDS
PERCENT OF TIME EQUALLED OR EXCEEDED
4.8 MW Plant
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
20.00
40.00
60.00
80.00
100.00

LOCK & DAM #8

MISSISSIPPI RIVER

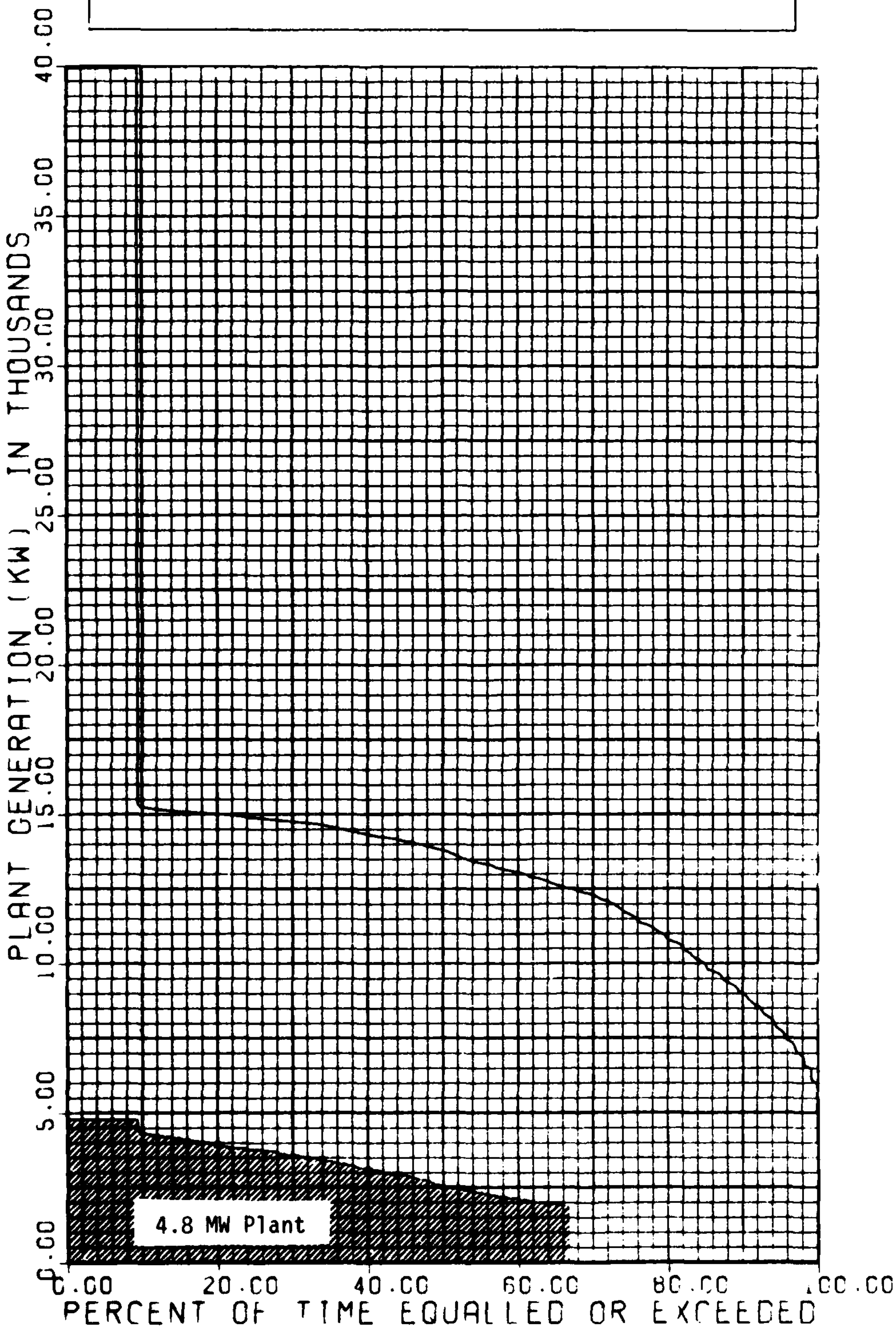
POWER DURATION CURVE FOR MAR

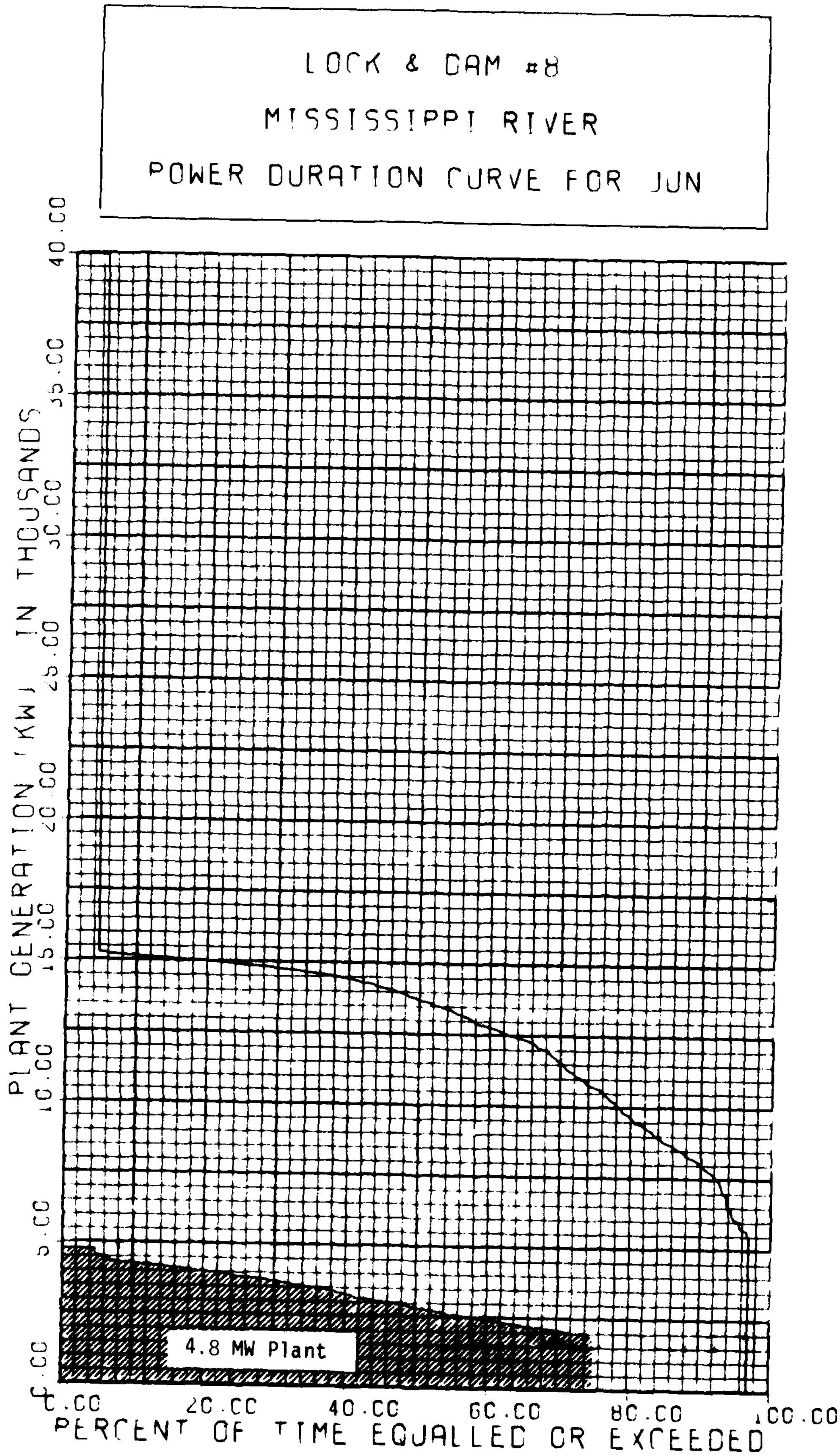




LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR APR
PLANT GENERATION (KW) IN THOUSANDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
4.8 MW Plant

LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR MAY

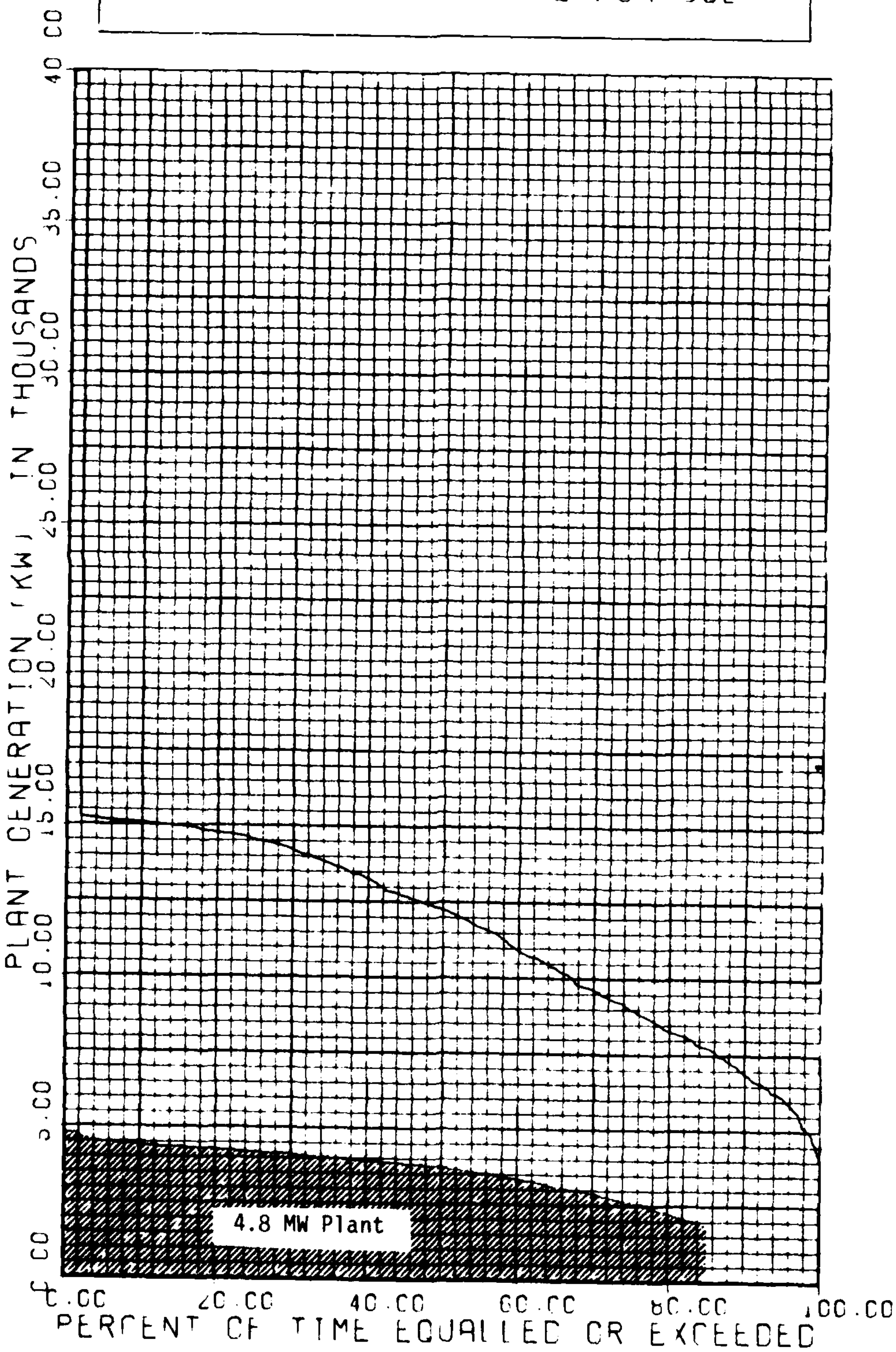



LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR JUN
PLANT GENERATION (KW) IN THOUSANDS
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
4.8 MW Plant

LOCK & DAM #8

MISSISSIPPI RIVER

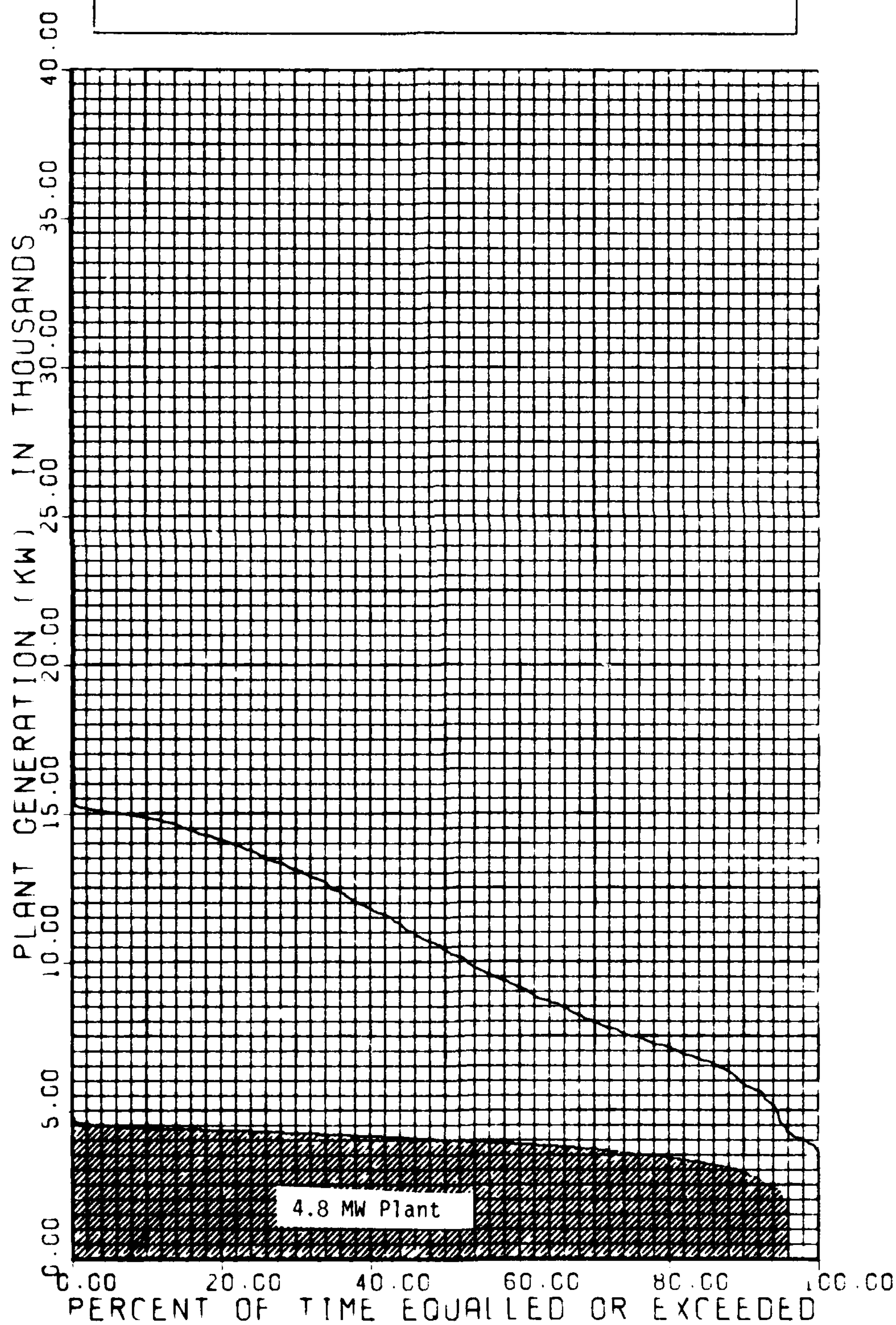
POWER DURATION CURVE FOR JUL

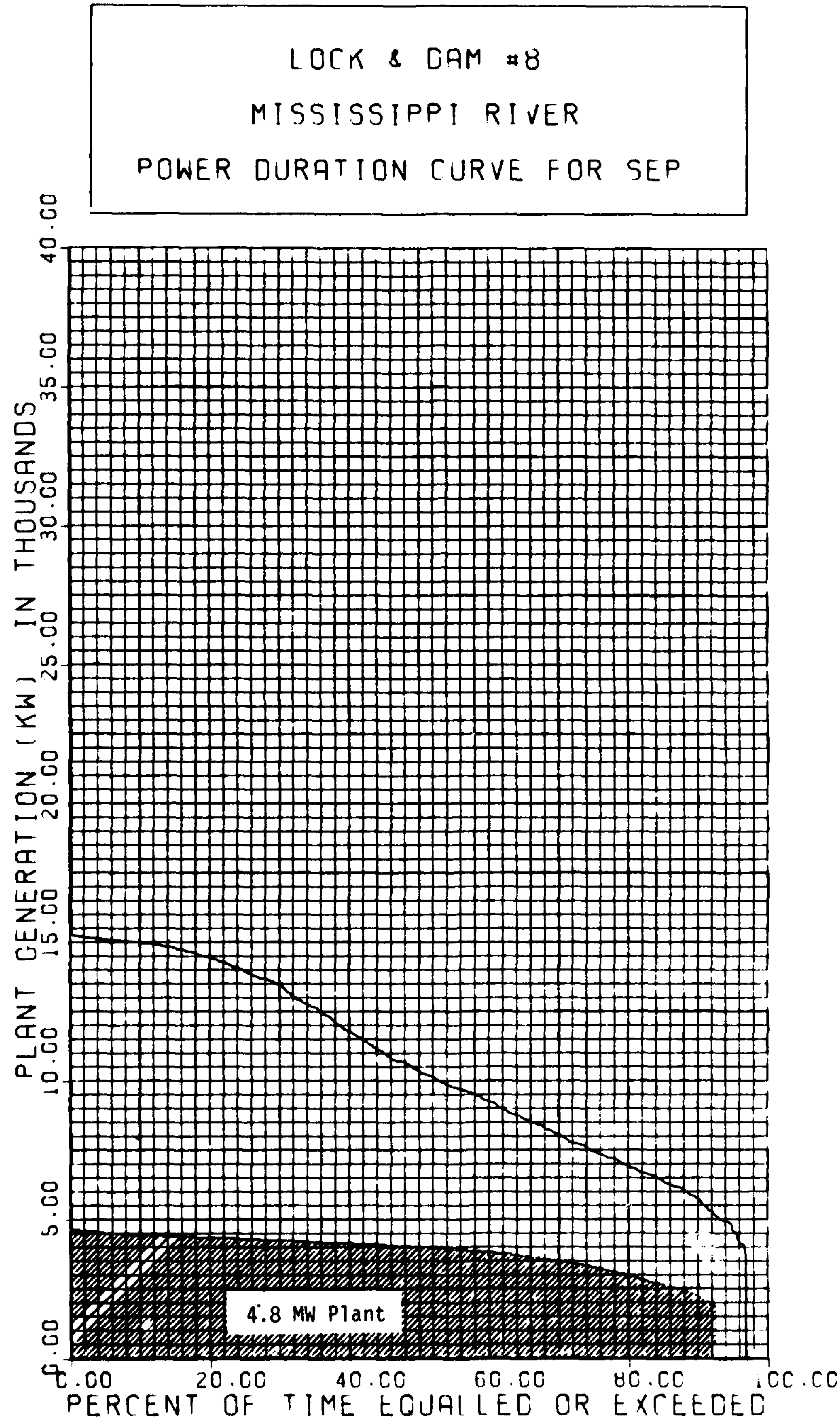


LOCK & DAM #8

MISSISSIPPI RIVER

POWER DURATION CURVE FOR AUG

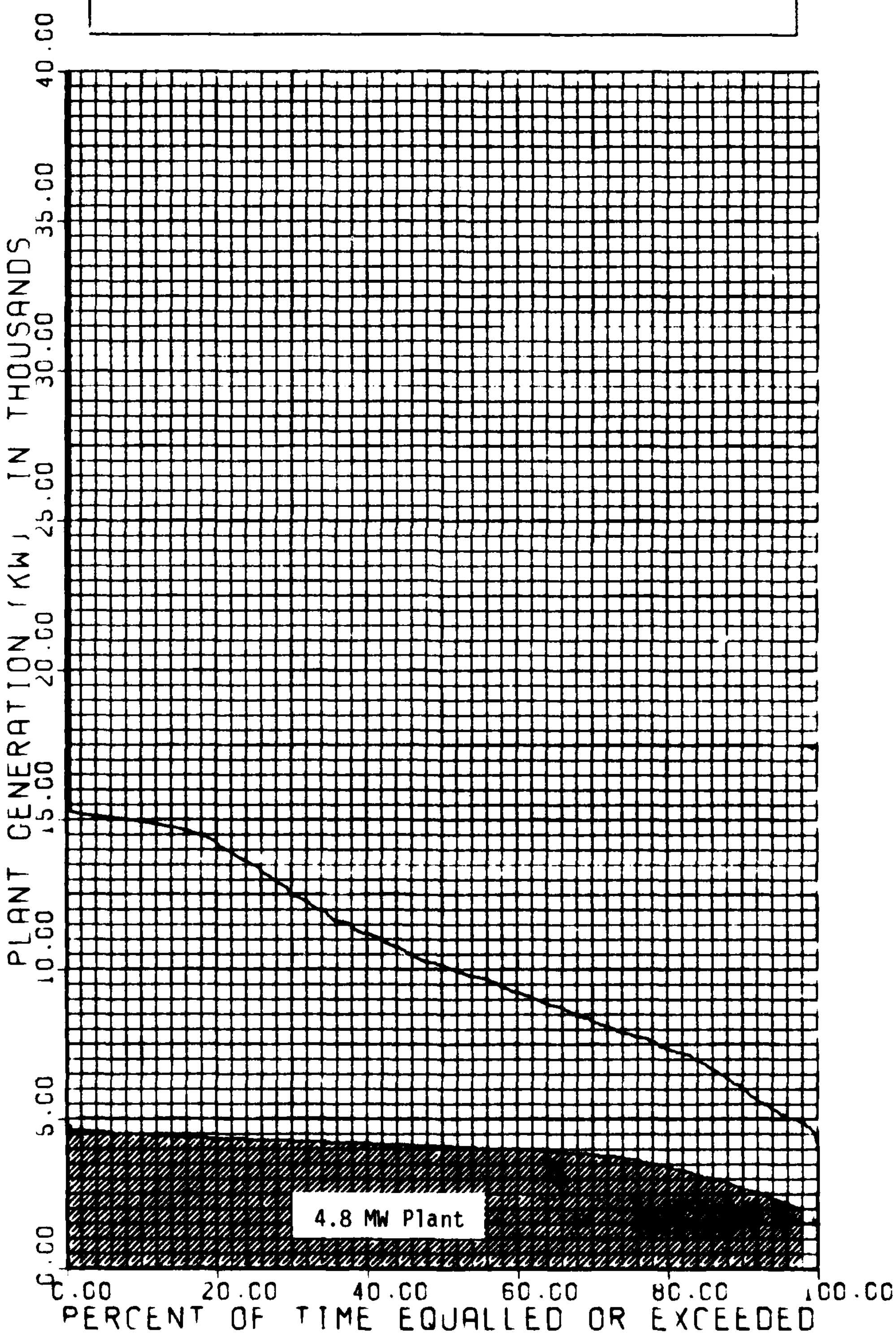


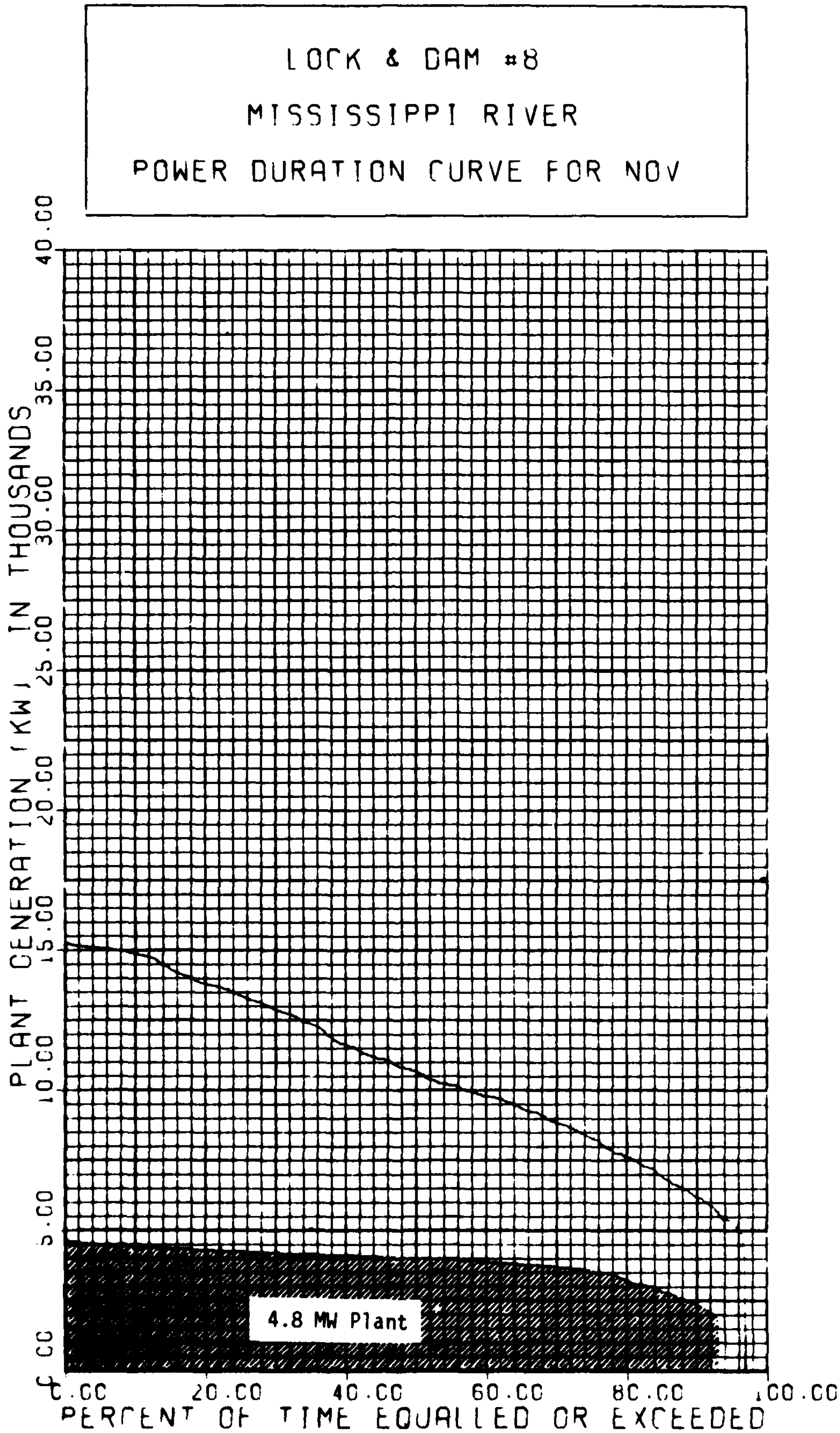

LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR SEP
PLANT GENERATION (KW) IN THOUSANDS
PERCENT OF TIME EQUALLED OR EXCEEDED
4.8 MW Plant
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
20.00
40.00
60.00
80.00
100.00

LOCK & DAM #8

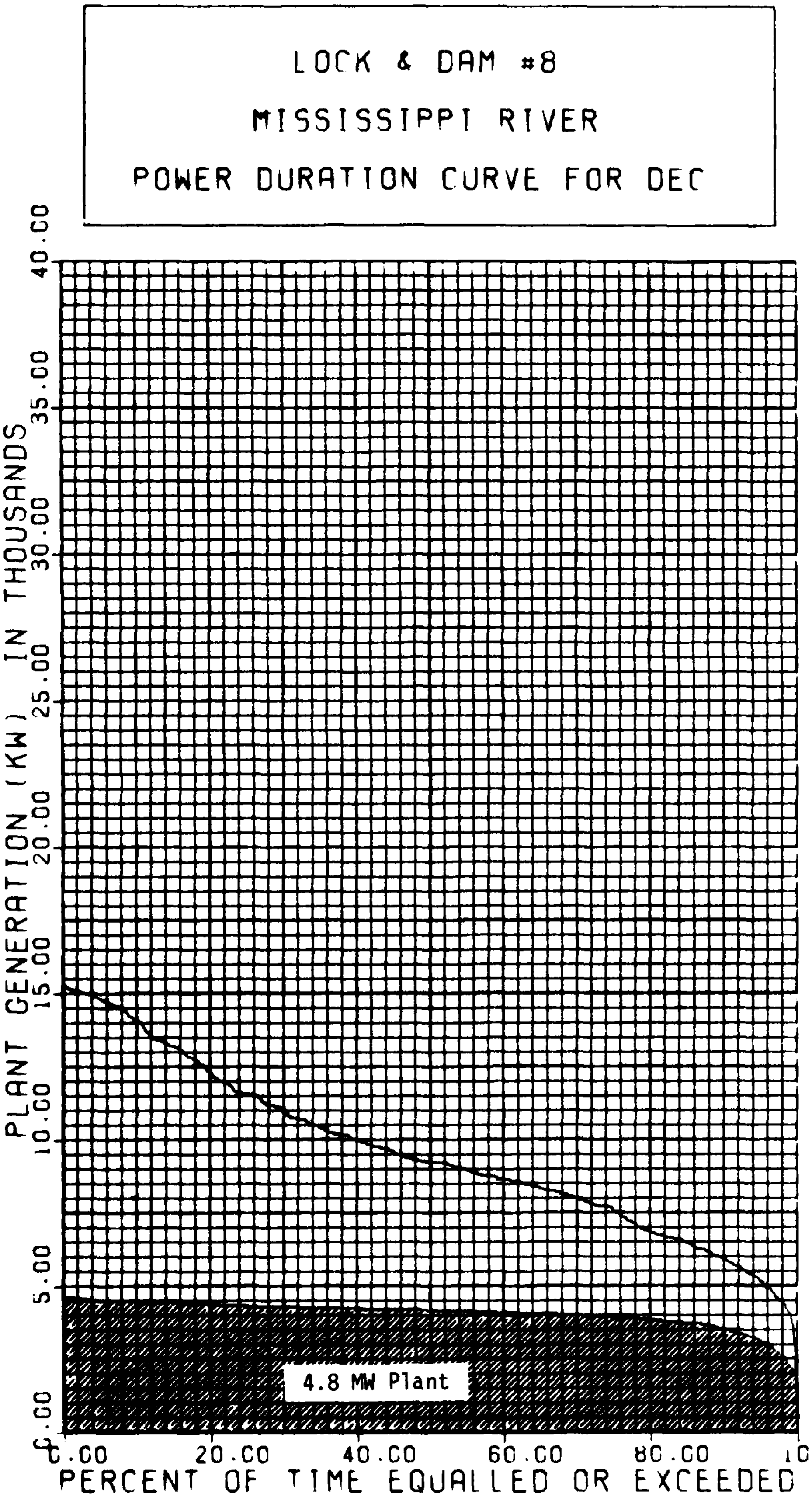
MISSISSIPPI RIVER

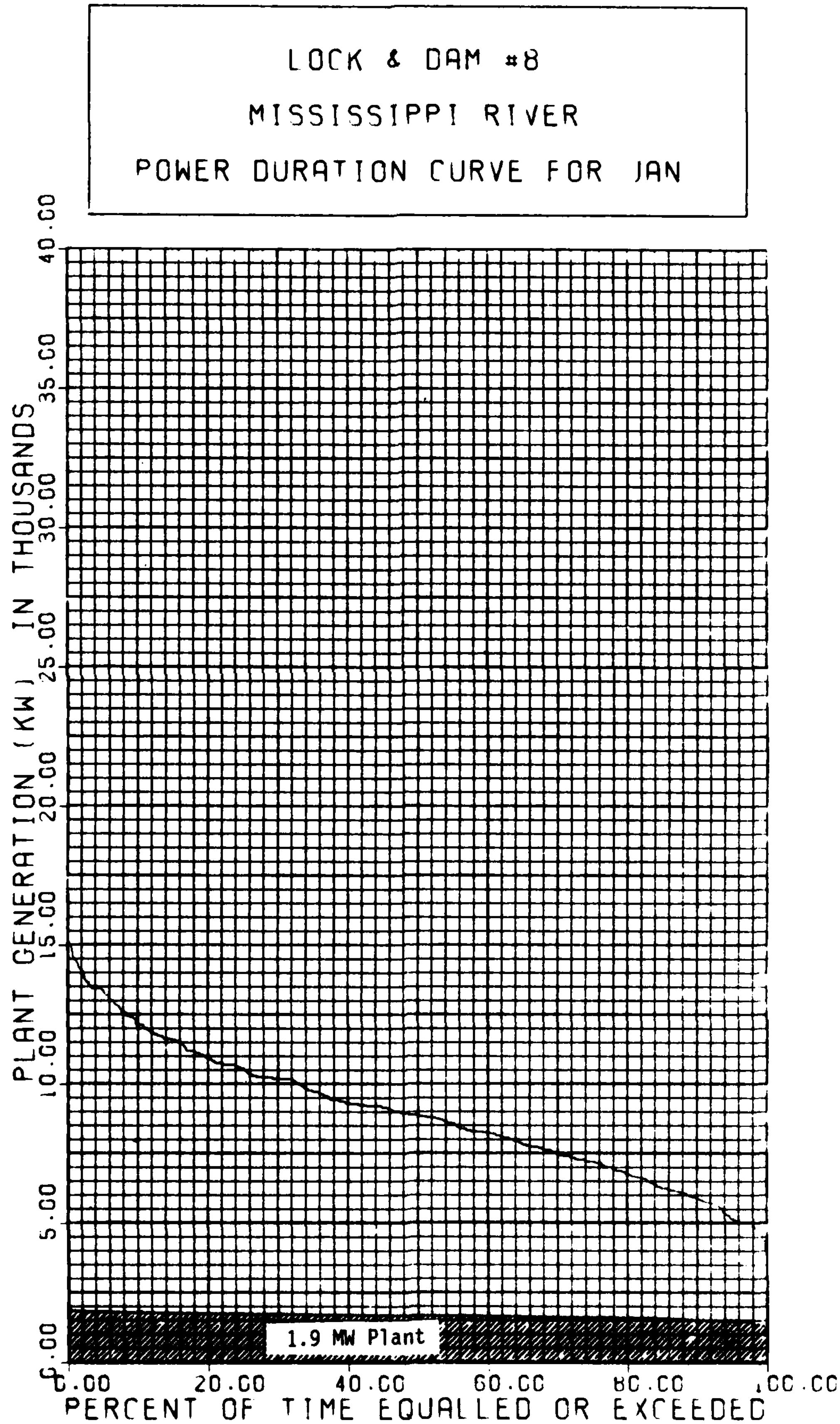
POWER DURATION CURVE FOR OCT





LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR NOV
PLANT GENERATION (KW) IN THOUSANDS
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
4.8 MW Plant

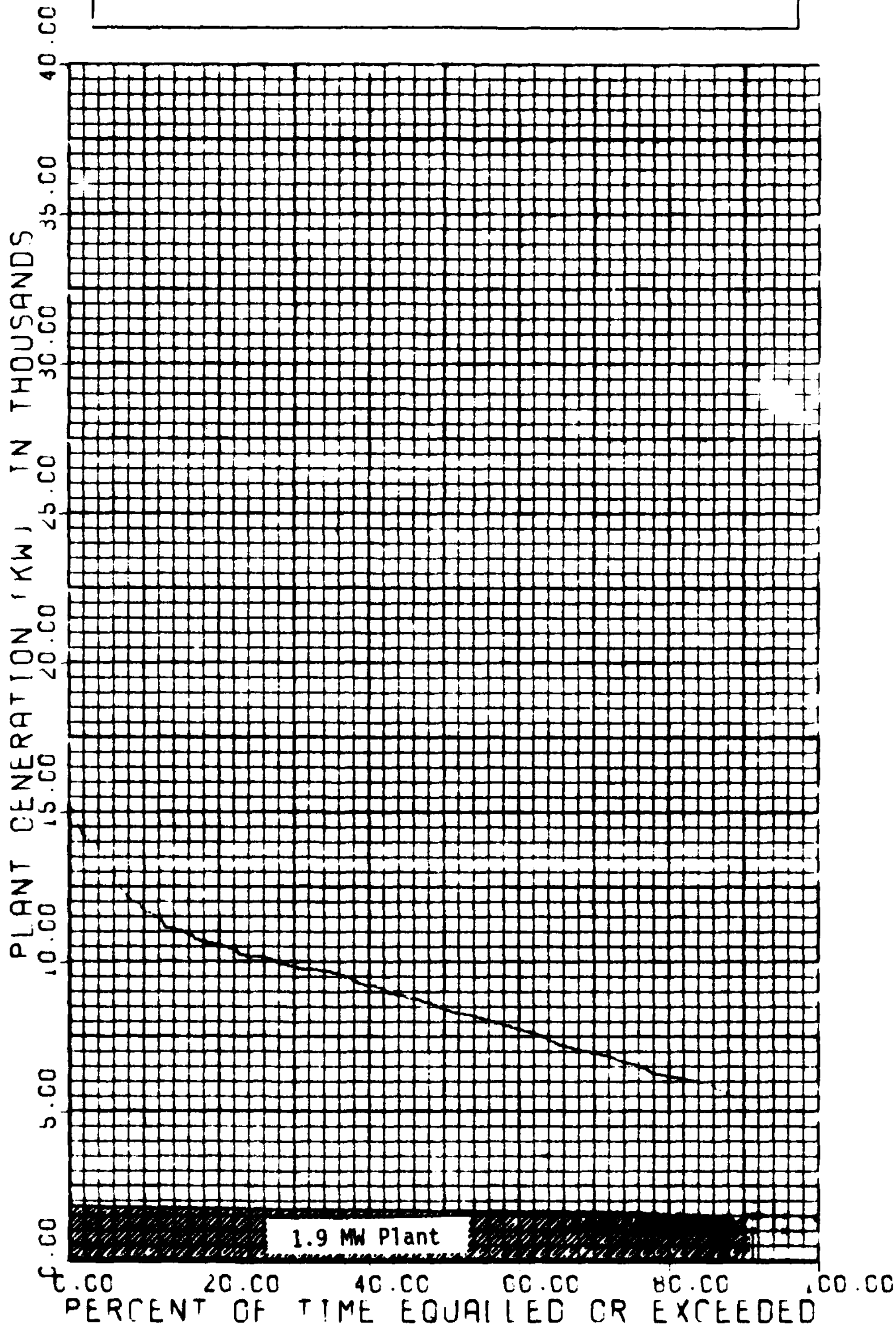

LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR DEC
PLANT GENERATION (KW) IN THOUSANDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
4.8 MW Plant
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED


LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR JAN
PLANT GENERATION (KW) IN THOUSANDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
1.9 MW Plant
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

LOCK & DAM #8

MISSISSIPPI RIVER

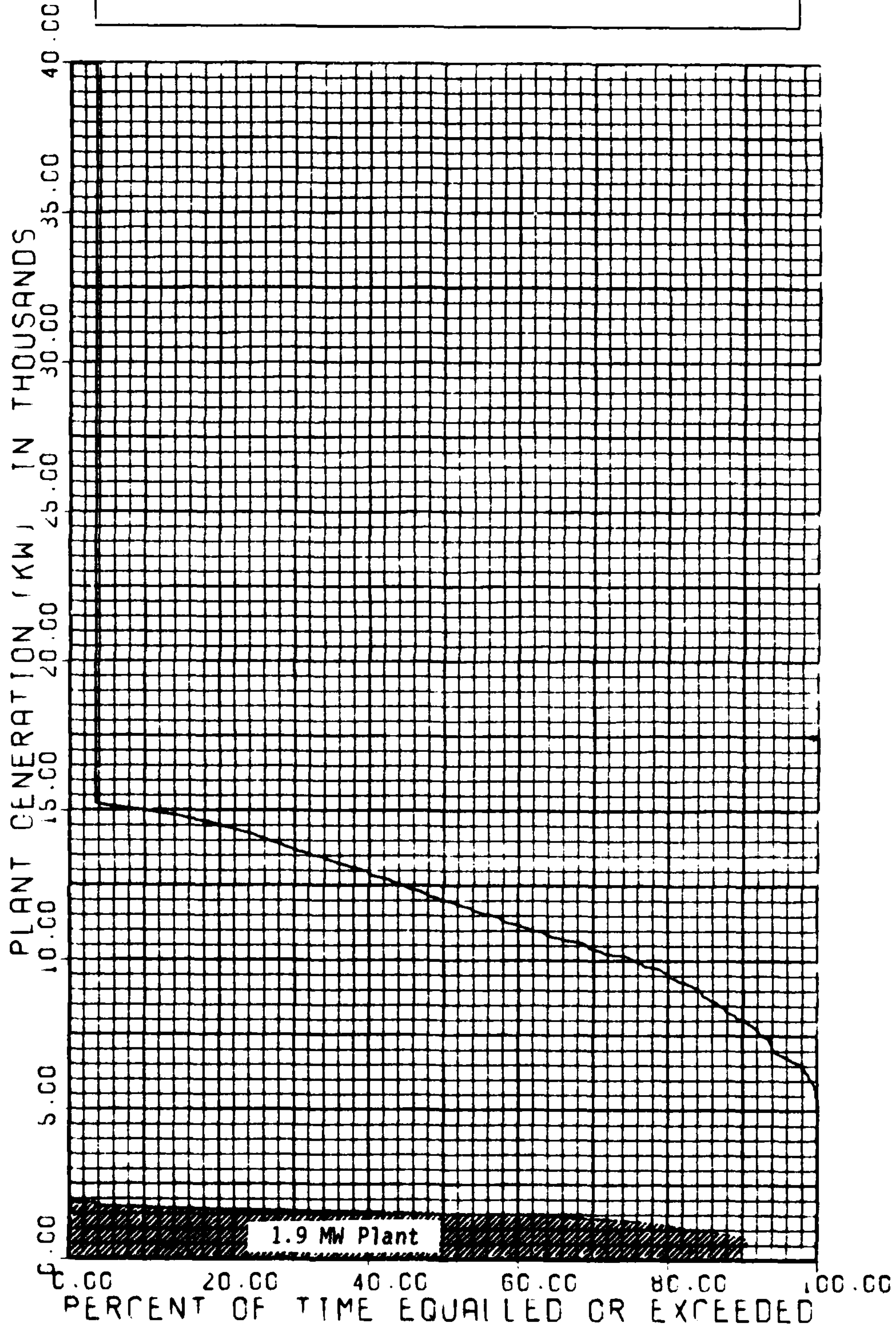
POWER DURATION CURVE FOR FEB



LOCK & DAM #8

MISSISSIPPI RIVER

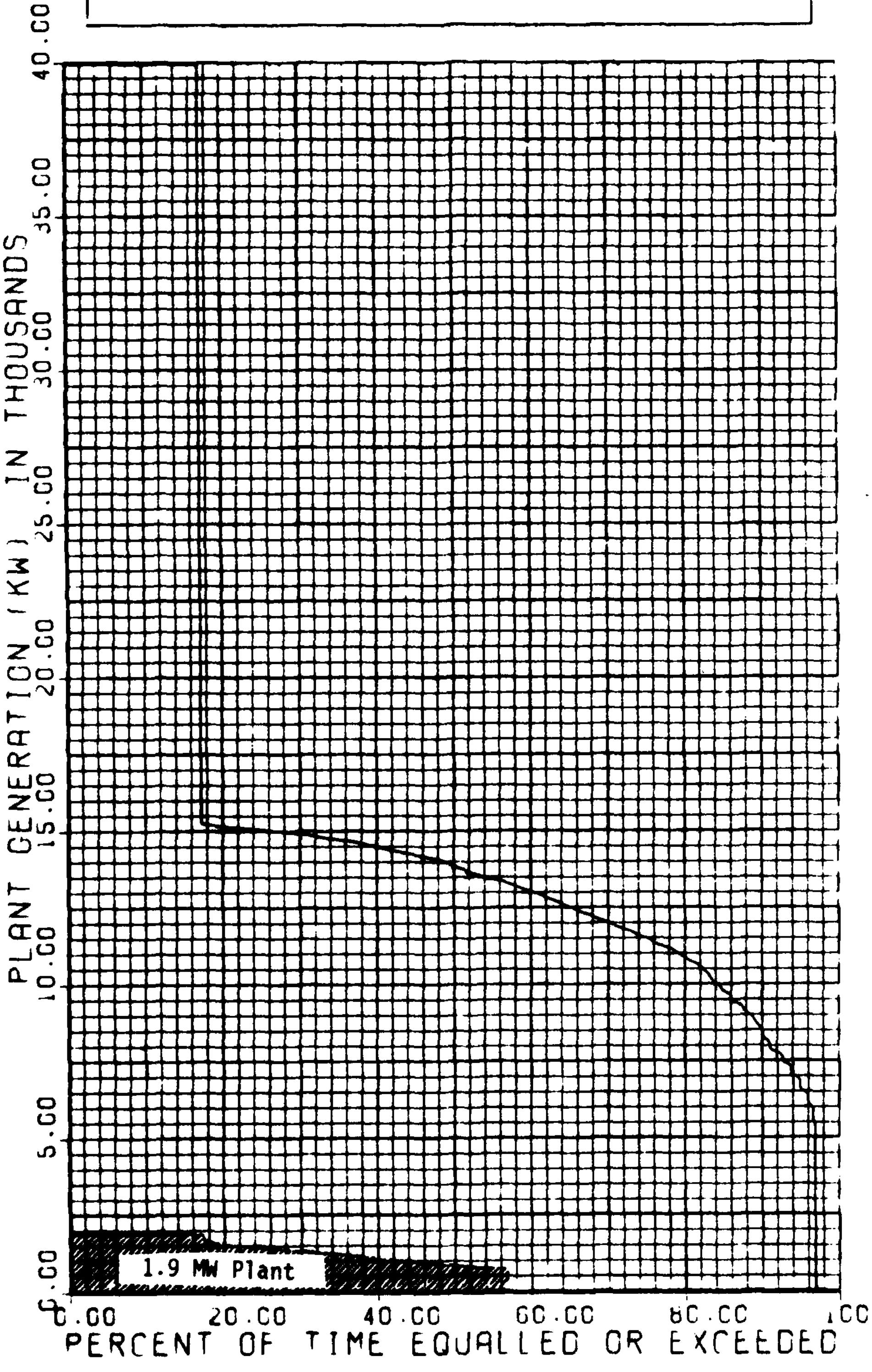
POWER DURATION CURVE FOR MAR



LOCK & DAM #8

MISSISSIPPI RIVER

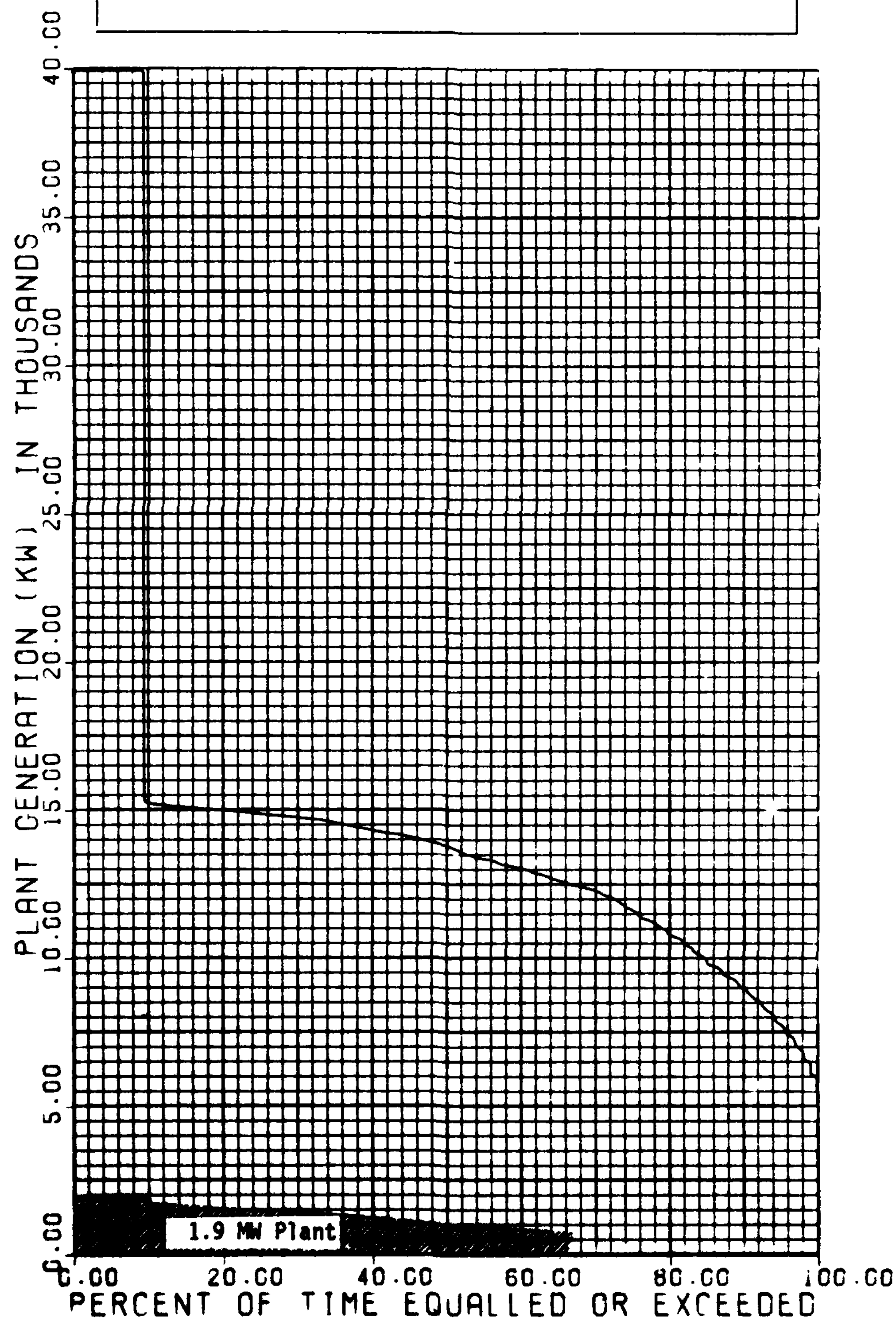
POWER DURATION CURVE FOR APR

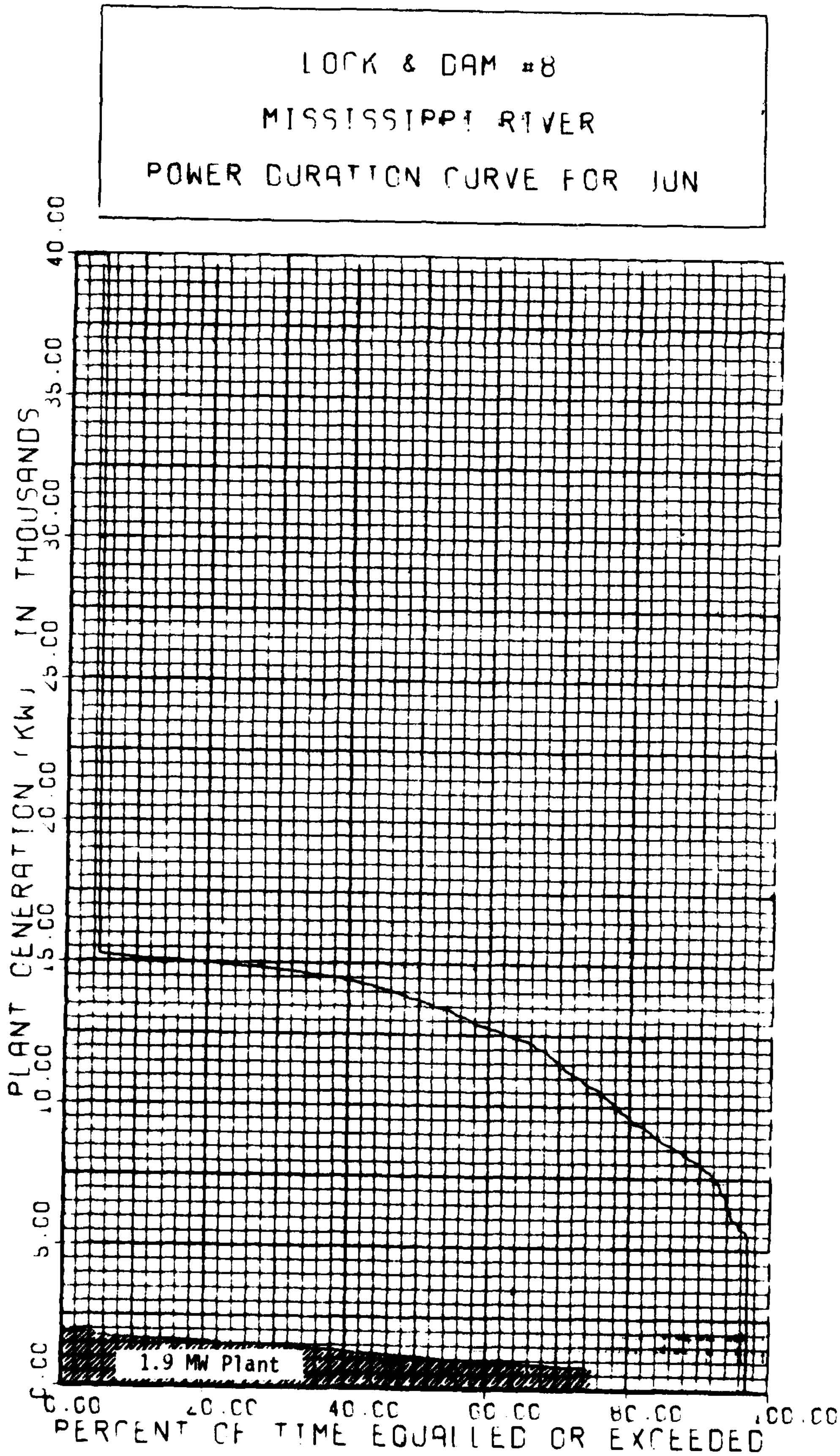


LOCK & DAM #8

MISSISSIPPI RIVER

POWER DURATION CURVE FOR MAY

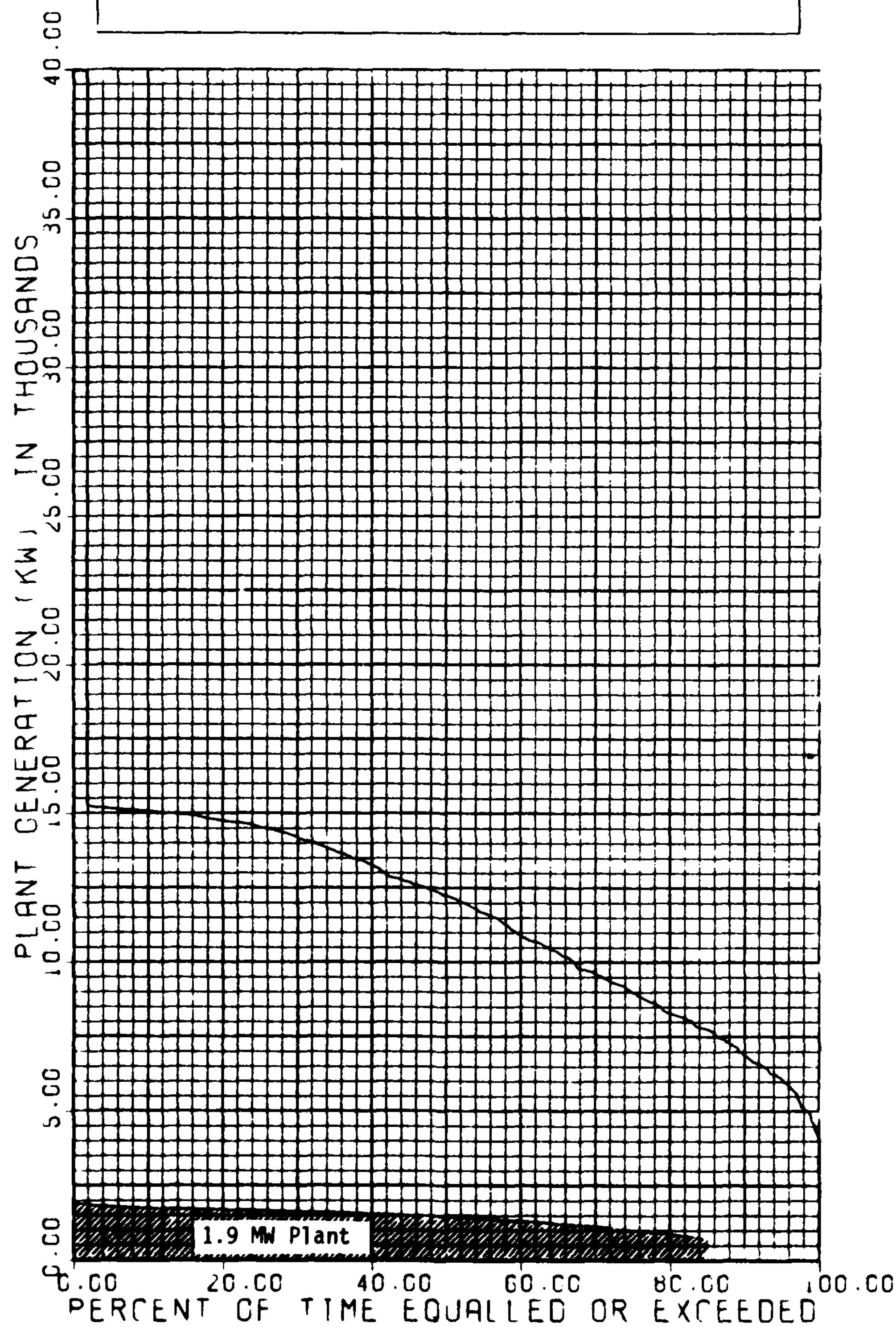


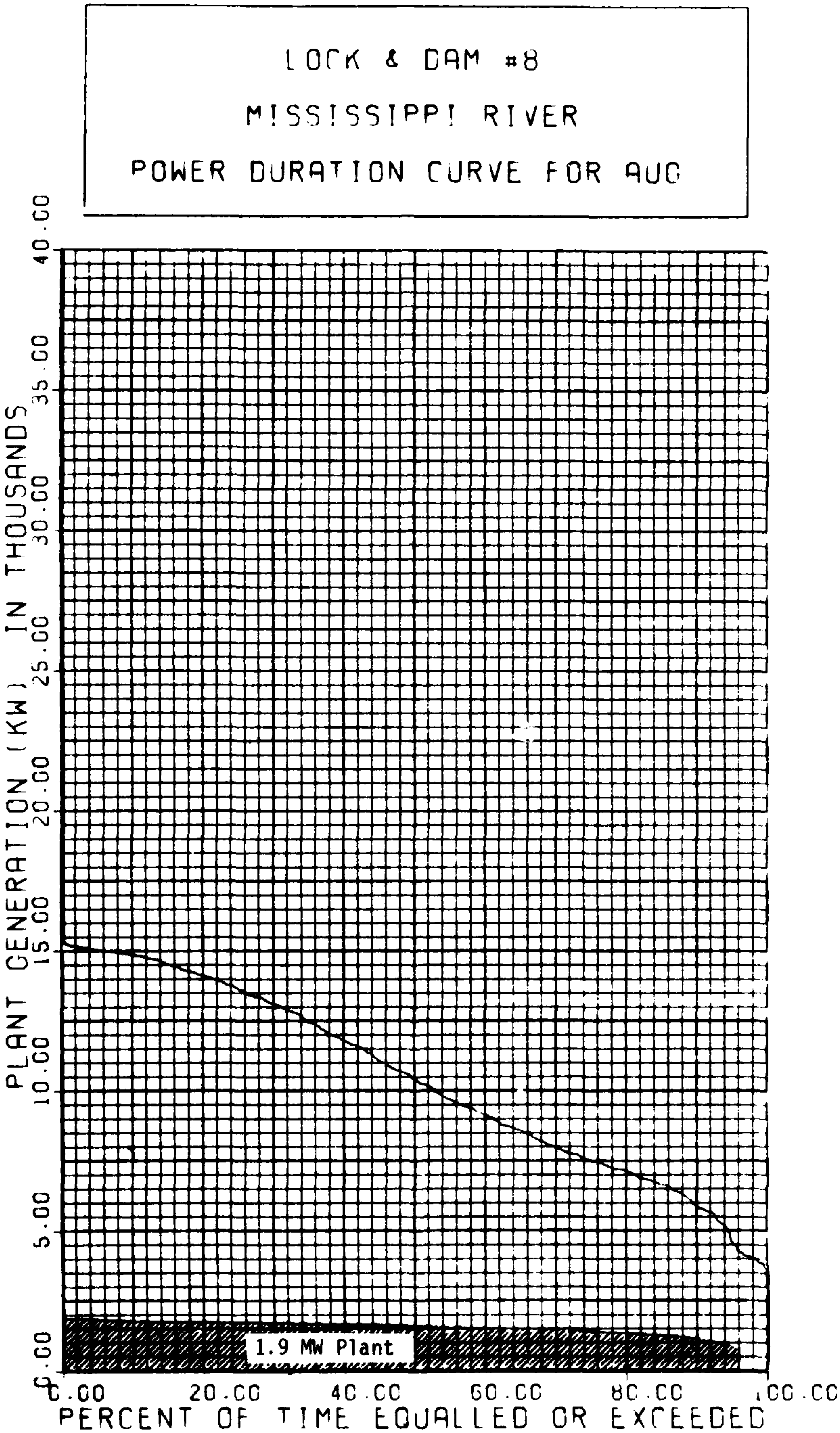

LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR JUN
PLANT GENERATION (KW) IN THOUSANDS
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
1.9 MW Plant

LOCK & DAM #8

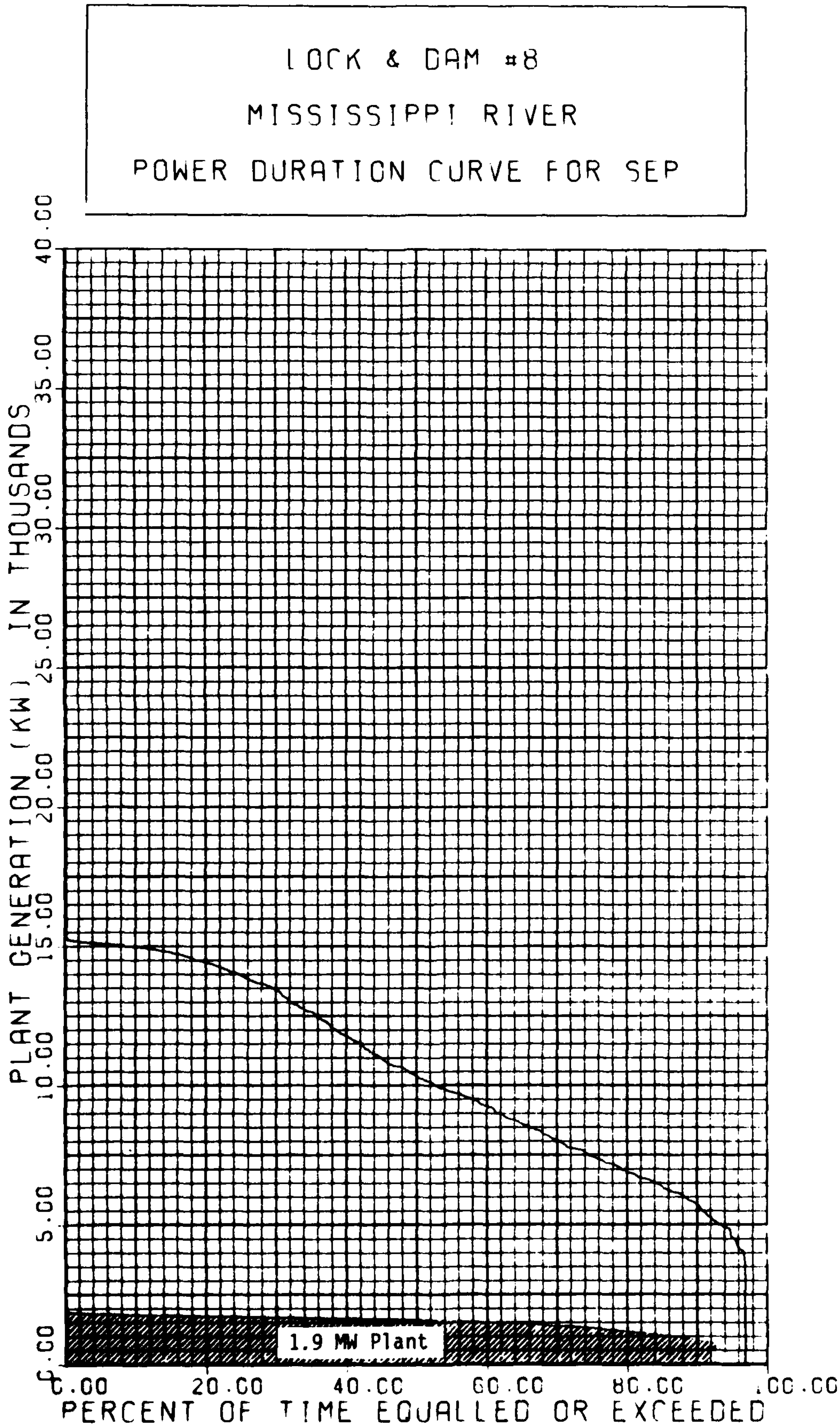
MISSISSIPPI RIVER

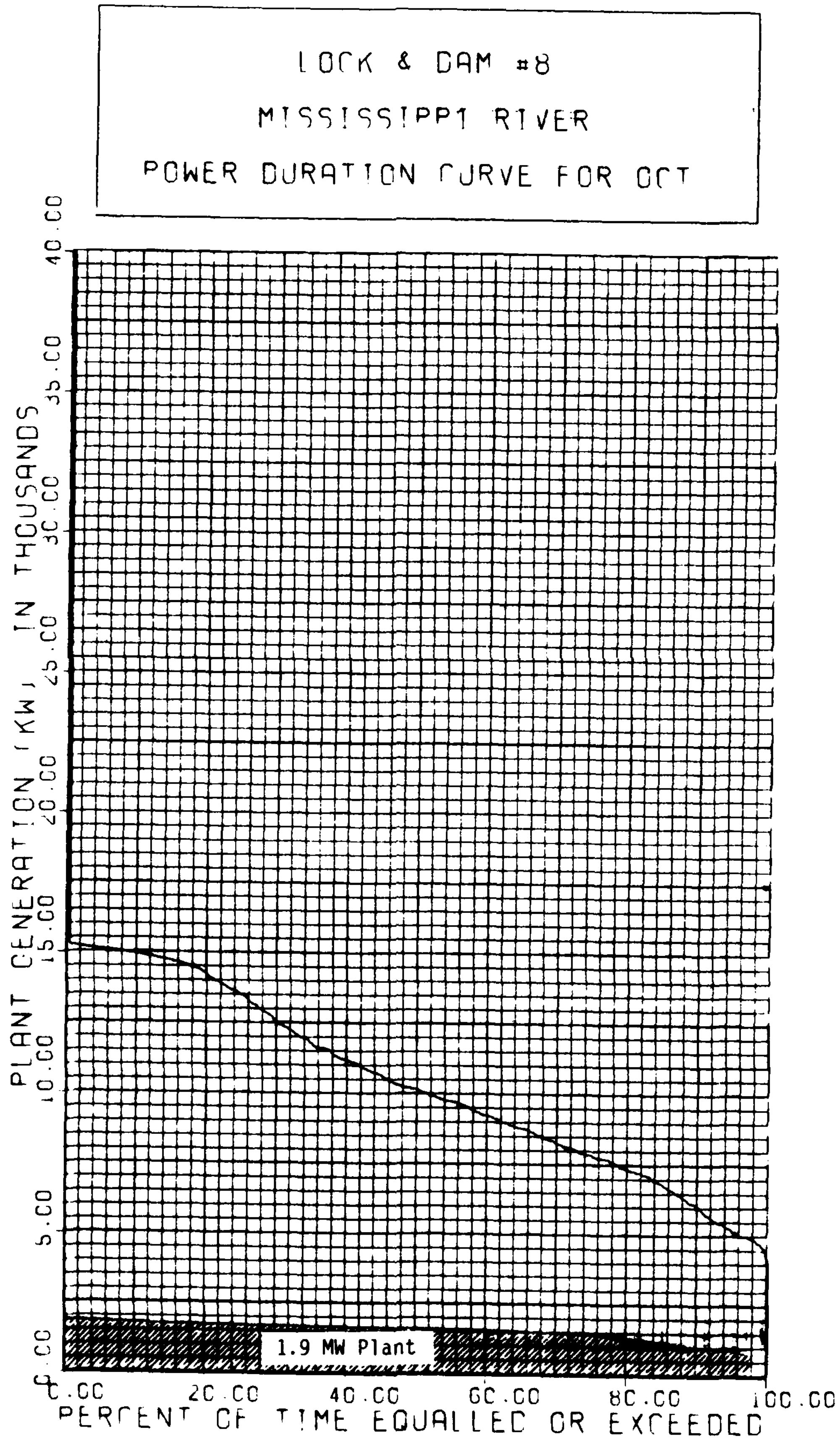
POWER DURATION CURVE FOR JUL

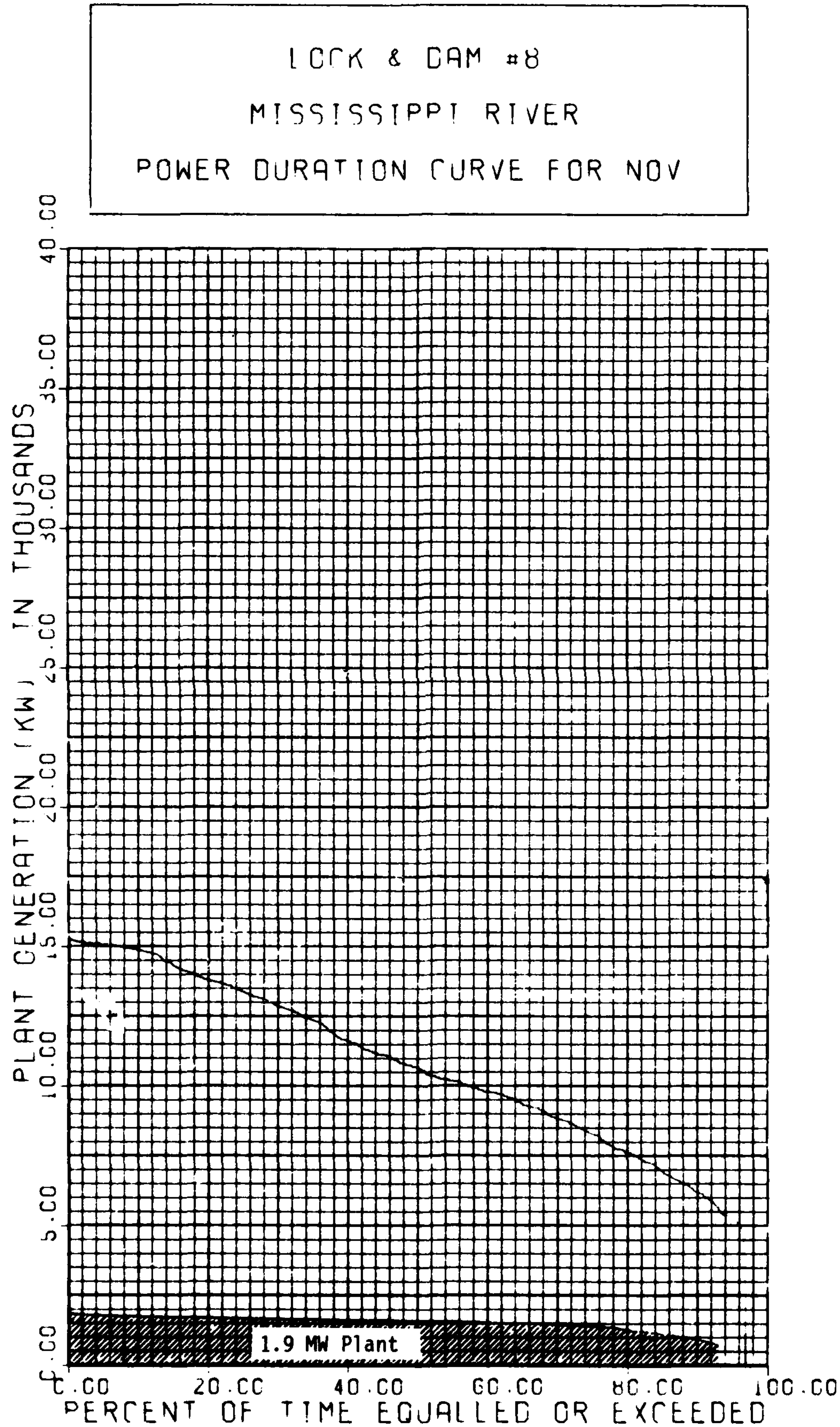




LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR AUG
PLANT GENERATION (KW) IN THOUSANDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
1.9 MW Plant


LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR SEP
PLANT GENERATION (KW) IN THOUSANDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
1.9 MW Plant

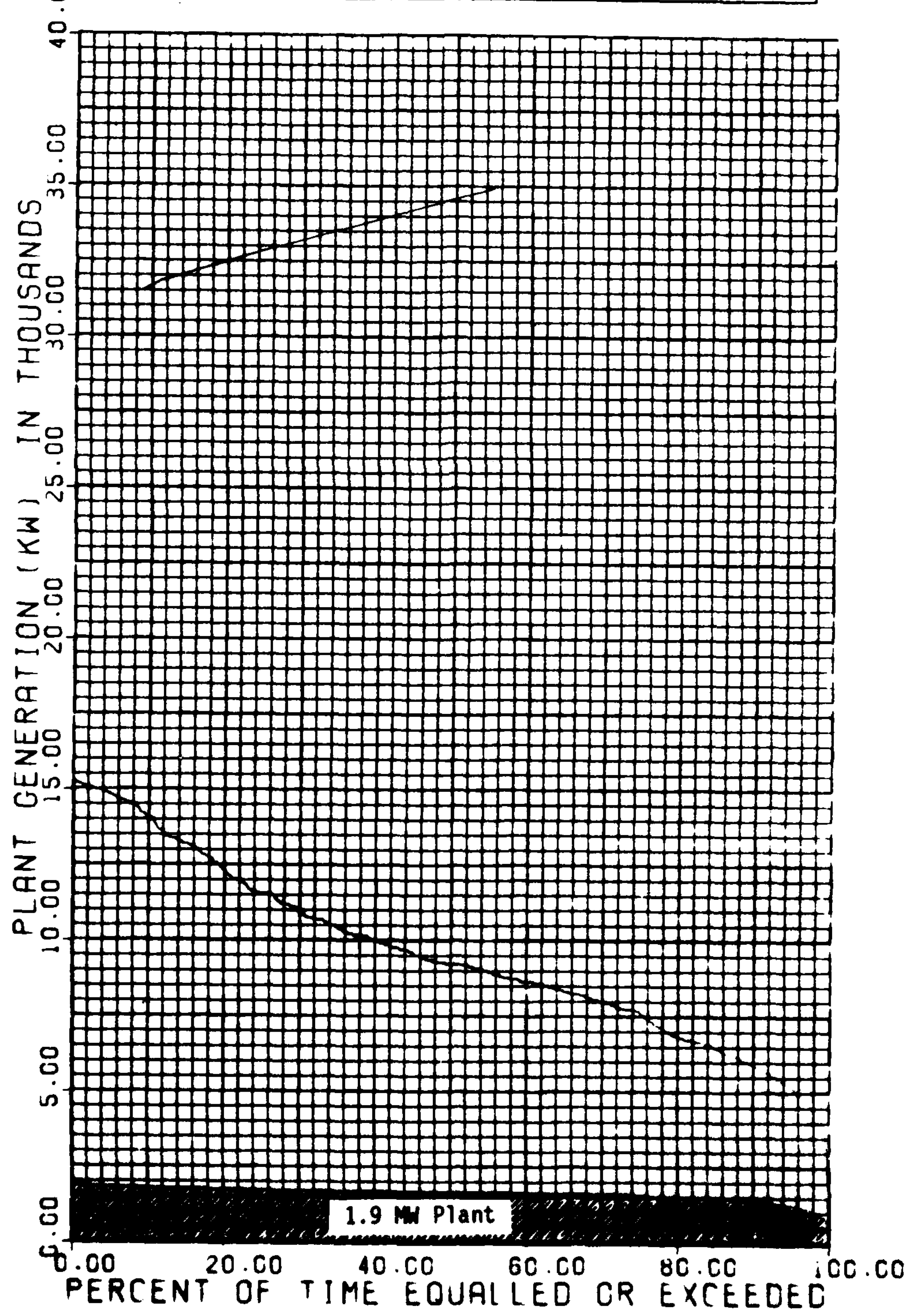

LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR OCT
PLANT GENERATION (KW) IN THOUSANDS
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1.9 MW Plant
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED


LOCK & DAM #8
MISSISSIPPI RIVER
POWER DURATION CURVE FOR NOV
PLANT GENERATION (KW) IN THOUSANDS
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED
1.9 MW Plant

LOCK & DAM #8

MISSISSIPPI RIVER

POWER DURATION CURVE FOR DEC



APPENDIX B

PERTINENT DATA AND CORRESPONDENCE

US Army Corps of Engineers
St. Paul District

Public Notice

Project: HYDROPOWER FEASIBILITY STUDIES AT LOCKS AND DAMS 2, 5, 7, AND 8

Date: December 17, 1984

In Reply Refer to: Planning Division, Plan Formulation Branch

FINAL REPORT

CORPS HYDROPOWER STUDIES HALTED

The Federal hydropower feasibility studies for locks and dams 5 (Minneiska, Minnesota) and 8 (Genoa, Wisconsin) have been terminated. The Corps of Engineers hydroelectric design center at Portland, Oregon, determined that there is no conventional hydropower design that is feasible using current economic factors. Feasibility reports will therefore not be prepared for the two sites. However, information developed during the studies is available at the St. Paul District office.

The lock and dam 7 (Dresbach, Minnesota) hydropower study ended in December 1983 because no hydropower design appeared feasible using current economic factors. The lock and dam 2 (Hastings, Minnesota) hydropower potential was never studied for Federal development beyond the reconnaissance stage because Hibbing, Minnesota, was issued a license to construct at that location.

The termination of Corps hydropower studies does not preclude development by non-Federal groups. The Federal Energy Regulatory Commission (FERC) remains responsible for review and approval of these non-Federal proposals. The Corps of Engineers will still be involved with review of any non-Federal hydropower proposals at Corps lock and dam sites, both from a permit or general regulatory standpoint and from the standpoint of determining whether a non-Federal proposal is compatible with the existing navigation project and related project purposes.

INFORMATION AVAILABLE

A number of products resulted from the Corps hydropower study efforts for locks and dams 5 and 8. These products consist of unpublished reports and information that are available for review in the District office or that are available from the National Technical Information System (NTIS).

Some of the more pertinent data available as indicated above include the following:

- Historical Resources Evaluation - September 1983 - Jon Gjerde.
- Analysis of Existing Information on Icnthyoplankton Drift on the Mississippi River - February 1984 - National Fishery Research Laboratory, La Crosse, Wisconsin.
- Analysis of Existing Information on Adult Fish Movements through Mississippi River Dams - February 1984 - National Fishery Research Laboratory, La Crosse, Wisconsin.
- River Morpnology and Substrate Survey, River Current Velocity and Direction Survey - 1983, 1984 - River Studies Center, University of Wisconsin at La Crosse, Wisconsin.
- Velocity Profiles in Roller and Tainter Gates for Lock and Dam 8 - November 1984 - Waterways Experiment Station, Vicksburg, Mississippi.
- Flow Simulation Model for the Lock and Dam 8 Site (RMA-2 Model) - December 1984 - Hydrologic Engineering Center, Davis, California.
- Ichthyoplankton Drift Study - November 1984 - National Fishery Research Laboratory, La Crosse, Wisconsin.
- Hydropower Technical Report, Lock and Dam 8 - December 1984 - North Pacific Division, Corps of Engineers.
- Potential Environmental Effects of Hydropower Development at Upper Mississippi Locks and Dams - in preparation - St. Paul District, Corps of Engineers.
- Potential Effects of Hydropower Operation on the Opportunity for Upstream Fish Passage through Lock and Dam 8, Upper Mississippi River - in preparation - St. Paul District, Corps of Engineers.
- The Influence of River Discharge and Hydropower Operation on Aquatic Habitat in the Tailwater of Lock and Dam 8, Upper Mississippi River - in preparation - St. Paul District, Corps of Engineers.

STUDY RESULTS

As a result of the feasibility study it was determined that no conventional hydropower plant was feasible at locks and dams 5 or 8 at October 1984 price levels.

A number of potentially significant environmental effects of hydropower development on the Upper Mississippi River were identified during the study. In an attempt to predict and quantify these potential effects, physical site surveys, literature searches, hydraulic modeling, and fishery surveys were conducted. Predictive analyses were not carried through to completion, but some conclusions were reached.

Department of Energy
Washington, D.C. 20585

November 1, 1984

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:

We have reviewed your draft feasibility report on construction of additional hydropower facilities at Lock and Dam #1, Mississippi River, transmitted to us on September 17, 1984.

We have analyzed the costs and electrical characteristics of the power that would be produced, and have examined the load characteristics of potential customers. Also, we have discussed marketability of the power with selected preference customers located within 50 miles of the proposed project. Based on our analyses and discussions, we are pleased to advise you that power output from the project could be marketed to repay all associated costs--investment costs allocated to power, interest costs, replacement costs, and transmission costs--within the repayment period.

Power from the project would be marketed under guidelines set forth in Section 5 of the Flood Control Act of 1944. Specific institutional and marketing arrangements would be developed to transmit and dispose of the power to encourage the most widespread use at the lowest possible rates to consumers consistent with sound business principles. Preference in the sale of power would be given to public bodies and cooperatives.

We appreciate the opportunity to work with you on the marketability aspects of this important renewable energy project. We look forward to continuing this close working relationship in subsequent phases of development.

Sincerely,

J. Emerson Harper

J. Emerson Harper, Acting Director
Power Marketing Coordination
Conservation and Renewable Energy

cc: Herbert Nelson, St. Paul District
Orv Bruton, North Pacific Division

Besides energy resources saved by hydropower operation, fish and fish habitat are the resources most likely to be significantly affected by hydropower development on the Upper Mississippi River. Hydropower operation could affect the fishery by changing the survival of fish passing downstream through the dams, by further restricting opportunity for upstream passage of fish through the dams, and by changing the quality and distribution of tailwater habitat. Further analyses would be necessary to quantitatively predict the effects of hydropower development and operation on the fishery.

INFORMATION SOURCE

You may contact the following address concerning the format and availability of study information or you may call (612) 725-7472.

District Engineer
St. Paul District
U.S. Army Corps of Engineers
ATTN: NCSPD-PF
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer

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

August 8, 1984

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 June 29, 1984 letter requests power values, developed at discount rates of 8.375 and 14.0 percent and based on October 1984 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 enclosed 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) 353-6710, and he will assist you.

Sincerely,

David L. Simon

for Lawrence F. Coffill, P.E.
Regional Engineer

Enclosure:
As stated

Power Values at October 1984 Cost Levels

	Capacity Value 1/ ($/kW-yr)		Energy Value ($/mwh) Current	Escalated	
	@ 8.375	@ 14.0%	-	@8.375	@14.0%
St. Anthony Falls Upper Dam	210.60	355.70	26.2	38.5	35.9
Lower Dam	210.60	355.70	26.0	38.2	35.6
Lock and Dam 1	210.60	355.70	26.0	38.2	35.6

1/ These data do not include hydrologic availability.

Summary of Input Data:

Coal Plant Investment Cost
@ 8.375% $1,401/kW
14% $1,623/kW

Coal plant Fuel Cost - $1.87 per million Btu

Unadjusted Capacity Value
@ 8.375% $156.50 kW-yr.
@ 14% $264.30 kW-yr.

Unadjusted Energy Value - $20.1/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 DOE projections published in the May 1984 "Annual Energy Outlook 1983".

Courier Press. Monday. October 17. 1983

Genoa Chosen As Pilot Hydro Project For Upper Miss. River

Increased costs of power generation are providing new looks at low head hydro generation. The Genoa Lock and Dam No. 8 is being considered to be one of the pilot hydro projects on the Upper Mississippi.

The Western Municipal Power Group has announced their intention to install the pilot hydrobarge at the Genoa Dam. The first barge is to be placed on line for one year. The other two hydrobarges would be constructed the following year.

From current information Jeffboat is being considered to be one of the prime contractors for the special hydrobarge Allis Chalmers would be the company providing the generators which are located in each barge

Backers of the power construction phase are a group of municipalities currently generating their own power. They are also purchasing some of their power from Dairyland Power, LaCrosse. The group would provide their power to the Dairyland system for credit in their power needs They are also considering the potential purchase of some of the transmission loans to improve their abilities.

The members of Western Municipal Power Group include Argyle, Fennimore, Viola, Cashton, New Lisbon, Elroy, Merrilan, Arcadia, LaFarge and Cumberland Charles City, Iowa, is also considering assisting in their abilities of gaining power needs.

Nick Kramer of Fennimore, one of the group of legal counsel for the group, stated the estimated cost is $21 million

During this fall and part of '84 the group will seek their license Construction would start this year; the intent is to have the pilot project in operation sometime in '86

Following the first year of operation the barge and the generators would be evaluated during the winter Any modifications could be made and incorporated in the other barges

Kramer stated, "The intent is to have three of this type of unit operating at the Genoa Lock and Dam This would be a run of the river type of generation "

The Corps of Engineers has their daily control of the dam Those changes are directed by the St Paul office in this area of the river In one of the hearings or meetings, the Corps indicated they could manage to maintain their same river controls with the various hydro units

In the other proposals, the people sponsoring the hydro power were placing their units in special construction at the end of the dam or being incorporated into several sections of taintor gates This is the first design being offered which included the bays of the roller gates

There is technology in several European countries where they have low head hydro power This is one of the first movable units being proposed

Gilbert Commonwealth consultants and engineers, have proposed these units

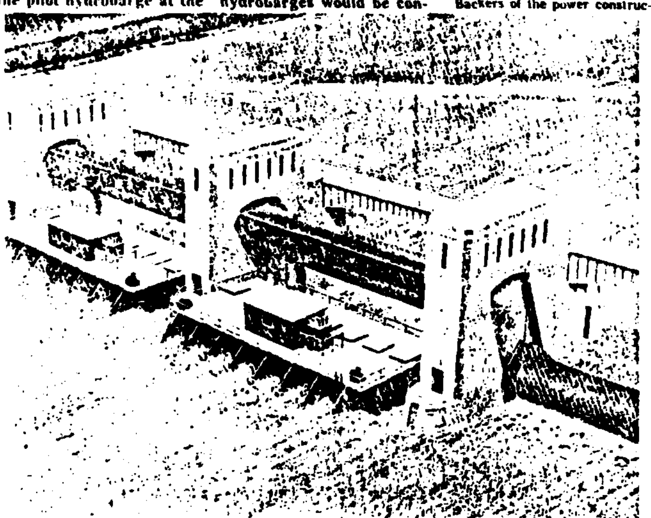
The company states they have developed a new concept of hydroelectric generation applicable to existing low head locks and dams They are developed to overcome the high costs and environmental impact associated with conventional low head hydro generation

The hydrobarge is a specially manufactured vessel containing hydroelectric units It is floated in and out of spillway openings on a seasonal basis for power production

This new unit is constructed at a shipyard, then as a barge transported to the dam The hydrobarge is utilized at those dams with spillways and control gates which have a geometric configuration and design suitable for low cost installation with a minimum of conflict with existing water uses

During those non-flood periods, the barge is submerged in place at the gate openings It is removed during those times when there are forecasts of higher river flow

Gilbert Commonwealth stated this is one of the more economical basis, which is a favorable alternative to satisfy future power needs in developing the nation's renewable resources



An artist's conception of two hydrobarges.

COMPUTATION SHEET

NAME OF OFFICE: ED-D Spms & Est Sec

COMPUTATION:

DATE: June '84

PAGE OF PAGES

SUBJECT: L/D#8 HYDROPOWER ESTIMATE ALT#1

SIPHON - OPEN FLUME

PRICE LEVEL:

COMPUTED BY: WM

CHECKED BY:

APPROVED BY:

ITEM	UNIT	UNIT PRICE	TWO UNITS QUANTITY	TWO UNITS COST	FOUR UNITS QUANTITY	FOUR UNITS COST
CONCRETE REMOVAL	CY	$40	1140	$45,600	1,513	$60,520
REPLACE CONCRETE SLABS	EA	$200	12	2,400	18	3,600
EXCAVATION	CY	$4	26,774	107,096	53,084	212,336
RIPRAP	CY	$30	2,695	80,850	4,067	122,010
BEDDING	CY	$10	1,112	11,120	1,679	16,790
CONCRETE	CY	$250	232	58,000	514	128,500
RETAINING WALL	SF	$14	2,860	40,040	2,860	40,040
BACKFILL	CY	$7	6,915	48,405	7,414	51,898
STRUCTURE PROTECTION	LS	-	LS	1,600,000	LS	1,650,000
SHEET PILE CELLS	EA	$50,000	5	250,000	5	250,000
EARTH COFFERDAM	CY	$7	6,429	45,003	10,718	75,026
DEWATERING	LS		LS	966,000	LS	1,186,000
		SUBTOTAL		2,404,517		2,996,720
		CONT. 25%		601,483		749,280
		TOTAL		$3,006,000		$3,746,000

COMPUTATION SHEET

NAME OF OFFICE: ED-D, [illegible]

COMPUTATION:

DATE: June '84

PAGE ___ OF ___ PAGES

SUBJECT: L/D #8 Hydropower Estimate ALT 2

Siphon - Tube Turbine

PRICE LEVEL:

COMPUTED BY: WAS

CHECKED BY:

APPROVED BY:

Item	Unit	Unit Price	Two Units Quantity	Two Units Cost	Four Units Quantity	Four Units Cost
Concrete Removal	C.Y.	$40	1140	$45,600	1253	$50,120
Remove Conc. Slabs	Ea	$200	12	2,400	18	3,600
Excavation	CY.	$4	34,805	139,220	65,644	262,576
Riprap	CY	$30	3,434	103,020	5,052	151,560
Bedding	CY	$10	1,393	13,930	2,053	20,530
Concrete	CY	$250	250	62,500	532	133,000
Retaining Wall	SF	$14	3,502	49,028	3,502	49,028
Backfill	CY	$7	7,021	49,147	7900	55,300
Structure Protection	LS	–	LS	750,000	LS	850,000
Sheet Pile Cells	Ea	$50,000	5	250,000	5	250,000
Earth Cofferdam	CY	$7	8,081	56,567	12,369	86,583
Dewatering	LS	–	LS	790,500	LS	955,500
Subtotal				2,311,912		2,867,797
Contingencies				578,088		717,203
Total				$2,890,000		$3,585,000

COMPUTATION SHEET

NAME OF OFFICE: ED-D Spec & Est Sec

COMPUTATION:

DATE: June 1984

PAGE OF PAGES

SUBJECT: L/D# 8 HYDROPOWER ESTIMATE Alt 3
Syphon/Pump turbine

PRICE LEVEL

COMPUTED BY: WHS

CHECKED BY

APPROVED BY

ITEM			UNIT	UNIT PRICE	TWO QUAN	UNITS COST	FOUR QUAN	UNIT COST
~~CONCRETE REMOVAL~~			~~CY~~	~~$40~~				
~~REPAIR CONCRETE SURFACE~~			~~SF~~	~~$200~~				
EXCAVATION			CY	~~$4~~ $5	247	1235	440	2200
RIPRAP			CY	$30	484	14,520	608	18,240
BEDDING			CY	~~$40~~ 20	194	3,880	244	4880
CONCRETE		MA 22	CY	~~$250~~ 400	29	11,600	57	22,800
RETAINING WALL (SHEETPILE)			SF	$14	2040	28,560	2340	32,760
BACKFILL			CY	$15	214	3,210	373	5,595
~~STRUCTURE PROTECTION~~			~~LS~~					
~~SHEET PILE GUIDE~~			~~SF~~	~~$30,000~~				
EARTH COFFERDAM			CY	$7.10	2413		2904	
DEWATERING			LS			53,000		58,500
				Subtotal		116,905		144,975
				Contingencies		28,000		36,025
				Total		$ 145,000		$ 181,000

COMPUTATION SHEET

NAME OF OFFICE ED-D Specs & Est Sec | COMPUTATION | DATE June '84 | PAGE OF PAGES

SUBJECT L/D#8 HYDROPOWER ESTIMATE Alt #4

Tube Turbine | PRICE LEVEL

COMPUTED BY WHS | CHECKED BY | APPROVED BY

ITEM	UNIT	UNIT PRICE	TWO UNITS QUANTITY	TWO UNITS COST	FOUR UNITS QUANTITY	FOUR UNITS COST
CONCRETE REMOVAL	CY	$40	1007	40,280	1,125	45,000
REPLACE CONCRETE SLABS	EA	$200	9	1,800	18	3,600
EXCAVATION	CY	$4	22,150	88,600	34,811	139,244
RIPRAP	CY	$30	2,316	69,480	2,926	87,780
BEDDING	CY	$10	917	9,170	1,162	11,620
CONCRETE	CY	$250	195	48,750	250	62,500
RETAINING WALL	SF	$14	4726	66,164	4,726	66,164
BACKFILL	CY	$7	5,712	39,984	5,712	39,984
STRUCTURE PROTECTION	LS	–	—	750,000	—	850,000
SHEET PILE CELLS	EA	$50,000	5	250,000	5	250,000
EARTH COFFERDAM	CY	$7	4,837	33,859	6,767	47,369
DEWATERING	LS	–	—	790,000	—	889,000
		Subtotal		2,188,087		2,492,261
		Cont		546,913		622,739
		Total	$	2,735,000	$	3,115,000