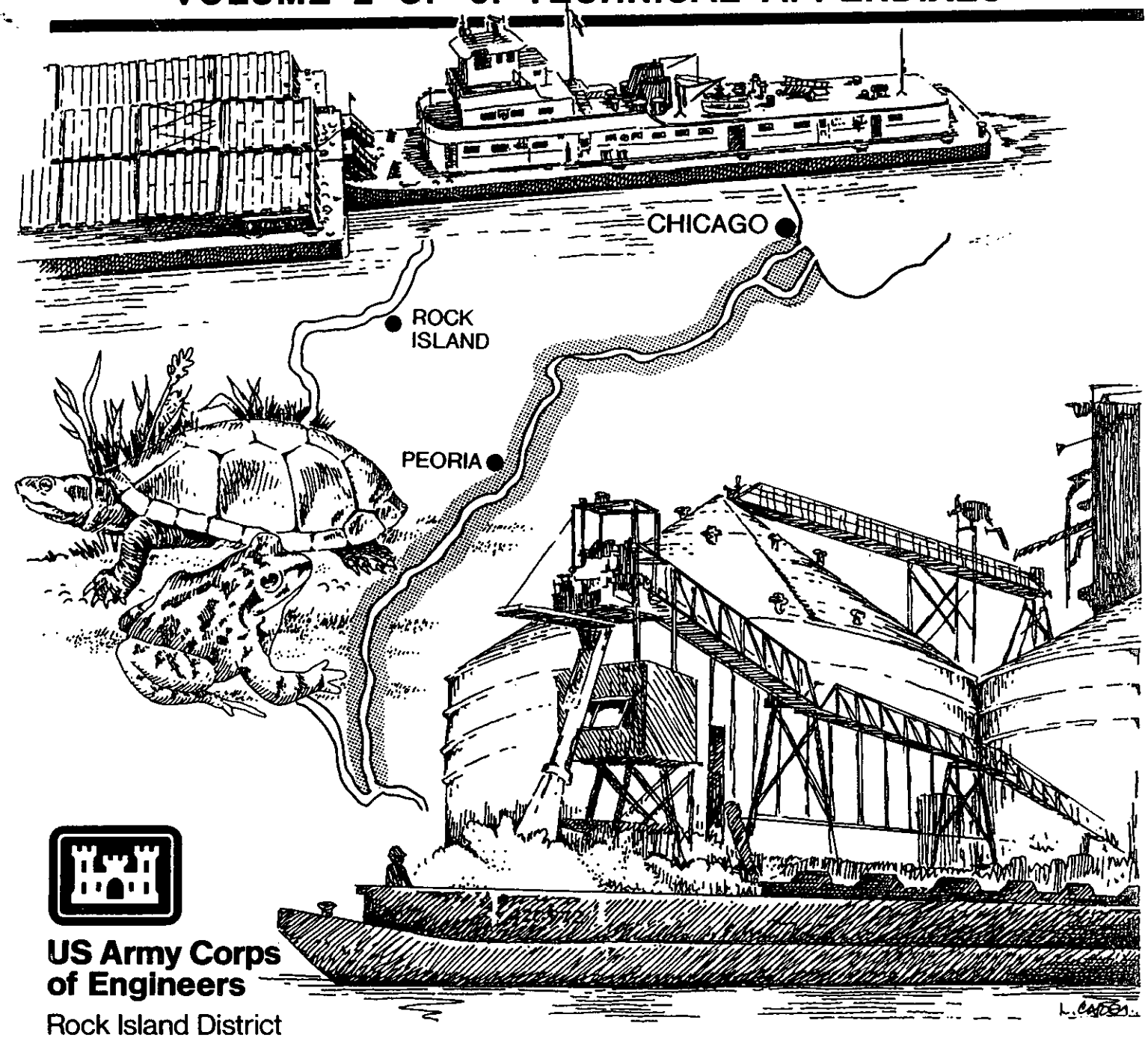
ILLINOIS WATERWAY NAVIGATION STUDY

RECONNAISSANCE REPORT (FINAL)

VOLUME 2 OF 3: TECHNICAL APPENDIXES



US Army Corps of Engineers
Rock Island District

OCTOBER 1990

DEPARTMENT OF THE ARMY
ROCK ISLAND DISTRICT, CORPS OF ENGINEERS
CLOCK TOWER BUILDING—P.O. BOX 2004
ROCK ISLAND, ILLINOIS 61204-2004

REPLY TO
ATTENTION OF:

CENCR-PD-W

RECONNAISSANCE REPORT
FOR
ILLINOIS WATERWAY NAVIGATION STUDY

TECHNICAL APPENDIXES
VOLUME 2 of 3

APPENDIX C - ECONOMIC ANALYSIS
APPENDIX D - HYDROLOGY AND HYDRAULICS

OCTOBER 1990

ECONOMIC ANALYSIS

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RECONNAISSANCE REPORT
FOR
ILLINOIS WATERWAY NAVIGATION STUDY

APPENDIX C
ECONOMIC ANALYSIS

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RECONNAISSANCE REPORT
FOR
ILLINOIS WATERWAY NAVIGATION STUDY

APPENDIX C
ECONOMIC ANALYSIS

SECTION 1 - SYSTEM DESCRIPTION

The Illinois River has a history of navigation dating back to 1803. The construction of locks and dams began in 1871 and continued until the system, as we know it today, was completed in 1939.

The Illinois Waterway System contains 327 miles of navigable channel from Grafton, Illinois, to Chicago, Illinois. The physical features of the river vary considerably from the upper to lower ends. The upper reach from Lockport to Starved Rock has a narrow channel and a relatively steep slope. From Starved Rock to the mouth of the Illinois, the channel is wider and much flatter.

The system provides year-round navigation with a series of eight locks and dams. Physical characteristics of the locks are summarized in table C-1. The Chicago lock is not included in this table; it is not considered part of the system because of the small tonnage that transits this lock. Peoria and LaGrange have two of the four remaining wicket dams in the United States. The wickets can be laid on the river bottom during high flows, allowing tows to pass over the wicket dam.

TABLE C-1

Physical Characteristics of Locks
Illinois Waterway

Lock	Age as of 1990	Width (Feet)	Length (Feet)	Lift (Feet)
T. J. O'Brien	30	110	1000	5
Lockport	57	110	600	40
Brandon Road	57	110	600	34
Dresden Island	57	110	600	22
Marseilles	57	110	600	24
Starved Rock	57	110	600	19
Peoria	51	110	600	11
LaGrange	51	110	600	10

Commodities on the Illinois Waterway reflect the influence of an agriculturally dominated lower waterway, with the Chicago metropolitan area exerting a strong influence on commodities moved on the upper portion of the waterway. The upper portion is tied more toward the industrial sector, with coal, petroleum products, and chemical products accounting for about half of all commodities shipped and received. There are 138 terminal facilities on the Illinois Waterway to load and unload the wide variety of products transported on the system.

Waterborne commerce on the Illinois Waterway has experienced moderate growth over the past decade (see figure 1). Total traffic has been over 40 million tons for 7 of the past 10 years. Grain tonnage grew from 12.5 million in 1979 to a peak in 1982 of 18.6 million (45 percent of total traffic in that year), then declined to 13.8 million in 1986. The volume of coal traffic has generally been increasing, from a low of 4.2 million tons in 1978 to a high of 7.5 million tons in 1986. Petroleum products tonnage has remained fairly stable throughout the decade.

Waterborne Commerce Statistics for 1988 (the most recent available) show that total traffic on the Illinois Waterway was 40.5 million tons. Grain constituted 34 percent of the traffic (13.6 million tons) followed by petroleum products at 16 percent (6.5 million tons), coal at 15 percent (5.9 million tons), and chemical products at 11 percent (4.5 million tons).

The *1988 Inland Waterway Review* projects tonnage transported on the Illinois Waterway to increase at an average annual rate between 1.2 and 2.5 percent through the year 2000. Farm products are the largest factor affecting future projections. By the year 2000, movements of farm products on the Illinois River are forecast to range between 21.4 and 25.3 million tons. Traffic of coal and petroleum products is projected to experience slow, steady growth, while the movement of non-metallic minerals is projected to remain static. Figures 2, 3, and 4 show historic tonnage and trends for locks representing the upper, middle, and lower portions of the river.

Modern towboats moving commodities on the Illinois Waterway are limited to about 5,000 horsepower and move a typical tow size of about 5 to 10 barges. The four general types of barges used are open hopper, covered hopper, deck, and tank. Open hopper barges are used for all types of bulk solid cargo (primarily coal) and account for about 45 percent of the tonnage capacity of all barges operating on the inland waterways. Covered hopper barges, carrying mainly grain and fertilizer, account for about 25 percent of the total tonnage capacity. Tank barges, for petroleum and chemicals, and deck barges make up about 22 and 8 percent, respectively.

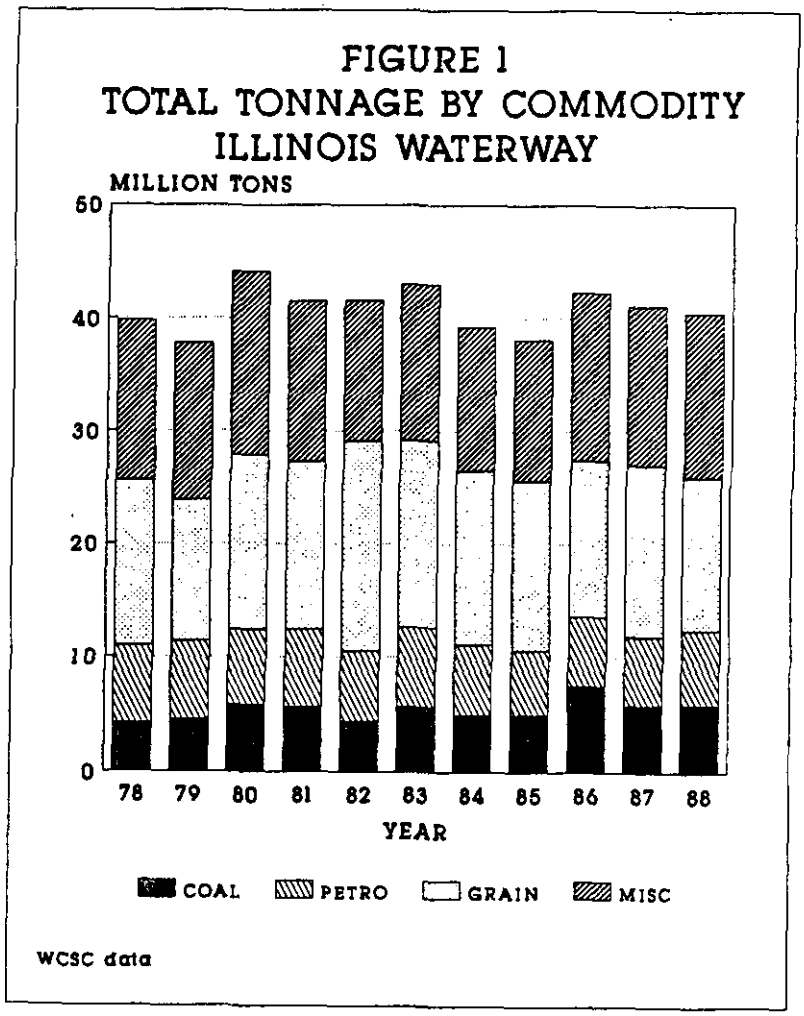


FIGURE 1
TOTAL TONNAGE BY COMMODITY
ILLINOIS WATERWAY
MILLION TONS
50
40
30
20
10
0
78
79
80
81
82
83
84
85
86
87
88
YEAR
COAL
PETRO
GRAIN
MISC
WCSC data

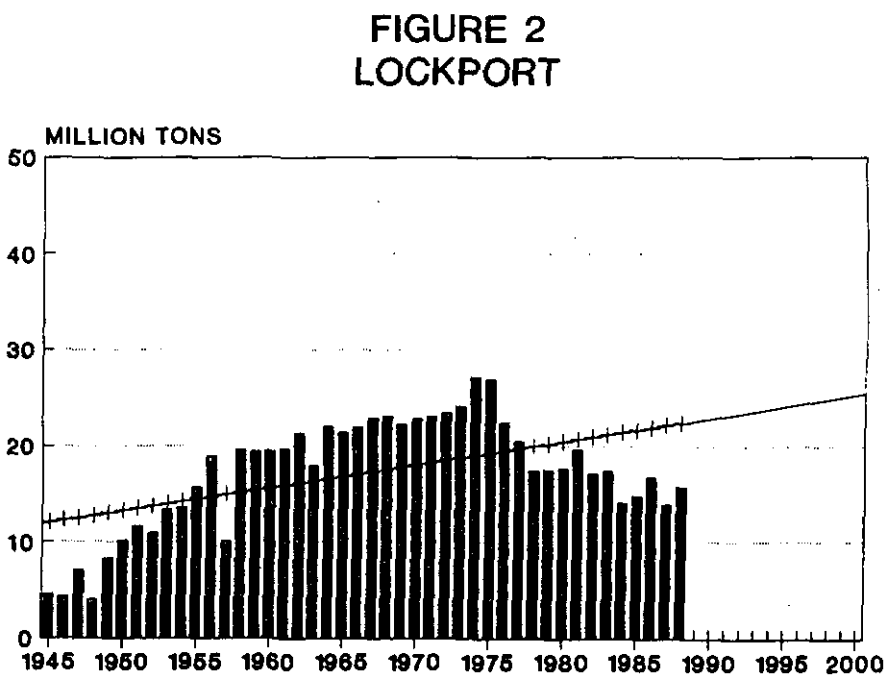


FIGURE 2
LOCKPORT
MILLION TONS
50
40
30
20
10
0
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

FIGURE 3
MARSEILLES

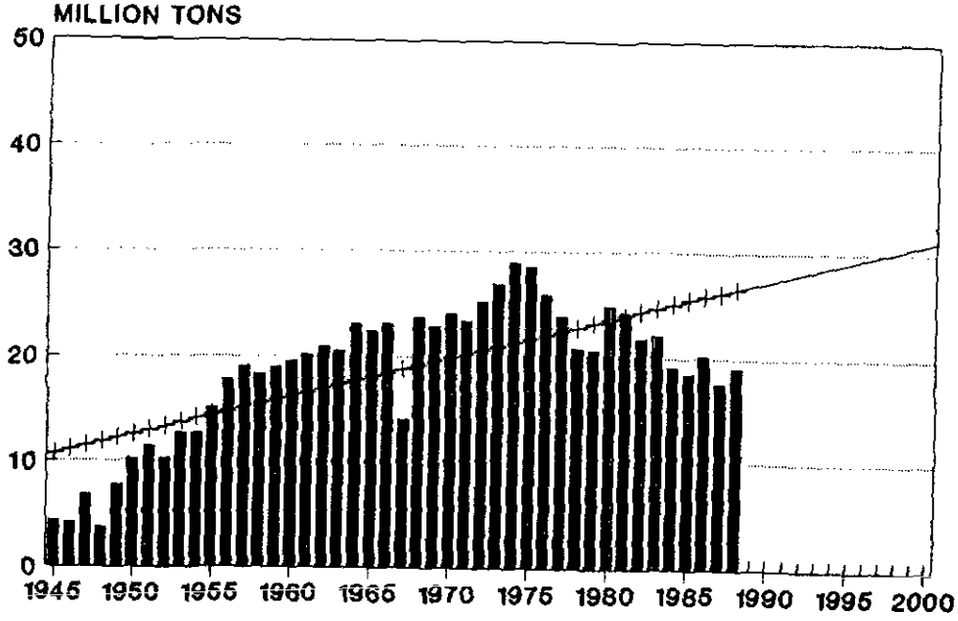
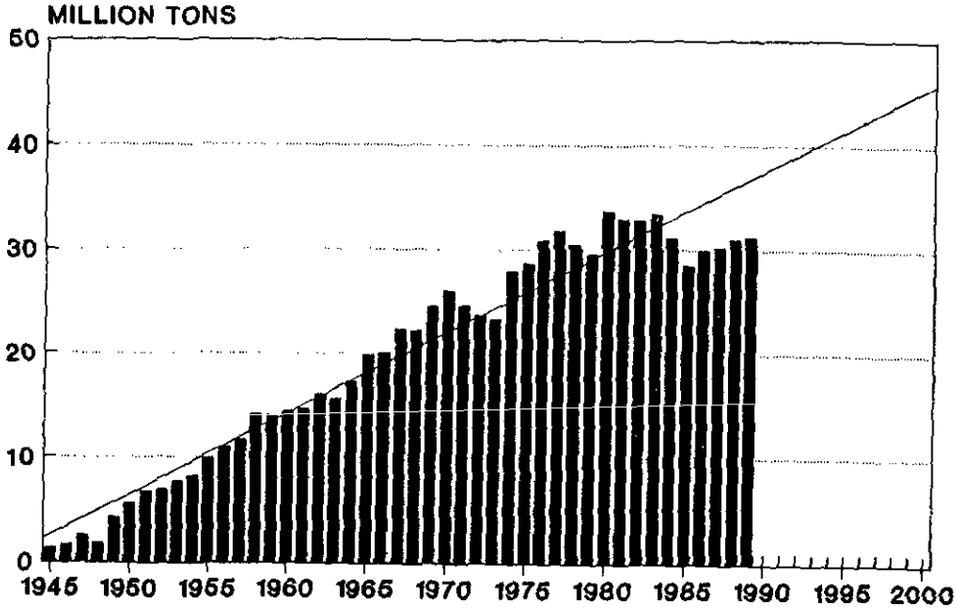


FIGURE 4
LAGRANGE



SECTION 2 - SYSTEM ANALYSIS

GENERAL EQUILIBRIUM MODEL RATIONALE AND METHODOLOGY

Measurement and allocation of transportation savings, benefits, and costs for alternative system configurations on the Illinois Waterway require the consideration of several important issues. Foremost among these issues is the inter-relationship between locks in the system and the manner in which alterations at one lock affect the efficiency of the system as a whole. This issue is referred to as systems analysis.

The General Equilibrium Model (GEM) is the system navigation model used in this study. GEM uses a nonlinear programming formulation to find the economic equilibrium over a set of potential waterway movements. That is to say, movements using the waterway have an economic incentive to do so while non-waterway movements have no economic incentive to use the waterway.

The input requirements of the model are as follows:

a. **Costs**: Cost per Kton per hour of delay for each (aggregate) commodity group at each lock.

b. **Locks**: Capacity and delay at half capacity for each lock in the system. For solution, the model requires that delay be an increasing function of tonnage. The delay function used in the model's present configuration is:

$$D = k. \frac{T}{C-T}$$

D = delay per ton
T = tonnage
k = delay at ½ capacity
C = lock capacity

To use this formulation, Capacity (C) and delay at one-half capacity (k), for each lock in the system, are required input parameters.

c. **Movements**: For aggregate commodity groups, this input requires a waterway routing vector (shows which locks the movement will transit), the number of Ktons, the gross rate savings (defined as the difference between water and land transportation without delay costs), and an indication of whether alternate water routings are possible. Movements of the same commodity which have different ultimate origins and/or destinations but the same water routing may be distinguished by a difference in the gross rate savings.

Output from the GEM model includes total transportation resource costs, delay times at each lock, tonnages moved through each lock, and the Net Rate Savings for each movement via all possible alternate routings.

Benefits for navigation projects consist of two components: transportation savings from lock delay reductions resulting from a navigation improvement, and transportation savings over an alternative mode. This idea is graphically demonstrated in figure 5. The demand curve DD shows for each ton of commerce the difference between total water transportation costs with no lock delays and the total costs of movement via the next least costly alternative mode of shipment (i.e., rail transport). This difference will be called the Gross Rate Savings of that ton's potential movement via the waterway. The supply curve SS represents simply the delay costs incurred by each movement as different levels of tonnage transit the lock. It is upward sloping to represent the notion that as more tons pass through a given lock, greater levels of congestion occur, and, consequently, higher per ton costs of delay are incurred. The equilibrium price or congestion cost is P with tonnage of T actually transitting the lock. All tonnage to the "left" of T find it still cheaper to move on the waterway than on the next cheapest alternative mode, whereas all tonnage to the "right" of T find it economically more advantageous to use some transportation mode other than the waterway. Hence, T tons will pass through the lock and incur delay costs of P dollars.

Now, consider the impact of a system change (such as the installation of a new lock chamber at one lock) on the level of system traffic and shipping costs. Figure 6 illustrates the effect of the change and the measurement of resulting benefits.

The equilibrium level of traffic increases from T_0 to T_1, with the reduction in shipping costs due to the improvement. The demand curve is assumed to remain the same. The benefits for system change can be broken into two components: (1) the cost savings on the pre-improvement level of traffic, $T_0 \times (P_0 - P_1)$ (the shaded area to the left of T_0); and (2) the benefits to the new traffic that can now move on the waterway, $\frac{1}{2}[(T_1 - T_0) \times (P_0 - P_1)]$ (the shaded triangle to the right of T_0).

The difference in the cost to move the commodities under with- and without-project conditions represents the benefit to the nation on inland navigation improvements. Transfer of income to barge from other modes as a result of navigation improvements is not a benefit to the Nation. The cost of moving the commodities is what matters. The basic assumptions in this analysis are that:

(a) Movements will divert from the waterway when the cost of total delay expected by the movement on the portion of the system it traverses exceeds rate savings.

(b) The delays and traffic computed for each component for the system must be logically consistent with the delays and traffic computed for all

FIGURE 5
CONCEPTUAL MODEL FOR WATERWAY ECONOMIC ANALYSIS

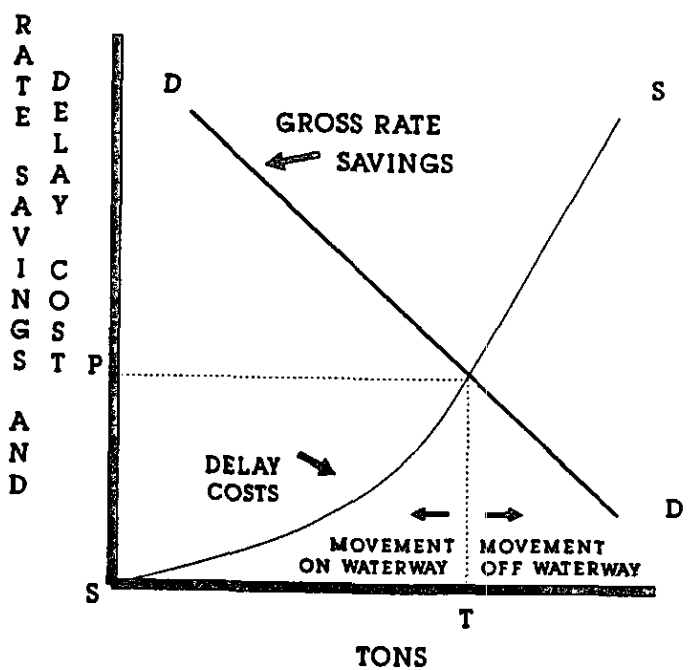
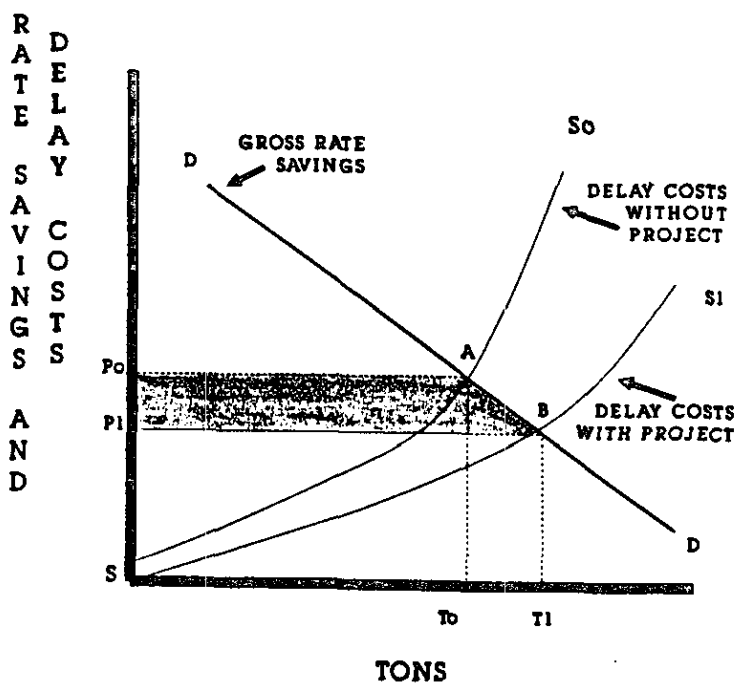


FIGURE 6
SYSTEM BENEFITS FOR LOCK IMPROVEMENT



other locks in the system. This requires that the equilibrium calculation at all system locks take place simultaneously.

MODEL DATA REQUIREMENTS

This section of the report describes input requirements of the General Equilibrium Model (GEM).

COSTS PER HOUR OF DELAY

Translating tow hours of delay into the corresponding cost per ton by commodity group is the focus of this section.

Three major factors are involved in estimating per hour lock and commodity specific delay costs. The first is tow size (barges per tow) and barge type. Tow size and barge type affect per hour delay costs due to the capital and operating cost per barge-hour.

The average number of barges per tow transitting each lock was determined from Performance Monitoring System (PMS) data using a 3-year average (1987-1989). Hourly barge costs for the primary barge types covered hopper barges (195' x 35') and tank barges (195' x 35') were used in determining average barge costs. These costs were obtained from Corps of Engineers published shallow draft vessel costs for Fiscal Year 1989. Barge costs per tow hour at each lock are shown for covered hopper barges in table C-2.

TABLE C-2

Barge Cost/Tow Hour by Lock

Lock	Average Barge/Tow	X	Barge Cost/Hour (Jumbo Hopper)	=	Barge Cost/ Tow Hour
T. J. O'Brien	3.24		4.11		13.32
Lockport	5.07		4.11		20.84
Brandon Road	5.19		4.11		21.33
Dresden Island	6.20		4.11		25.48
Marseilles	6.50		4.11		26.72
Starved Rock	6.92		4.11		28.44
Peoria	8.37		4.11		34.40
LaGrange	9.76		4.11		40.11

The second major factor in estimating delay costs is tow horsepower. Greater tow horsepower affects delay costs per hour because these tows cost more to own and operate.

To determine the tow horsepower component of cost, tow horsepower distributions by tow size were determined for tows pushing jumbo hopper barges and for integrated tows, primarily associated with tank barges. Distributions were compiled at each lock using May 1989 PMS data (May is a typical month.)

Towboat linehaul operating costs were obtained from Corps of Engineers published shallow draft vessel costs for Fiscal Year 1989. Using this information, a weighted average tow operating cost was determined for each lock on the Illinois Waterway for tows pushing jumbo hopper barges and for integrated tows, primarily associated with tank barges. An illustration of tow hour costs for tows pushing jumbo hopper barges at Peoria lock is shown in table C-3. A similar calculation was made for integrated tows.

TABLE C-3

Tow Cost/Hour at Peoria Lock
(Tows Pushing Jumbo Hopper Barges)

Lock	Horse-Power Size	Tow Horsepower Distribution	X	Tow Cost Per Hour	=	Weighted Tow Cost Per Hour
Peoria	501-1000	0.18		92.51		16.65
	1001-1500	0.18		127.20		22.90
	1501-2000	0.27		165.59		44.71
	2001-3000	0.00		231.79		0.00
	3001-4000	0.00		254.41		0.00
	4001-5000	0.36		317.52		114.31
						198.57

The final component in the cost of delay is commodity inventory carrying costs. These costs were established applying the Federal interest rate to the value per ton of commodities carried on the waterway. Commodity costs are summarized in table C-4.

TABLE C-4

Commodity Cost/Ton Hour
for Illinois Waterway Locks

Commodity	Value/ Ton ($)	X	1/8400 Hrs Per Year	=	Commodity Cost/Ton Hr ($)
Coal	24		0.0000105655		0.000254
Petro	200		0.0000105655		0.002113
Stone/Conc	109		0.0000105655		0.001152
Grain	84		0.0000105655		0.000887
Chem/Fert	368		0.0000105655		0.003888
Iron/Steel	104		0.0000105655		0.001099
Nonmet/Minerals	33		0.0000105655		0.000349
Misc.	132		0.0000105655		0.001395

For each of eight commodity groups, barge and tow cost/tow hour of delay were converted to costs per ton hour by using average tons/tow and added to commodity specific inventory carrying costs. An example of the calculation of resulting commodity specific cost per ton hour of delay at Peoria Lock is summarized in table C-5. As shown, commodities typically carried in jumbo hopper barges were assigned jumbo hopper barge cost and associated tow costs, and commodities carried in tank barges were assigned tank barge costs and tow costs for integrated tows.

Total per hour lock and commodity specific delay costs at all lock sites on the Illinois Waterway are shown in table C-6.

Summary

A major factor to be addressed in determining delay costs is the number of empty barges.

Commodities such as industrial chemicals and petroleum products and grain tend to move in "dedicated" tows on the Illinois Waterway. These are tows where the barges always move in the same group and have no return backhaul commodity. Delay costs are then incurred twice, once with loaded barges and once with returning empty barges. At present, the cost of empty backhauls is equally distributed among all commodities.

TABLE C-5

Commodity Specific
Total Cost/Ton Hour of Delay
(Peoria Lock)

Lock	Commodity	Commodity Cost/Ton Hour of Delay ($)		Barge Cost/ Ton Hour of Delay ($)		Tow Cost/ Ton Hour of Delay ($)	=	Total Cost/ Ton Hour of Delay ($)
Peoria	Coal	0.00025	+	.00414 1/	+	.02392 3/	=	0.02831
	Petro	0.00211	+	.00882 2/	+	.03931 4/	=	0.05024
	Concrete	0.00115	+	.00414	+	.02392	=	0.02921
	Grain	0.00089	+	.00414	+	.02392	=	0.02895
	Chemicals	0.00389	+	.00882	+	.03931	=	0.05202
	Iron	0.00110	+	.00414	+	.02392	=	0.02916
	Nonmet. Minerals	0.00035	+	.00414	+	.02392	=	0.02841
	Misc.	0.00139	+	.00414	+	.02392	=	0.02945

Footnotes: Petroleum and chemicals typically move in tank barges which are moved by greater horsepower towboats; all other commodities move primarily in jumbo hopper barges.

1/ 34.40 (Jumbo) Barge Cost Per Tow Hour/8,300 Tons Per Tow = .00414
2/ 73.24 (Tank) Barge Cost Per Tow Hour/8,300 Tons Per Tow = .00882
3/ 198.56 (Jumbo) Tow Cost Per Hour/8,300 Tons Per Tow = .02392
4/ 326.28 (Tank) Tow Cost Per Hour/8,300 Tons Per Tow = .03931

TABLE C-6

Total Cost/Ton Hour of Delay
for Illinois Waterway Locks ($)

Commodities

Lock	Nonmetallic Coal	Petro	Concrete	Grain	Chemicals	Iron	Minerals	Misc.
O'Brien	.04589	.04527	.04679	.04653	.04705	.04674	.04599	.04703
Lockport	.03254	.07556	.03441	.03317	.07734	.03338	.03263	.03368
Brandon Road	.03773	.07272	.03862	.03836	.07449	.03857	.03782	.03887
Dresden Island	.02559	.06303	.02649	.02623	.06480	.02644	.02569	.02673
Marseilles	.02405	.05857	.02495	.02468	.06035	.02489	.02414	.02519
Starved Rock	.02614	.05092	.02704	.02677	.05269	.02699	.02624	.02728
Peoria	.02831	.05024	.02921	.02895	.05202	.02916	.02841	.02946
LaGrange	.02402	.04626	.02492	.02466	.04803	.02487	.02412	.02516

LOCK CAPACITY AND DELAY ANALYSIS

As traffic grows on a waterway, the volume of traffic can create bottlenecks on the system. Generally, these constraints occur at navigation locks. Quantifying the relationship between tonnage moving through a lock and the delay at the lock is essential to the economic analysis of the navigation system.

There are two distinct ways to establish the delay-tonnage relationship; analytically or through simulation. For this level of study, the analytical approach is more appropriate.

To determine the delay-tonnage relationship at a navigation lock analytically, queuing theory must be applied. If arrivals for service (locking) are assumed to follow a Poisson process (i.e,. random), then the wait for service (delay at lock) is given by the formula:

$$D = \frac{U(S^2 + 1)P}{2(1-U)}$$

where:
- D = Delay
- U = Lock Utilization
- P = Average Processing Time
- S = Ratio of Standard Deviation to Average Processing Time

It can be seen from this formulation that as lock utilization approaches unity the delay at the lock will grow without bound. The tonnage required to produce 100 percent utilization, under projected future conditions, is defined as "practical lock capacity."

The above shows that delay can be related to lock utilization. It remains, however, to find the relationship between tonnage and delay. In order to do this, a system of equations was developed which model the relationship between tonnage and utilization. Solving this model for a given level of tonnage will allow us to find the corresponding utilization and hence delay. By solving the model over a range of tonnages, we can produce the familiar "delay curve." Further, by backsolving the model, we can determine the tonnage required to produce a given level of delay. As an illustration, delay curves for Lockport, Peoria, and LaGrange Locks are shown in figures 7, 8, and 9, respectively. These delay curves also show years corresponding to unconstrained projected tonnage.

The system of equations required to accomplish the above task is of sufficient complexity to warrant a computer for solution. With this in mind, the model was developed using the software package TK Solver. This software's ability to iteratively solve (and backsolve) systems of equations made it the ideal tool for developing and solving the model. The following discussion describes roughly how the model works.

FIGURE 7

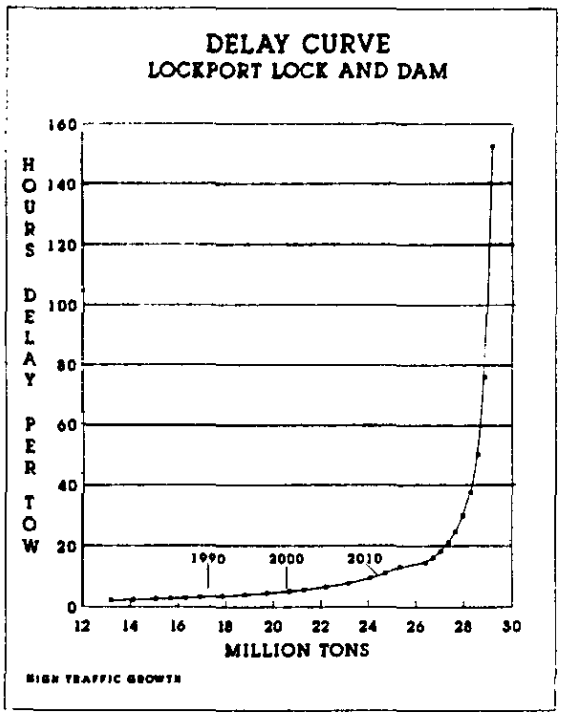


FIGURE 8

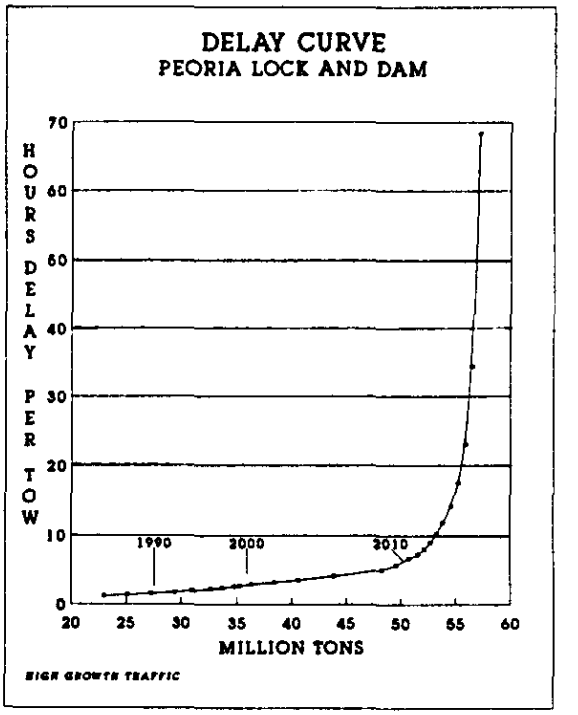
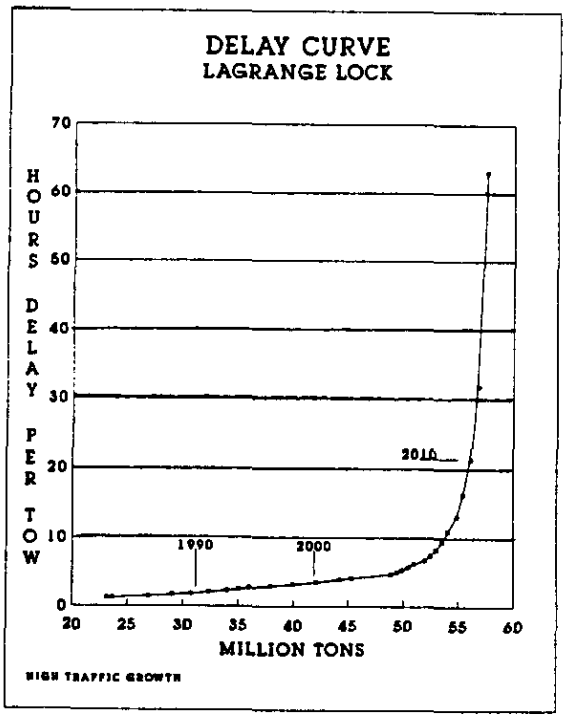


FIGURE 9



STEP 1 - Base year tonnage is specified (input) for each of eight commodity groups both upbound and downbound. The model contains equations specifying tonnage growth in each of the commodity groups. For any given level of tonnage, these growth equations are backsolved to yield the tonnage in each commodity group. As a by-product of this solution, the year in which this tonnage is projected to occur also is found. The growth rates used are those published in the *1988 Inland Waterway Review*.

The model, in its present form, can only accommodate a constant percentage growth rate for each commodity group. Allowing for variable growth (i.e., 2% until year 2000, 1% from 2000-2010, 2% from 2010-2020, etc.) is a possible improvement that can be made for future studies.

STEP 2 - The model has, as part of its input, the proportion of upbound and downbound tonnage in each commodity group and tons per barge load by commodity. This information is readily determined from PMS data. Using these inputs, along with the tonnage by commodity from step 1, the number of loaded barges both upbound and downbound is determined.

STEP 3 - The imbalance of upbound and downbound tonnage necessitates the movement of empty barges. Moreover, even if movements were perfectly balanced, a certain percentage of the barges would, for various reasons, still return empty; these are referred to as dedicated movements.

The percent of dedicated movements is a model input and, using this, as well as the imbalance in upbound and downbound traffic, the number of empty barges, both upbound and downbound are determined.

STEP 4 - At this point, the total number of barges traversing the lock, both upbound and downbound, is known. These numbers inherently must be roughly equal and, although it is not an explicit requirement of the model, this is the case.

Examination of PMS data shows that as tonnage transitting a lock increases, the average tow size also increases. From an economic perspective, this is reasonable as shippers and carriers will, to the extent possible, take advantage of the economies of scale.

Average tow sizes cannot, however, exceed limits physically imposed by the waterway or tow horsepower. To account for both these factors, the model allows for average tow size to increase linearly with tonnage until a "theoretical" maximum is reached, at which point average tow size remains constant.

STEP 5 - Knowing both number of barges and average tow size, the number of tows transitting the lock can be determined.

STEP 6 - Nearly all of the lockages taking place on the Illinois Waterway are either double lockages, straight single lockages, knockout single lockages, or setover single lockages. The model assumes that all lockages taking place are of one of these types. The percent of double

lockages is a function of average tow size. After determining the number of double lockages, the model determines the number of straight, knockout, and setover lockages based upon historical data. Even though multi-tow lockages do not presently occur in significant numbers, this could change under congested conditions. Allowing for this type of lockage in the future is a possible model improvement.

STEP 7 - A major part of the model inputs are the lockage component times. These component times are input for the various lockage types, and entry/exit types. In all, there are 21 component time inputs required for each lock modeled. These times may be determined, in the case of existing locks, from PMS data. In other cases, they may be estimated from design parameters or by comparison with similar locks. Note that, since each fly, turnback, or exchange approach corresponds to a fly, turnback, or exchange exit, the sum of exit and approach is treated as a single timing component.

STEP 8 - The number of lockages of each type (i.e., single, double, etc.) has already been determined. It remains to determine the proportion that will use fly, turnback, or exchange approach/exits. Since we are already assuming that arrivals for lockage occur randomly, it follows that the proportion of fly approach/exits is given by 1 minus utilization. If the lock utilization is less than .85, the model assumes that the lock operates using a FIFO (First-In/First-Out) policy and, hence, the proportion of turnback and exchange approach/exits are both equal to 1/2 of utilization.

At higher levels of utilization, the model compares the relative efficiency of turnback versus exchange approach/exits and assigns the appropriate lockage policy -- either 1-up 1-down, or n-up n-down. At locks where turnback is more efficient than exchange, the model assumes a 3-up 3-down policy at 85 percent utilization. As utilization increases, so does the proportion of turnback lockages so that at 100 percent utilization a 10-up 10-down policy is being implemented. At locks where exchange is more efficient than turnback, a 1-up 1-down policy is assumed at 90 percent utilization.

STEP 9 - It should be noted that the above analysis implies that utilization is known. Utilization, however, cannot be known since it is dependent (among other factors) on the relative proportion of exchange/exit types. This is why the iterative capabilities of TK Solver are essential. The calculations are done using a seed value (guess) for utilization. The results of this calculation allow the model to adjust the utilization value. After a number of iterations, the model converges on a solution which satisfies all the equations.

STEP 10 - Having determined the total number of tows, the proportion of each lockage type, and the proportion of each approach/exit type, it is a simple matter for the model to sum the lockage component times to find the total time devoted to commercial lockages. Also, the average tow processing time, needed in the delay calculation, can now be found.

STEP 11 - The total time used for non-commercial lockages is a model input, based upon historical data. At most locks this is largely due to the lockage of pleasure craft. Although this time seems to be trending upward, it is not clear whether this trend can be maintained when competition with commercial lockages increases. For this reason, it was assumed that this input would be constant.

STEP 12 - The time that the lock would be unavailable for locking of any type (stall time) also was determined by historical data and assumed to remain constant. While this is reasonable for stalls created by weather conditions, stalls created by mishaps will increase along with increasing tow usage. It is proposed that the model be modified to take this effect into account in future studies.

STEP 13 - Lock utilization is determined adding the times the lock is being used for either commercial or non-commercial lockages to the time the lock is unavailable for lockages (stalls) and dividing by the total time in the navigation season. For the purposes of this study, it was determined that the seasonal variation in traffic was small enough that the entire year could be considered as a whole. For a different system, or where more precision is called for, the model can be run for shorter time periods.

STEP 14 - Delay is calculated using the queuing theory formulation previously mentioned. The ratio of standard deviation to lockage times(s) is obtained from historical data and assumed to remain constant. If applicable, an adjustment is made to delay to account for open pass conditions.

It should be noted that the above steps are only an aid in explaining how the model works. The model will (and must) find a solution that will simultaneously satisfy all of the model conditions.

Further, although some variables in the above discussion are called input variables, the model is indifferent to which variables are input and which are output. As long as enough variables are specified to define a solution, TK Solver will find the values for the remaining variables. The form of the delay equation used in the GEM requires capacity and delay at half capacity as input parameters. Lock capacity can be found using this model by inputting 100 percent as an input value for utilization and allowing the model to solve for tonnage. After capacity is determined, half of this value is input for tonnage and the model can solve for delay. The results of this are displayed in the following table. It should be noted that since the GEM uses a very simplified form for the delay equation there will be some discrepancy between the delay used in GEM and that found by this model. This difference, however, is within the uncertainty bounds of the analysis. For future studies, we may want to change the delay formulation within the GEM programming.

TABLE C-7

Lock Capacities

Lock	Capacity (millions of tons)	Delay at One-Half Capacity (hours)
O'Brien Lock	72.1	0.51
Lockport Lock	29.5	1.12
Brandon Road Lock	32.1	1.13
Dresden Island Lock	42.4	1.06
Marseilles Lock [1]	36.8	2.49
Starved Rock Lock	47.5	0.96
Peoria Lock	58.5	0.88
LaGrange Lock	58.9	0.84
Hypothetical 1,200-Foot Lock at LaGrange	128.7	0.21
Hypothetical 1,200-Foot Lock at Peoria	136.5	0.37
Hypothetical Improvement to Upstream Approach at Marseilles	42.4	1.06

[1] Includes effects of canal upriver of Marseilles.

It is neither possible, nor desirable, to account for every phenomenon which may affect delay at a lock. The model attempts to accommodate the most fundamental parameters while allowing for future refinements.

ORIGIN-DESTINATION DATA BASE

For each lock on the Illinois Waterway, a file was furnished by the Corps of Engineer's Waterborne Commerce Statistics Center (WCSC). These files contained origin and destination Port and Dock Codes, WCSC Commodity Code and Tonnage for all reported movements transitting each lock in CY 1987.

Initially, these data were compared to 1987 tonnage recorded in the Lock Performance Monitoring System (PMS) data base. Agreement, adequate for this level of study, was found at all the locks, with the exception of O'Brien. Since no significant congestion is projected at O'Brien over the planning horizon, this discrepancy will not impact the study results. A comparison of WCSC and PMS tonnage is presented in table C-8.

Following the initial check, the data were made significantly more manageable by aggregation into 10 commodity groups. The aggregation used is shown in table C-9.

The data then were accumulated into a single file. Duplicate records were eliminated and flags were added to indicate the locks the movement transits. This accumulation yielded a file consisting of 2,738 records. The data then were aggregated geographically by Port Equivalent Code (a less geographically specific location than Port and Dock codes). This aggregation yielded a file consisting of 1,042 records, representing total movements of 35.4 million tons. This is somewhat less than the 40.9 million tons of total system traffic reported for 1987 since not all movements on the Illinois Waterway transit locks on the system. From this file, a sample was drawn to evaluate barge and rail rates.

After rates were obtained for the sample, it was evident that further aggregation was possible. Agricultural Chemicals were combined with Industrial Chemicals, and Crude Petroleum was combined with Petroleum Products to reduce the number of commodity groups to eight. Further aggregation using river reaches also was accomplished. This final aggregation yielded a file consisting of 504 records.

From this file, other files were built to reflect future traffic, by applying the high, medium, and low growth rates by commodity group. All files were then appropriately formatted for input into the GEM model.

TABLE C-8

Comparison of WCSC and
PMS Data, Tonnage Passing IWW Locks in 1987

Lock	WCSC Tonnage	PMS Tonnage	Percent Difference	# of WCSC Records	# of Records After Aggregation by Commodity Group
O'Brien 1/	5,017,961	6,792,154	-35.4	3,396	749
Lockport	13,750,145	12,965,105	5.7	8,492	1,328
Brandon	14,279,519	14,443,260	1.1	8,825	1,359
Dresden	15,999,026	16,701,678	-4.4	9,774	1,459
Marseilles	17,221,004	16,536,900	4.0	10,748	1,626
Starved Rock	18,975,441	19,373,042	-2.1	11,900	1,729
Peoria	26,392,558	25,118,494	4.8	16,812	2,174
LaGrange	30,386,576	28,814,470	5.2	19,185	2,530

1/ No significant congestion is projected at O'Brien Lock over the planning horizon. This discrepancy between PMS and WCSC tonnage data will not impact the study results, but has been noted for further investigation.

TABLE C-9

Aggregation of WCSC Commodity Groups

	Waterborne Commerce Statistics Center Commodity Code	Commodity Group
1.	1311	Crude Petroleum
2.	1121	Coal
3.	2911-2918, 2920-2921, 2951-2991	Petroleum Products
4.	2810-2861, 2891	Industrial Chemicals
5.	1011, 1021-1091, 3311-3319, 3321-3324,4011, 4012, 3411	Metallic Minerals
6.	1411,1412,1442,1451, 1491-1499	Nonmetallic Minerals
7.	3211,3241,3251,3271, 3281,3291	Concrete, Stone, Clay, Glass
8.	0101,0103-0107,0111, 0112,0119,0121-0191, 2049,2042,2011-2039, 2061-2099,2111	Farm Products
9.	1471,1479,2871-2879,	Agricultural Chemicals
10.	All other codes.	Miscellaneous & Unknown

RATE/COST ANALYSIS

Introduction

For each individual commodity movement that will use Illinois Waterway locks in the inland navigation system, the difference between total water transportation cost with no lock delays and total cost for the movement via the next least costly alternative mode of shipment (i.e., rail) is referred to as the gross rate savings of that ton's potential movement via the waterway.

Economic Principles and Guidelines directs that costs be determined for waterway transport and for the least cost alternative mode of transport (rail, truck, or pipeline). Rates may be used as a proxy for costs.

Rate/Cost Matrix

The overall goal of the rate/cost analysis is the construction of a matrix which accurately reflects the costs shippers face in the modal choice decision between waterway transportation and some alternative mode. In constructing this matrix, it is necessary to derive the three categories that comprise transportation costs, namely, the line-haul charge, access costs to or from a particular mode used in a movement, and transfer cost associated with the movement. By ascertaining each of these components, it is then possible to construct total transportation charges by mode.

a. Line Haul Costs. For our analysis, a sample of (aggregated) commodity specific movements was identified from the origin-destination data base for each of the major commodities included in this analysis. Movements were aggregated by common pools of origin and destination and by the following commodity groups.

(1) Crude Petroleum
(2) Coal
(3) Petroleum Products
(4) Industrial Chemicals
(5) Metallic Minerals
(6) Nonmetallic Minerals
(7) Concrete, Stone, Etc.
(8) Farm Products
(9) Agricultural Chemicals
(10) Miscellaneous and Unknown

Aggregated movements over 200,000 tons for farm products and movements over 100,000 tons for all other commodities were included in this sample. This resulted in a total of 60 pool-to-pool movements which accounted for 66 percent of total tonnage moved.

Line haul costs were computed for each movement in the sample for barge and rail transport using the REEBIE barge and rail cost analysis models.

b. Access and Transfer Costs from a particular mode used in a movement, and transfer costs (loading and unloading costs) associated with the movement were determined through telephone survey of the major river terminals on the Illinois Waterway. A discussion of the results of this survey related to commodity specific costs follows.

(1) Grain: Along the Illinois Waterway, shipping terminals receive grain primarily by truck from an average distance of about 30 miles. Generally this grain originates at country elevators, although smaller percentages are shipped directly from farms (estimated 20 percent) or are shipped by rail from much further distances (estimated 5 percent). Grain mill products are often produced on site and hence incur no additional cost of access to barge transportation.

The average cost of the 30-mile truck haul is 10 to 12 cents per bushel ($3.50 to $4.20 per ton). Additionally, there is a cost of between $3.00 and $4.00 per ton to elevate the grain from truck to barge. This cost includes the overhead of terminal operation.

For the purposes of this analysis, it is assumed that rail cars are loaded directly at country elevators at a cost of between $1.00 and $2.00 per ton. Additionally, there is a cost of approximately $2.00 per ton for grain movements to a terminal or subterminal for consolidation into a unit train. For the purposes of the Illinois Waterway Navigation Study. the following differentials will be used:

TABLE C-10

Access Cost Differential for Grain Movements

Percent of Tonnage	Per Ton Cost of Access to Barge Transportation Less Cost of Access to Rail Transportation
20	$0.00
20	$0.88
20	$2.63
20	$4.37
20	$6.13

(2) Agricultural Chemicals: The transportation pattern of agricultural chemicals is generally the reverse of grain movements. The average radius serviced by a river terminal unloading agricultural chemicals is about 50 miles. The larger service radius is due in part to the fact terminals that unload chemicals are more sparsely distributed along the

river. Further, the greater linehaul savings for barge shipments of chemicals (as opposed to grain) provide an economic incentive for longer movements from the river terminal.

The per ton cost of loading and unloading agricultural chemicals is about the same for both barge and rail.

The longer off river haul along with the slightly higher cost of truck transportation for chemicals (tank trailers) combine to make the cost of land transportation for agricultural chemicals about $1.00 per ton higher than that for grain.

(3) Western Coal: Most western coal originates in the Powder River Basin located in northeastern Wyoming and eastern Montana. It moves to the Upper Mississippi and Illinois Waterway generally by Unit Train at a cost of between $16.00 and $20.00 per ton. The Burlington Northern is the dominant railroad involved in these moves.

Western coal which moves via the Illinois Waterway generally does so because all rail transportation is not available to the ultimate destination (usually a power plant). Therefore, the alternative to barge transportation would be a truck haul. Sources in the industry indicate that the additional cost of using truck transportation is in excess of $20.00 per ton.

(4) Eastern Coal: An overland access cost of $2.00 per ton was used.

(5) All Other Commodities: It was assumed that there was no difference in the cost of rail and water access.

SECTION 3 - SYSTEM ANALYSIS RESULTS

WITHOUT-PROJECT CONDITION

One of the first steps in the formulation process is to identify the most likely condition expected to exist in the future in the absence of any improvements to the existing navigation system. The without-project condition serves as a baseline against which alternative improvements are evaluated. The increment of change between an alternative plan and the without-project condition provides the basis for evaluating the beneficial or adverse economic, environmental, and social effects of the considered plan.

It has long been recognized that any significant modification to the Nation's waterway system can have far reaching impacts that can be either negative or positive. National economic benefits of a project, a principal evaluation criteria for water resources studies, are then determined by computing the net difference of the average annual transportation costs and navigation system savings for with and without-project conditions. Definition of the without-project condition is presented below.

The without-project condition selected for use in this study includes the following:

a. Ordinary operation and maintenance of Illinois Waterway locks and dams will be continued through the period of economic analysis to ensure continued navigability.

b. All existing waterway projects or those under construction are to be considered in place and will be operated and maintained through the period of analysis.

c. All reasonable nonstructural measures for improving lock efficiency that are within the purview of the Corps of Engineers were assumed to be implemented at the appropriate time. Specifically, all locks on the Illinois Waterway Navigation System were assumed to be using the most efficient locking policy.

d. Waterway user taxes would continue in the form of the towboat fuel tax prescribed by the Water Resources Development Act of 1986, Public Law 99-662.

e. Alternative surface transportation systems (rail, truck) are assumed to have sufficient capacity to move the waterway traffic at current rates over the period of analysis.

PLANS

To evaluate plans, capacity and delay at one-half capacity under with-project condition was input to GEM. System model runs then were made to define the with-project benefits, traffic, and delays over the period of analysis. Plans considered in this analysis include the following:

Plan 1 - Building a 1,200-Foot by 110-Foot Lock at LaGrange, retaining the existing 600-foot by 110-foot lock. Two lock chambers in close proximity will create interference during lock approach and exit. To account for this phenomenon, the capacity of the 600-foot by 110-foot lock has been reduced to 60 percent of normal. To calculate the capacity of a 1,200-foot by 110-foot lock, it was assumed that all lockages would be singles with approach, chambering, and exit times based on Performance Monitoring System (PMS) records. At this level of capacity, significant delays are eliminated at LaGrange lock for the time span of our period of analysis.

Plan 2 - Building a 1,200-Foot by 110-Foot Lock at Peoria, retaining the existing 600-foot by 110-foot lock. This plan assumes that the lock addition at LaGrange, described in Plan 1, is in place. Plan 2 also assumes 60 percent capacity for the existing 600-foot by 110-foot lock at Peoria. At this level of capacity, significant delays are eliminated at both Peoria and LaGrange locks for the time span of our period of analysis.

Plan 3 - Improvement to Approach at Marseilles. This plan assumes that the capacity and delay at Marseilles is improved to be equivalent to the Dresden Island lock. This plan assumes that Plans 1 and 2 are in place.

Capacity and delay at one-half capacity used for each plan is shown in table C-11.

AVERAGE ANNUAL COSTS

The first costs developed in this report and interest during construction are displayed in table C-12. Annual costs for all plans considered were computed using an 8-7/8 percent interest rate, a 50-year project life, and July 1990 price levels. Interest during construction was calculated based on a 4-year construction period for Plans 1 and 2 (addition of 1,200-foot locks at LaGrange and Peoria, respectively), and a 2-year construction period for Plan 3 (widening the Marseilles canal).

TABLE C-11

Capacity and Delay Parameters
for Plans

Plans	Without-Project Capacity (millions of tons)	Without-Project Delay at One-Half Capacity (hours)	With-Project Capacity (millions of tons)	With-Project Delay at One-Half Capacity (hours)
1 - LaGrange	58.9	.84	164.0	.210
2 - LaGrange	164.0	.210	164.0	.210
- Peoria	58.5	.88	170.8	.370
3 - LaGrange	164.0	.210	164.0	.210
- Peoria	170.8	.370	170.8	.370
- Marseilles	36.8	2.49	42.4	1.060

Note that capacities shown in this table account for both the capacity of the existing lock and the proposed improvement where appropriate.

TABLE C-12

Summary of First Cost,
Interest During Construction, and Annual Cost
($1,000,000)

Plan	First Cost	Interest During Construction	Investment Cost	Annual Investment Cost
1. LaGrange	380.0	72.5 1/	452.5	40.7
2. Peoria	390.0	74.4 1/	464.4	41.8
3. Marseilles	8.1	0.7 2/	8.8	.8

1/ Based on 4-year construction period.
2/ Based on 2-year construction period.

SYSTEM BENEFITS AND TIMING OF IMPLEMENTATION

The benefits creditable to each plan are entirely general navigation. Two measures of these benefits were estimated for each plan: total benefits and incremental benefits. Total benefits represent the transportation cost savings creditable to the system of Illinois Waterway locks, whereas the incremental benefits include only those system benefits attributable to the improvements called for under each plan. The incremental benefits are the appropriate values for use in the economic analysis of plans. System analysis techniques were used to measure the performance of the Illinois Waterway Navigation System with and without the alternative plans.

To establish the base case or without-project condition, the General Equilibrium System Navigation Model (GEM) was run using the previously described inputs for existing 1987 traffic, and projected traffic in 1990 and in 10-year increments through 2040. The primary outputs of GEM over the 50-year period of analysis are delays at each system lock, tonnage at each lock, system tonnage moved, and total system transport costs (gross rate savings minus delay costs) for all movements transitting the Illinois Waterway.

The lock which shows up to be the major system constraint (the lock with the highest delays over the period of analysis) is analyzed for alternative solutions to reduce or eliminate the delays. On the Illinois Waterway, LaGrange lock was identified as clearly being the first major constraint. Figures 10 and 11 show projected delays in hours/tow and tonnage at LaGrange lock, respectively, over the 50-year period of analysis. Annual tonnage moved on the system over the 50-year period is displayed in figure 12. (Note that this does not include tonnage that does not transit at least one Illinois Waterway lock.) Unconstrained tonnage assumes that the locks have adequate capacity to pass projected traffic. It is simply base

FIGURE-10 WITHOUT PROJECT DELAYS AT LAGRANGE LOCK (HIGH TRAFFIC GROWTH)

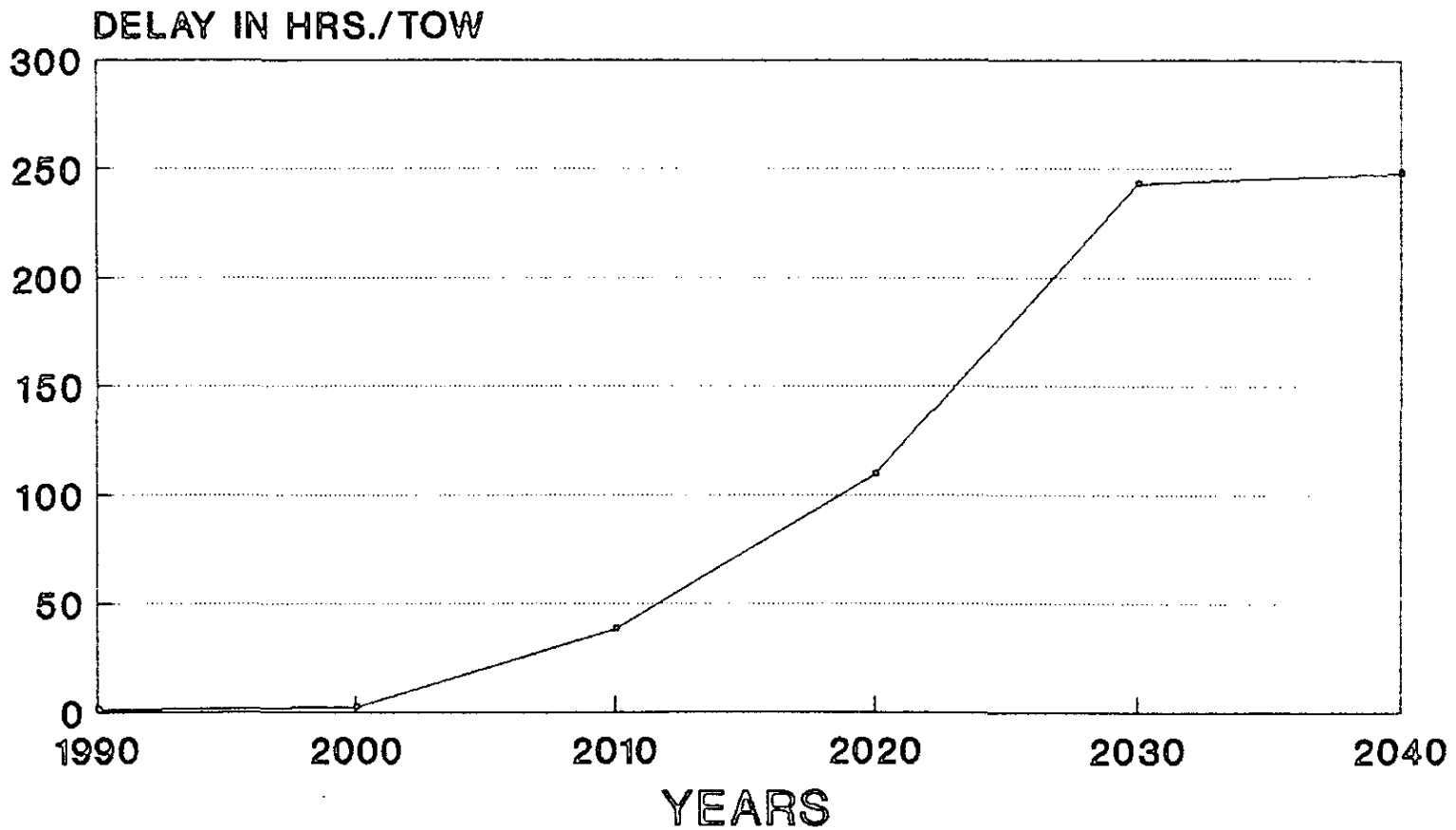


FIGURE-11 WITHOUT PROJECT TONNAGE AT LAGRANGE LOCK (HIGH TRAFFIC GROWTH)

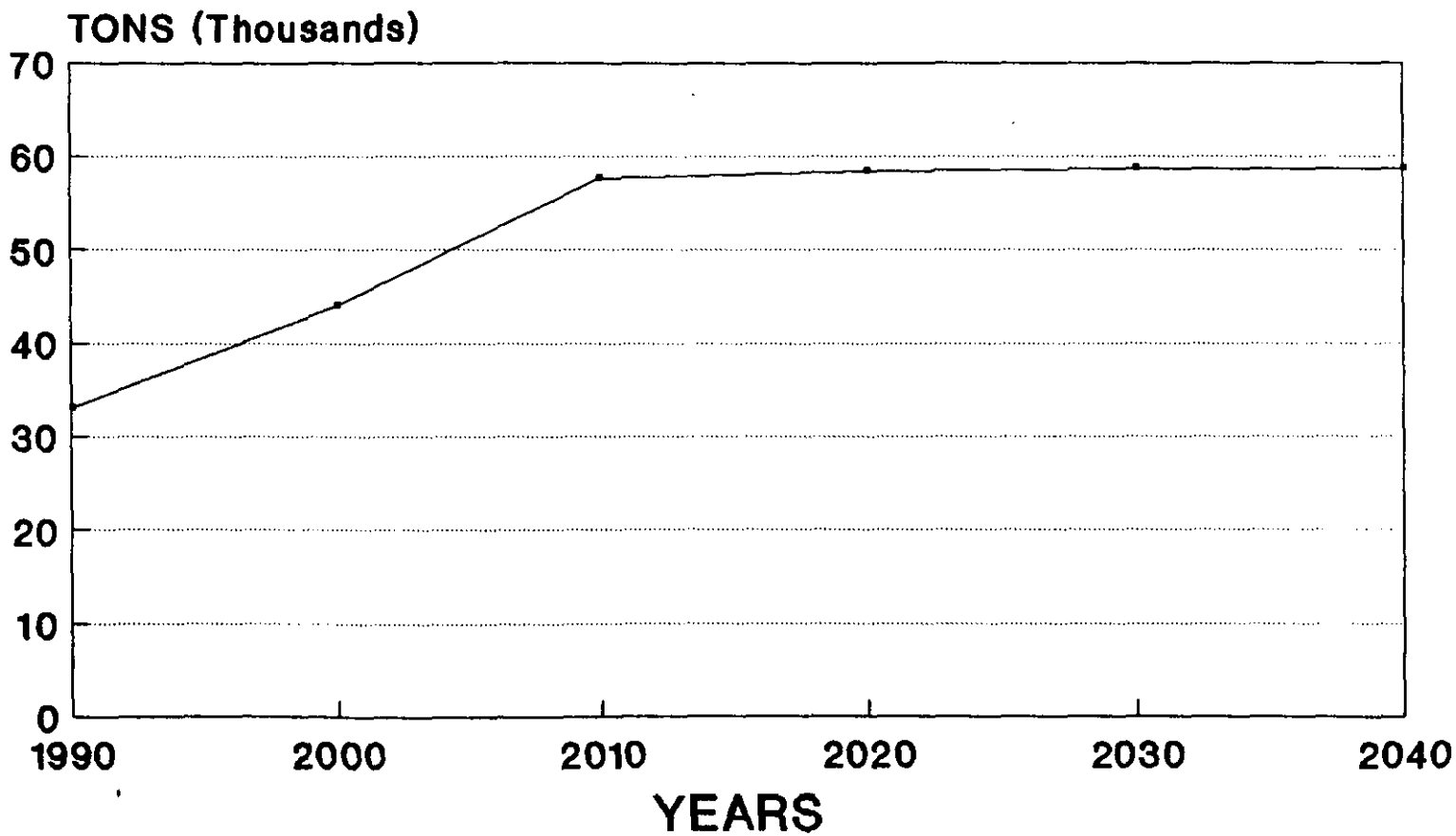
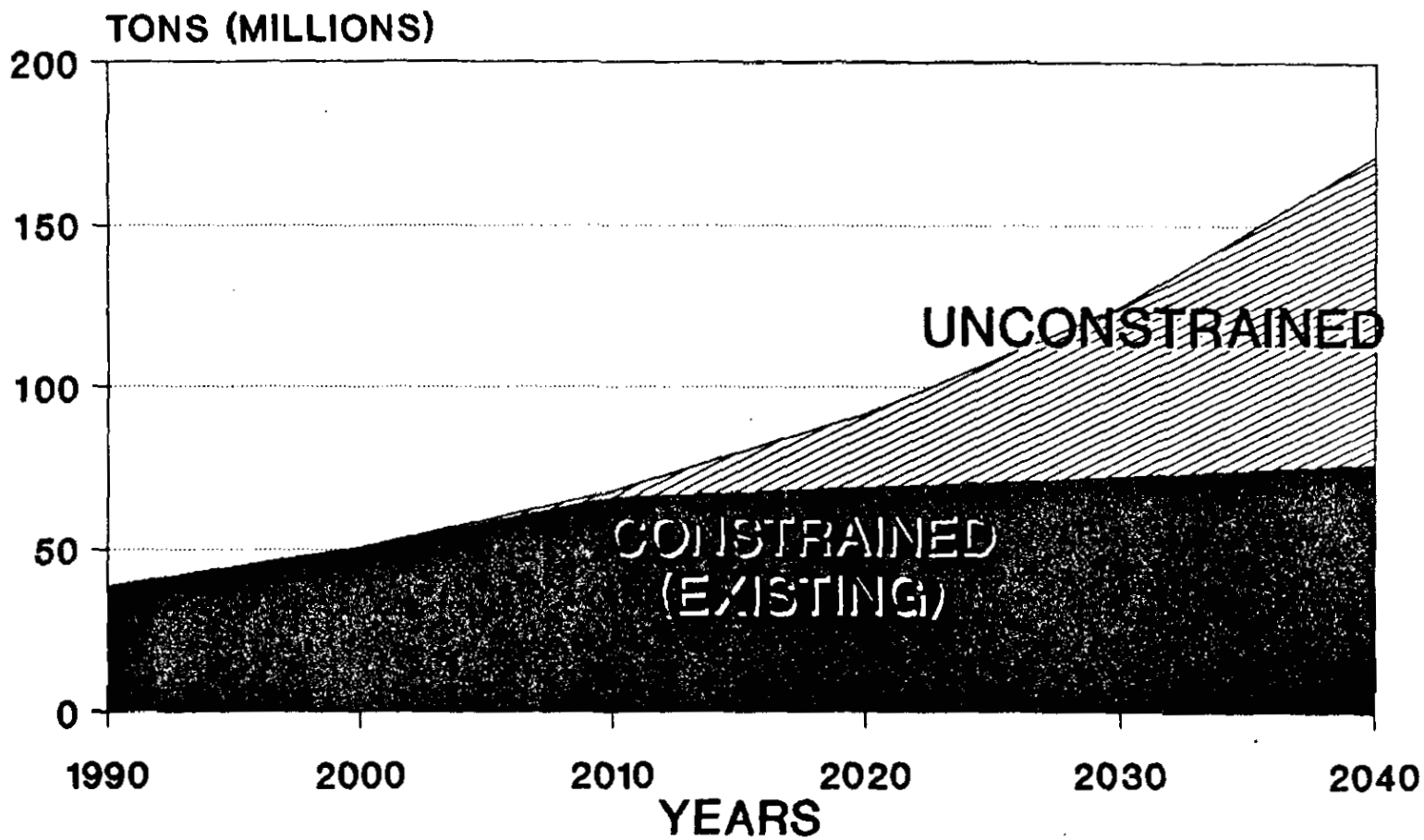


FIGURE-12 SYSTEM TONNAGE ON THE ILLINOIS WATERWAY WITHOUT IMPROVEMENTS (HIGH TRAFFIC GROWTH)



traffic multiplied by the projected traffic growth rate. Constrained traffic accounts for the limited capacity of the Illinois Waterway locks. Figure 13 shows the added increment of traffic that moves on the system with each plan. When delay costs exceed the gross rate savings that water transport has over rail, then movements divert from water to rail transport. As can be seen in figure 12, significant diversion off the waterway occurs just after the year 2010 under the without-project condition. Removing a constraint on the system reduces the cost of delay allowing commodities to move on the waterway at a reduced cost.

Total dollar annual system benefits for the base case or without-project condition over the 50-year period of analysis are displayed in figure 14. As previously explained, system benefits are the gross rate savings water transport has over rail minus the delay costs on the waterway summed for all water movements in the analysis. Undiscounted (incremental) annual benefits for each plan are also shown in figure 14.

As previously explained, incremental benefits include only those system benefits attributable to the improvements called for under each plan. They represent the difference between without-project and with-project system model runs.

Incremental benefits for Plan 1 are the increase over the base condition. Incremental benefits for Plan 2 are increase over Plan 1. Incremental benefits for Plan 3 are the increase over Plan 2.

For further illustration, incremental system benefits for a 1,200-foot lock addition at LaGrange over the 50-year period of analysis are presented in figure 15. These data are presented in tabular form (discounted) in table C-13, along with benefit-to-cost ratios and net benefits. System benefits generally grow over time with increasing traffic, then decline when delays build at another system lock or constraint. Accounting for future (discounted) benefits shows the average annual benefits over the projected life of the project.

FIGURE-13 SYSTEM TONNAGE ON THE ILLINOIS WATERWAY WITH IMPROVEMENTS (HIGH TRAFFIC GROWTH)

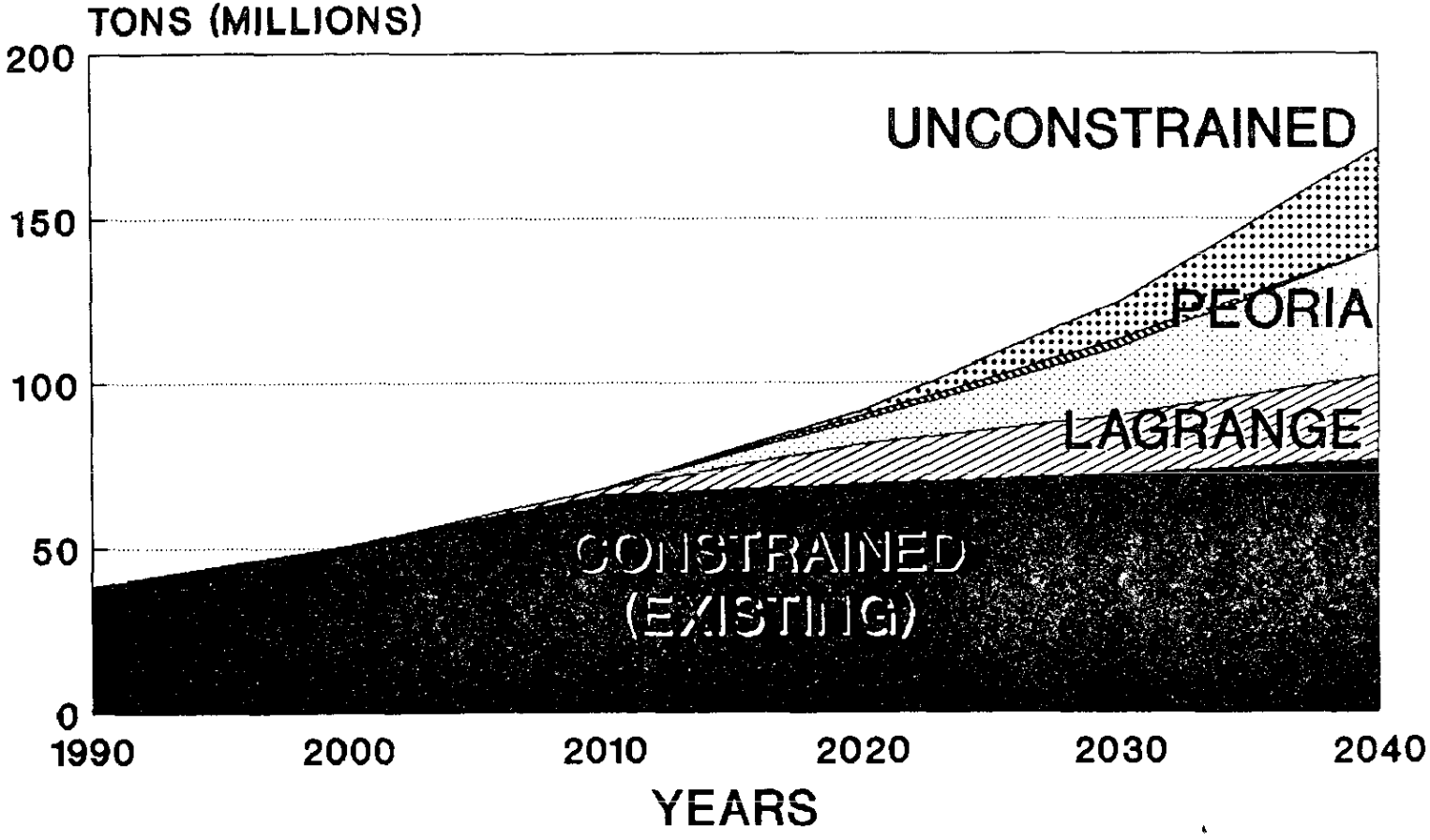


FIGURE-14 ILLINOIS WATERWAY SYSTEM BENEFITS (HIGH TRAFFIC GROWTH)

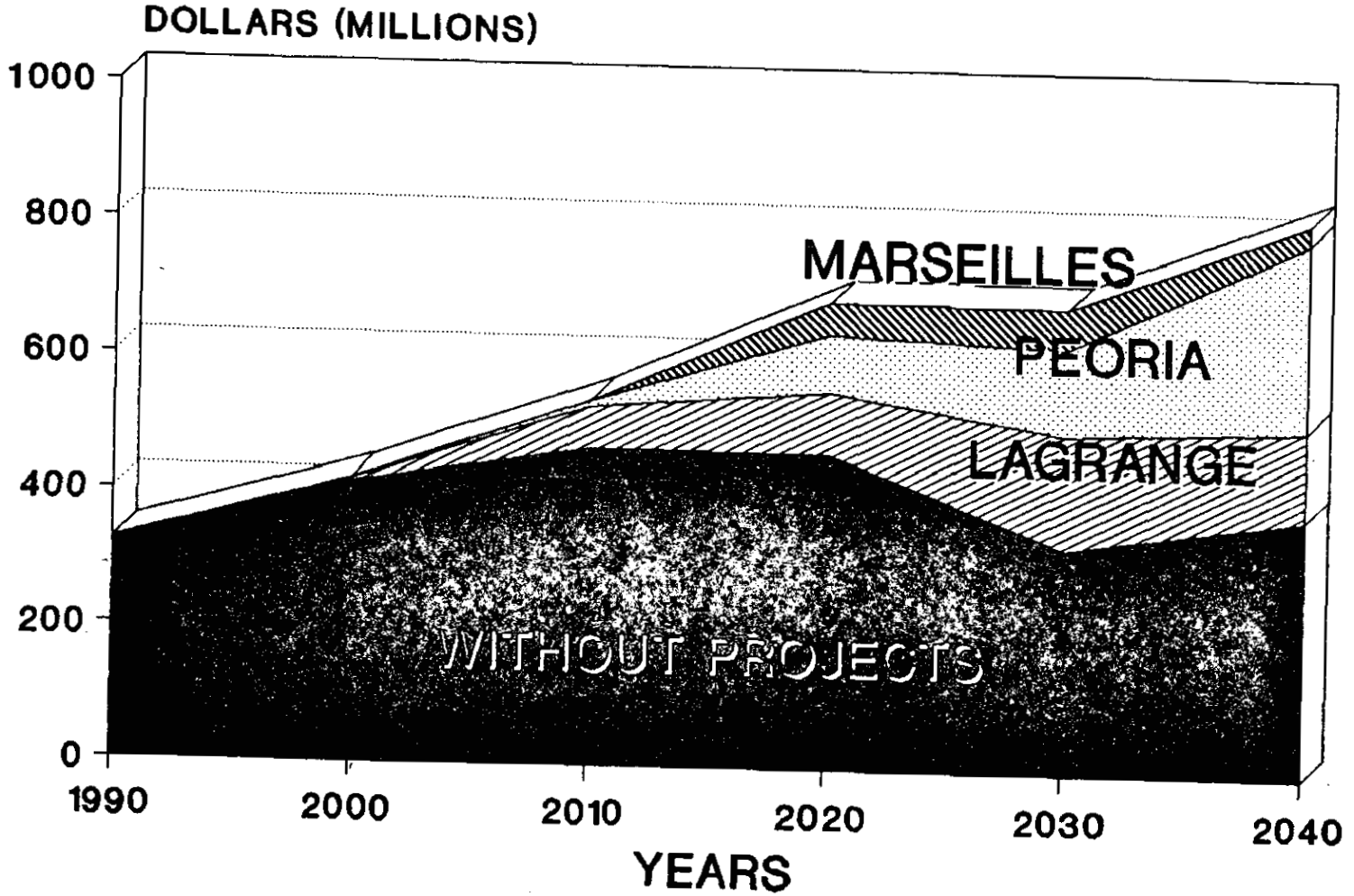
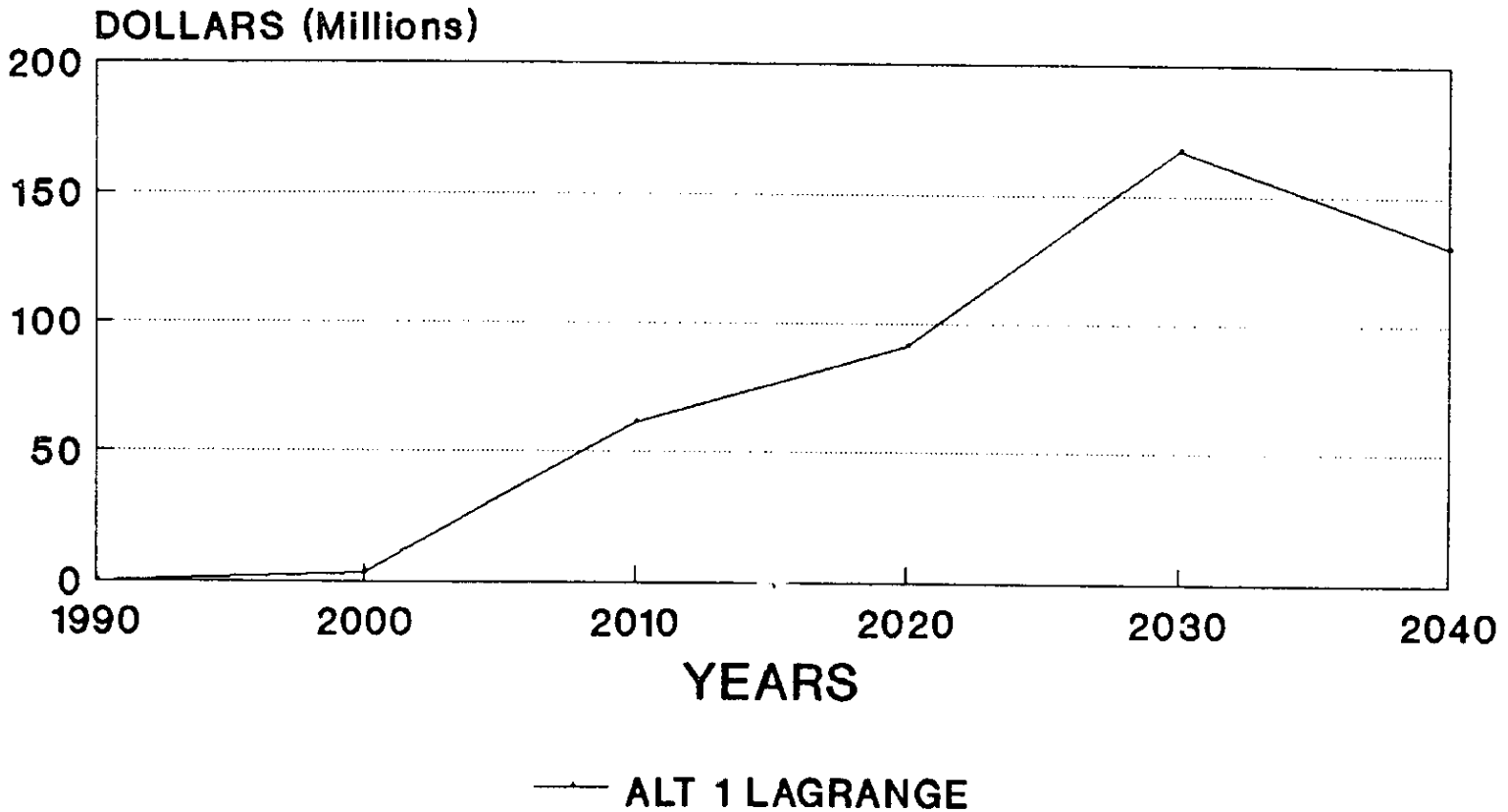


FIGURE-15 INCREMENTAL SYSTEM BENEFITS 1200 FT. LOCK ADDITION AT LAGRANGE HIGH GROWTH SCENARIO



BENEFITS TO ADD A 1200 FT. LOCK TO THE EXISTING SYSTEM AT LAGRANGE.

TABLE C-13

Average Annual Discounted Benefits
and Cost for Final Plans
July 1990 Price Levels 8-7/8%
($1,000,000) 1/

Plan	Average Annual Systems Benefits	Incremental System Benefit 2/	Average Annual Cost	Benefit/Cost Ratio	Net Benefits
Without Project	437.8				
1 LaGrange	492.8	55.0	40.7	1.4	14.3
2 LaGrange and Peoria	541.4	48.6	41.8	1.2	6.8
3 LaGrange, Peoria, & Marseilles	558.3	16.9	0.8	21.1	16.1

1/ Base year or year project is implemented is 2000. Period of analysis 2000-2050.

2/ Incremental benefits for Plan 1 are the increase over the base condition (492.8 - 937.8 = 55.0). Incremental benefits for Plan 2 are increase over Plan 1 (541.4 - 492.8 = 48.6). Incremental benefits for Plan 3 are the increase over Plan 2 (558.3 - 541.4 = 16.9).

NOTE: To construct these plans out of sequence would result in significant reductions in incremental system benefits, or negative benefits in the case of Marseilles, as delay would shift to the major constraint. Benefits for construction of Peoria and LaGrange together or a single lock to replace both Peoria and LaGrange amount to (55.0 + 48.6) $103.6 million by addition of incremental benefits.

SENSITIVITY ANALYSIS

Traffic growth rates have a significant impact on system benefits, and, in turn, on how early a project can be implemented. The Illinois Waterway System Analysis used commodity specific high traffic growth rates from the *1988 Inland Waterway Review*.

Table C-14 compares of historical tonnage growth and the *1988 Inland Waterway Review* traffic growth rates. As can be seen, the annual historical rate of 4.6 percent exceeds the high *1988 Inland Waterway Review* rate of 2.8 percent at LaGrange lock. Also, the historical period 1973-1980 shows an even higher annual growth of 5.4 percent for LaGrange lock.

TABLE C-14

Comparison of Historical and 1988
Inland Waterway Review Traffic Growth Rates
Inland 1988 Waterway Review 1/

Lock	Low	Med	High	Historical 1950-1988
O'Brien	0.6	1.1	2.0	2.2
Lockport	0.5	1.2	1.9	1.2
Brandon	0.5	1.2	1.9	1.1
Dresden	0.5	1.2	1.9	1.4
Marseilles	0.8	1.5	2.2	1.6
Starved Rock	1.0	1.6	2.4	2.0
Peoria	1.3	1.9	2.7	2.7
LaGrange	1.4	2.0	2.8	4.6

1/ Commodity-specific traffic growth rate applied to commodity distribution at the lock.

Using medium *Inland Waterway Review* growth rates would result in a significant reduction in system benefits but still show project justification (the addition of a 1,200-foot lock with a B/C greater than 1) in year 2003 at LaGrange lock.

Using the low growth rate, a 1,200-foot lock at LaGrange is justified in the year 2012.

Summary

This analysis has clearly shown a near-term Federal interest in construction of additional locks on the Illinois Waterway. Justification for a

1,200-foot lock at LaGrange (B/C greater than 1) occurs earlier than the year 2000 using the *Inland Waterway Review* high traffic growth rates, which are clearly supported by historical PMS data, and discussions with shippers and carriers on the waterway. Justification for a 1,200-foot lock at Peoria and improvements to the upstream approach at Marseilles also are justified before the year 2000, given that a 1,200-foot lock is in place at LaGrange. With 1,200-foot lock additions in place at LaGrange and Peoria and improvements to the Marseilles canal, the next major constraint identified was Starved Rock lock, with justification for an additional lock in the 2000-2010 timeframe.

SECTION 4 - SCOPE OF STUDIES FOR ILLINOIS WATERWAY FEASIBILITY STUDY

PROCEDURES

The procedures to be used in the feasibility study will be consistent with the Principles and Guidelines for Water and Related Land Resources Planning. All lock sites in the Illinois Waterway System will be analyzed to determine the relative magnitude of the constraint that each poses to the efficient flow of traffic and determine the potential transportation resource cost savings that could be realized through modernization. An overview of the procedures is presented in figure 16.

WORK TASK

All Illinois Waterway locks and critical channel constraints will be analyzed and modeled in the first feasibility study with emphasis on the major constraint identified in the reconnaissance study.

The following work tasks expand on the work completed in the reconnaissance study and make up the economic work effort for the first feasibility study on the Illinois Waterway.

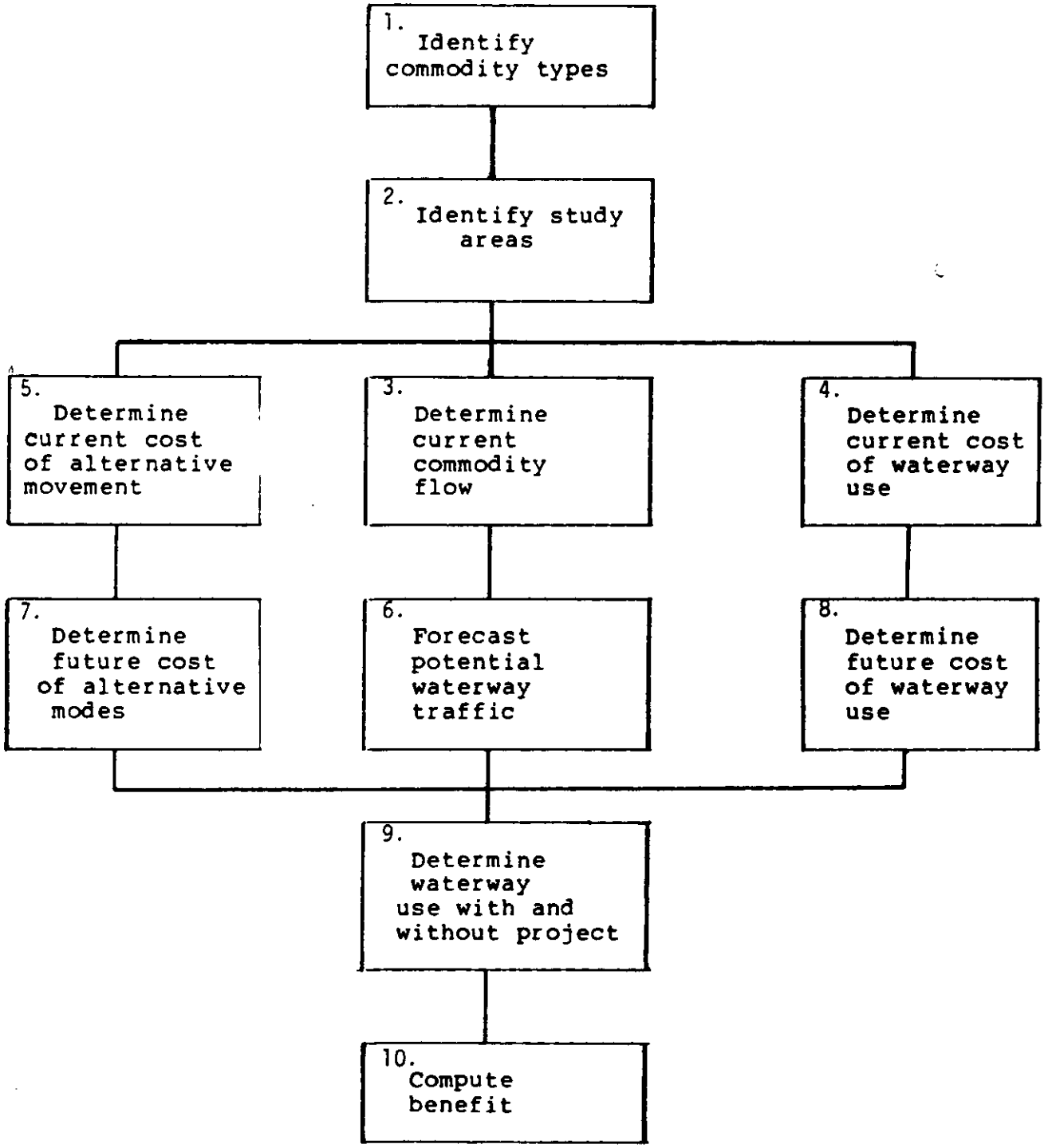
a. Further Development and Refinement CAPACITY AND DELAY ESTIMATES AND DELAY COSTS. TK solver program used to calculate capacity in the reconnaissance study will be reevaluated. Sensitivity tests will be conducted to determine confidence intervals around estimates. Other sensitivity tests will examine impact of recreational traffic on system delays to commercial traffic. Alternate capacity calculations will be made using lock simulation model (LOCKSIM), and Waterway Analysis Model (WAM).

Both capacity and delays and delay costs will be evaluated on a seasonal basis and for historical and projected future conditions (i.e., changing tow size, horsepower, barge loading).

Delay costs will be reevaluated. This evaluation will include discussions with a variety of industry groups, reviewing historical and current monthly PMS/OMNI data, and using barge cost and rate data.

b. Origin - Destination Data Base. Available origin-destination data for the most current 3 years will be obtained and changes in origins and destinations will be analyzed. The origin-destination data used in the analysis will be developed from these data and analysis. This origin-destination matrix will be reviewed with industry groups and discussed with shippers to assure the accuracy of the existing data. Seasonal changes in

Figure 16 -- Flowchart of Inland Navigation Benefit Evaluation Procedure



origins for grain will also be analyzed. The availability of year-round navigation causes changes in the origin of grain.

c. Rate/Cost Studies. A statistically adequate sample of water movements will be developed. From this sample of origin destination pairs, costs for both water and alternative mode (i.e., rail, truck) will be developed using cost models for linehaul portion and extensive surveys of carriers and shippers for access, loading and unloading changes. This effort will be a significant expansion of the reconnaissance study effort. Linehaul costs will also be obtained through surveys to verify the cost models. A 1 percent rail waybill sample will be obtained and evaluated to verify rail cost modeling. The resulting rate/cost matrix will be reviewed with industry groups and adjusted as necessary to reflect actual transportation routes, costs, and modes of transport. Particular attention will be given to grain and coal to determine the basic origin and destination. Since these two commodities are general intermodal shipments, the distribution of grain origins and source of coal could be important factors in alternative rates and costs.

d. Traffic Projections. Traffic demand projections will be developed by commodity group for the entire Illinois Waterway System by relating the existing traffic base to indexes of growth in the specific regions served by the waterway.

Traffic projections developed for the *Inland Waterway Review* will be reviewed with industry groups, updated, and revised as needed based on current trends and the latest information available and incorporated into feasibility level traffic projections. The current increase in grain shipped on the Illinois Waterway and the changes from eastern to western coal sources makes this analysis important to accurately predicting future traffic.

e. Navigation Model. Determine which system model is most appropriate for use for Illinois Waterway feasibility studies. Set up and run both General Equilibrium Model and tow cost model to estimate system impacts of various plans considered in this feasibility study, to include sensitivity analyses. Plans addressed will include both structural and nonstructural solutions as well as congestion fees.

f. Plans. The first feasibility study will define the order and timing of system improvements. A full range of plans will be evaluated separately and in combination and sequenced at each lock site or constraint on the Illinois Waterway. These plans can be categorized as major structural improvements, minor structural improvements, floating plant, and nonstructural plans and are shown in table C-15.

TABLE C-15

Alternative Solutions

Major Structural Improvements

a. 1,200-Foot Lock Replacement
b. New 1,200-Foot Lock and Dam Replacing Both Peoria and LaGrange Locks and Dams.
c. Enlarging Lock from 600 Feet to 1,200 Feet
d. Mooring Cells
e. Extended Guidelines
f. Wind Deflectors
g. Improved Gates to Pass Ice
h. Recreational Locks

Minor Structural Improvements

a. Improved Tow Haulage Equipment (Traveling Kevels)
b. Air Bubbler Systems
c. Floating Mooring Bitts
d. Modify Intake/Outlet Structures
e. Improved Lock Operating Equipment

Floating Plant

a. Helper Boats
b. Mandated Bow Thrusters for Larger Tows
c. Switch Boats

Nonstructural Plans

a. N-Up/N-Down Policy
b. Mandated (Efficient) Tow Configurations
c. Recreational Lockage Hours
d. User Fees

g. Risk and Uncertainty Analysis. Multiple runs of the system model will be made to examine the sensitivity of system benefits to changes in capacity, delay, delay costs, and rates/costs. A risk analysis will be conducted examining the probability of open pass at Peoria and LaGrange Locks. This analysis will analyze the probability of open pass in relation to traffic on a periodic rather than annual basis.

h. Coordination and Report Preparation. The objective of this task is to prepare a draft and final report which explains the systems analysis and prioritization of improvements on the Illinois Waterway System. Work conducted in completing each task will be summarized and results from model runs will be presented. The analysis will be fully coordinated within the Rock Island District and with North Central Division and higher headquarters. Coordination will be maintained with industry groups and environmental interests throughout the study process.

HYDROLOGY AND HYDRAULICS

APPENDIX D

RECONNAISSANCE REPORT
FOR
ILLINOIS WATERWAY NAVIGATION STUDY

APPENDIX D
HYDROLOGY AND HYDRAULICS

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RECONNAISSANCE REPORT
FOR
ILLINOIS WATERWAY NAVIGATION STUDY

APPENDIX D
HYDROLOGY AND HYDRAULICS

SECTION 1 - THE ILLINOIS WATERWAY SYSTEM

GENERAL

The Illinois Waterway, a part of the Inland Waterway Navigation System of the United States, links the Mississippi River navigation system with the Great Lakes and the St. Lawrence Seaway. The waterway is 327 miles long from its mouth at Grafton, Illinois, to Lake Michigan in downtown Chicago. Most of the waterway is administered by the Rock Island District, Corps of Engineers (plate D-1). The lower 80 miles, downstream from LaGrange Lock and Dam, is administered and operated by the St. Louis District, Corps of Engineers. The extreme upper part, east of the junction of the North and South Branches of the Chicago River, is administered and operated by the Chicago District, Corps of Engineers.

The Illinois Waterway is made up of the Illinois River from its mouth to the confluence of the Kankakee and Des Plaines Rivers (273 miles); the Des Plaines River from there to Lockport lock (18 miles); and the Chicago Sanitary and Ship Canal, South Branch Chicago River, and Chicago River from Lockport to Chicago Harbor (36 miles). A second arm of the waterway leaves the Chicago Sanitary and Ship Canal about 12.5 miles above Lockport and proceeds to the Calumet Harbor on Lake Michigan via the Cal-Sag Canal, and the Little Calumet and Calumet Rivers (30 miles). Dams control water levels along the waterway, and locks provide the means for waterway traffic to move from one pool to another. Plate D-2 shows a general representation of the waterway setting.

PHYSICAL COMPONENTS

Tables D-1 and D-2 contain pertinent information on the physical features of the locks and dams in the system.

At Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock, the facilities consist of a lock and a gated dam for water control. Power plants utilizing the head created by the dams also are located at Lockport and Marseilles. The village of Rockdale, Illinois, applied for a license to generate power at the Brandon Road site in August of 1983. On August 16, 1990, the Federal Energy Regulatory Commission issued a license to the

TABLE D-1

LOCK DATA

(Elevations referred to National Geodetic Vertical Datum)

FEATURE	CHICAGO HARBOR	THOMAS J. O'BRIEN	LOCKPORT	BRANDON ROAD	DRESDEN ISLAND	MARSEILLES	STARVED ROCK	PEORIA	LA GRANGE
River mile	327.0	326.0	291.0	286.0	271.5	244.6	231.0	157.7	80.2
Bank	L. Michigan	Right	Left	Right	Left	Left	Right	Left	Right
Normal pool elev., ft.	578.18	578.18	577.5	538.5	504.5	483.17	458.7	440.0	429.0
Size of chamber, ft.	80 W x 600 L	110 W x 1,000 L	110 W X 600 L	110 W x 600 L	110 W x 600 L	110 W x 600 L	110 W x 600 L	110 W x 600 L	110 W x 600 L
Maximum lift, ft.	9.0	9.0	42.0	36	22	27	19	11	10
Average lift @ 50% duration, ft.	5.0	5.0	39.5	34.0	20	24	17	6	4.5
Upper service gate sill elev., ft.	551.74	561.18	557.5	520.7	487.65	464.6	441.65	424.5	413.5
Lower service gate sill elev., ft.	551.74	561.18	523.5	490.7	470.5	445.0	425.5	417.0	406.0
Chamber floor elev., ft.	554.54	561.0	522.5	489.7	469.5	443.7	424.5	415.5	405.0
Top chamber wall elev., ft.	584.48	586.5	584.5	542.5	509.5	486.0	463.5	445.0	434.0
Top upper guidewall elev., ft.	584.48	586.5	584.5	542.5	509.5	486.0	463.5	445.0	434.0
Length upper guidewall, ft.	696.25E. 94.5NE	1,000	*1,000	**598	578.5		598	300	500
Top lower guidewall elev., ft.	585.18	584.5	546.5	513.5	495.5	466.5	458.5	445.0	430.0
Length lower guidewall, ft.	641.0	1,000	444.0	Rvr side 185:Land side 594	594		594	500	500
Type, upper gate	Sector	Sector	Vertical Lift	Miter	Miter	Miter	Miter	Miter	Miter
Height, upper gate, ft.	33.4	24.0	24	20	20	20	20	17.5	17.5
Type, lower gate	Sector	Sector	Miter	Miter	Miter	Miter	Miter	Miter	Miter
Height, lower gate, ft.	33.4	24.0	65	50	37	39	36	25	25
Valve tunnels	NONE	10 x 10	2-12'diam.	2-12'diam.	2-12'diam.	2-12'diam.	2-12'diam.	2-14'diam.& 12.5'x12.5'	2-14'diam.& 12.5'x12.5'
Valve tunnel intakes	NONE	10 x 10			2-18'W x 12'H	2-18'W x 12'H	2-18'W x 12'H	12-5'W x 7.5'H	12-5'W x 7.5'H
Chamber wall ports			22-5'W x 3.5'H	5'W x 3.5'H each port	20-5'W x 3.5'H	20-5'W x 3.5'H	20-5'W x 3.5'H	40-4'W x 3'H	40-4'W x 3'H
Filling time, min.	7	10 - 12	22.5	19	14	15	12	10	10
Emptying time, min.	7	10 - 12	15	15	12	10	9	10	10
Average annual tonnage, 1935-83				18.2 mil.	18.2 mil.	15.5 mil.	16.0 mil.	(a) 19.4 mil	(b) 15.8 mil.
Max. annual tonnage, year					30.8 mil.: 1974	28.9 mil.: 1974	30.2 mil.: 1974	34.5 mil.: 1975	33.8 mil.: 1980
Min. annual tonnage, year					0.3 mil.: 1935	0.3 mil.: 1935	0.3 mil.: 1935	.04 mil.: 1938	0.3 mil.: 1939

* Along right (west) bank from river mile 291.15 to 292.17, there is an embankment, earth fill with concrete core wall overlain by rock and rip rap, having a top width of 32.85 ft., top elevation of 584.5 ft., and side slopes of 1:1. From river mile 292.17 to 293.09, the embankment consists of an earth core overlain by rock, with top width of 50 ft., top elevation of 584.5 ft., and side slopes of 1:1.

Along left (east) bank from river mile 291.15 to 292.17, there is an embankment with a vertical-face rock retaining wall at channel edge behind which is earth and rubble fill. Total top width of section is 50 ft., top elevation is 584.5 ft., and side slope of 1:1 on landward side.

** Flood barriers consisting of concrete gravity retaining walls and embankment extend from the lock and dam to the upstream limits of the city of Joliet approximately 3 miles. The walls vary in height from 15 to 40 ft. The minimum top elevation is 541.5 ft.

TABLE D-2

DAM DATA, ILLINOIS WATERWAY

	BRANDON ROAD	DRESDEN ISLAND	MARSEILLES	STARVED ROCK	PEORIA	LA GRANGE
River Mile	286.0	271.5	247.0	231.0	157.7	80.2
Tainter gate section						
Length, ft.	1,110	616	552	684		
No. of gates	21	9	8	10		
Size of each gate	50'W x 2.29'H	60'W x 16'H	60'W x 16'H	60'W x 17'H		
Sill elevation, ft.	536.3	490.5	469.85	441.5		
Type of gate	Non-submersible	Non-submersible	Submersible	Non-Submersible		
Headgate section						
Length, ft.	320	298		518		
No. of gates	16	18		30		
Size of each gate	15'W x 16'H	13.33'W x 16'H		14'W x 16'H		
Sill elevation, ft.	510.5	488.5		442.5		
No. of gates operable	8	0		0		
No. of gates sealed	8	18		30		
Type of gate	Single leaf vert. lift			Vertical lift		
Fixed dam section	Former ice chute					
Length, ft.	30	35		30.0		
Crest width, ft.						
Sill elevation, ft.	538.5	504.5				
Earth dike						
Length, ft.	About 822	Very short, R. bank	64		Short	390
Core			Concrete wall			
Top width, ft.	20				14	20
Top elevation, ft.	543.5				443.0	430.0
Upstream side slope	1:3					
Downstream side slope	1:2.5					
Sluice gate section						
Length, ft.	91					
No. of gates	6					
Size of each gate	7.75'W x 8.42'H					
Sill elevation, ft.	509.5					
Type of gate	Vertical lift					
No. of gates operable	0					
No. of gates sealed	6					
Boiler house section, ft.	18.0	18.0		18.0		
Ice chute, length, ft.		30.0	30.0	30.0		
Sill elevation, ft.		499.5	a. 483.67	454.0		
Type of gate		Submersible tainter	a. No gate	Submersible tainter		
Gate operable		No		No		
Arch dam section						
Length between abutments, ft.		110				
Sill elevation, ft.		509.5				
Headrace dams						
South channel						
Tainter gate section, ft.			76			
No. & size of gates			1-60'W x 16'H			
Sill elevation, ft.			469.85			
Fixed dam section, ft.			35			
Sill elevation, ft.						
North channel						
Tainter gate section, ft.			144			
No. & size of gates			2-60'W x 16'H			
Sill elevation, ft.			469.85			
Fixed dam section, ft.			62			
Movable dam						
Length, ft.					536	540
No. of wickets					134	135
Sill elevation, ft.					424.6	415.0
Top elev. of wickets, ft.					440.0	429.0
Regulating dam						
Length, ft.					b. 34	136
No. of butterfly valves					6	12
Valve opening, ft.					6 x 6	6 x 6
Valve sill elevation, ft.					421.85	417.0

a. After major rehabilitation

village for the project. However, because of stringent water quality concerns, construction of the project is doubtful. The village of Channahon, Illinois, was issued a license to generate power at the Dresden Island Dam site on August 15, 1990. Water quality concerns also may impact construction feasibility at this site. A license was issued on June 24, 1988, to the city of Peru, Illinois, for a power project at Starved Rock Lock and Dam. The current proposal calls for a power plant to be installed at the headgate section of the dam having two turbines, each with a rated capacity of 5,000 kilowatts at a rated head of 16 feet. On September 12, 1990, the licensee met with the Illinois Municipal Electric Association in Springfield, Illinois, to discuss the possibilities of a joint effort to construct the project. The two downstream locations, Peoria and LaGrange, each have a lock and a collapsible wicket dam that can be lowered to the river bottom during moderate and high flows to allow waterway traffic to pass over them, eliminating the need for lockage. At the Chicago Harbor Works, the facilities consist of a lock and sluice gates to control the diversion of water from Lake Michigan and to prevent reversal of flows into Lake Michigan. The Wilmette Pumping Station provides an additional means of diverting Lake Michigan water into the system.

The lock at the Chicago Harbor Controlling Works is 600 feet long and 80 feet wide, and the lock at the Thomas J. O'Brien Lock and Controlling Works is 1,000 feet long and 110 feet wide. The remaining seven locks are all 600 feet long and 110 feet wide. As seen in table D-2, the physical features of the dams vary.

DESCRIPTION OF THE WATERSHED

The Illinois River basin (plate D-1) covers 28,906 square miles, including the 673 square miles of the Lake Michigan basin that now drains into the waterway. It extends from the vicinities of Milwaukee, Wisconsin, and South Bend, Indiana, to the Mississippi River. The average natural slope of the river is about 1 foot per mile above the "Great Bend" near Hennepin and about 0.1 foot per mile below. Principal tributaries of the Illinois River are shown on plate D-2. Drainage areas of tributaries and at various points along the waterway are listed in table D-3. The Illinois Waterway profile is shown on plate D-3.

CLIMATE

GENERAL

Continental type climate dominates the area, which is characterized by frequent penetrations throughout the year of different types of air masses and their associated weather disturbances. The basin lies in the path of

TABLE D-3

DRAINAGE AREAS, ILLINOIS WATERWAY AND TRIBUTARIES

LOCATION	RIVER MILE	DRAINAGE AREA Sq. Mi.
Chicago Sanitary & Ship Canal (Head of Illinois Waterway)		
At Chicago Harbor, Lake Michigan	327.0	
Chicago Sanitary & Ship Canal at mouth of Calumet		
Sag Channel	303.4	346
Calumet Sag Channel	303.4	391
Chicago Sanitary & Ship Canal at Lockport Lock & Dam	291.0	740
Des Plaines River	289.9	705
Des Plaines River (Illinois Waterway) at Brandon		
Road Lock & Dam	286.0	1,506
Hickory Creek	286.3	109
Sugar Run	286.3	14.7
Cedar Creek	280.2	14.4
Jackson Creek	279.5	52.7
DuPage River	276.9	376
Grant Creek	275.0	15.9
Des Plaines River at mouth	273.0	2,111
Kankakee River	273.0	5,165
Illinois River (Waterway) at Dresden Island Lock & Dam	271.5	7,278
Aux Sable Creek	268.1	187
Mazon River	263.5	524
Nettle Creek	262.7	74.1
Waupecan Creek	260.7	57.1
Illinois River at Marseilles (USGS gage 05543500)	246.5	8,259
Illinois River at Marseilles Lock	244.5	8,272
Fox River	239.6	2,658
Covel Creek	236.3	74.6
Illinois River at Starved Rock Lock & Dam	231.0	11,056
Vermilion River	226.3	1,331
Little Vermilion River	225.7	126
Cedar Creek	220.7	27.7
Spring Creek	218.6	50.9
Negro Creek	214.3	29.9
Allforks Creek	214.0	24.7
Coffee Creek	207.0	7.25
Senachwine Creek	203.5	39.3
Sandy Creek	196.2	146
Illinois River at Henry (USGS gage 05558300)	196.1	13,543
Crow Creek	191.6	81.7
Illinois River at Lacon (USGS gage 05558995)	189.2	13,666
Gimlet Creek	189.1	5.81
Strawn Creek	185.5	12.2
Pigeon Creek	184.5	10.8
Crow Creek	182.2	130
Senachwine Creek	181.6	89.3
Snag Creek	181.1	33.3
Richland Creek	180.4	44.9
Partridge Creek	177.3	27.1

TABLE D-3 (CONTINUED)

DRAINAGE AREAS, ILLINOIS WATERWAY AND TRIBUTARIES

LOCATION	RIVER MILE	DRAINAGE AREA Sq. Mi.
Dickinson Run	173.3	19.9
Blue Creek	173.0	10.1
Tenmile Creek	166.2	17.2
Illinois River at Peoria (USGS gage 05560000)	164.2	14,170
Farm Creek	162.0	61.3
Kickapoo Creek	159.5	306
Illinois River at Peoria Lock & Dam	157.7	14,554
Lick Creek	156.4	19.2
Lost Creek	151.0	23.0
LaMaran Creek	149.7	40.2
Mackinaw River	147.7	1,136
Illinois River at Kingston Mines (USGS gage 05568500)	145.4	15,819
Copperas Creek	137.4	127
Duck Creek	131.7	20.5
Buckheart Creek	128.2	20.6
Big Sister Creek	126.3	28.4
Quiver Creek	122.6	261
Spoon River	120.5	1,855
Illinois River at Havana (USGS gage 05570500)	119.6	18,299
Otter Creek	111.8	126
Wilson Creek	108.3	13.3
Elm Creek	102.7	9.2
Sangamon River	98.0	5,419
Sugar Creek	94.2	162
Lost Creek	89.0	16.5
Illinois River at Beardstown (USGS gage 05584000)	88.8	24,227
Crane Creek	84.9	40.2
LaMoine River	83.5	1,350
Illinois River at LaGrange Lock & Dam	80.2	25,648
Indian Crek	78.7	286
Illinois River at Meredosia (USGS gage 05585500)	71.3	26,028
McKee Creek	67.0	444
Mauvaise Terre Creek	63.2	178
Illinois River at Valley City (USGS gage 05586100)	61.3	26,800 *
Sandy Creek	50.0	166
Illinois River at Pearl (USGS gage 05586450)	43.2	27,136
Apple Creek	38.3	406
Macoupin Creek	23.2	961
Illinois River at Hardin (USGS gage 05587060)	21.5	28,690
Otter Creek	14.7	89.9
Illinois River at mouth at Grafton	0.0	28,906

* Drainage Area is Approximate

low and high pressure areas that pass from west to east at more or less frequent intervals of about 3 to 5 days. Great variations in temperature occur from day-to-day, month-to-month, and year-to-year. The seasons are conspicuously distinct. Summers are commonly warm-to-hot and often humid. Winters are moderately cold. July is the warmest month and January is the coldest. Lake Michigan moderates temperatures locally in the Chicago area and causes relatively heavy snowfall in a narrow band adjacent to the lake. The growing season varies from about 200 days near the mouth of the Illinois River to about 160 days in the Fox River basin west of Chicago.

PRECIPITATION

Annual mean precipitation over the basin is shown on plate D-4 and monthly mean precipitation over the basin on plates D-5 through D-7.

STORMS

Storms in the Illinois River basin are commonly of two types; the wide-spread frontal type and the local thermal convection (thunderstorm) type. There are no orographic storms because of the low relief.

Flood-producing storms can occur at any time, but their frequency is greatest from late spring to early fall. During the cold weather season, large-area storms from 2 to 5 days duration predominate. In the warm weather season, storms are shorter but more intense. The average number of thunderstorms per year varies from about 40 in the northeast to about 55 in the downstream end of the basin. June is the month of maximum thunderstorm activity. Thunderstorms account for about 40 to 45 percent of the annual precipitation.

HYDROLOGY

Flow-duration plots for the U.S. Geological Survey (USGS) gages at Meredosia, Kingston Mines, and Marseilles are shown on plates D-8 through D-46.

Elevation-duration profiles for year-round and growing seasons are shown on plates D-47 through D-50.

NAVIGATION AND ICE PERIODS

Year-round navigation is maintained on the Illinois Waterway. Downriver from Lockport, the principal constraints upon the waterway system are

caused by flood and ice. Ice thickness tends to increase with distance downstream from Dresden Island to Lake Peoria where the thickest ice is usually encountered. Ice thickness remains about the same or decreases somewhat downstream from this point. In the canal section of the waterway, there is normally little difficulty with ice because of industrial and municipal discharges.

At the Peoria and LaGrange lock and dam sites, the wickets are lowered for flows greater than 16,000 and 20,000 cubic feet per second (cfs), respectively. This permits boat traffic over the wicket dam rather than through the navigation locks. These navigable pass conditions occur on the average at Peoria for approximately 42 percent of the year and at LaGrange for approximately 48 percent of the year.

REGULATION PLAN

GENERAL OBJECTIVES

The overall objective in water control on the Illinois Waterway is to provide an all-season navigation link of at least 9-foot depth between Lake Michigan and the Mississippi River. The operation of locks enables river traffic to pass from one pool to another. A second important objective is diverting waste waters originating in the Chicago area away from Lake Michigan, the source of the city's water supply. A third, but less significant, objective is the operation of the headwater system in a way to provide a degree of flood control to alleviate flooding in the Chicago area.

OVERALL PLAN FOR REGULATION

Water control is achieved with sluice gates at the three Lake Michigan structures (Wilmette, Chicago Harbor, and O'Brien); with sluice gates and turbines at Lockport; with head and tainter gates at Brandon Road; with tainter gates at Dresden Island, Marseilles, and Starved Rock; and with movable wickets, butterfly valves, and a tainter gate at Peoria and LaGrange. The locks play a minor role in water control.

The Water Reclamation District (WRD), with cooperation from the Corps of Engineers, is responsible for water control from Lockport to Lake Michigan. The minimum stage to which the Chicago Sanitary and Ship Canal can be drawn down is 570.5 feet National Geodetic Vertical Datum (NGVD) at Lockport and 575.5 feet NGVD at the Calumet-Sag Junction. When the stage at either place approaches to within 0.2 foot of these limits, preparations are made to reduce the Lockport discharge. During large flood events, the sluice gates at the Lockport Controlling Works supplement the discharge capacity of the sluice gates and turbines at Lockport. Reversal of flows into Lake

Michigan is implemented at Wilmette when the North Shore Channel reaches 584.5 feet NGVD, and at the Chicago Harbor Controlling Works and the O'Brien Lock and Dam when the Chicago and Calumet Rivers reach 582.5 feet NGVD. If the river is near-peak and there is no longer significant rainfall, a stage of 583.0 feet NGVD can be reached before action is taken to divert Chicago and Calumet River flows into Lake Michigan.

Procedures to maintain water control within the limitations imposed by these criteria have been developed by the Metropolitan Sanitary District of Greater Chicago (MSDGC). Their Waterways Operations Manual details the procedures.

Downstream from Lockport, all of the water-control structures are operated on a run-of-the-river basis. When flow changes are made at any facility, they are reported to downstream facilities in a chain sequence. The amount of change made at any water control structure is based principally upon the judgment and experience of Operations Division personnel, but guided by input from the Regulation Section on existing and predicted weather and river conditions.

Although judgment and experience always will be important factors in water-control operations, it is anticipated that the implementation of the unsteady flow model will facilitate water control operations by providing more specific guidelines and rules of operation.

SEDIMENT

As part of its maintenance and operation of the Illinois Waterway, the Corps of Engineers performs periodic channel dredging on an as-needed basis. During the past 10 years, the Corps annually has dredged an average of nearly half a million cubic yards of bottom material to maintain the 9-foot channel depth authorized by Congress. Active sediment stations in the Illinois River Basin are shown in table D-4. Maintenance dredging of the Illinois Waterway for the period 1969-1985 is shown in table D-5.

RELATED STUDIES

WATER RESOURCE ANALYSIS

The U.S. Army Engineer District, Rock Island, developed a *Master Plan for Resource Management*, October 1987, for all pools utilizing interagency expertise. Studies have been made on the feasibility of hydropower at Brandon Road, Dresden Island, Marseilles, and Starved Rock (U.S. Army Engineer District, Rock Island, 1982). An unsteady flow model study is currently under way to investigate means of improving the relationship between stage and discharge.

TABLE D-4

ACTIVE SEDIMENT STATIONS IN THE ILLINOIS RIVER BASIN

STATION NUMBER	STATION NAME	DRAINAGE AREA SQ. MI.	PERIOD OF RECORD, WATER YEARS	DATA COLLECTION FREQUENCY (1) SUSPENDED SEDIMENT CONCEN-TRATION	SUSPENDED PARTICLE SIZE	SUSPENDED SEDIMENT DISCHARGE	DATA SOURCE (2)
05520500	Kankakee River at Momence, IL	2,294	1979-81	D	I	D	8
			1982-	W	I	W	15
05527500	Kankakee River near Wilmington, IL	5,150	1979-82	D	I	D	8
			1983-	W	I	W	15
05536000	North Branch Chicago River at Niles, IL	100	1985	D	I	D	8
05542000	Mazon River near Coal City, IL	455	1981-	W	I	W	15
05543500	ILlinois River at Marseilles, IL	8,259	1975-80, 1982-	I	I	I	8
05555300	Vermilion River near Leonore, IL	1,251	1983-	W	I	W	15
05556500	Big Bureau Creek at Princeton, IL	196	1981-	W	I	W	15
05558300	Illinois River at Henry, IL	13,543	1983-	D	I	D	8
05567510	Mackinaw River below Congerville, IL	776	1983-	D	I	D	8
05569500	Spoon River at London Mills, IL	1,062	1981-	W	I	W	15
05570370	Big Creek near Bryant, IL	41.2	1972-	D	I	D	8
05572000	Sangamon River at Monticello, IL	550	1981-	W	I	W	15
05583000	Sangamon River near Oakford, IL	5,093	1981, 1983	D	I	D	8
05584500	LaMoine River at Colmar, IL	655	1981-	W	I	W	15
05585000	LaMoine River at Ripley, IL	1,293	1983-	W	I	W	15
05586100	Illinois River at Valley City, IL	26,564	1980-	D	I	D	8

1. D = Daily Records
   I = Intermittent Records
   W = Weekly Sampling

2. 8 = U.S. Geological Survey
   15 = Illinois State Water Survey

TABLE D-5

MAINTENANCE DREDGING, ILLINOIS WATERWAY
(cubic yards)

YEAR	SANITARY & SHIP CANAL	CALUMET SAG CHANNEL	BRANDON ROAD POOL	DRESDEN ISLAND POOL	MARSEILLES POOL	STARVED ROCK POOL	PEORIA POOL	LA GRANGE POOL	TOTAL
1969			700	1,250	11,850	5,150	41,217	0	60,167
1970		1,475	425	2,200	12,700	8,400	0	18,838	44,038
1971	450		800	3,200	13,850	10,100	64,142	34,761	127,303
1972			1,600	4,900	3,300	0	0	446,170	455,970
1973			0	2,550	17,900	8,650	61,521	0	90,621
1974			1,100	7,450	17,200	32,150	0	180,002	237,902
1975			1,350	45,110	2,100	11,200	0	85,233	144,993
1976			3,000	65,100	25,400	20,400	6,605	55,690	176,195
1977			1,400	500	52,950	150	173,296	642,483	870,779
1978			100	700	4,500	0	0	0	5,300
1979			0	0	900	24,900	43,616	256,572	325,988
1980			No Record	No Record	No Record	No Record	0	0	-
1981			do	do	do	do	0	0	-
1982	*4,120		*481	*4,573	*4,273	*2,114	0	322,808	338,369
1983			20,120	6,244	75,554	19,671	0	32,540	154,129
1984			0	18,168	10,560	4,830	0	497,383	530,941
1985			0	29,800	9,480	12,780	10,350	174,680	237,090
TOTAL	4,570	1,475	31,076	191,745	262,517	160,495	400,747	2,747,160	3,799,785

* Does not include dredging for January, February and March

Major rehabilitation for all of the Illinois Waterway locks and dams was completed in the 1980's. The lock and dam structures (most of which were built in the 1930's) required addition of new, and/or replacement of, existing tainter gates, removal and replacement of deteriorated concrete, and replacement of mechanical and electrical equipment. The rehabilitation programs varied from site to site.

The U.S. Army Engineer District, Chicago, made and published duplicate locks interim survey and general design memorandum studies in 1957 and 1975.

The U.S. Army Engineer Districts, Chicago and Rock Island, made and published Lake Michigan flow diversion studies in 1981 and 1987.

An Information Report to the Congress entitled, *Increased Lake Michigan Diversion at Chicago, Demonstration and Study Program*, April 1981, contains a study of the impacts of increased Lake Michigan diversion on Great Lakes water levels, and on water quality, flooding, and the environment along the Illinois Waterway.

Illinois Waterway Pool Volume Curves, December 1984, contains water volume information for the Brandon Road, Dresden Island, Marseilles, and Starved Rock pools.

Discharge ratings for all of the waterway dams from Brandon Road downstream are contained in USGS Open-File Report 81-1009.

USGS Water-Resources Investigation Report 86-4112, *Channel-Storage/ Discharge Relations for the Peoria and LaGrange Dams on the Illinois River in Illinois.*

House Document 472, 87th Congress, 2nd Session, *Illinois River and Tributaries, Wisconsin, Indiana, and Illinois*, 1962, reports on a Corps of Engineers study concerned principally with flood control.

Lake Michigan Water Allocation, by the Illinois Division of Water Resources contains the allocation for northeastern Illinois of the Lake Michigan diversion permitted by the amended 1967 Supreme Court Decree.

UNSTEADY FLOW MODEL

The Illinois River downstream of the Marseilles Dam has an extremely flat gradient. The bed slope of the stream is about 0.1 foot per mile or less. This flat slope makes computing or predicting flood elevations very difficult. Backwater effects due to channel conditions and tributary floods can have significant impacts extending long distances upstream. Although flood profiles computed by the standard step method such as HEC-2 are calibrated, the existing gage data are impacted by downstream flow conditions which may vary in an unpredictable way with flood conditions. Typically,

gage data exhibit large hysteresis loops in the magnitude of several feet. Since the river is so flat, the moving flood wave causes most of the hydraulic slope. On the rising side of the flood hydrograph, the increasing flow causes a positive hydraulic gradient. However, after the flood wave has passed the hydraulic slope is decreased and velocities are reduced. The stage continues to rise for a lesser discharge, and stage-flow relationships are altered.

Due to the complex hydraulic conditions and conflicting estimates of flood profiles, the Rock Island District has begun an effort to compute probable flood profiles for the Illinois River using an unsteady flow model. The model selected is entitled, "A Mathematical Model of Unsteady Flow Through a Dendritic Network" and was developed by Dr. Robert Barkau, formerly an employee of the St. Louis District, Corps of Engineers, as a requirement for the Degree of Doctor of Philosophy at Colorado State University.

The model simulates unsteady, tranquil flow through a dendritic network of channels. It routes flow through both the channel and floodplain, taking into account the differing flow patterns. Levee systems are simulated as storage cells which can abruptly fail and interact with the river system. The cross sections can be divided into areas of differing roughness and areas of active and inactive flow. The modified, unsteady flow equations are solved using a linear, implicit finite difference scheme. This procedure results in a direct solution for each time step, thus eliminating the oscillations and nonconvergence which plague the non-linear implicit models. Preliminary flow-frequency profiles are shown on plate D-51.

CHANNEL AND FLOODWAY IMPROVEMENT

Flood insurance studies for a number of communities and counties along the Illinois River have been published by the Federal Emergency Management Agency.

REGULATIONS - USE, ADMINISTRATION, AND NAVIGATION

The following regulations will guide the lockmaster and the local crew in their duties in supervising the movements of navigation in the vicinity of the locks and dams under their jurisdiction.

The Law - Section 7 of the Rivers and Harbors Act of August 8, 1917, provides as follows:

"That it shall be the duty of the Secretary of War to prescribe such regulations for the use, administration and navigation of the navigable waters of the United States as in his judgment the public necessity may require for protection of life and property, or of operations of the United States in channel improvement, covering all matters not specifically

delegated by law to some other executive department. Such regulations shall be posted, in conspicuous and appropriate place, for the information of the public; and every person and every corporation which shall violate such regulations shall be deemed guilty of a misdemeanor and, on conviction thereof in any district court of the United States within whose territorial jurisdiction such offense may have been committed, shall be punished by a fine not exceeding $500, or by imprisonment (in the case of a natural person) not exceeding 6 months, in the discretion of the court."

The Regulations - In pursuance of the law above quoted on January 4, 1933, the Secretary of War prescribed *Regulation to Govern the Use, Administration and Navigation of the Ohio River, Mississippi River Above Cairo, Illinois, and Their Tributaries*. These regulations, as amended, govern the operation of the locks and dams in the Illinois Waterway.

1957 PROPOSED IMPROVEMENTS

The 1957 *Interim Survey Report, Duplicate Locks, Illinois Waterway* states:

"The plan of improvement presented provides for the augmentation of existing locking facilities on the Illinois Waterway by the construction of additional locks at Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and LaGrange. This plan is considered as best meeting the needs and desires of navigation.

"The seven duplicate locks proposed in the plan of improvement would be 110 feet wide and 1,200 feet long as compared with the existing locks which have a width of 110 feet and a length of 600 feet. The 110-foot width for locks has become standardized on a majority of inland waterways including the Ohio and Upper Mississippi Rivers, since it can readily accommodate multiples of barge widths ranging from 26 to 54 feet, and is adequate for the widths of tows that can efficiently navigate channels below Lockport.

"The practical capacity of the existing single locks is least for the Lockport and Brandon Road locks and increases progressively proceeding downstream. With the anticipated growth of traffic, the indicated priority of construction would hence be in the following sequence, as the capacities of the respective locks were approached:

1. Lockport and Brandon Road
2. Marseilles
3. Dresden Island
4. Starved Rock, Peoria, and LaGrange"

1975 STUDY PROPOSALS

The 1975 *Duplicate Locks GDM, Phase I* states:

"Lockport to Brandon Road - The Dresden Island pool would be extended through Joliet to Lockport eliminating the need for Brandon Road lock and dam. The improvements for this reach of the waterway include:

"Lock - A new 73.5-foot lift lock, 110 feet wide by 1,200 feet long, will be constructed approximately 1,200 feet eastward of the existing Lockport lock. Provisions have been made in siting the lock to provide for a future 1,200-foot lock between the new lock and controlling works. The chamber walls will consist of concrete facing over rock cut. Gate bays will be concrete gravity walls. The filling system will be the longitudinal type. Service gates will be miter gates with a submersible gate for emergency closure upstream of the upper miter gate. Minimum depth over the lower sill will be 17 feet and 24 feet over the upper sill.

"Dam - A new dam and controlling works with a 73.5-foot head will replace the existing controlling works and powerhouse. The controlling works will consist of three 10-foot round steel-lined conduits and 3 tainter gates. A 200 square foot stilling basin will be provided downstream.

"Hydroelectric Power Generation - The justification of replacing rather than removing the existing Lockport powerhouse will be investigated. This study will be coordinated with the Metropolitan Sanitary District of Greater Chicago and the Federal Power Commission.

"Channels:

Navigation Channel - A bypass channel will be constructed east of the existing navigation channel from approximately mile 285.3 to Brandon Road dam. Brandon Road lock and dam will be removed and Dresden Island pool will be extended to Lockport. This will necessitate that the channel through Joliet to the new lock be lowered 34 feet. The new channel will have a 325-foot horizontal clearance or as restricted by the existing channel walls. There will be some minor channel realignment at Ruby Street in Joliet. The lowered channel invert will be set to provide for a project depth of 9 feet, plus 2 feet for squat and clearance, and 1-1/2 feet for over-depth. Straight, unobstructive approaches in excess of 3,000 feet will be provided at the new Lockport lock.

"New Walls - A new concrete wall is proposed from mile 292.4 (approximately 1,600 feet downstream of 9th Street) to the upper gates of the new Lockport lock. This wall will serve as the guide wall for the upstream approach to the new lock. Another concrete wall is provided in the upper pool at mile 291.35. It begins from the new lock and extends westward to the controlling works and then continues on the west side of the controlling works to the existing west wall of the Chicago Sanitary and Ship Canal. This wall is approximately 1,600 feet long, excluding the controlling works structure.

"Fleeting Areas - The existing fleeting areas in Brandon Road pool will be eliminated. Two fleeting areas, with a total capacity of 150 standard barges, will be provided upstream of the new lock. One is located at about mile 291.7 and the other at mile 292.4. Mooring piers with floating mooring bits will be provided.

"Dresden Island - A new supplemental lock will be located at mile 271.5 to the south (landward side) of the existing lock. The landward side was chosen to eliminate the navigation difficulties that would be present in a riverward lock due to the cross currents across the upper approach to the existing lock. The landward location will also require less cofferdamming and be less costly to construct than a riverward lock. The new lock will have a lift of approximately 22 feet with a bottom lateral filling system. The usable chamber of the new lock will be 110 feet wide by 1,200 feet long. The walls will be of the concrete gravity type founded on rock. Both upper and lower service gates will be miter gates. An emergency gate will also be provided for emergency closures and for passing ice when the need arises. In addition to the recommended lock improvements, stabilization of the spillway section of the existing Dresden Island dam would be required.

"Marseilles - A new supplemental lock will be located in the Marseilles Canal north of the existing lock at mile 244.6. Future widening of the Marseilles Canal from its present width of 200 feet for a distance of about 8,400 feet was authorized by the Rivers and Harbors Act of 1935. It is proposed that widening of Marseilles Canal be accomplished at the time of lock construction to reduce congestion at the upper approaches. The canal will be widened along its entire 2-1/2 mile length from 200 to 300 feet. The Illinois River Rapids north of the new lock will be diverted slightly to prevent turbulence at the downstream approach. The design features of the new lock will be similar to the new lock at Dresden Island described in the previous paragraph, except for the lift which will be approximately 24 feet. In addition to the work described above, the tainter gate piers of the existing Marseilles dam will require strengthening. The strengthening will be accomplished by the use of grouted tendons.

"Starved Rock - A new supplemental lock will be located north of the existing lock at mile 231.0. Although this site will require extensive excavation and the relocation of the Corps of Engineers equipment storage yard, it provides a good alignment of both upstream and downstream approaches and does not interfere with the existing dam structure. In addition, lock construction at this site can be completed in the dry, eliminating the need for cofferdamming. The design features of the new lock will be similar to the new lock at Dresden Island, except for the lift which will be approximately 18.5 feet.

"Peoria - A new supplemental lock will be located at the west abutment of the existing dam across the channel from the existing lock. This site provides a good alignment for both upstream and downstream approaches and avoids costly relocation of oil and chemical company facilities and

railroads along the east bank of the river. It does require the relocation of the Keystone Canal. The underlying geologic formation at the selected site consists of glacial till necessitating the use of steel "H" piles to support the lock masonry which will consist of concrete gravity type walls. The usable lock chamber will be 110 feet wide by 1,200 feet long with miter service gates for both the upstream and downstream ends. The lift will be approximately 11 feet and, because of this low lift, a side port filling system was selected. An emergency gate was not considered because an accidental breach in the gates of the lock would not cause any loss to life or damage to property downstream from the lock. Also, an emergency closure by the use of bulkheads would save the navigation pool and Peoria Lake.

"LaGrange - The proposed location for a new supplemental lock is on the east end of the existing dam on the northern end of LaGrange Island across the channel from the existing lock at mile 80.2. This location will require excavation of much of the island, a diversion channel for the South Beardstown pumping station, and reconstruction of approximately 3,000 feet of levee. The design features of the new lock at LaGrange are similar to those of the new supplemental lock at Peoria, described in the previous paragraph."

1990 NAVIGATION STUDY PROPOSED IMPROVEMENTS

Hydrologic/Hydraulic Work Identified in the Reconnaissance Study to be Performed in the Feasibility Study:

Navigation Alternatives

1. Extend 600-foot to 1,200-foot lock (w/temporary lock)
2. 1,200-foot duplicate lock (at LaGrange)
3. 600 feet duplicate lock
4. Extend existing guide walls
5. Marseilles Canal widening
6. Combine Peoria and LaGrange (new lock and dam in LaGrange vicinity eliminating old Peoria and LaGrange and increasing LaGrange pool a minimum of 10 feet).

Work to be Performed in Feasibility Study for Alternatives 1 Through 5:

A. TABS-2 numerical modeling to evaluate velocity and sediment distribution.

   Channel cross-sectional data, velocity measurements, bed material samples, and suspended sediment samples would be required.

B. Physical modeling to evaluate velocity and sediment distributions and tow traffic simulation.

The physical model design would be based on a TABS-2 calibration. A vessel simulation iteration may be required depending on the site selected.

C. With new lock location, evaluate new approach bendways.

The lock location evaluation would be in accordance with Engineering Manual 1110-2-1611.

D. Riprap design analysis for shore and structure (guide wall) protection.

Riprap design analysis may require a separate physical model.

E. Cofferdam design...determine design height, impacts on flood heights, deposition and scour.

The cofferdam design would include water surface profile numerical computer modeling (HEC-2). Riprap protection may need to be designed for the cofferdam.

F. Regulation plan revisions (if regulation gates are removed or modified).

A revised regulation plan would be written in accordance with the guidance provided in ER 1110-2-240.

G. Hydraulic design of lock structure:

-- filling and emptying layout and sizing
-- sill depths
-- physical modeling

The hydraulic design of the lock structure and appurtenances would be in accordance with guidance provided in EM 1110-2-1604 and EM 1110-2-1610.

H. Existing hydropower (impacts to).

Work to be Performed in Feasibility Study for Alternative 6 (in Addition to the Above Analyses A-H):

I. Water surface profiles to assess impacts and determine necessary modifications to existing:

-- levees
-- interior drainage
-- pumping stations
-- municipal/industrial intakes and outlets
-- bridge clearances
-- flood heights

Significant field reconnaissance; coordination with other agencies, municipalities, industries, and drainage districts; and interior drainage analyses will be required. The interior drainage analysis would include seepage computations and additional pumping requirements.

J. Physical modeling for new dam regulation gate(s).

This modeling would be included in the physical model described in Item B.

K. Numerical modeling and profile computations for tributaries with regard to deposition.

Tributary channel cross section survey data would be required. Deposition numerical modeling (HEC-6) also may be necessary.

L. Groundwater issues and modeling.

Groundwater and water quality issues will need to be identified.

REFERENCES

"Hydraulic Design of Lock Culvert Valves," EM 1110-2-1610, 15 August 1975.

"Ice Control at Navigation Locks," ETL 1110-2-237, 26 December 1978.

"Layout of Navigation Locks and Dams," ETL 1110-2-220, 7 June 1976.

"Navigation Lock Sill Depths and Hydraulic Loads on Gates," ETL 1110-2-223, 30 June 1977.

U.S. Army Corps of Engineers, "Layout and Design of Shallow-Draft Waterways," EM 1110-2-1611, 31 December 1980.

U.S. Army Corps of Engineers, Chicago District, *Duplicate Locks General Design Memorandum (GDM), Phase I, A Plan for Modernization of the Illinois Waterway*, April 1975.

Waterways Experiment Station, "Hydraulic Design of Navigation Locks," M.P.HL-89-5, September 1989.

Waterways Experiment Station, "Lock Design, Sidewall Port Filling, and Emptying System," M.P.H-75-7, July 1975.

SECTION 2 - LOCKPORT LOCK AND DAM

GENERAL

The Lockport Lock and Dam is a part of the impounding structure of the Lockport pool. The structure is located on the Chicago Sanitary and Ship Canal at RM 291.0, referenced from the confluence of the Illinois River with the Mississippi River at Grafton, Illinois. The general location of the Lockport Lock and Dam and associated watershed along the Illinois Waterway is shown on plate D-52. The lock and dam are approximately 2 miles southwest of the city of Lockport, Will County, Illinois. A more detailed location of the lock and dam is shown on plate D-53.

The purpose of the Lockport lock is to provide navigational services for the Chicago Sanitary and Ship Canal by raising and lowering waterway vessels between the Lockport pool and the Brandon Road pool. The lock coordinates its operation with the Lockport Powerhouse and Controlling Works which serve as power generating and flood control facilities on the canal and which control the diversion of Lake Michigan at Chicago.

PHYSICAL COMPONENTS

LOCK

The Lockport lock is a gravity wall design founded in dolomitic limestone. The interior lock dimensions are 110 feet by 600 feet.

The upstream end has two vertical lift gates which are similar in construction and operate independently. The upper gate functions as a guard gate, and the lower gate functions as a service gate. In the open position, the gates are submerged beneath the gate sill. In the closed position, the gates are raised to a point where the bottom of the gate is nearly flush with the gate sill.

The downstream end of the lock has conventional miter gates. The gates are hinged on a vertical axis of the east and west lock walls. In the open position, the gates are recessed into the lock walls to allow unobstructed movement across the full 110-foot width of the lock. In the closed position, the gates are rotated into the lock to rest against the lower lock sill.

The lock filling and emptying system is the wallport type. Twenty-two rectangular wallports 5 feet wide and 3.5 feet high are located along the bottom of the lock chamber. Wallports are connected to the 12-foot-diameter filling and emptying culverts which are located longitudinally

in the base of the east and west lock walls. Filling ports are located at the upstream end of the lock between the two upstream vertical lift gates. The emptying ports are located below the downstream lock miter gates. Each of the filling and emptying ports are gated by vertical roller culvert valves.

The filling operation is accomplished by opening the two upstream culvert valves with the lower culvert valves in the closed position. This allows water to enter the lock chamber through the culverts and wallport distribution system to a water level equal to that of the upstream pool. The emptying operation is accomplished by closing the upstream culvert valves and opening the lower culvert valves. This allows water to drain from the lock through the wallports and culverts, lowering the water level in the lock to that of the downstream pool.

The east, or left, bank of the canal upstream and downstream of the Lockport lock is protected by guide walls. The upper guide wall is curved, forming the convex surface of the east bank of the channel. The upper guide wall extends approximately 1,000 feet upstream. The lower guide wall also is curved, forming a guide wall that extends approximately 450 feet downstream of the lock.

Upstream and downstream lock approach channel cross sections are located on plate D-53 and are shown on plates D-54 and D-55.

DAM

The Lockport dam consists of the abandoned MSDGC lock and the MSDGC powerhouse and associated controlling works. This structure, along with the Lockport lock, make up the downstream impounding structure of the Lockport pool. The MSDGC lock is located adjacent to and west of the Corps of Engineers Lockport lock. When in operation, the MSDGC lock was a navigational facility. Due to the limited dimensions of the lock chamber, the larger Lockport lock was constructed and the MSDGC lock was taken out of operation in 1946. The lock is 22 feet wide and 130 feet long. The lock has wooden miter gates at the upstream and downstream ends which are not operable. The upstream end of the lock has been sealed with a concrete bulkhead.

The Lockport powerhouse is located adjacent to and west of the MSDGC lock. The primary purpose of the Lockport powerhouse is to generate electricity. A secondary purpose of the powerhouse is to function as a part of the controlling works for the Lockport pool.

HYDROLOGY

GENERAL

The Chicago Sanitary and Ship Canal runs in a southwesterly direction from the south branch of the Chicago River located in the Chicago Loop area to approximately 1 mile south of the Lockport Lock and Dam. The canal upstream of the Lockport Lock and Dam has a drainage area of 740 square miles. Prior to construction of the Chicago Sanitary and Ship Canal and the Calumet-Sag Channel, approximately 673 square miles, or 91 percent of the watershed, drained to Lake Michigan via the Chicago and Calumet River systems. The remaining 67 square miles was part of the Des Plaines River watershed until the area was cutoff by the canal.

The principal waterways of the watershed are the Chicago River System, the Chicago Sanitary and Ship Canal, the North Shore Channel, the Calumet River System, and the Calumet-Sag Channel. The Chicago River System includes the Chicago River, the north branch of the Chicago River, and the south branch of the Chicago River. The Calumet River System includes the Calumet River, the Little Calumet River, and the Grand Calumet River.

The maximum regulatory pool elevation of the Chicago Sanitary and Ship Canal is 582.50 feet NGVD. Under extreme weather conditions when sufficient lead time is not available to draw down the canal pool for additional stormwater storage, this elevation may be exceeded, resulting in limited flooding within the metropolitan area. A last resort to avoid severe flooding is to discharge stormwater to Lake Michigan. Water may be discharged to Lake Michigan at the Chicago River Lock and Controlling Works, the Thomas J. O'Brien Lock and Controlling Works, and the Wilmette Pumping Station. Discharging excess stormwaters to Lake Michigan minimizes the potential for severe flooding along the Chicago Sanitary and Ship Canal.

ELEVATION HYDROGRAPHS

The elevation hydrographs at the Lockport Lock and Dam site for the period 1970 through 1989 are shown on plates D-56 and D-57.

REGULATION PLAN

The Lockport lock was designed and is regulated to lift and lower vessels for navigational purposes. The Lockport powerhouse is used to help regulate canal levels for hydroelectric power generation and may serve as a backup measuring point for Lake Michigan diversion water. The Lockport Controlling Works is used to help regulate the Sanitary and Ship Canal levels and to measure diversion water. The Wilmette Pumping Station is

used to regulate the elevation in the North Shore Channel. The Chicago River Lock and Controlling Works is used for navigation and to control the movement of water between Lake Michigan and the Chicago River. The Thomas J. O'Brien Lock and Controlling Works is used to control the movement of water between Lake Michigan and the Calumet River while maintaining navigational activity. The canal system above Lockport may be used for limited flood control storage when its level is drawn down prior to a storm.

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I* states:

"The Dresden Island pool would be extended through Joliet to Lockport, eliminating the need for Brandon Road lock and dam. The improvements for this reach of the Waterway include:

"Lock - A new 73.5-foot lift lock, 110 feet wide by 1,200 feet long, will be constructed approximately 1,200 feet eastward of the existing Lockport lock. The upper and lower guide walls are approximately 1,200 feet long. Provisions have been made in siting the lock to provide for a future 1,200-foot lock between the new lock and controlling works. The chamber walls will consist of concrete facing over rock cut. Gate bays will be concrete gravity walls. The filling system will be the longitudinal type. Service gates will be miter gates with a submersible gate for emergency closure upstream of the upper miter gate. Minimum depth over the lower sill will be 17 feet and 24 feet over the upper sill.

"Dam - A new dam and controlling works with a 73.5-foot head will replace the existing controlling works and powerhouse. The controlling works will consist of three 10-foot round steel lined conduits and 3 tainter gates. A 200 square foot stilling basin will be provided downstream."

HYDROELECTRIC POWER GENERATION

The justification of replacing rather than removing the existing Lockport powerhouse will be investigated in the Phase II GDM. This study will be coordinated with the MSDGC and the Federal Power Commission.

NAVIGATION CHANNEL

A bypass channel will be constructed east of the existing navigation channel from approximately RM 285.3 to Brandon Road dam. Brandon Road Lock and Dam will be removed and Dresden Island pool will be extended to

Lockport. This will necessitate that the channel through Joliet to the new lock be lowered 34 feet. The new channel will have a 325-foot horizontal clearance or as restricted by the existing channel walls. There will be some minor channel realignment at Ruby Street in Joliet. The lowered channel invert will be set to provide for a project depth of 9 feet, plus 2 feet for squat and clearance and 1.5 feet for over-depth. Straight, unobstructive approaches in excess of 3,000 feet will be provided at the new Lockport lock.

NEW WALLS

A new concrete wall is proposed from RM 292.4 (approximately 1,600 feet downstream of 9th Street) to the upper gates of the new Lockport lock. This wall will serve as the guide wall for the upstream approach to the new lock. Another concrete wall is provided in the upper pool at RM 291.35. It begins from the new lock and extends westward to the controlling works and then continues on the west side of the controlling works to the existing west wall of the Chicago Sanitary and Ship Canal. This wall is approximately 1,600 feet long, excluding the controlling works structure.

FLEETING AREAS

The existing fleeting areas in Brandon Road pool will be eliminated. Two fleeting areas, with a total capacity of 150 standard barges, will be provided upstream of the new lock. One is located at about RM 291.7 and the other at RM 292.4. Mooring piers with float mooring bits will be provided.

Lockport Lock and Dam
Pertinent Data

General Information

Name of Project:	Lockport Lock and Dam
Location:	Chicago Sanitary and Ship Canal RM 291.0 (referenced upstream of the confluence of Illinois River with the Mississippi River at Grafton, Illinois). Two miles southwest of the city of Lockport, Will County, Illinois.
Objective of Regulation:	Navigation, power generation, and flood control.
Other Interagency Agreements:	Upper Mississippi River Basin Commission.

Hydrology

Drainage Area:	740 square miles
Contributing Watersheds:	Lake Michigan, Chicago River, Calumet River, Des Plaines River
Water Volume Resulting from 1-Inch of Runoff:	39,500 acre-feet
Minimum Average Daily Flow and Date of Occurrence:	1,060 cfs, January 11, 1973
Minimum Average Monthly Flow and Date:	1,890 cfs, November 1980
Minimum Average Annual Flow and Water Year:	3,182 cfs, 1940
Average Annual Flow:	5,256 cfs
Maximum Average Daily Flow and Date:	29,787 cfs, March 4, 1979
Maximum Average Monthly Flow and Date:	9,195, January 1957

Maximum Average Annual Flow and Water Year:	9,746, 1928 (7,058 cfs in 1938 after lock was built)

Lockport Lock

Location:	Chicago Sanitary and Ship Canal, RM 291.0
Owner/Operator:	U.S. Army Corps of Engineers
Controlling Agency:	U.S. Army Corps of Engineers
Annual Operation Period:	All year
Lock Dimensions:	110 feet wide by 600 feet long
Maximum Lift:	42.0 feet
Average Lift:	39.5 feet
Upper Guard Gate:	
Type	Submersible vertical lift
Dimensions	118 feet wide by 24 feet high
Upper Service Gate:	
Type	Submersible vertical lift
Dimensions	118 feet wide by 24 feet high
Lower Service Gates:	
Type	Miter
Dimensions (each leaf)	65 feet wide by 65 feet high
Elevations:	
Upper Gate Sill	
Guard Gate	557.5 feet NGVD
Service Gate	557.5 feet NGVD
Lower Gate Sill	523.5 feet NGVD
Top of Lock Chamber	584.5 feet NGVD
Chamber Floor	522.5 feet NGVD
Upper Guide Wall	584.5 feet NGVD
Lower Guide Wall	546.5 feet NGVD

Filling and Emptying Tunnels:	2- to 12-foot diameter
Tunnel Valves Type:	Vertical roller, culvert valves
Average Filling Time:	22.5 minutes
Average Emptying Time:	15.0 minutes

Thomas J. O'Brien Lock and Controlling Works

Location:	Calumet River - RM 326.0
Owner/Operator:	U.S. Army Corps of Engineers
Lock Dimensions:	110 feet wide by 1,000 feet long
Maximum Lift:	5.0 feet
Upper and Lower Gates:	Sector-type
Sluice Gates:	
Number	8
Dimensions (each gate)	10 feet square
Sill elevation	562.5 feet NGVD - 17.0 feet CCD

SECTION 3 - BRANDON ROAD LOCK AND DAM

GENERAL

The Brandon Road Lock and Dam is located at RM 286 of the Illinois Waterway on the Des Plaines River, in the city of Joliet, Illinois. The lock is 110 feet by 600 feet with miter gates at both ends. Normal lift is 34 feet. The dam includes tainter gates, sluice gates, head gates, an overflow section, and earth embankment sections. The lock and dam maintain the waterway pool at elevation 539.0 feet NGVD. This location is also the junction of the Des Plaines River and the historical Illinois and Michigan Canal.

The primary functions of Brandon Road dam are to provide slack water for navigation and to maintain flow in the canal that connects Lake Michigan to the Mississippi River. The dam forms a pool that extends upstream about 5 miles to Lockport dam.

PHYSICAL COMPONENTS

LOCK

The lock is a gravity wall design founded on limestone. The walls are concrete with a top width of 10 feet at elevation 542.5 feet NGVD. The right wall is designated as the land wall and retains the embankment upon which the lock office and maintenance buildings are located. The left wall is designated as the river wall and adjoins the earth embankment between the lock and dam.

The usable lock chamber is about 600 feet long by 110 feet wide. The lock has a nominal lift of 34.0 feet. The normal lock tailwater elevation is 504.5 feet NGVD, and the normal upper pool elevation is 538.5 feet NGVD. The upstream end of the chamber is sealed by two sets of horizontally framed miter gates, with each gate 20 feet high by 65 feet long. The upstream set of gates functions as an upper guard gate and does not have an operating mechanism. The other set of gates functions as an upper service gate and is operated by a motor driven bull gear and strut arm assembly. The downstream end is sealed by two 50-foot-high by 65-foot-long miter gates which function as the lower service gate. This gate also is operated by a motor driven bull gear and strut arm. The gates are hinged on a vertical axis on the lock walls. In the open position, the gates are recessed into the lock walls to allow unobstructed movement across the full 110-foot width of the lock to rest against the lock sill.

The lock filling and emptying system is the side port type. There are 10 rectangular side ports, 50 feet wide by 3 feet 6 inches high, located along the bottom of each lock wall. The side ports in each wall are connected to a 12-foot-diameter filling and emptying culvert which is located longitudinally in the base of the wall. The filling ports are located in the chamber walls at the upstream end of the longitudinally located culverts in the forebay between the upper service and guard gates. The filling operation takes about 19 minutes and is accomplished by opening the two upstream vertical wagon wheel gates after closing the downstream vertical wagon wheel gates. This allows water to enter the lock chamber through the side port distribution system to a water level equal to that of the upstream pool. The lock emptying operation takes about 15 minutes and is accomplished by opening two vertical wagon wheel gates located downstream of the lower service gate after closing the upstream vertical wagon wheel gates. This allows water to drain through the side ports and empty into the downstream pool, lowering the water level in the lock to that of the downstream pool.

Guide walls protect both banks of the channel downstream of the lock and the river side upstream of the lock. The lower guide walls are gravity type, approximately 20 feet tall, with the top of the walls at elevation 513.5 feet NGVD. The lower guide walls are stabilized with post tensioned anchors. The riverside guide wall extends for 185 feet and the landside lower guide wall extends for 594 feet. The upper guide wall segments are bridged between piers founded on limestone. The upper guide wall is 598 feet long with the top of the wall at elevation 543.5 feet NGVD. Both the upper and lower guide walls are capped and armored with concrete and steel. An ice protection wall connects the dam section with the upper guide wall.

Upstream and downstream lock approach channel cross sections are located on plate D-58 and are shown on plates D-59 and D-60.

DAM

The dam is composed of a concrete section on an earth embankment section. The concrete dam has a total length of about 1,569 feet which includes 1,521 feet of movable or gated sections, 30 feet of concrete overflow section, and 18 feet of boilerhouse. The nonoverflow earth dike section abuts each side of the lock and extends from the concrete dam section to the Illinois and Michigan Canal, a total length of nearly 1,000 feet. The dam contains 21 tainter gates, 6 sluice gates, and 16 headgates, 8 of which are not operable.

The headgate section is 320 feet long with a crest width of 24 feet at elevation 542.5 feet NGVD. The headgate section contains eight single-leaf vertical lift gates. Each gate is 15 feet wide by 16 feet high. Three of the gates have permanently mounted electric hoist mechanisms, and the remaining five gates are operated by a mobile electric hoist car on a rail

system. Eight additional headgates are from the original dam section. These headgates are bulkheaded of concrete on the downstream side.

The normal tailwater elevation at the headgate section is approximately elevation 508.5 feet NGVD, which is about 4 feet higher than the lock tailwater. The headgate section and lock are separated by the earthfill embankment.

The overflow section is a converted ice chute gate. The conversion consisted removing the existing steel gate and appurtenances, removing approximately 100 cubic yards of concrete, and placing of concrete to form the overflow. It is 30-feet-wide, and the crest is at elevation 538.5 feet NGVD.

The tainter gate section is 1,110 feet long and contains 21 tainter gates, each 50 feet wide by 2 feet 3.5 inches high. The flow line at the gate sill is at elevation 536.3 feet NGVD. The tainter gates are used to maintain the upper pool at elevation 538.5 feet NGVD while passing the river flows. Each tainter gate has a maximum capacity of 550 cfs.

The earth embankment abuts each side of the lock and extends from the concrete dam section to the Illinois and Michigan Canal, a distance of nearly 1,000 feet. The earth embankment accounts for about 822 feet. The earth embankment section has a crest width of 20 feet at elevation 543.5 feet NGVD, and the embankment is about 34 feet high.

Six vertical lift sluice gates span a distance of 91 feet. Each gate is 7 feet 9 inches wide by 8 feet 5 inches high, with a sill elevation of 509.5 feet NGVD. The sluice gates are all inoperable.

HYDROLOGY/WATERSHED

GENERAL

The Illinois Waterway in the Brandon Road Lock and Dam area consists of a raised and deepened portion of the Des Plaines River, the Chicago Sanitary and Ship Canal, and the Calumet-Sag Channel. The latter two werebuilt to reverse the flow of water in the Chicago and Calumet Rivers to the Mississippi River. The Chicago Sanitary and Ship Canal was constructed primarily for sewage disposal and secondarily for navigation. The completion of the Calumet-Sag Channel in 1922 diverted industrial wastes from the Calumet River in the Chicago Sanitary and Ship Canal above Lockport. The total area drained by these channels at Brandon Road Lock and Dam is 1,506 square miles. This area is extensively urbanized and sewered, and is subject to rapid runoff during severe thunderstorms.

FLOW DURATION

Annual and monthly flow duration curves for Brandon Road were developed using the daily flow files mentioned above. These flow duration curves are presented as plates D-61 through D-64.

In general, flows are never less than 1,500 cfs. Flows are generally highest in the spring and winter, and lowest in the summer and fall. Flows can fluctuate widely from day to day. For 90 percent of the time, the flows are in the range of 1,600 to 4,600 cfs.

HEAD DURATION

Brandon Road maintains both a pool and tailwater gage from which daily stage readings are taken. Daily stage readings for these gages are available for the period 1940-1979 from computer tapes developed by Chicago District, Corps of Engineers. The pool and tailwater gages are located upstream and downstream of the lock chamber. Daily heads then were developed by using a computer program which subtracted the daily tailwater stages from the daily pool stages. This daily head file was later used to develop head duration.

Head duration curves were developed from the daily head information mentioned above. These curves are presented as plates D-65 through D-68 for annual as well as monthly intervals. It should be noted that heads are plotted for present time exceedence as are flows in the flow duration curves. For Brandon Road, there is an inverse relationship between head and flow; i.e., low flows result in high heads, and high flows result in low heads. Therefore, a 20 percent exceedence on the head duration curve corresponds to an 80 percent exceedence on the flow duration curve. It also should be noted that the heads plotted in these curves represent gross heads, not net heads.

Heads are generally higher during the summer and fall, and lower in the winter and spring. The 50 percent duration head is about 33.5 feet. Heads range between 33 to 34.5 feet 90 percent of the time and over 28 feet 99 percent of the time.

Brandon Road is operated as a run-of-the-river facility. The upper pool remains fairly constant at elevation 539.0 NGVD, with variations of plus or minus 0.5 foot. Only rarely has the upper pool exceeded these limits. Head variations are, therefore, strictly a result of tailwater effects below the dam.

ELEVATION HYDROGRAPHS

The elevation hydrographs at the Brandon Road Lock and Dam site for the period 1970 through 1989 are shown on plates D-69 and D-70.

REGULATION PLAN

The Brandon Road Lock and Dam are regulated by the U.S. Army Corps of Engineers. The Rock Island District Regulation Branch personnel talk to the MSDGC forecaster on a daily basis. The inflow to the Brandon Road pool is dependent on outflow released from the MSDGC facility at Lockport.

The Brandon Road dam is a run-of-the-river dam and cannot store water for flood control purposes. The maximum stage for the Brandon Road pool is 540.5 feet NGVD, while the minimum stage is 537.2 feet NGVD. The Joliet channel walls are at a minimum elevation of 541.5 feet NGVD, which allows a minimum freeboard of 1 foot at the maximum stage. The maximum and minimum tailwater elevations are 513.3 feet NGVD and 501.1 feet NGVD, respectively. There is no freeboard on the lower guide wall at which the lock becomes inoperable.

The McDonough Street Bridge crossing of the channel at RM 587.3 is the control channel section of the Illinois Waterway above the Brandon Road dam. Discharge which exceeds the top of the Joliet floodwall, or the bank full stage, at the control section would not normally re-enter the channel upstream of the dam. The bank full discharge capacity of the channel at the control section is estimated at 58,000 cfs.

SEDIMENTATION

In 1972, an investigation of bottom sediments was made between Lockport lock at RM 291 and Brandon Road lock at RM 286. The report indicates a fairly clean bottom from Lockport Lock to about RM 28. The river is narrow in this area, and flow may keep the bottom scoured off. As the river widens below RM 288, the investigation revealed deposits of black sludge which are described below.

The percentage of volatile soils in sediments approximates the amount of organic matter present in the sediment material. The organic content of sediment is an environmental indicator. If the sediment contains appreciable amounts of oxidizable organic matter, it indicates that the organic supply exceeds the bacterial decomposition. T. A. Butts (1974) described the sediment material in the Brandon Road pool as follows:

> The general description of the bottom material contained in wide areas of the Brandon Road and Dresden Island pools would fit that

of a thick black fibrous muck having either an oily or musty smell. The fibrous material, when examined closely, was often found to be massive populations of sludge worms (sic). For the most part, the bottom sediments in these two pools can be categorized simply as highly infested with pollution-tolerant organisms. Heavy oils or petroleum products are widely distributed throughout most of the sediments in these two pools.

RELATED REPORTS

A General Design Memorandum entitled *Illinois Waterway, Brandon Road Lock and Dam Major Rehabilitation, Design Memorandum No. 1* was published in April 1983. The memorandum discussed the present condition and the proposed plan for rehabilitation of the Brandon Road Lock and Dam.

Rehabilitation of the lock and dam was started in 1984 and scheduled for completion in 1987. The work included resurfacing of the lock and guide walls and rehabilitating the lock gates; replacing electrical system and miter gate machinery; resurfacing the dam and rehabilitating the dam gates; new dam gate machinery; new electrical system on the dam; and new headgates.

Design Memorandum No. 2 for the Joliet Channel Walls Rehabilitation was published in August 1984. The memorandum discussed the present condition of the Joliet channel walls which extend from the upper limits of the city of Joliet downstream to the Brandon Road Lock and Dam, and the proposed rehabilitation plan. The rehabilitation was started in 1985 and was scheduled for completion in 1987.

The Brandon Road Lock and Dam Power Project, published in August 1983, was an application for a license to generate power at the Brandon Road site by the village of Rockdale, Illinois.

The *Lock Breach Report on the Illinois Waterway for Brandon Road Lock*, published in May 1980, analyzed the theoretical failure of the Brandon Road lock gates and the resulting downstream effect.

The *Waterway Operations Manual*, published in 1978, was designed to provide information to assist lockmen and dam keepers in carrying out preventive maintenance programs, and it established rules for proper operation, improved service, and reduced repair costs.

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I* states:

"The Dresden Island pool would be extended through Joliet to Lockport eliminating the need for Brandon Road lock and dam. The improvements for this reach of the waterway include:

"Lock - A new 73.5-foot lift lock, 110 feet wide by 1,200 feet long, will be constructed approximately 1,200 feet eastward of the existing Lockport lock. The upper and lower guide walls are approximately 1,200 feet long. Provisions have been made in siting the lock to provide for a future 1,200-foot lock between the new lock and controlling works. The chamber walls will consist of concrete facing over rock cut. Gate bays will be concrete gravity walls. The filling system will be the longitudinal type. Service gates will be miter gates with a submersible gate for emergency closure upstream of the upper miter gate. Minimum depth over the lower sill will be 17 feet and 24 feet over the upper sill.

"Dam - A new dam and controlling works with a 73.5-foot head will replace the existing controlling works and powerhouse. The controlling works will consist of three 10-foot round steel lined conduits and 3 tainter gates. A 200 square foot stilling basin will be provided downstream.

"Hydroelectric Power Generation - The justification of replacing rather than removing the existing Lockport powerhouse will be investigated in the Phase II GDM. This study will be coordinated with the Metropolitan Sanitary District of Greater Chicago and the Federal Power Commission.

"Navigation Channel - A bypass channel will be constructed east of the existing navigation channel from approximately mile 285.3 to Brandon Road dam. Brandon Road lock and dam will be removed and Dresden Island pool will be extended to Lockport. This will necessitate that the channel through Joliet to the new lock be lowered 34 feet. The new channel will have a 325-foot horizontal clearance or as restricted by the existing channel walls. There will be some minor channel realignment at Ruby Street in Joliet. The lowered channel invert will be set to provide for a project depth of 9 feet, plus 2 feet for squat and clearance and 1-1/2 feet for over-depth. Straight, unobstructive approaches in excess of 3,000 feet will be provided at the new Lockport lock.

"New Walls - A new concrete wall is proposed from mile 292.4 (approximately 1,600 feet downstream of 9th Street) to the upper gates of the new Lockport lock. This wall will serve as the guide wall for the upstream approach to the new lock. Another concrete wall is provided in the upper pool at mile 291.35. It begins from the new lock and extends westward to the controlling works and then continues on the west side of the controlling works to the existing west wall of the Chicago Sanitary and Ship Canal. This wall is approximately 1,600 feet long, excluding the controlling works structure.

"Fleeting Areas - The existing fleeting areas in Brandon Road pool will be eliminated. Two fleeting areas, with a total capacity of 150 standard barges, will be provided upstream of the new lock. One is located

at about mile 291.7 and the other at mile 292.4. Mooring piers with float mooring bits will be provided."

Brandon Road Lock and Dam
Pertinent Data

General Information

Location:	Joliet, Illinois, on the Des Plaines River at RM 286 (referenced upstream of the confluence of the Illinois Waterway with the Mississippi River at Grafton, Illinois).
Purpose:	Navigation
Authority:	Rivers and Harbors Act, dated July 3, 1930.
Drainage Area Above Dam:	1,506 square miles

Dam

Type:	Concrete and earth
Length of Concrete Embankment:	1,569 feet
Length of Earth Embankment:	822 feet
Number of Gates:	16 headgates (8 operational, 8 bulkheaded closed), 21 tainter gates (all operational), 6 sluice gates (all bulk-headed closed).
Size of Headgate:	16 feet high by 15 feet wide
Type of Headgate:	Single-leaf vertical lift
Size of Tainter Gates:	50 feet wide by 2 feet 3.5 inches high

Size of Sluice Gates:	7 feet 9 inches wide by 3 feet 5 inches high
Type of Sluice Gates:	Single-leaf vertical lift

Lock

Location:	Joliet, Illinois
Normal Size of Chamber:	110 feet wide by 600 feet long
Normal Lift:	34.0 feet

Elevations (NGVD):

Upper pool normal	538.5
Upper pool minimum	537.2
Upper pool maximum	540.5
Lower pool normal (no flow)	504.5
Lower pool minimum	501.1
Lower pool maximum	513.3
Top of upper lock walls	542.5
Top of upper guide walls	542.5
Top of lower guide walls	513.5
Upper mite sill	520.7
Lower miter sill	490.7
Chamber floor	489.7

Dimensions (in feet):

Depth Above Lower Sill (Normal)	15
Type and Height of Upper Guard Gate:	Horizontally framed miter gate; 20
Type and Height of Upper Service Gate:	Horizontally framed miter gate; 50
Upper Guide Wall Length:	598
Lower Guide Wall Length:	River side - 185, Land side - 594
Width Top of Chamber Wall:	10
Culvert Diameter:	10
Operative Period:	Year round

Type and Dimensions of Culvert Valves:	Side ports; 5 feet wide by 3 feet 6 inches high.
Minimum Submergence of Culvert Valves:	539.0 feet NGVD for upper valves; 505.0 feet NGVD for lower valves.
Lock Filling Time:	19 minutes average time
Lock Emptying Time:	15 minutes average time
Average Annual Tonnage:	18.2 million tons
Maximum Elevation to Permit Navigation:	No maximum elevation
Freeboard on Lower Guide Wall When Lock Becomes Inoperative:	No freeboard at which lock inoperative

Hydrology

Flows[1]

Minimum Average Daily Flows and Date of Occurrence:	1,457 cfs, November 9, 1947
Minimum Average Monthly Flow and Date:	2,098 cfs, March 1968
Minimum Average Annual Flow and Water Year:	3,426 cfs, 1977

[1] Flows at Brandon Road were determined by adding the recorded flows at the Lockport gage to the adjusted flows from the Riverside gage. The flows were adjusted to account for the difference in drainage area at Riverside (630 square miles) and at the confluence of the Des Plaines River and the Chicago Sanitary and Ship Canal (705 square miles). The square-root ratio method was used to adjust the Riverside flows.

$$\frac{Q1}{Q_2} = \frac{DA1}{DA_2}$$

It was estimated that flow at Riverside took about 24 hours longer to reach Brandon Road than did flow from Lockport. For this reason, the average daily flows at Riverside for the date preceding the average daily flow recorded at Lockport were adjusted and added to the Lockport flows to determine daily maximum and minimum average flows at Brandon Road.

Average Annual Flow:	5,743 cfs
Maximum Average Daily Flow and Date:	32,960 cfs, March 3, 1979
Maximum Average Monthly Flow and Date:	12,597 cfs, March 1979
Maximum Average Annual Flow and Water Year:	9,756 cfs, 1928[2]
Maximum Instantaneous Flow and Date:	37,455 cfs, May 16, 1974[3]
Type of Hydrometeorologic Data Recorded at Dam Site:	Precipitation and temperatures
Number of Sediment Ranges:	Five

[2] This flow was recorded at the Chicago Sanitary and Ship Canal gage at Lockport, Illinois. The Riverside gage on the Des Plaines was not in operation until 1944. The maximum annual combined flow is 4,917 cfs in 1957.

[3] This flow is composed of the maximum instantaneous flow at Lockport (34,948 cfs) and the adjusted daily flow for the previous day at Riverside.

SECTION 4 - DRESDEN ISLAND LOCK AND DAM

GENERAL

The Dresden Island Lock and Dam is immediately downstream of the confluence of the Des Plaines and Kankakee Rivers and is located at Illinois RM 271.5 near Morris, Illinois. The lock has a usable chamber of 110 feet by 600 feet with miter gates at both ends. Maximum lift is 21.75 feet. The dam includes an overflow spillway, tainter gates, ice chute, head gates, and a concrete arch. The arch is constructed over what was to be the sill of the smaller navigation lock which never was built. The lock and dam maintain the waterway pool at elevation 504.4 feet NGVD.

PHYSICAL COMPONENTS

LOCK

The lock at the left bank of the waterway has a usable chamber 110 feet wide by 600 feet long. The maximum lift is 22 feet and the average lift is 20 feet. Concrete gravity type lock walls are 925 feet long and have a top width of 10 feet and a top elevation of 509.5 feet NGVD. Upper and lower left guide walls are 578.5 and 594 feet long, respectively. Miter type upper and lower service gates are 64.91 feet long from center to center of bearings. The upper gate is 20 feet high and the lower gate is 27 feet high. About 80 feet upstream from the upper service gate are miter type guard gates that are submerged almost fully at all times. Valve tunnels or culverts 12 feet in diameter with centerline at elevation 474.5 NGVD are in each lock wall for filling and emptying the lock chamber. The intake to each tunnel is 18 feet wide by 12 feet high and is covered by a trash rack. The lock floor is at elevation 469.5 feet NGVD, the upper gate sill is at 487.65 feet NGVD, and the lower gate sill is at elevation 470.5 feet NGVD.

Upstream and downstream lock approach channel cross sections are located on plate D-71 and are shown on plates D-72 and D-73.

DAM

The total length of the concrete structure between the earth embankment on the right and the upper end of the river side of the small lock on the left is about 1,005 feet. This includes a headgate section, a boiler house, an ice chute, a tainter gate section, and a fixed dam section.

The small lock, originally planned to lie adjacent to the existing lock, was never completed and now serves as a part of the dam and is called the arch dam. It is a concrete section with a crest length of 110 feet and a crest elevation of 509.5 feet NGVD.

The fixed dam is between the arch dam and the tainter gate section. Its ogee spillway section is about 35 feet long, and the crest is at elevation 504.5 feet NGVD.

The tainter gate section is 616 feet long and contains 9 gates that are 60 feet wide by 16 feet high. The radius of the steel gates is 24.92 feet. The gates close on steel channels imbedded in the concrete sill at elevation 490.5 feet NGVD. The tainter gates are used to maintain desired pool elevations.

The ice chute is an ogee section 30 feet long containing a submersible tainter gate. In its upper position, the gate provides 2 feet of freeboard above normal pool. In its lowered position, the flow line is at elevation 499.5 feet NGVD, 5 feet below normal pool. Because the ice chute is about 500 feet from the lock, it is not used for passing ice broken up by river traffic. The gate is now inoperable.

The headgate section is 298 feet long, has a crest width of 14 feet at elevation 512.5 feet NGVD, and a lower deck 5.7 feet wide upstream of the gate slot and at elevation 509.5 feet NGVD. The section contains 18 headgates with each opening 13.33 feet wide by 16 feet high and a flow line elevation of 488.5 feet NGVD. All gate openings were filled with 3-foot concrete plugs in 1982.

The headgate section ties into an earth embankment that dams off the Illinois and Michigan Canal from the Illinois Waterway.

MAJOR REHABILITATION

The following major rehabilitation has been performed at Dresden Island Lock and Dam:

1941 -	The outer 240 feet of the upper approach wall was reconstructed.
1953 -	The lower guard wall was reconstructed.
1954 -	The lock chamber walls of the upper half of the lock were resurfaced.
1961 -	The top surfaces and the upper 3 feet of the vertical walls of the lock and of the small lock were resurfaced. Eight counterweights of the tainter gates were repaired.
1968 -	Culvert valves and operating machinery were replaced.
1976 -	Two new mooring piers in the upper pool above the lock were constructed.

1977 - The arch dam was rehabilitated. The work included resurfacing of the entire downstream face of the arch dam, resurfacing of the top and the upstream face above the level of the upper pool, and installing new hand railing. Four new mooring cells also were constructed in the lower pool below the lock.

1980-83 - General rehabilitation of the dam, headgate openings filled with 3-foot concrete plugs, ice chute demobilized, and tainter gates 4 and 9 replaced.

HYDROLOGY

GENERAL

Two principal tributaries, the DuPage and Kankakee Rivers, account for 96 percent of the area tributary to this reach of the waterway. The DuPage River rises in Cook County a short distance north of the north boundary of DuPage County. It flows southward through western DuPage and Will Counties, emptying into the Illinois Waterway (Des Plaines River) at RM 276.9.

The Kankakee River rises in St. Joseph County, Indiana, and enters Illinois 57.2 miles upstream from its confluence with the Des Plaines River.

Along the waterway, the Kankakee Bluffs, rising about 100 feet above normal pool level, flank the right bank from Dresden Island Lock and Dam upstream to the mouth of the DuPage River. From there the bluffs continue north, forming the west wall of the DuPage River Valley. Similarly, bluffs about 100 feet high are close to the waterway along the left bank from about RM 281.5 to Brandon Bridge.

FLOW DURATION

Annual and monthly flow duration curves for Dresden Island are presented as plates D-74 through D-77.

In general, flows are never less than 2,000 cfs due to the Lake Michigan diversion; the maximum flow recorded was 93,900 cfs on July 14, 1957. The annual 50 percent duration flow is about 7,000 cfs. Flows are generally highest in the spring and winter, and lowest in the summer and fall months. Flows can fluctuate widely from day to day. For 90 percent of the time, the flows are in the range of from 3,000 to 17,000 cfs.

HEAD DURATION

Dresden Island maintains both a pool and tailwater gage from which daily stage readings are taken. Daily stage readings for these gages are available for the period 1940-1979 from computer tapes developed by Chicago District, Corps of Engineers. The pool and tailwater gages are located upstream and downstream of the lock chamber. Daily heads then were developed using a computer program which subtracted the daily tailwater stages from the daily pool stages. This daily head file was later used to develop head duration.

Head duration curves were developed from the daily head information mentioned above. These curves are presented as plates D-78 through D-81 for annual as well as monthly intervals. It should be noted that heads are plotted for present time exceedence as are flows in the flow duration curves. For Dresden Island, there is an inverse relationship between head and flows; i.e., low flows result in high heads, and high flows result in low heads. Therefore, a 20 percent exceedence on the head duration curve corresponds to an 80 percent exceedence on the flow duration curve. It also should be noted that the heads plotted in these curves represent gross heads, not net heads.

Heads are generally higher during the summer and fall, and lower in the winter and spring. The 50 percent duration head is about 20 feet. Heads range between 16 to 22 feet 90 percent of the time and over 9 feet 99 percent of the time.

Dresden Island is operated as a run-of-the-river facility. The upper pool remains fairly constant at elevation 504.5 NGVD, with variations of plus or minus 0.5 foot. Only rarely has the upper pool exceeded these limits. Head variations are, therefore, strictly a result of tailwater effects below the dam.

CHANNEL

The Illinois Waterway flows southwestwardly through a bluff-lined valley ranging in width from about 1.5 to more than 4 miles from Brandon Road Lock and Dam to Dresden Island Lock and Dam. The dredged width of the navigation channel is maintained at 300 feet, except at Treats Island Cutoff (RM 279.2 to 280.0) where it is 250 feet. The thalweg falls gently from near the foot of Brandon Road Lock to Dresden Island Lock and Dam at a slope of less than 0.1 foot per mile. At normal pool level, the depth ranges from about 14 feet to more than 20 feet in the same reach.

ELEVATION HYDROGRAPHS

The elevation hydrographs at the Dresden Island Lock and Dam site for the period 1970 through 1989 are shown on plates D-82 and D-83.

OTHER STUDIES

The *Comprehensive River Basin Study for the Upper Mississippi River Basin*, 1972, is primarily a planning report. However, it contains a wealth of information on the Illinois Waterway.

An information report to the Congress entitled, *Increased Lake Michigan Diversion at Chicago, Demonstration and Study Program*, was published by the Chicago District, Corps of Engineers, in April 1981. In this study, the impacts of increased diversion from Lake Michigan on Great Lakes water levels and on water quality, flooding, and the environment along the Illinois Waterway were investigated.

A Floodplain Information Report on the Des Plaines River, Illinois and Wisconsin, was prepared by the Corps of Engineers in 1966.

Flood information for the Dresden Island pool reach of the Illinois Waterway is contained in a flood insurance study report for Will County. A flood insurance study report also has been published for the village of Channahon as well as for Grundy County.

Information on water volume in the Dresden Island pool is reported in *Illinois Waterway Pool Volume Curves* prepared for the Rock Island District, Corps of Engineers, in December 1984 (plate IV-4).

The USGS defined relationships between tainter gate opening and discharge by current-meter measurements at several of the dams along the Illinois Waterway. These are contained in USGS Open-File Report 81-1009 entitled, *Stage-Discharge Relations at Dams on the Illinois and Des Plaines Rivers in Illinois*, 1981.

REGULATION PLAN

The Dresden Island Lock and Dam project was designed and constructed, and is regulated, to maintain navigation on the Illinois Waterway. The dam is operated to maintain a normal pool elevation of 504.5 feet NGVD in order to provide a 9-foot navigation channel between RM 271.5 and 286.0 on the waterway. Pool elevations 1940-83 have been maintained with 0.5 foot of elevation 504.5 for about 95 percent of the time.

Drift and debris have not been serious problems because the thread of the current is on the right side of the channel, away from the lock. Drift and debris are flushed from the pool through the tainter gates.

The rigors of severe winter weather pose the greatest constraints upon operations. Problems associated with ice have become more numerous and severe in recent years as water quality in the waterway has improved. Ice floes jamming into the lock chamber and approaches and impeding the operation of the miter gates have been a problem. Ice discharges from the Kankakee River, especially when ice jams form and break loose upstream, create problems in maintaining the pool level as well as coping with ice at the lock and tainter gates. At the tainter gates, the electric motors do not have sufficient power to lift the gates when a mass of ice has accumulated on them. The gates are then operated manually using hand cranks or a heavy-duty electric drill fitted with a special chuck that is engaged in the hand-crank assembly. Hand chipping and steam are used to free ice from the gates. Electric heat tapes have been installed in the right wall and along the bottoms of Gates 6 through 9 to alleviate ice conditions. Gates 6 and 7 also have been fitted for application of steam to the gate and gate walls, and these gates are in general use during the winter. At other gates, steam must be applied manually by hose and nozzle.

Commonwealth Edison's Dresden Island Nuclear Power Plant is situated on the left bank floodplain at the junction of the Kankakee and Des Plaines Rivers about 1.5 miles upstream from the lock and dam. Cooling water withdrawn from the Kankakee River is circulated in cooling ponds. Some heated effluent is discharged into the river and helps to ease freezing conditions in the winter season.

In normal operations, tainter gates nearest the right bank are opened first. Even-numbered gates are used in even-numbered months; odd-numbered gates are used in odd-numbered months. Whenever gates are opened 2 feet or more, lock and dam personnel call the Harbor Service in Morris which, in turn, relays the message to river traffic.

SEDIMENTATION

Data on the particle size distribution of the suspended sediment are available for the stations operated by the USGS.

Sediment yields are low in this area. Sediment yield curves contained in the *Upper Mississippi River Comprehensive Basin Study* show that average annual sediment yields range from about 40 tons per square mile for a drainage area of 1,000 square miles to about 100 tons per square mile for a drainage area of 1 square mile.

Sedimentation and subsequent turbidity resulting from resuspension of sediment by water currents, wave action, and boat traffic have brought

about reduction in marsh plants and the near eradication of submerged and floating plants from the Upper Illinois Waterway.

T. A. Butts of the Illinois State Water Survey (1974) described the bottom sediments in the Dresden Island pool as follows:

> The general description of the bottom material contained in wide areas of the Brandon Road and Dresden Island pools would fit that of a thick black fibrous muck having either an oily or musty smell. The fibrous material, when examined closely, was often found to be massive populations of sludge worms (sic). For the most part, the bottom sediments in these tow pools can be categorized simply as highly infested with pollution-tolerant organisms. Heavy oils or petroleum products are widely distributed throughout most of the sediments in these two pools.

The Illinois State Water Survey estimated the oxygen demand of the bottom sediments in the Dresden Island pool to range from 0 to more than 4 grams per square meter per day. The minimum was between RM 278.5 and 280 and between 285 and 286; the maximum was between RM 281 and 282. In most of the pool, it was between 1 and 4 grams per square meter per day. Computed dissolved oxygen depletions due to sediment oxygen demand ranged from 0.6 milligrams per liter near average flow to 2.0 milligrams per liter near the 7-day 10-year low flow.

DREDGED MATERIAL INVESTIGATIONS

Table D-6 contains the record of channel maintenance dredging that has been carried on since 1969. The total volume of material dredged from the Dresden Island pool 1969-1978, 1981-1984 was 161,945 cubic yards. Although shoaling has not been a serious problem in this pool, the locations requiring most attention have been the Bonnell Bend area just upstream from the Kankakee River and the area near the mouth of the DuPage River.

TABLE D-6

Dredging in Dresden Island Pool

Year	Cubic Yards
1969	1,250
1970	2,200
1971	3,200
1972	4,900
1973	2,550
1974	7,450
1975	45,110
1976	65,100
1977	500
1978	700
1979	0
1980	(a)
1981	(a)
1982	4,573 (b)
1983	6,244
1984	18,168

(a) Records not available
(b) Does not include January through March dredging

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I* states:

"A new supplemental lock will be located at mile 271.5 to the south (landward side) of the existing lock. The landward side was chosen to eliminate the navigation difficulties that would be present in a riverward lock due to the cross currents across the upper approach to the existing lock. The landward location will also require less cofferdamming and be less costly to construct than a riverward lock. The new lock will have a lift of approximately 22 feet with a bottom lateral filling system. The usable chamber of the new lock will be 100 feet wide by 1,200 feet long. The walls will be of the concrete gravity type founded on rock. Both upper and lower service gates will be miter gates. An emergency gate will also be provided for emergency closures and for passing ice when the need arises. In addition to the recommended lock improvements, stabilization of the spillway section of the existing Dresden Island dam would be required."

Dresden Island Lock and Dam
Pertinent Data

General

Location:	At RM 271.5, 1.5 miles downstream from mouth of Kankakee River
Purpose:	Navigation
Drainage Area Above Dam:	7,278 square miles
Time of Water Travel:	From Brandon Road Lock and Dam to Dresden Island Lock and Dam is 2 hours
Maximum Discharge of Record:	75,000 cfs, December 4, 1982

Dam

Type:	Gated concrete gravity
Length:	Total length of lock and dam between abutments is about 1,320 feet
Arch Dam Section:	Arch dam between future lock abutments (110 feet between abutments) with crest elevation of 509.5 feet NGVD, adjacent to existing lock chamber.
Fixed Spillway Section:	Between arch dam and tainter gate sections, about 35 feet long with crest at elevation 504.5 feet NGVD.
Tainter Gate Section:	616 feet long with 9 tainter gates 60 feet wide by 16 feet high. Ogee spillway crest elevation under tainter gates is 490.5 feet NGVD.
Ice Chute Section:	30 feet long with submersible tainter gate at the top. Gate is inoperable. Crest elevation, 499.5 feet NGVD.
Boiler House Section:	About 18 feet along dam crest at right abutment of ice chute.

Headgate Section:	298 feet long containing 18 headgates with flow line at elevation 488.5 feet NGVD. Gate openings were plugged with concrete in 1982. Very short earthfill section connects headgate section to right abutment.

Lock

Width:	110 Feet
Length:	600 Feet
Maximum Lift:	22 Feet
Average Lift Based on 50 Percent Flow Duration:	20 Feet
Lock Filling and Emptying Time:	Average time for filling is 14 minutes; average time for emptying is 12 minutes.
Valve Tunnel:	Culverts in each lock wall are 12 feet in diameter.
Valve Tunnel Intakes:	18 feet wide by 12 feet high
Lock Chamber Wall Ports:	10 ports in each wall, each port 5 feet wide by 3.5 feet high

Hydrology

Drainage Area:	7,278 square miles
Climate:	Continental, variable
One Inch Run-Off Equals:	388,160 acre-feet
Storm Types:	Variable
Flood Season:	Spring and summer
Low Flow Season:	Fall and winter
Minimum Daily Average Flow and Date:	1,460 cfs, October 16, 1943

Minimum Monthly Average Flow and Date:	3,200 cfs, January 1963
Minimum Annual Average Flow and Date:	5,640 cfs, 1964
Average Annual Flow:	10,000 cfs
Maximum Annual Average Flow and Date:	16,500 cfs, 1927
Maximum Monthly Average Flow and Date:	34,000 cfs, March 1979
Maximum Daily Average Flow and Date:	70,000 cfs, December 4, 1982
Maximum Instantaneous Flow and Date:	75,000 cfs, December 4, 1982
Maximum Daily Flood Volume and Date:	138,843 acre-feet, December 4, 1982
Maximum Headwater Stage:	509.34 feet NGVD, December 3, 1982
Minimum Headwater Stage:	Between 502.0 and 502.5 in 1940-73 period.
Name and Location of Key Streamflow Stations:	Illinois Waterway at Brandon Road Lock and Dam, Kankakee River near Wilmington, Illinois, DuPage River at Shorewood, Illinois.
Type of Hydrometeorological Data Obtained at Site:	Precipitation, temperature
Number of Sediment Ranges:	13
Ice Break-Up Period:	February-March

SECTION 5 - MARSEILLES LOCK AND DAM

GENERAL

Marseilles Lock and Dam is located on an island in the Illinois River. The dam is situated at RM 247 on the upstream end of the island, across the north channel. The south channel is the navigation channel, with the lock located approximately 2 miles downstream of the dam. Marseilles pool extends from the Marseilles lock at RM 244.6 to Dresden Island Lock and Dam at RM 271.5. Hydroelectric power generation, utilizing the head created by a dam spanning the Illinois River has taken place at this location for more 100 years. Construction of the navigation project, consisting of the lock, canal, and replacement of the old dam with the existing dam, was begun by the State of Illinois in late 1920 and completed by the U.S. Army Corps of Engineers and placed in service in 1933.

PHYSICAL COMPONENTS

LOCK

Marseilles Lock is on the left bank of the Illinois River near the foot of Bells Island and the Marseilles Canal. It has a usable chamber 110 feet wide by 600 feet long, a maximum lift of 27 feet, and an average lift of 24 feet. Concrete gravity type lock walls have a top width of 5 feet and top elevation of 486.5 feet NGVD. Miter type upper and lower service gates are 64.91 feet long from center to center of bearings. The upper gate is 20 feet high, and the lower gate is 39 feet high. Miter type guard gates are located about 80 feet upstream from the upper service gates. Valve tunnels, or culverts, 12 feet in diameter with centerline at elevation 451.0 feet NGVD are in each lock wall for filling and emptying the lock chamber. The intake to each tunnel is 18 feet wide by 12 feet high and is covered by a trash rack. Connecting the tunnels to the lock chamber are 10 ports, 5 feet wide by 3.5 feet high, in each lock wall. The lock floor is at elevation 443.7 feet NGVD, the upper gate sill is at elevation 464.6 feet NGVD, and the lower gate sill is at elevation 445.0 feet NGVD.

Upstream and downstream lock approach channel cross sections are located on plates D-84 and D-85 and are shown on plates D-86 and D-87.

DAM

A main dam spans the Illinois River and two headrace dams span the north and south channel headraces. The main dam consists of a 552-foot-wide section containing 8 submersible tainter gates and a 46.5-foot-wide section containing a 30-foot-wide ice chute.

The dimensions of the gates are 60 feet wide, 16 feet high, and a radius of 25 feet. The new gates are designed to pass water under the gate as well as over the gate with a maximum 8 feet of gate submergence.

The 30-foot-wide ice chute has been converted to an ogee section with a crest elevation 0.5 foot above normal pool level.

The south channel headrace dam consists of a 76-foot-wide section containing one tainter gate and a 35-foot-wide fixed dam section on the right of the tainter gate section. The tainter gate is 60 feet wide by 16 feet high. The normal head on the tainter gate is about 3 feet. The Federal Paper Board Company, located near the foot of the south channel, withdraws water from the channel for its manufacturing process and fire protection.

A 64-foot-long buried wall composed of concrete and sheet piling ties the right end of the south channel fixed dam section to the left end of the north channel fixed dam section.

The north channel headrace dam consists of a 62-foot-wide fixed dam section on the left of a 144-foot-wide section containing two tainter gates. The tainter gates are 60 feet wide by 16 feet high. The normal head on the gates is about 3 feet. The north channel serves as the headrace for the Illinois Power Company's hydroelectric plant located at the foot of the channel. Discharge capacity through all turbines is about 3,000 cfs.

MAJOR REHABILITATION

The following rehabilitation work has been performed at Marseilles Lock and Dam:

1975-78 - Major lock rehabilitation.

1977 - Extended apron added to main dam. Significant erosion problems were experienced at Marseilles dam and have been corrected through the dumping of large rocks and the extension of the apron in 1977.

1978 - Electrical rehabilitation of the lock. Prestressed anchors extending through the upstream end of the piers 20 feet into the shale bedrock were installed for stabilization of the dam.

1979 - Ice chute gate abandoned in the raised position and

operating valves in the ice chute valve room partially dismantled. Electrical rehabilitation of the boiler-house and dam. Installation of flood lights at tainter gates.

1985-87 - Replace main dam tainter gates and machinery. Replace main dam walkway bridge. Modify spillways for gate submergence. Convert ice chute to ogee spillway. Fill ice chute valve room with concrete. Resurface main dam tainter gate piers. Sandblast and repaint headrace tainter gates, machinery, and bridges. Water-proof horizontal surfaces of headrace piers. Install remote operation system.

HYDROLOGY

GENERAL

The drainage area of the Illinois Waterway at Marseilles, Illinois, is 7,640 square miles. The Marseilles dam is located 247.0 river miles above the mouth of the Illinois Waterway at Grafton, Illinois, at the confluence with the Mississippi River. Marseilles dam is located 26 miles below the confluence of the Kankakee and Des Plaines Rivers, the beginning of the Illinois Waterway. The Marseilles Lock is located at Illinois River mile 244.5.

A kidney-shaped area of 981 square miles drains into the Marseilles pool downstream from Dresden Island Lock and Dam. The Mazon River basin accounts for more than half of this area, 524 square miles.

The waterway width varies from about 400 to about 1,000 feet in this reach. The navigation channel maintained by the Corps of Engineers is 300 feet wide. The thalweg has an extremely gentle slope in the Marseilles pool. Islands in the reach include Little Dresden Island (RM 271.1), Sugar Island (RM 261.2-260.3), Barry Island (RM 257.0), Johnson Island (RM 249.7), and Clark Island (RM 248.3-247.6). As will be discussed later, a cut at Johnson Island presents occasional navigation problems.

FLOW-FREQUENCY RELATIONSHIPS

Discharge-frequency relationships were developed for the USGS streamgaging station (05543500) at Marseilles, Illinois. The discharge record at the gaging station is shown in table D-7.

The discharge-frequency relationships were developed analytically using the principles from the *Guidelines for Determining Flow Frequencies*. Plate D-88 shows the discharge-frequency curve for the Marseilles gage.

TABLE D-7

Discharge-Frequency Relationships at Marseilles Gage 05543500

MARSEILLES.....05543500

.....EVENTS ANALYZED.....				.....ORDERED EVENTS.....			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	WEIBULL PLOT POS
0	0	1892	72500.	1	1983	94100.	0.0111
0	0	1894	18000.	2	1957	93900.	0.0222
0	0	1895	9640.	3	1970	92500.	0.0333
0	0	1896	39500.	4	1981	88500.	0.0444
0	0	1897	38000.	5	1985	84800.	0.0556
0	0	1898	44500.	6	1950	83300.	0.0667
0	0	1900	57600.	7	1908	77000.	0.0778
0	0	1904	63700.	8	1982	75800.	0.0889
0	0	1905	32600.	9	1942	74400.	0.1000
0	0	1906	20400.	10	1943	73800.	0.1111
0	0	1907	39000.	11	1892	72500.	0.1222
0	0	1908	77000.	12	1947	72000.	0.1333
0	0	1909	31800.	13	1979	71100.	0.1444
0	0	1910	30600.	14	1978	66900.	0.1556
0	0	1911	26600.	15	1966	66500.	0.1667
0	0	1912	33000.	16	1973	64900.	0.1778
0	0	1913	54000.	17	1948	64400.	0.1889
0	0	1914	26000.	18	1974	64000.	0.2000
0	0	1915	45500.	19	1904	63700.	0.2111
0	0	1916	40000.	20	1919	63000.	0.2222
0	0	1917	28400.	21	1964	62800.	0.2333
0	0	1918	48500.	22	1933	62300.	0.2444
0	0	1919	63000.	23	1922	60600.	0.2556
0	0	1920	48000.	24	1900	57600.	0.2667
0	0	1921	19500.	25	1927	56700.	0.2778
0	0	1922	60600.	26	1955	56600.	0.2889
0	0	1923	27200.	27	1978	56600.	0.3000
0	0	1924	51200.	28	1944	56100.	0.3111
0	0	1925	23600.	29	1913	54000.	0.3222
0	0	1926	41000.	30	1968	52200.	0.3333
0	0	1927	56700.	31	1951	51900.	0.3444
0	0	1928	37500.	32	1924	51200.	0.3556
0	0	1929	46500.	33	1975	50200.	0.3667
0	0	1930	35100.	34	1980	49700.	0.3778
0	0	1931	22500.	35	1959	49500.	0.3889
0	0	1932	27800.	36	1961	49500.	0.4000
0	0	1933	62300.	37	1958	48900.	0.4111
0	0	1934	15400.	38	1918	48500.	0.4222
0	0	1935	36000.	39	1920	48000.	0.4333
0	0	1936	36400.	40	1929	46500.	0.4444
0	0	1937	26400.	41	1962	46200.	0.4556
0	0	1938	35100.	42	1915	45500.	0.4667
0	0	1939	38800.	43	1954	44700.	0.4778
0	0	1940	21100.	44	1898	44500.	0.4889
0	0	1941	18500.	45	1952	44100.	0.5000
0	0	1942	74400.	46	1946	43500.	0.5111
0	0	1943	73800.	47	1945	42300.	0.5222
0	0	1944	56100.	48	1960	42300.	0.5333
0	0	1945	42300.	49	1972	41300.	0.5444
0	0	1946	43500.	50	1926	41000.	0.5556
0	0	1947	72000.	51	1965	40900.	0.5667
0	0	1948	64400.	52	1916	40000.	0.5778
0	0	1949	38200.	53	1896	39500.	0.5889
0	0	1950	83300.	54	1967	39000.	0.6000
0	0	1951	51900.	55	1907	39000.	0.6111
0	0	1952	44100.	56	1939	38800.	0.6222
0	0	1953	32600.	57	1949	38200.	0.6333
0	0	1954	44700.	58	1897	38000.	0.6444
0	0	1955	56600.	59	1928	37500.	0.6556
0	0	1956	30900.	60	1936	36400.	0.6667
0	0	1957	93900.	61	1977	36100.	0.6778
0	0	1958	48900.	62	1935	36000.	0.6889
0	0	1959	49500.	63	1969	35200.	0.7000
0	0	1960	42300.	64	1930	35100.	0.7111
0	0	1961	49500.	65	1938	35100.	0.7222
0	0	1962	46200.	66	1912	33000.	0.7333
0	0	1963	28500.	67	1905	32600.	0.7444
0	0	1964	19300.	68	1953	32600.	0.7556
0	0	1965	40900.	69	1909	31800.	0.7667
0	0	1966	66500.	70	1956	30900.	0.7778
0	0	1967	39000.	71	1910	30600.	0.7889
0	0	1968	52200.	72	1963	28500.	0.8000
0	0	1969	35200.	73	1917	28400.	0.8111
0	0	1970	92500.	74	1932	27800.	0.8222
0	0	1971	27100.	75	1923	27200.	0.8333
0	0	1972	41300.	76	1971	27100.	0.8444
0	0	1973	64900.	77	1911	26600.	0.8556
0	0	1974	64000.	78	1937	26400.	0.8667
0	0	1975	50200.	79	1914	26000.	0.8778
0	0	1976	66900.	80	1925	23600.	0.8889
0	0	1977	36100.	81	1931	22500.	0.9000
0	0	1978	56600.	82	1940	21100.	0.9111
0	0	1979	71100.	83	1906	20400.	0.9222
0	0	1980	49700.	84	1921	19500.	0.9333
0	0	1981	88500.	85	1964	19300.	0.9444
0	0	1982	75800.	86	1941	18500.	0.9556
0	0	1983	94100.	87	1894	18000.	0.9667
0	0	1984	62800.	88	1934	15400.	0.9778
0	0	1985	84800.	89	1895	9640.	0.9889

-FREQUENCY CURVE- 05543500

.....FLOW,CFS.....			...CONFIDENCE LIMITS...	
COMPUTED	EXPECTED PROBABILITY	EXCEEDANCE PROBABILITY	0.05 LIMIT	0.95 LIMIT
125000.	128000.	0.002	148000.	109000.
114000.	116000.	0.005	133000.	100000.
105000.	107000.	0.010	122000.	93100.
95900.	97300.	0.020	110000.	85700.
86500.	87400.	0.040	98000.	78000.
73100.	73600.	0.100	81400.	66800.
62000.	62200.	0.200	68000.	57200.
44200.	44200.	0.500	47800.	41100.
30600.	30500.	0.800	33200.	28000.
25000.	24800.	0.900	27400.	22400.
21000.	20700.	0.950	23300.	18400.
14800.	14400.	0.990	17000.	12500.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	4.6366	HISTORIC EVENTS	0
STANDARD DEVIATION	0.1827	HIGH OUTLIERS	0
COMPUTED SKEW	-0.2479	LOW OUTLIERS	1
GENERALIZED SKEW	-0.4000	ZERO OR MISSING	0
ADOPTED SKEW	-0.3000	SYSTEMATIC EVENTS	89

MARSEILLES 05543500

FLOW DURATION

Plates D-34 through D-46 show the flow-duration curve for the Marseilles USGS gage for the period 1920-1987.

HEAD DURATION

Plates D-89 through D-100 show the Marseilles head duration curves for the years 1940-1978.

ELEVATION HYDROGRAPHS

The elevation-hydrographs at the Marseilles Lock and Dam site for the period 1970-1989 are shown on plates D-101 and D-102.

OTHER STUDIES

Flood Insurance Studies for Grundy and LaSalle Counties, the city of Morris, and the village of Seneca contain water surface profiles for the 10-, 50-, 100-, and 500-year floods and inundation limits for the 100- and 500-year floods.

Map Atlas of the Upper Illinois River published in 1971 by the Illinois Department of Public Works, Division of Waterways, shows the Illinois Waterway and topography of its floodplain using a 2-foot contour interval.

Information on the December 1982 floods in Illinois is contained in USGS Open-File Report 83-213, *Floods of December 1982 and January 1983 in the Central and Southern Mississippi River Basin*. Additional flood information is contained in USGS Water Resources Investigations 77-117, *Techniques for Estimating the Magnitude and Frequency of Floods in Illinois*.

Information on the magnitude and frequency of low flows is found in USGS Open-File Report, *Statistical Summaries of Illinois Streamflow Data*, 1969, and in Illinois State Water Survey Bulletin No. 1, *The 7-Day 10-Year Low Flows of Illinois Streams*, 1973.

A *Feasibility Report for Hydropower, Marseilles Lock and Dam* was prepared by the Rock Island District, Corps of Engineers.

REGULATION PLAN

The Marseilles Lock and Dam project was designed and constructed, and is regulated, to maintain navigation on the Illinois Waterway. The dam is operated to maintain a normal pool elevation of 483.17 feet NGVD, in order to provide a 9-foot navigation channel between RM 244.5 and 271.5 on the waterway. The lock permits passage of river traffic from the lower to the upper pool and vice versa. The maximum lift is 27.0 feet.

MAJOR CONSTRAINTS

Marseilles Lock and Dam is operated for the maintenance of year-round navigation on the Illinois Waterway. At times, navigation is severely hampered by flood and ice conditions on the waterway. The clearance between high water stages and low steel at the railroad bridge at Seneca and the highway bridge at Morris limits navigation for large river boats during floods.

The smaller river boats have difficulty negotiating a reach at Johnson Island, RM 249 to 250, whenever gate openings at Marseilles dam exceed a total of 20 feet. When total gate opening exceeds 40 feet, the larger river boats have difficulty in this reach. In order to alleviate these navigation problems, an effort is made to hold the pool elevation between 482.8 and 483.0 feet. Tainter gate openings from 5 to 8 feet are seldom used; no problems have been experienced with openings up to 5 feet.

The rigors of severe winter weather pose the greatest constraints upon operations. Problems associated with ice have become more numerous and severe in recent years as water quality in the waterway has improved. Ice floes and frazil ice accumulations jamming the lock chamber and approaches and impeding the operation of the miter gates has, on occasion, required reduction of tow widths. A bubbler system to alleviate icing conditions at the lock has been installed. At the dam, it is expected that all, or most, of the problems associated with winter operation would be eliminated with the installation of submersible tainter gates and new operating machinery.

Accumulation of drift and debris on the screens at the intakes to the valve tunnels has been a fairly frequent problem at Marseilles Lock. Cleaning the screens usually is done with a crane and clamshell bucket. When this has not been effective, divers have been used to help dislodge the debris. Lock and dam personnel suggest that screens be cleaned about every 6 months.

Occasionally, during low flow, the lockmaster has requested a reduction in power generation at the Illinois Power Company hydroelectric plant in order to maintain pool level. Maintenance of navigation takes precedence over power generation when these water uses conflict.

In normal operations, tainter gates on the main dam nearest the right bank are opened first. Even-numbered gates are used in even-numbered months; odd-numbered gates are used in odd-numbered months.

SEDIMENTATION

Especially during heavy rainstorms, large amounts of untreated sewage solids and sediments are released to the waterway from the Chicago area, supplemented by releases from industries and municipalities along the waterway. Obviously, the impact of these releases is greatest in the upper part of the waterway downstream from Chicago. In 1971, the Illinois State Water Survey made a study of the sediments and their oxygen demand between Chillicothe (RM 180) and Lockport (RM 292). In the Marseilles pool, the bottom sediments were found to be sand, gravel, and in some places large rocks, and generally clean. Estimated sediment oxygen demand ranged between 0 and 1 gram per square meter per day for about a mile downstream from Dresden Island Lock and Dam and from 1 to 2 grams per square meter per day for the remainder of the reach to Marseilles dam. Computed dissolved oxygen depletion rates due to sediment oxygen demand in the Marseilles pool ranged from 0.4 milligrams per liter at average river flow to 1.5 milligrams per liter at the 7-day 10-year low flow.

No daily records of suspended sediment have been obtained in the area between the Dresden Island and Marseilles Locks and Dams. Fragmentary records of suspended sediment concentration, discharge, and particle size have been collected by the USGS on the Illinois River at Marseilles since 1974. The Illinois State Water Survey has collected records of suspended sediment concentration, discharge, and particle size on the Mazon River near Coal City since October 1980. Samples are collected weekly at this location. The Illinois State Water Survey has calculated the average annual sediment yield at the Coal City site to be 304 tons per square mile.

DREDGED MATERIAL INVESTIGATIONS

Table D-8 contains the record of channel maintenance dredging since 1969. The total volume of materials dredged from the Marseilles pool 1969-1979, April 1982-1984 was 253,037 cubic yards. The places requiring most attention included the reach in the Johnson Island cut, a reach adjacent to Grist Island, a reach at the Seneca shipyard, and a reach just downstream from Dresden Island Lock. No information is available on the composition of the dredged material.

TABLE D-8

Dredging in Marseilles Pool

Year	Cubic Yards
1969	11,850
1970	12,700
1971	13,850
1972	3,300
1973	17,900
1974	17,200
1975	2,100
1976	25,400
1977	52,950
1978	4,500
1979	900
1980	0
1981	0
1982	4,273
1983	75,554
1984	10,560

Note: Records not available January 1980 through March 1982.

HYDROELECTRIC POWER

The Rock Island District recently (1985) completed a feasibility study on hydropower at Marseilles Lock and Dam. This report considers three alternatives for hydropower: (1) making improvements to the existing power plant in the north channel; (2) constructing a new hydroplant in the north channel; and (3) constructing a new plant farther downstream adjacent to the Marseilles lock.

CHANNEL SURVEY AND MAINTENANCE

Channel surveys are not made on a regular schedule. If problems are encountered in the pool, lock and dam personnel notify the Corps of Engineers' Peoria field office. They, in turn, dispatch a boat to conduct soundings or otherwise identify the problem source. Remedial action is scheduled following problem identification.

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I* states:

"A new supplemental lock will be located in the Marseilles Canal north of the existing lock at mile 244.6. Future widening of the Marseilles Canal from its present width of 200 feet for a distance of about 8,400 feet was authorized by the Rivers and Harbors Act of 1935 as described in paragraph 21. It is proposed that widening of Marseilles Canal be accomplished at the time of lock construction to reduce congestion at the upper approaches. It is proposed to widen the canal along its entire 2-1/2 mile length from 200 to 300 feet. The Illinois River Rapids north of the new lock will be diverted slightly to prevent turbulence at the downstream approach. The design features of the new lock will be similar to the new lock at Dresden Island described in the previous paragraph, except for the lift which will be approximately 24 feet. In addition to the work described above, the tainter gate piers of the existing Marseilles Dam will require strengthening. The strengthening will be accomplished by the use of grouted tendons."

1990 MARSEILLES NAVIGATION CANAL STUDY

GENERAL

Hydraulic analysis performed for this study included backwater computations, unsteady flow numerical modeling, and various tow squat computations. The 1988 navigation canal soundings were used for these computations.

EXISTING CONDITIONS - LOCK FILLING DRAWDOWN

An unsteady flow model was developed to analyze the drawdown experienced during the lock filling process. Lock filling data dictated a lock chamber filling time of 20 minutes. This was based on opening the valve one-third of the way until the elevation in the lock chamber is 464.6, then the valves are open to "full open." The lock filling hydrograph peak was computed (using Waterways Experiment Station Program H5320 Lock Filling and Emptying-Symmetrical System) to be between 2,200 cfs and 3,000 cfs. This is the normal and most optimal operation filling sequence possible. Immediately upstream of the lock chamber the unsteady flow model computed 0.3 foot of drawdown in water surface elevation. At the upstream entrance of the navigation canal the model computed 0.1 foot of drawdown in water surface elevation. Based on this insignificant drawdown, it was felt that other (less than optimum) lock gate valve speeds/operations were not required.

The model results were field verified on March 24, 1988, using a survey rod and a video camera.

This model also analyzed the drawdown experienced at the narrowest section (width) of the navigation channel (RM 246.1-246.2) with and without a tow in the navigation canal. The drawdown in water surface elevation at this narrow location is 0.5 foot for both conditions.

TOW SQUAT

Tow squat is the vertical drop of the tow due to motion, measured from the still water level. There are several possible mechanisms for producing tow squat.

DISPLACEMENT SQUAT

Displacement squat occurs when the water adjacent to the tow is set into motion by the displacement of the tow. To maintain the same total energy, the water surface must drop by an amount equivalent to the kinetic energy of the moving water. This drop in water level results in squat of the tow. Displacement squat is related mainly to tow speed, ratio of tow cross-sectional area to waterway cross-sectional area, and depth of water.

At the upstream entrance to the navigation canal, a displacement squat computation was performed assuming a channel width of 200 feet, a tow width of 105 feet, channel depth of 10.5 feet, tow draft of 9 feet, and a tow speed of 4 feet/second. The resulting displacement squat was 0.76 foot. If the tow draft was increased to 9.5, the resulting displacement squat increased to 0.97 foot.

Other types of squat (supersquat, piston, propeller, and moment squat as discussed in Waterways Experiment Station TR HL-87-3) were considered to be insignificant for conditions of this study.

DESIGN ALTERNATIVE CONDITIONS

It was found that displacement squat was significant enough to cause downbound towboat traffic "striking" at the entrance of the navigation canal. Because displacement squat is a function of tow speed, cross-sectional area, and depth of water, several canal configurations were considered. Table D-9 summarizes the alternatives considered. These existing/design alternatives assume a triple barge width (35 x 3) of 105 feet and a tow speed of 4 feet/second.

TABLE D-9

Towboat Displacement Squat

	Squat in Feet with Tow Draft 9 feet	9.5 feet
Existing Condition Canal Dimensions:		
200 feet wide by 10.5 feet deep	.76	.97
Design Condition Canal Dimensions:		
200 feet wide by 12.0 feet deep	.47	.54
300 feet wide by 10.5 feet deep	.29	.32
300 feet wide by 12.0 feet deep	.22	.24

The table above indicates that maximum benefits can be obtained with a deeper channel as compared to a shallower-wider channel. A 200-foot-wide 12-foot-deep channel will provide clearance of 1.96 feet, while a 300-foot-wide 10.5-foot-deep channel will provide only 0.68 foot of clearance assuming a tow draft of 9.5 feet. Although the squat is somewhat reduced in the wider channel, alternatives providing a deeper channel result in a more significant increase in clearance.

Marseilles Lock and Dam
Pertinent Data

General

Location:	Dam is at head of Bells Island at Marseilles, Illinois, RM 247.0. Lock is at the foot of Bells Island, RM 244.6.
Purpose:	Navigation
Drainage Area Above Dam:	8,259 square miles
Time of Water Travel:	From Dresden Island Lock and Dam to Marseilles is 6 hours.
Maximum Discharge of Record:	94,100 cfs, December 4, 1982

Dam

Type:	Gated concrete gravity
Length:	Main dam, 598.5 feet; south channel headrace dam, 111 feet; north channel headrace dam, 206 feet.
Number and Kind of Gates:	Main dam, 8 tainter gates and ogee spillway at ice chute; south channel headrace dam, 1 tainter gate; north channel headrace dam, 2 tainter gates.

Lock

Width:	110 Feet
Length:	600 Feet
Maximum Lift:	27 Feet
Average Lift Based Upon 50 Percent Flow Duration:	24 Feet
Lock Filling and Emptying Time:	Average filling time is 15 minutes; average emptying time is 10 minutes.
Valve Tunnels:	Culverts in each lock wall are 12 feet in diameter.
Valve Tunnel Intakes:	18 feet wide by 12 feet high.
Lock Chamber Wall Ports:	10 ports in each wall, each port 5 feet wide by 3.5 feet high.

Hydrology

Drainage Area:	8,259 square miles
Climate:	Continental, variable
One Inch Runoff Equals:	440,480 acre-feet
Storm Types:	Variable

Flood Season:	Spring and summer
Low Flow Season:	Fall and winter
Minimum Daily Average Flow and Date:	1,460 cfs, October 16, 1943
Minimum Monthly Average Flow and Date:	3,202 cfs, January 1963
Minimum Annual Average Flow and Date:	5,731 cfs, 1964 C.Y.
Average Annual Flow:	10,760 cfs
Maximum Annual Average Flow and Date:	17,600 cfs, 1927 C.Y.
Maximum Monthly Average Flow and Date:	41,290 cfs, March 1979
Maximum Daily Average Flow and Date:	87,800 cfs, December 4, 1982
Maximum Instantaneous Flow and Date:	94,100 cfs, December 4, 1982
Maximum Daily Flood Volume and Date:	174,150 acre-feet, December 4, 1982
Maximum Headwater Stage:	484.55 feet NGVD, December 5, 1982
Minimum Headwater Stage:	Between 480.5 and 481.0 feet NGVD, sometime in 1940-1973 period.
Name and Location of Key Streamflow Stations:	Illinois Waterway at Dresden Island Lock and Dam; Mazon River near Coal City, Illinois; Illinois River at Marseilles, Illinois.
Type of Hydrometeorological Data Obtained at Site:	Precipitation, temperature
Number of Sediment Ranges:	17
Ice Break-Up Period:	February-March

REFERENCES

U.S. Army Engineer Waterways Experiment Station, Carl J. Huval, *Lock Approach Canal Surge and Tow Squat at Lock and Dam 17 Arkansas River Project*, Technical Report HL-80-17, September 1980.

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U.S. Army Engineer Waterways Experiment Station, Stephen T. Maynord, *Safe Navigation Speeds and Clearance at Lower Sill, Temporary Lock 52, Ohio River*, Technical Report HL-87-3, April 1987.

U.S. Army Engineer Waterways Experiment Station, M.B. Boyd, *Chicago Sanitary and Ship Canal and Des Plaines River Surge Study*, August 1974.

U.S. Army Engineer District, Rock Island, *Illinois Waterway Marseilles Dam Major Rehabilitation, Design Memorandum No. 1, General Design Memorandum and Draft Environmental Assessment*, November 1984.

Interagency Advisory Committee on Water Data, *Guidelines for Determining Flood Flow Frequency*, (Bulletin No. 17B of the Hydrology Subcommittee) September 1981.

Barkau, R.L., *A Mathematical Model of Flow through a Dendritic Network*, Dissertation, Colorado State University, Ft. Collins, Colorado, 1985.

SECTION 6 - STARVED ROCK LOCK AND DAM

GENERAL

The primary function of Starved Rock Lock and Dam is to maintain navigation on the Illinois Waterway. The Starved Rock Lock and Dam is located at Illinois RM 231, 5 miles upstream of the city of LaSalle, Illinois. The drainage area of the Illinois River at Starved Rock is 11,056 square miles. The lock chamber has miter gates at both ends and an area of 110 feet by 600 feet. The maximum lift between the upper and lower pools is 18.7 feet. The dam facilities include 10 tainter gates, a 30-foot ice chute, and 30 headgate structures. The dam maintains a pool that usually varies between elevations of 485.5 and 459.0 feet NGVD. The pool extends upstream about 13.5 miles to Marseilles Lock.

PHYSICAL COMPONENTS

LOCK

The lock at the right bank of the waterway has a usable chamber 110 feet wide by 600 feet long. The maximum lift is 19 feet, and the average lift is 17 feet. Concrete gravity type lock walls are 925 feet long, have a top width of 10 feet, and a top elevation of 463.5 feet NGVD. Upper and lower right guide walls are 598 and 594 feet long, respectively. Miter type upper and lower service gates are 64.91 feet long from center to center of bearings. The upper gate is 20 feet high, and the lower gate is 36 feet high. About 80 feet upstream from the upper service gate, are miter type guard gates that are submerged and in open position at all times. Valve tunnels, or culverts, 12 feet in diameter with centerline at elevation 429.5 feet NGVD are in each lock wall for filling and emptying the lock chamber. The intake to each tunnel is 18 feet wide by 12 feet high and is covered by a trash rack. Connecting the tunnels to the lock chamber are 10 ports, 5 feet wide by 3.5 feet high, in each lock wall. The floor of the lock chamber is at elevation 424.5 feet NGVD, the upper gate sill is at elevation 441.65 feet NGVD, and the lower gate sill is at elevation 425.5 feet NGVD.

Upstream and downstream lock approach channel cross sections are located on plate D-103 and are shown on plates D-104 and D-105.

DAM

The dam is 1,280 feet long from the left bank of the waterway to the left abutment of the lock. It consists of a fixed dam section, a headgate section, boiler house, ice chute, and a tainter gate section.

The fixed dam section is 30 feet long. It ties the headgate section into the lock abutment.

The headgate section is 518 feet long and contains 30 vertical lift gates. Each headgate opening is 16 feet high and 14 feet wide with the flow line at elevation 442.5 feet NGVD. The gate openings were filled with 3-foot-thick concrete plugs in 1982.

The boiler house is 18 feet wide and lies between the headgate section and the ice chute. It houses a boiler and miscellaneous equipment used for tainter gate operation.

The ice chute has a spillway section 30 feet wide and a submersible tainter gate. The gate is no longer operable.

The tainter gate section is 684 feet long and contains 10 gates that are 60 feet wide by 17 feet high. The gates close on steel channels imbedded in the concrete sill at elevation 441.5 feet NGVD. The gates are used to maintain the desired pool elevation.

MAJOR REHABILITATION

1957 - Completed reconstruction of upper guide wall.
1963 - Resurfaced top of lock walls.
1968 - Installed floating mooring bit recesses.
1974 - Resurfaced upper headgate section.
1978 - Resurfaced vertical face of lock walls and rehabilitated gate machinery.
1978-79 - Electrical rehabilitation of the lock.
1980-82 - General rehabilitation of the dam.

HYDROLOGY

GENERAL

The area tributary to the project reach is 2,784 square miles. The Fox River, with a drainage are of 2,658 square miles, accounts for more than 95 percent of this area. The Fox River rises northwest of Milwaukee, Wisconsin, near the north line of Waukesha County, flows southerly to its

junction with the Illinois Waterway at Ottawa, Illinois; 870 square miles of its drainage basin is in Wisconsin.

The waterway width in this reach varies from about 600 to 4,000 feet. The navigation channel maintained by the Corps of Engineers is 300 feet wide. The thalweg has a gentle slope of less than a foot per mile. Bulls, Scherer, Hitt, Mayo, Sheehan, and Delbridge Islands occur along the reach. Bluffs along each bank vary from about 50 to more than 150 feet in height above the floodplain. The width of the valley between bluffs varies from about 1.2 to 2.0 miles.

FLOW DURATION

In general, flows are never less than 2,000 cfs due to the Lake Michigan diversion. The annual 50 percent duration flow at Starved Rock is about 8,000 cfs. Flows, which are generally highest in the spring and winter and lowest in the summer and fall months, can fluctuate widely from day to day. Flows range from 3,000 to 21,500 cfs on an annual basis 90 percent of the time. Annual and monthly flow duration curves for Starved Rock are presented as plates D-106 through D-118.

HEAD DURATION

Features at Starved Rock include pool and tailwater gages from which daily stage readings are taken. Daily stage readings for these gages are available for the period 1940-1979 from computer tapes developed by the Chicago District, Corps of Engineers. The pool and tailwater gages are located upstream and downstream of the lock chamber. A daily head file was developed by a computer program which subtracted the daily tailwater stages from the daily pool stages. This daily gross head file was used to develop head duration curves. Head duration curves were developed from the daily gross head data. These curves are presented as plates D-119 through D-131 for annual as well as monthly intervals.

ELEVATION HYDROGRAPHS

The elevation hydrographs at the Starved Rock Lock and Dam site for the period 1970 through 1989 are shown on plates D-132 and D-133.

OTHER STUDIES

Flood Insurance Studies for the city of Ottawa and for the Unincorporated Areas of LaSalle County show water surface profiles for the 10-, 50-, 100- and 500-year floods and inundation limits for the 100- and 500-year floods.

REGULATION PLAN

The Starved Rock Lock and Dam project was designed and constructed, and is regulated, to maintain navigation on the Illinois Waterway. The dam is operated to maintain a normal pool elevation of 458.7 feet NGVD in order to provide a 9-foot navigation channel between RM 231 and 244.5 on the waterway. The lock permits passage of river traffic from the lower to the upper pool and vice versa. The maximum lift is about 19 feet.

MAJOR CONSTRAINTS

Starved Rock Lock and Dam is operated for the maintenance of year-round navigation on the Illinois Waterway. At times, navigation is severely hampered by flood and ice conditions on the waterway. The clearance between high water stages and low steel at the railroad and the highway bridges at Ottawa limits navigation for large river boats during floods. Silt accumulation, requiring rather frequent dredging, and ice gorges at Bulls Island Cut just upstream from Ottawa occasionally have presented problems.

A number of drownings have occurred at, and near, this facility. Starved Rock State Park, heavily used by the public, obviously increases the potential for accidents and mishaps in this area.

SEDIMENTATION

Especially during heavy rainstorms, large amounts of untreated sewage solids and sediments are released to the waterway from the Chicago area, supplemented by releases from industries and municipalities along the waterway. Obviously, the impact of these releases is greatest in the upper part of the waterway downstream from Chicago. In 1971, the Illinois State Water Survey made a study of the sediments and their oxygen demand between Chillicothe (RM 180) and Lockport (RM 292). In the Starved Rock pool, the bottom sediments were found to be relatively clean sands and gravels from Marseilles lock to Ottawa. Below Ottawa, bottom sediments were composed of mud and muck, having an oily smell in some places. Estimated sediment oxygen demand ranged between 0 and 1 gram per square meter per day from Marseilles dam downstream to RM 243.7 and from 1 to 2 grams per square

meter per day for the remainder of the reach to Starved Rock dam. Computed dissolved oxygen depletion rates due to sediment oxygen demand in the Starved Rock pool ranged from 0.5 milligram per liter at average river flow to 1.6 milligrams per liter at the 7-day 10-year low flow.

Currently, there are no active sediment stations in the area between Marseilles and Starved Rock. For the Fox River at Dayton, the Illinois State Water Survey calculated the sediment yield for the water year ending September 30, 1981, to be 74 tons per square mile.

DREDGED MATERIAL INVESTIGATIONS

Table D-10 contains the record of channel maintenance dredging January 1969 through December 1979, April 1982 through December 1984. No information is available on the composition of the dredged material.

TABLE D-10

Dredging in Starved Rock Pool

Year	Cubic Yards
1969	5,150
1970	8,400
1971	10,100
1972	0
1973	8,650
1974	32,150
1975	11,200
1976	20,400
1977	150
1978	0
1979	24,900
1982	2,114
1983	19,671
1984	4,830

Note: Dredging quantity by pool not available January 1980 through March 1982.

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I* states:

"A new supplemental lock will be located north of the existing lock at mile 231.0. Although this site will require extensive excavation and the

relocation of the Corps of Engineers equipment storage yard, it provides a good alignment for both upstream and downstream approaches, and does not interfere with the existing dam structure. In addition, lock construction at this site can be completed in the dry, eliminating the need for cofferdamming. The design features of the new lock will be similar to the new lock at Dresden Island, except for the lift which will be approximately 18.5 feet."

Starved Rock Lock and Dam
Pertinent Data

General

Location:	About 1.5 miles southeast of Utica, Illinois, RM 231.0.
Purpose:	Navigation
Drainage Area:	11,056 square miles
Time of Water Travel:	From Marseilles Lock and Dam, 2 hours
Maximum Discharge of Record:	108,500 cfs, December 5, 1982

Dam

Type:	Gated concrete gravity
Length:	Overall length, 1,280 feet
Fixed Dam Section:	At right end of dam, 30 feet long
Headgate Section:	518 feet long having 30 headgates with flow line at 442.5 feet NGVD. Gates plugged with concrete in 1982.
Ice Chute Section:	52 feet long; submersible tainter gate is inoperable.
Tainter Gate Section:	680 feet long with 10 tainter gates. Elevation of spillway crest under gates is 441.5 feet NGVD.

Lock

Width:	110 feet
Length:	600 feet
Maximum Lift:	19 feet
Average Lift Based Upon 50 Percent River Stage Duration:	17 feet
Lock Filling and Emptying Time:	Average filling time is 12 minutes; average emptying time is 9 minutes.
Valve Tunnels:	Culverts in each lock wall are 12 feet in diameter.
Valve Tunnel Intakes:	18 feet wide, 12 feet high
Lock Chamber Wall Ports:	10 ports in each wall, each port 5 feet wide, 3.5 feet high.

Hydrology

Drainage Area:	11,056 square miles
Climate:	Continental, variable
One Inch Runoff Equals:	589,653 acre-feet
Storm Types:	Variable
Flood Season:	Spring and summer
Low Flow Season:	Fall and winter
Minimum Daily Average Flow and Date:	1,840 cfs, October 16, 1943
Minimum Monthly Average Flow and Date:	3,640 cfs, January 1963
Minimum Annual Average Flow and Date:	6,535 cfs, 1964
Average Annual Flow:	12,603 cfs

Maximum Annual Average Flow and Date:	19,650 cfs, 1927
Maximum Monthly Average Flow and Date:	53,500 cfs, March 1979
Maximum Daily Average Flow and Date:	108,300 cfs, December 5, 1982
Maximum Instantaneous Flow and Date:	108,500 cfs, December 5, 1982
Maximum Daily Flood Volume and Date:	214,810 acre-feet, December 5, 1982
Maximum Headwater Stage:	466.1 feet NGVD, December 5, 1982
Minimum Headwater Stage:	455.1 feet NGVD, March 28, 1982
Name and Location of Key Streamflow Stations:	Illinois River at Marseilles, Illinois; Fox River at Dayton, Illinois.
Type of Hydrometeorological Data Obtained at Site:	Precipitation, temperature
Number of Sediment Ranges:	11
Ice Break-Up Period:	February-March

SECTION 7 - PEORIA LOCK AND DAM

GENERAL

The Peoria pool extends from the Peoria Lock and Dam at RM 157.7 to Starved Rock Lock and Dam at RM 231.0.

PHYSICAL COMPONENTS

LOCK

The Peoria lock is on the left bank of the Illinois River, 4 miles downstream of the city of Peoria, just downstream of the Keystone Canal. It has a usable chamber 110 feet wide by 600 feet long and a maximum lift of 11 feet. The concrete gravity type lock walls have a top elevation of 445.0 feet NGVD. The river wall is 923 feet long and 29.0 feet wide, and the land wall is 937.5 feet long. Guide walls 500 feet long extend upstream and downstream from the land wall of the lock. The upper and lower service gates are 64.91 feet long from center to center of bearings. The upper gate is 17.5 feet high, and the lower gate is 25 feet high. In each lock wall there is a 14-foot diameter valve tunnel with centerline at elevation 422.5 feet NGVD and about 437 feet long paralleling the central portion of the lock chamber. At each end of these culverts, the valve tunnels transition to 12.5- by 12.5-foot tunnels with centerline at elevation 421.75 feet NGVD. Just downstream from the intakes near the upper end of the lock, the valve tunnels are 12.5 feet wide by 14 feet high with centerline at elevation 428.0 feet. Six openings, each 5 feet wide by 7.5 feet high, are the intakes to each valve tunnel. These are covered by trash racks. Connecting the valve tunnels to the lock chamber are 20 ports, 4 feet wide by 3 feet high, in each lock wall. The lock floor is at elevation 415.50 feet NGVD, the upper gate sill is at elevation 424.5 feet NGVD, and the lower gate sill is at elevation 417.0 feet NGVD.

Upstream and downstream lock approach channel cross sections are located on plate D-134 and are shown on plates D-135 and D-136.

WICKET DAM

The Chanoine Wicket Dam extends 436 feet from the lock wall to the regulating weir at the right bank. It consists of 108 wickets, 3.75 feet wide, 16.42 feet high, and 1.0 foot thick. There is a 3-inch gap between wickets. The wickets form a 20-degree angle from vertical when in the upright (closed) position. The wickets are used to regulate the streamflow

by completely raising various numbers of them to maintain an upstream pool elevation of approximately 440.0 feet NGVD. The wickets are lowered during high and medium flows to permit boat traffic over the wicket dam rather than through the navigation locks. Two rows of baffle blocks downstream of the wickets dissipate the energy of the current to prevent scour downstream of the dam.

The wickets are supported by an A-frame structural steel horse, with a forged steel prop that rests against a concrete step on the downstream portion of the sill. The wickets are operated individually by a maneuver boat equipped with a hoist to raise and lower the wickets. Hurters, located near the downstream end of the dam base, guide and support the props as the wickets are operated.

REGULATING DAM

The regulating dam, located on the right side of the stream channel adjacent to the wicket dam, consists of an abutment with a single inlet and six outlet ports. A 6-foot by 6-foot cast steel butterfly valve is located in each outlet port. The inlet port sill elevation is 425.0 feet NGVD. The six outlet ports' sill elevations are at 421.85 feet NGVD. The ports are submerged at all times. The flow enters the upstream inlet through a screened opening 26 feet wide by 9.5 feet high and is discharged through the six outlet ports parallel to the wicket dam onto the stilling basin apron. Each valve has a net cross section area of 29.4 square feet when full open. The net cross section of the trash rack opening is 157 square feet, therefore controlling the flow when all six valves are open. Each butterfly valve is operated manually using an electric drill with a special chuck. The regulating dam is used to provide additional regulation for the wicket dam.

MAJOR REHABILITATION

Since the original construction, the following major rehabilitation work has been performed:

1981-82 - Replacement of all electrical service to control stands, traffic lights, navigational lights, and tow haulage units.

1982 - Installation of bubbler system to alleviate ice conditions in lock.

1984 - Replacement of lock lighting with two high-masted high-pressure sodium light standards. Replacement of second floor windows of control house with new energy-efficient windows and removal of all first floor windows and filling voids with brick and mortar.

1987-89 - Installation of riprap and derrick stone as scour protection at the wicket dam. Installation of submersible tainter gate to replace 26 wickets on the wicket dam. Replacement of the upper guide wall of the lock. Rehabilitation and replacement of some of the existing lock machinery. Plugging with concrete the regulating structure housing the butterfly valves.

HYDROLOGY

GENERAL

Between Starved Rock and Peoria, 3,234 square miles drain into the Illinois Waterway. Two-thirds of this tributary area is accounted for by the Vermilion River and Big Bureau and Kickapoo Creeks. The largest of these is the Vermilion River, a left-bank tributary about 110 miles long and draining 1,331 square miles.

CHANNEL AND FLOODWAY

Lakes, sloughs, and marshes abound in this reach of the waterway. USGS topographic maps reveal the presence of more than 20 off-stream sloughs and lakes and 5 on-stream lakes. The width of the waterway varies greatly, from about 400 feet at Peru to more than 11,000 feet in the Upper Peoria Lake area. The navigation channel maintained by the Corps of Engineers is 300 feet wide. Numerous islands also dot the waterway.

Very low-flow conditions in the Illinois River and tributaries in late August and September 1984 created a condition in the Peoria pool in which towboats had difficulty navigating the waterway both above and below the Peoria Lock and Dam. The lockmaster raised the wickets and placed as many needles as possible without reducing the flow to a critical level. An emergency release was made from Lake Michigan for about 48 hours in an attempt to raise the Peoria Lake water level. This resolved the problem as the volume required was stored and raised the pool to navigable level.

STAGE DURATION

Plates D-137 through D-148 shown the stage duration curves at Peoria for the years 1946 through 1985.

ELEVATION HYDROGRAPHS

The elevation hydrographs at the Peoria Lock and Dam site for the period 1970 through 1989 are shown on plates D-149 and D-150.

REGULATION PLAN

Peoria Lock and Dam was designed and constructed, and is regulated, to maintain navigation on the Illinois Waterway. The dam is operated to maintain a normal pool elevation of 440.0 feet NGVD, in order to provide a 9-foot navigation channel between RM 157.7 and 231 on the waterway. The lock is operated to enable river traffic to pass from the lower to the upper pool and vice versa. The maximum lift is about 11 feet.

MAJOR CONSTRAINTS

Peoria Lock and Dam is operated for the maintenance of year-round traffic on the Illinois Waterway. At high and medium flows, there is sufficient depth in the waterway so that open river conditions prevail. The wickets are in the down position and the lock is not used under these circumstances. As the flow recedes, a point is reached when wickets at the dam have to be raised in order to maintain navigation depths. The principal control point is at Henry, and a supplementary control point is the headwater at the dam.

With the new tainter gate installation, operation of the regulating weir ceased, the remaining wickets are operated in the all-up or the all-down positions, wicket changes are reduced and made under low head conditions, and ice will be passed more effectively. Thus, tainter gate operation has increased the efficiency while reducing the hazards of regulating flows at the facility.

A bubbler system using compressed air has been installed at the upper and lower lock gates and along a "deflector" line running diagonally upstream from the head of the river wall of the lock to the land wall. The system has proven to be quite effective in alleviating problems with winter operation of the lock.

At times, drift and debris have accumulated at the trash rack at the entrance to the butterfly valve chamber.

SEDIMENTATION

Presently, there are only two active suspended sediment stations in the area between Starved Rock and Peoria. The Illinois State Water Survey has collected weekly suspended sediment samples on the Vermilion River near Leonore since 1983. Records of daily suspended sediment concentration and discharge and several particle size analyses were obtained by the USGS at this site from June 1980 to September 1981. On the Illinois River at Henry, the USGS has obtained records of daily suspended sediment concentration and discharge and periodic records of particle size distribution since June 1983.

The Illinois State Water Survey (1983) calculated the sediment yield for the year ending September 1981 as 238 tons per square mile for the Vermilion River at McDowell (drainage area 551 square miles) and 529 tons per square mile for Big Bureau Creek at Princeton (drainage area 196 square miles).

Although the water discharge for the 1984 water year was well above average, the suspended sediment yield at the gaging station on the Illinois River at Henry was low. This indicates that a large part of the sediment inflow from tributaries settles out when it reaches the slow-moving Illinois River.

In 1972, the Illinois State Water Survey investigated the Illinois Waterway from Chillicothe (RM 179) to Lockport (RM 292). The upper reaches of the Peoria pool were found to consist principally of muddy sand bottoms; the middle reaches contained small coal and shell fragments; and in the lower reaches below Lacon thick, oily muck was predominant.

DREDGED MATERIAL INVESTIGATIONS

Table D-11 shows the record of dredging in the Peoria pool for the period 1955-1985. The most persistent shoaling locations are between Peoria Lock and Dam and Farm Creek, RM 157.7 to 163; the upper end of the Upper Peoria Lake, RM 174 to 178; the mouth of Senachwine Creek in Chillicothe, RM 181.8; and between Spring Valley and Peru, RM 218.5 to 220.5. The Corps of Engineers conducts intensive sampling of bed material cores and of the water column just prior to, during, and immediately after dredging operations. These samples are analyzed in the laboratory by a contractor. Dredged spoil is generally spread along the banks of the waterway near the dredging sites.

TABLE D-n

Dredging in Peoria Pool

Year	Cubic Yards
1955	0
1956	57,000
1957	0
1958	0
1959	125,000
1960	0
1961	20,000
1962	175,000
1963	0
1964	0
1965	0
1966	8,000
1967	18,000
1968	70,000
1969	40,000
1970	0
1971	67,000
1972	0
1973	62,000
1974	0
1975	0
1976	9,000
1977	171,000
1978	0
1979	42,000
1980	0
1981	0
1982	0
1983	0
1984	0
1985	11,000

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I states:*

"A new supplemental lock will be located at the west abutment of the exist ing dam across the channel from the existing lock. This site provides a good alignment for both upstream and downstream approaches and avoids costly relocation of oil and chemical company facilities and railroads along the east bank of the river. It does require the relocation of the Keystone Canal. The underlying geologic formation at the selected site

consists of glacial till necessitating the use of steel "H" piles to support the lock masonry which will consist of concrete gravity type walls. The usable lock chamber will be 110 feet wide by 1,200 feet long, with miter service gates for both the upstream and downstream ends. The lift will be approximately 11 feet and because of this low lift, a side port filling system was selected. An emergency gate was not considered in the new lock because an accidental breach in the gates of the lock would not cause any loss to life or damage to property downstream from the lock. Also, an emergency closure by the use of bulkheads would save the navigation pool and Peoria Lake."

Peoria Lock and Dam
Pertinent Data

General

Location:	About 4 miles downstream from Peoria, Illinois, RM 157.7.
Purpose:	Navigation
Drainage Area:	14,554 square miles
Time of Water Travel:	From Starved Rock Lock and Dam, about 2 days.
Maximum Tailwater Stage of Record:	455.9 feet, May 1943

Dam

Type:	Movable wicket-type, concrete and timber.
Length:	Overall length, 570 feet
Movable Dam:	436 feet long containing 108 Chanoine wickets. Each wicket 3.75 feet wide, 16.42 feet high, 0.25-foot gap between wickets. Sill elevation, 424.6 feet NGVD.
Regulating Dam:	34 feet wide from river face of longitudinal intake culvert to right abutment. Six butterfly valves in river side of intake

	culvert. Valve openings are 6 feet by 6 feet with sill elevation of 421.85 feet NGVD.
Earth Dike:	Dike with 14-foot crown at elevation 443.0 feet NGVD, extends landward from right abutment of butterfly valve intake culvert 110 feet.
Length:	600 feet
Maximum Lift:	11 feet
Average Lift Based Upon 50 Percent River Stage Duration:	6 feet
Lock Filling and Emptying Time:	10 minutes
Valve Tunnels:	12.5- by 12.5-foot culvert joining with 14-foot-diameter culvert in each wall.
Valve Tunnel Intakes:	Six 5- by 7.5-foot intakes in each wall.
Lock Chamber Wall Ports:	20 ports in each wall, each 4 feet wide by 3 feet high.

Hydrology

Drainage Area:	14,554 square miles
Climate:	Continental, variable
One Inch Runoff Equals:	776,213 acre-feet
Storm Types:	Variable
Flood Season:	Spring and summer
Low Flow Season:	Fall and winter
Minimum Daily Average Flow and Date:	1,680 cfs, August 29 to September 1, 1984
Minimum Monthly Average Flow and Date:	3,400 cfs, February 1963

Minimum Annual Average Flow and Date:	6,900 cfs, 1963 C.Y.
Average Annual Flow:	14,300 cfs
Maximum Annual Average Flow and Date:	22,370 cfs, 1982 C.Y.
Maximum Monthly Average Flow and Date:	51,400 cfs, April 1979
Maximum Daily Average Flow and Date:	86,700 cfs, December 7, 1982, at Kingston Mines, Illinois.
Maximum Instantaneous Flow and Date:	Same as maximum daily average.
Maximum Daily Flood Volume and Date:	171,970 acre-feet, December 7, 1982, at Kingston Mines, Illinois.
Maximum Headwater Stage:	456.07 feet, May 28, 1943
Minimum Headwater Stage:	437.4 feet, February 8, 1971
Name and Location of Key Streamflow Stations:	Illinois River at Kingston Mines, Illinois.
Type of Hydrometeorological Data Obtained at Site:	Precipitation, temperature
Number of Sediment Ranges:	None
Ice Break-Up Period:	February-March

SECTION 8 - LA GRANGE LOCK AND DAM

GENERAL

The LaGrange pool extends from RM 80.2 to the Peoria Lock and Dam at RM 157.7.

PHYSICAL COMPONENTS

LOCK

The LaGrange Lock is on the right bank of the Illinois Waterway about 3 miles downstream from LaMoine River and 8 miles downstream from Beardstown, Illinois. It has a usable chamber 110 feet wide by 600 feet long and a maximum lift of 10 feet. The lock walls are of the concrete gravity type. The river wall is 923 feet long and 29.0 feet wide and the top is at elevation 434.0 feet NGVD. The land wall is 937.5 feet long, varies from 22.5 to 29.0 feet in width, and the top is at elevation 434.0 feet NGVD, except for the downstream 71 feet which is at elevation 430.0 feet NGVD. Guide walls 500 feet long extend upstream and downstream from the land wall of the lock. The upper and lower miter gates are 64.91 feet long from center to center of bearings. The upper gate is 17.5 feet high and the lower gate is 25 feet high. In each lock wall there is a 14-foot-diameter valve tunnel about 420 feet long along the central portion of the lock chamber. The centerline of the valve tunnel is at elevation 412.0 feet NGVD. At each end of these culverts, the valve tunnels transition to 12.5- by 12.5-foot tunnels with centerline at elevation 411.25 feet NGVD. Just downstream from the intakes near the upper end of the lock, the valve tunnels are 12.5 feet wide and 14 feet high with centerline at elevation 417.0 feet NGVD. Six screened openings, each 5 feet wide by 7.5 feet high, serve as the intake to each valve tunnel. Eight similar openings near the downstream end of each lock wall serve as outlets for the valve tunnels. Connecting the valve tunnels to the lock chamber are 20 ports, 4 feet wide by 3 feet high, in each lock wall. The lock floor is at elevation 405.0 feet, the upper gate sill is at elevation 413.5 feet, and the lower gate sill is at elevation 406.0 feet NGVD.

Upstream and downstream lock approach channel cross sections are located on plate D-151 and are shown on plates D-152 and D-153.

WICKET DAM

The Chanoine Wicket Dam extends 440 feet from the lock wall to the regulating weir at the left bank. It consists of 109 wickets, 3.75 feet wide, 14.92 feet high, and 1.0 foot thick. There is a 3-inch gap between wickets. The wickets form a 20-degree angle from vertical when in the upright (closed) position. The top few feet of eight flip-top wickets are hinged so that by dropping the top few feet an opening is provided for the passage of ice. The wickets are used to regulate the streamflow by completely raising various numbers of them to maintain an upstream pool elevation of approximately 429.0 feet NGVD. The wickets are lowered during high and medium flows to permit boat traffic over the wicket dam rather than through the navigation lock.

The wickets are raised or lowered individually with a large "maneuver" boat equipped to hook the tops of the wickets. A workboat is required for positioning because the maneuver boat is not self-powered. Once in position, the maneuver boat is held in place with its spuds.

Each wicket is supported by a steel horse and prop. Hurters, located near the downstream end of the dam base, guide and support the props as the wickets are operated.

REGULATING DAM

The concrete regulating dam is located in the left side of the river channel between the wicket dam and the left bank where it abuts the earthen dam. It is 136 feet long, has a crest elevation of 430.0 feet NGVD, and contains 12 butterfly valves that can be operated individually. The 6- by 6-foot cast steel butterfly valves have a net cross-sectional area of 29.4 square feet when fully open. The sill of the butterfly valves is at elevation 417.0 feet NGVD. The upstream opening at each valve is screened. The butterfly valves are operated manually using a heavy duty electric drill with a special chuck. They are normally operated in either the open or closed position. However, lock personnel are hesitant to close some of the valves all the way because of resistance encountered when closing them.

MAJOR REHABILITATION

Since the original construction the following major rehabilitation work has been completed:

1982 - Complete electrical rehabilitation at the lock and dam and rehabilitation of the tow haulage units.

1982-83 - Installation of a bubbler system to alleviate ice removal from the miter gates.

1984 - Replacement of lock lighting with two high-masted high-pressure sodium light standards. Replacement of second-floor windows of control station with new energy-efficient windows, removal of all first-floor windows and filling voids with concrete, and permanent installation of air compressor for the bubbler system on the second floor.

1986-88 - Installation of riprap and derrick stone scour protection at the wicket dam. Installation of a submersible tainter gate to replace 26 wickets on the wicket dam. Replacement of upper and lower guide walls of the lock. Rehabilitation of the lock to include refacing of lock walls, sandblasting and painting miter gate machinery, top slab resurfacing, and replacing various arms, blocks, seals, and valves. Resurfacing regulating weir with concrete.

With the tainter gate installed, the remaining wickets are operated in either the all-up or all-down positions, wicket changes are made less frequently and under low-head conditions, and ice is passed more effectively. The regulating weir remains operative to provide additional flexibility for the handling of river discharges. The rehabilitation has enhanced the efficiency and reduced the hazards of regulating flow at this facility.

HYDROLOGY

GENERAL

Four principal tributaries enter the Illinois Waterway in this project reach. The combined drainage areas of these tributaries account for 88 percent of the 11,094 square miles of area draining into the waterway between Peoria and LaGrange Locks and Dams. The largest of these tributaries is the Sangamon River which accounts for 49 percent of the area between Peoria and LaGrange. It is a left-bank tributary that enters the waterway about 9 miles above Beardstown. The Mackinaw River, another left-bank tributary, enters the waterway about 5 miles below Pekin. The Spoon and LaMoine Rivers are right-bank tributaries that enter the waterway at Havana and about 3 miles above LaGrange Lock and Dam, respectively. These increase the difficulty of maintaining required headwater elevations at the lock and dam.

Several reservoirs are in the Sangamon River basin, namely Lake Decatur, Lake Taylorville, Sangchris Lake, Lake Springfield, Lake Bloomington, and Clinton Reservoir. None of these reservoirs, however, are operated for flood control purposes, but are used principally for municipal water supply, to provide cooling water for power plants, and for recreation.

Regulation for these uses does not significantly affect the regulation of the LaGrange pool.

Very low-flow conditions in the Illinois River and tributaries in late August and in September 1984 created a condition in which towboats had difficulty navigating the waterway in both Peoria and LaGrange pools. The lockmaster raised the wickets and placed as many needles as possible without reducing the flow to a critical level. An emergency release was made from Lake Michigan for about 48 hours to raise the water level in these pools. This resolved the problem as the volume required was stored and raised the pools to navigable levels.

CHANNEL AND FLOODWAY

The Illinois River follows a winding course between fairly high banks in a wide flood pain bordered by bluffs. The main channel width varies from about 450 to 1,100 feet in this reach. Within the main channel, the Corps of Engineers maintains a 300-foot navigation channel. Tributaries drop their sediment loads upon entering the slow-moving waterway, causing sediment deposits to build up in the waterway and adjacent slack-water areas. One of the most noted of these areas is at the mouth of the Sangamon River. The limit of backwater effect from the Mississippi River is at Beardstown, RM 88. Lakes, bays, ponds, sloughs, and connecting channels abound on the bottom lands, providing a great deal of valley storage. The largest of the lakes are Lake Chautauqua, Clear Lake, Anderson Lake, and Rice-Big Lake. Valley width ranges from about 2 miles near Peking to more than 5 miles near Beardstown. At LaGrange Lock and Dam, the valley width is about 2.5 miles. The St. Louis District, Corps of Engineers, administers the waterway downstream from LaGrange Lock and Dam.

Much of the floodplain below Peoria is protected by agricultural levees constructed or rehabilitated by the Federal Government. Levee construction began in the late 1800's, and the levee situation was fairly well stabilized by 1931. A federally constructed flood protection project at Beardstown consisting of levee and floodwalls provides protection against the 100-year flood. There are numerous private levees along the tributaries.

Large areas of the undeveloped bottom lands and adjacent land are publicly owned areas set aside for recreation, hunting and fishing, and game preservation. State-owned areas include the Anderson Lake, Sanganois, Rick Lake, and Spring Lake Conservation Areas and the Sand Ridge State Forest. The Rice Lake Conservation Area occupies the land of the former Wauconda Drainage and Levee District which was abandoned in 1927. The Federal Government purchased the lands of the former Chautauqua Drainage and Levee District in 1936 and it is now operated by the U.S. Fish and Wildlife Service as the Chautauqua National Migratory Waterfowl Refuge. The Illinois River is in the Mississippi Flyway, a principal migratory bird

route. The levee around Chautauqua Lake, in the refuge, does not provide protection against the 100-year flood.

STAGE DURATION

Plates D-154 through D-166 show stage duration relationships for the years 1946 through 1985.

A number of barge terminals, small boat harbors, and marinas are along this reach of the waterway, especially in and near urban areas.

ELEVATION HYDROGRAPHS

The elevation hydrographs at the LaGrange Lock and Dam site for the period 1970 through 1989 are shown on plates D-167 and D-168.

REGULATION PLAN

LaGrange Lock and Dam was designed and constructed, and is regulated, to maintain navigation on the Illinois Waterway. The dam is operated to maintain a normal pool elevation of 429.0 feet NGVD in order to provide a 9-foot navigation channel between RM 80.2 and 157.7 on the waterway. The lock is operated to enable river traffic to pass from the lower to the upper pool and vice versa. The maximum lift is about 10 feet.

MAJOR CONSTRAINTS

When the Illinois River is falling and Peoria has started to raise its wickets, the wickets should be raised using the criteria discussed below. When the pool elevation at LaGrange reaches 428.0 to 428.3 feet NGVD, raise 17 wickets. As the flows continue to fall and the falling pool reaches elevation 426.5 to 426.8 feet an additional 98 to 103 wickets will be raised. The number of wickets raised will depend on the inflow to the LaGrange pool from Peoria dam and from the Sangamon, Mackinaw, Spoon, and LaMoine Rivers. Raising the remaining wickets will occur when the flow drops below 10,000 cfs. The pool then will be maintained at about elevation 429.0 feet NGVD.

When wickets are in the "up" position and flow begins to rise, a difference of 2.0 feet of head or less between the pool and tailwater stages triggers action to drop wickets. Initially, 25 wickets are normally lowered; then, as the pool continues to rise and reaches a stage of 430.0 feet NGVD, all of the wickets are lowered. The tailwater will be approximately equal to

the pool. There are times when existing and imminent flow conditions require that all wickets are lowered during one operation.

Occasionally, drift and debris have accumulated at trash racks at butterfly valve intakes and on upright wickets. Light accumulations are removed manually working from the "maneuver" boat; heavy accumulations are removed with crane and clam.

A continuing problem has been the scour holes which develop in the riverbed downstream of the dam. With changing flow conditions, these holes develop, fill in, and shift location in a nearly unending cycle. Scour holes as deep as 45 feet have been observed. Local quarry stone is stockpiled on each bank for placement in the scour holes.

SEDIMENTATION

For the stations operated by the USGS, records of daily mean concentrations, daily loads, and periodic particle size analyses of suspended sediment are published in the annual *USGS Water Resources Data Reports*. For stations operated by the Illinois State Water Survey, that agency should be contacted for information.

The daily records, though short, offer some insight into the suspended sediment characteristics of the drainage area. As would be expected, suspended sediment concentrations and discharges are greatest for the smaller, upland areas. For Big Creek near Bryant, the maximum daily mean concentration recorded was 5,760 milligrams per liter and the maximum daily load of suspended sediment was equivalent to 303 tons per square mile. Both of these occurred on May 8, 1973. On the other hand, the maximum daily mean concentration for the period of record on the Sangamon River near Oakford was 354 milligrams per liter June 9, 1984, and the maximum daily load was equivalent to 24 tons per square mile. The Illinois State Water Survey calculated the sediment loads for 1981 water year as follows: LaMoine River at Colmar, 1,055; Salt Creek near Greenview, 981; and Spoon River at London Mills, 880 tons per square mile. The 1981 water year was very wet. The runoff for that year was about 150 percent of normal for LaMoine River at Colmar. Sediment concentrations and discharges are very low on the main stem of the Illinois River, indicating that a large part of the sediment inflow from tributaries settles out upon reaching the slow-moving Illinois River.

DREDGED MATERIAL INVESTIGATIONS

Table D-12 shows the record of dredging in the LaGrange pool for the period 1950-1985. The most persistent shoaling locations are along Grand Island, RM 110 to 113; from Havana to Quiver Lake, RM 120 to 123; from Lancaster Landing to Pekin, RM 143 to 152; and from Pekin Lake to Peoria Lock and

Dam, RM 154 to 157.7. No information is available on the composition of the dredged material. The Corps conducts intensive sampling of bed material cores and of the water column just prior to, during, and immediately after dredging operations. These samples are analyzed in the laboratory by a contractor. Dredged spoil generally is spread along the banks of the waterway near the dredging sites.

TABLE D-12

Dredging in LaGrange Pool

Year	Cubic Yards
1950	965,000
1951	0
1952	405,000
1953	0
1954	0
1955	350,000
1956	0
1957	300,000
1958	75,000
1959	0
1960	60,000
1961	888,000
1962	51,000
1963	0
1964	255,000
1965	10,000
1966	147,000
1967	279,000
1968	0
1969	20,000
1970	35,000
1971	445,000
1972	0
1973	180,000
1974	85,000
1975	57,000
1976	642,000
1977	0
1978	258,000
1979	0
1980	0
1981	323,000
1982	32,000
1983	498,000
1984	175,000
1985	0

1975 PROPOSED IMPROVEMENTS

The 1975 *Duplicate Locks GDM, Phase I* states:

"The proposed location for a new supplemental lock is on the east end of the existing dam on the northern end of LaGrange Island across the channel from the existing lock at mile 80.2. This location will require excavation of much of the island, a diversion channel for the South Beardstown pumping station and the reconstruction of approximately 3,000 feet of levee. The design features of the new lock at LaGrange are similar to those of the new supplemental lock at Peoria."

La Grange Lock and Dam
Pertinent Data

General

Location:	About 8 smiles downstream from Beardstown, Illinois, RM 80.2
Purpose:	Navigation
Drainage Area:	25,648 square miles
Time of Water Travel:	From Peoria Lock and Dam, 24 to 36 hours
Maximum Tailwater Stage of Record:	447.25 feet, May 1943

Dam

Type:	Movable wicket-type, concrete and timber
Length:	Overall length, 1,066 feet
Movable Dam:	440 feet long containing 109 Chanoine wickets. Each wicket 3.75 feet wide, 14.92 feet high, 0.25 foot gap between wickets. Sill elevation, 415.0 feet NGVD.
Regulating Dam:	136 feet long from left end of movable (wicket) dam to earth dam.

	Twelve butterfly valves in regulating dam. Valve openings are 6 feet by 6 feet with sill elevation of 417.0 feet NGVD.
Earth Dam:	Dike 390.0 feet long with 20-foot crown at elevation 430.0 feet NGVD, extends landward from left end of regulating dam.

Lock

Width:	110 feet
Length:	600 feet
Maximum Lift:	10 feet
Average Lift Based Upon 50 Percent River Stage Duration:	4.5 feet
Lock Filling and Emptying Time:	10 minutes
Valve Tunnels:	12.5- by 12.5-foot culverts joining with 14-foot-diameter culvert in each wall.
Valve Tunnel Intakes:	Six 5- by 7.5-foot intakes in each wall.
Lock Chamber Wall Ports:	20 ports in each wall, each 4 feet wide by 3 feet high.

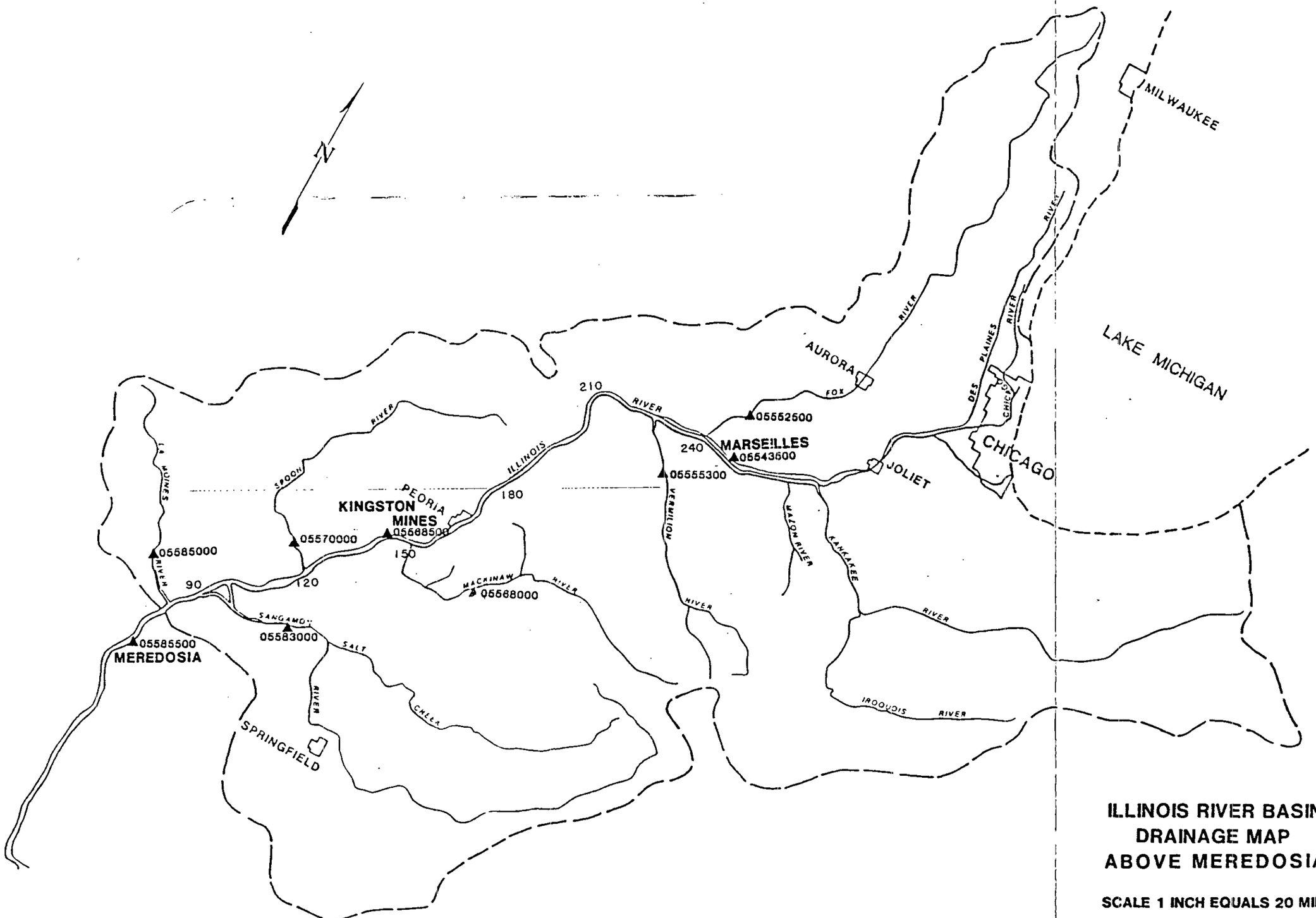
Hydrology

Drainage Area:	25,648 square miles
Climate:	Continental, variable
One Inch Runoff Equals:	1,367,893 acre-feet
Storm Types:	Variable
Flood Season:	Spring and summer

Low-Flow Season:	Fall and winter
Minimum Daily Average Flow and Date:	1,330 cfs, September 2, 1984
Minimum Monthly Average Flow and Date:	4,144 cfs, February 1963
Minimum Annual Average Flow and Date:	9,246 cfs, 1940 C.Y.
Average Annual Flow:	22,157 cfs
Maximum Annual Average Flow and Date:	37,560 cfs, 1973 C.Y.
Maximum Monthly Average Flow and Date:	94,940 cfs, March 1985
Maximum Daily Average Flow and Date:	123,000 cfs, May 26-28, 1943
Maximum Instantaneous Flow and Date:	123,000 cfs, May 26-28, 1943
Maximum Daily Flood Volume and Date:	243,970 acre-feet, May 26-28, 1943
Maximum Headwater Stage:	447.25 feet, May 26, 1943
Minimum Headwater Stage:	425.8 feet, February 7-10, 14, 16-18, 1979
Name and Location of Key Streamflow Station:	Illinois River at Meredosia, Illinois

NOTE: All flow figures are for Illinois River at Meredosia.

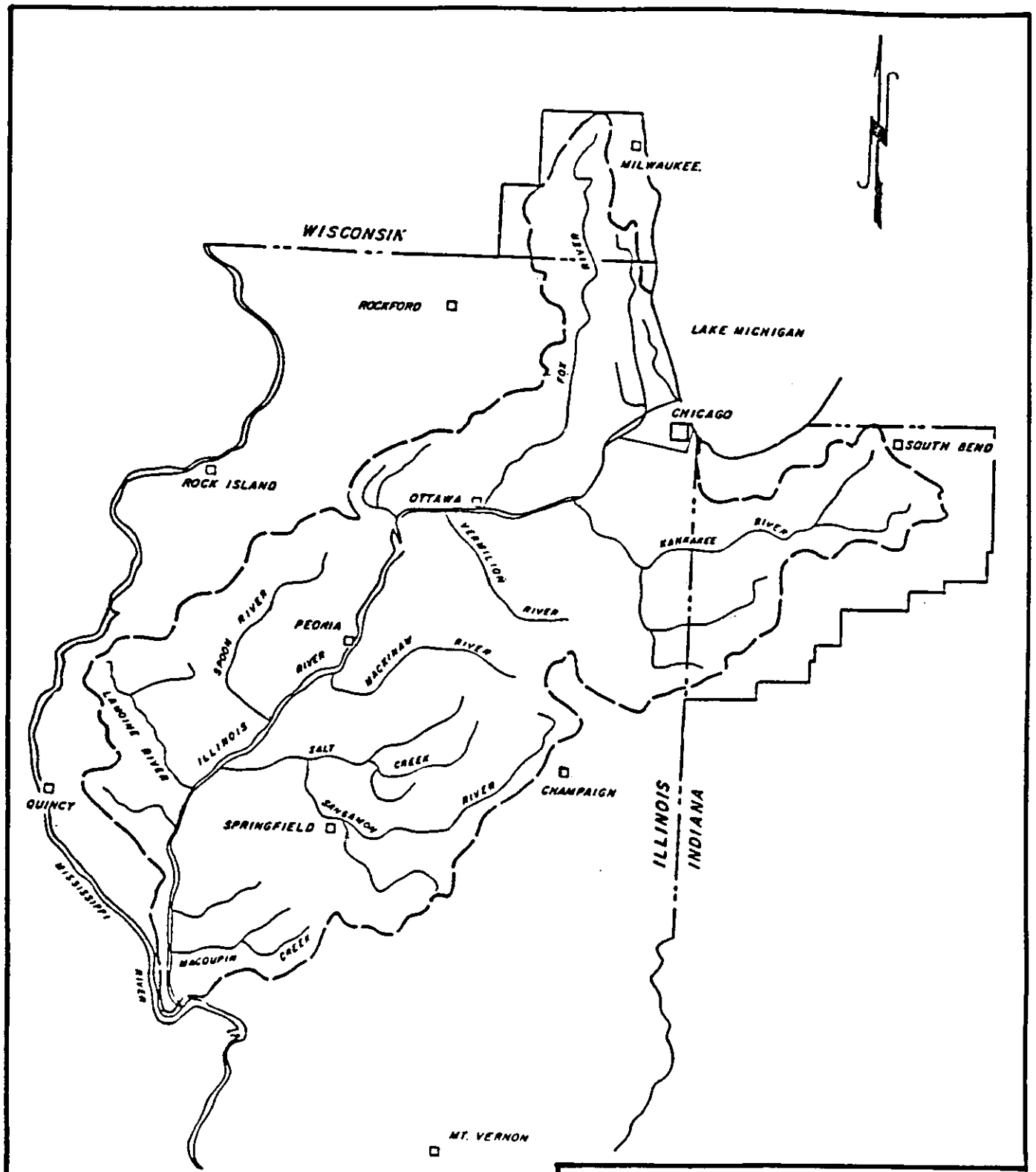
Type of Hydrometeorological Data Obtained at Site:	Precipitation, temperature
Number of Sediment Ranges:	None
Ice Break-Up Period:	February-March



ILLINOIS RIVER BASIN
DRAINAGE MAP
ABOVE MEREDOSIA

SCALE 1 INCH EQUALS 20 MILES

PLATE D-1



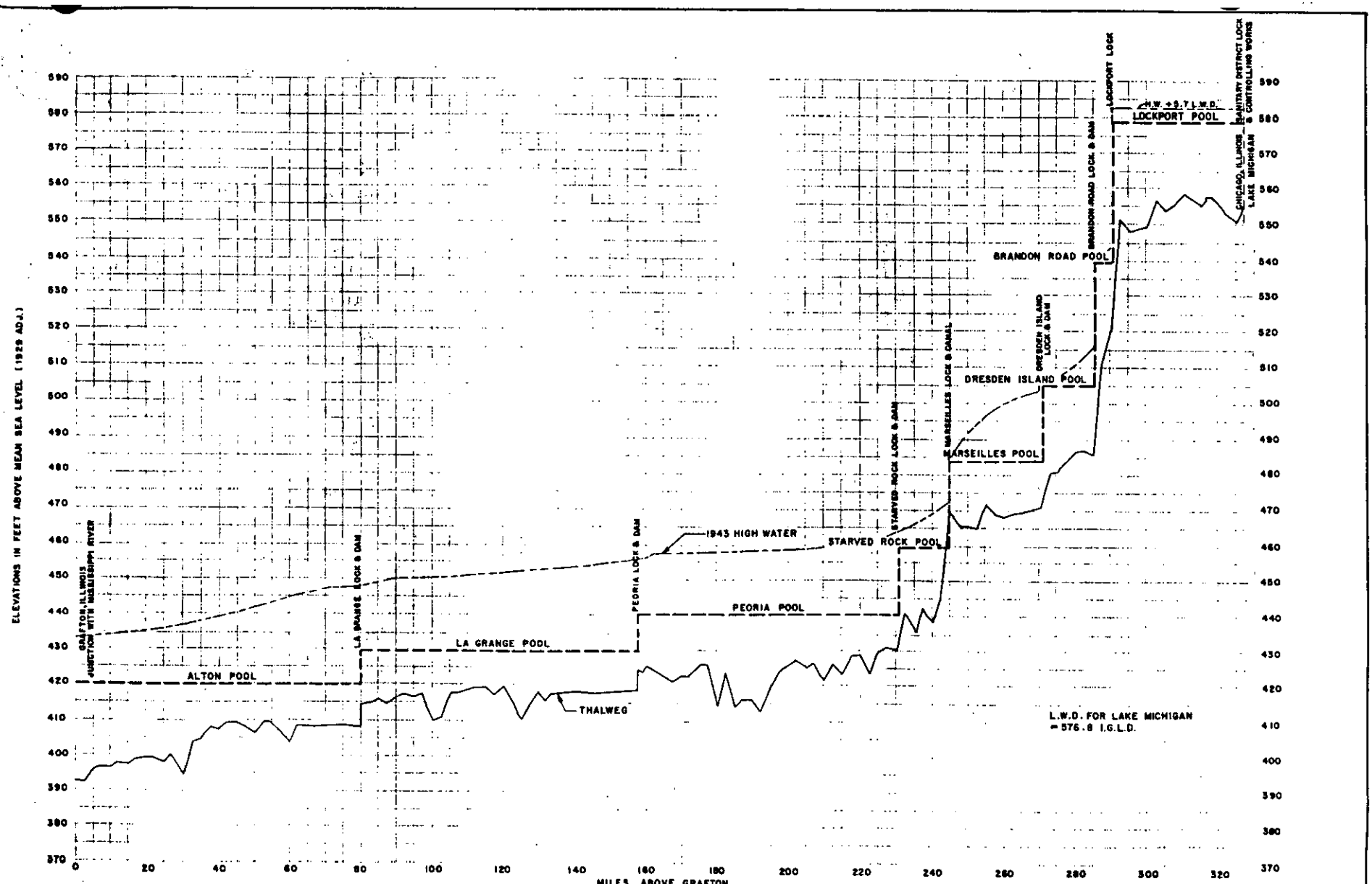
UPPER MISSISSIPPI RIVER BASIN
ILLINOIS WATERWAY

NINE FOOT CHANNEL

MAP OF ILLINOIS RIVER BASIN

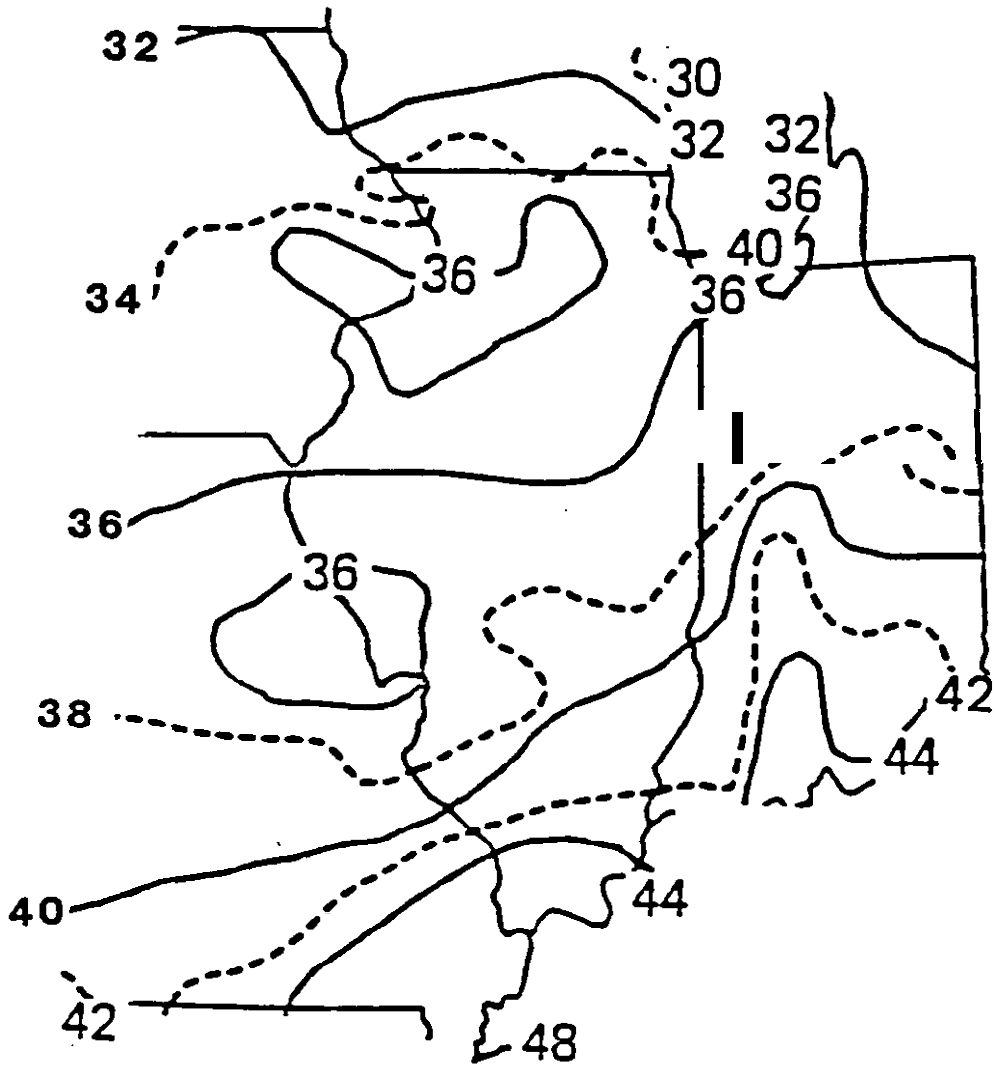
CORPS OF ENGINEERS U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT
PLATE D-2



ILLINOIS WATERWAY, ILLINOIS
PROFILE
MILE 0.0 TO MILE 327.2

PLATE D-3



PRECIPITATION IN INCHES

UPPER MISSISSIPPI RIVER BASIN
ILLINOIS WATERWAY

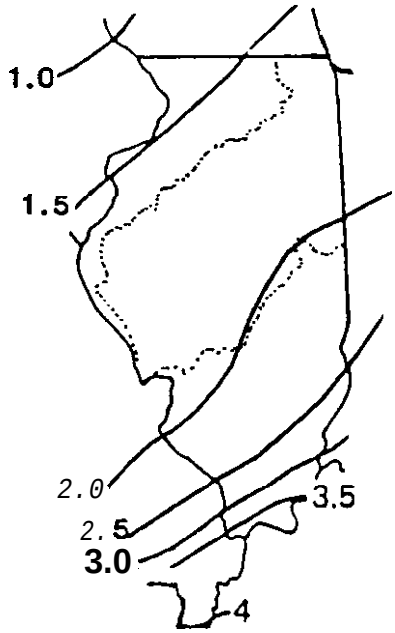
NINE FOOT CHANNEL

MEAN PRECIPITATION

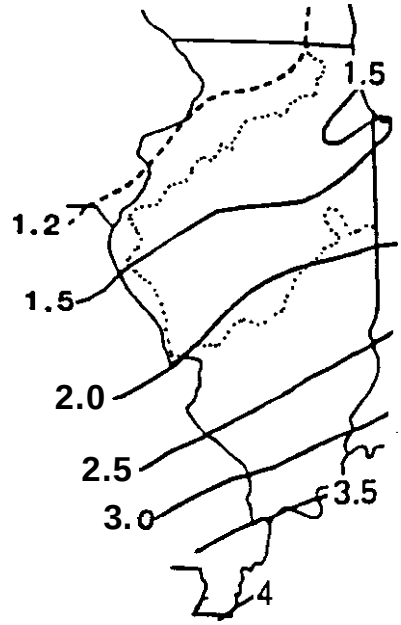
ANNUAL

CORPS OF ENGINEERS U.S. ARMY
ROCK ISLAND, ILLINOIS

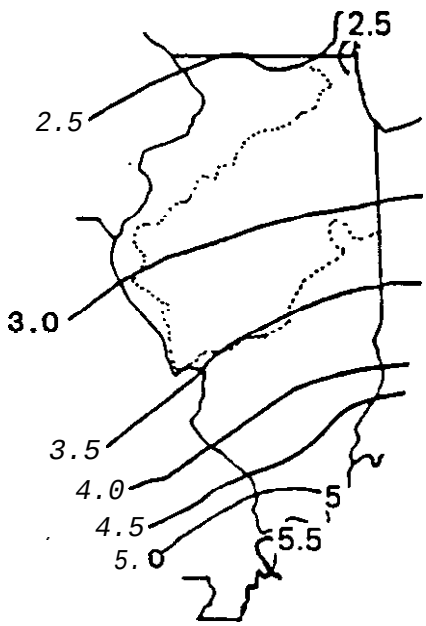
ROCK ISLAND DISTRICT
PLATE D-4



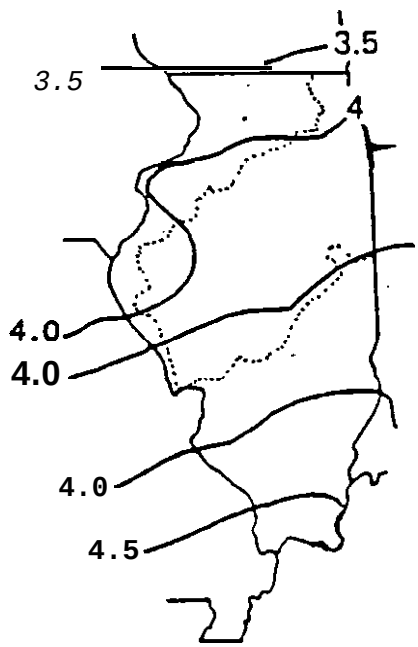
JANUARY



FEBRUARY



MARCH



APRIL

PRECIPITATION IN INCHES

UPPER MISSISSIPPI RIVER BASIN
ILLINOIS WATERWAY

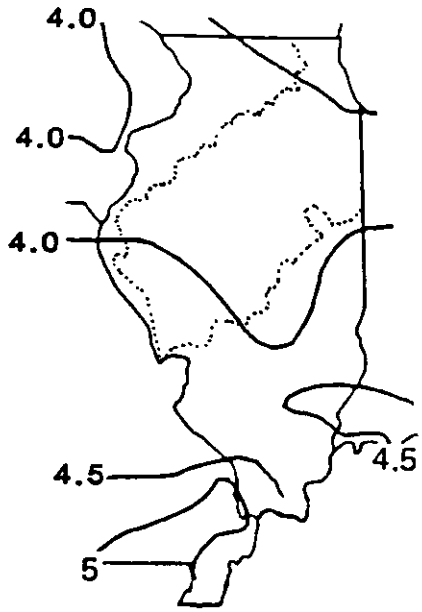
NINE FOOT CHANNEL

MEAN PRECIPITATION

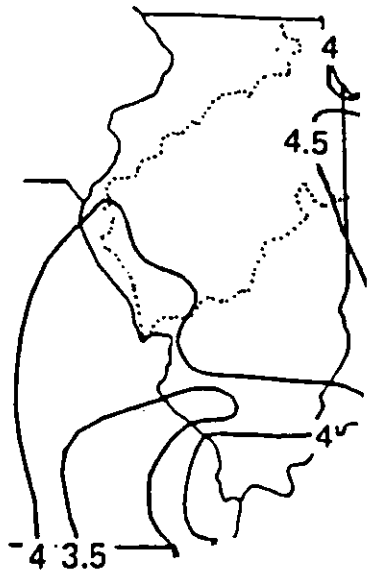
CORPS OF ENGINEERS U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT

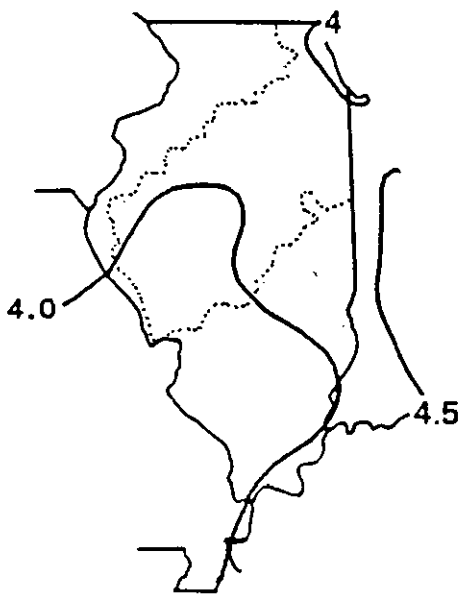
PLATE D-5



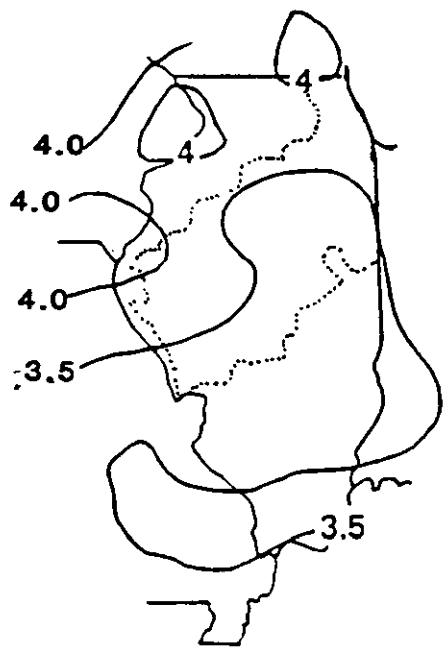
MAY



JUNE



JULY



AUGUST

PRECIPITATION IN INCHES

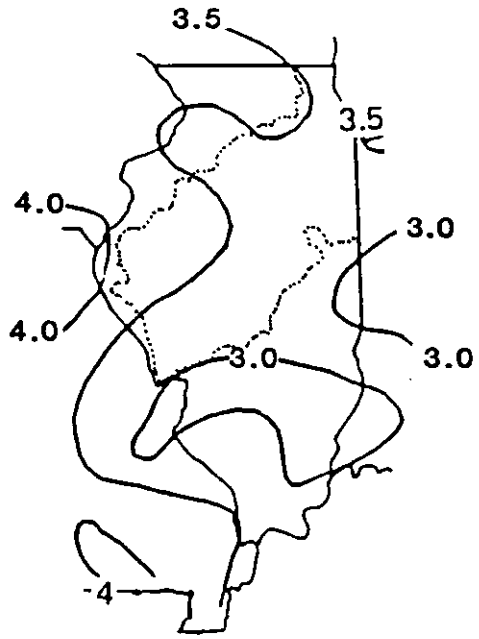
UPPER MISSISSIPPI RIVER BASIN
ILLINOIS WATERWAY

NINE FOOT CHANNEL

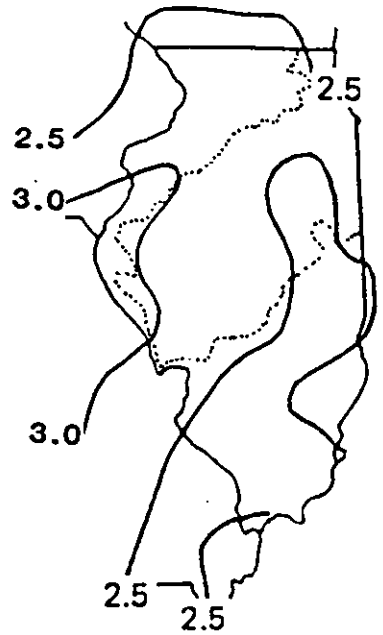
MEAN PRECIPITATION

CORPS OF ENGINEERS U.S. ARMY
ROCK ISLAND, ILLINOIS

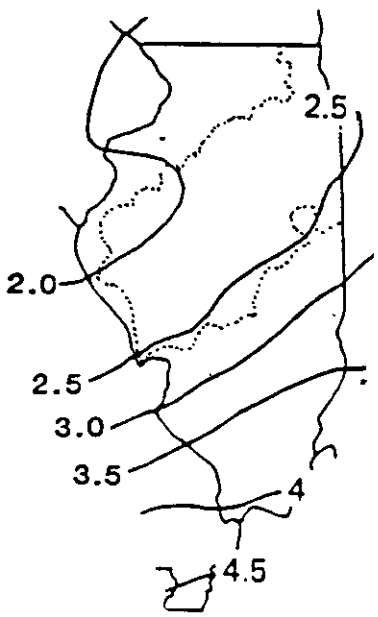
ROCK ISLAND DISTRICT
PLATE D-6



SEPTEMBER



OCTOBER



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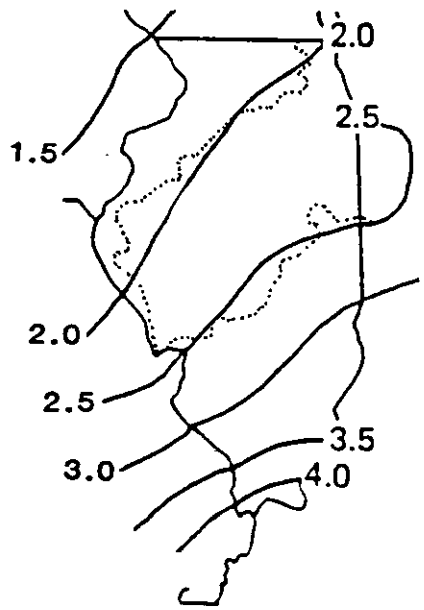


DECEMBER

PRECIPITATION IN INCHES

UPPER MISSISSIPPI RIVER BASIN
ILLINOIS WATERWAY

NINE FOOT CHANNEL

MEAN PRECIPITATION

CORPS OF ENGINEERS U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT
PLATE D-7

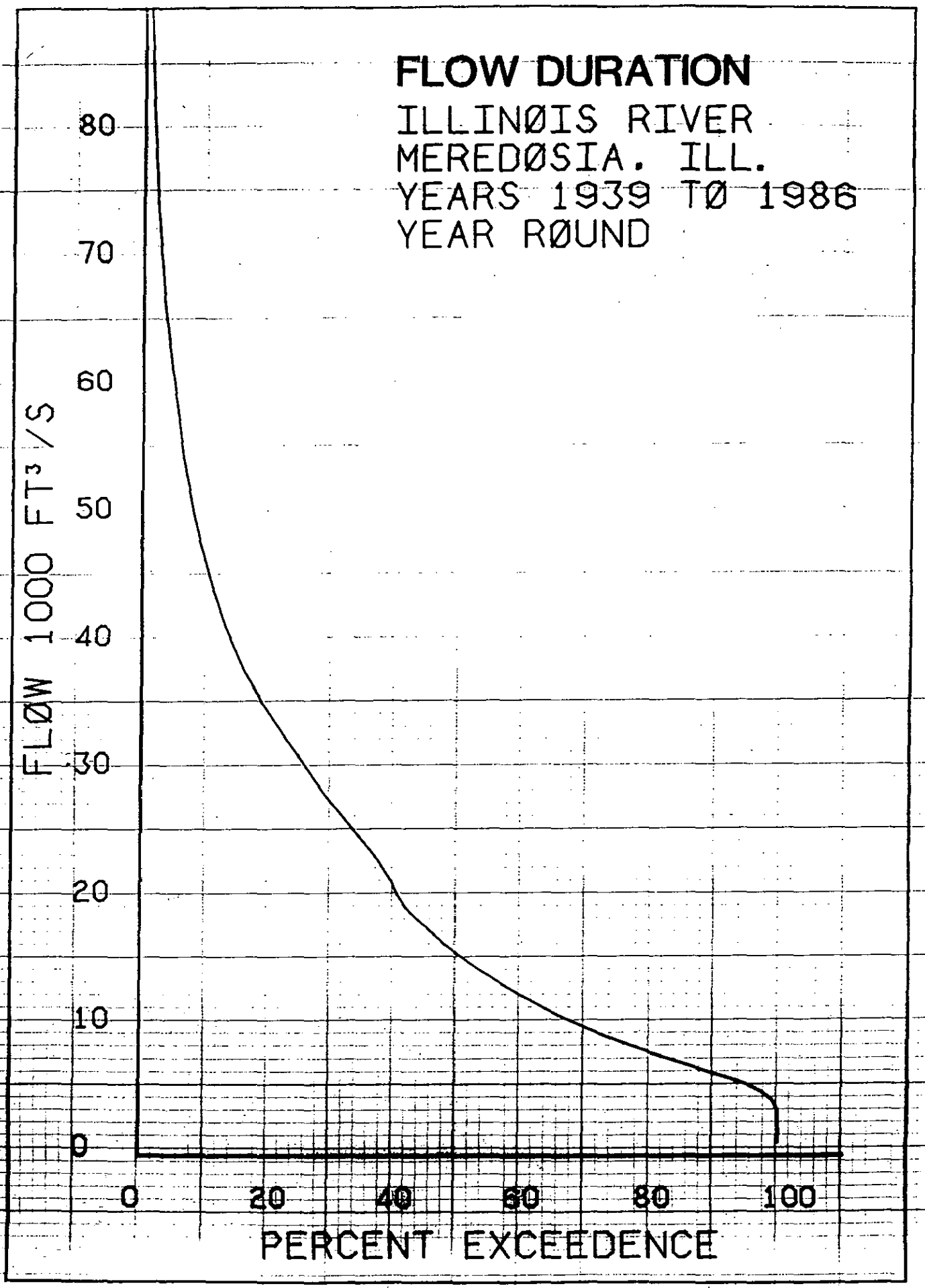

FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
YEAR RØUND
FLØW 1000 FT³/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-8

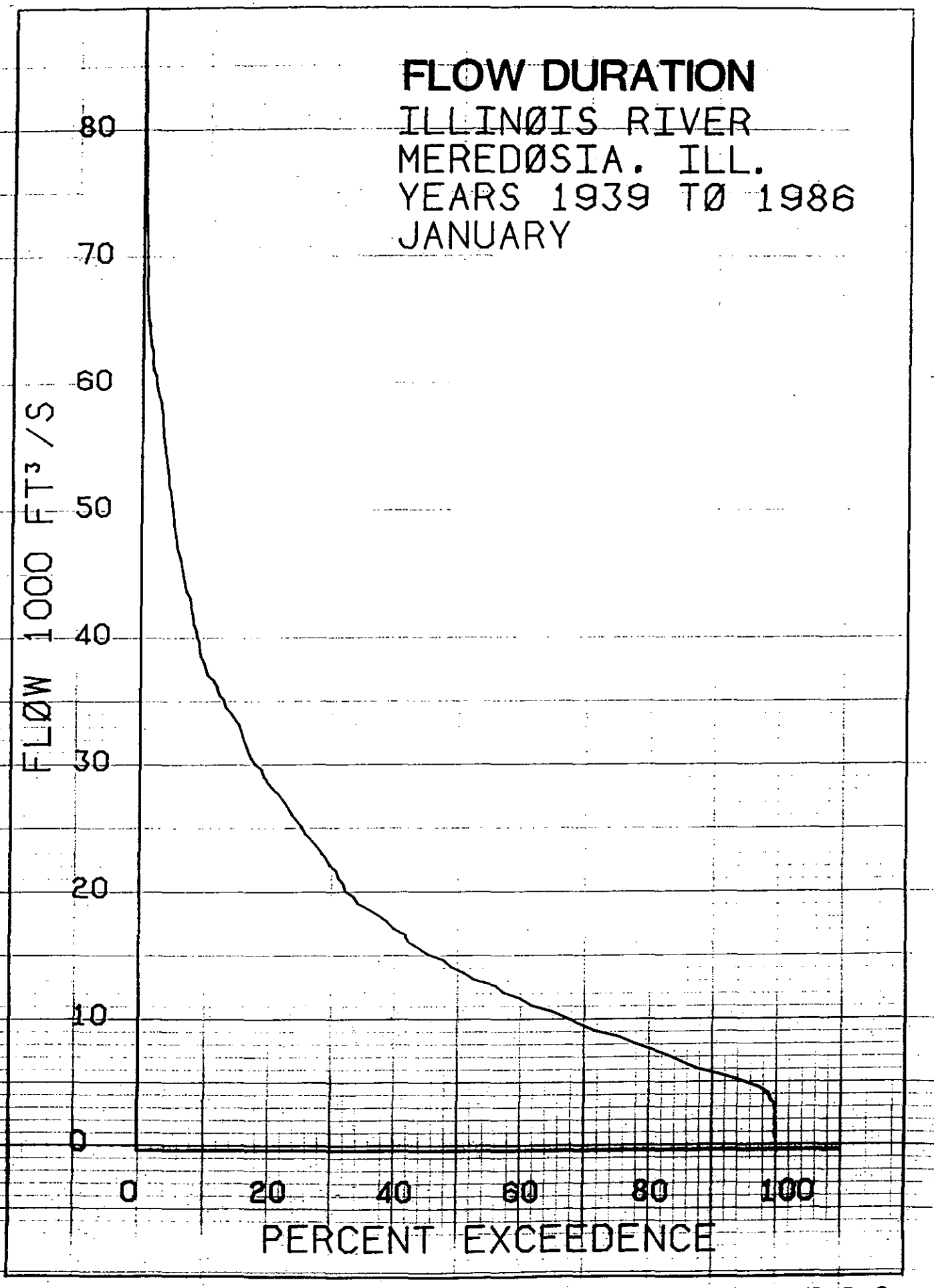

FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
JANUARY
FLØW 1000 FT³/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-9

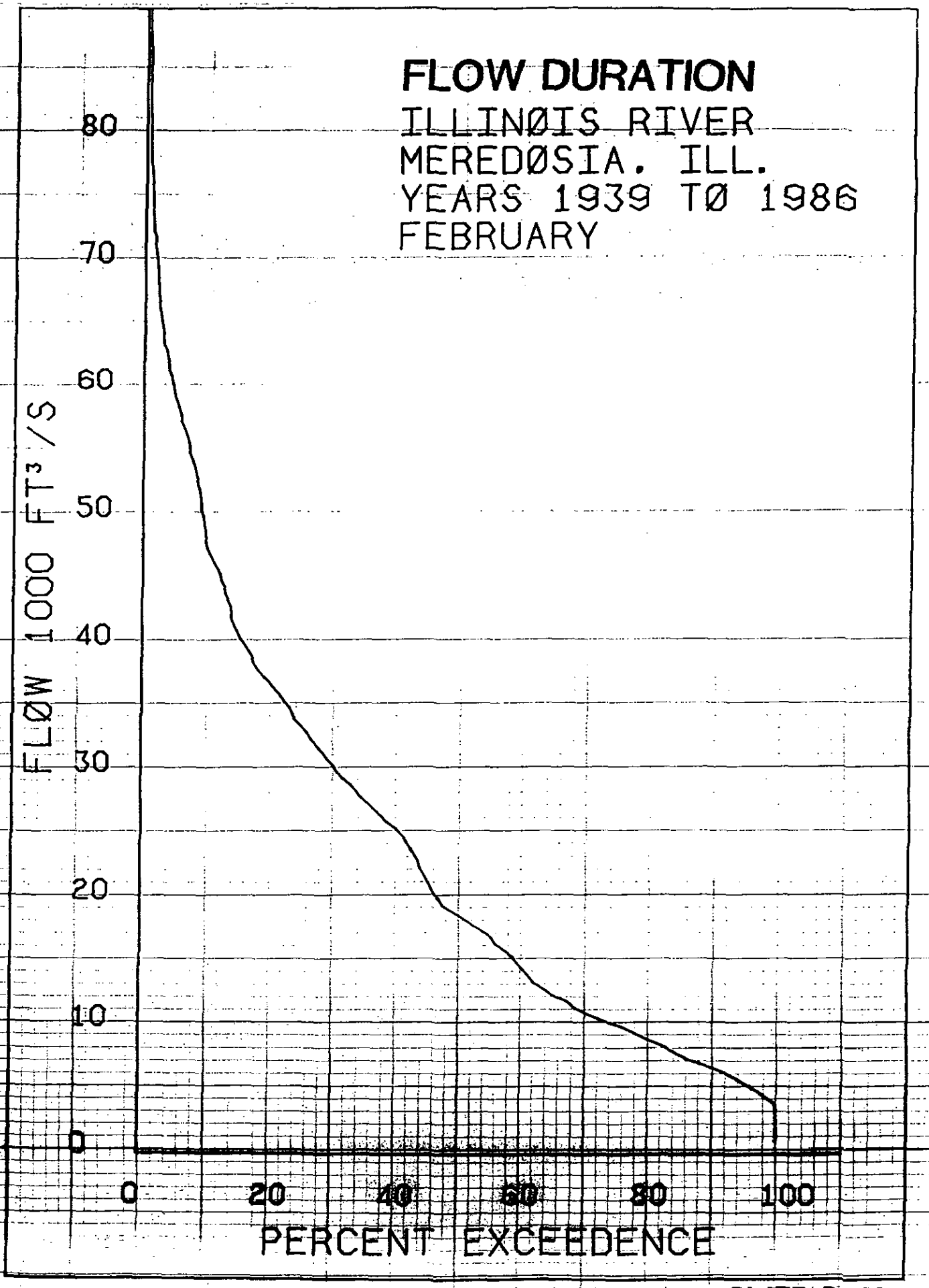
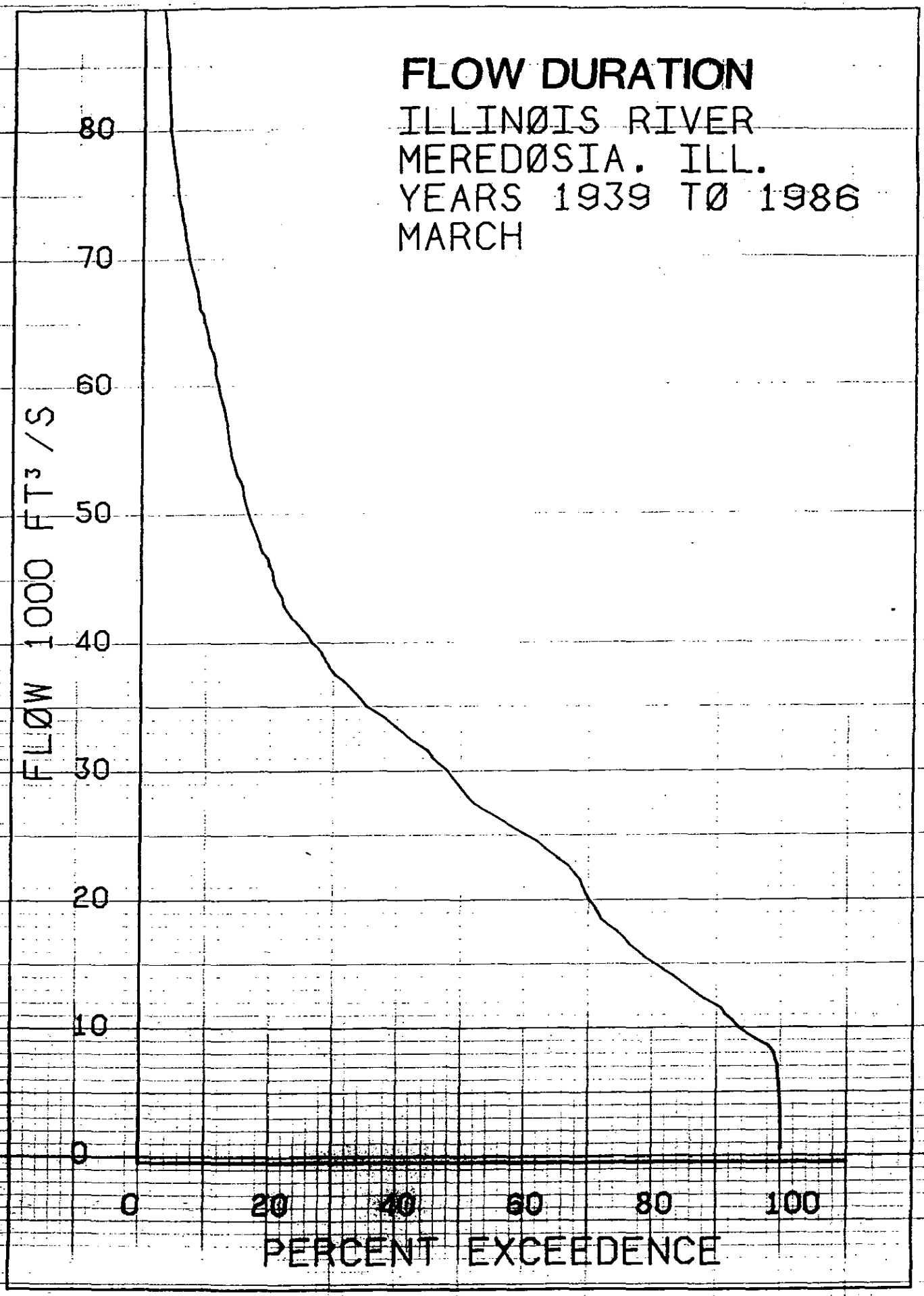

FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
FEBRUARY
FLØW 1000 FT³/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-10


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
MARCH
FLØW 1000 FT³/S
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40
30
20
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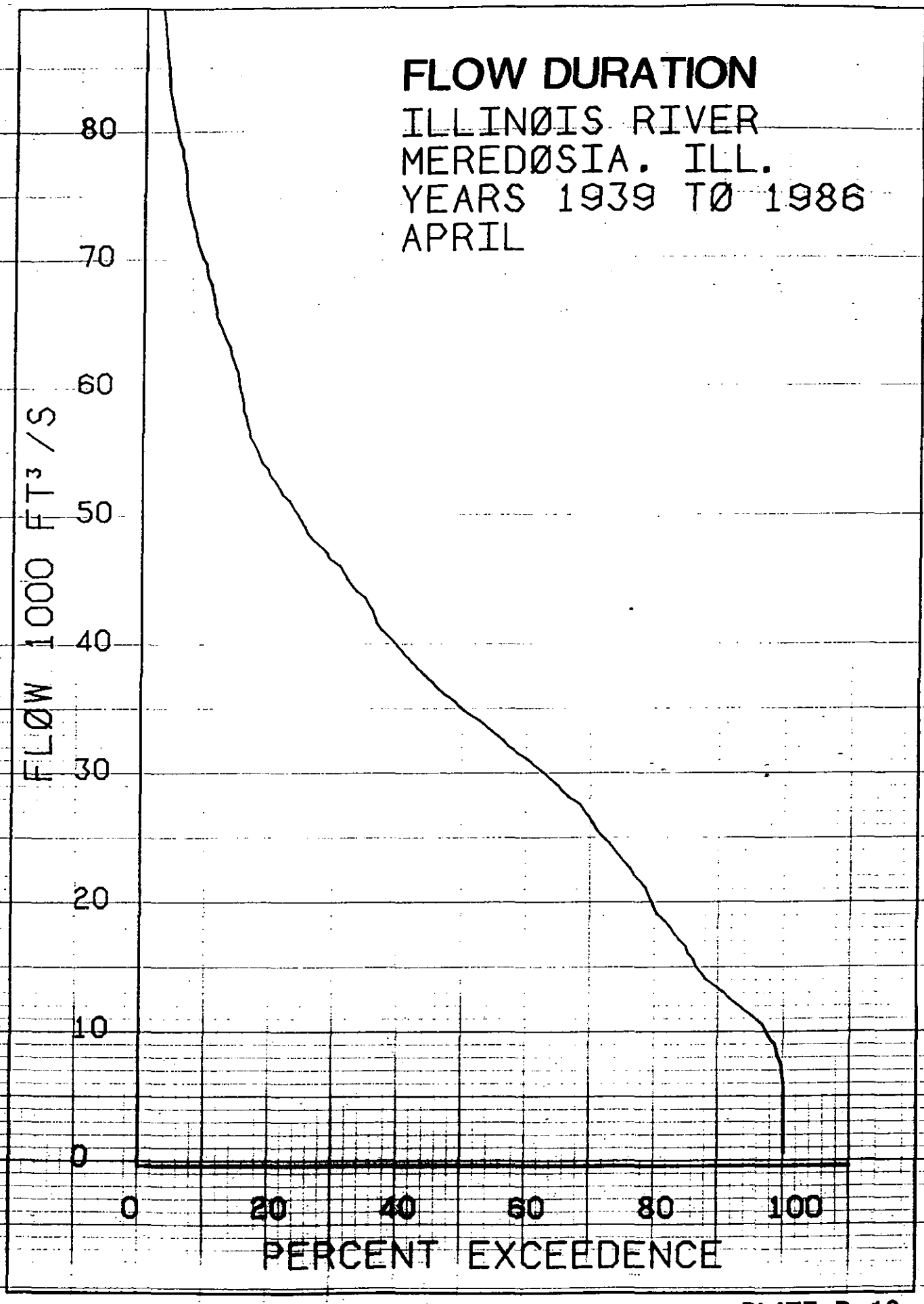
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-11


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
APRIL
FLØW 1000 FT³/S
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60
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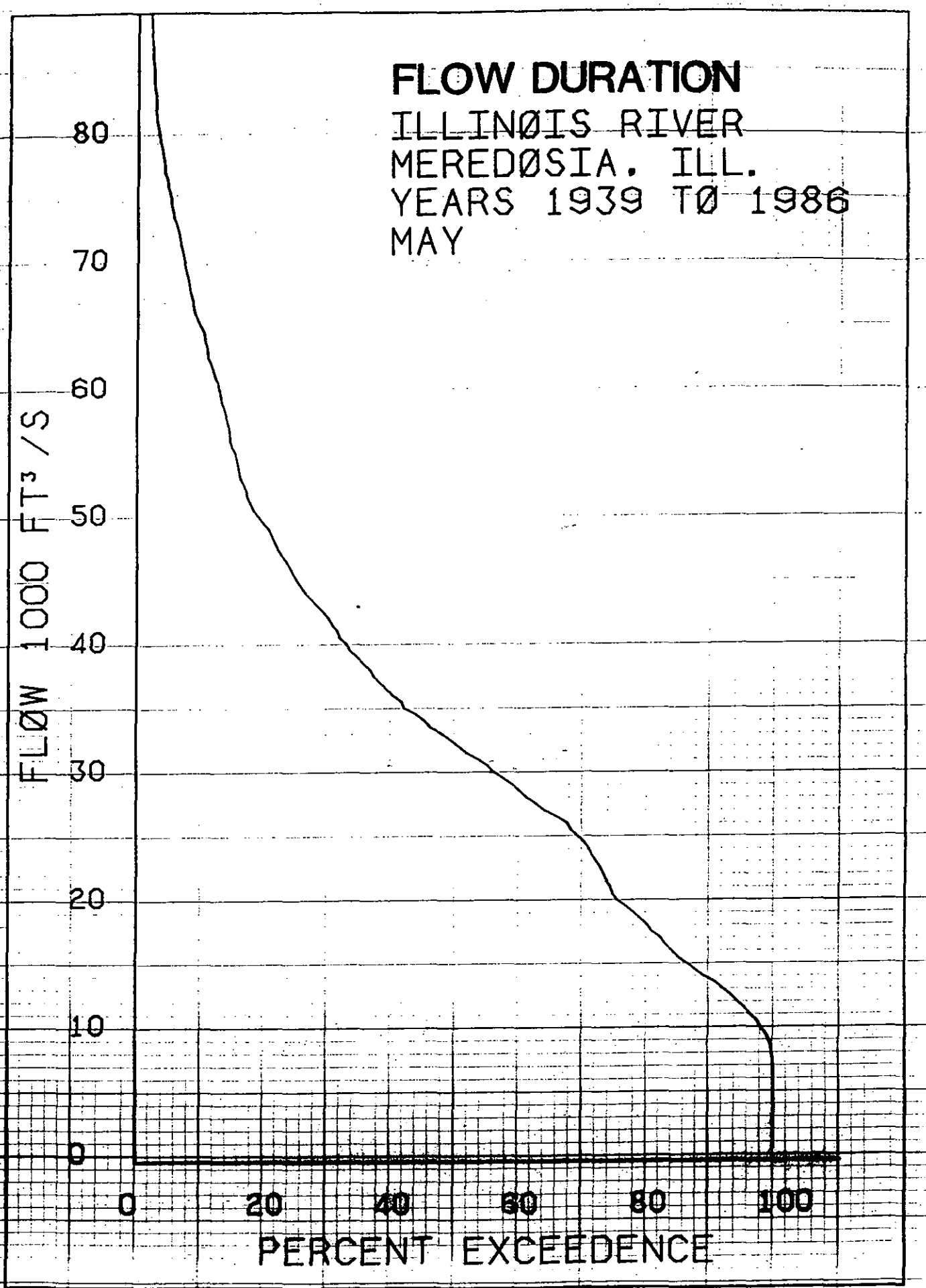
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-12


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
MAY
FLØW 1000 FT³/S
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60
50
40
30
20
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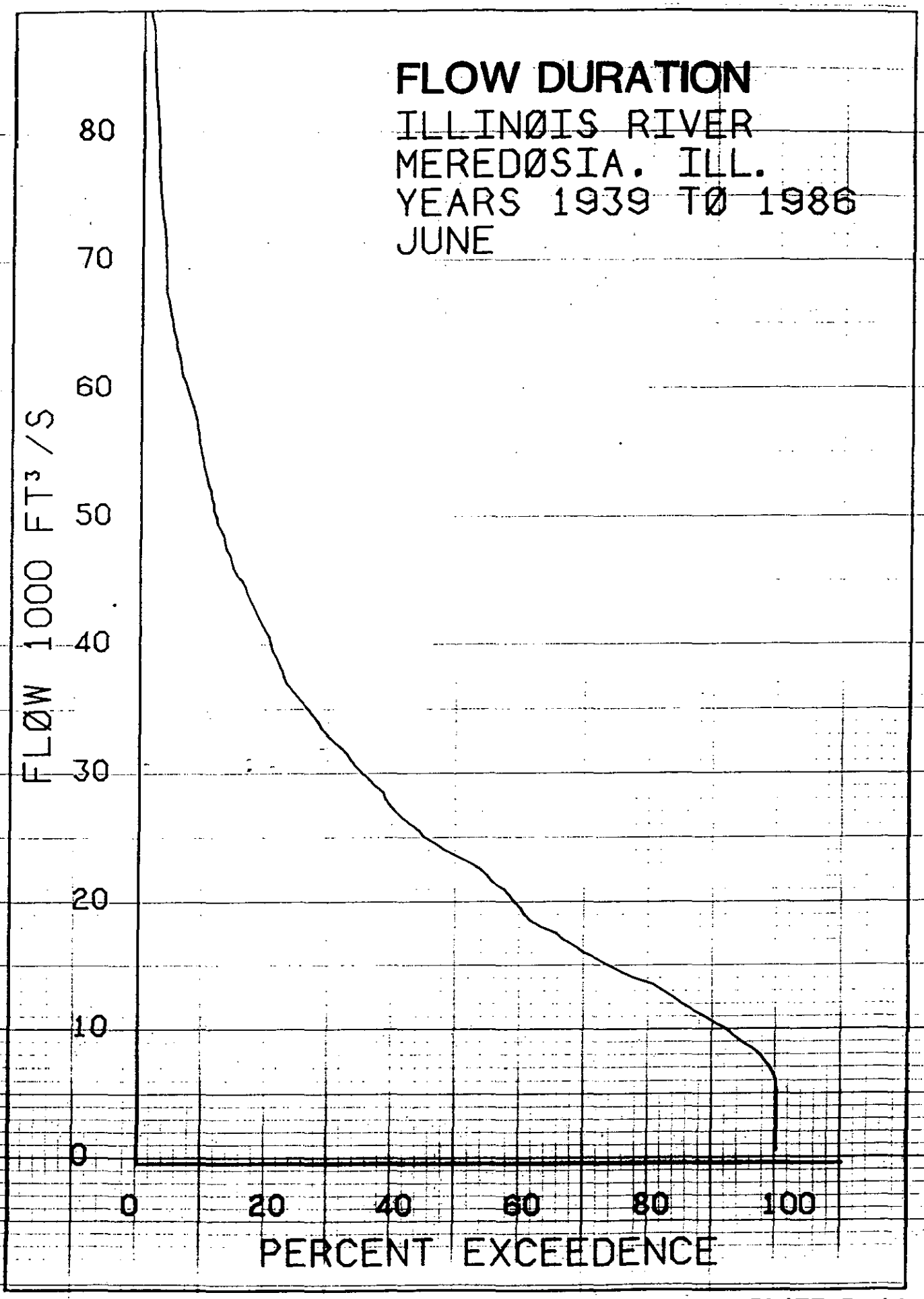
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
JUNE
FLØW 1000 FT³/S
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70
60
50
40
30
20
10
0
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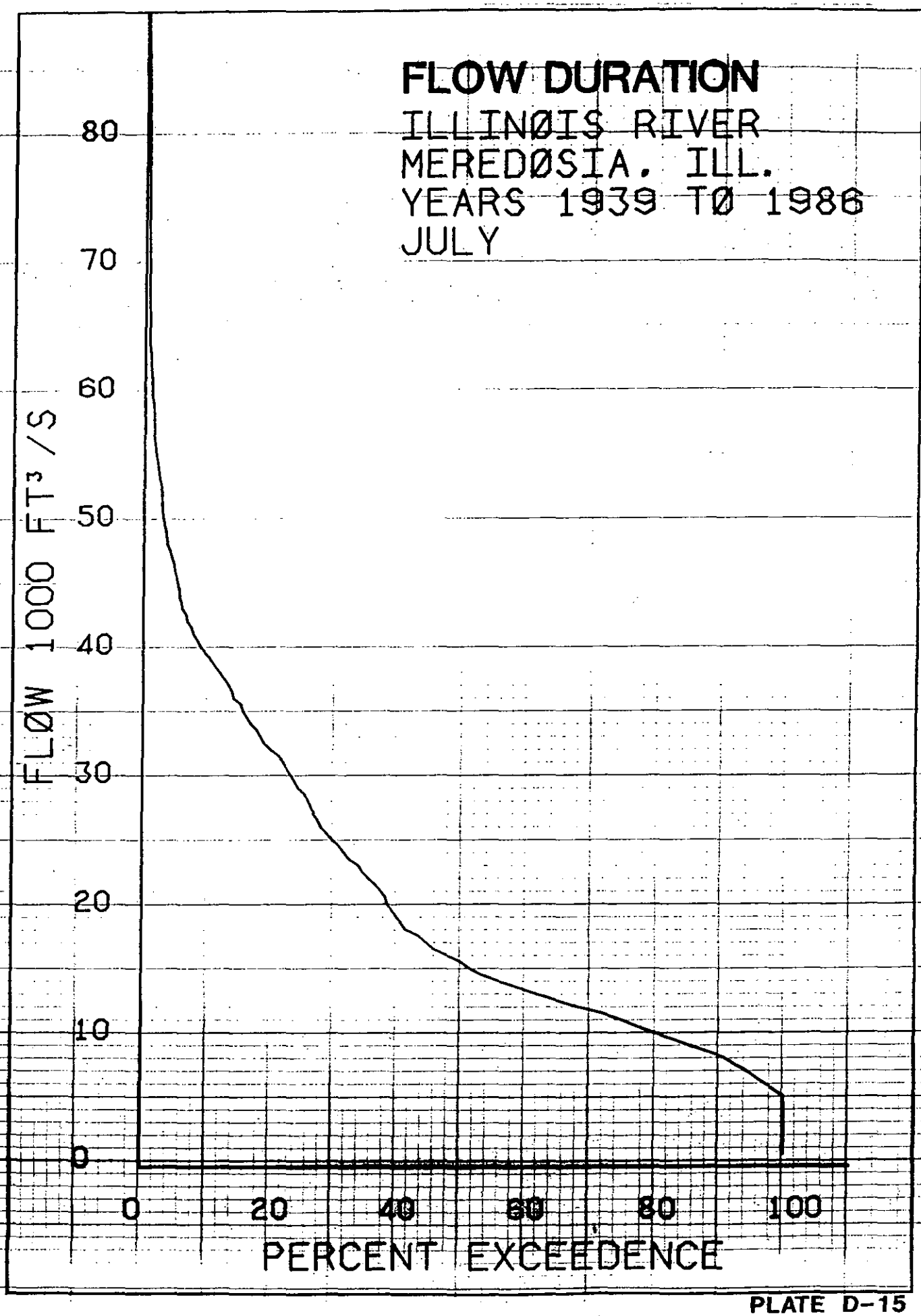
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
JULY
FLØW 1000 FT³/S
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40
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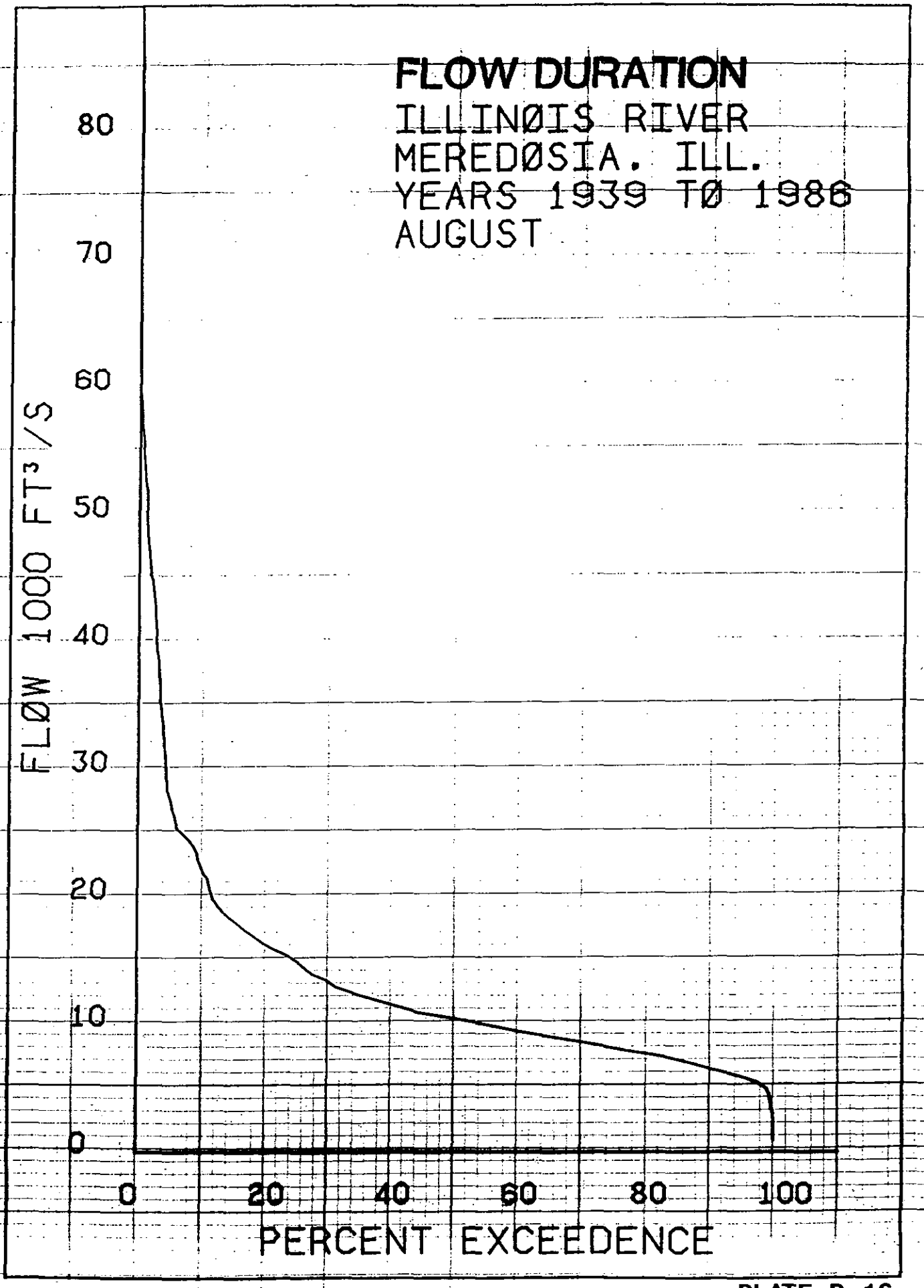
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-15


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
AUGUST
FLØW 1000 FT³/S
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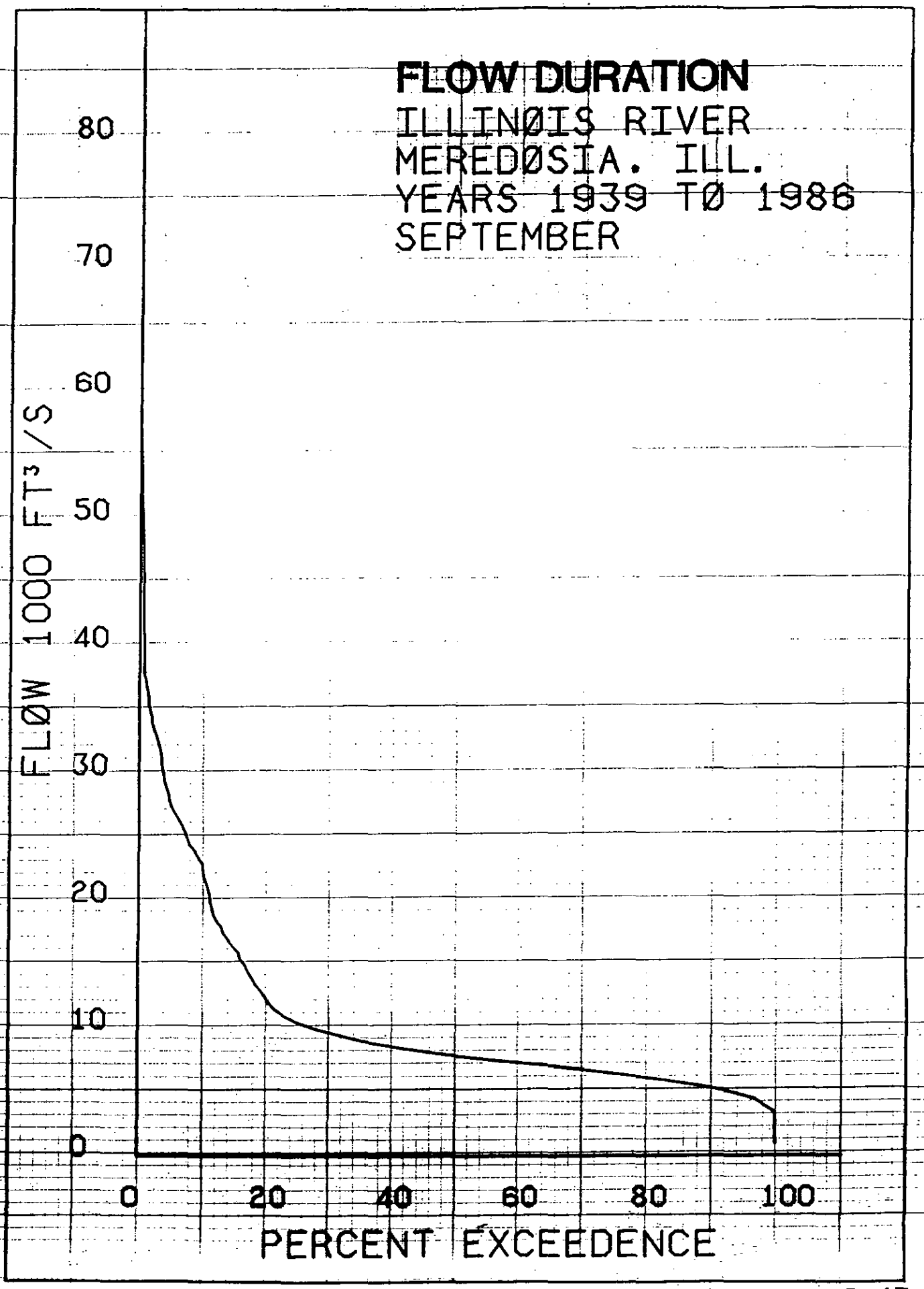
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-16


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
SEPTEMBER
FLØW 1000 FT³/S
80
70
60
50
40
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20
10
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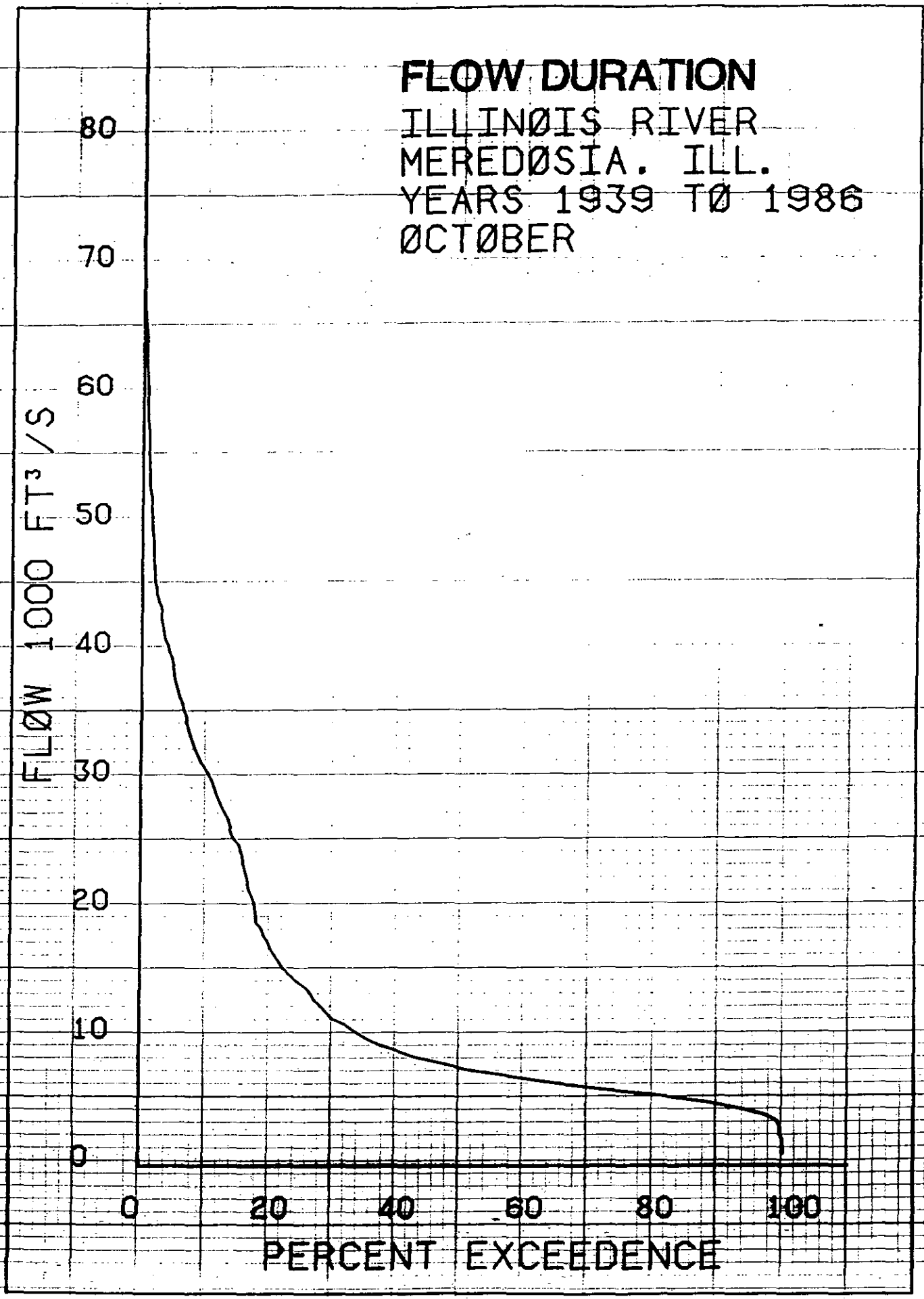
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
ØCTØBER
FLØW 1000 FT³/S
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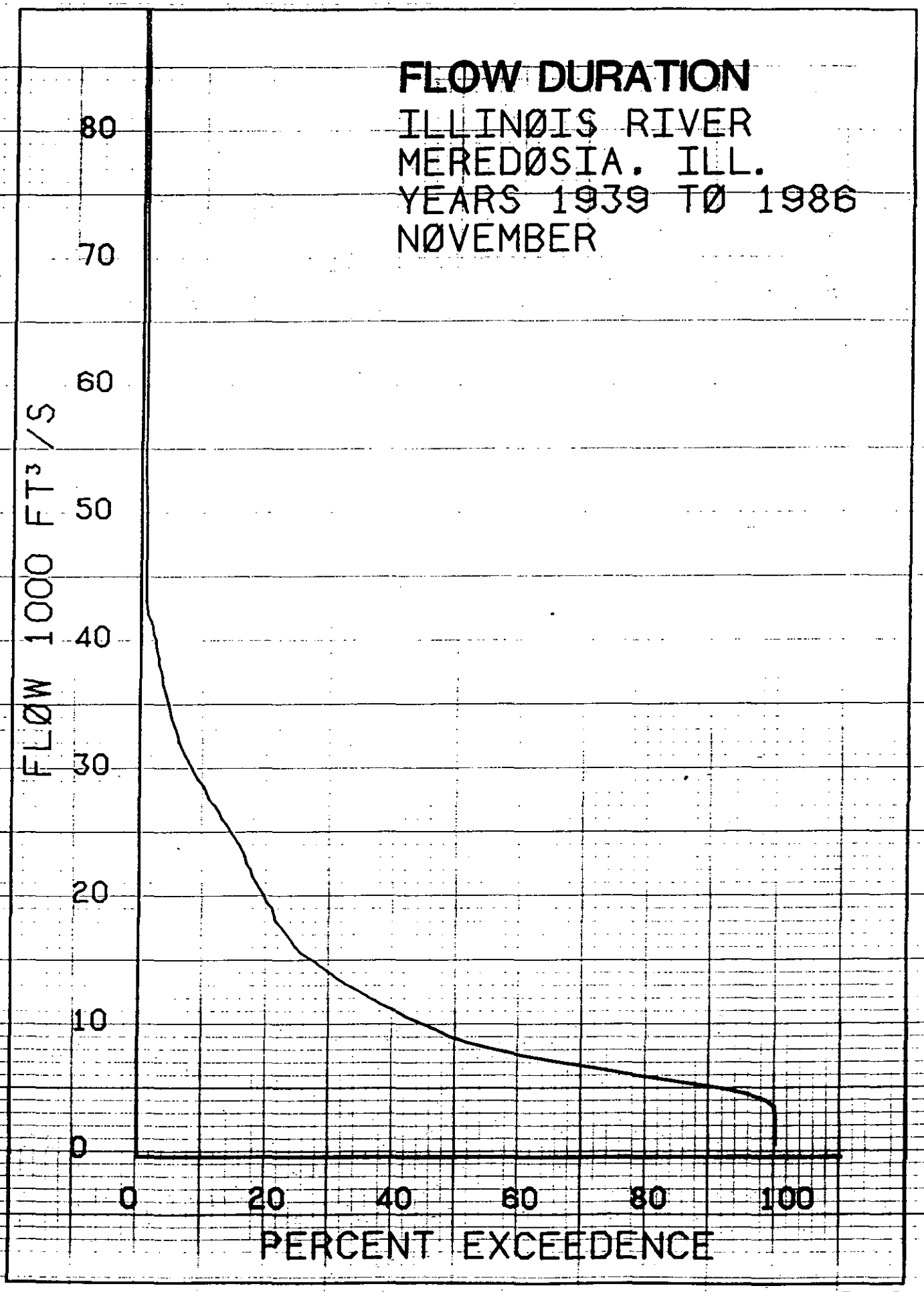
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-18


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
NØVEMBER
FLØW 1000 FT³/S
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40
30
20
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0
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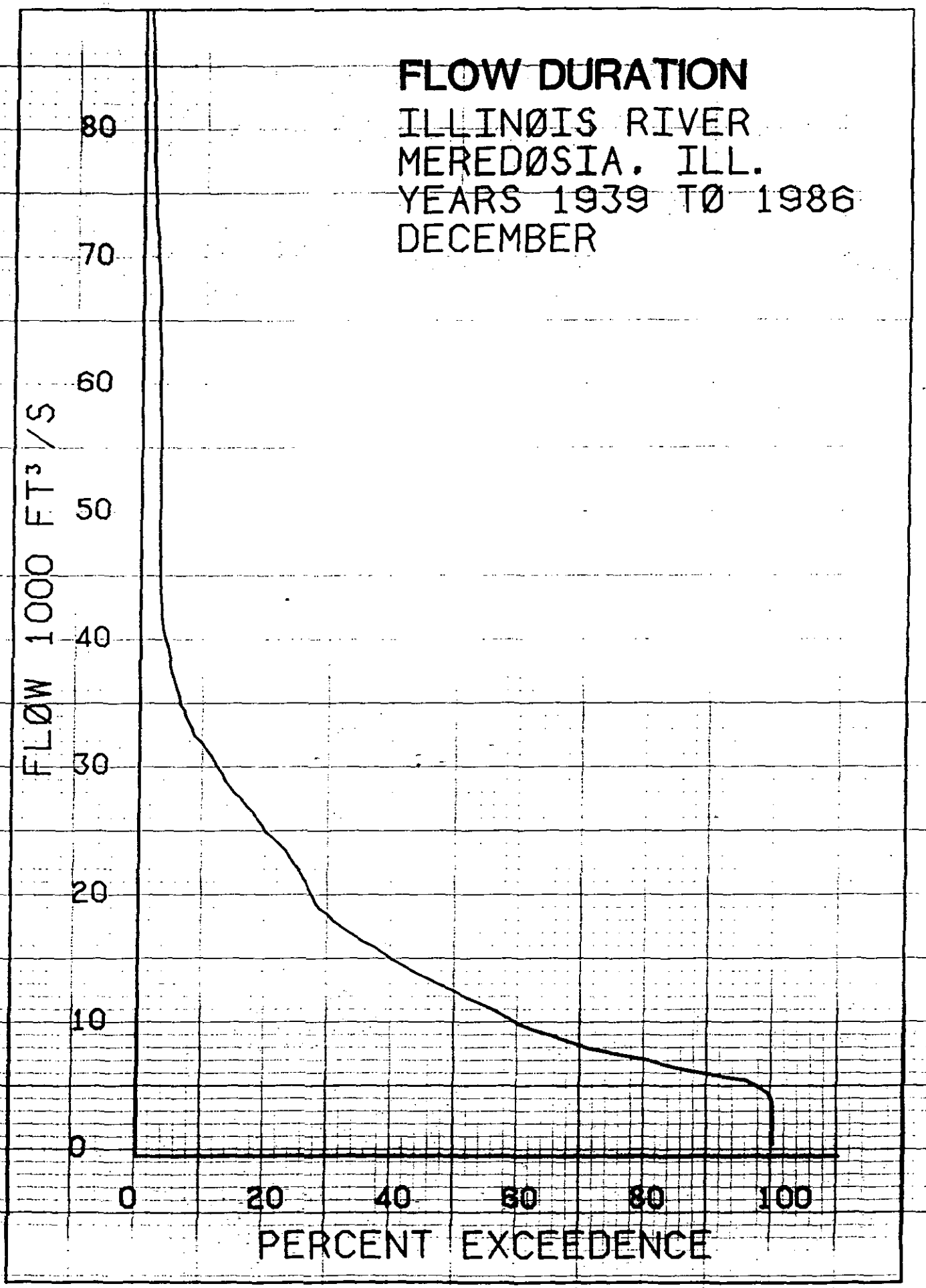
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-19


FLOW DURATION
ILLINØIS RIVER
MEREDØSIA. ILL.
YEARS 1939 TØ 1986
DECEMBER
FLØW 1000 FT³/S
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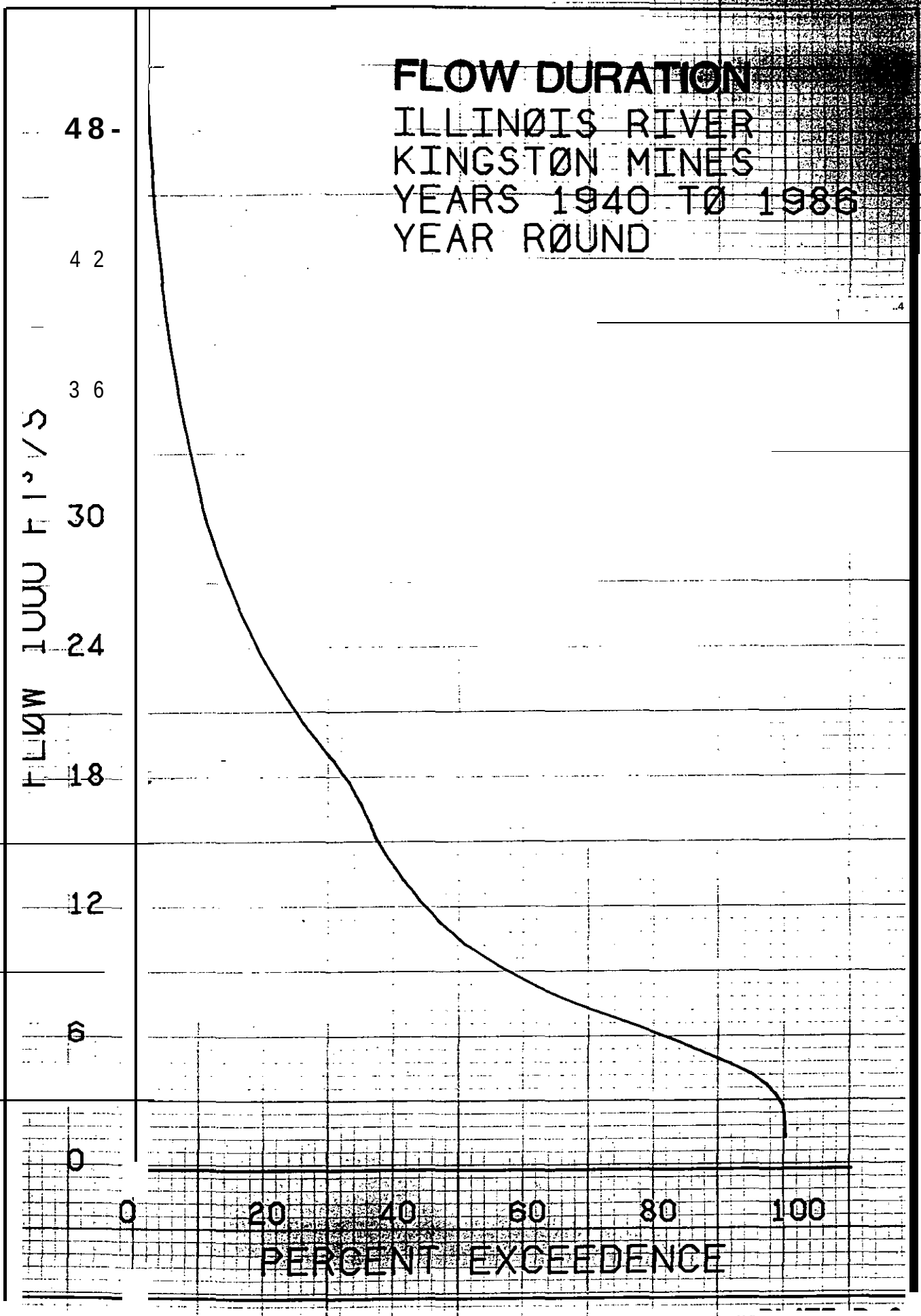
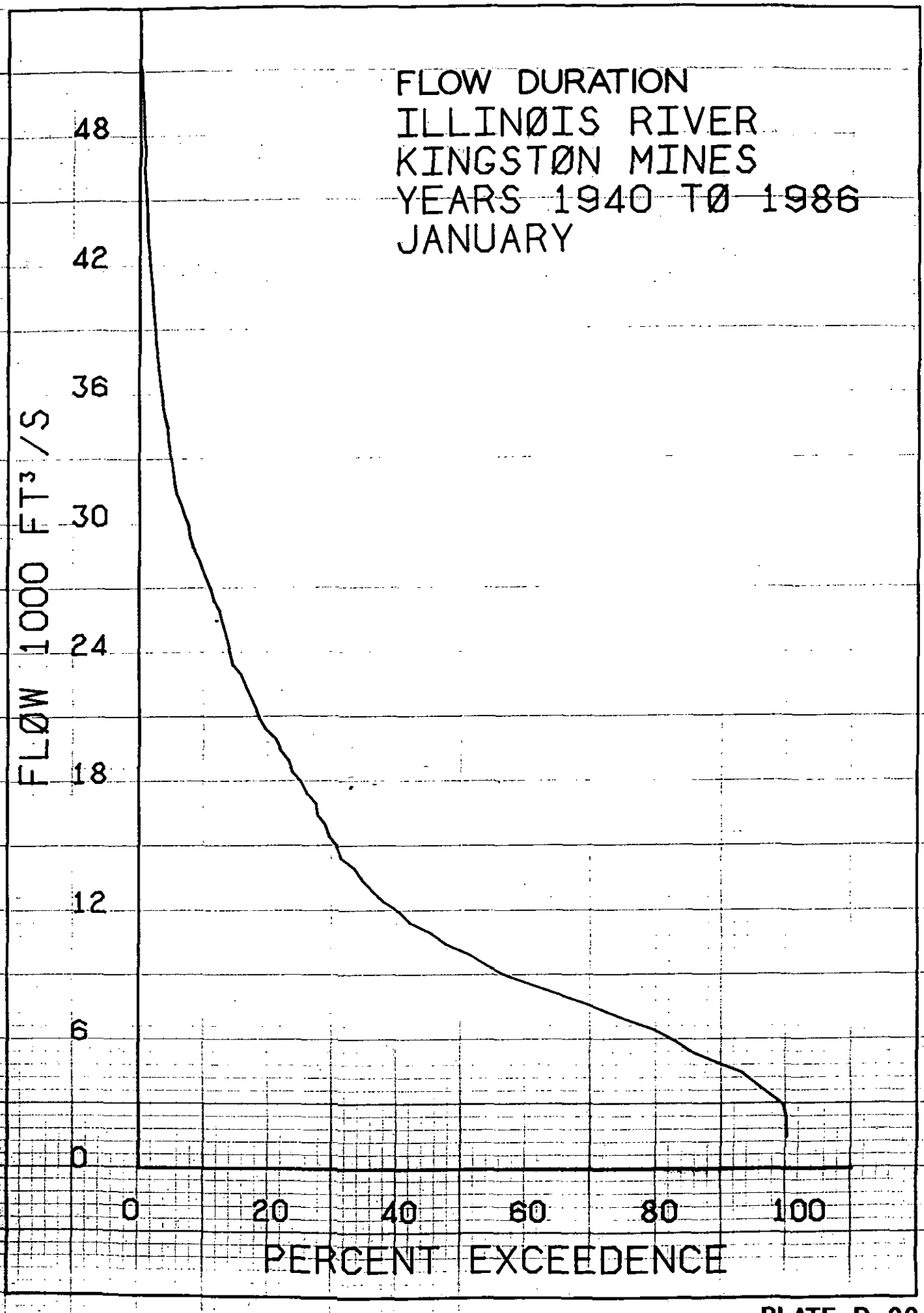
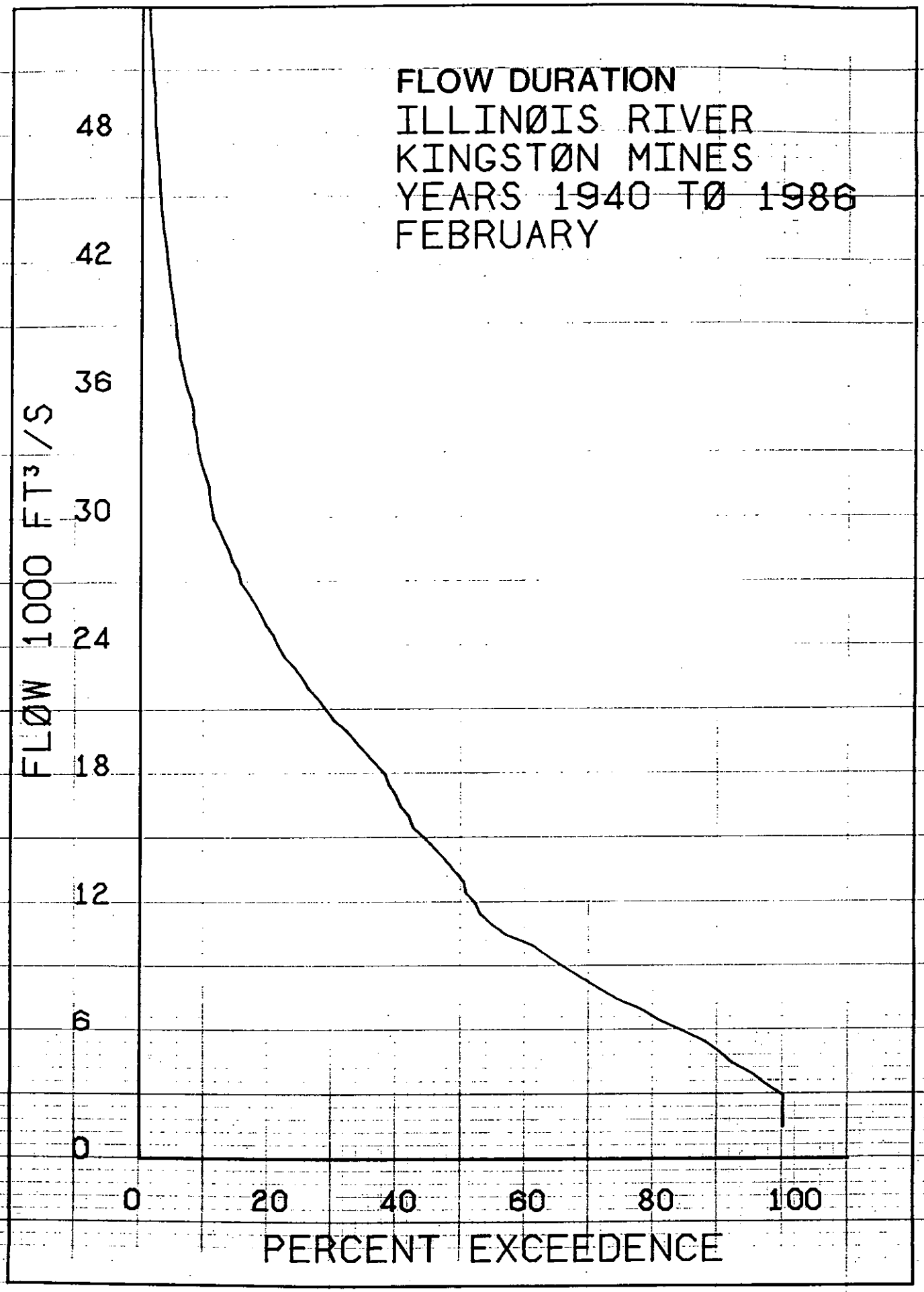
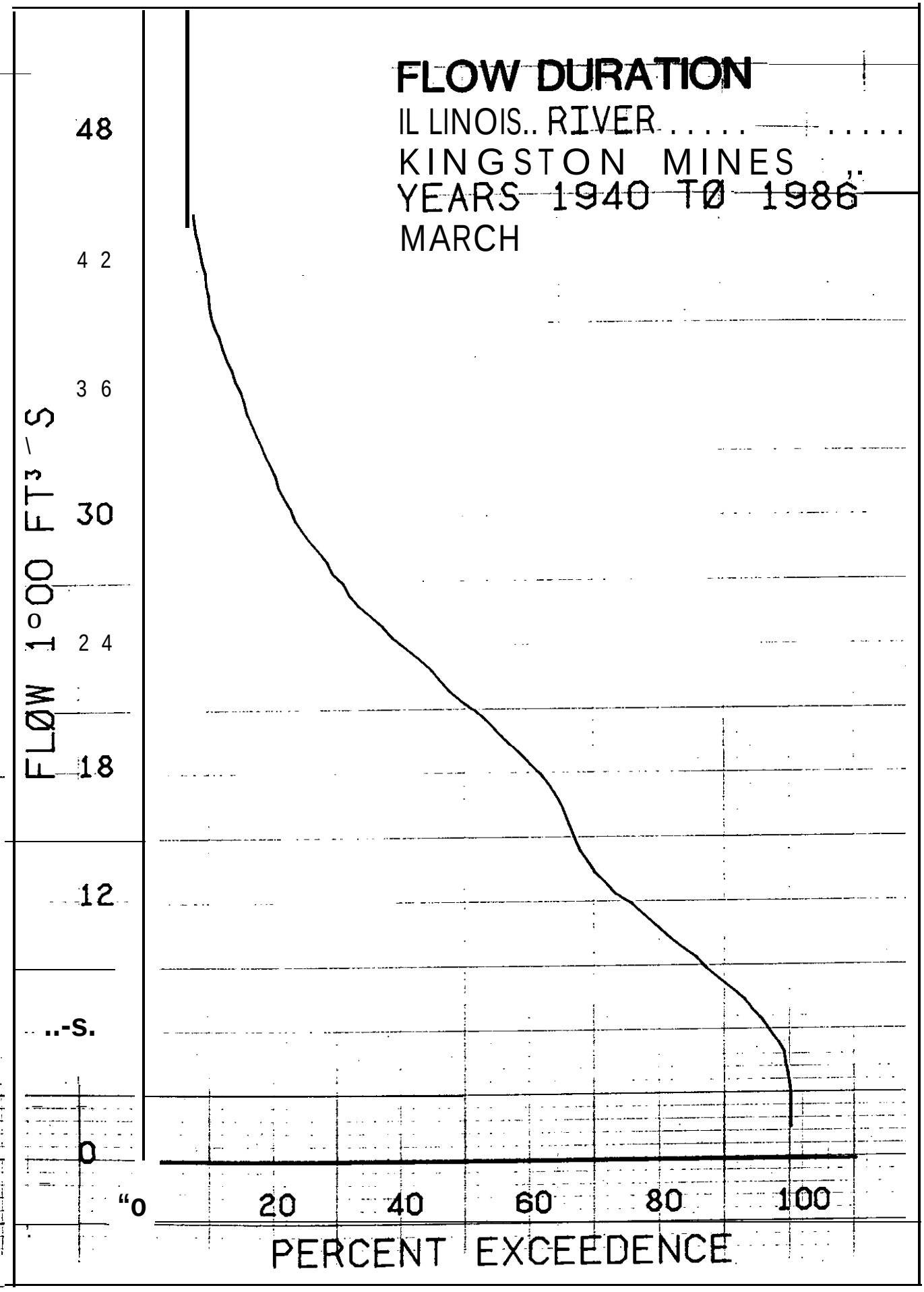
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

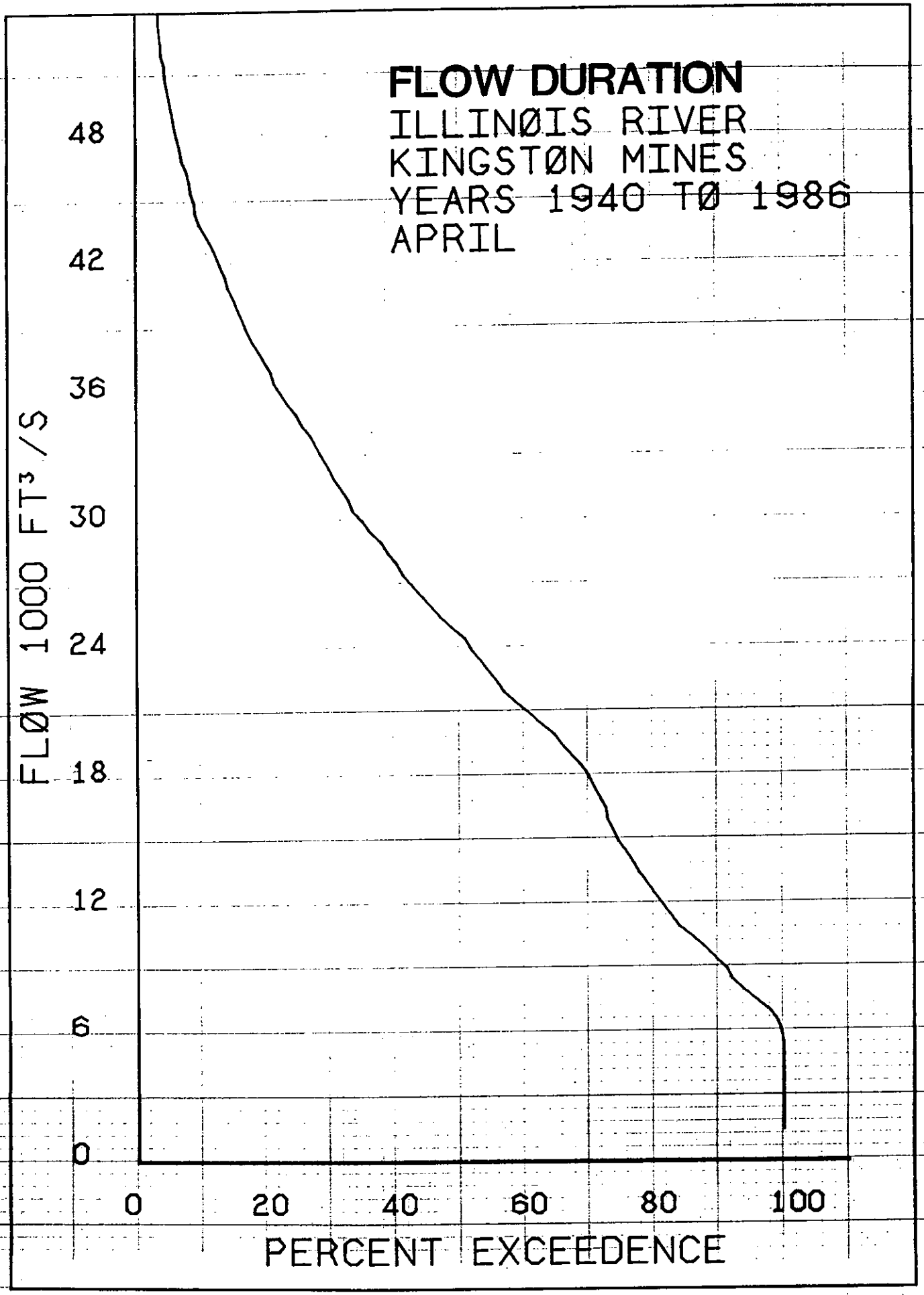
PLATE D-20


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
YEAR RØUND
48
42
36
30
24
18
12
6
0
FLOW 1000 FT³/S
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
JANUARY
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
FEBRUARY
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
IL LINOIS.. RIVER
KINGSTON MINES
YEARS 1940 TØ 1986
MARCH
FLØW 1°00 FT³-S
48
42
36
30
24
18
12
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
APRIL
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

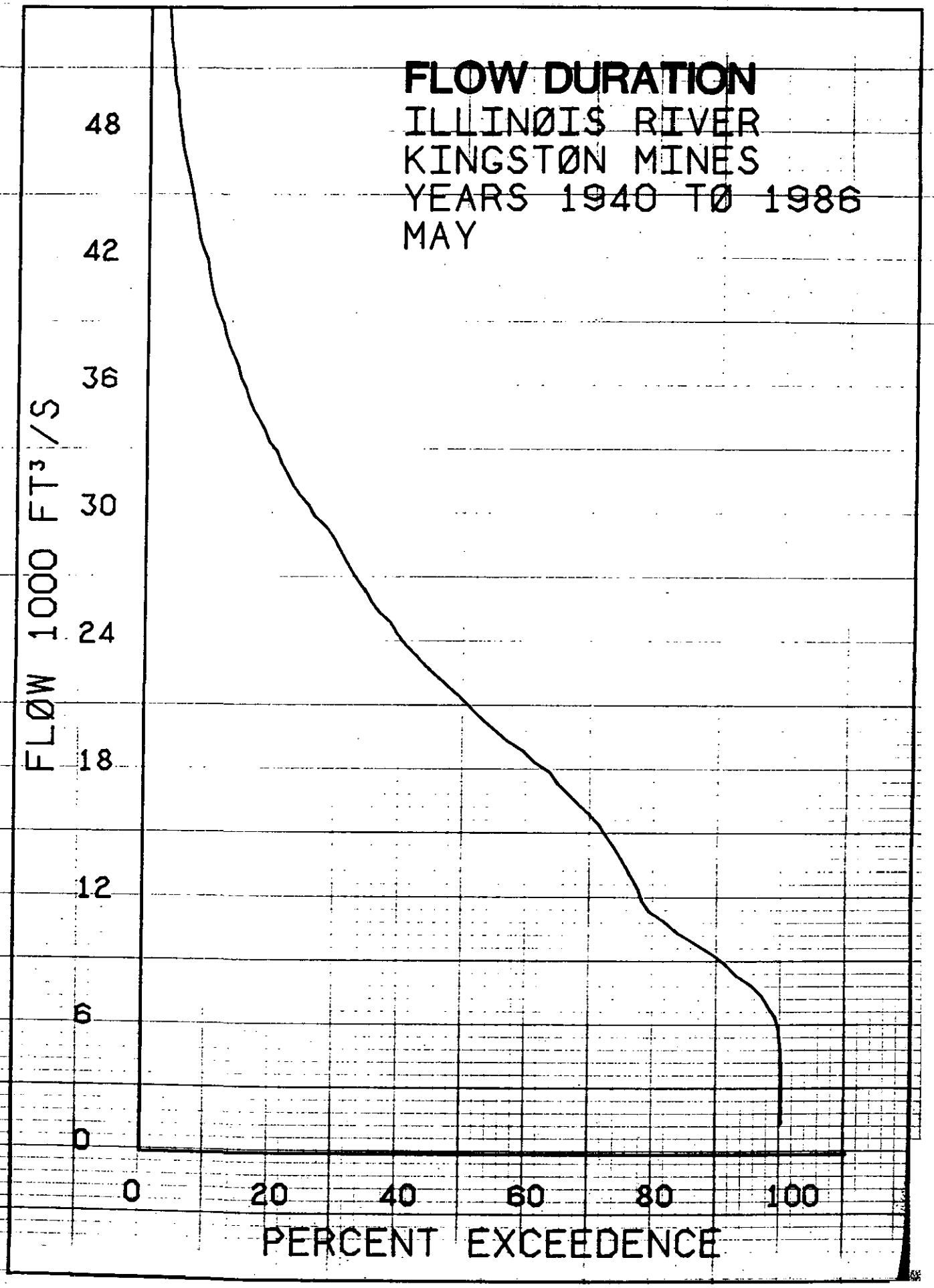

FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
MAY
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-26

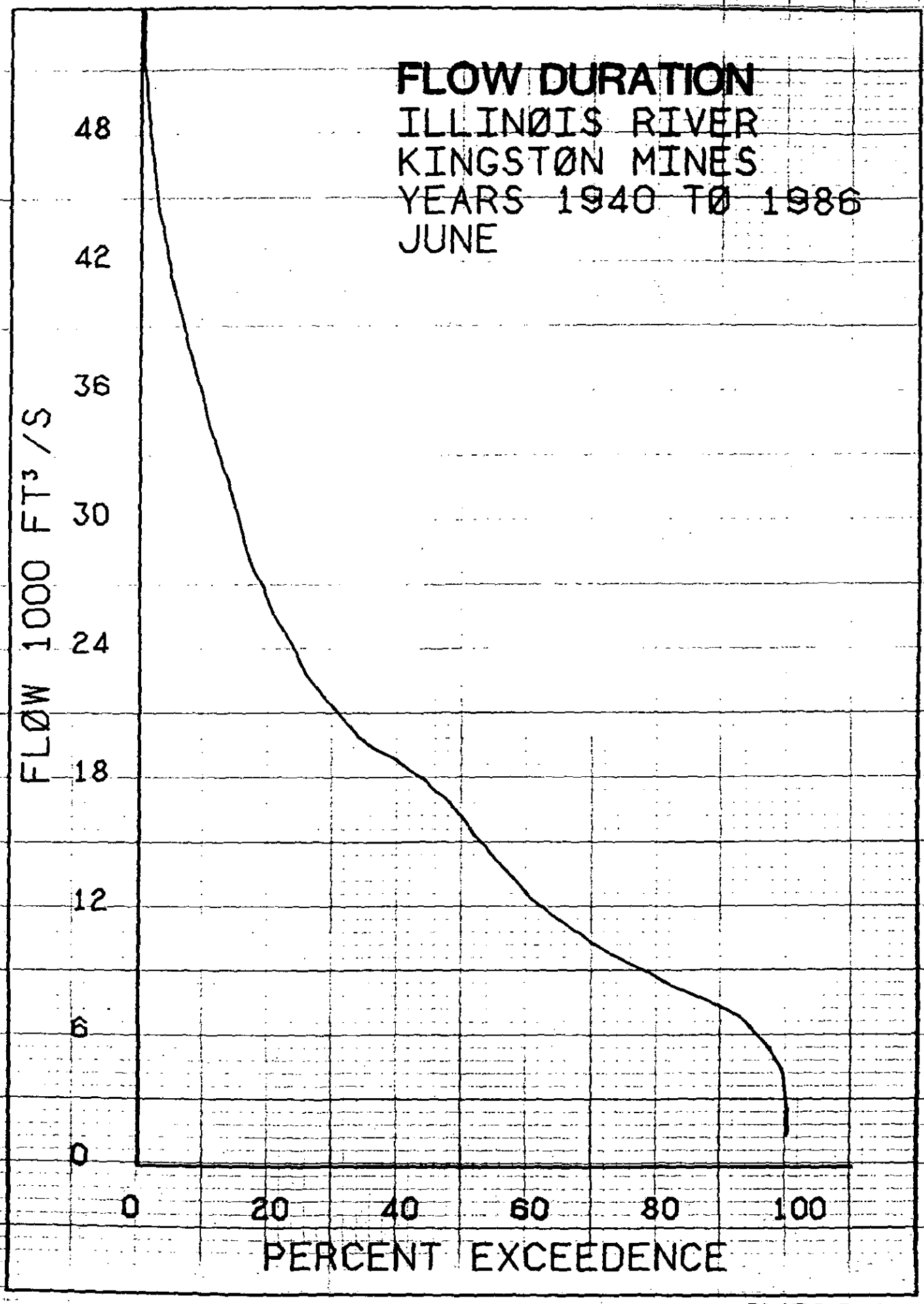
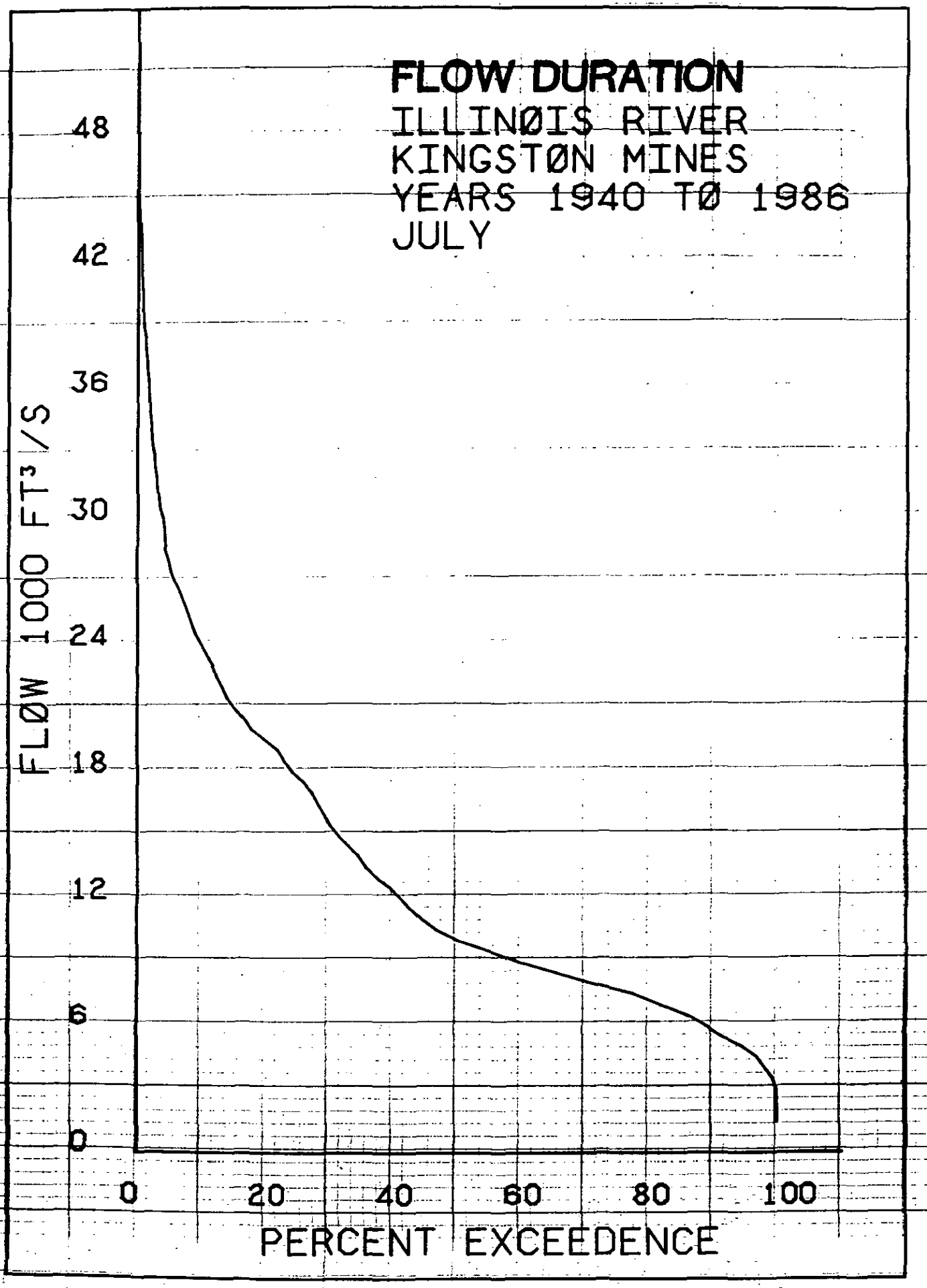

FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
JUNE
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-27


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
JULY
FLØW 1000 FT³/S
48
42
36
30
24
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12
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20
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60
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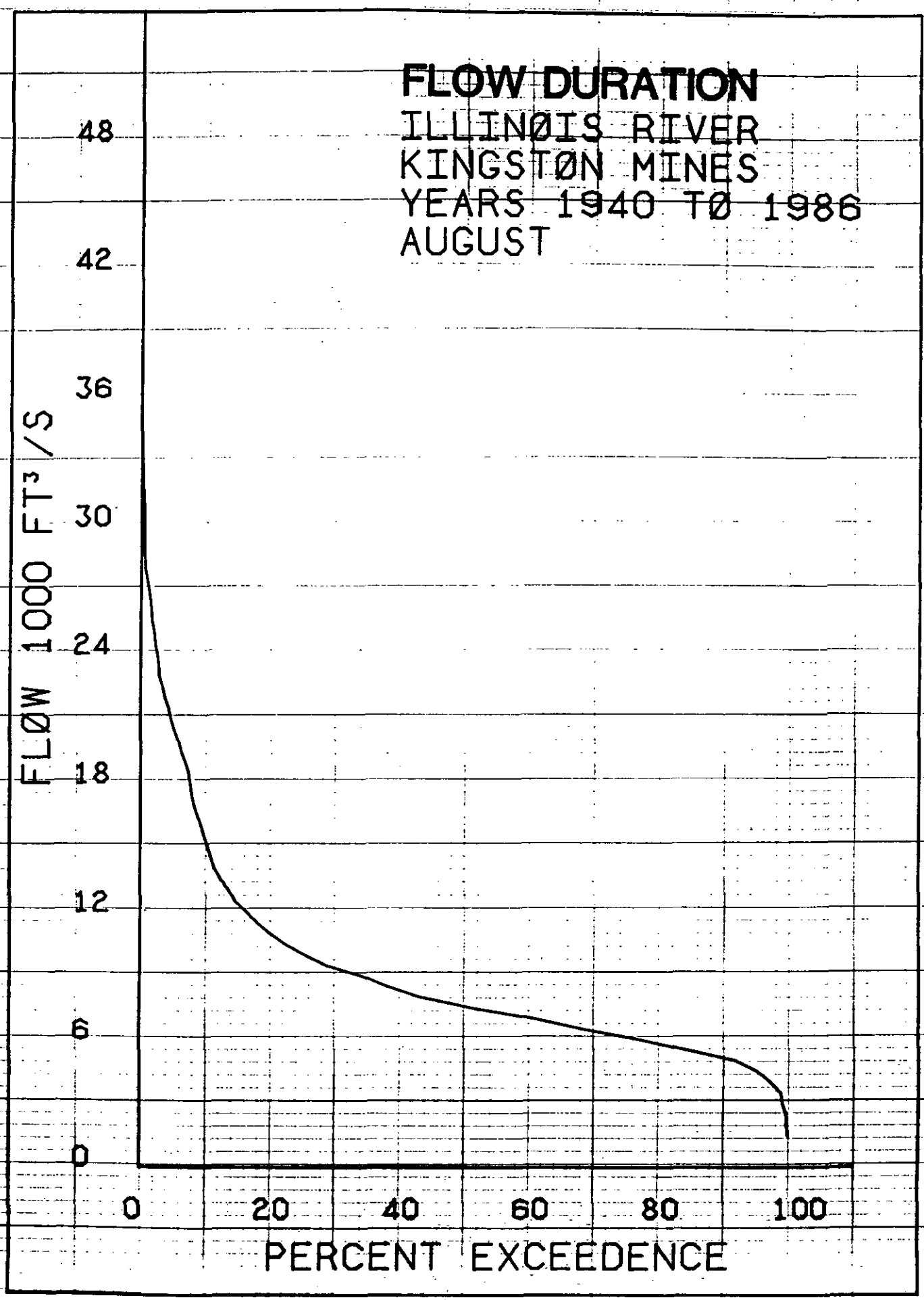
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
AUGUST
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

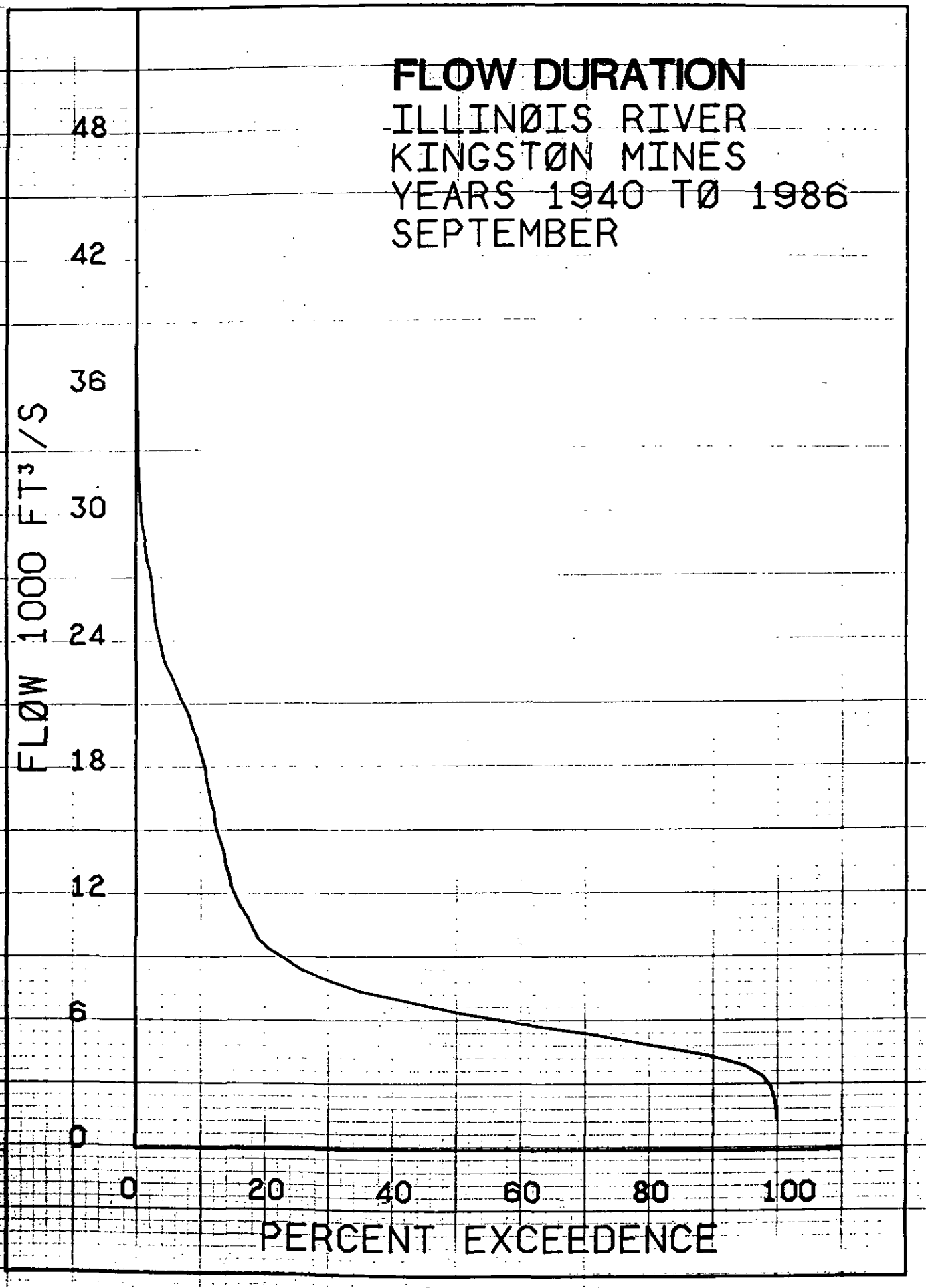
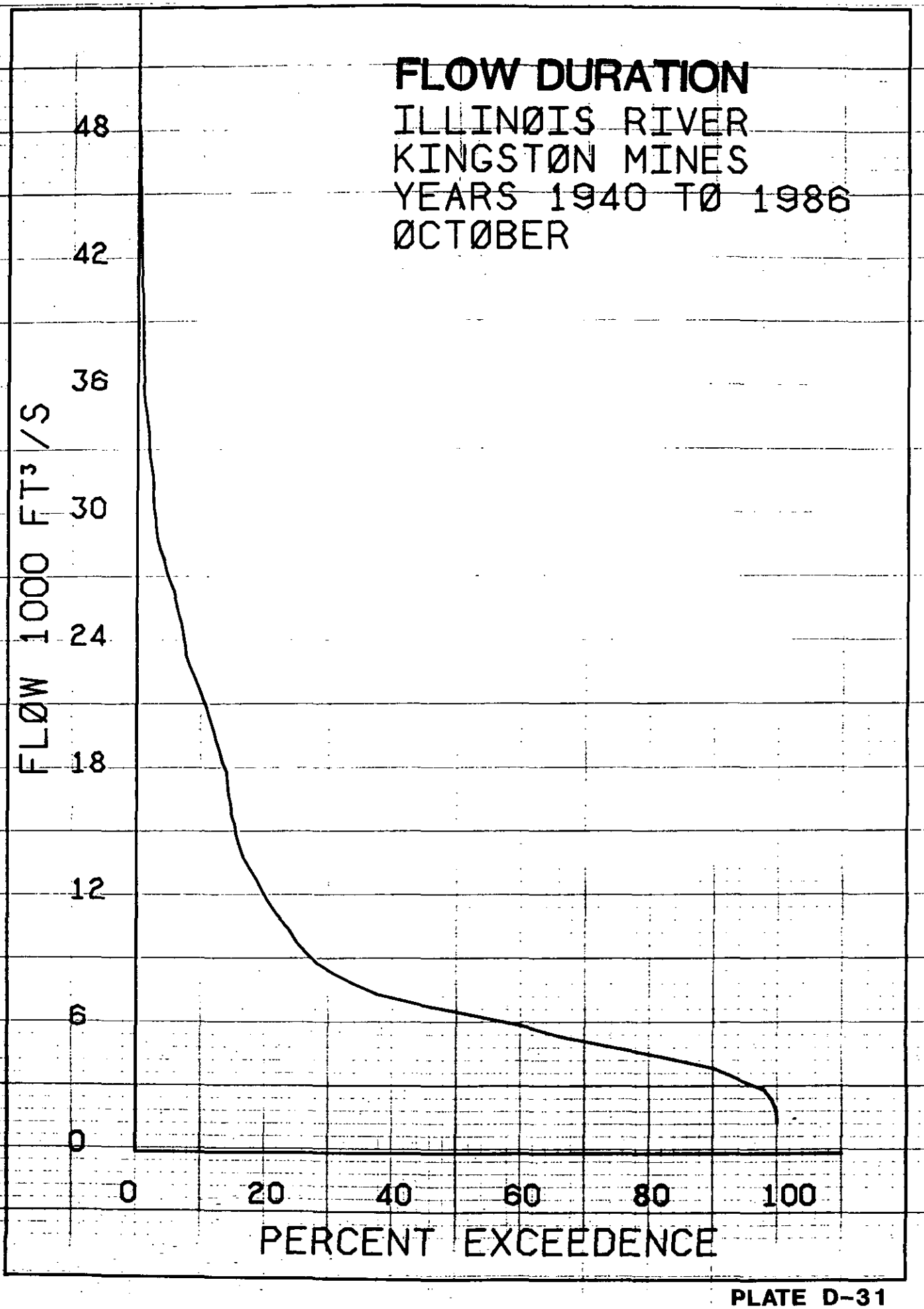
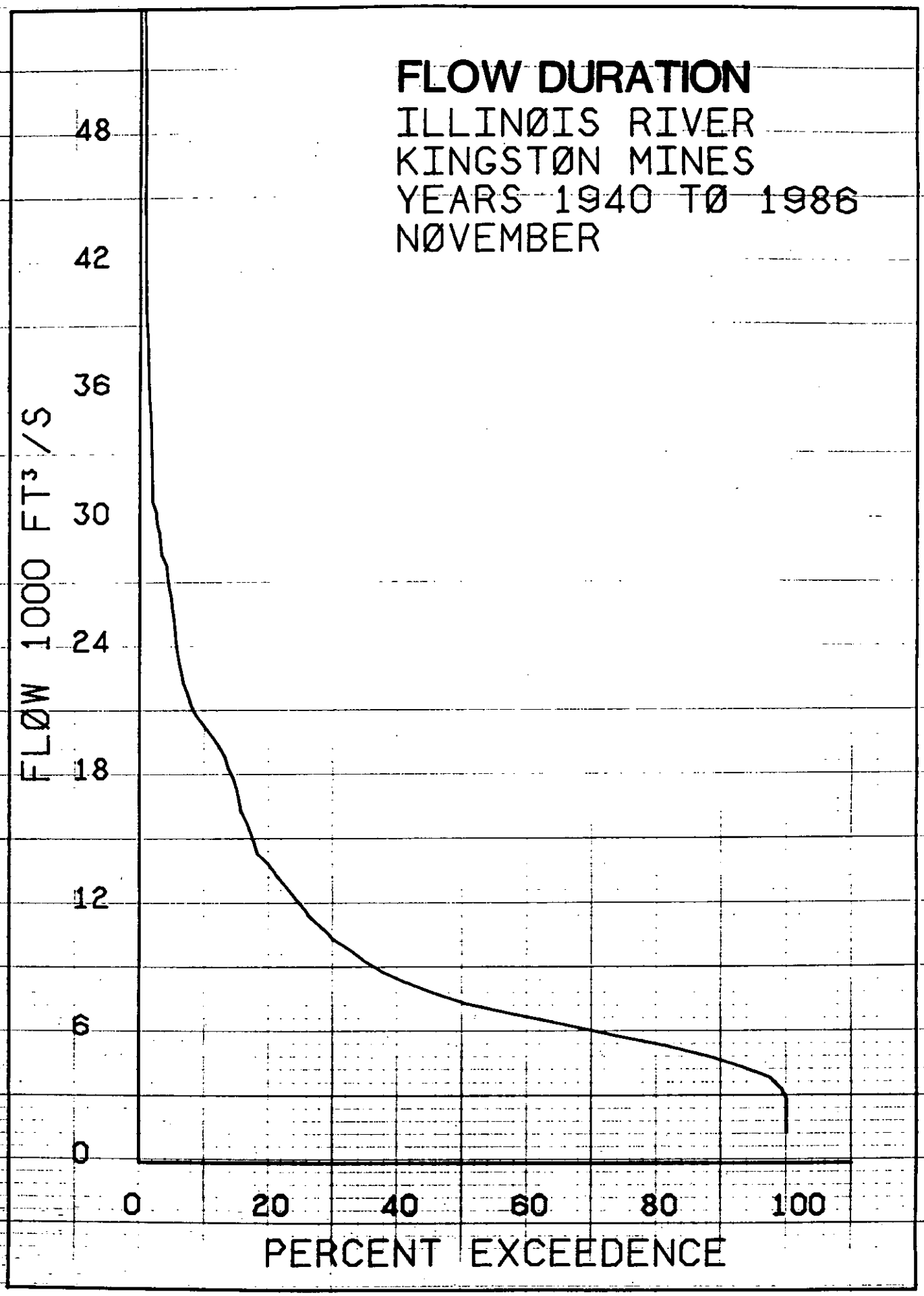

FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
SEPTEMBER
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-30


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
ØCTØBER
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
NØVEMBER
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

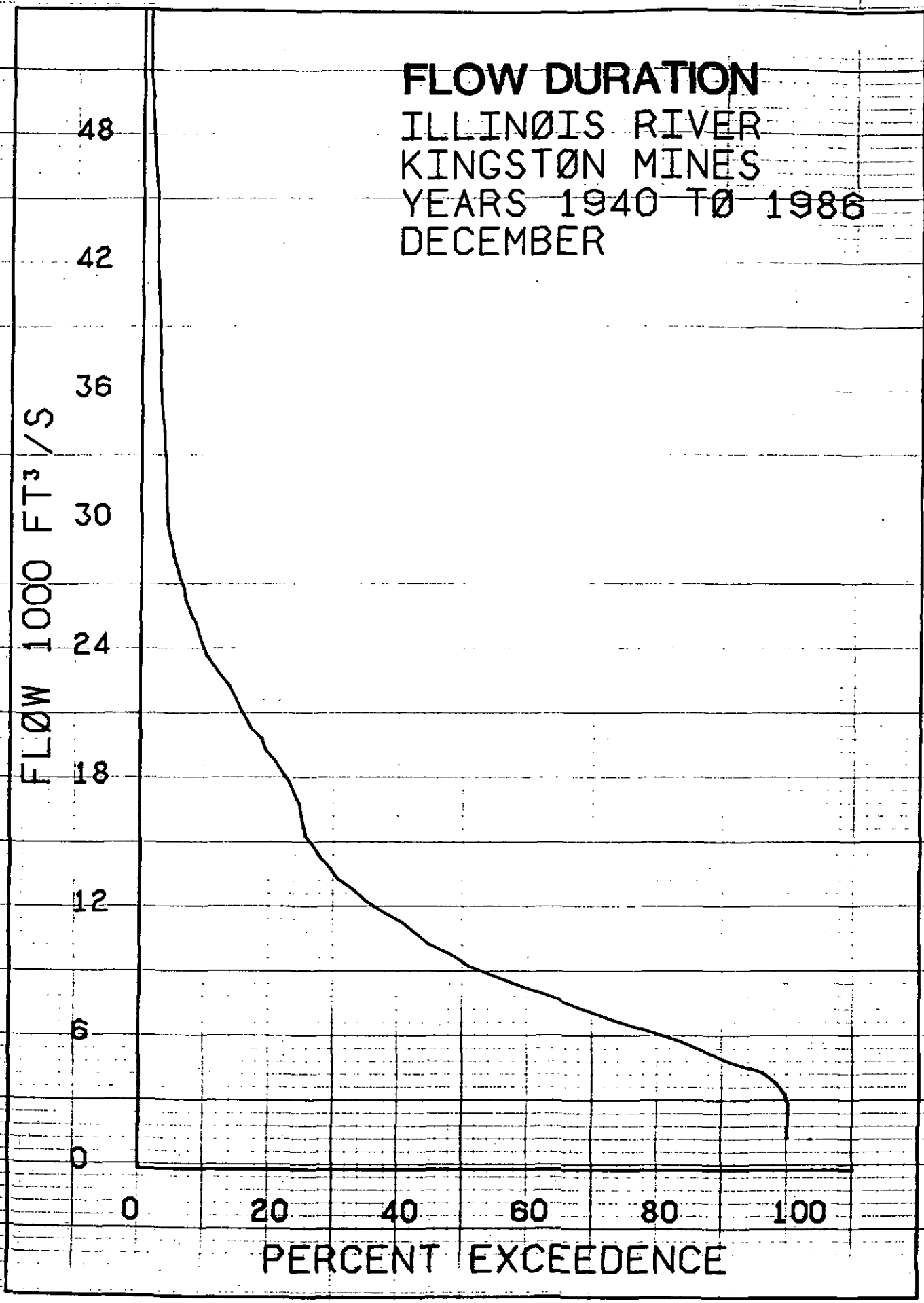

FLOW DURATION
ILLINØIS RIVER
KINGSTØN MINES
YEARS 1940 TØ 1986
DECEMBER
FLØW 1000 FT³/S
48
42
36
30
24
18
12
6
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-33

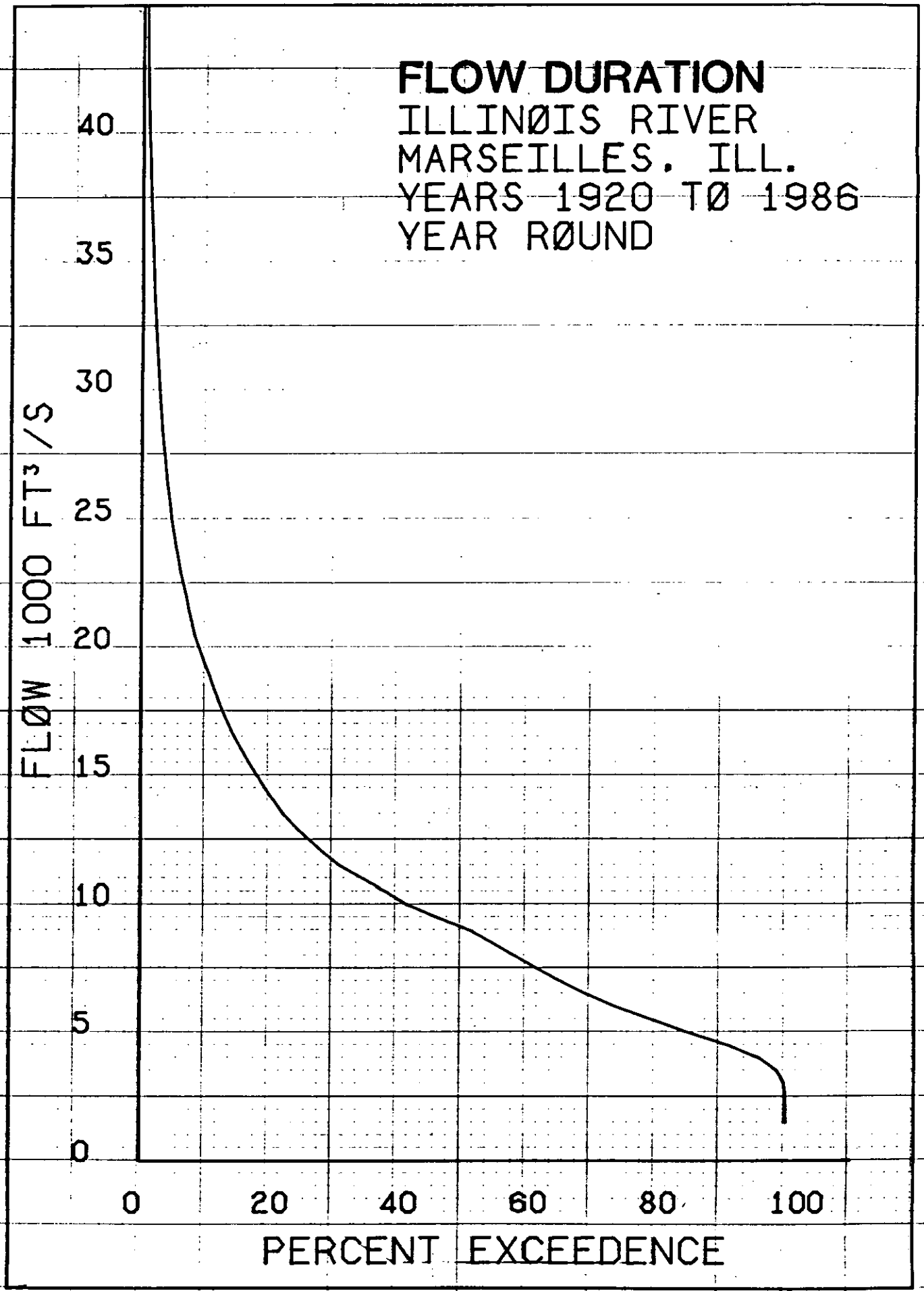

FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
YEAR RØUND
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-34

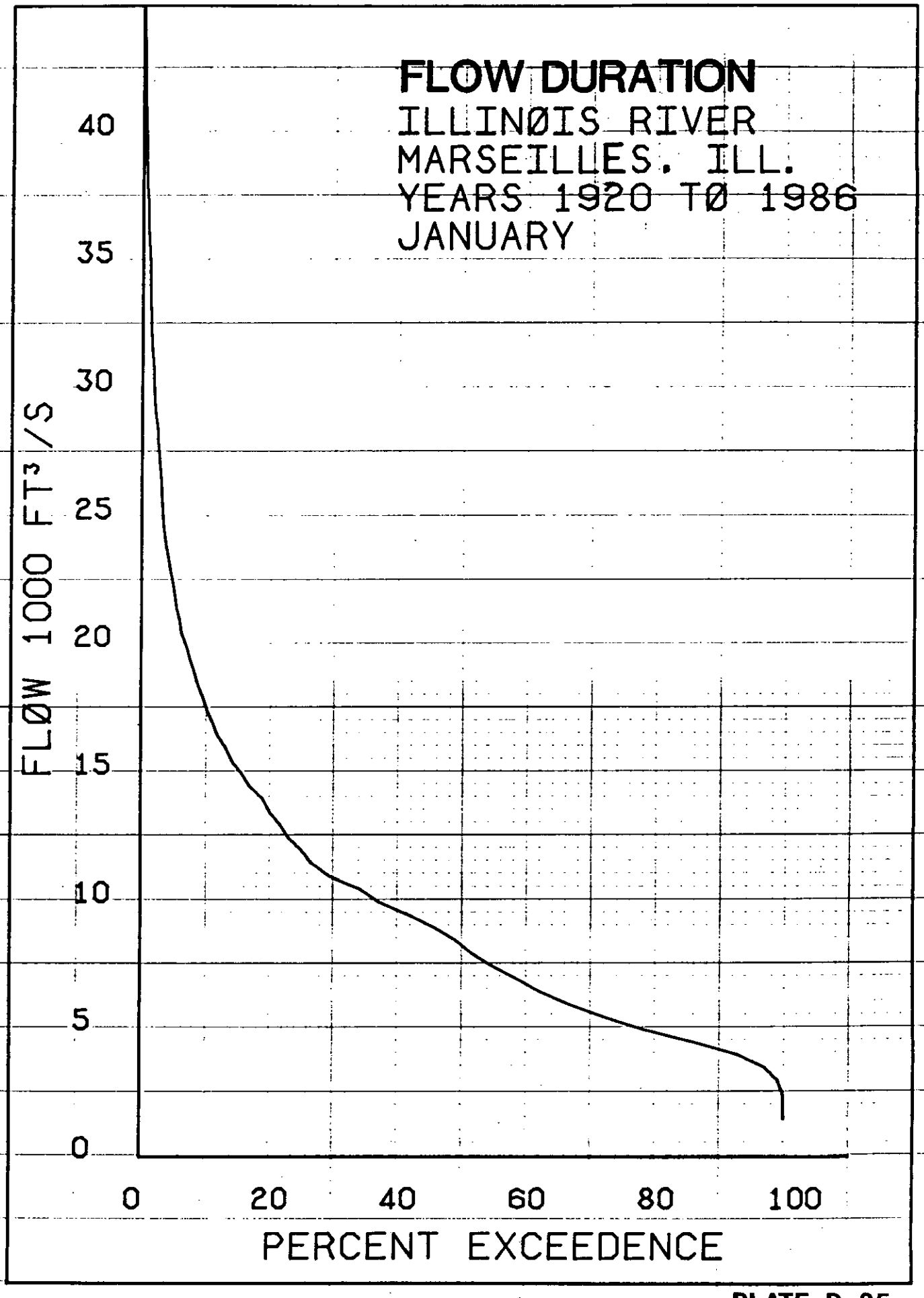
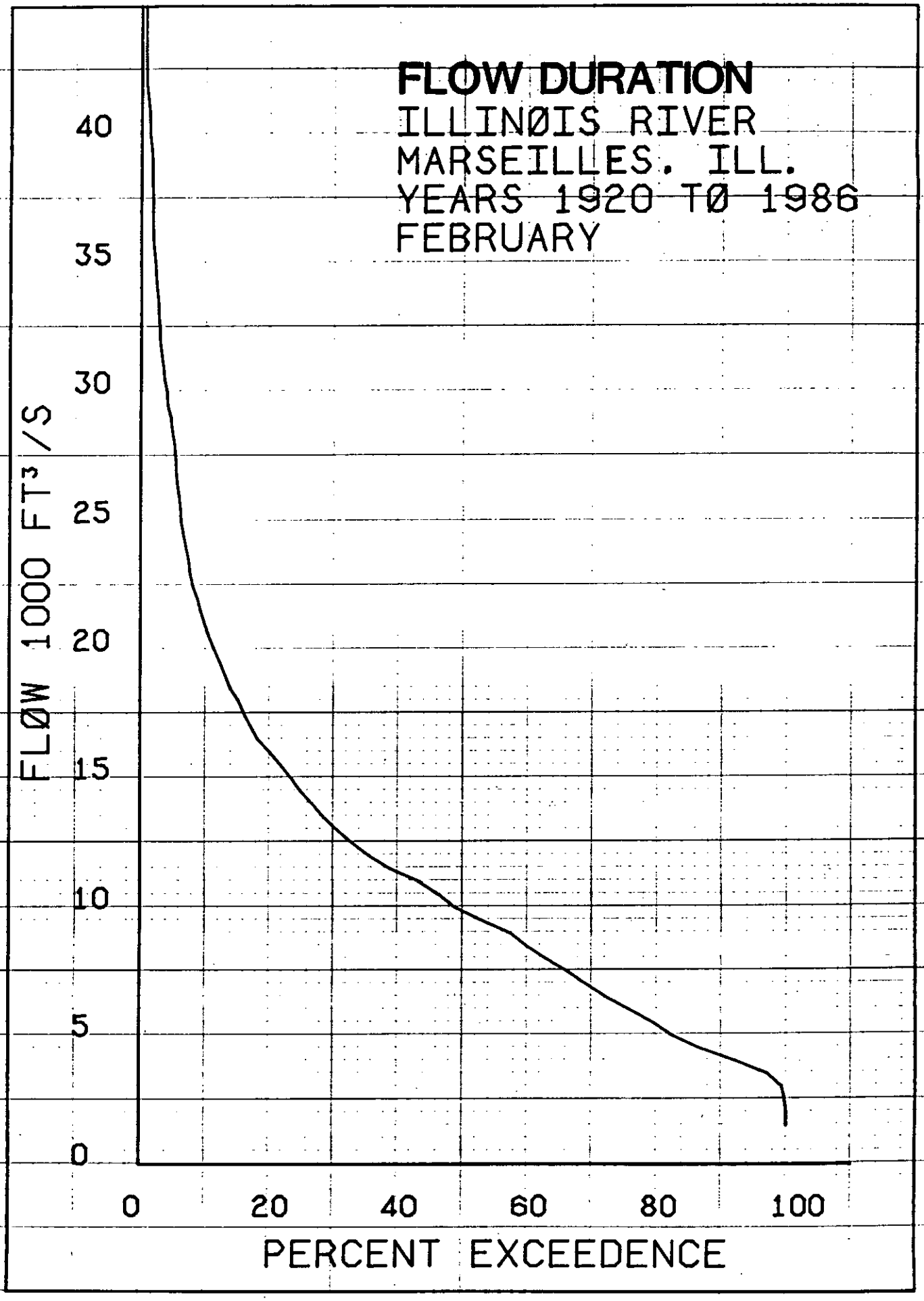
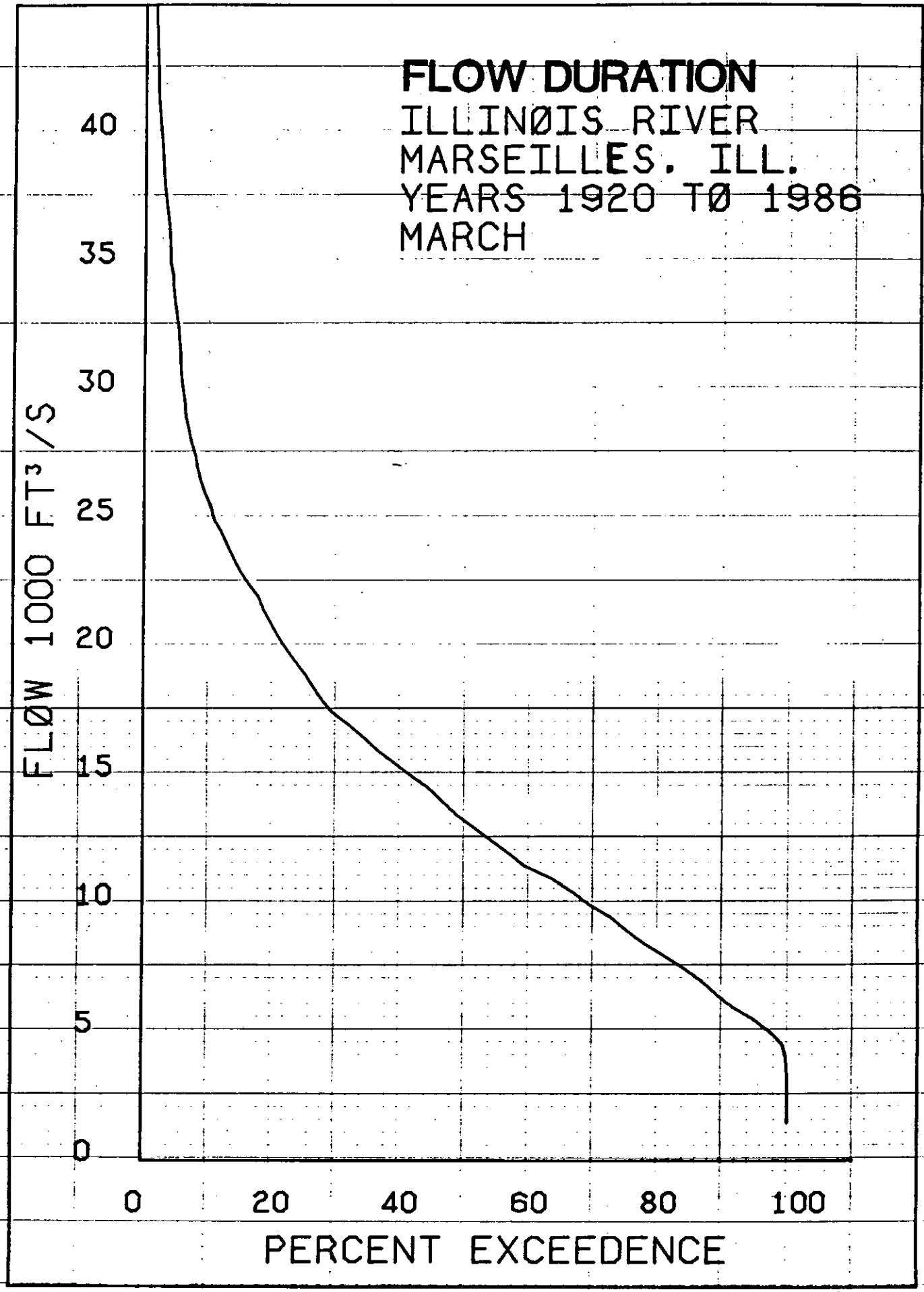
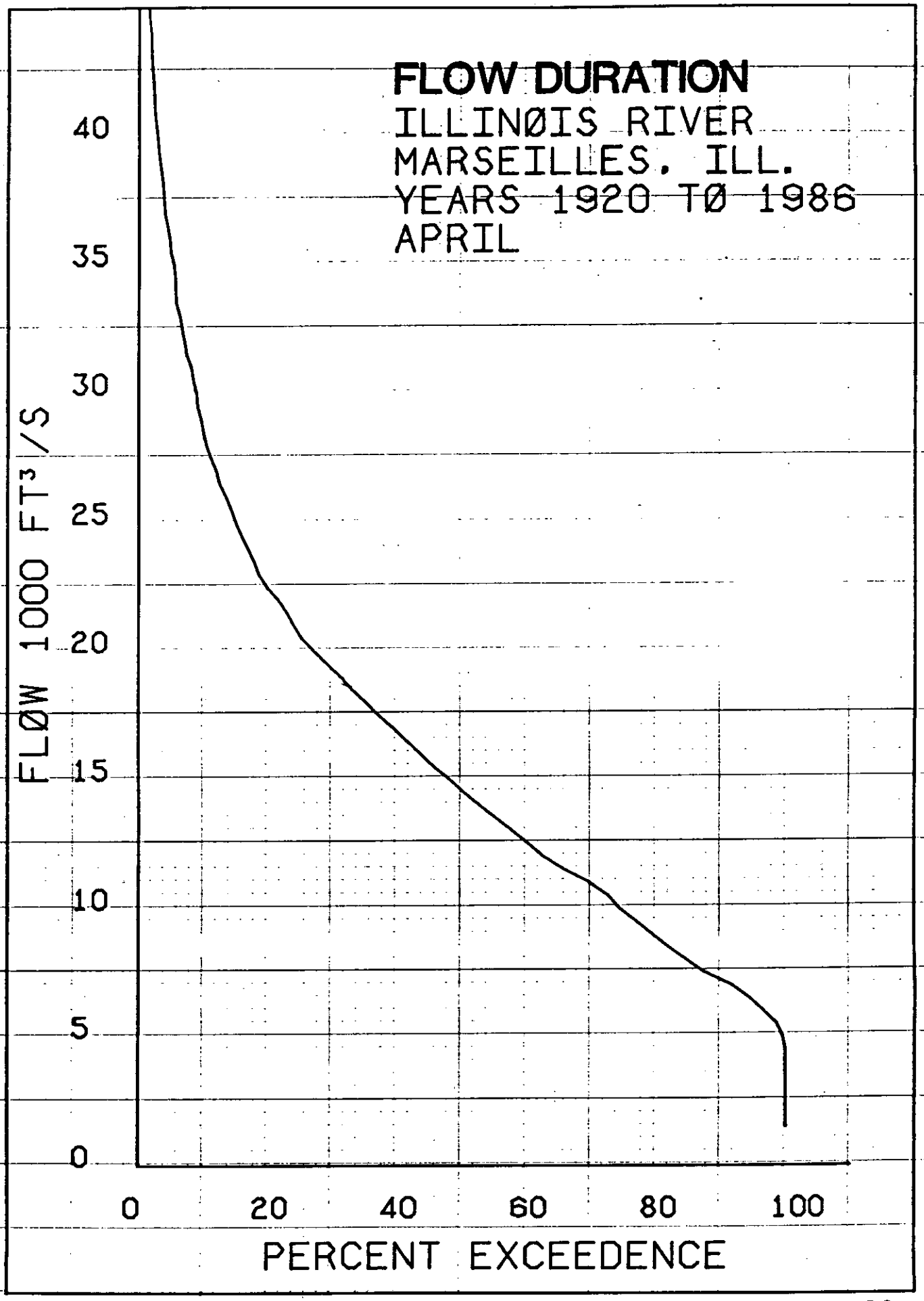
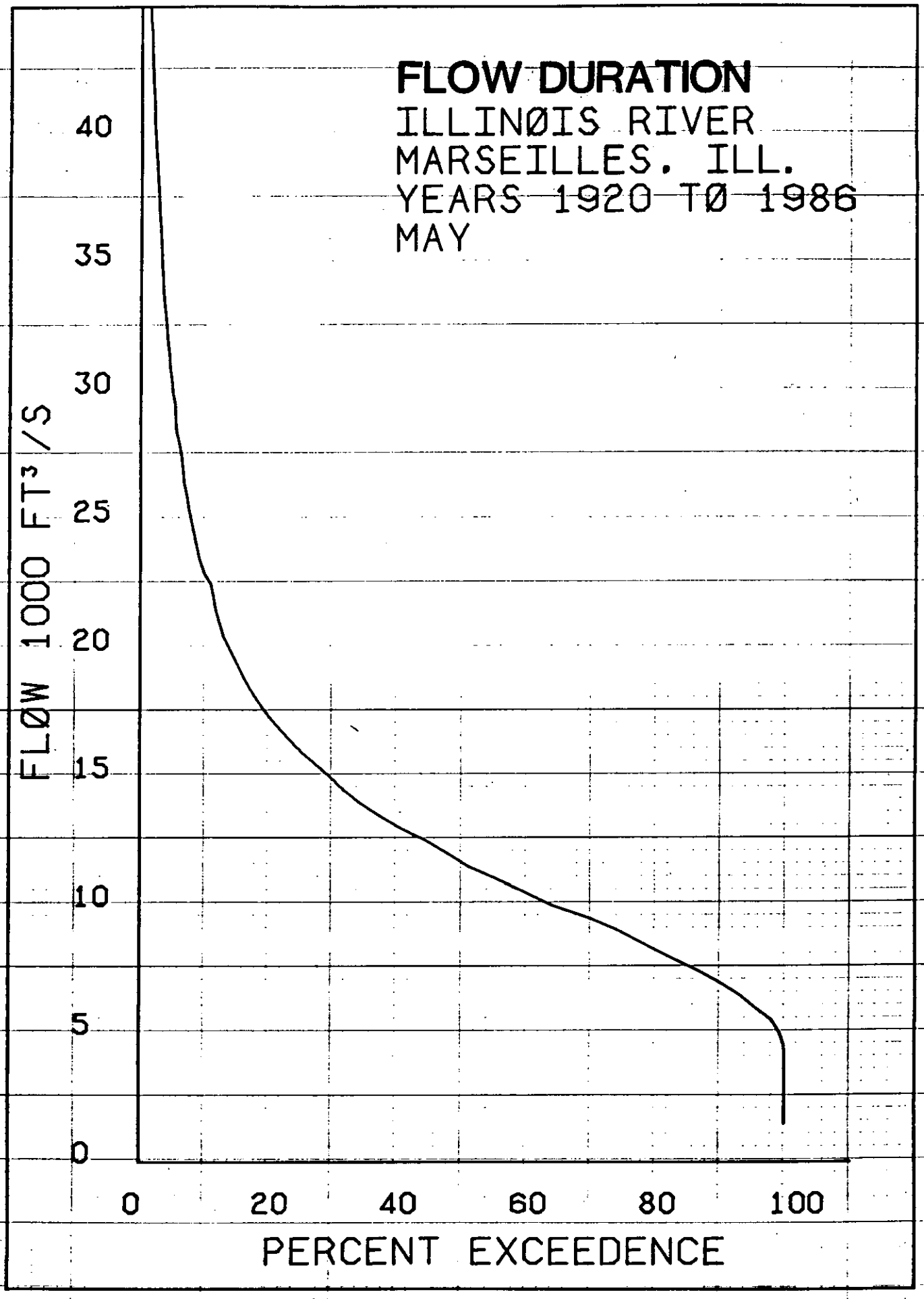

FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
JANUARY
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-35


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
FEBRUARY
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
MARCH
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
APRIL
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
MAY
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

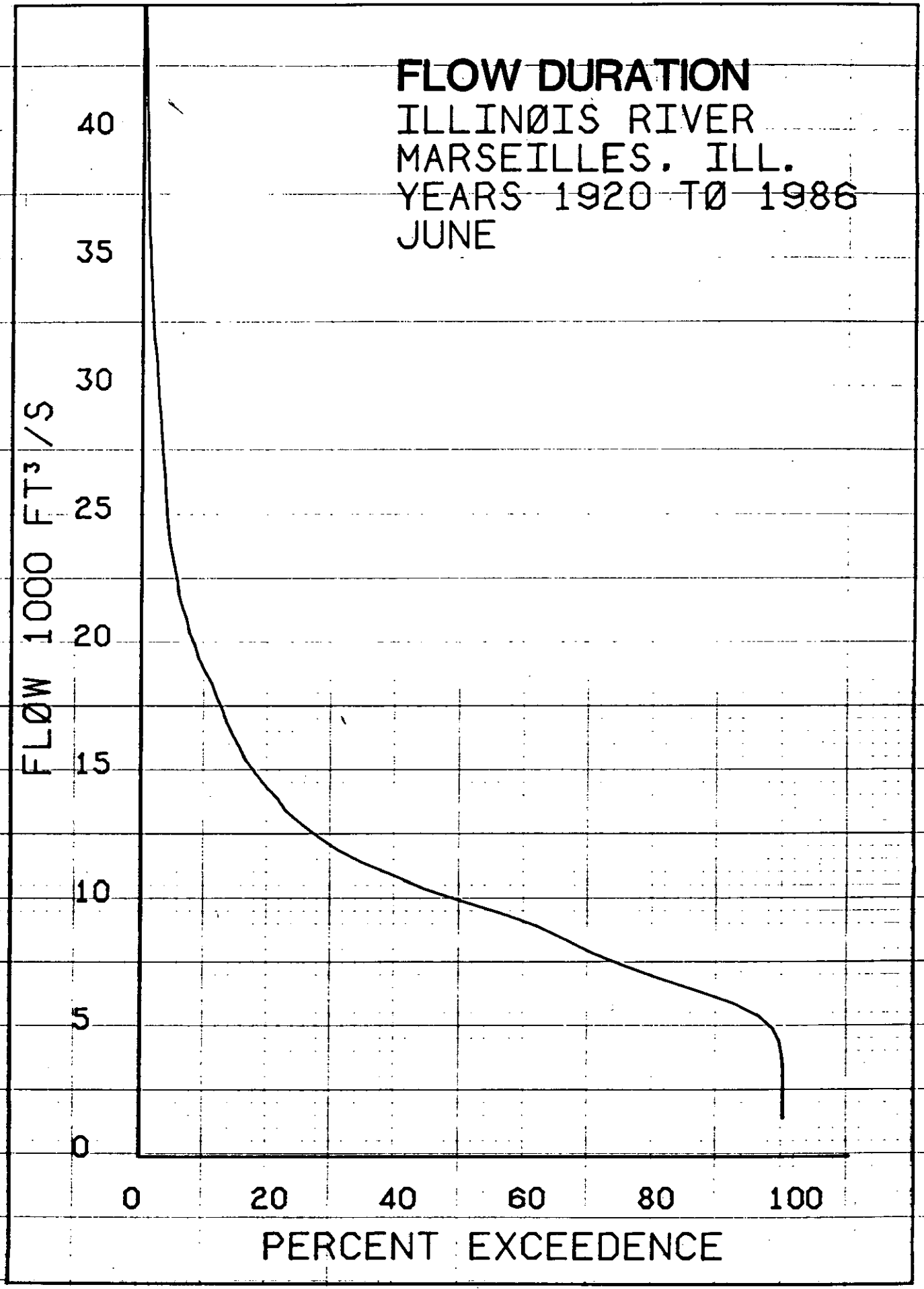
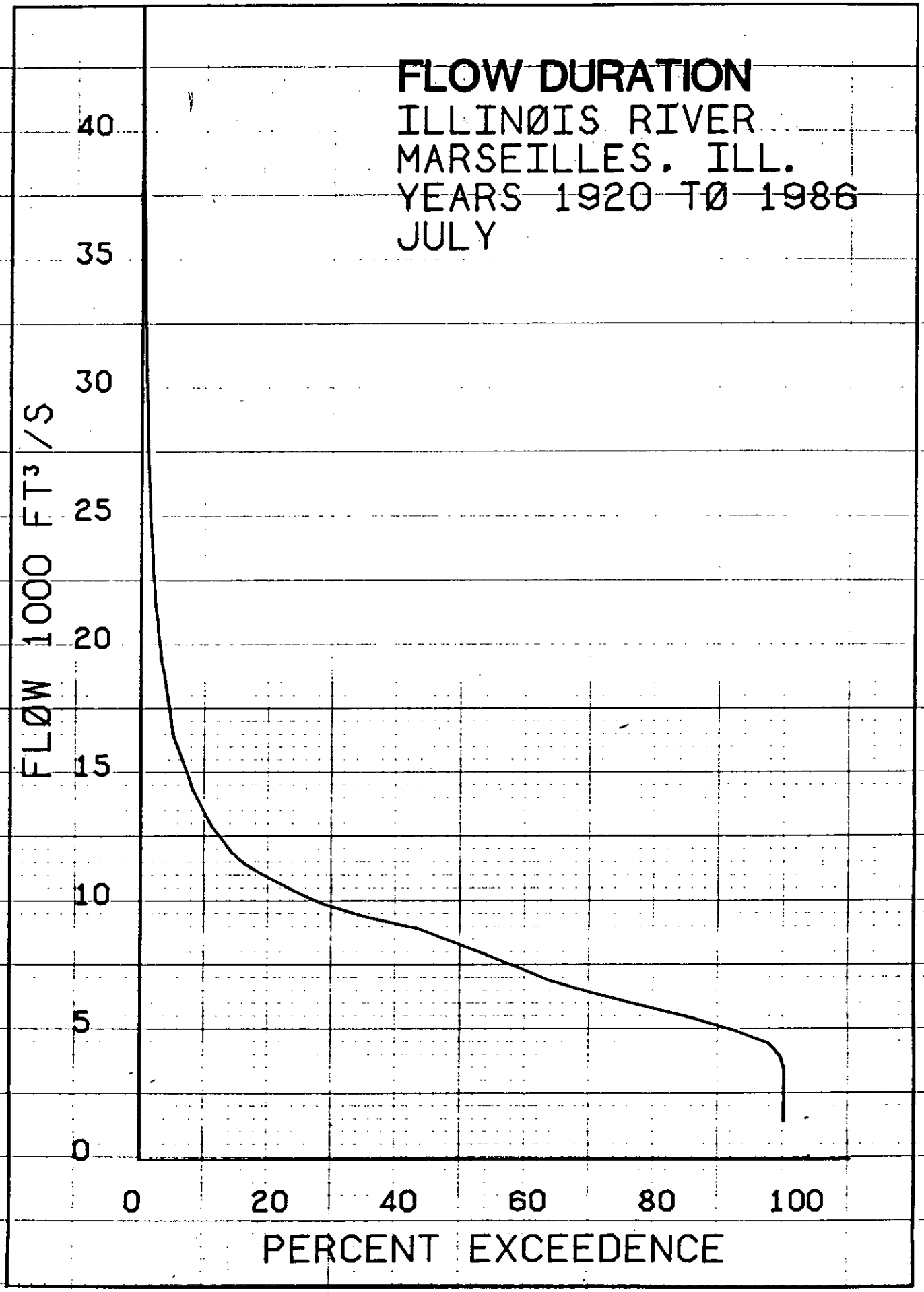
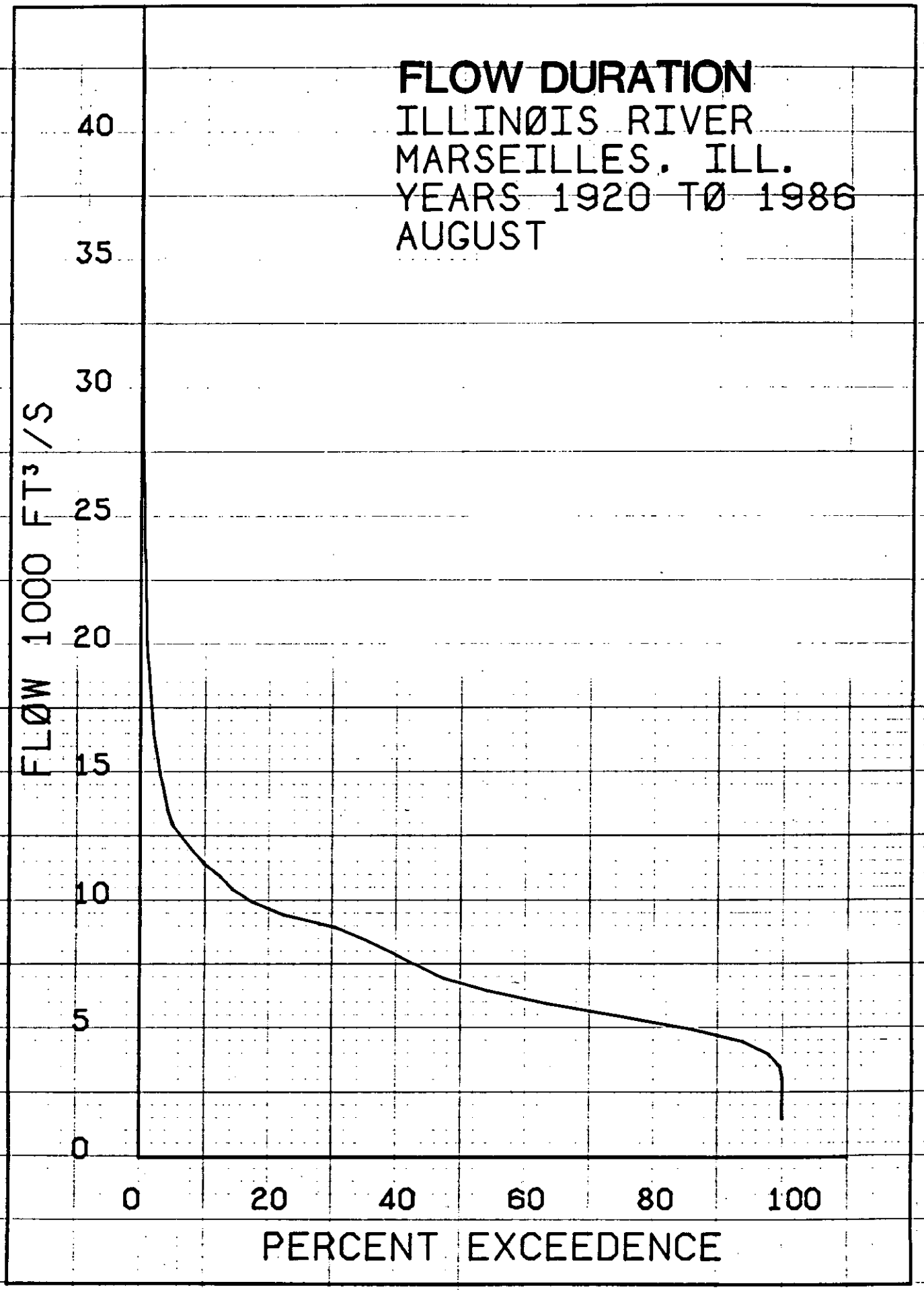

FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
JUNE
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-40


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
JULY
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
AUGUST
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

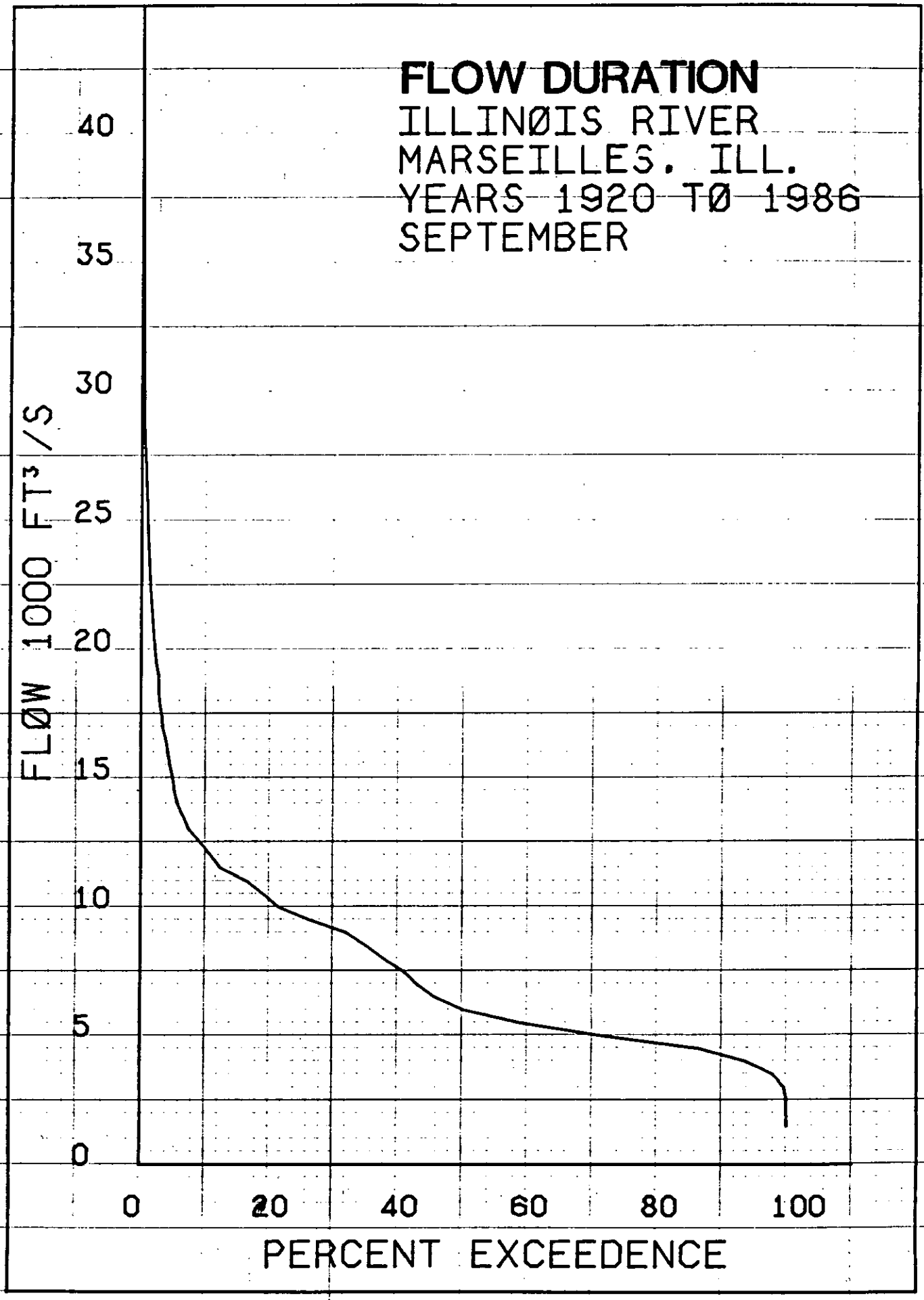
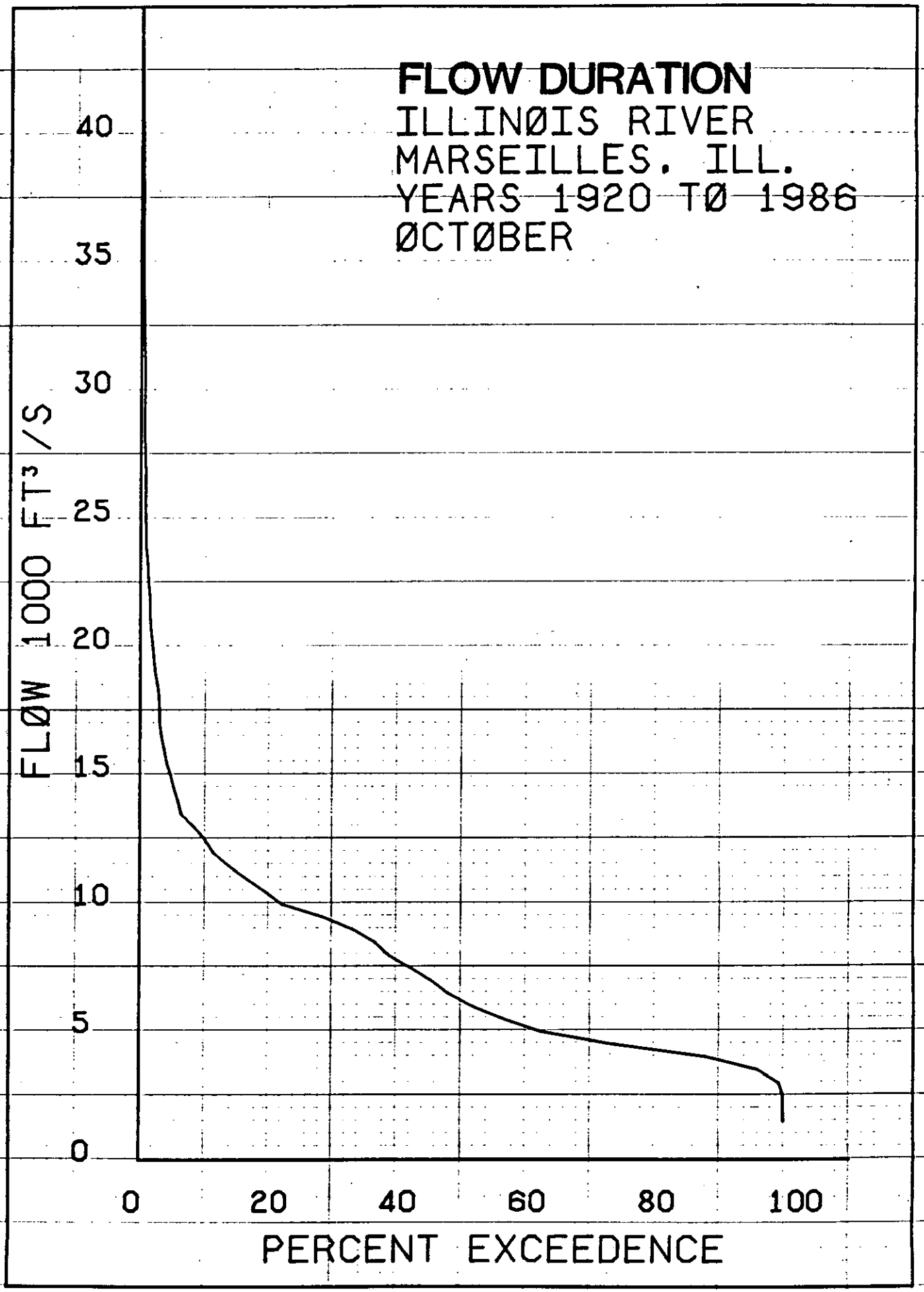
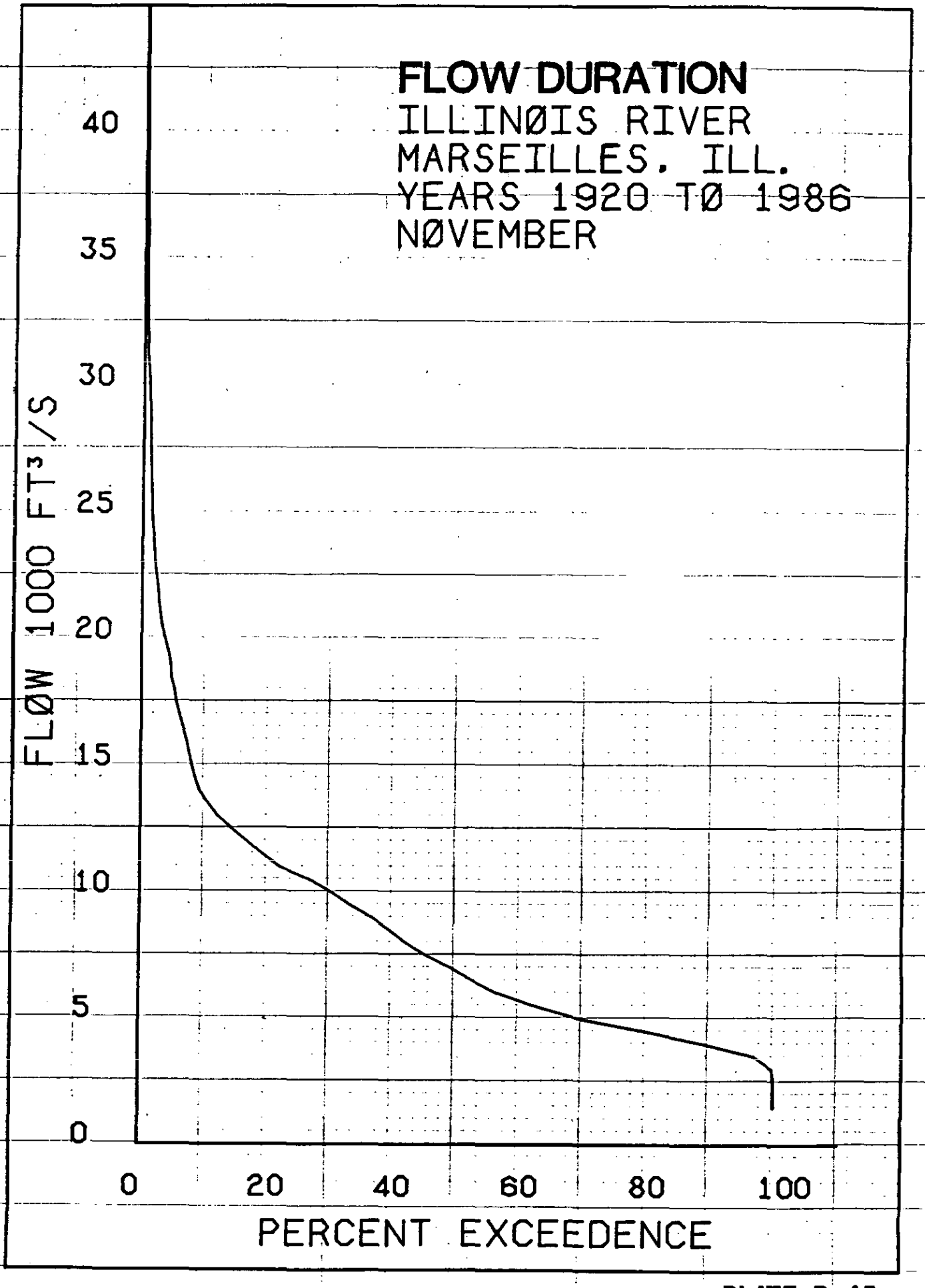
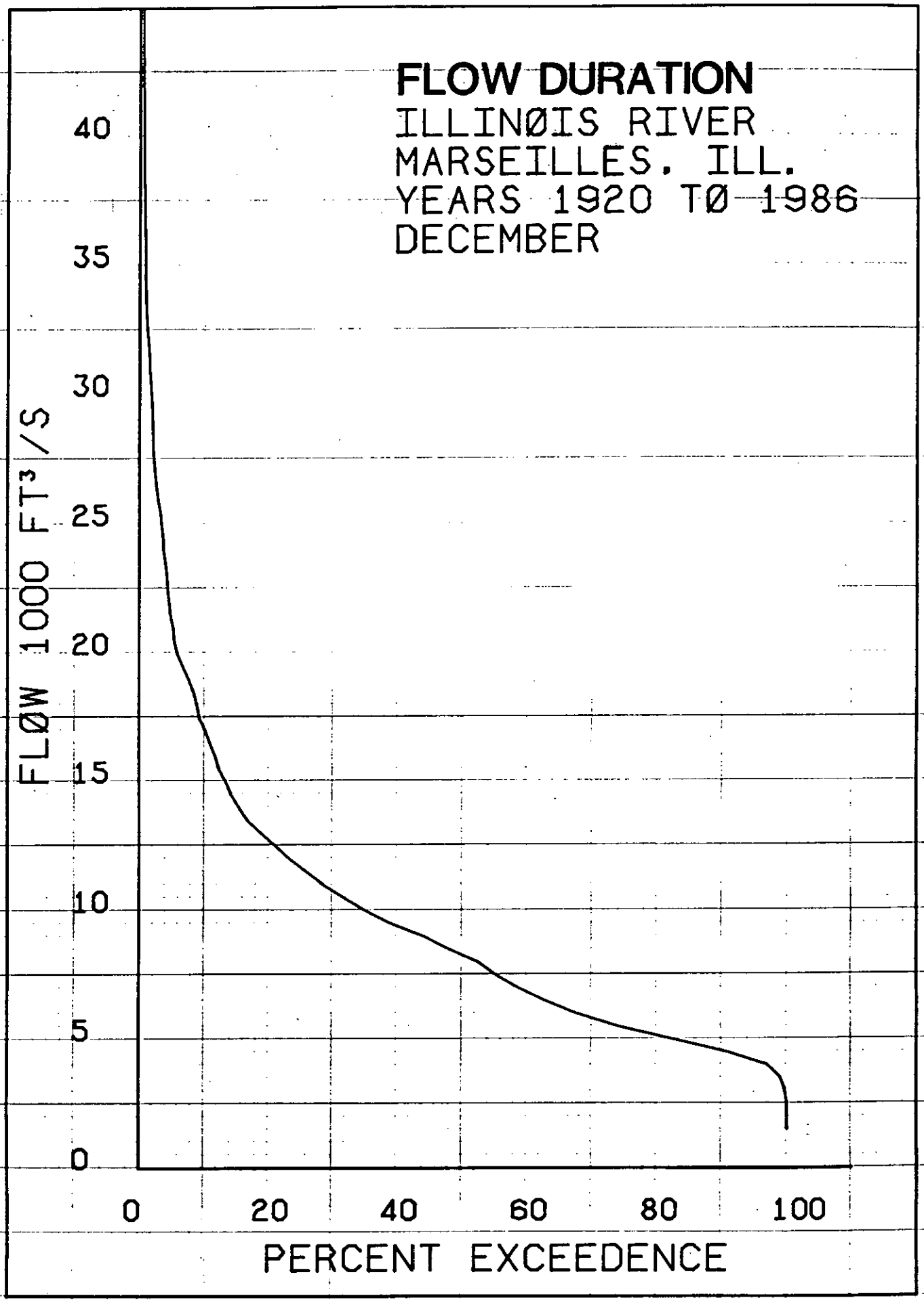
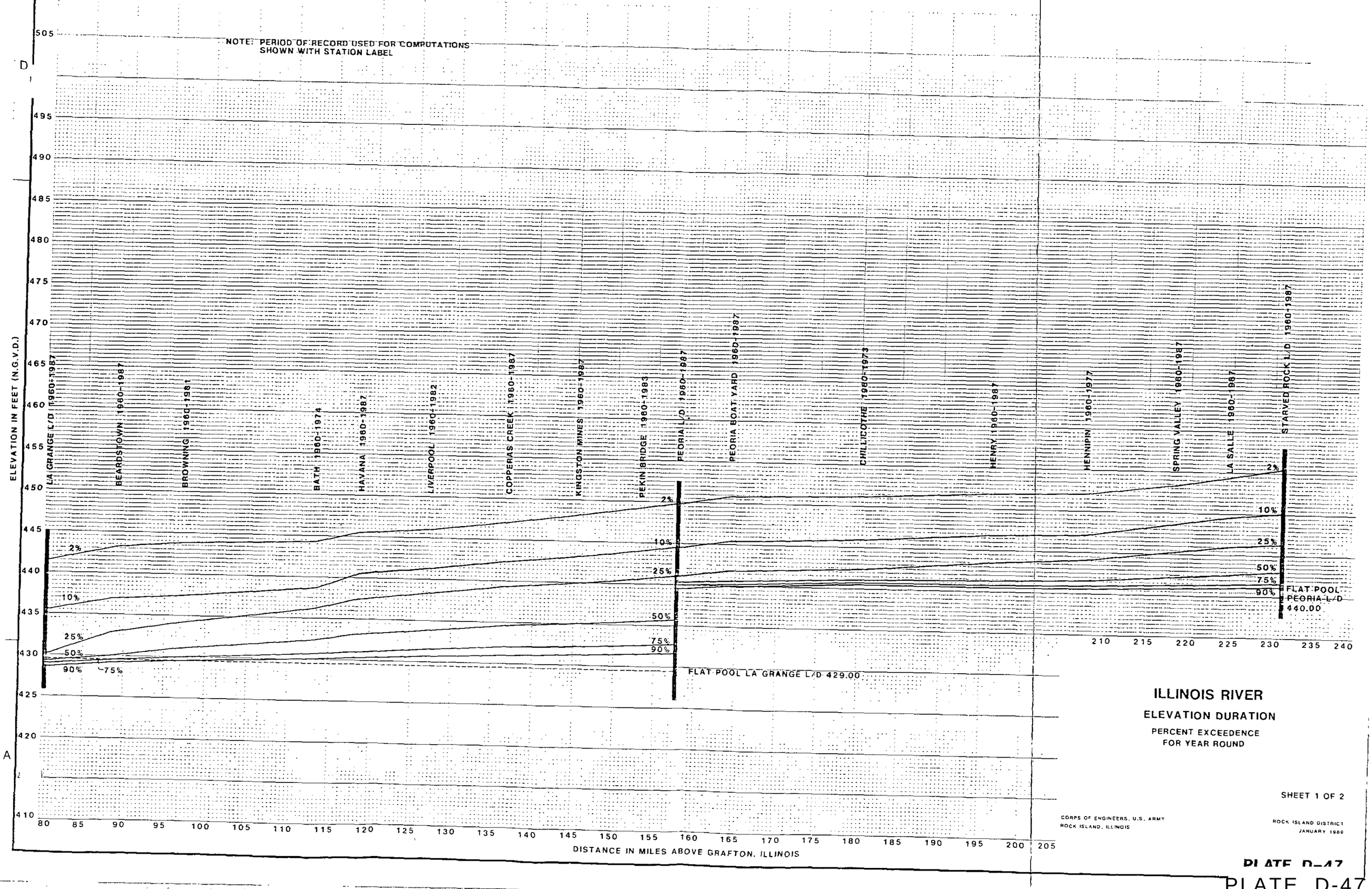

FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
SEPTEMBER
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-43


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
ØCTØBER
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
NØVEMBER
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLOW DURATION
ILLINØIS RIVER
MARSEILLES. ILL.
YEARS 1920 TØ 1986
DECEMBER
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE



ILLINOIS RIVER

ELEVATION DURATION

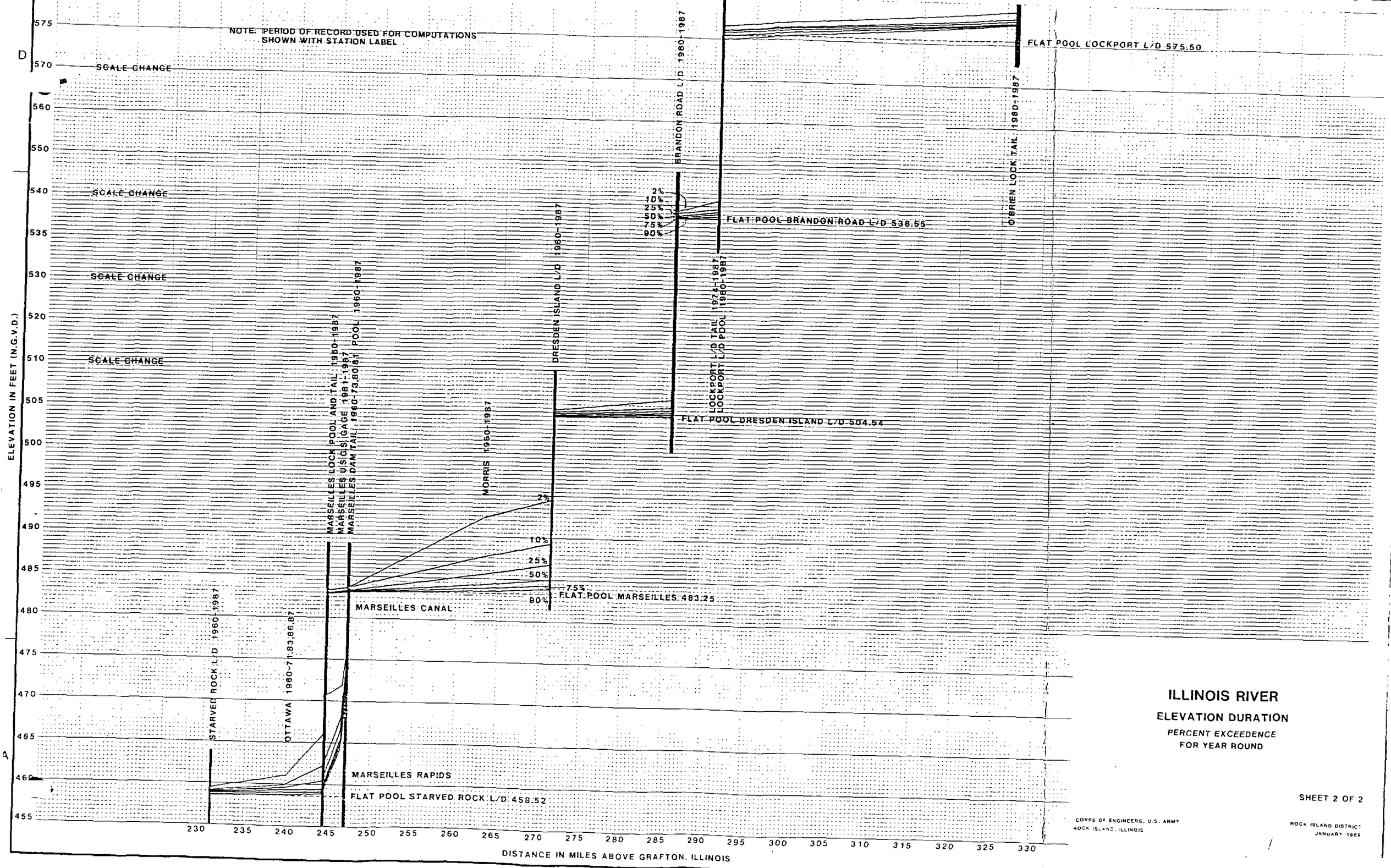
PERCENT EXCEEDENCE
FOR YEAR ROUND

SHEET 1 OF 2

CORPS OF ENGINEERS, U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT
JANUARY 1988

PLATE D-47



ILLINOIS RIVER

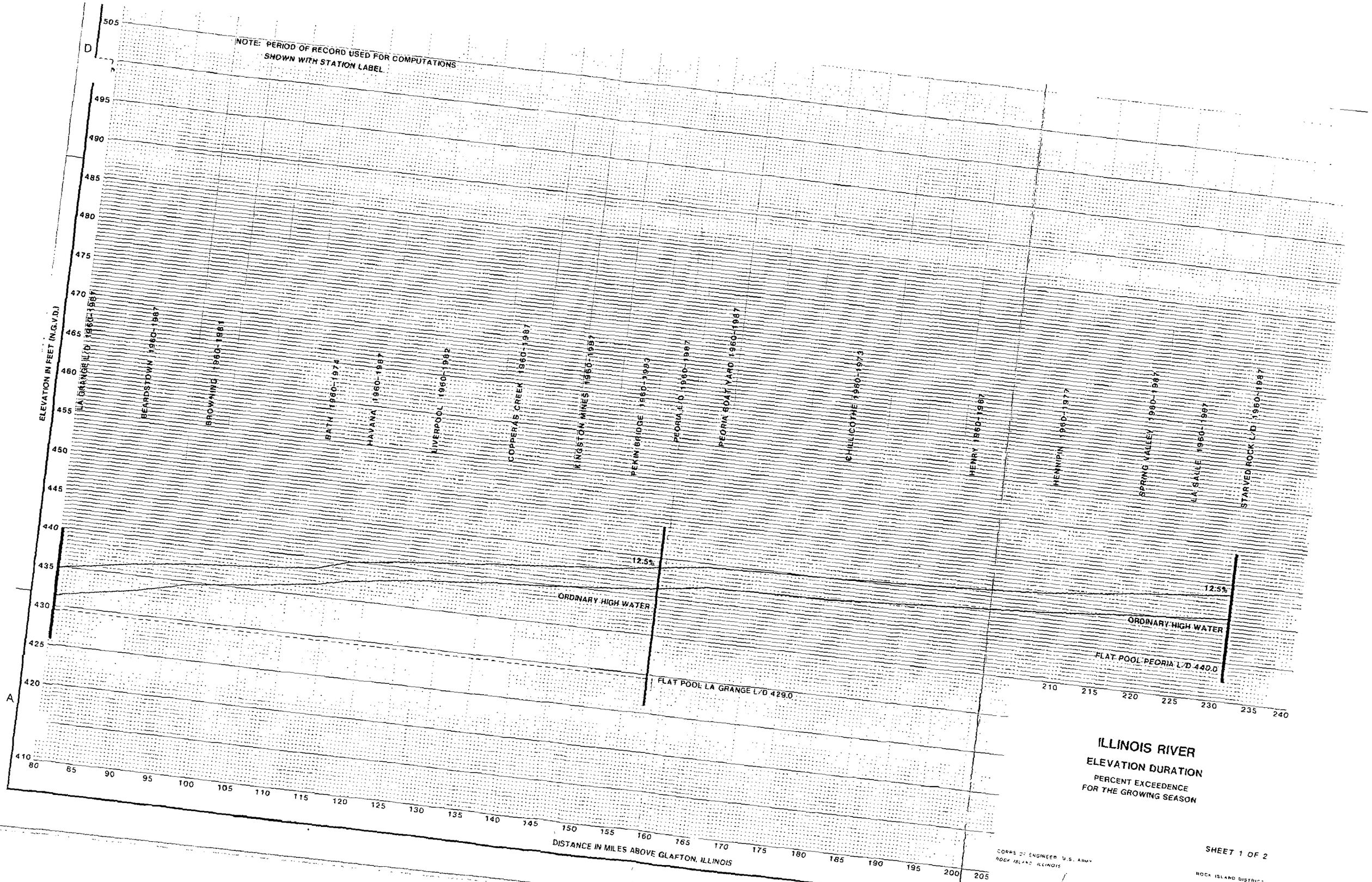
ELEVATION DURATION

PERCENT EXCEEDENCE
FOR YEAR ROUND

SHEET 2 OF 2

CORPS OF ENGINEERS, U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT
JANUARY 1989



ILLINOIS RIVER

ELEVATION DURATION

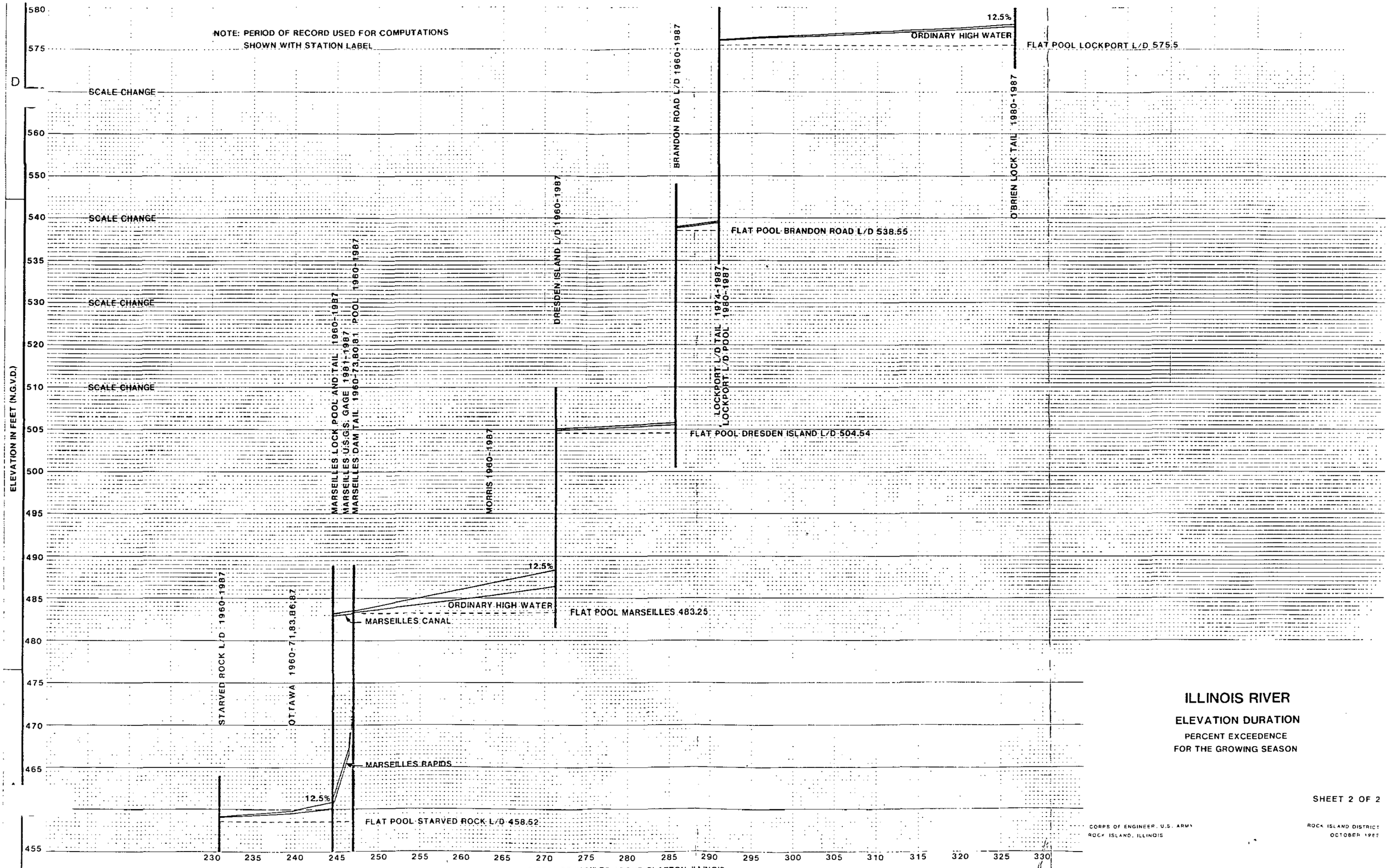
PERCENT EXCEEDENCE
FOR THE GROWING SEASON

CORPS OF ENGINEERS, U.S. ARMY
ROCK ISLAND, ILLINOIS

SHEET 1 OF 2

ROCK ISLAND DISTRICT
OCTOBER 1988

PLATE D-49



ILLINOIS RIVER

ELEVATION DURATION

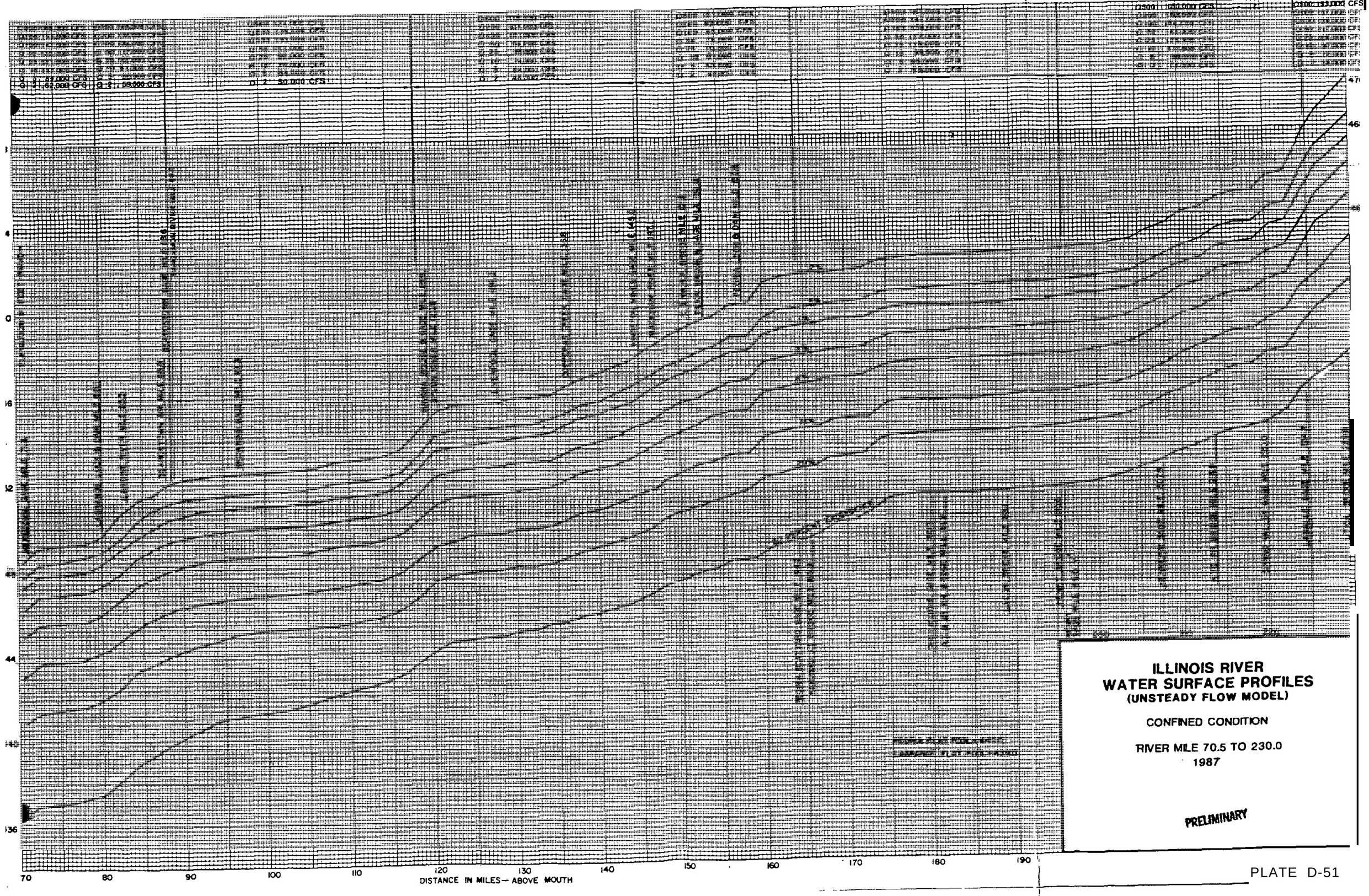
PERCENT EXCEEDENCE
FOR THE GROWING SEASON

SHEET 2 OF 2

CORPS OF ENGINEERS, U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT
OCTOBER 1985

PLATE D-50



ILLINOIS RIVER
WATER SURFACE PROFILES
(UNSTEADY FLOW MODEL)

CONFINED CONDITION

RIVER MILE 70.5 TO 230.0
1987

PRELIMINARY

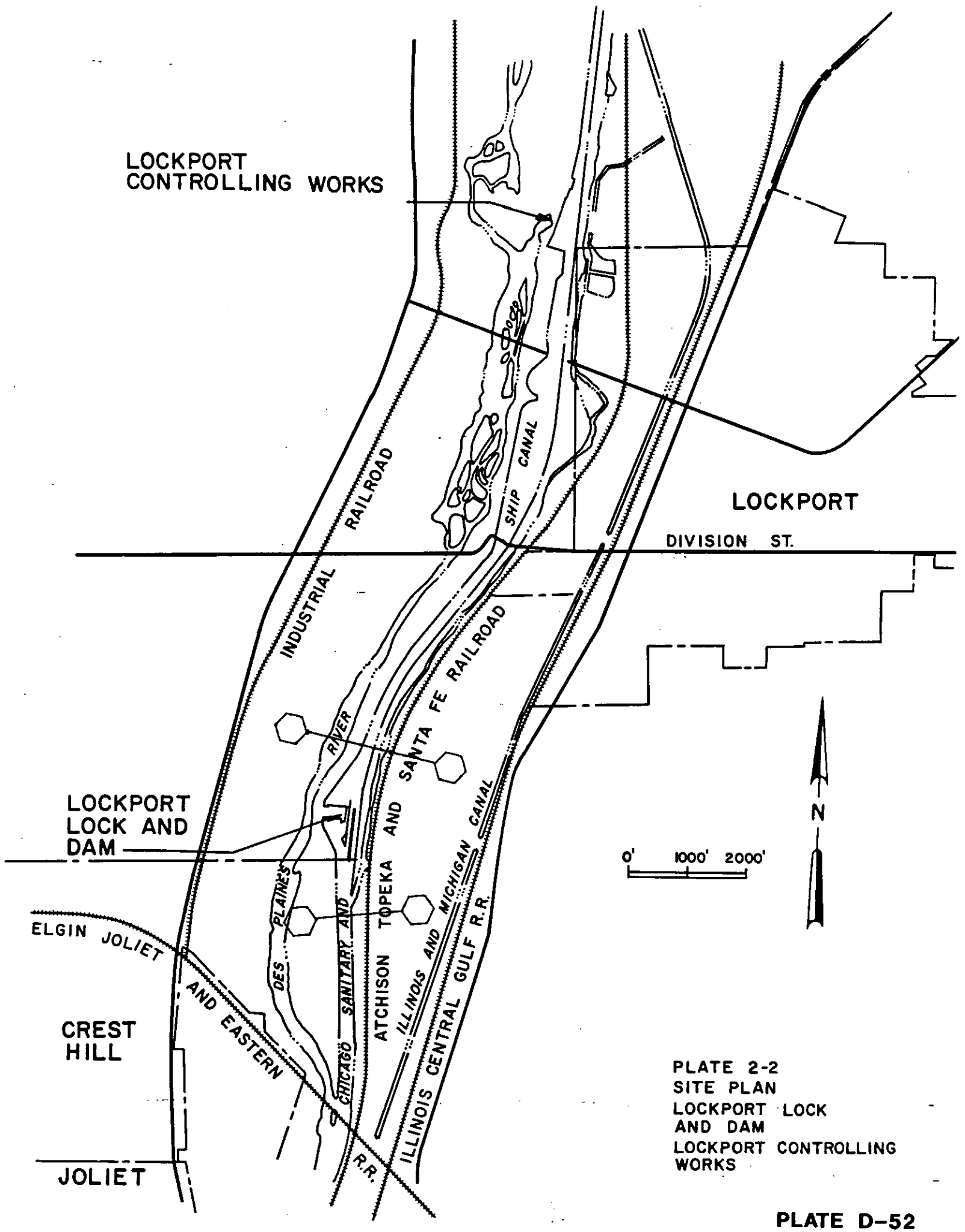
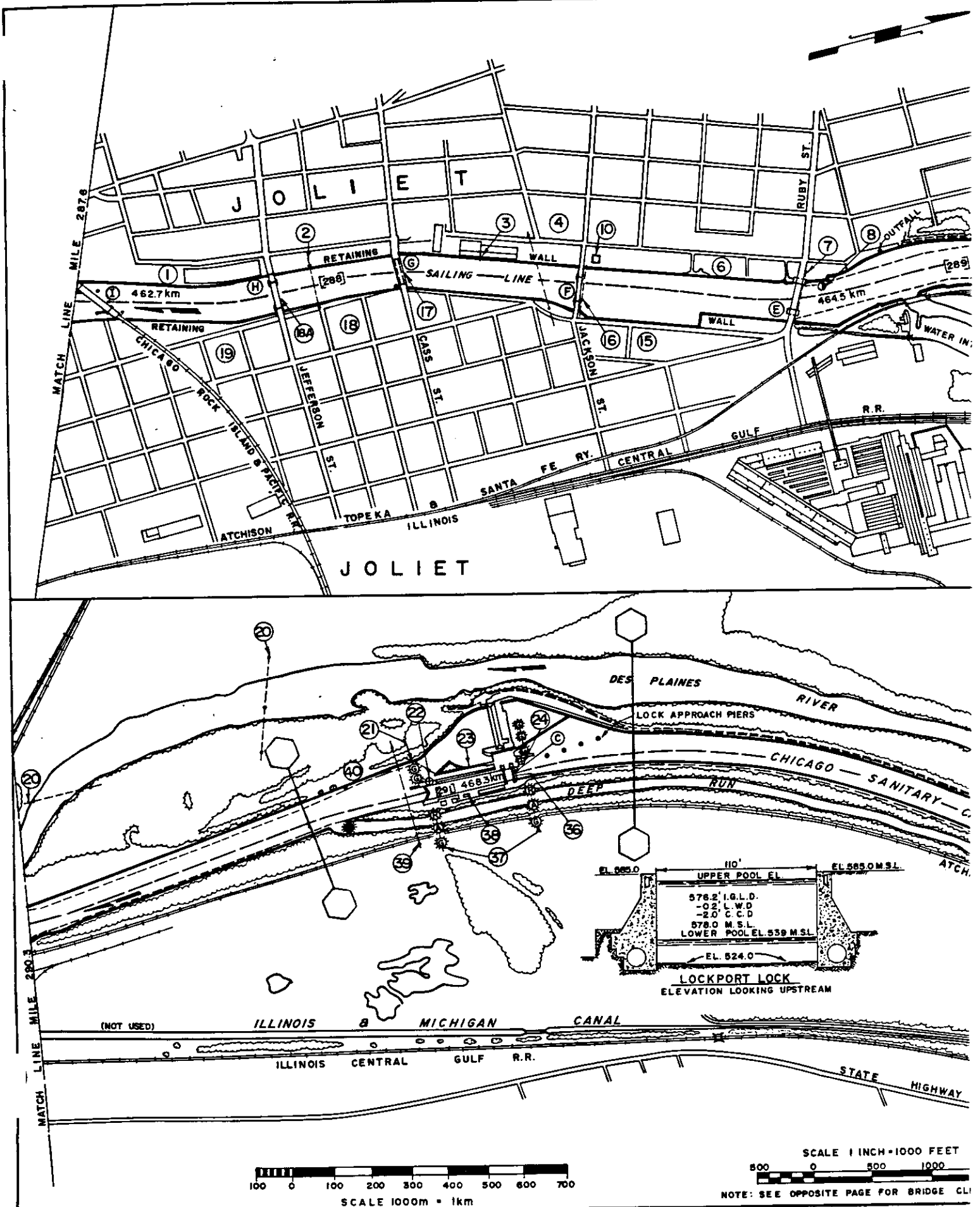
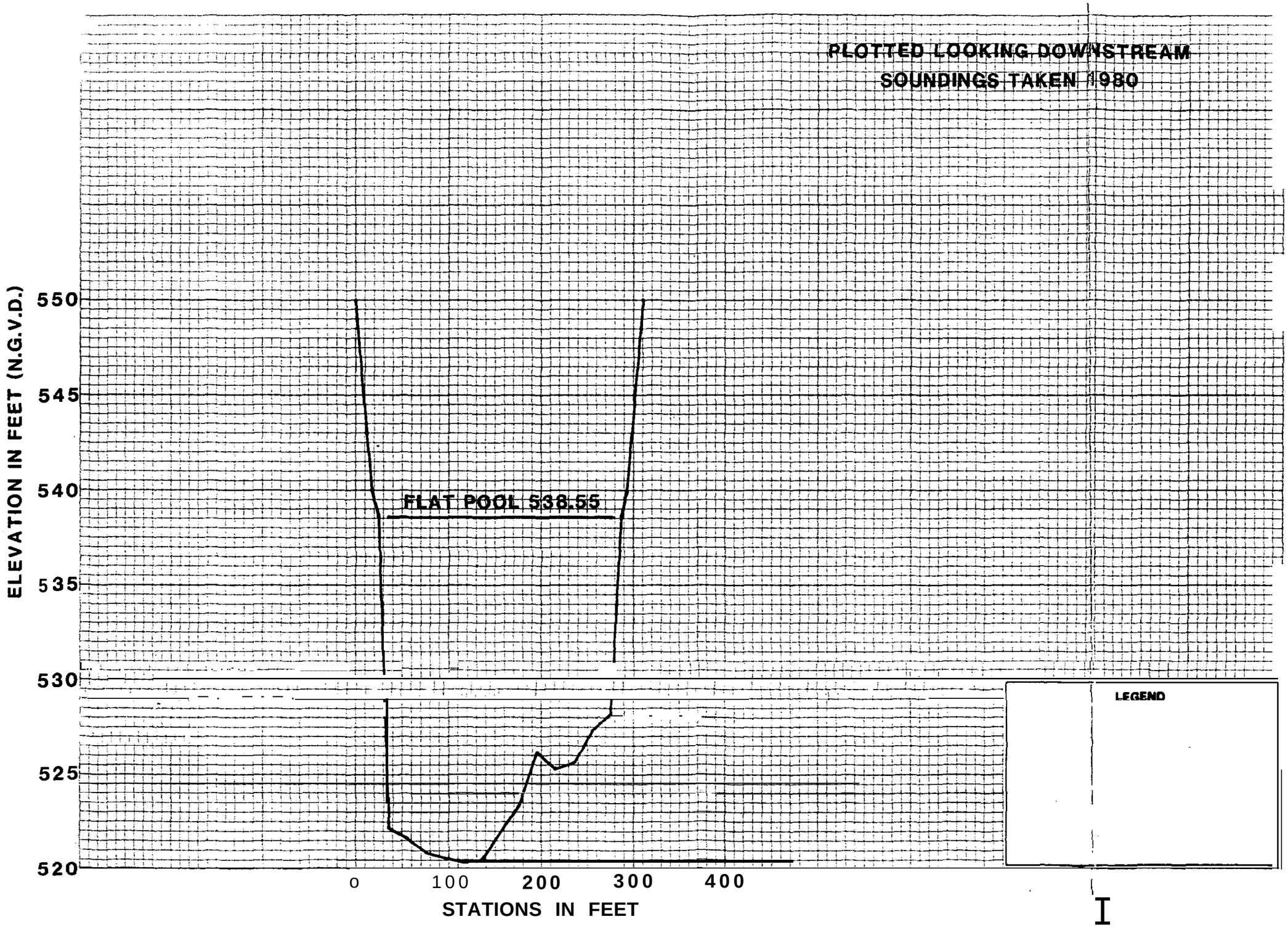


PLATE 2-2
SITE PLAN
LOCKPORT LOCK
AND DAM
LOCKPORT CONTROLLING
WORKS

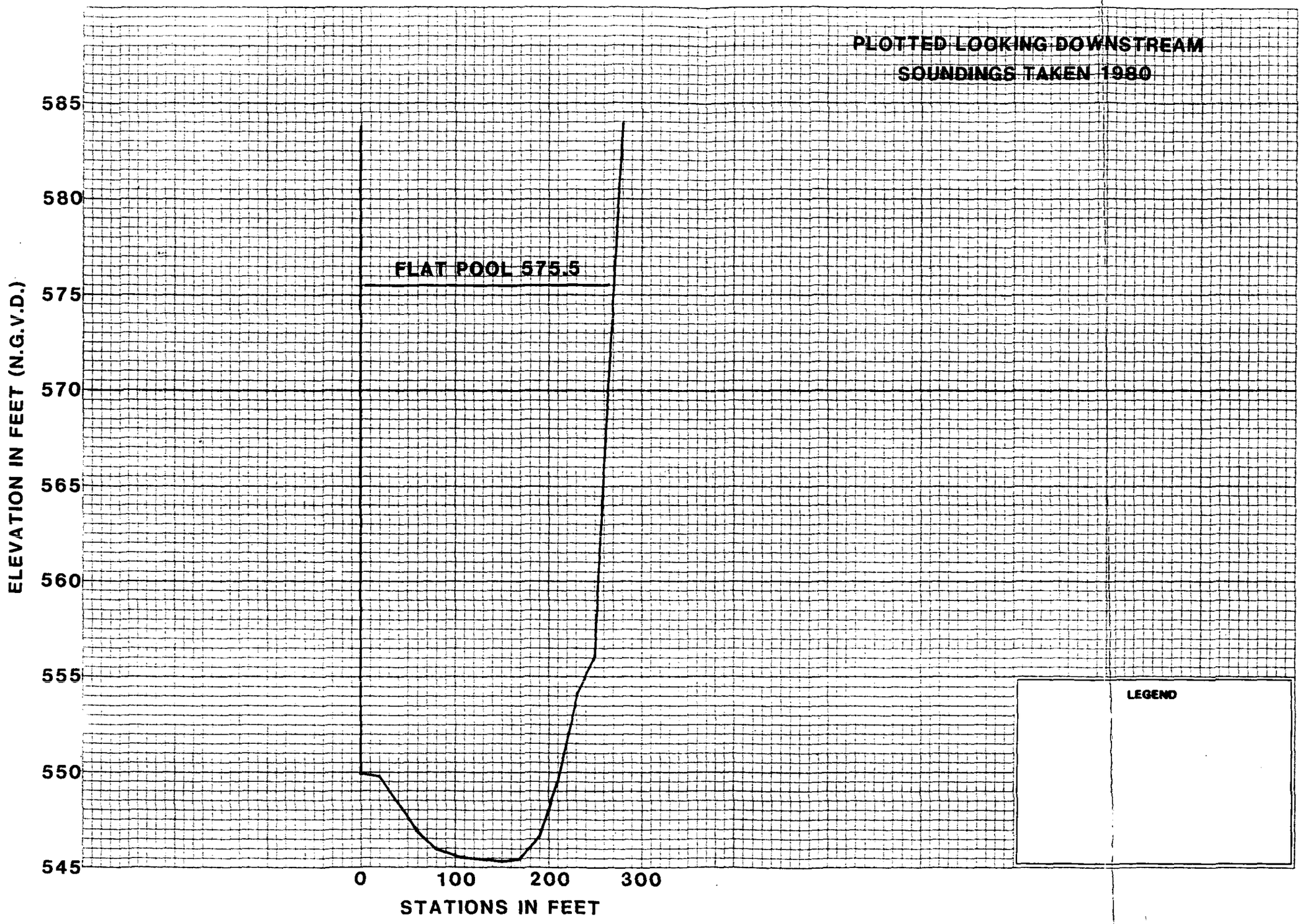

JOLIET
RETAINING WALL
SAILING LINE
462.7 km
464.5 km
468.3 km
RUBY ST.
OUTFALL
WATER IN
CASS ST.
JEFFERSON ST.
JACKSON ST.
CHICAGO ROCK ISLAND & PACIFIC R.R.
ATCHISON TOPEKA & SANTA FE RY.
ILLINOIS CENTRAL GULF R.R.
MATCH LINE MILE 287.8
MATCH LINE MILE 290.3
DES PLAINES RIVER
LOCK APPROACH PIERS
CHICAGO SANITARY & SHIP CANAL
DEEP RUN
ILLINOIS & MICHIGAN CANAL
(NOT USED)
ILLINOIS CENTRAL GULF R.R.
STATE HIGHWAY
UPPER POOL EL.
576.2' I.G.L.D.
-0.2' L.W.D
-2.0' C.C.D
578.0 M.S.L.
LOWER POOL EL. 539 M.S.L.
EL. 524.0
EL. 565.0
EL. 565.0 M.S.L.
110'
LOCKPORT LOCK
ELEVATION LOOKING UPSTREAM
SCALE 1 INCH = 1000 FEET
SCALE 1000m = 1km
NOTE: SEE OPPOSITE PAGE FOR BRIDGE CL



CHANNEL SECTION RIVER MILE 290.70

ILLINOIS RIVER

LOCK PORT TAIL

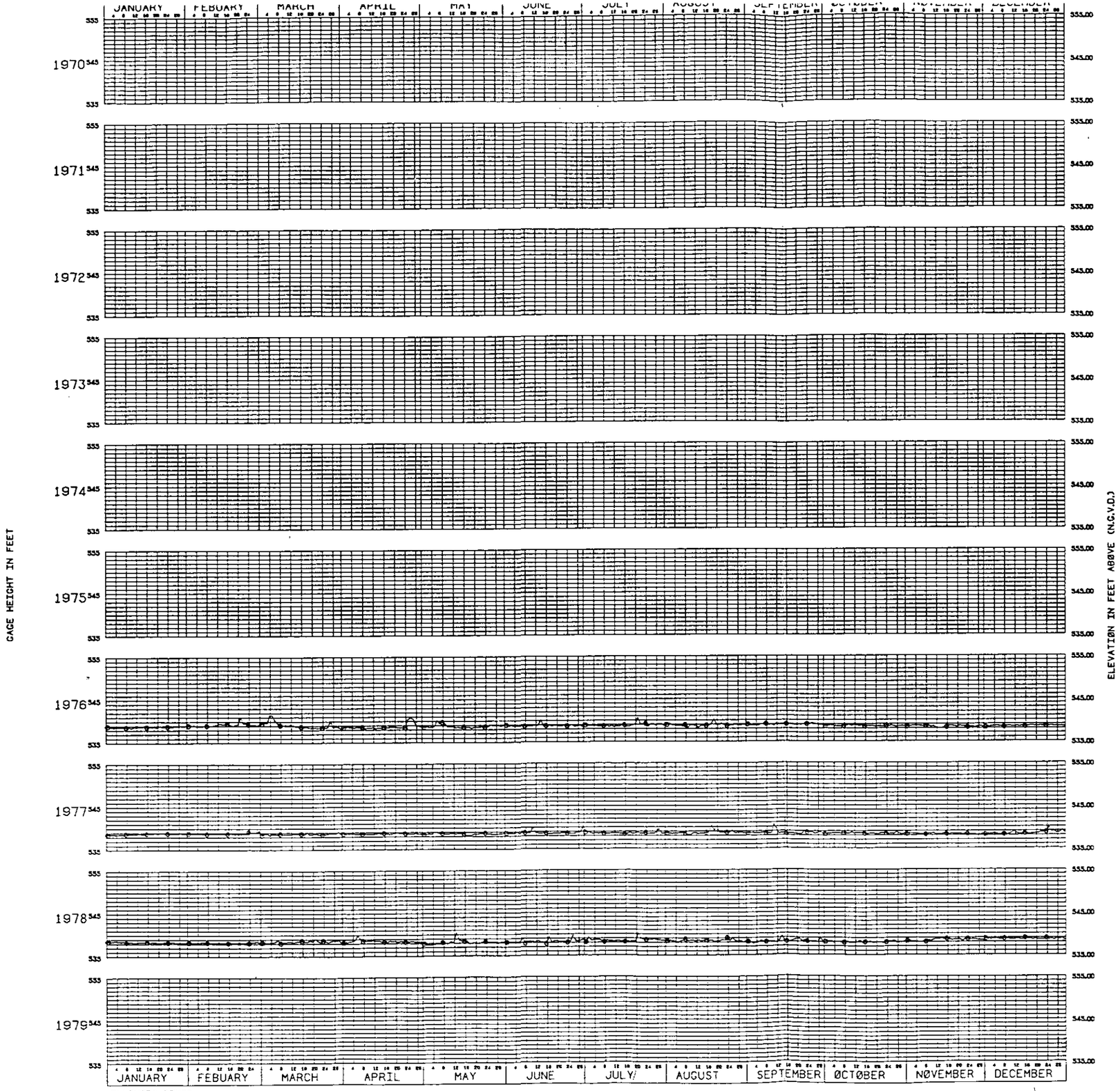


CHANNEL SECTION RIVER MILE 291.27

ILLINOIS RIVER

LOCK PORT POOL

PLATE D-55



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
LØCKPØRT'S TAILWATER

Symbol	Description of Revisions	Date	Approve

US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:

Drawn by:

Checked by:

PLATE D-56

Submitted by:
CHIEF DESIGN BRANCH

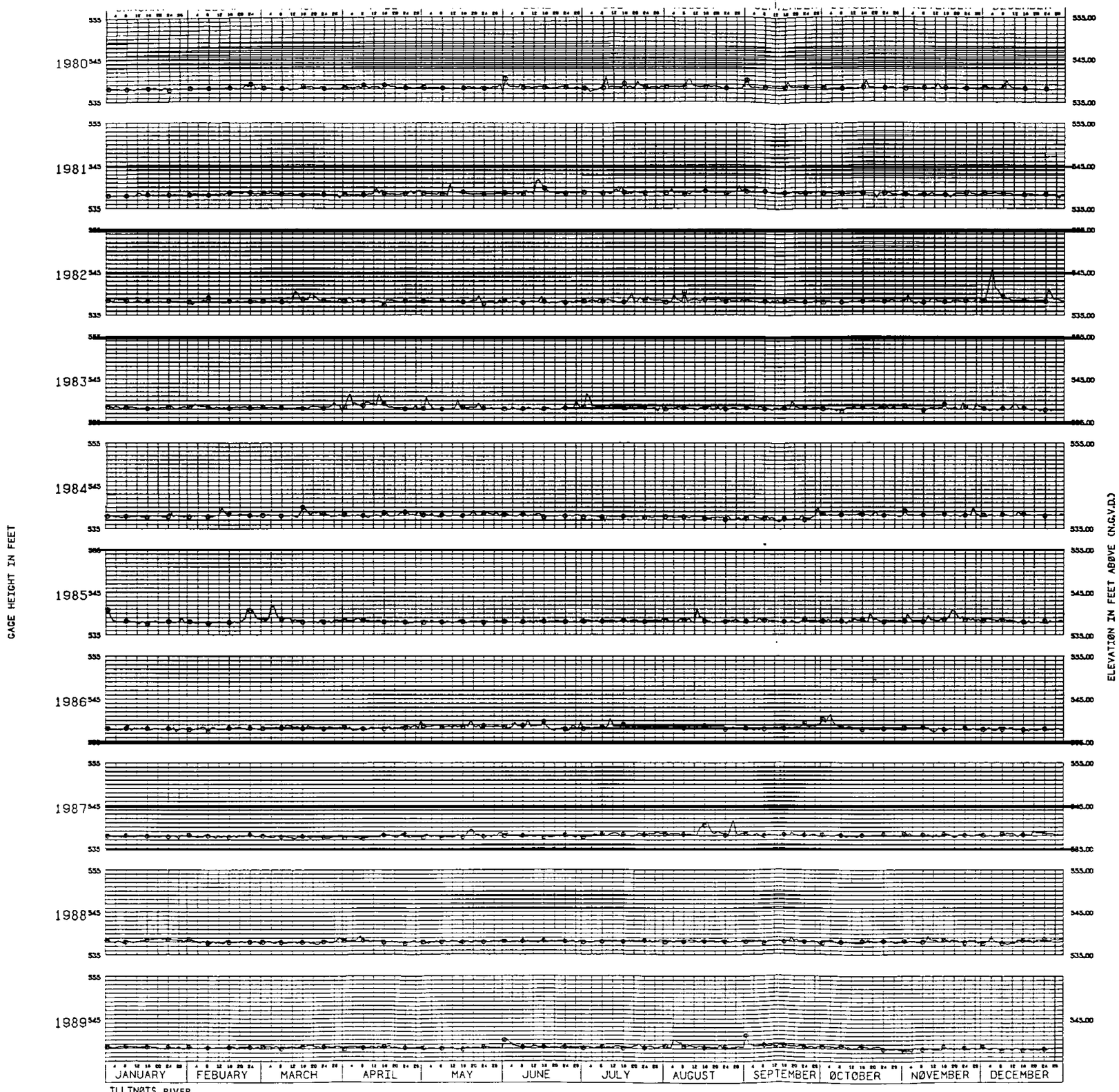
Approved by:
CHIEF ENGINEERING DIVISION

Scale:

Date:

Drawing number:

Sheet _ of _



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
LØCKPØRT'S **TAILWATER**

Symbol	Description of Revisions	Date	Approv

US Army Corps of Engineers

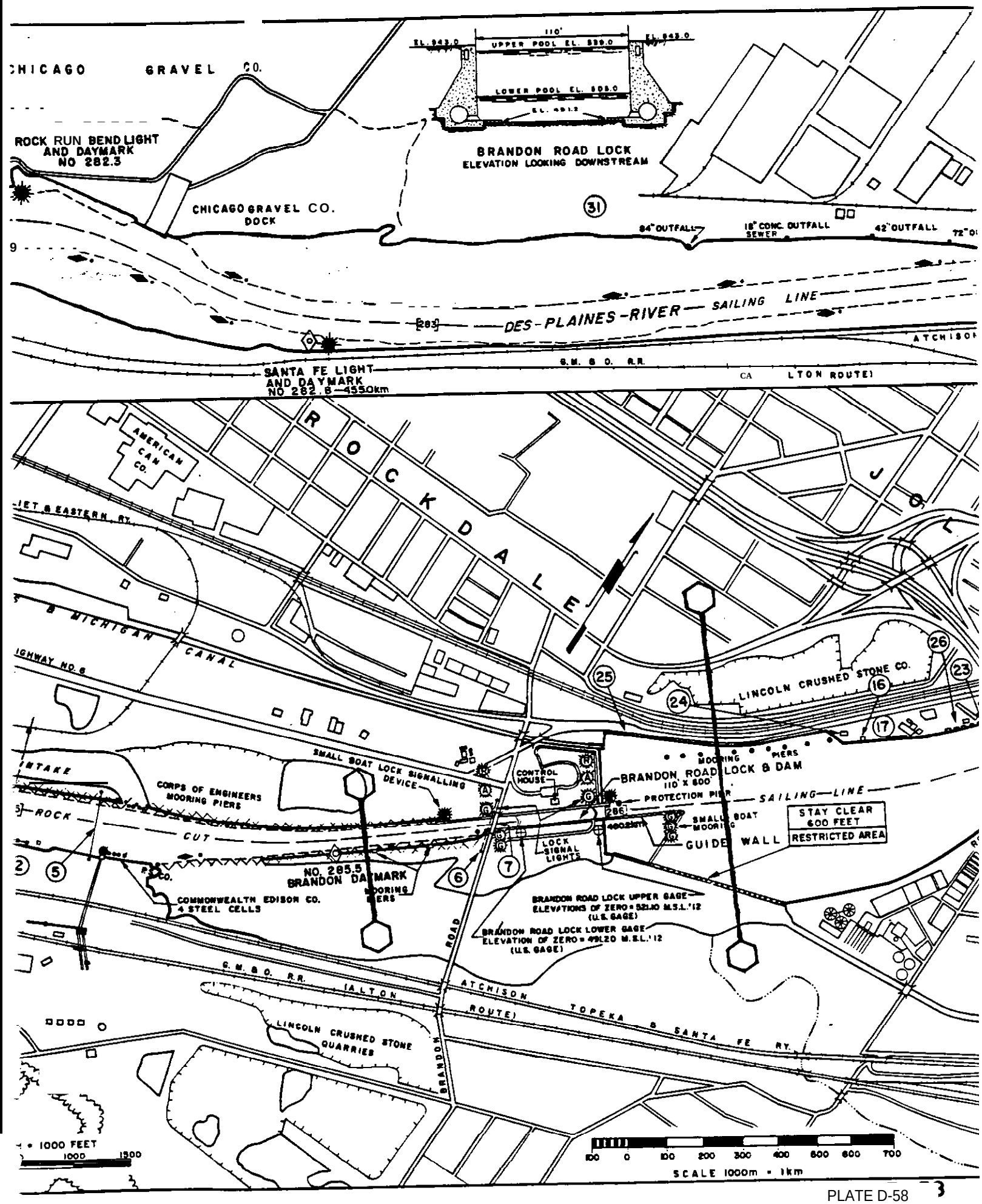
U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

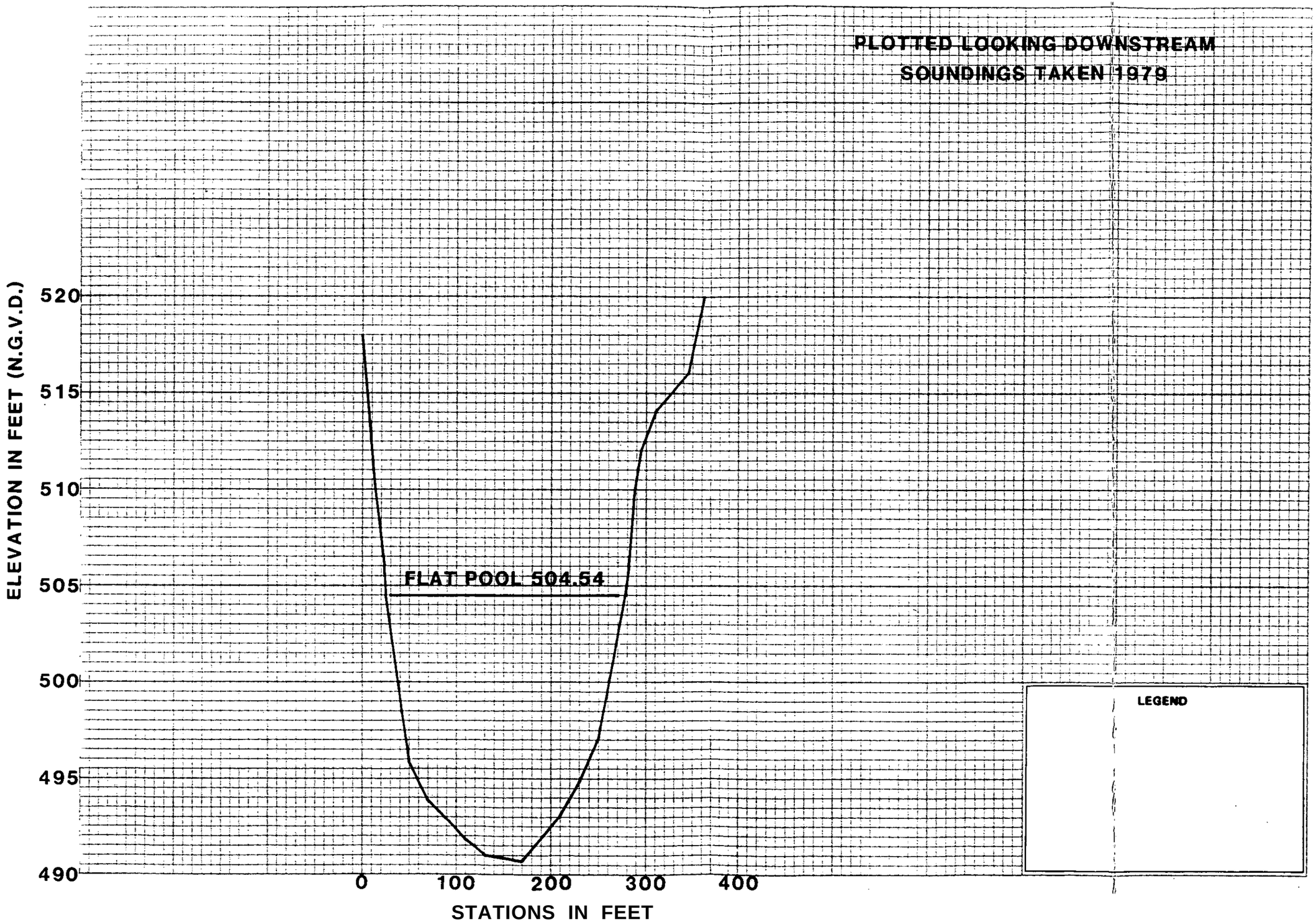
Designed by:
Drawn by:
Checked by:

PLATE D-57

Submitted by:
CHIEF DESIGN BRANCH
Approved by:
CHIEF ENGINEERING DIVISION

Scale:
Date:
Drawing number:
Sheet _ of _

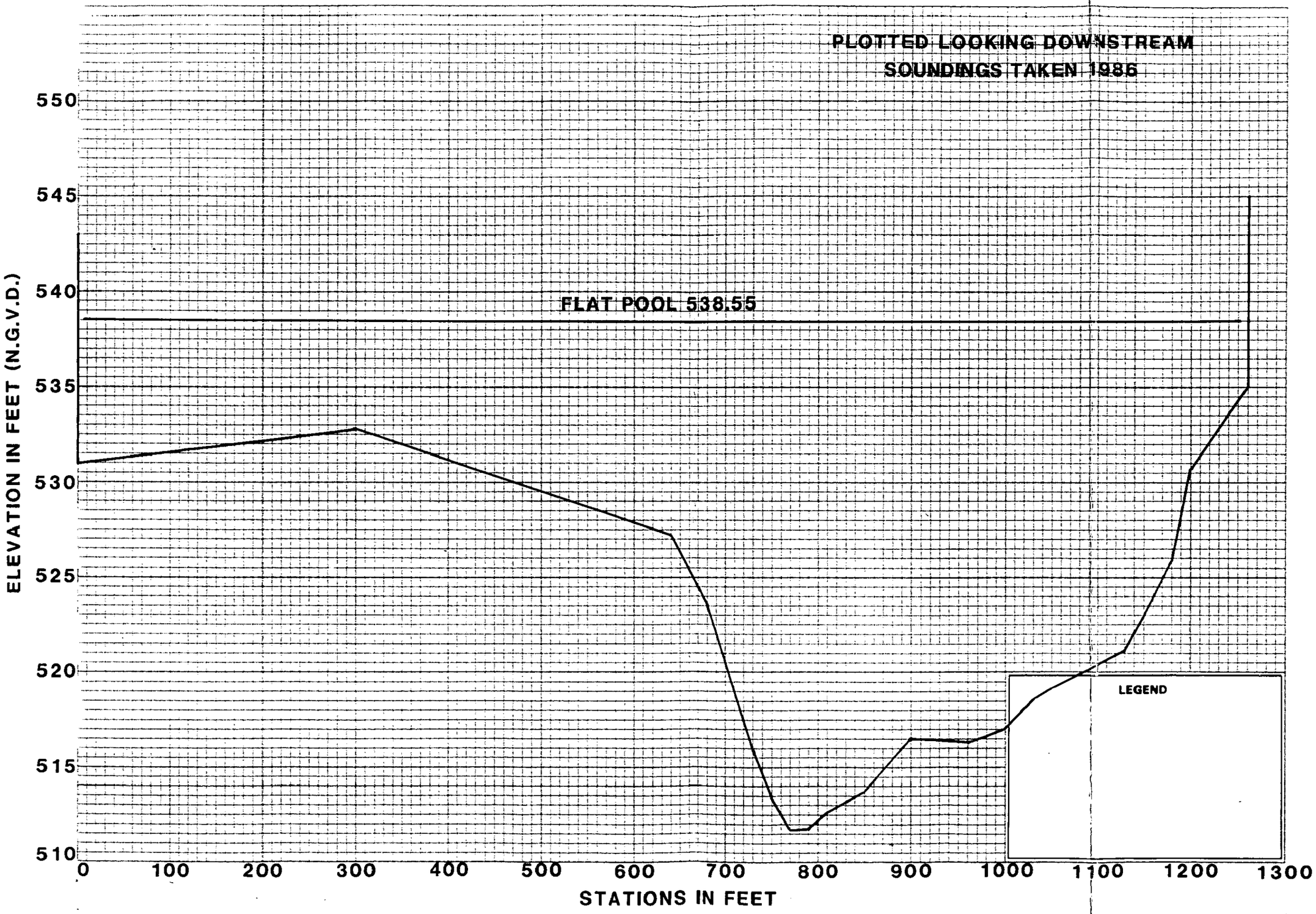

CHICAGO GRAVEL CO.
ROCK RUN BEND LIGHT AND DAYMARK NO 282.3
CHICAGO GRAVEL CO. DOCK
BRANDON ROAD LOCK
ELEVATION LOOKING DOWNSTREAM
UPPER POOL EL. 539.0
LOWER POOL EL. 505.0
84" OUTFALL
18" CONC. OUTFALL SEWER
42" OUTFALL
DES-PLAINES-RIVER
SAILING LINE
SANTA FE LIGHT AND DAYMARK NO 282.8—4550km
G. M. & O. R.R.
ROCKDALE
AMERICAN CAN CO.
MICHIGAN CANAL
LINCOLN CRUSHED STONE CO.
SMALL BOAT LOCK SIGNALLING DEVICE
CONTROL HOUSE
BRANDON ROAD LOCK & DAM
110' X 600'
MOORING PIERS
PROTECTION PIER
SAILING LINE
STAY CLEAR 600 FEET
RESTRICTED AREA
SMALL BOAT MOORING
GUIDE WALL
LOCK SIGNAL LIGHTS
CORPS OF ENGINEERS MOORING PIERS
ROCK CUT
NO. 285.5 BRANDON DAYMARK
COMMONWEALTH EDISON CO. 4 STEEL CELLS
BRANDON ROAD LOCK UPPER GAGE ELEVATIONS OF ZERO = 521.10 M.S.L.'12 (U.S. GAGE)
BRANDON ROAD LOCK LOWER GAGE ELEVATION OF ZERO = 499.20 M.S.L.'12 (U.S. GAGE)
BRANDON ROAD
ATCHISON TOPEKA & SANTA FE RY.
LINCOLN CRUSHED STONE QUARRIES
1000 FEET
SCALE 1000m = 1km



CHANNEL SECTION RIVER MILE 285.53

ILLINOIS RIVER

BRANDON ROAD TAIL



CHANNEL SECTION RIVER MILE 286.35

ILLINOIS RIVER

BRANDON ROAD POOL

PLATE D-60

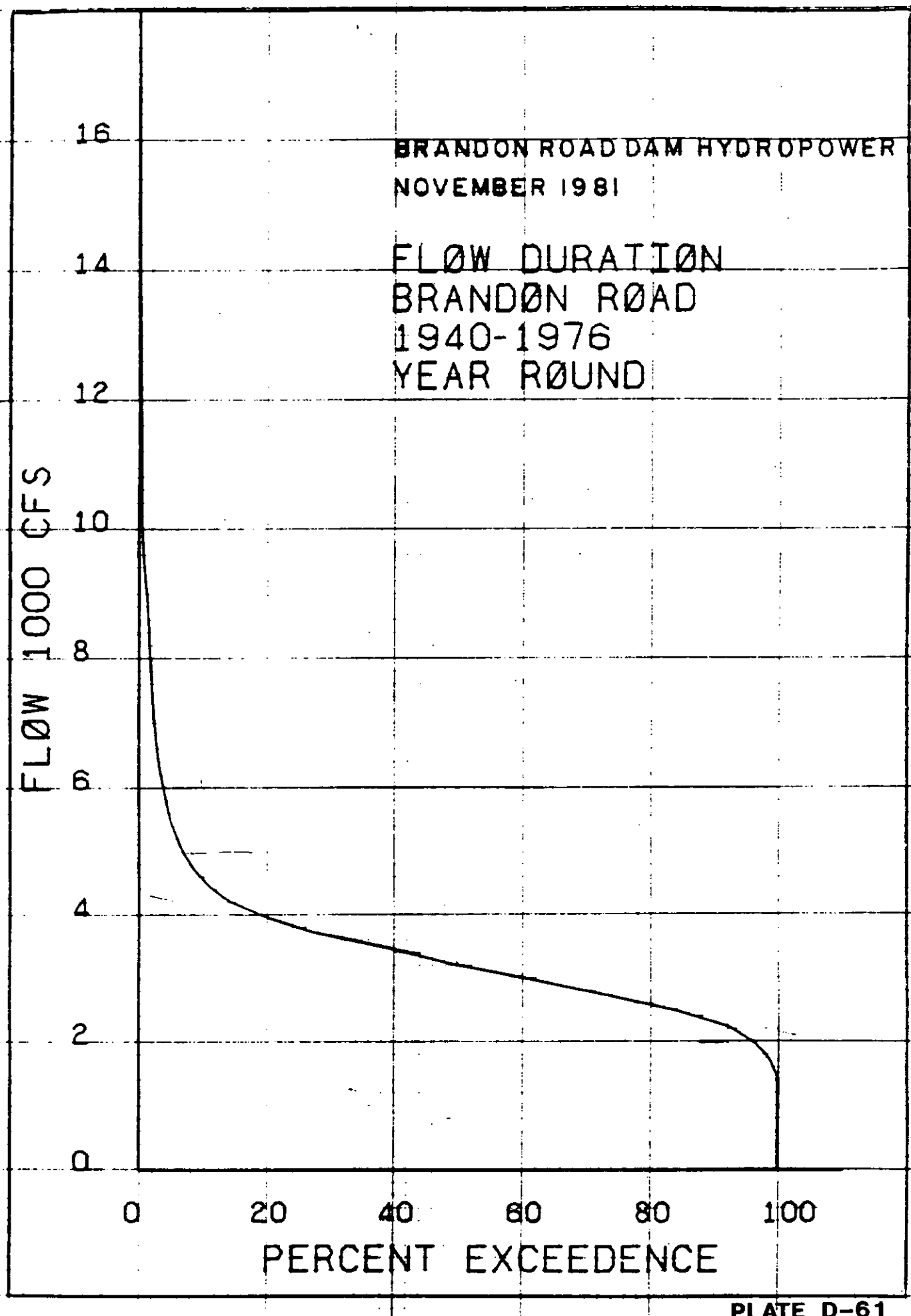
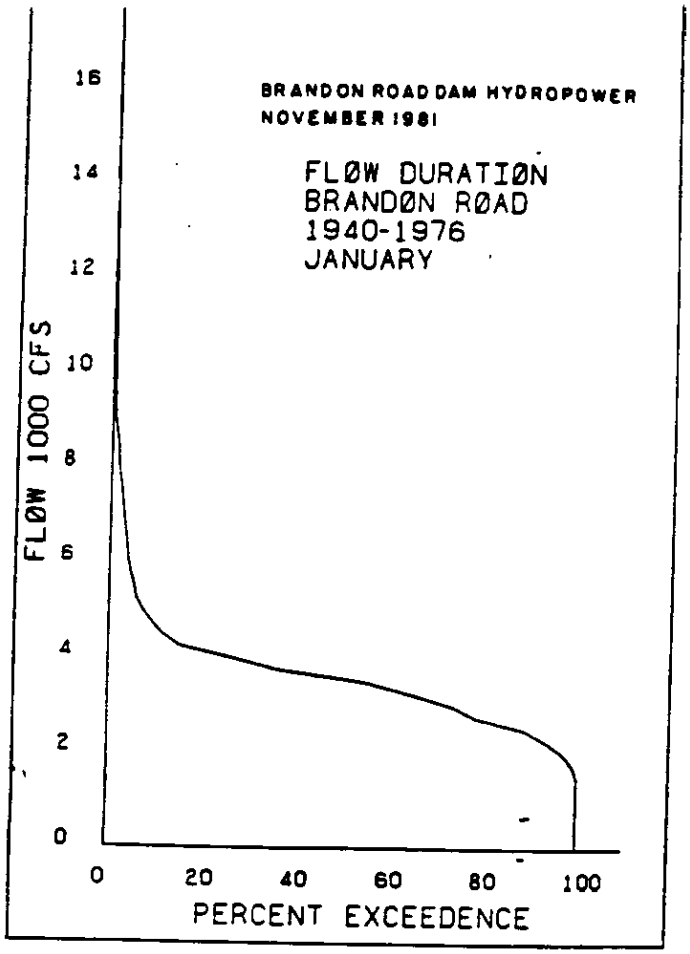
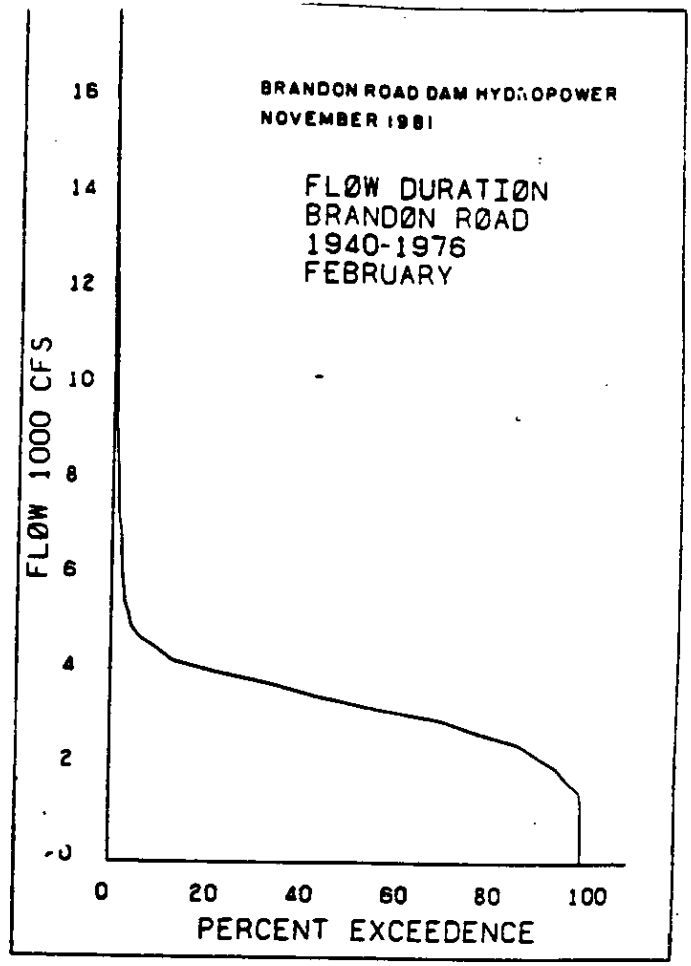
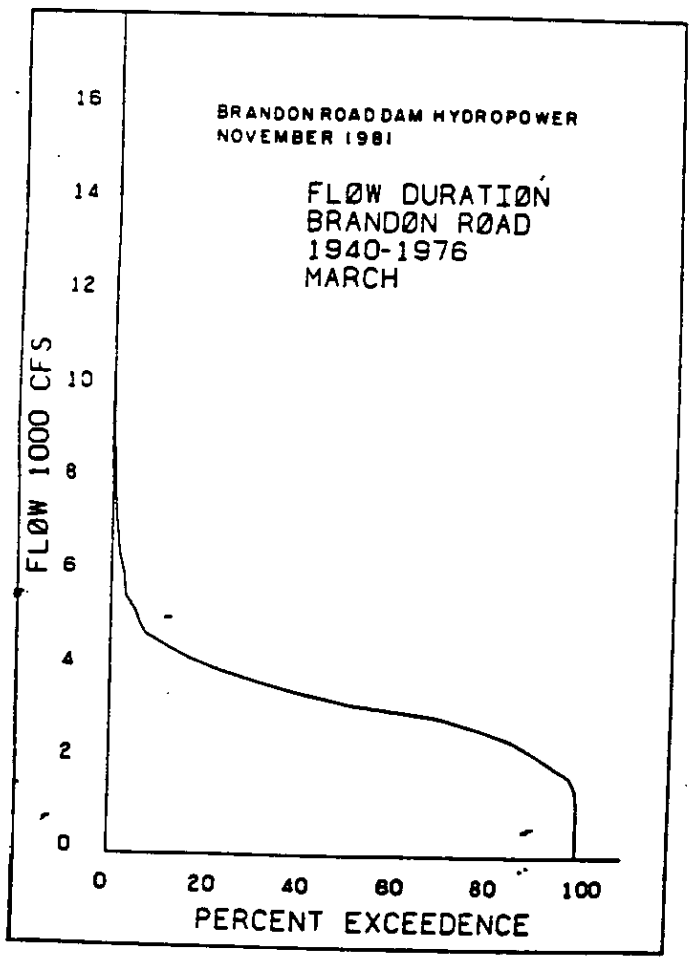

BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
YEAR RØUND
FLØW 1000 CFS
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-61


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
JANUARY
FLØW 1000 CFS
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
FEBRUARY
FLØW 1000 CFS
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
MARCH
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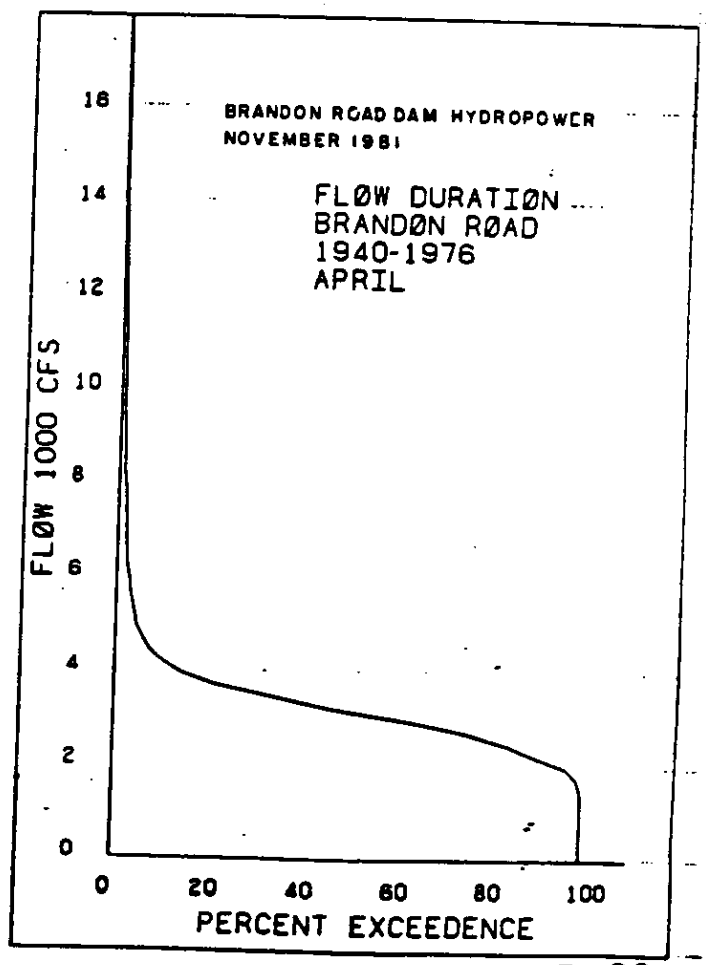
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
APRIL
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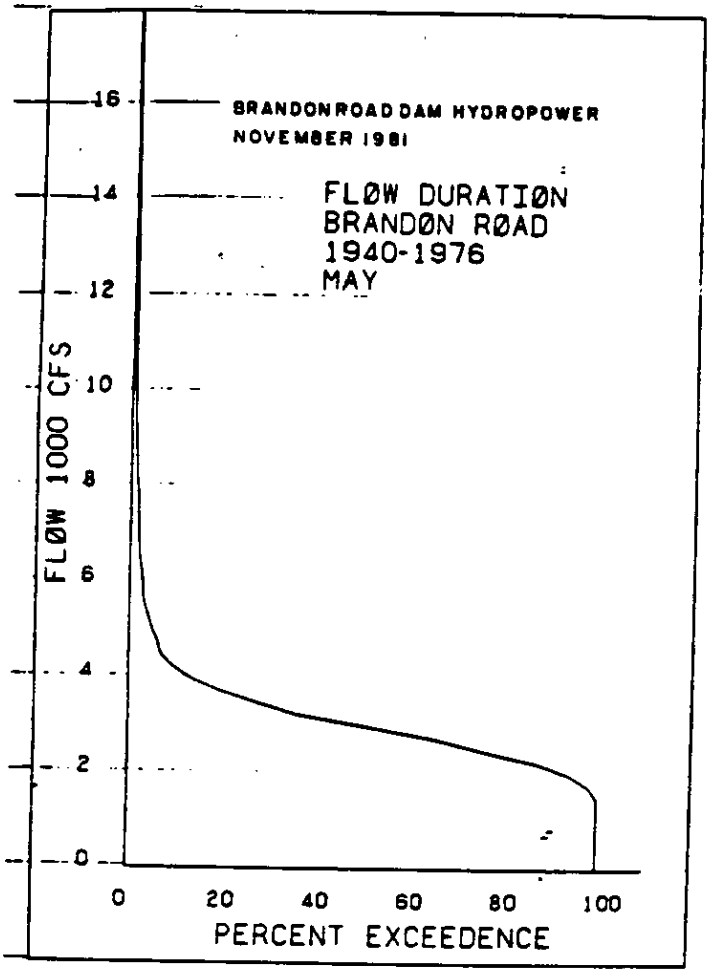
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BRANDØN RØAD
1940-1976
MAY
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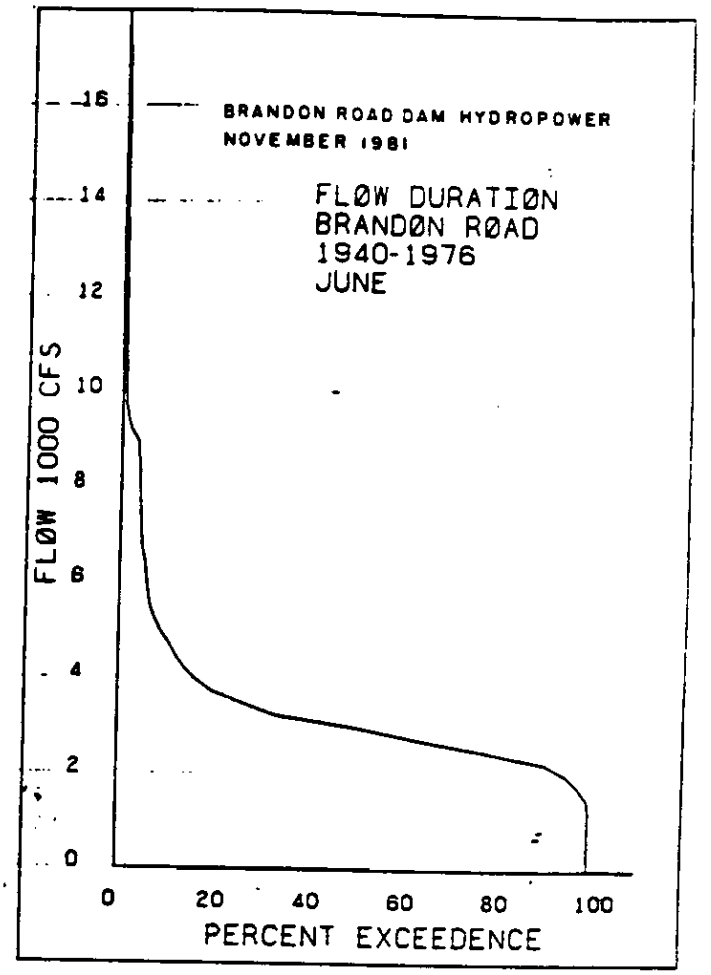
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NOVEMBER 1981
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BRANDØN RØAD
1940-1976
JUNE
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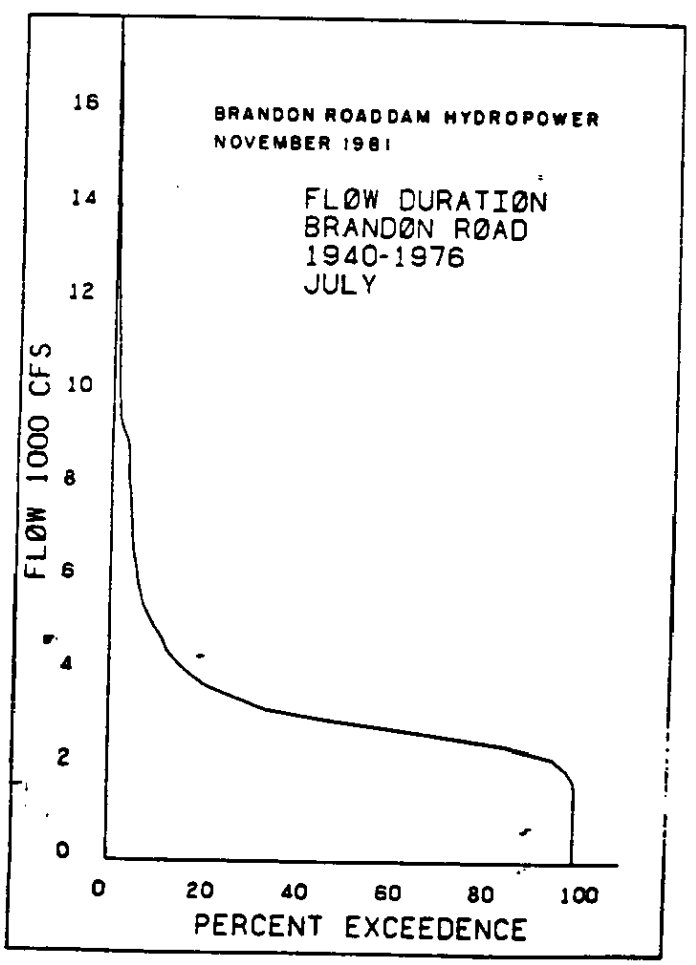
PERCENT EXCEEDENCE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NOVEMBER 1981
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BRANDØN RØAD
1940-1976
JULY
FLØW 1000 CFS
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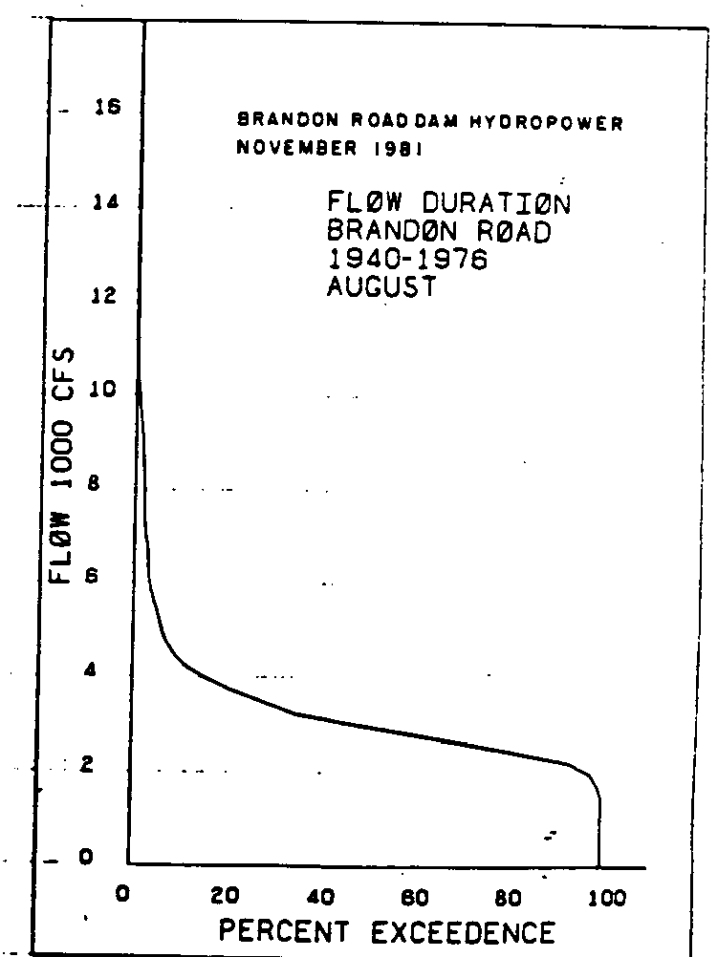
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
AUGUST
FLØW 1000 CFS
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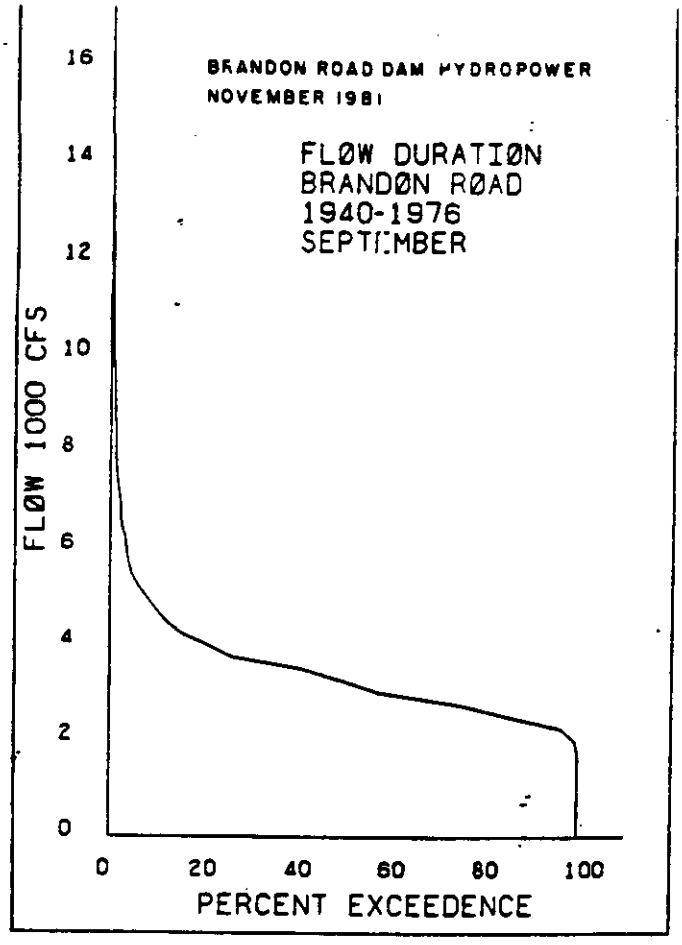
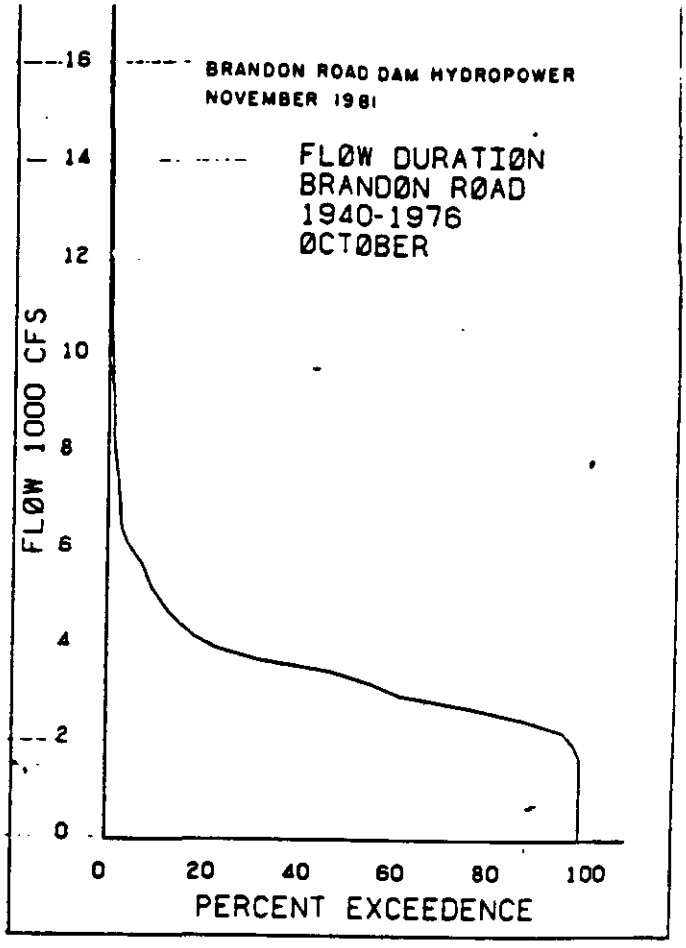
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
SEPTEMBER
FLØW 1000 CFS
PERCENT EXCEEDENCE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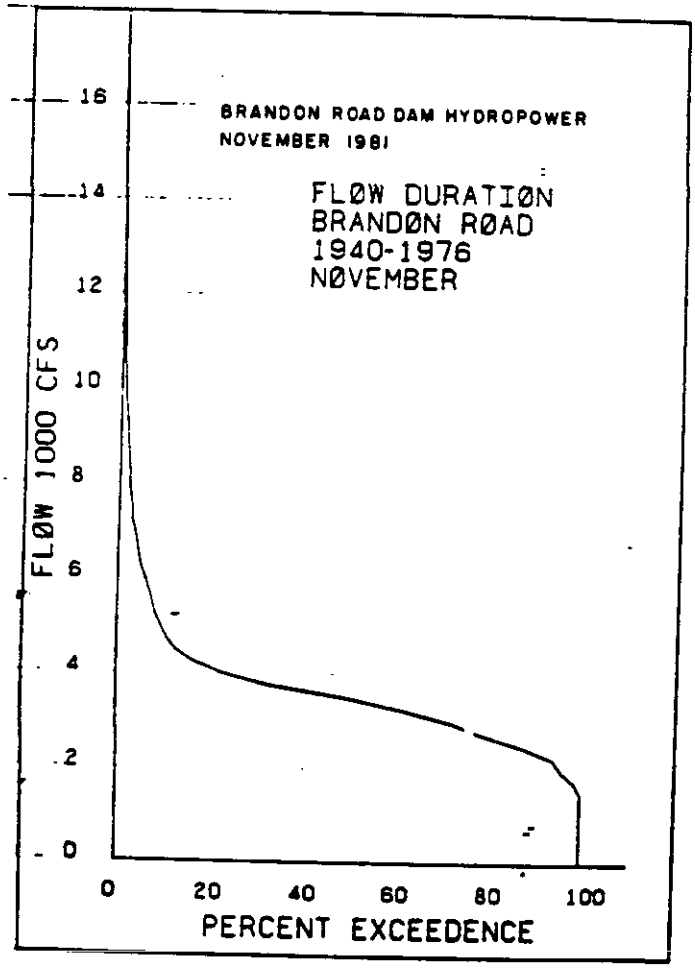
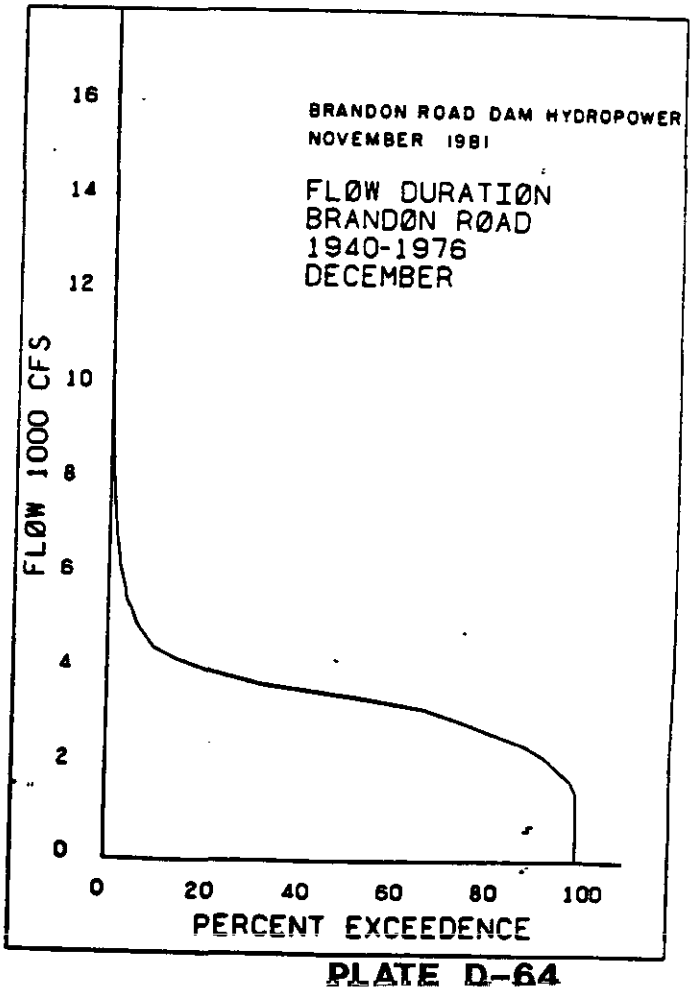
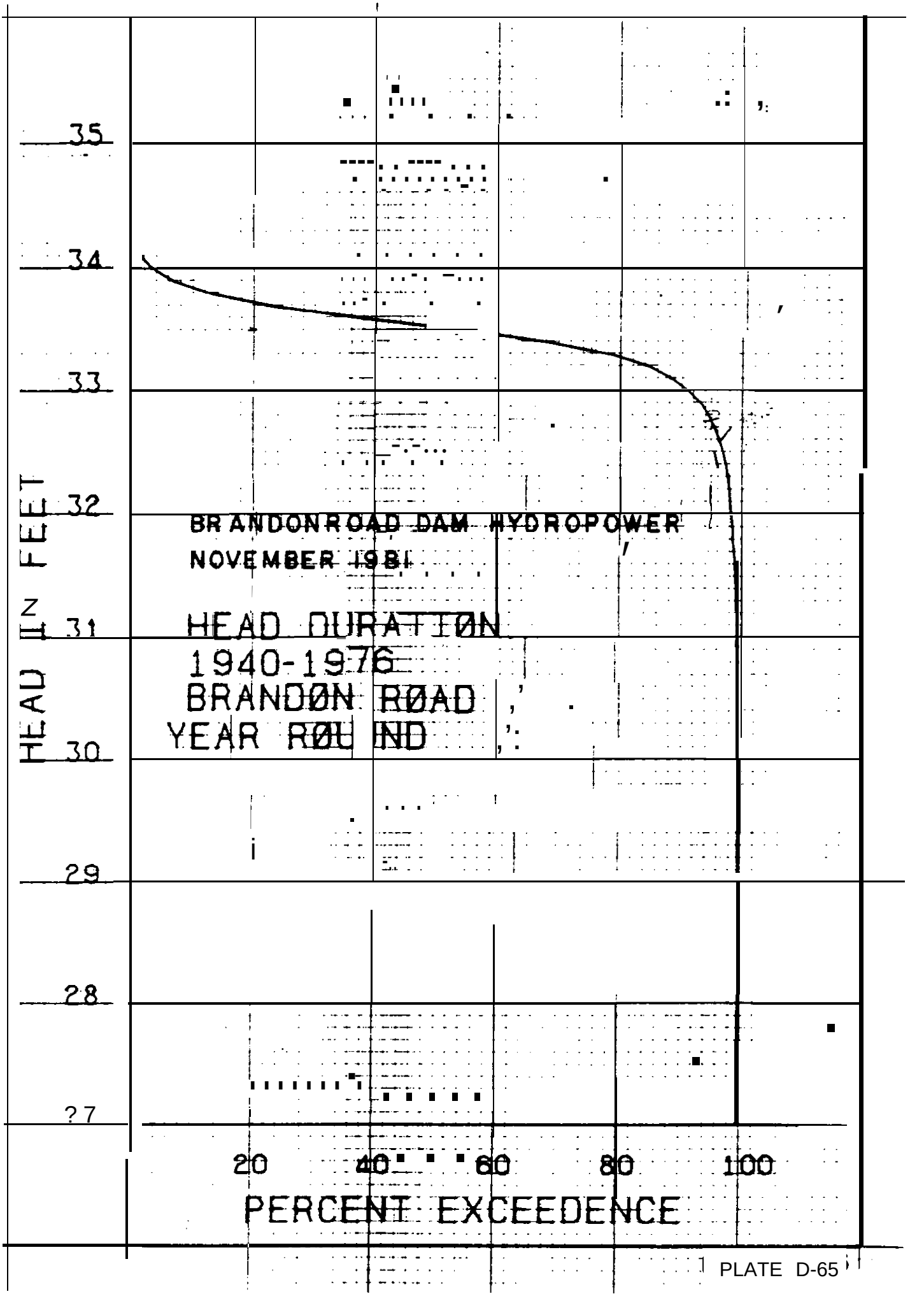
FLØW DURATIØN
BRANDØN RØAD
1940-1976
ØCTØBER
FLØW 1000 CFS
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
NØVEMBER
FLØW 1000 CFS
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
FLØW DURATIØN
BRANDØN RØAD
1940-1976
DECEMBER
FLØW 1000 CFS
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATION
1940-1976
BRANDON ROAD
YEAR ROUND
HEAD IN FEET
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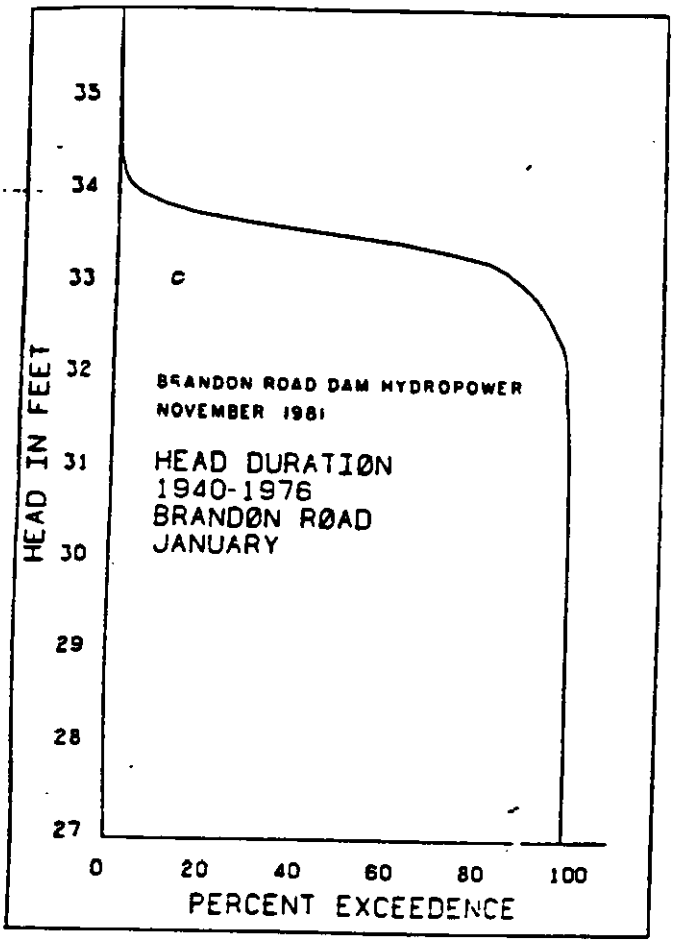
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
JANUARY
HEAD IN FEET
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33
32
31
30
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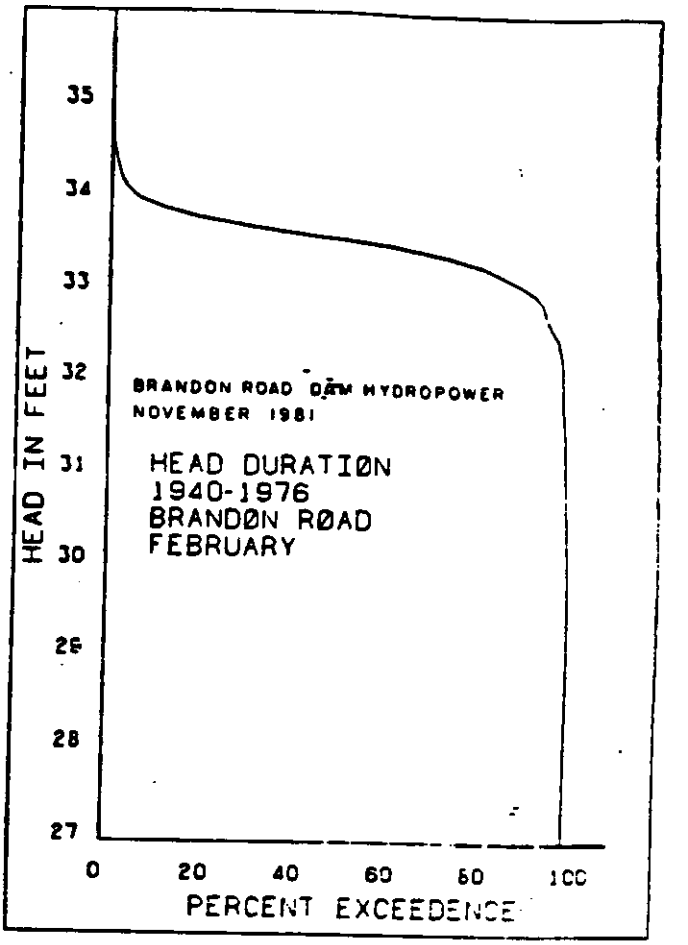
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
FEBRUARY
HEAD IN FEET
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34
33
32
31
30
28
27
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20
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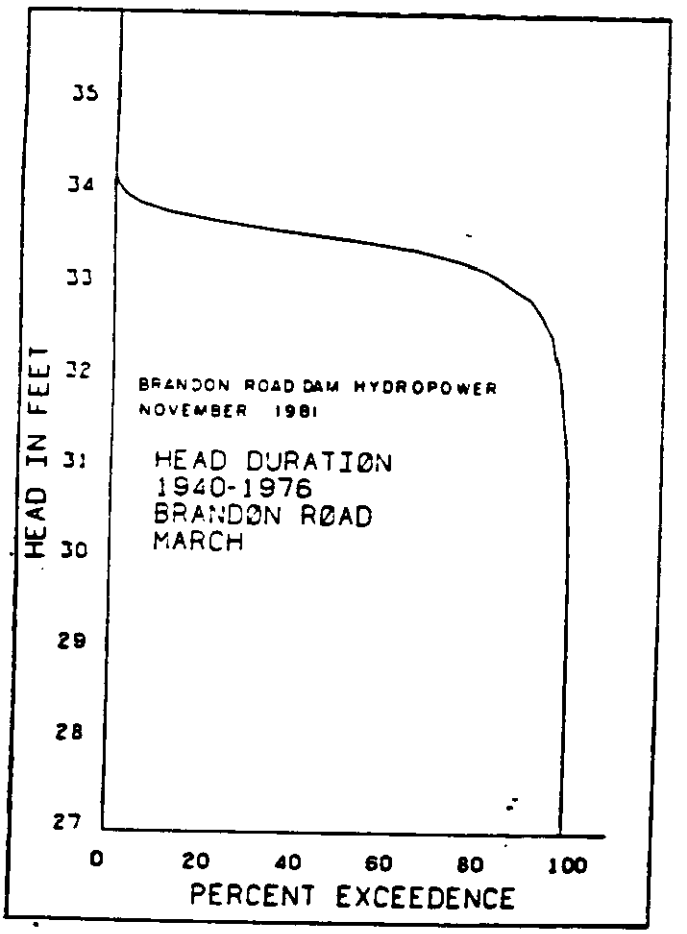
60
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
MARCH
HEAD IN FEET
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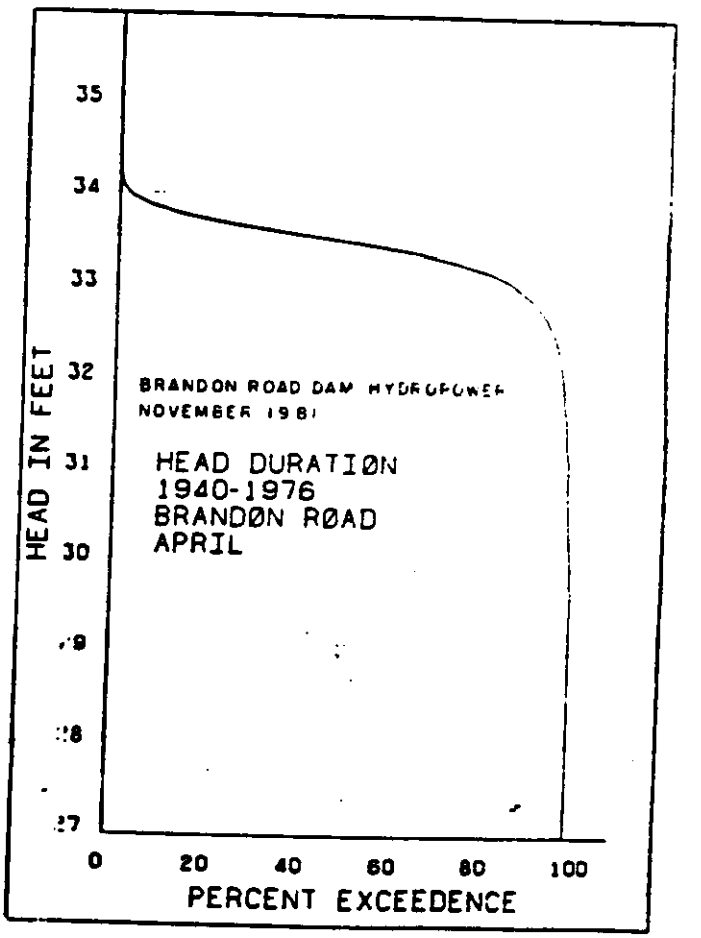
32
31
30
29
28
27
0
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
APRIL
HEAD IN FEET
35
34
33
32
31
30
0
20
40
60
80
100
PERCENT EXCEEDENCE

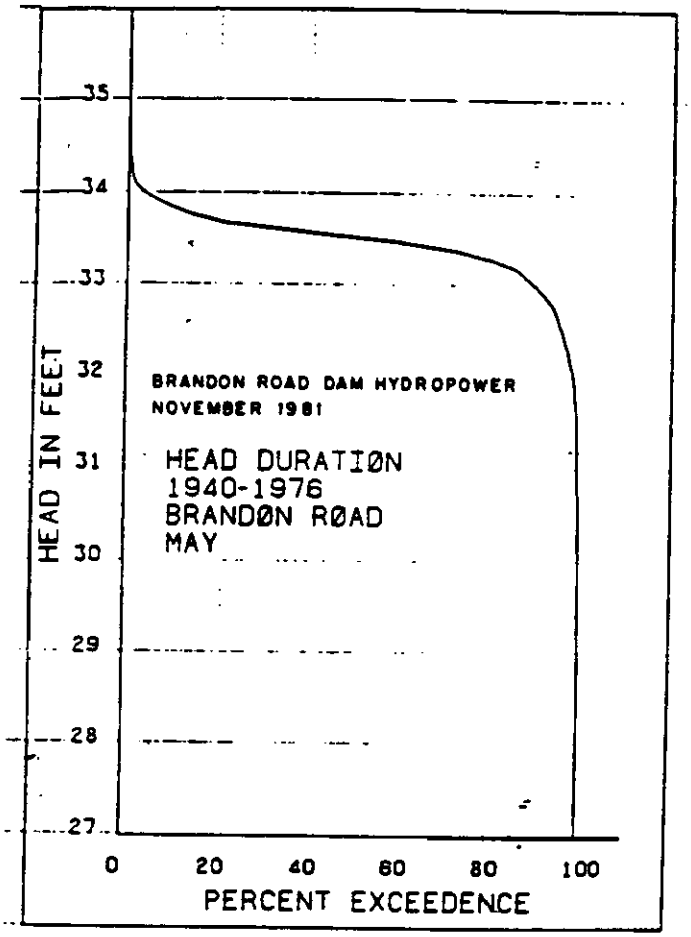


PLATE A-19

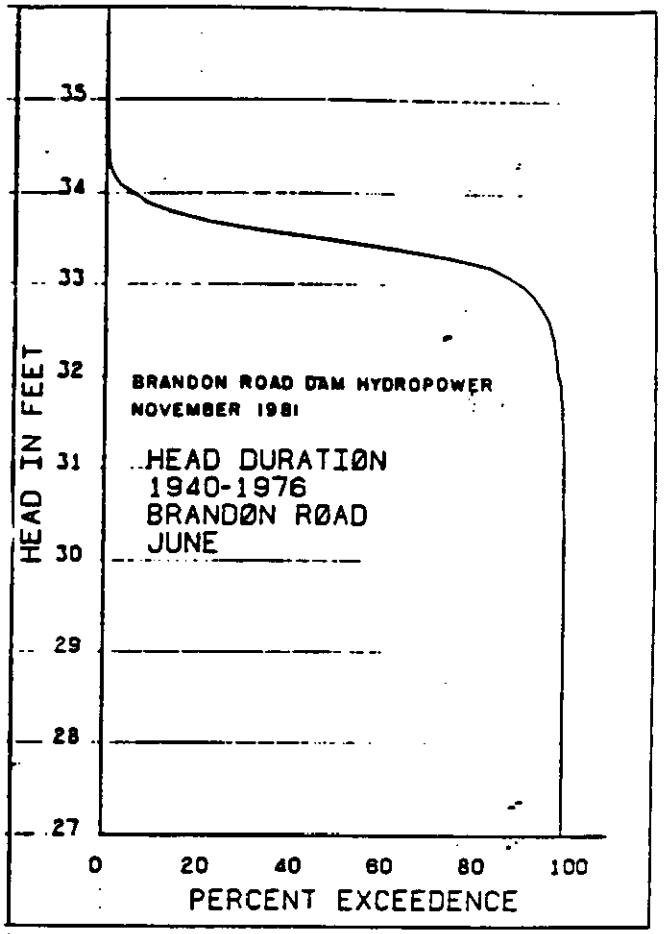
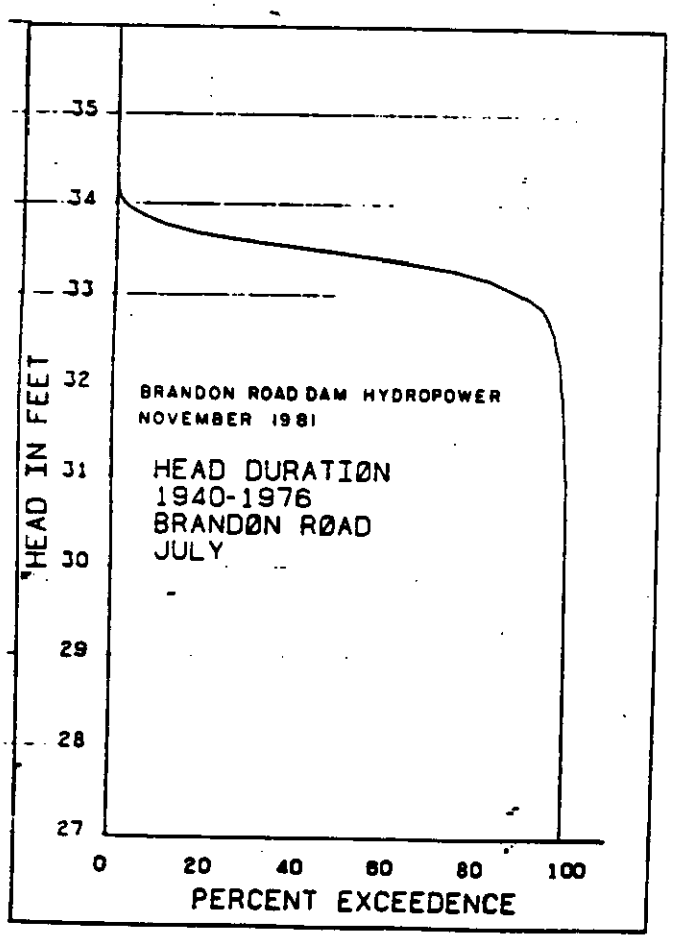
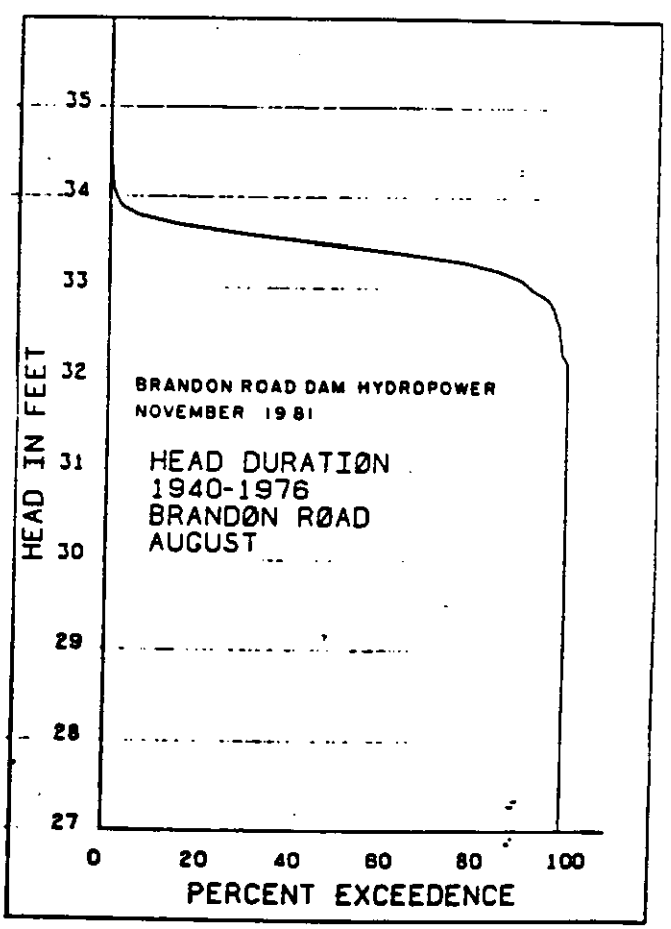
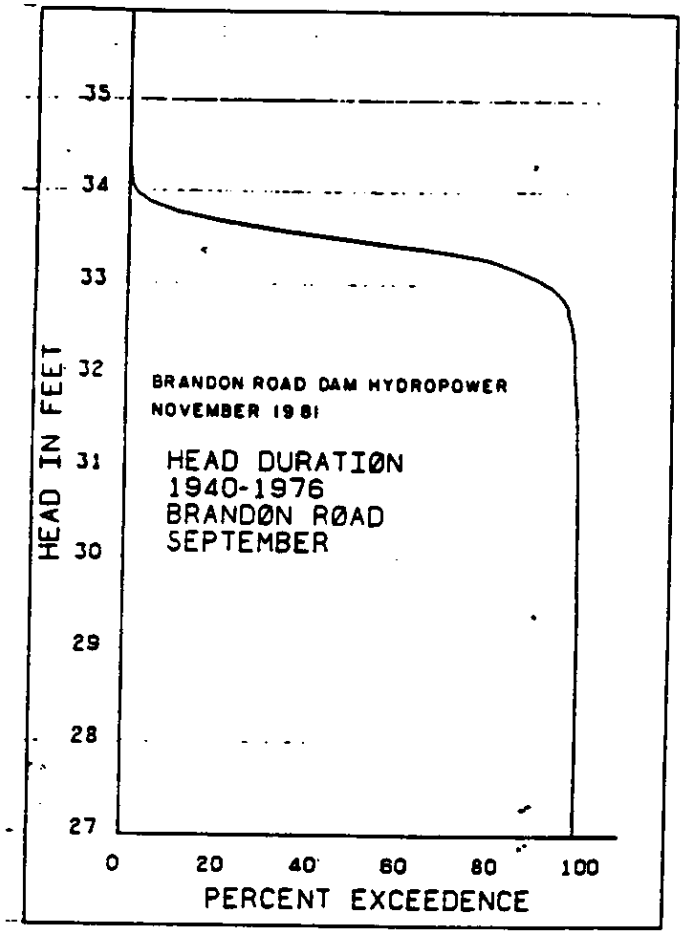
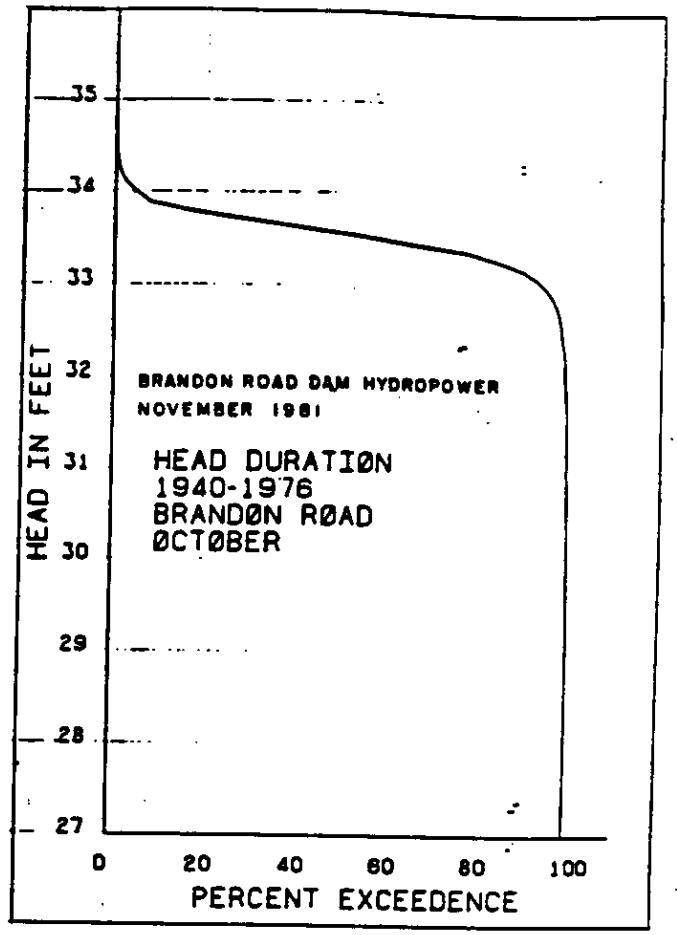


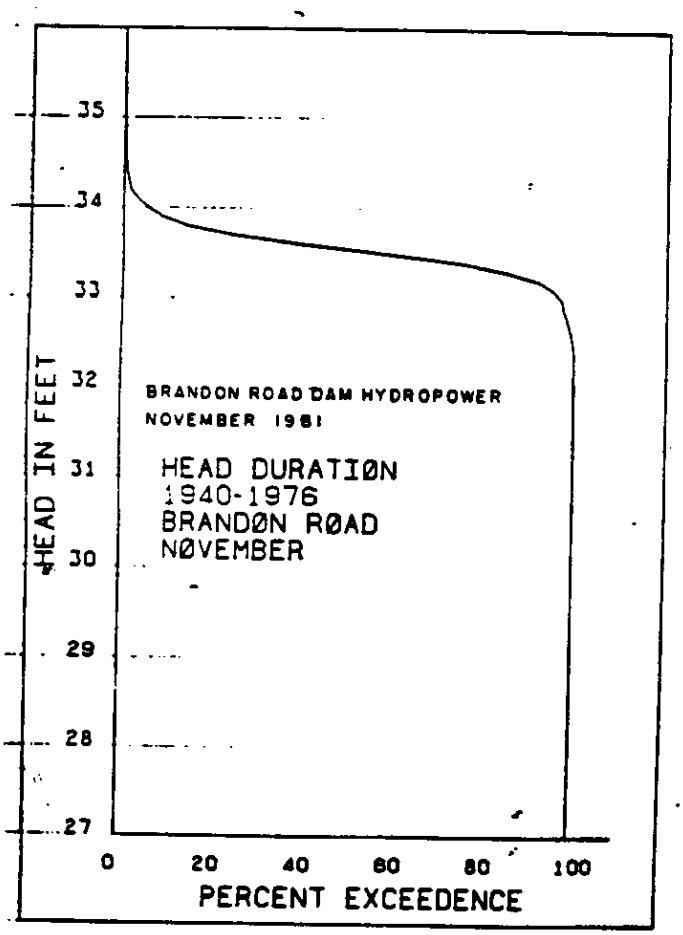
PLATE A-20






BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
SEPTEMBER
HEAD IN FEET
35
34
33
32
31
30
29
28
27
0
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
ØCTØBER
HEAD IN FEET
35
34
33
32
31
30
29
28
27
0
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
NØVEMBER
HEAD IN FEET
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32
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30
29
28
27
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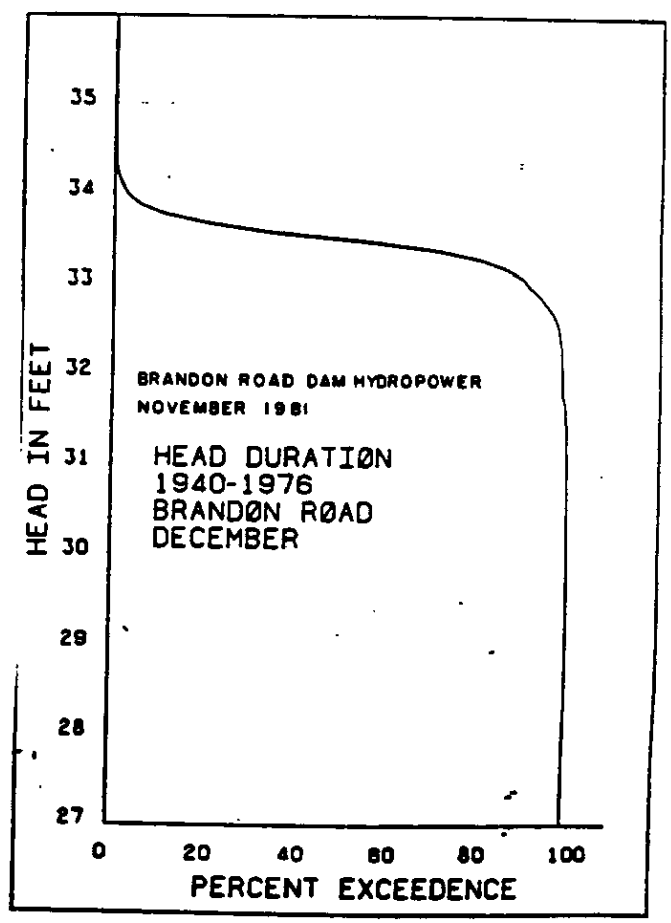
20
40
60
80
100
PERCENT EXCEEDENCE


BRANDON ROAD DAM HYDROPOWER
NOVEMBER 1981
HEAD DURATIØN
1940-1976
BRANDØN RØAD
DECEMBER
HEAD IN FEET
35
34
33
32
31
30
29
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27
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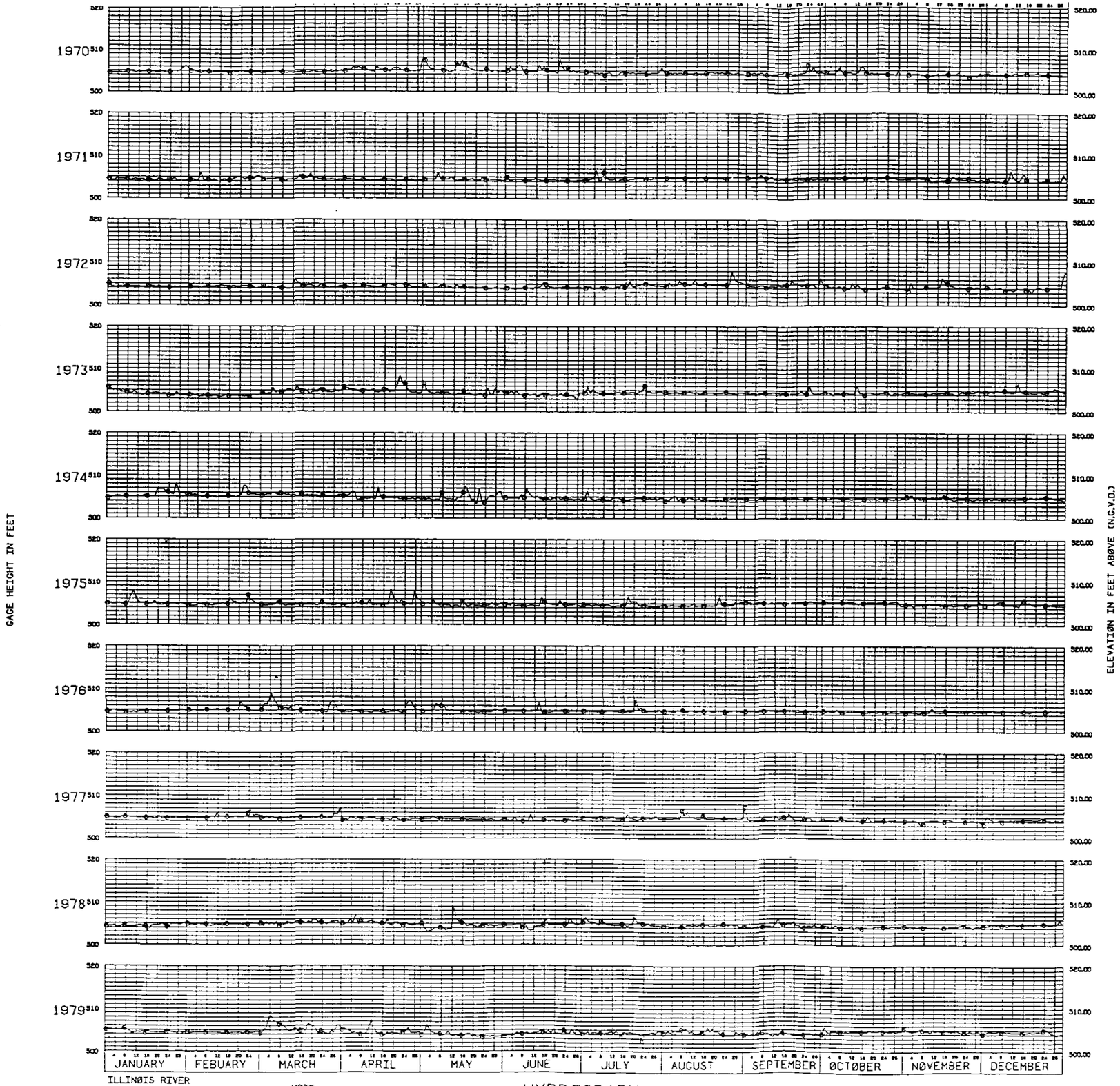
20
40
60
80
100
PERCENT EXCEEDENCE



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
BRANDØN RØAD'S TAILWATER

Symbol	Description of Revisions	Date	Approved

US Army Corps of Engineers

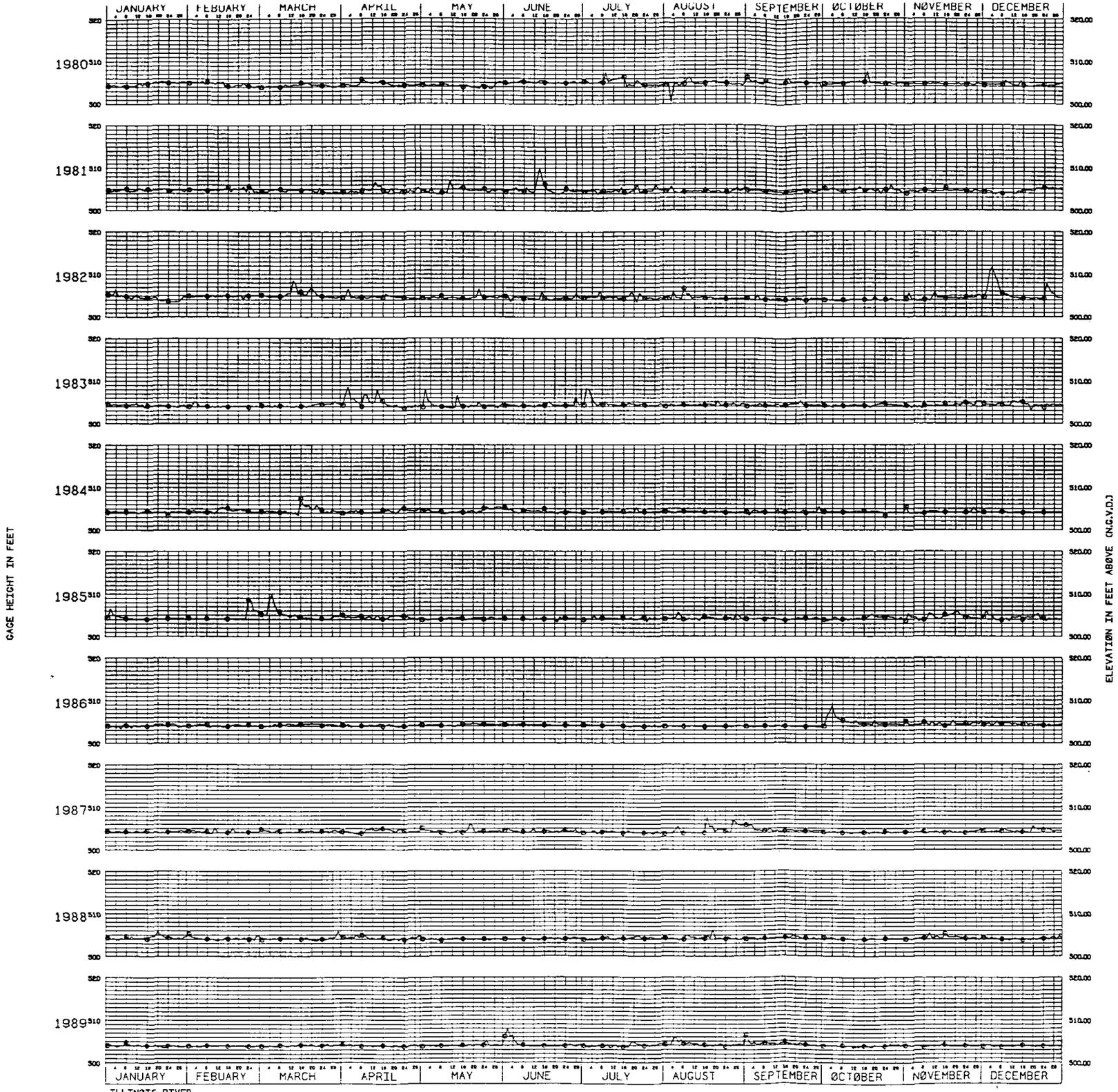
U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:

PLATE D-69

Submitted by:
CHIEF DESIGN BRANCH
Approved by:
CHIEF ENGINEERING DIVISION

Scale:
Date:
Drawing number:
Sheet _ of _



NØTE-

HYDRØGRAPH
BRANDØN RØAD'S TAILWATER

Symbol	Description of Revisions	Date	Approve

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

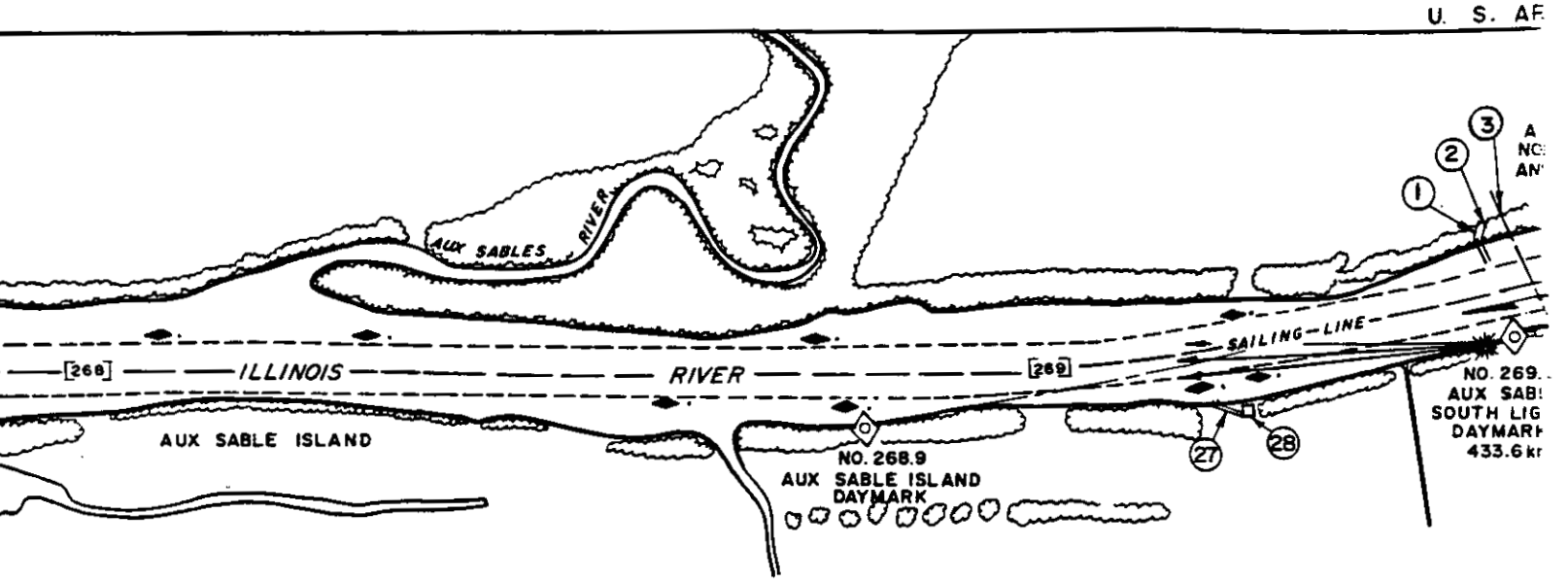
US Army Corps of Engineers

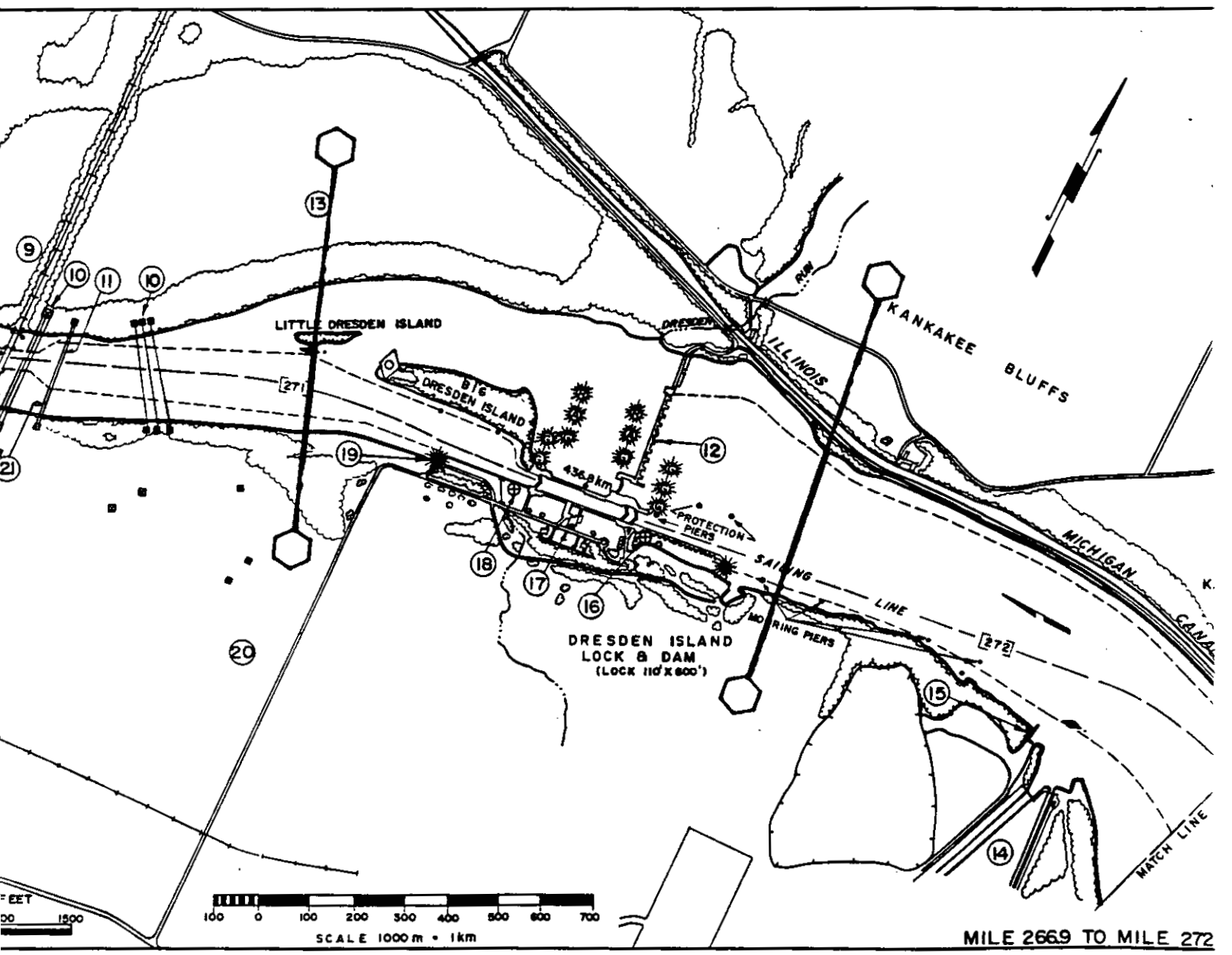
Designed by:
Drawn by:
Checked by:

PLATE D-70

Submitted by:
CHIEF, DESIGN BRANCH
Approved by:
CHIEF, ENGINEERING DIVISION

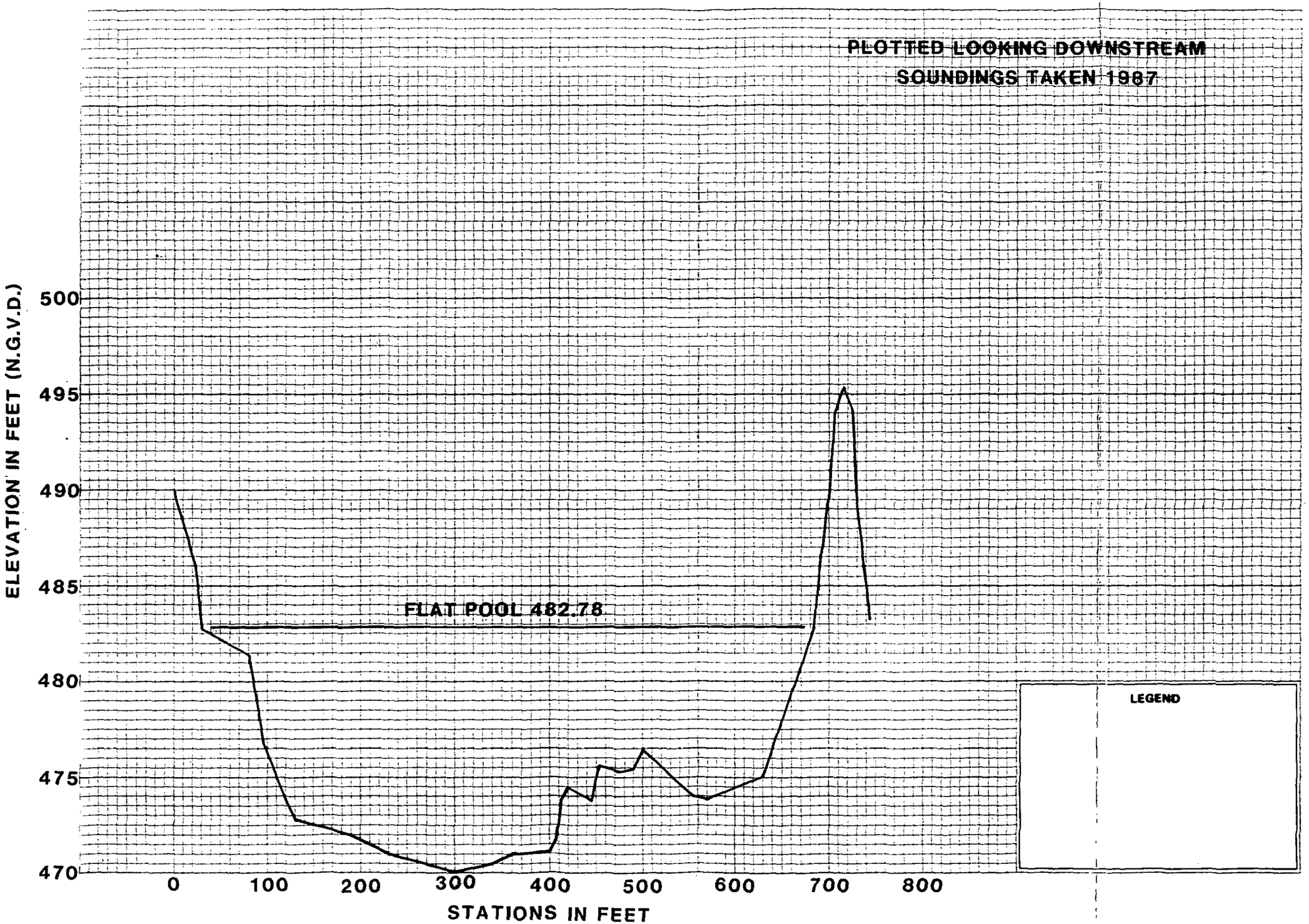
Scale:
Date:
Drawing number
Sheet ___ of ___





MILE 266.9 TO MILE 272

PLATE D-71

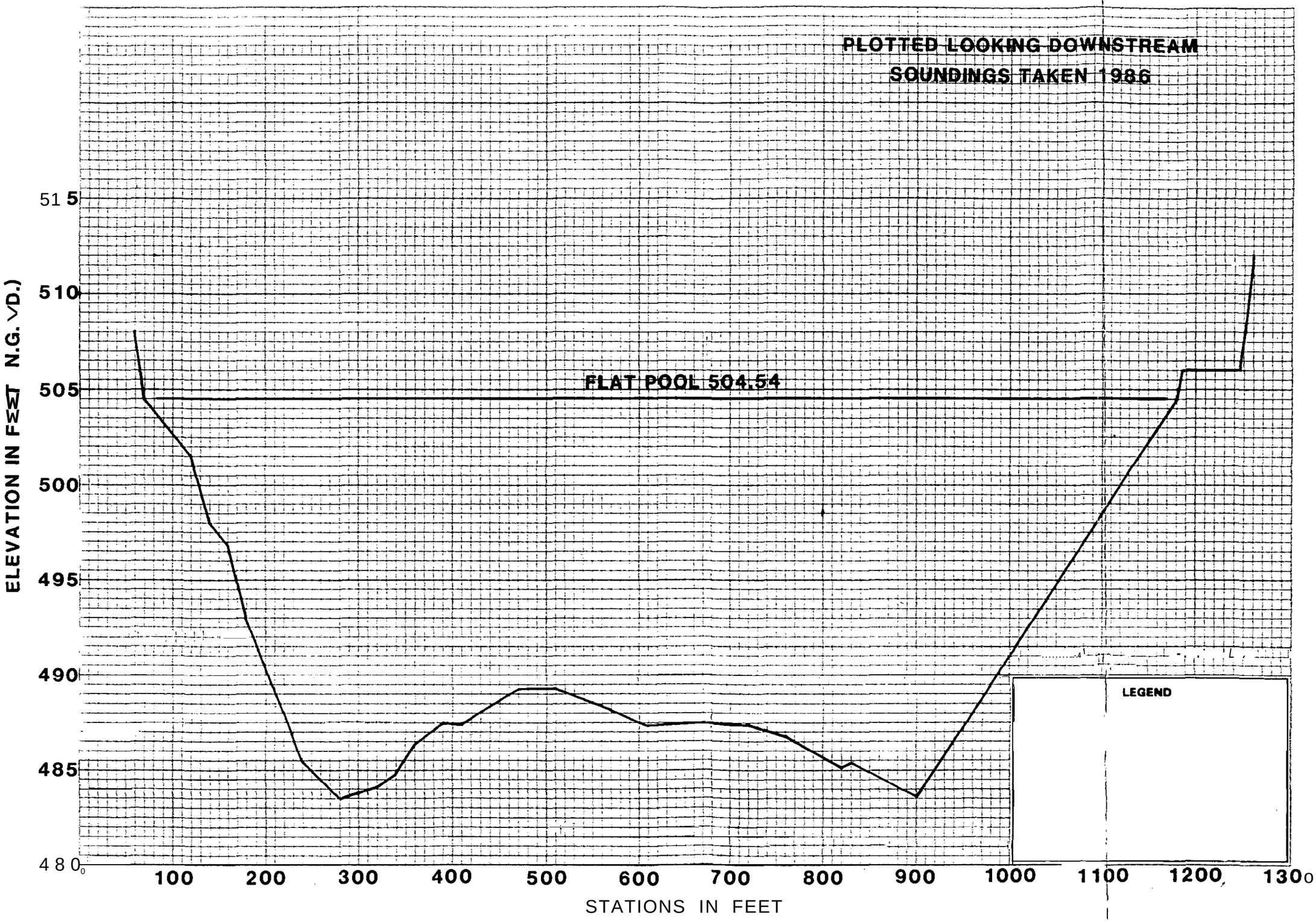


CHANNEL SECTION RIVER MILE 271.0

ILLINOIS RIVER

DRESDEN ISLAND TAIL

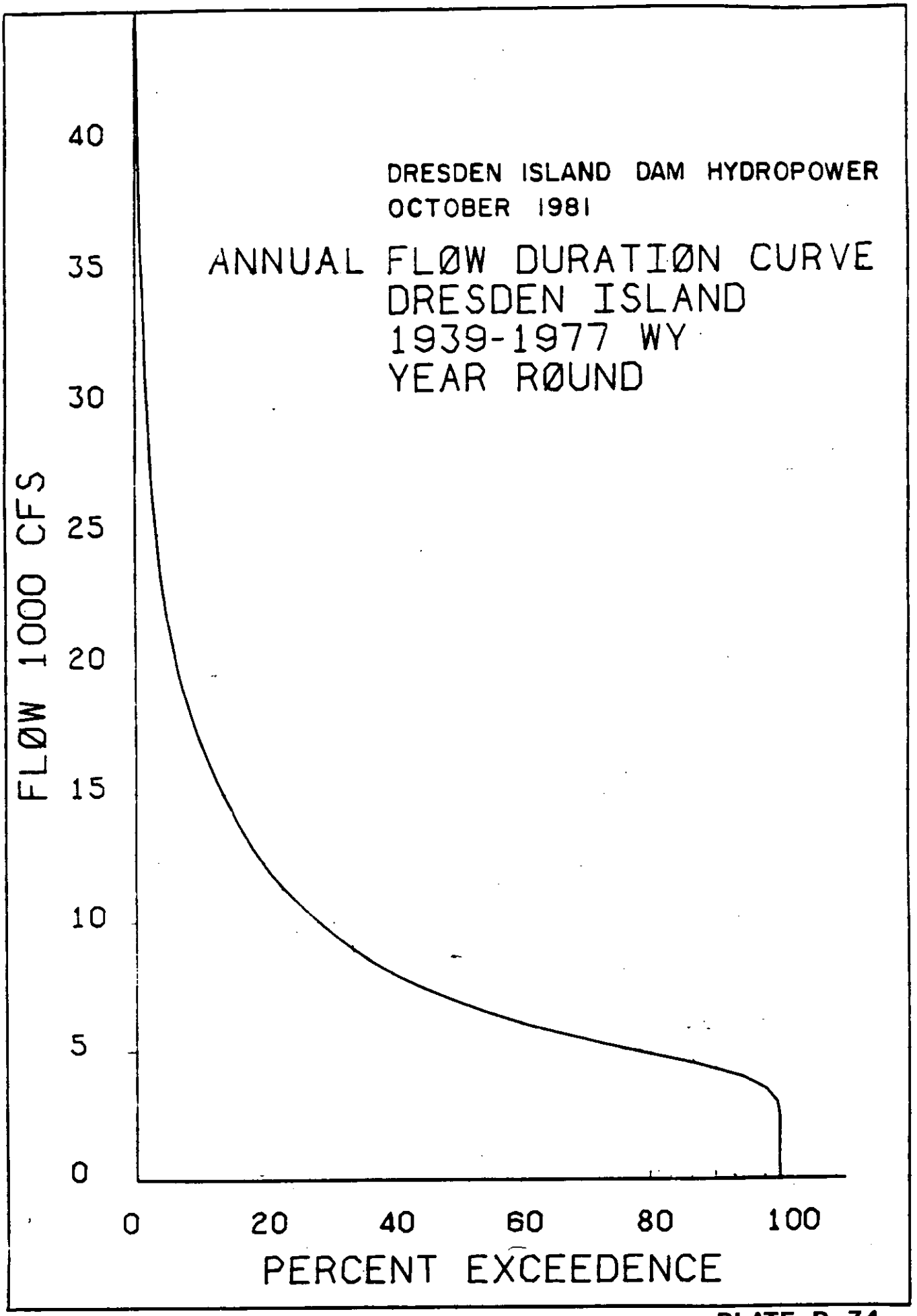
PLATE D-72



CHANNEL SEC ON RIVER MILE 271.71

ILLINOIS RIVER

DRESDEN SLAND POOL


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
ANNUAL FLØW DURATIØN CURVE
DRESDEN ISLAND
1939-1977 WY
YEAR RØUND
FLØW 1000 CFS
40
35
30
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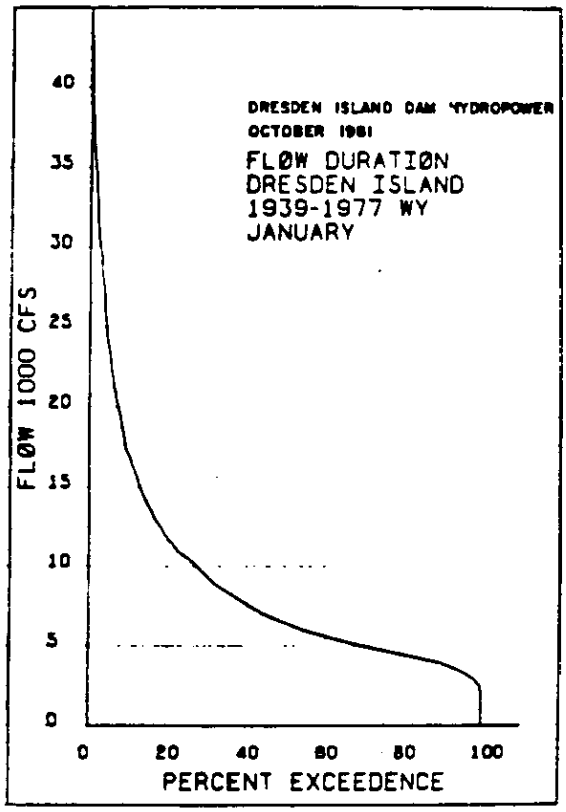
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-74


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
JANUARY
FLØW 1000 CFS
0
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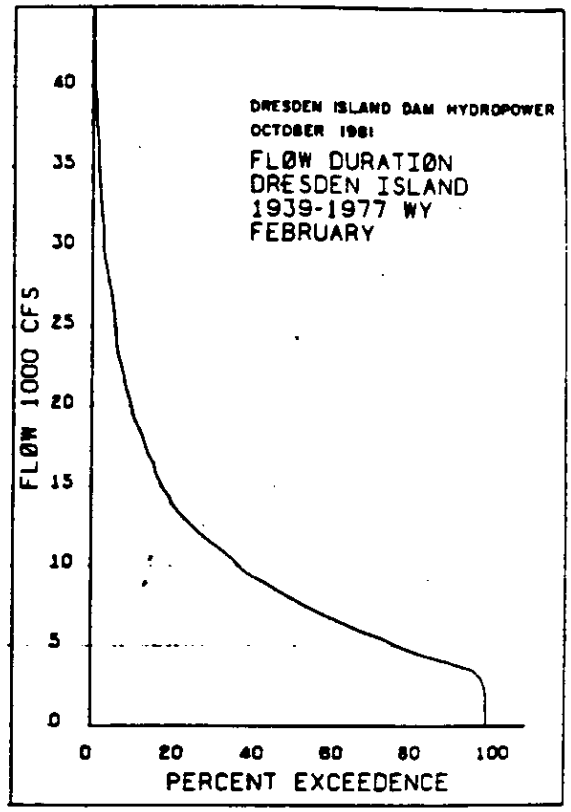
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
FEBRUARY
FLØW 1000 CFS
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25
30
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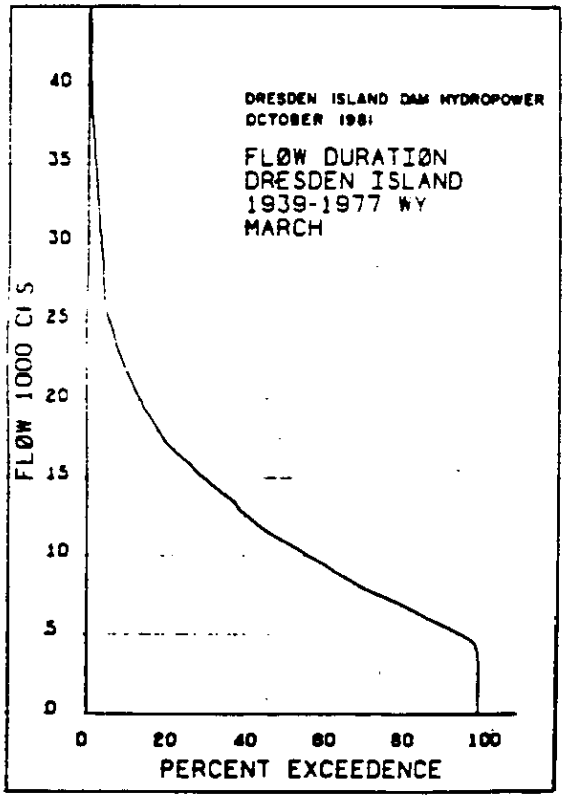
100
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
MARCH
FLØW 1000 CFS
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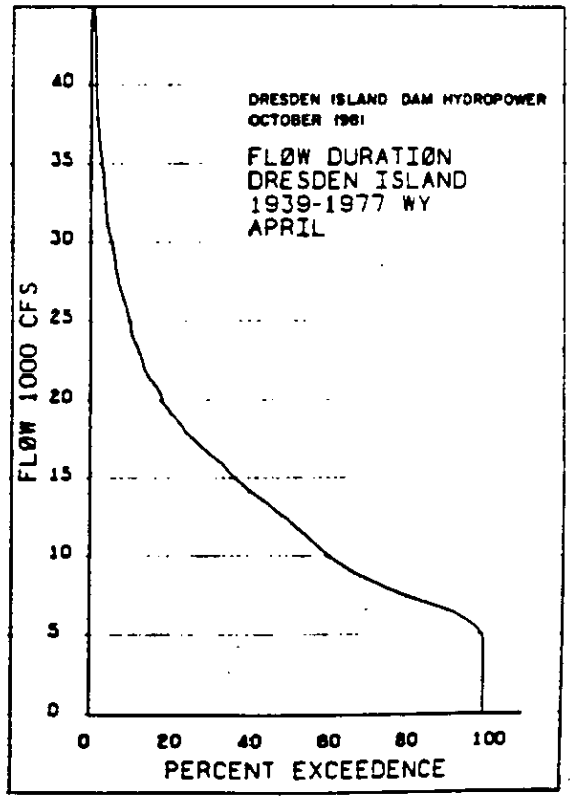
100
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
APRIL
FLØW 1000 CFS
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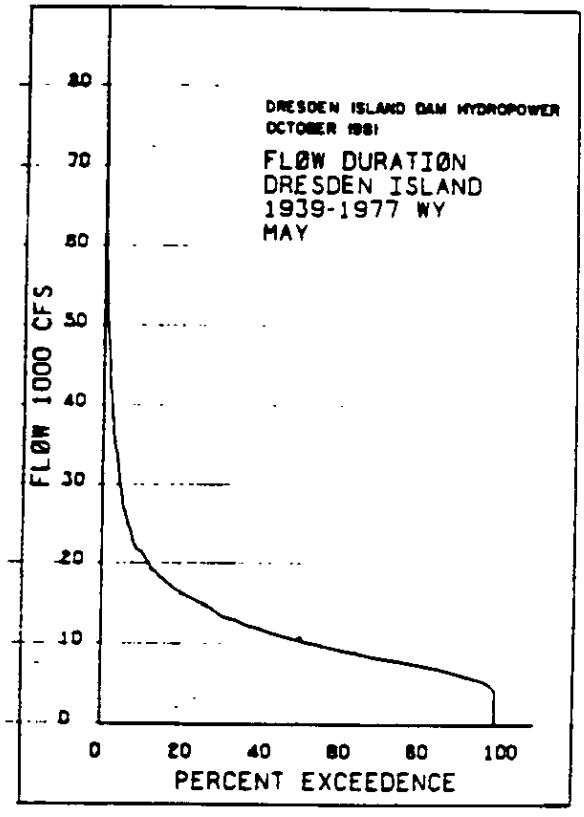
100
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
MAY
FLØW 1000 CFS
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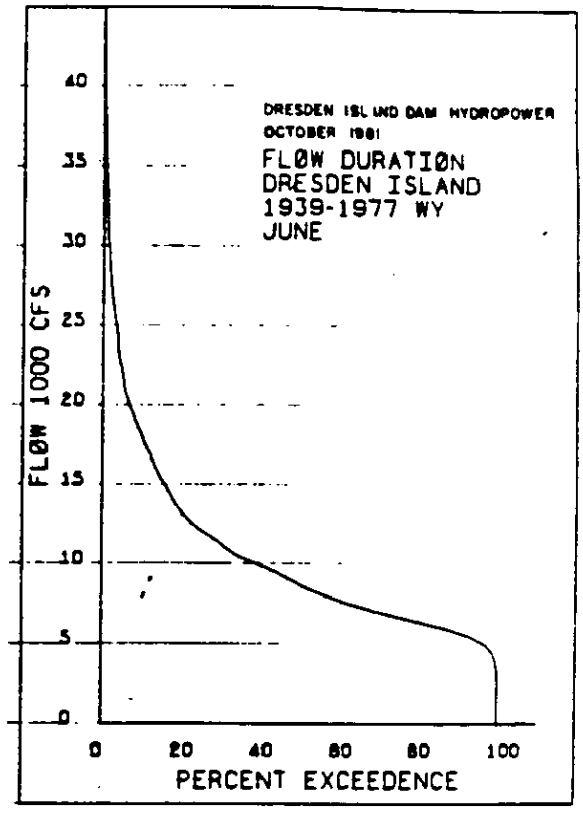
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
JUNE
FLØW 1000 CFS
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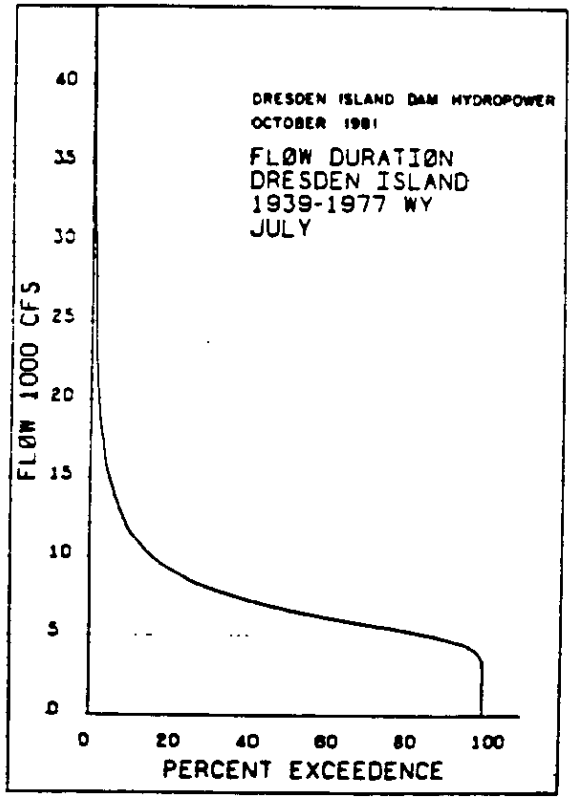
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
JULY
FLØW 1000 CFS
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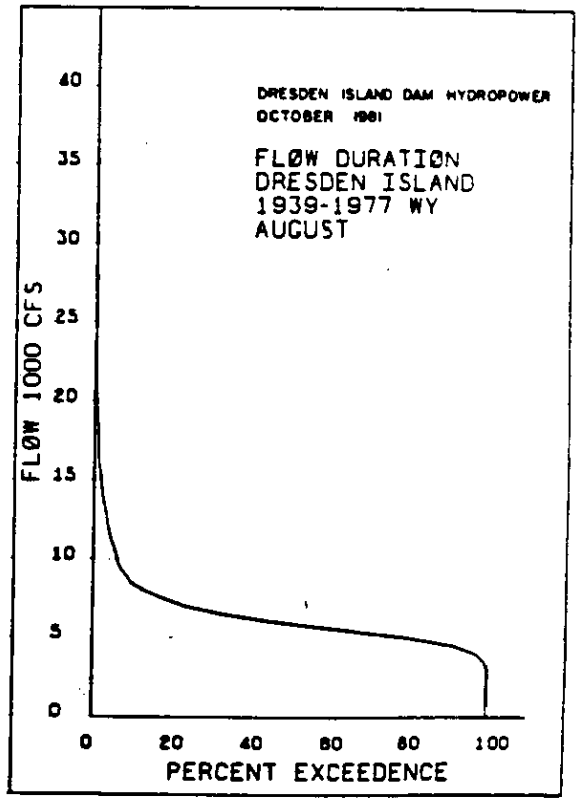
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLØW DURATIØN
DRESDEN ISLAND
1939-1977 WY
AUGUST
FLØW 1000 CFS
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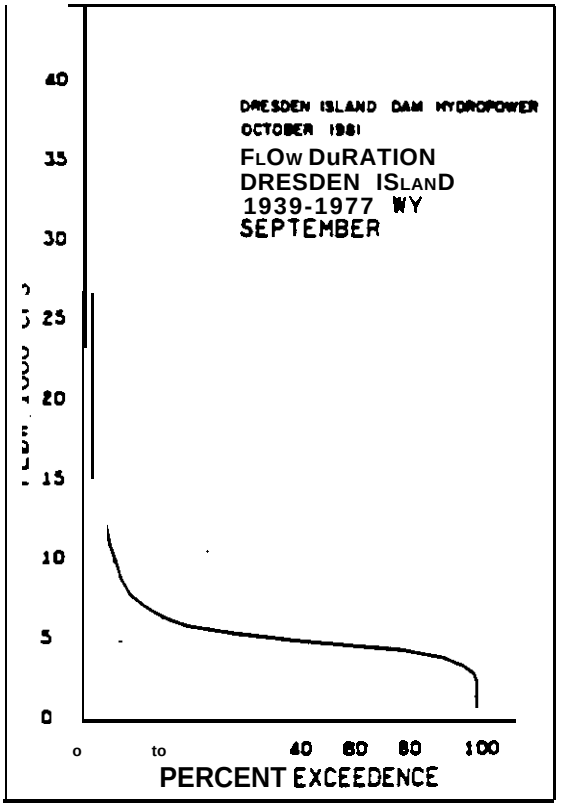
100
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLOW DURATION
DRESDEN ISLAND
1939-1977 WY
SEPTEMBER
40
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25
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to
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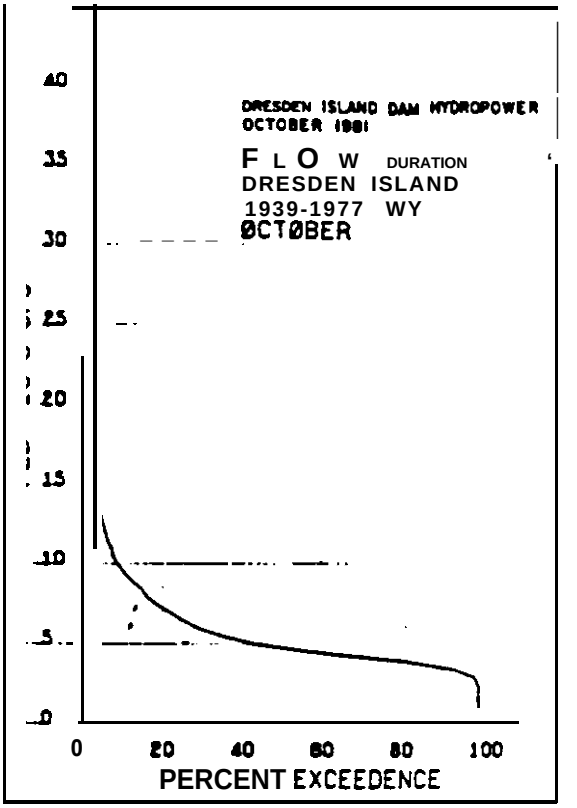
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLOW DURATION
DRESDEN ISLAND
1939-1977 WY
OCTOBER
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25
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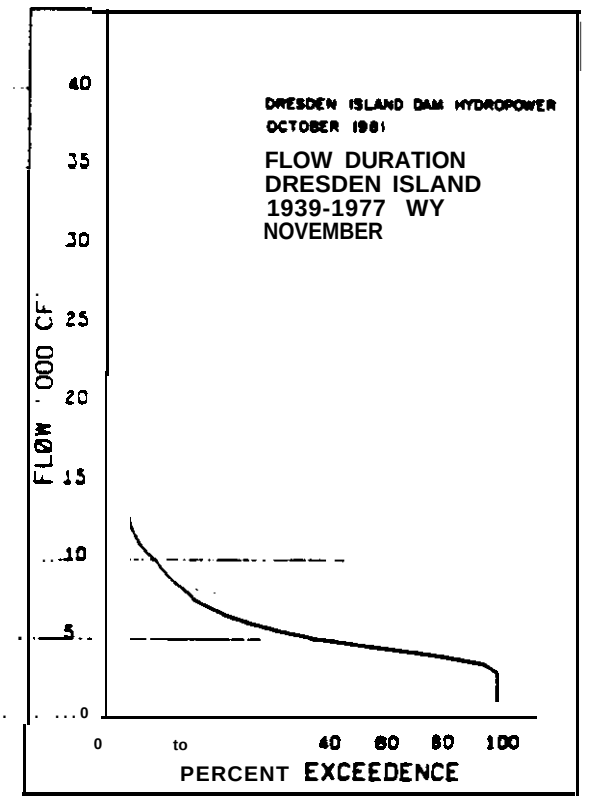
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLOW DURATION
DRESDEN ISLAND
1939-1977 WY
NOVEMBER
FLOW 1000 CF
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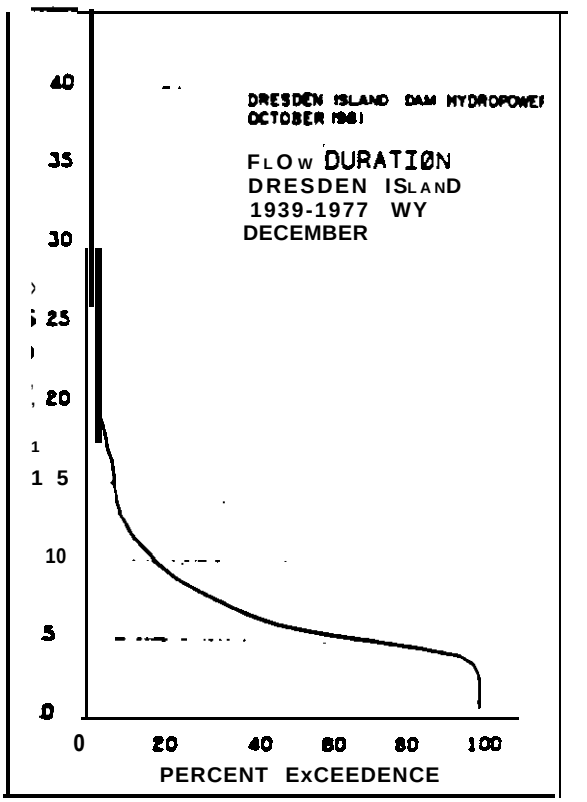
PERCENT EXCEEDENCE


DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
FLOW DURATION
DRESDEN ISLAND
1939-1977 WY
DECEMBER
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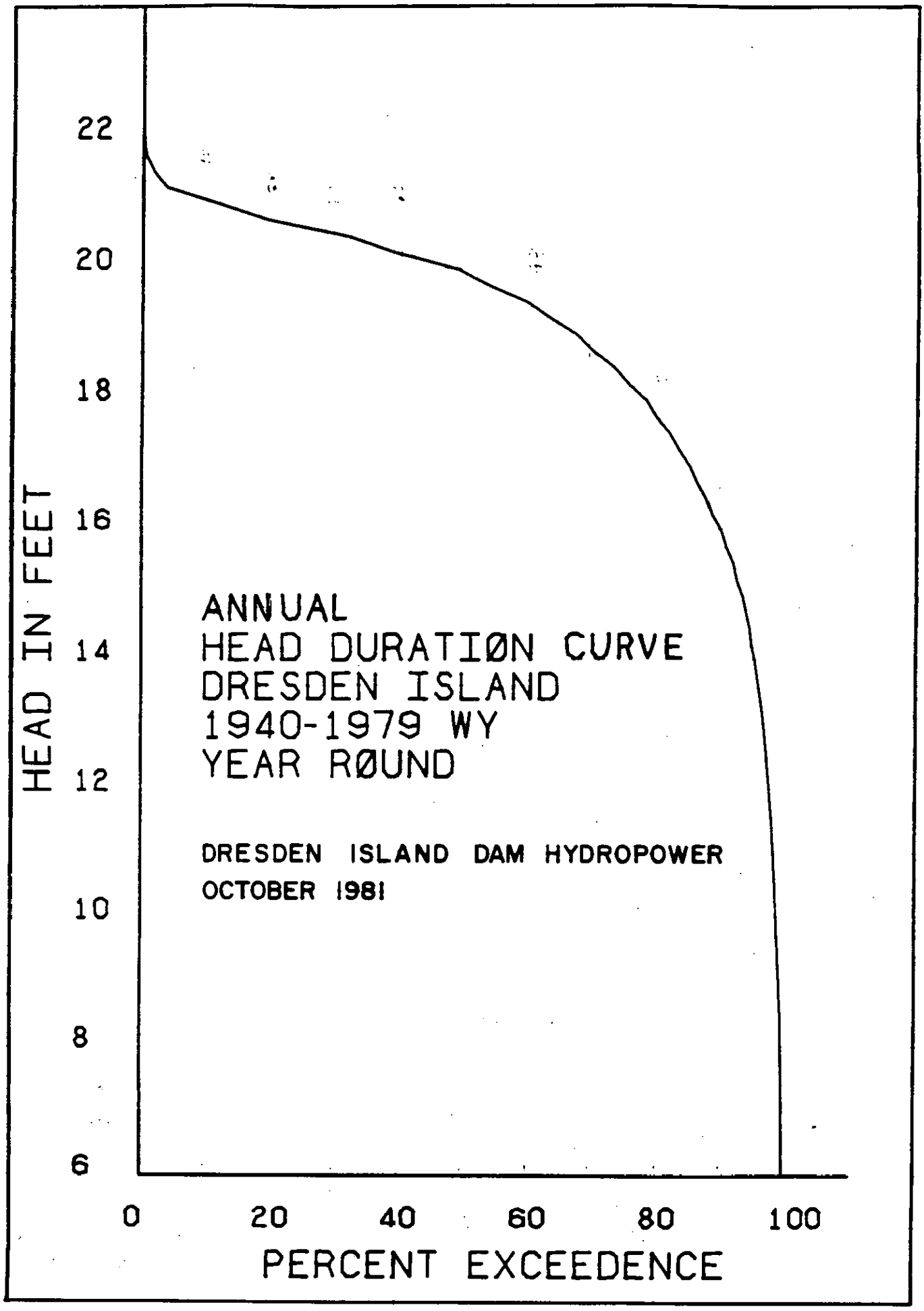
PERCENT EXCEEDENCE


ANNUAL
HEAD DURATIØN CURVE
DRESDEN ISLAND
1940-1979 WY
YEAR RØUND
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
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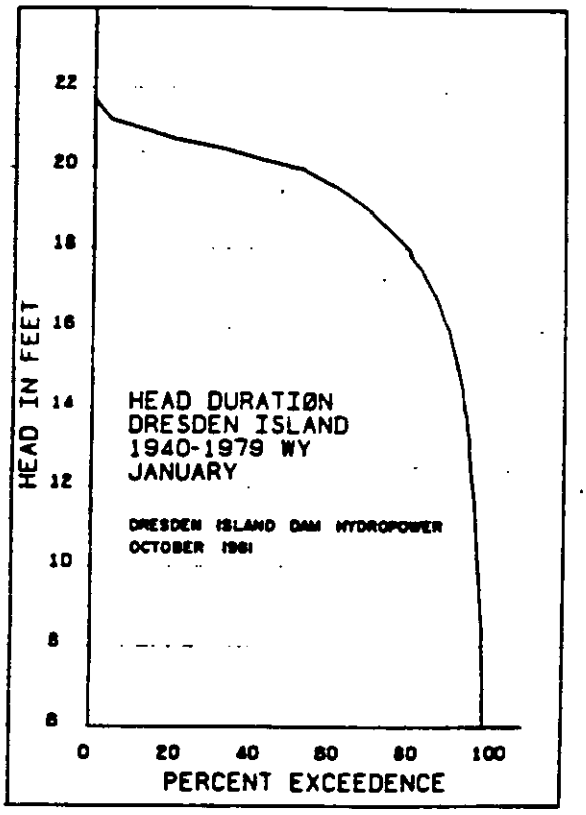
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
JANUARY
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
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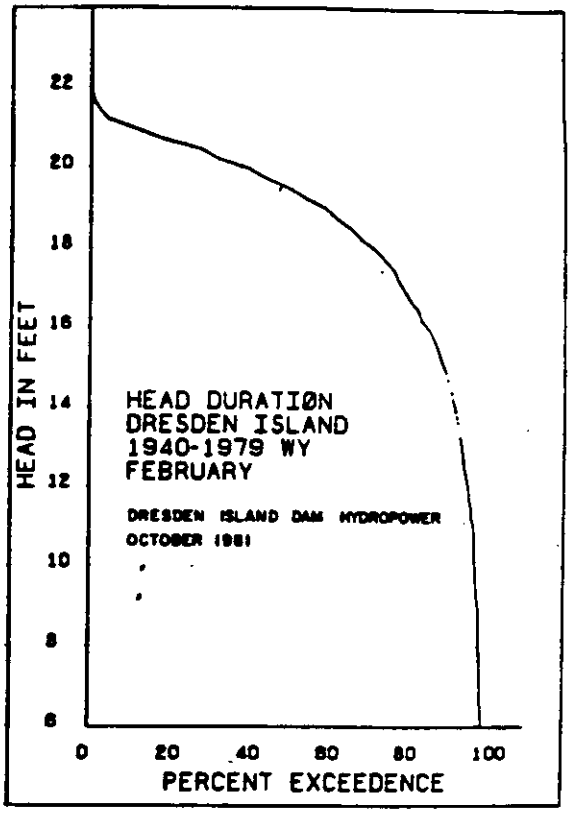
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
FEBRUARY
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
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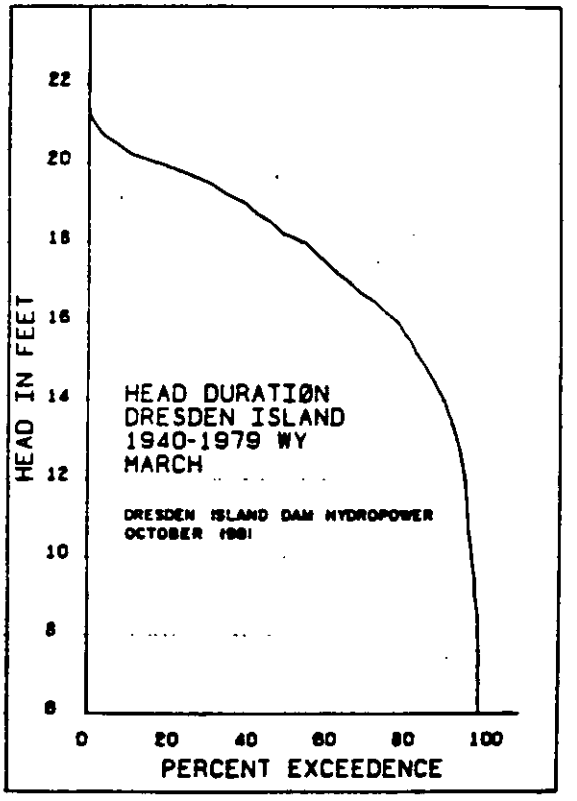
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
MARCH
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
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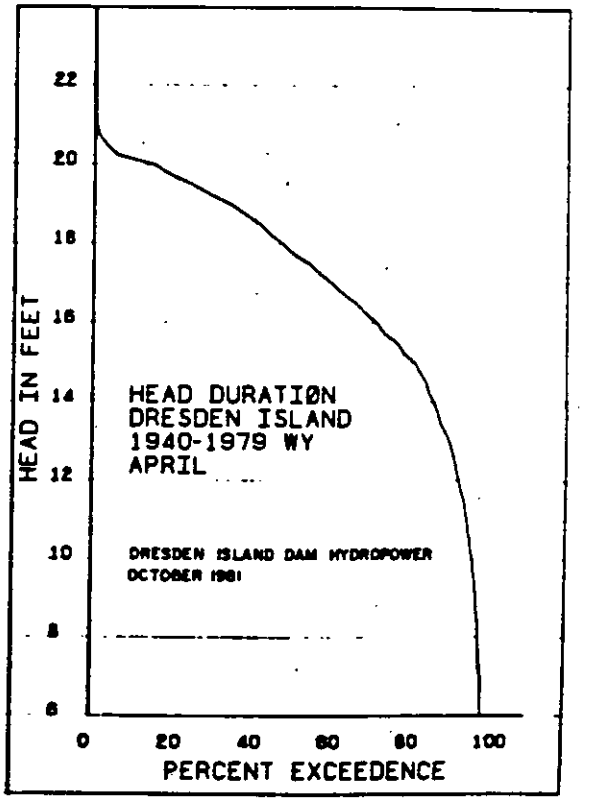
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
APRIL
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
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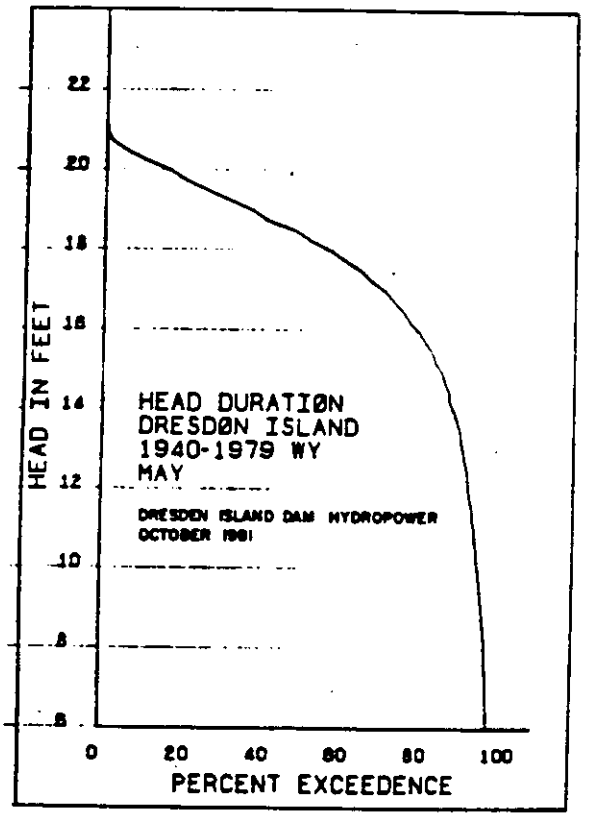
PERCENT EXCEEDENCE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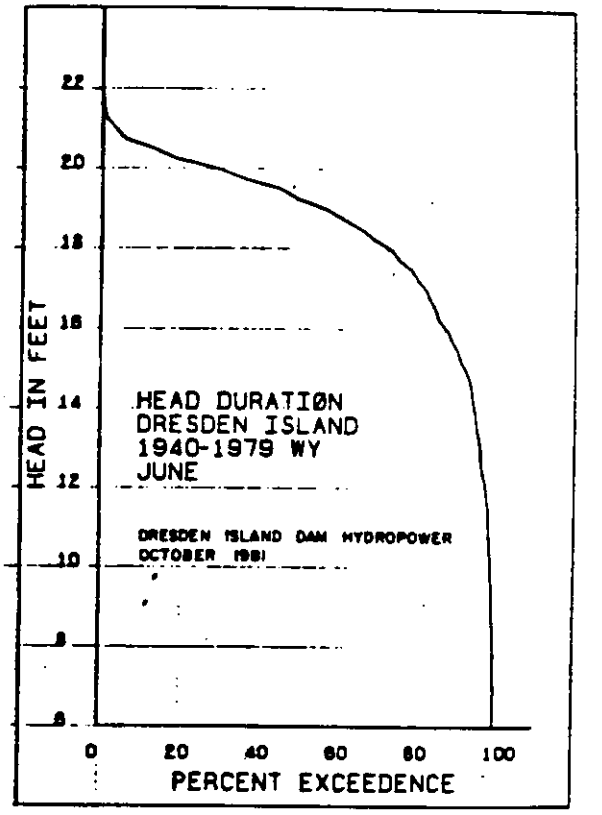
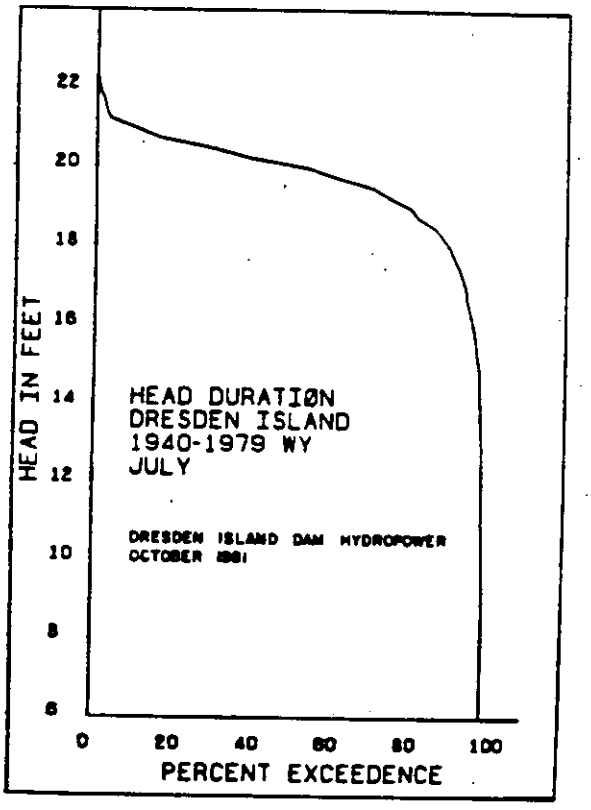
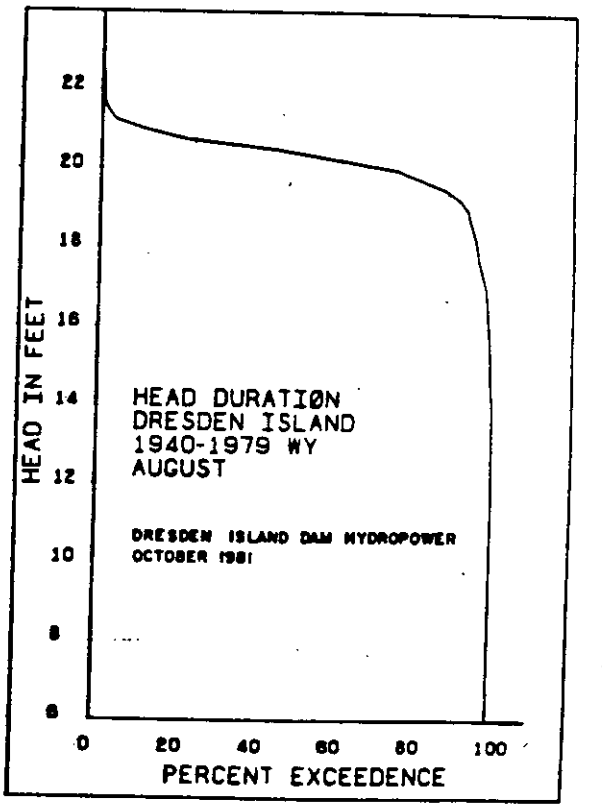
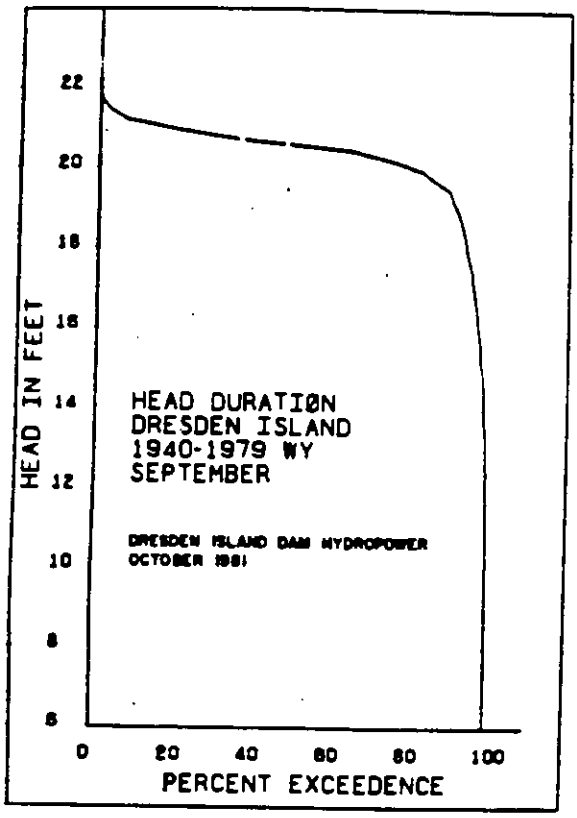
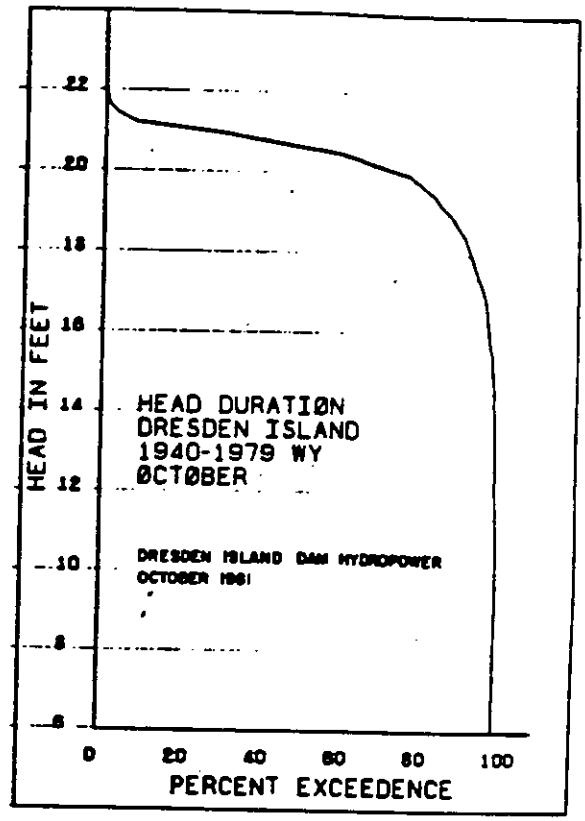
DRESDØN ISLAND
1940-1979 WY
MAY
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE

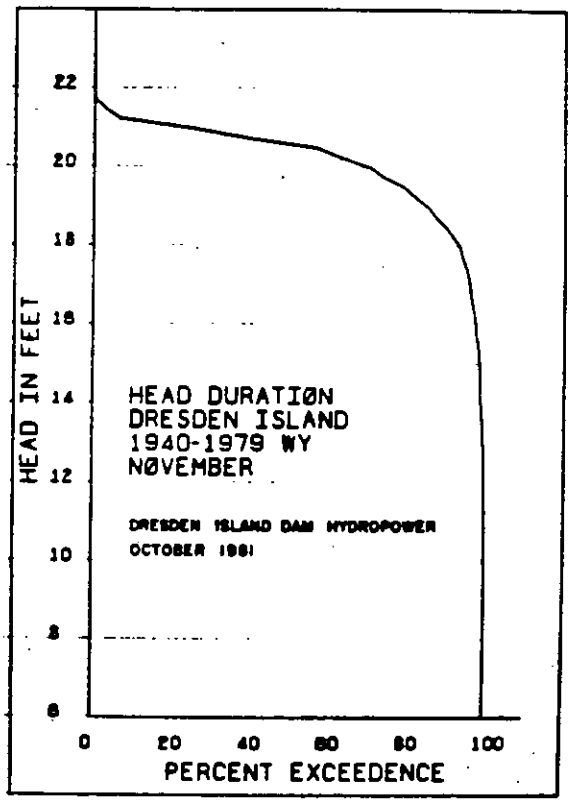

HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
JUNE
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE

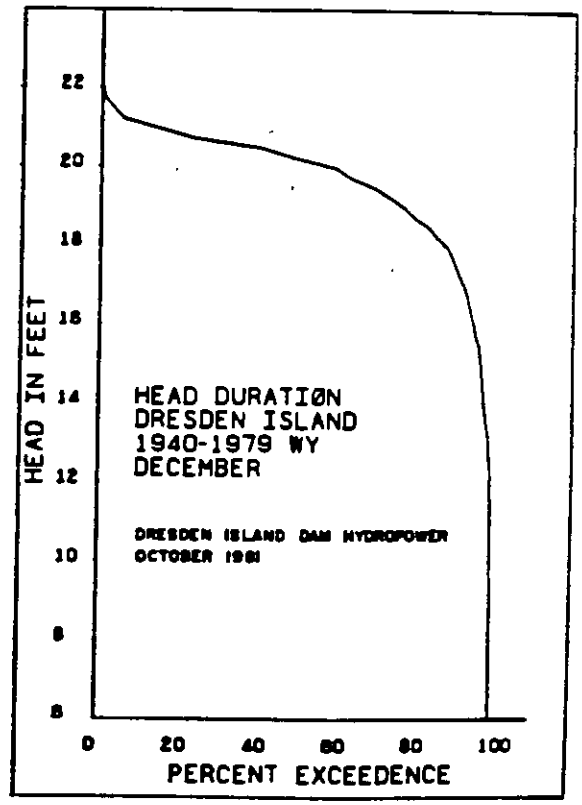

HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
JULY
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE

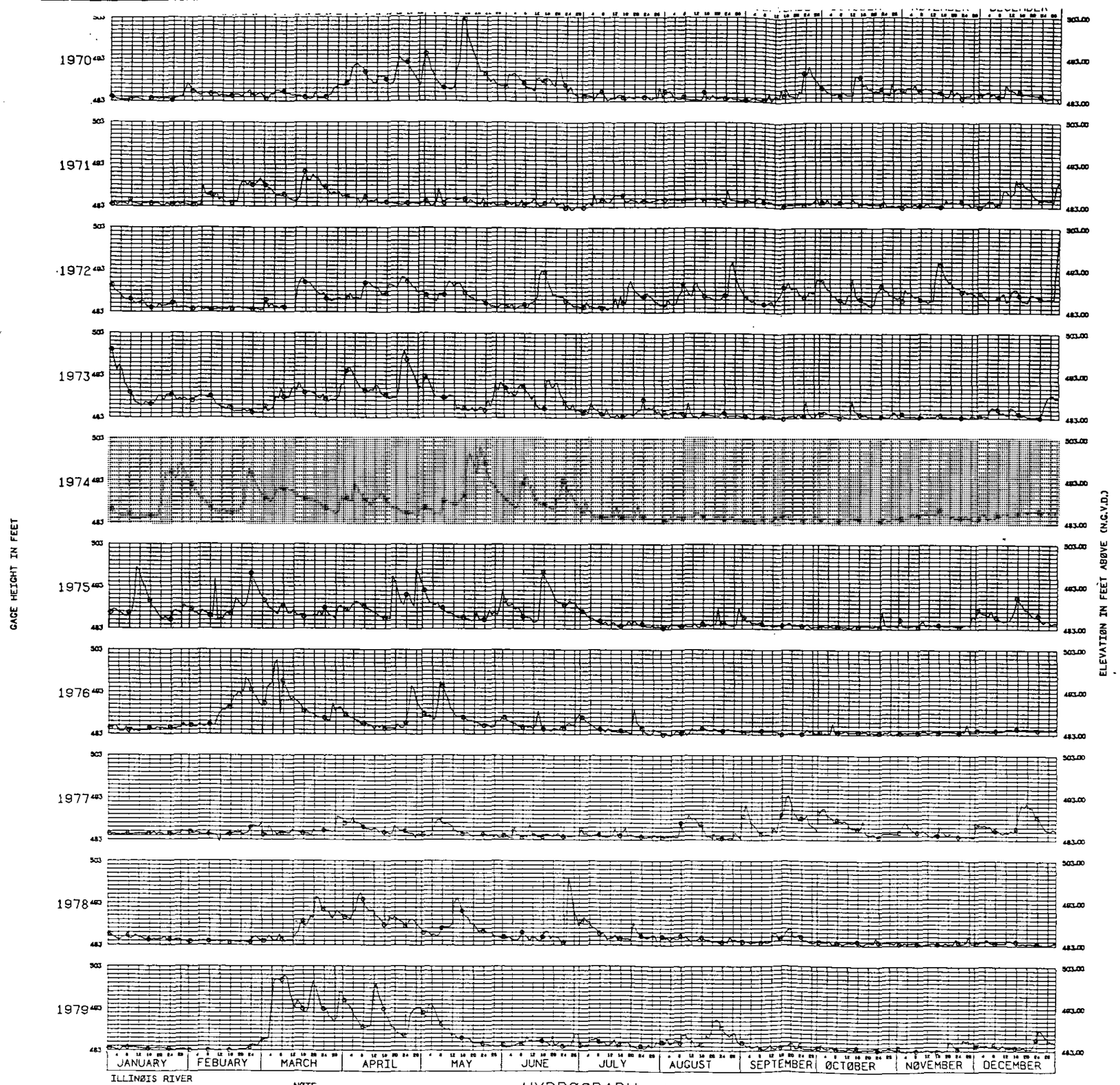

HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
AUGUST
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
SEPTEMBER
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
ØCTØBER
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
NØVEMBER
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE


HEAD DURATIØN
DRESDEN ISLAND
1940-1979 WY
DECEMBER
DRESDEN ISLAND DAM HYDROPOWER
OCTOBER 1981
HEAD IN FEET
PERCENT EXCEEDENCE



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
DRESDEN ISLAND'S TAILWATER

Symbol	....riptionof.evisions	Date	Approved

US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT, RoCK ISLAND
CORPS OF ENGINEERS
- ISLAND, ILLINOIS

Designed by:

Drawn by:

Checked by:

PLATE D-82

Submitted ....DESIGN BRANCH

Approved by:

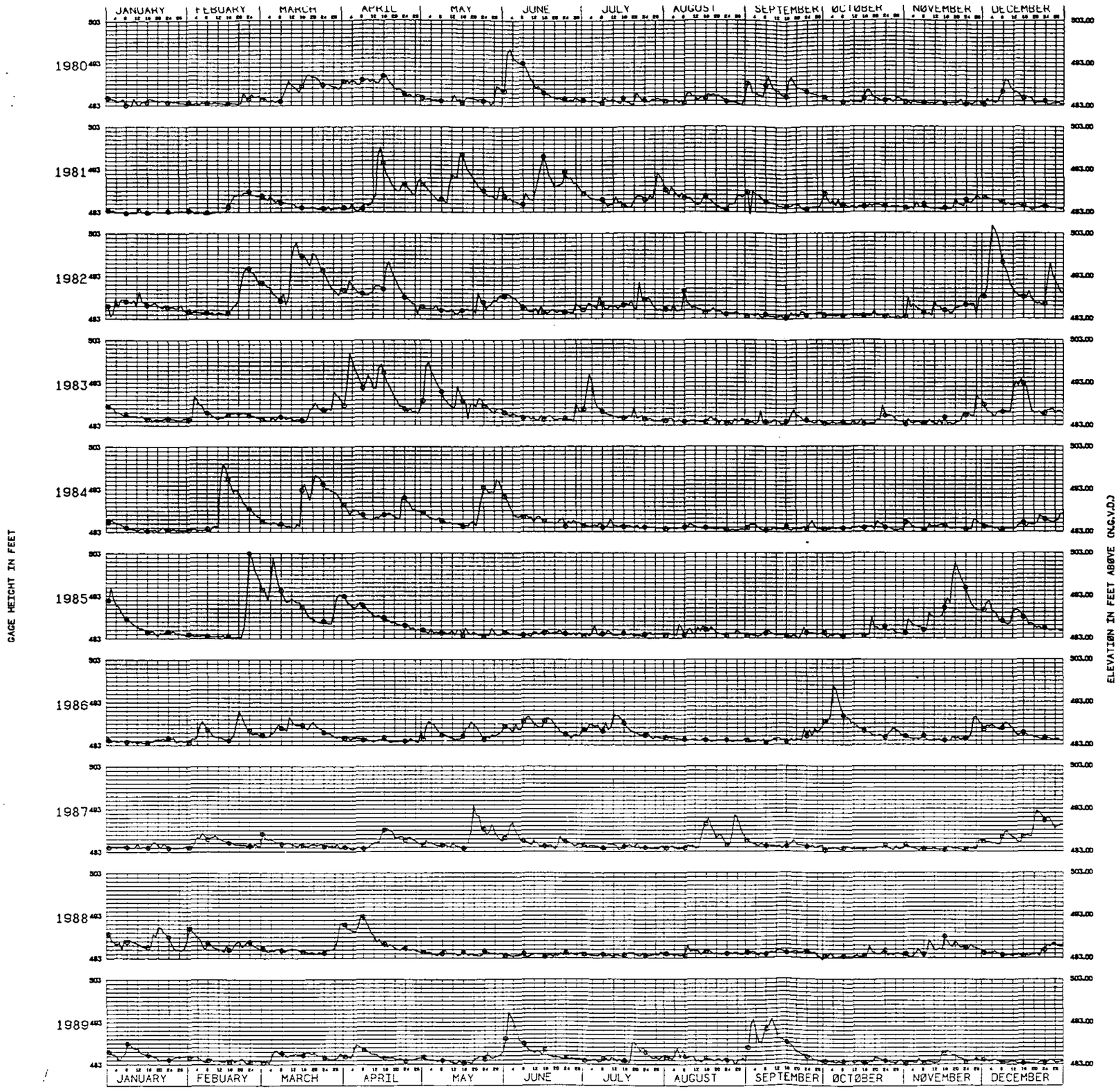
CHIEF ENGINEERING DIVISION

Scale:

Date:

Drawing number:

Sheet ___ of ___



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
DRESDEN ISLAND'S TAILWATER

Symbol	Description of Revisions	Date	Approve

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

US Army Corps of Engineers

Designed by:

Drawn by:

Checked by:

PLATE D-83

Submitted by:
CHIEF DESIGN BRANCH

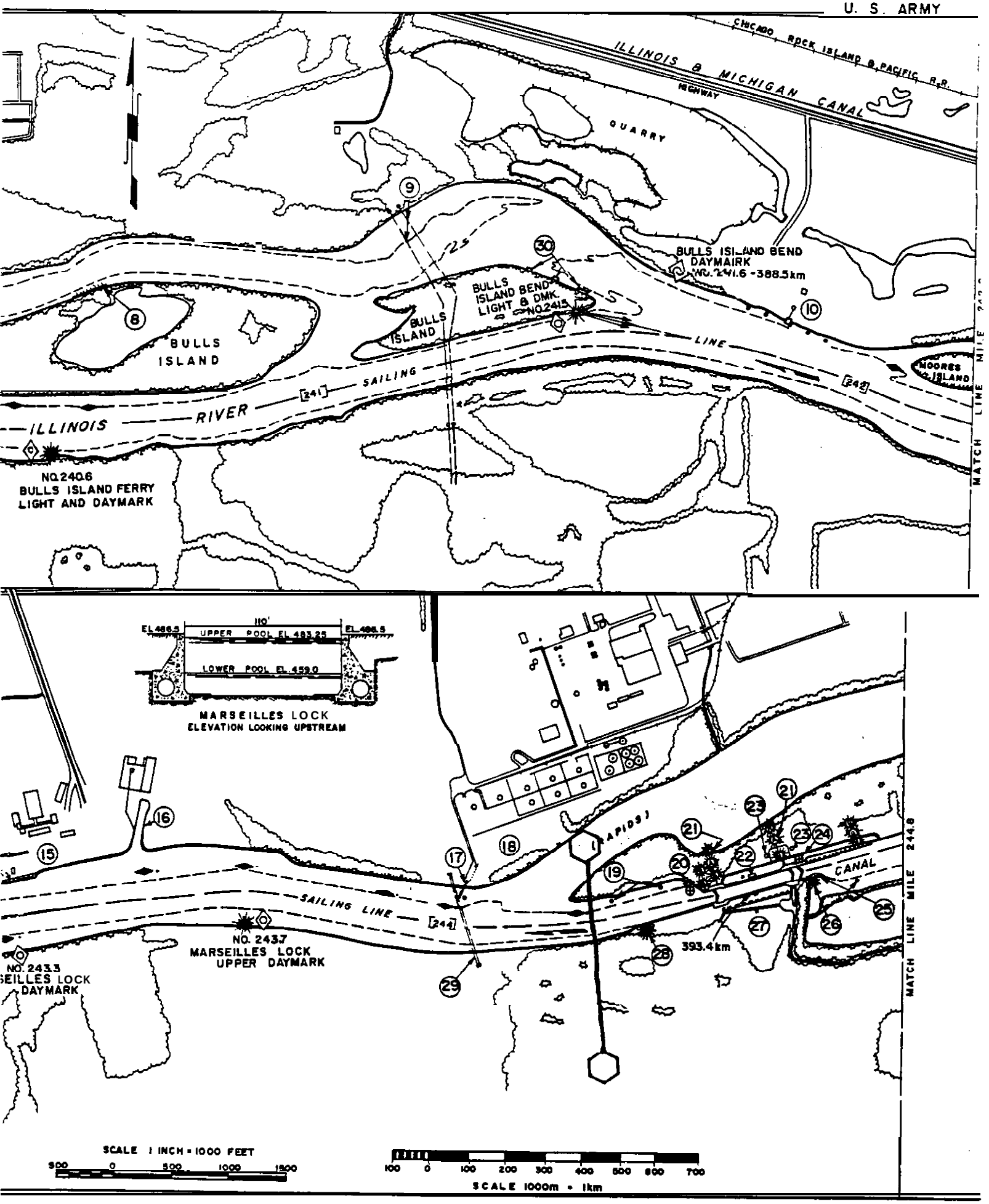
Approved by:
CHIEF ENGINEERING DIVISION

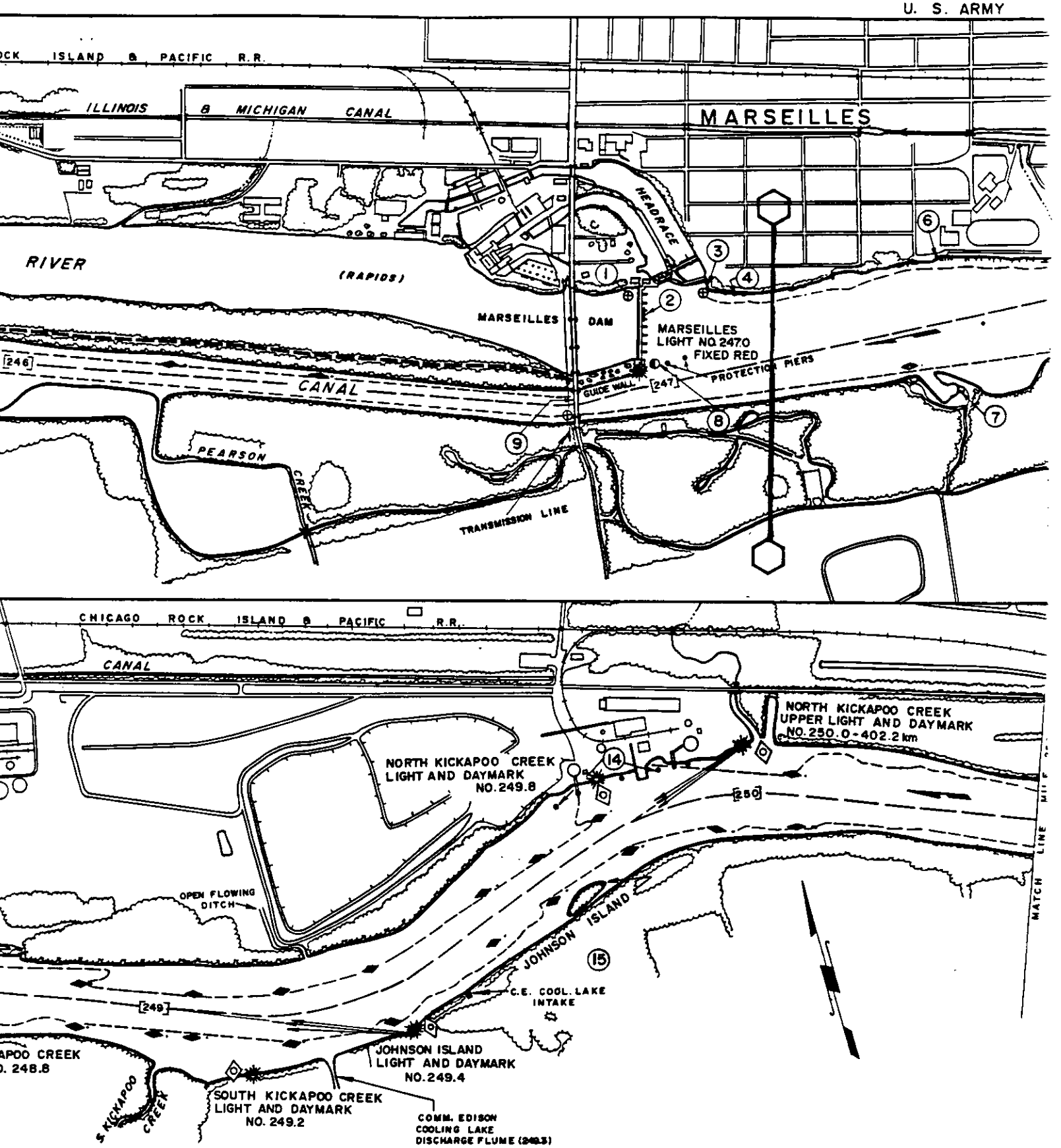
Scale:

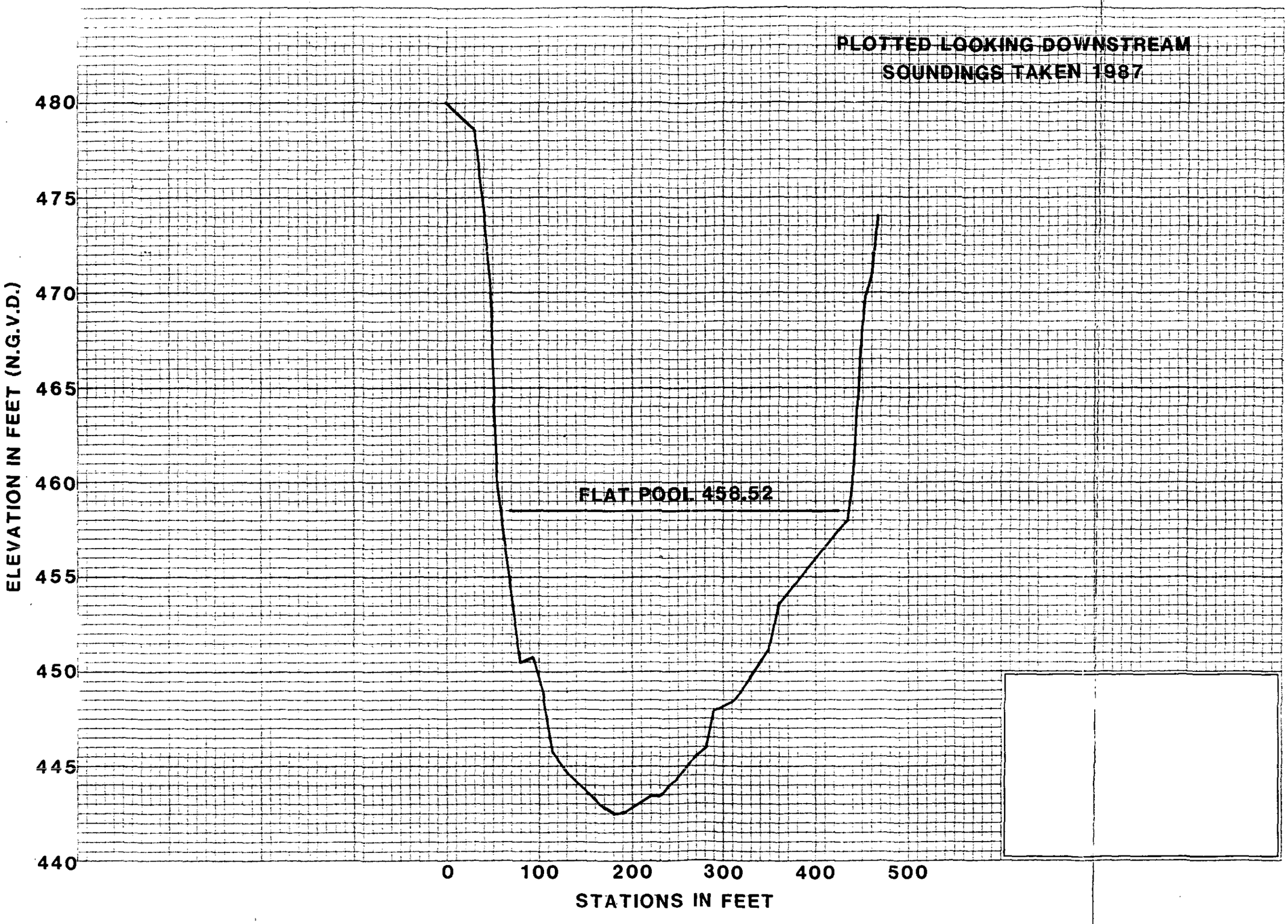
Date:

Drawing number:

Sheet _ _ of _


CHICAGO ROCK ISLAND & PACIFIC R.R.
ILLINOIS & MICHIGAN CANAL
HIGHWAY
QUARRY
BULLS ISLAND BEND DAYMAIRK NO. 241.6 - 388.5km
BULLS ISLAND BEND LIGHT & DMK. NO. 241.5
BULLS ISLAND
BULLS ISLAND
SAILING LINE
[241]
[242]
ILLINOIS RIVER
MOORES ISLAND
NO. 240.6 BULLS ISLAND FERRY LIGHT AND DAYMARK
MATCH LINE MILE 242.6
110'
EL. 486.5
UPPER POOL EL. 483.25
EL. 486.5
LOWER POOL EL. 459.0
MARSEILLES LOCK
ELEVATION LOOKING UPSTREAM
(RAPIDS)
CANAL
SAILING LINE
[244]
NO. 243.7 MARSEILLES LOCK UPPER DAYMARK
NO. 243.3 MARSEILLES LOCK DAYMARK
393.4km
MATCH LINE MILE 244.6
SCALE 1 INCH = 1000 FEET
500 0 500 1000 1500
100 0 100 200 300 400 500 600 700
SCALE 1000m = 1km


ROCK ISLAND & PACIFIC R.R.
ILLINOIS & MICHIGAN CANAL
MARSEILLES
HEADRACE
RIVER
(RAPIDS)
MARSEILLES DAM
MARSEILLES LIGHT NO. 247.0 FIXED RED
PROTECTION PIERS
GUIDE WALL
[246]
[247]
CANAL
PEARSON CREEK
TRANSMISSION LINE
CHICAGO ROCK ISLAND & PACIFIC R.R.
CANAL
NORTH KICKAPOO CREEK UPPER LIGHT AND DAYMARK NO. 250.0 - 402.2 km
NORTH KICKAPOO CREEK LIGHT AND DAYMARK NO. 249.8
[250]
MATCH LINE
OPEN FLOWING DITCH
JOHNSON ISLAND
C.E. COOL. LAKE INTAKE
[249]
JOHNSON ISLAND LIGHT AND DAYMARK NO. 249.4
SOUTH KICKAPOO CREEK LIGHT AND DAYMARK NO. 249.2
S. KICKAPOO CREEK
COMM. EDISON COOLING LAKE DISCHARGE FLUME (249.3)
SCALE 1 INCH = 1000 FEET
500 0 500 1000 1500

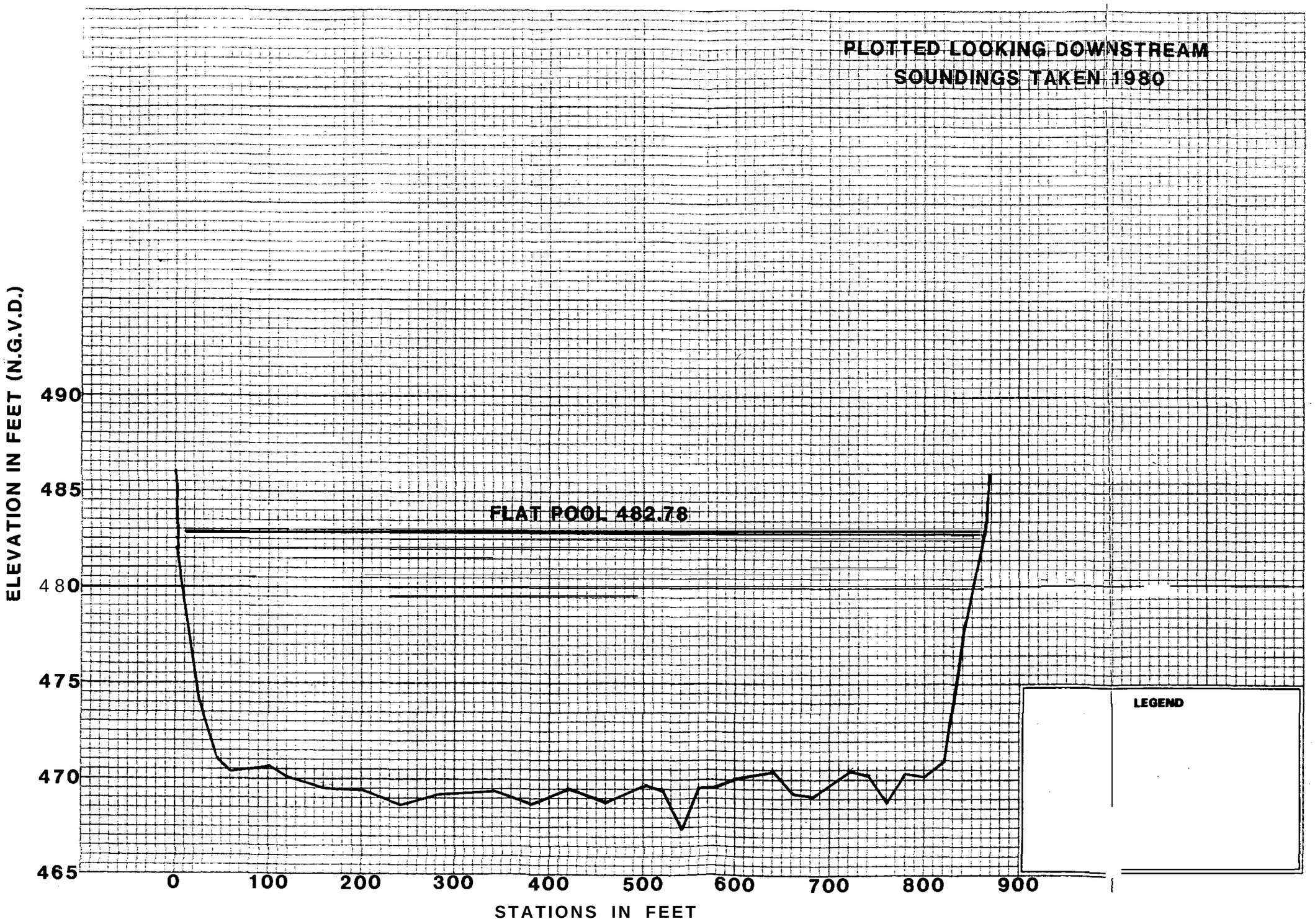


CHANNEL SECTION RIVER MILE 244.29

ILLINOIS RIVER

MARSEILLES TAIL

PLATE D-86

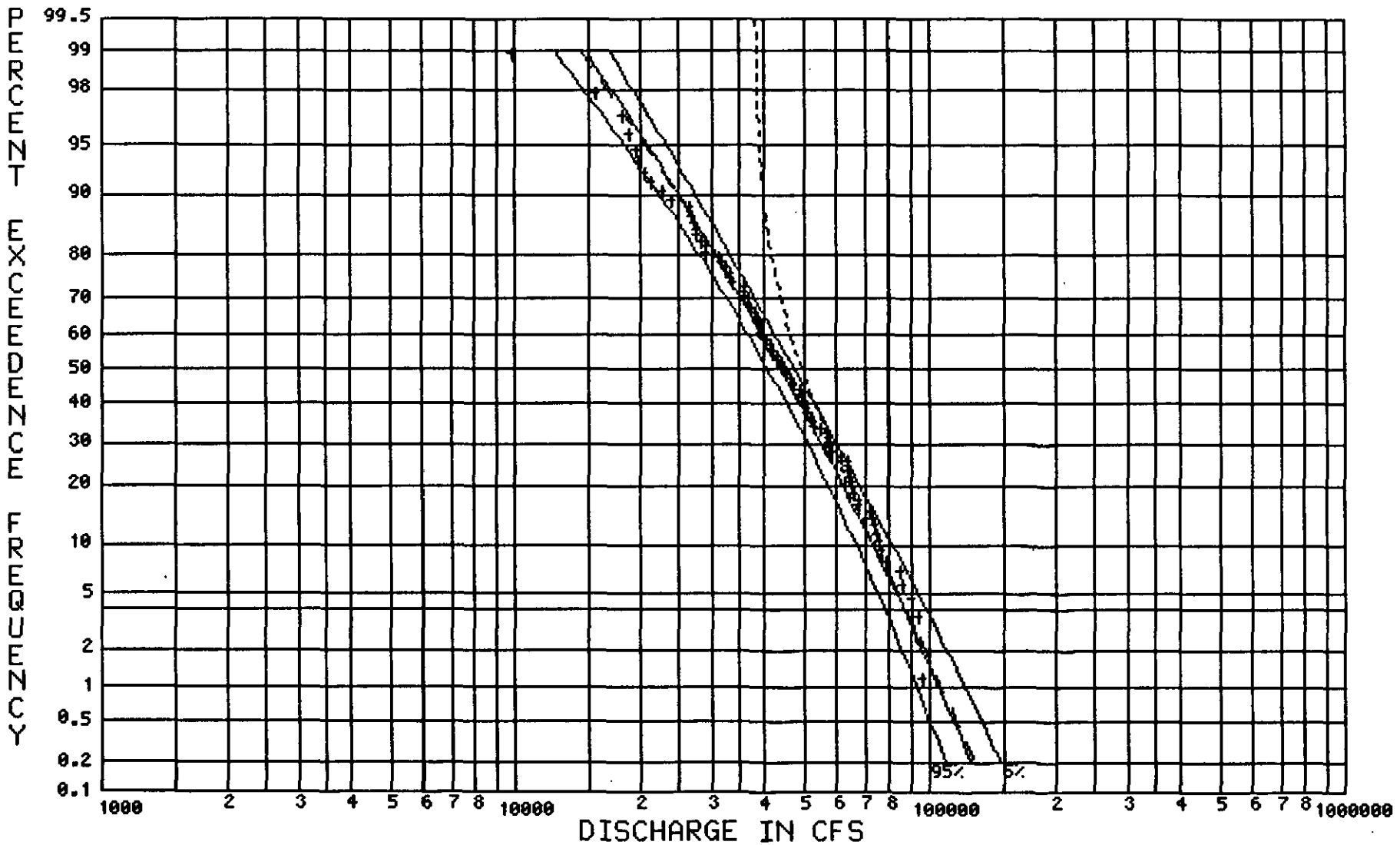


CHANNEL SECTION R VER MILE 247.20

ILLINOIS RIVER

MARSEILLES POOL

FREQUENCY ANALYSIS
05543500 -- MARSEILLES



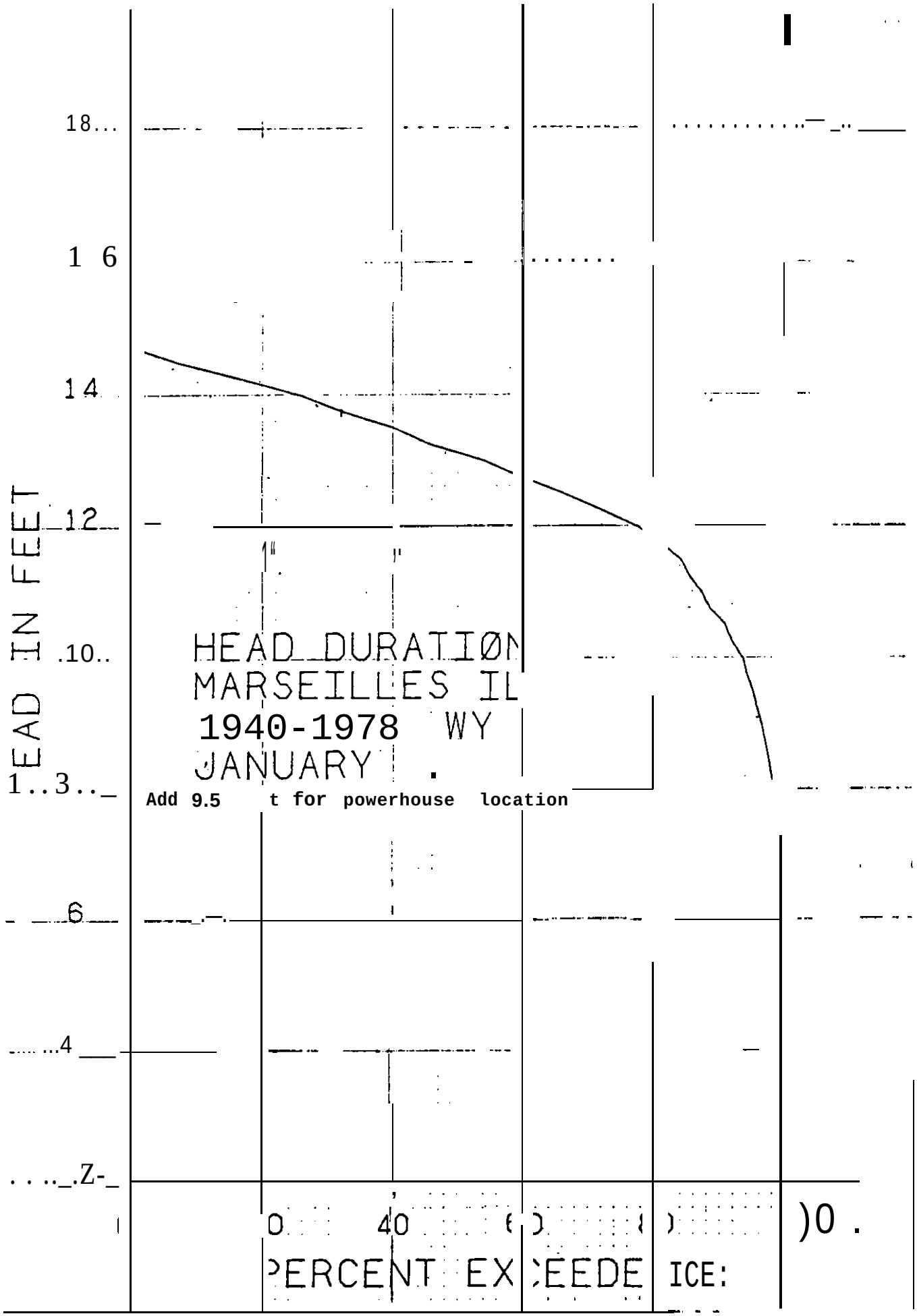
LEGEND

——————— W/O EXP PROB

— — — — WITH EXP PROB

--------- LANGBEIN P.D.

MEAN LOGARITHM	4.6366	*	HISTORIC EVENTS	0
STANDARD DEVIATION	0.1827	*	HIGH OUTLIERS	0
COMPUTED SKEW	-0.2479	*	LOW OUTLIERS	1
GENERALIZED SKEW	-0.4000	*	ZERO OR MISSING	0
ADOPTED SKEW	-0.3000	*	SYSTEMATIC EVENTS	89


18
1 6
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12
.10
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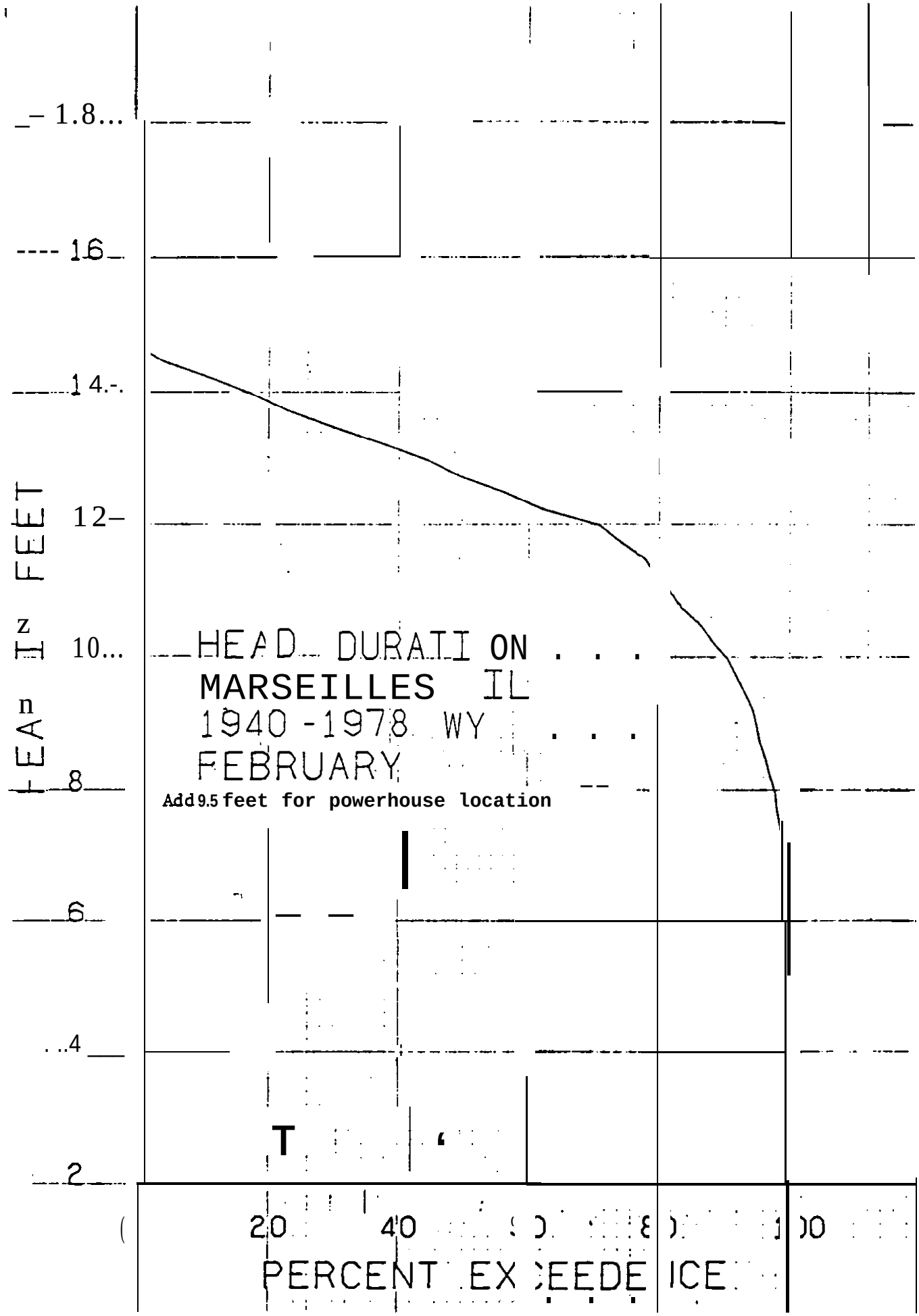
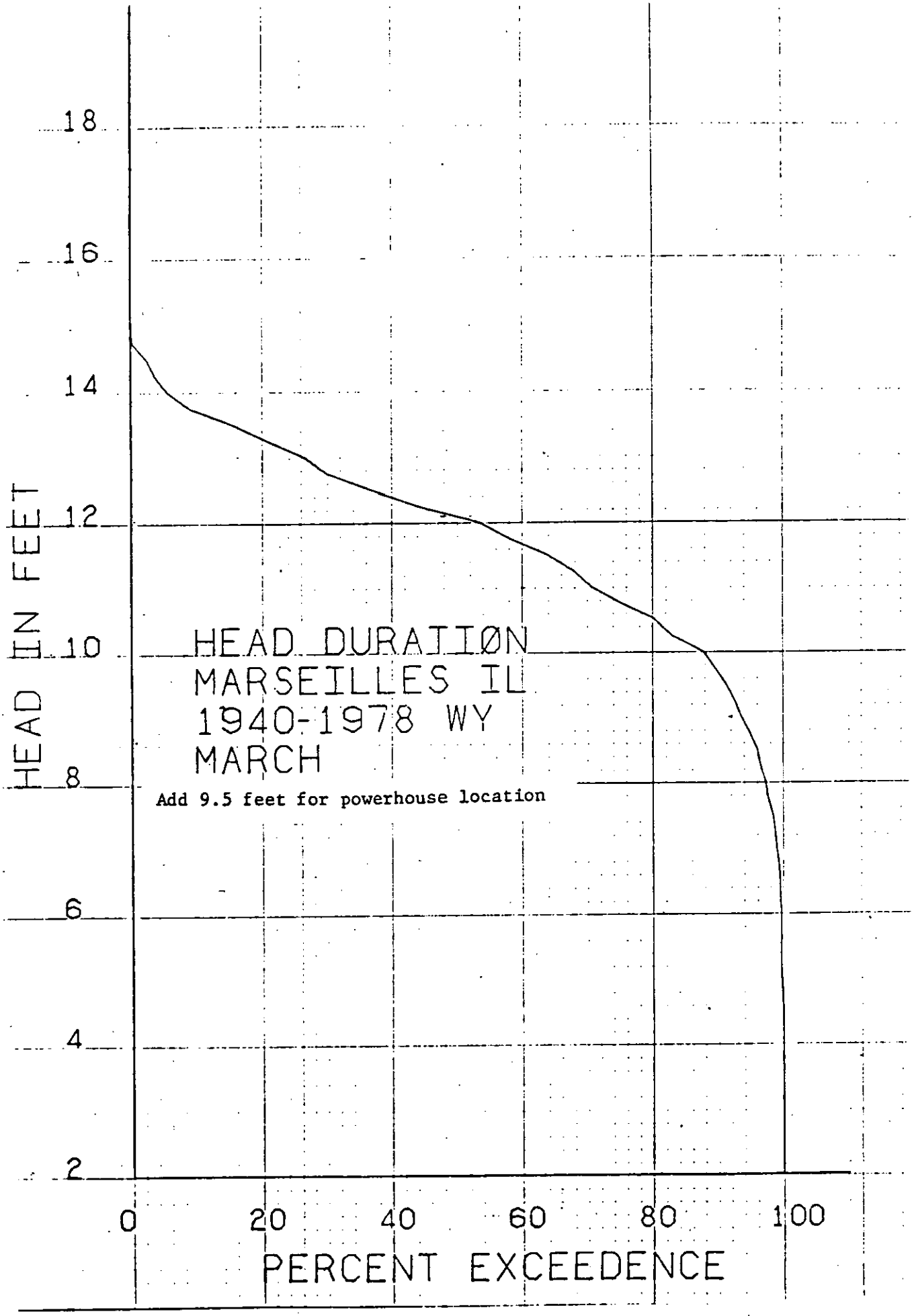
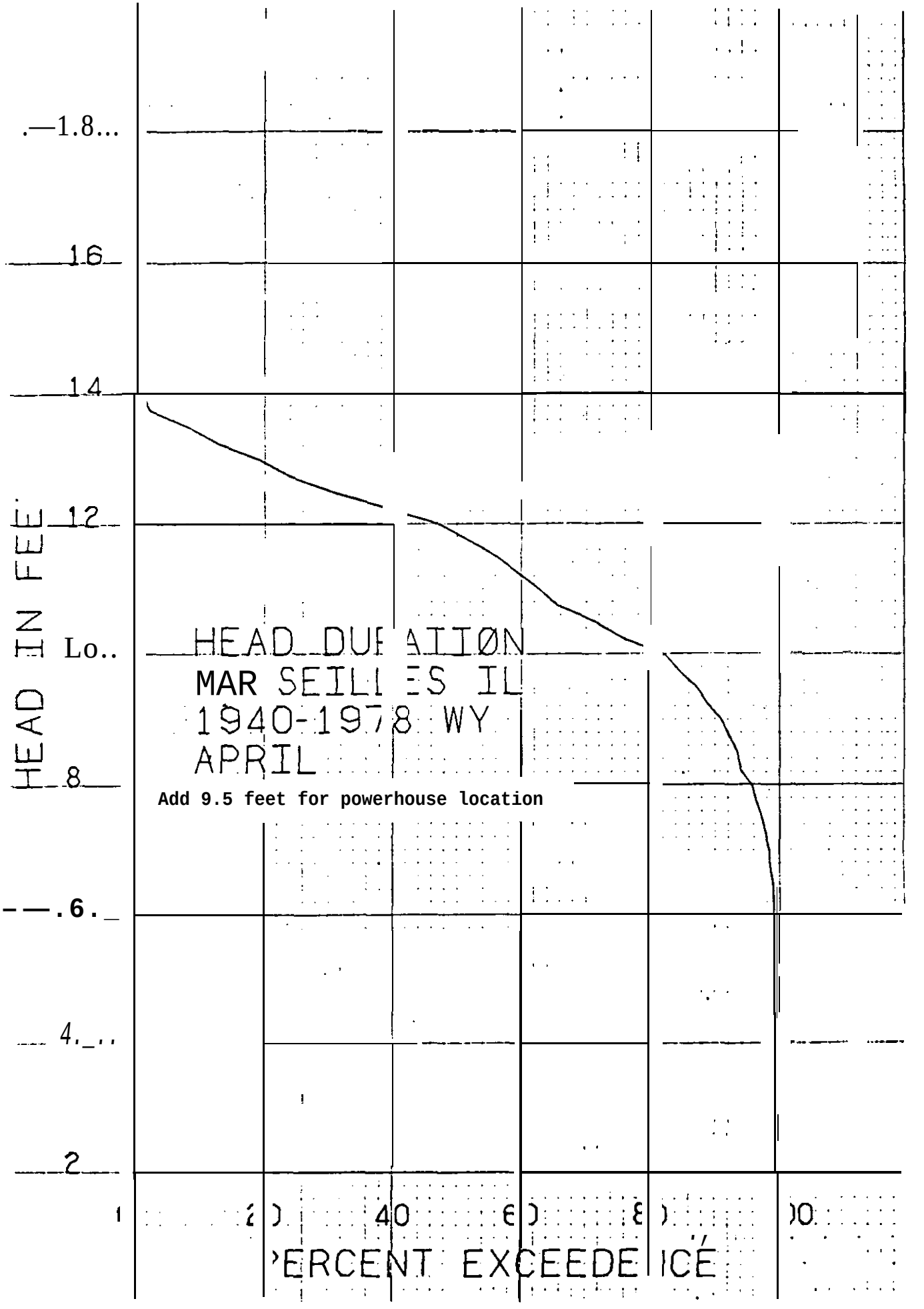
Z-
EAD IN FEET
HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
JANUARY
Add 9.5 t for powerhouse location
0
40
)0
PERCENT EXCEEDE ICE:


1.8
16
14
12
10
8
6
4
2
HEAD IN FEET
HEAD DURATION
MARSEILLES IL
1940-1978 WY
FEBRUARY
Add 9.5 feet for powerhouse location
20
40
100
PERCENT EXCEEDENCE


HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
MARCH
Add 9.5 feet for powerhouse location
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DUR ATIØN
MAR SEILI ES IL
1940-1978 WY
APRIL
Add 9.5 feet for powerhouse location
HEAD IN FEE
1.8
16
14
12
Lo..
8
.6
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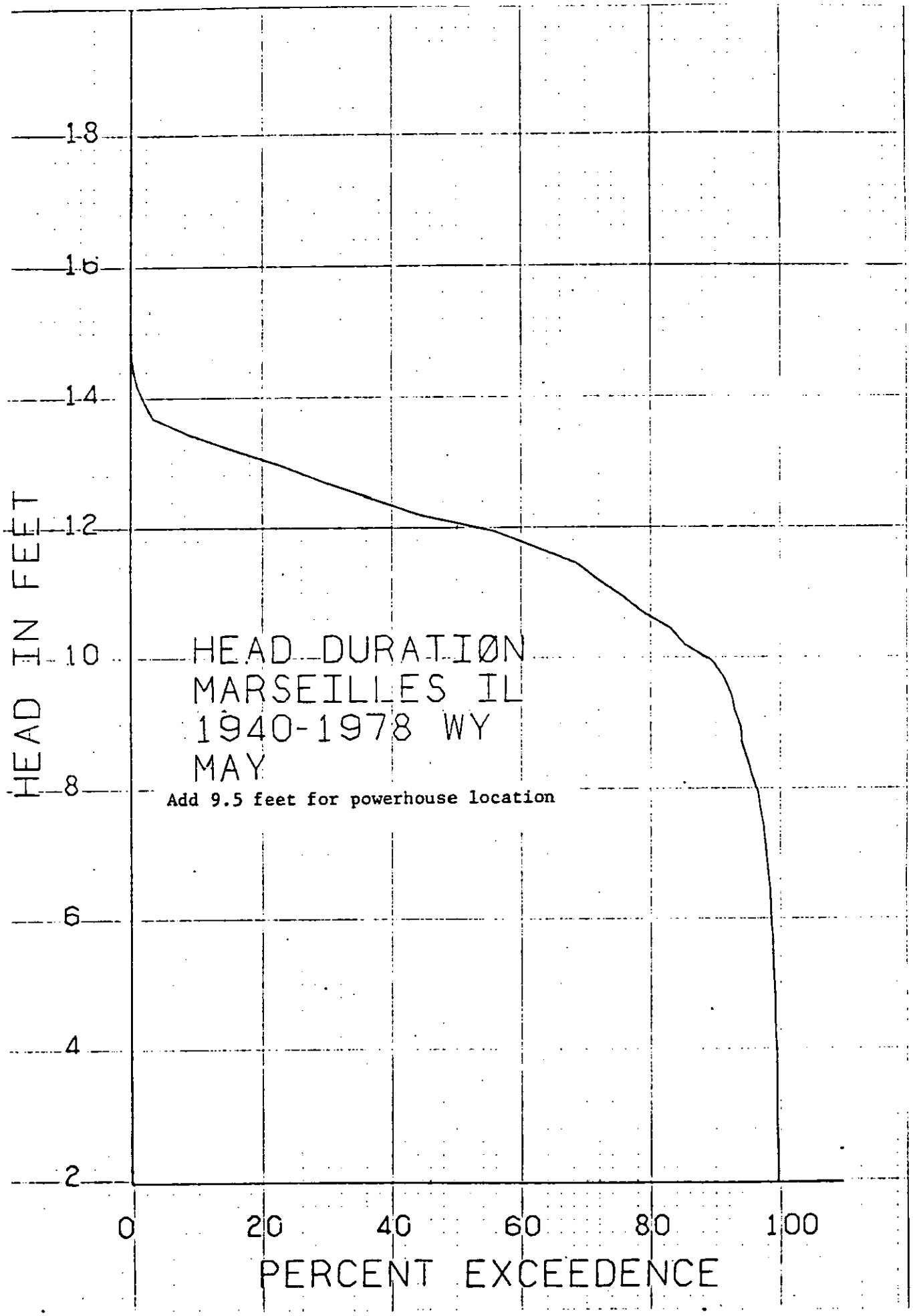
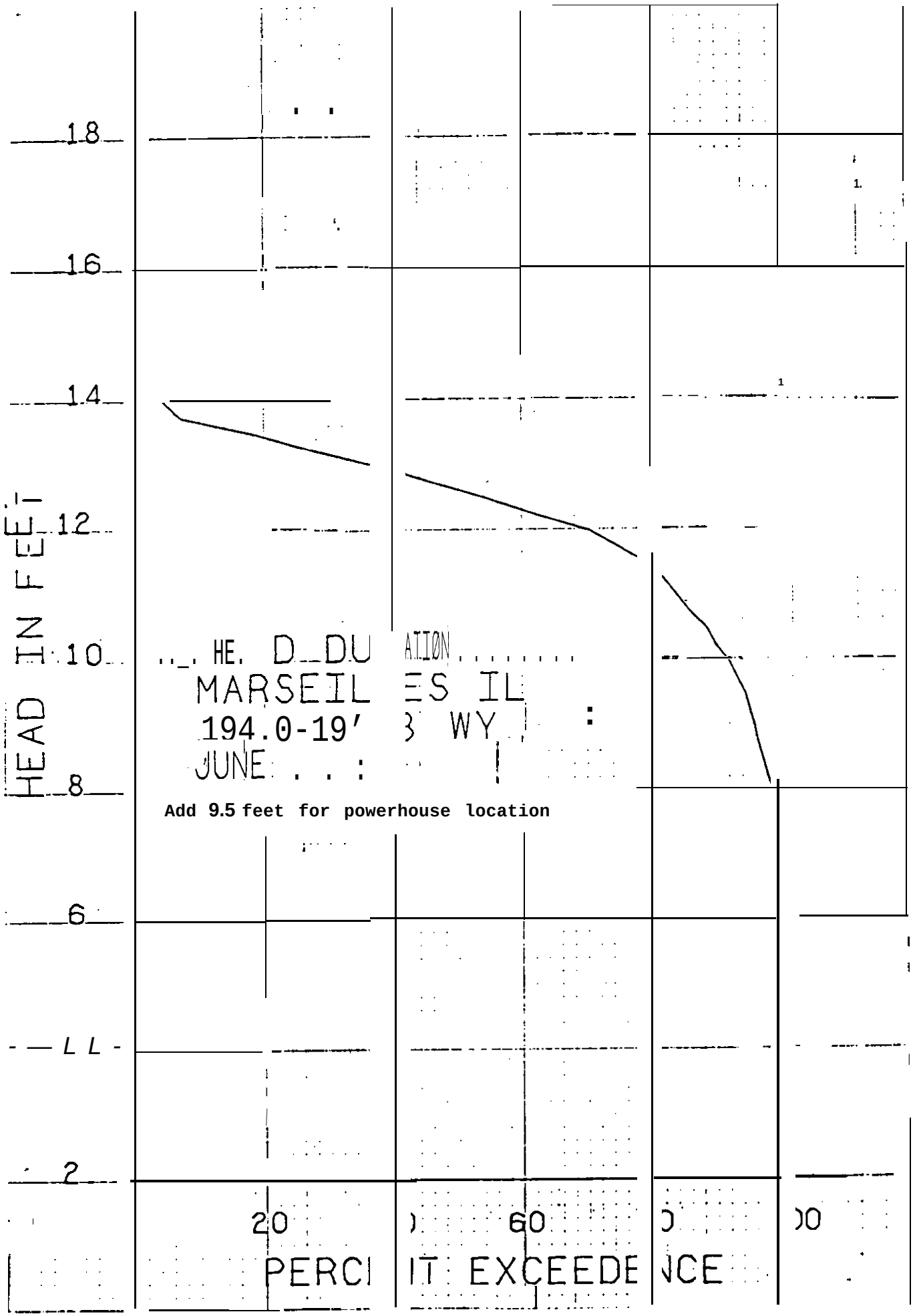
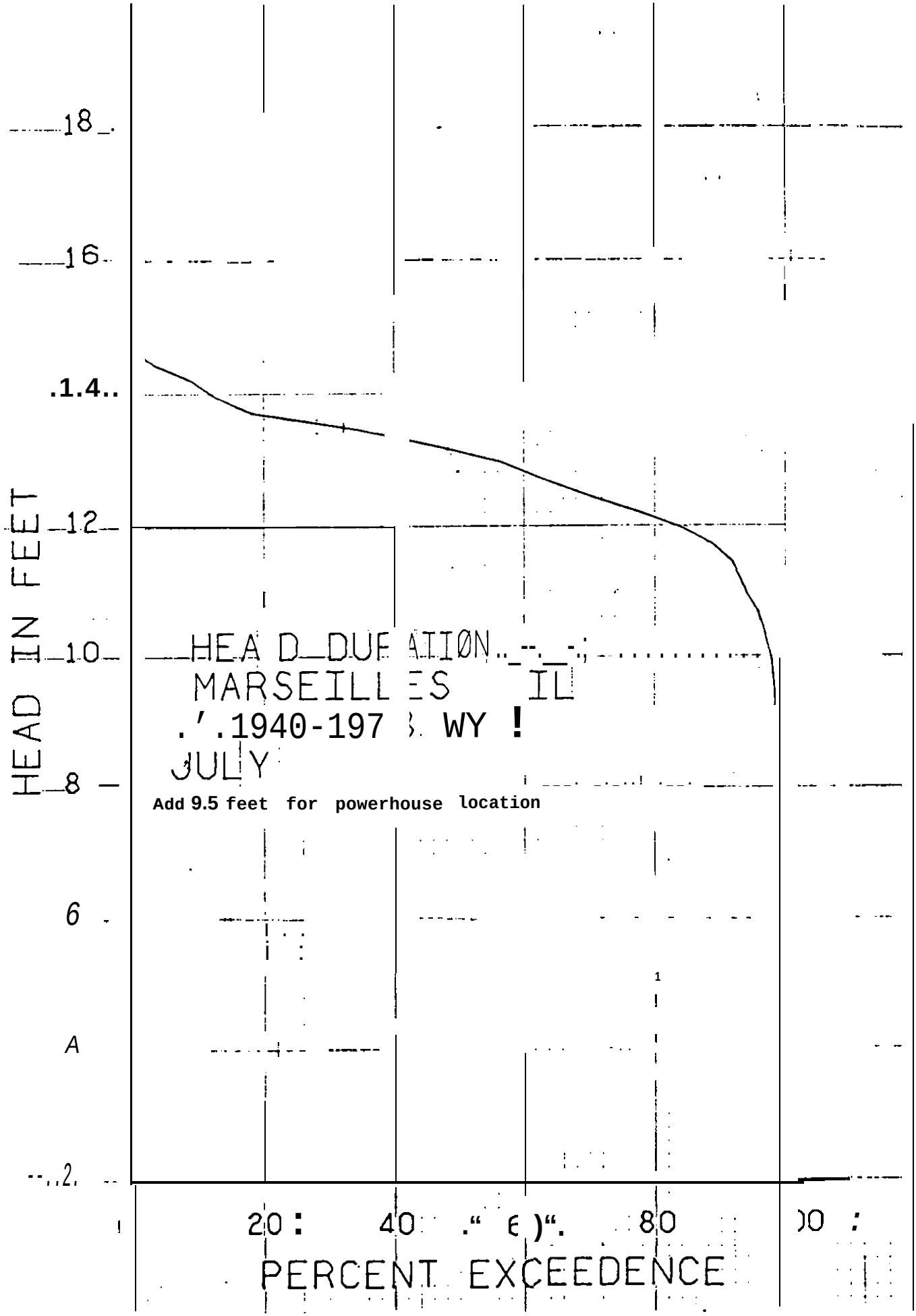
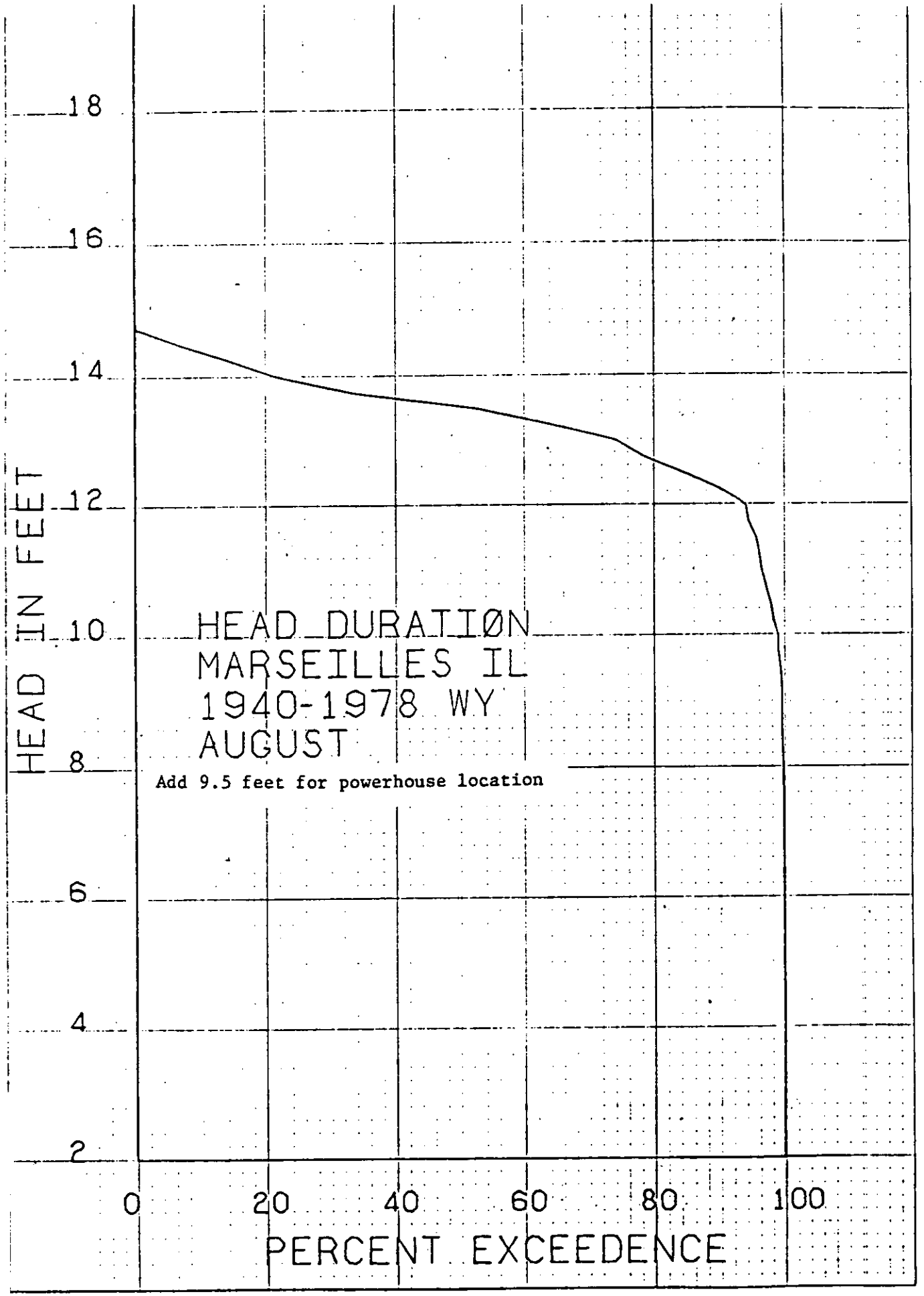
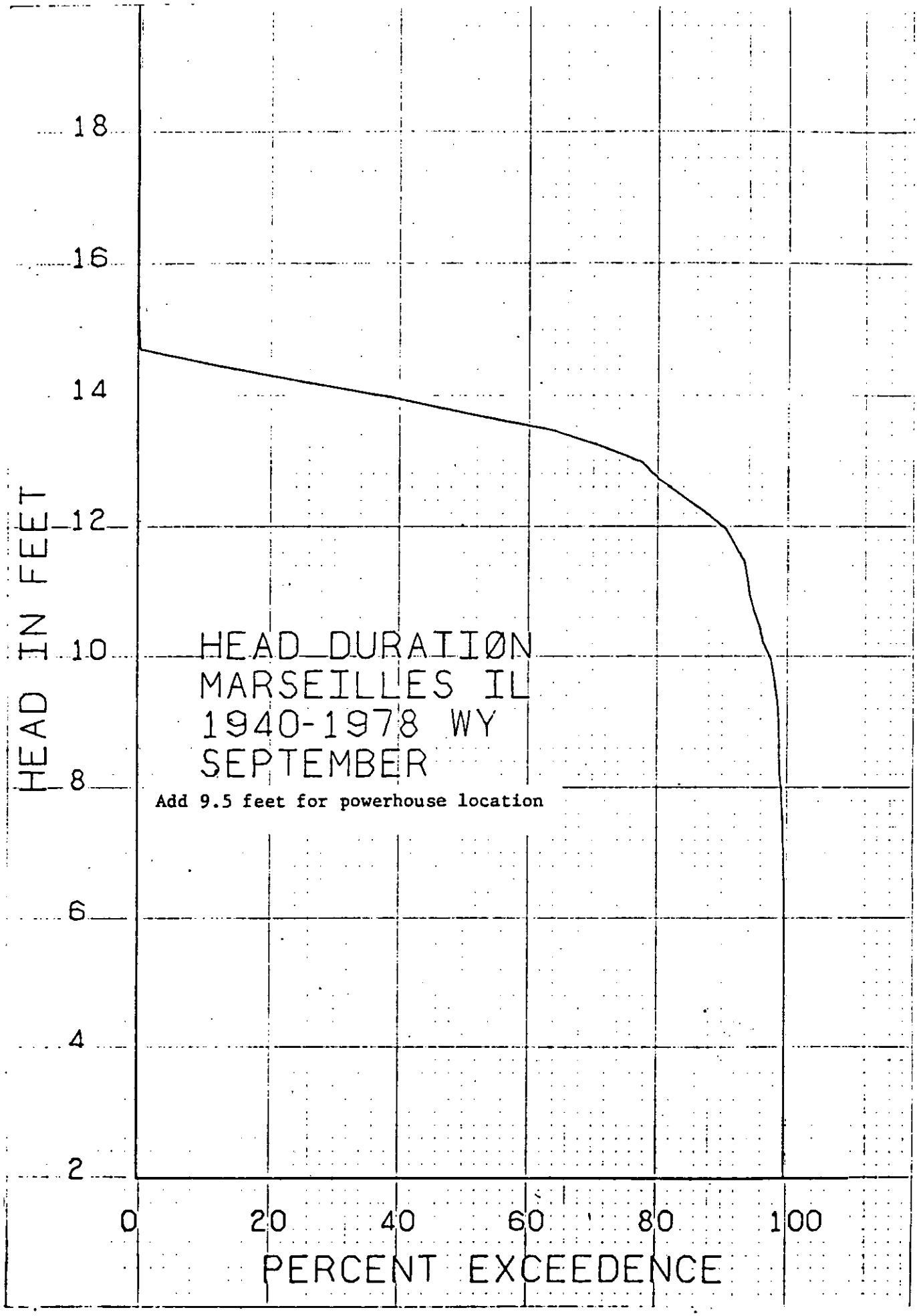
2
40
ERCENT EXCEEDE ICE

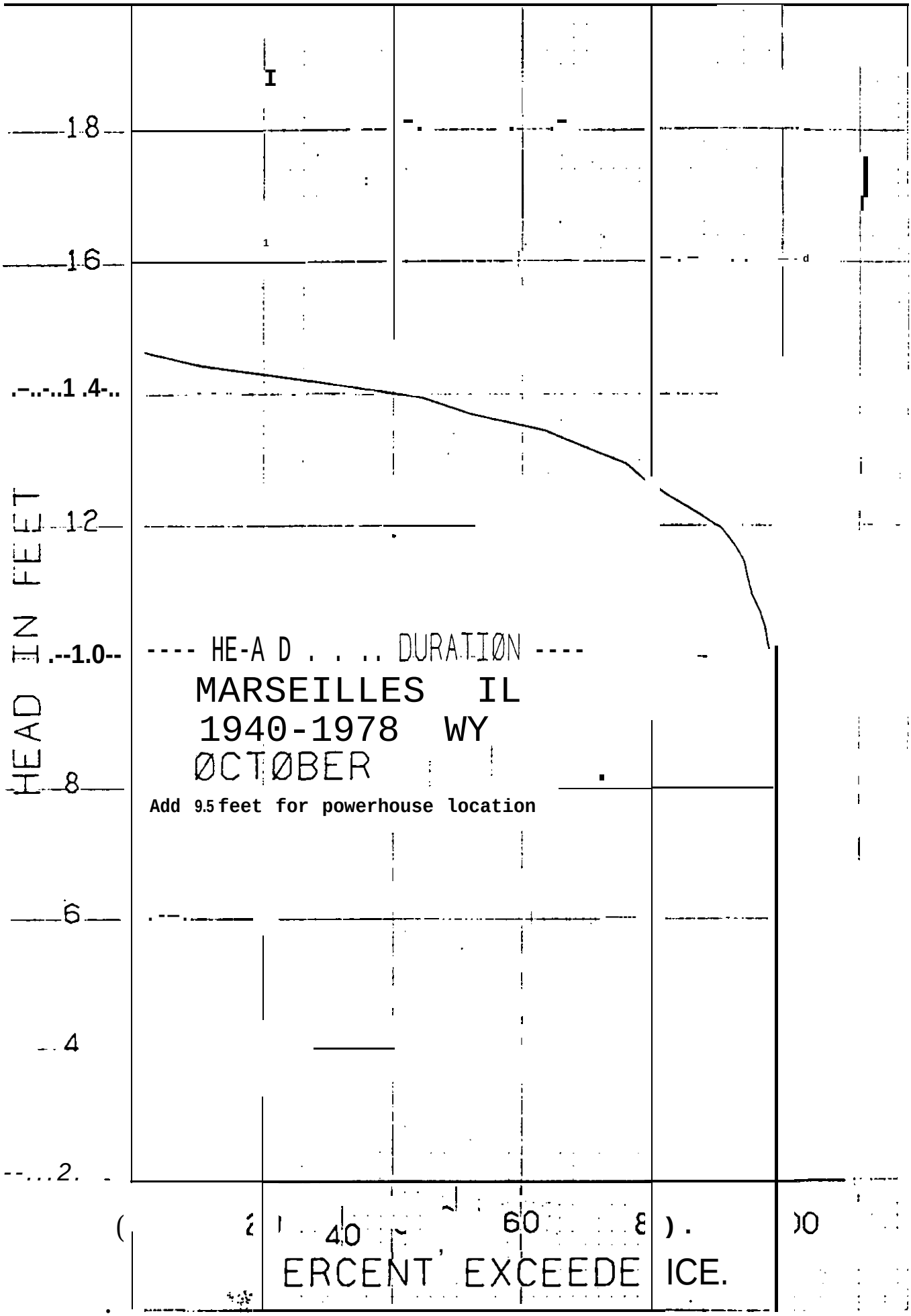

HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
MAY
Add 9.5 feet for powerhouse location
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

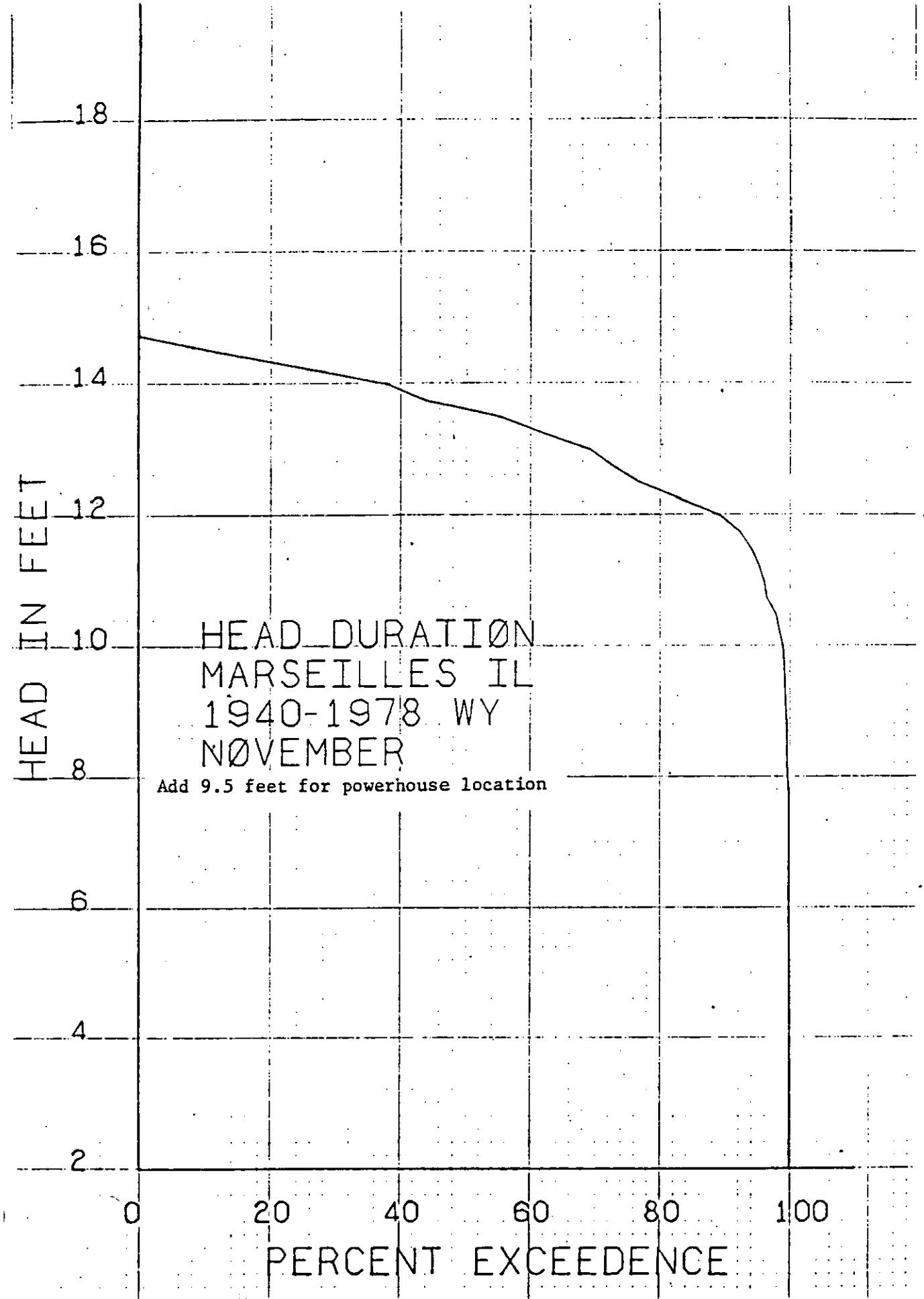

18
16
14
12
10
8
6
2
HEAD IN FEET
20
60
PERCENT EXCEEDENCE
HE. D DU ATION
MARSEILLES IL
194.0-19' 3 WY
JUNE
Add 9.5 feet for powerhouse location

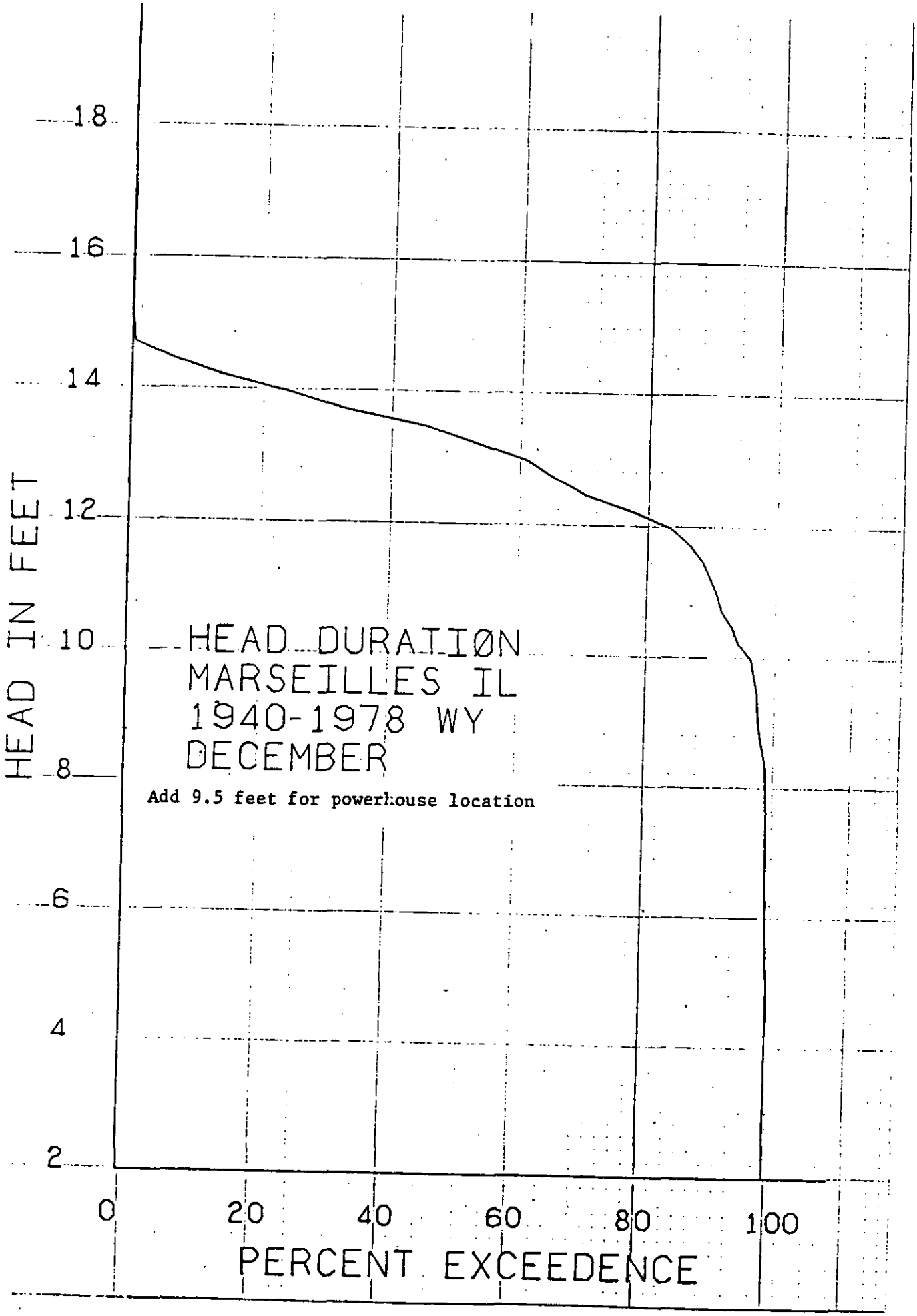

18
16
1.4
12
10
8
6
A
2
HEAD IN FEET
HEAD DURATION
MARSEILLES IL
1940-1973 WY
JULY
Add 9.5 feet for powerhouse location
20
40
80
PERCENT EXCEEDENCE

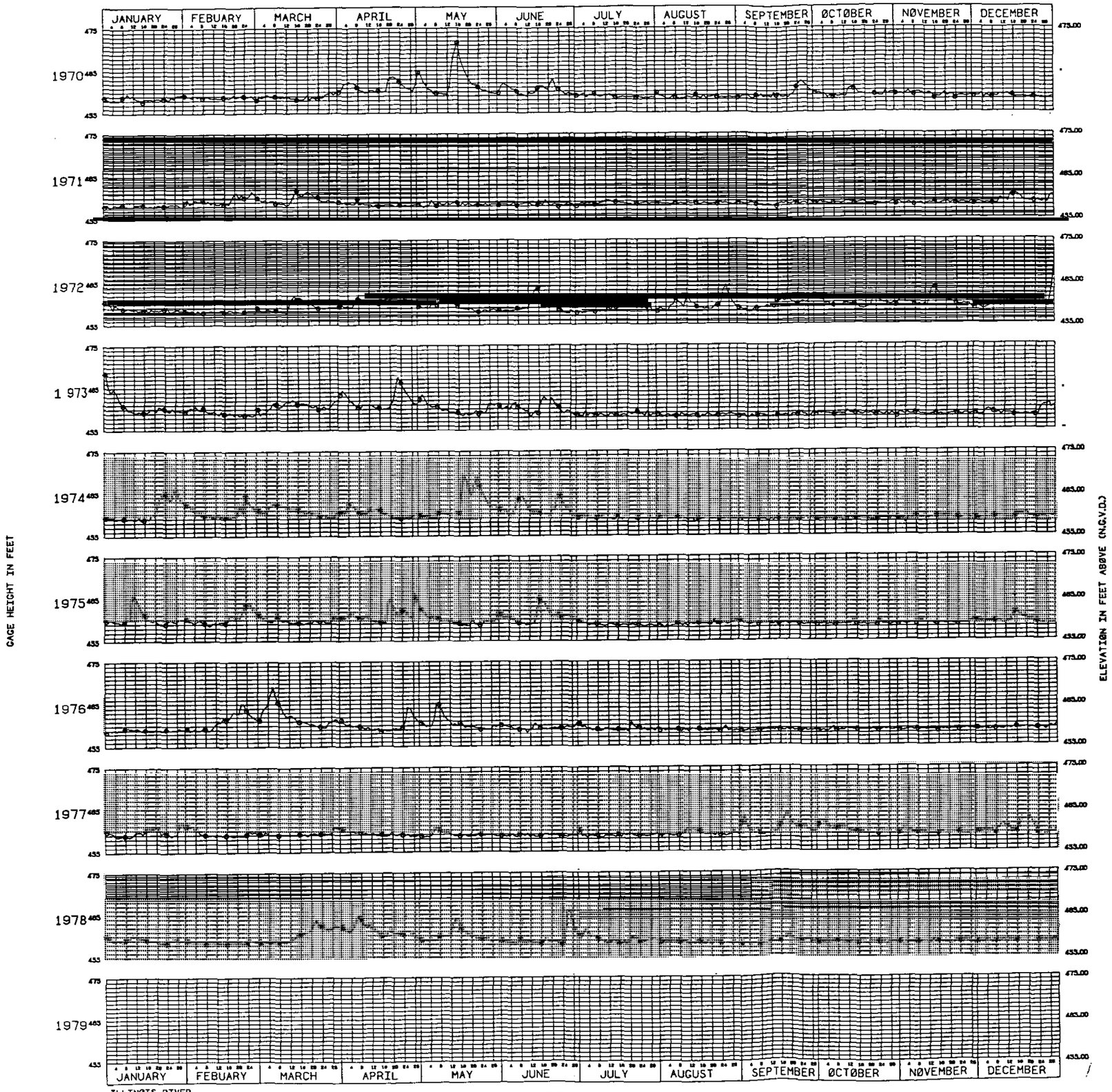

HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
AUGUST
Add 9.5 feet for powerhouse location
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
SEPTEMBER
Add 9.5 feet for powerhouse location
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
HEAD IN FEET
---- HE-A D . . . . DURATIØN ----
MARSEILLES IL
1940-1978 WY
ØCTØBER
Add 9.5 feet for powerhouse location
40
60
ERCENT EXCEEDE ICE.


HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
NØVEMBER
Add 9.5 feet for powerhouse location
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DURATIØN
MARSEILLES IL
1940-1978 WY
DECEMBER
Add 9.5 feet for powerhouse location
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE



NØTE-

HYDRØGRAPH
MARSEILLES LØCK LØWER PØØL

Symbol	Description of Revisions	Date	Approved

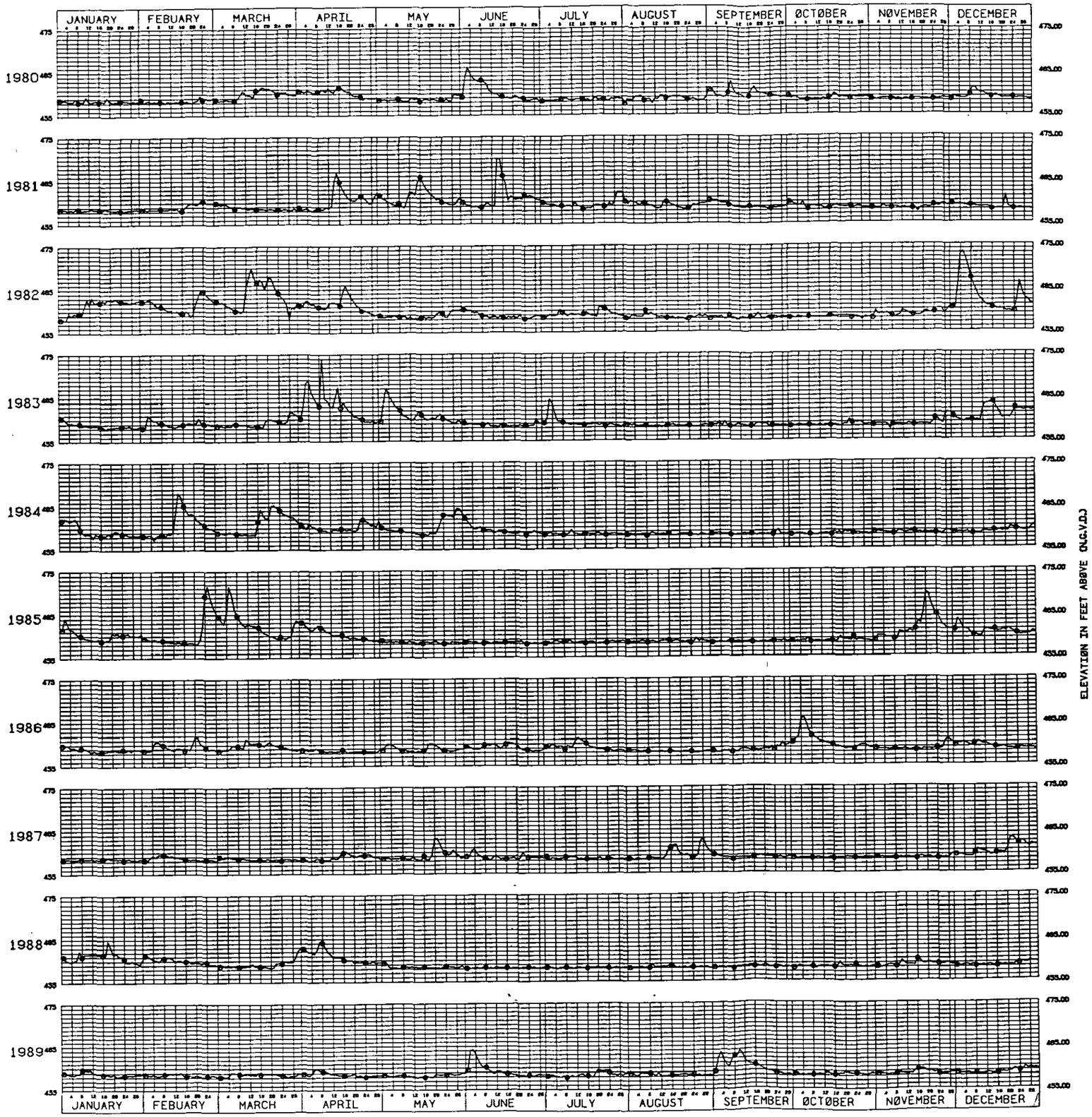
US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Submitted by:
CHIEF, DESIGN BRANCH
Approved by:

PLATE D-101

Scale:
Date:
Drawing
Sheet of



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
MARSEILLES LØCK LØWER PØØL

Symbol	Description of Revisions	Date	Approved

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

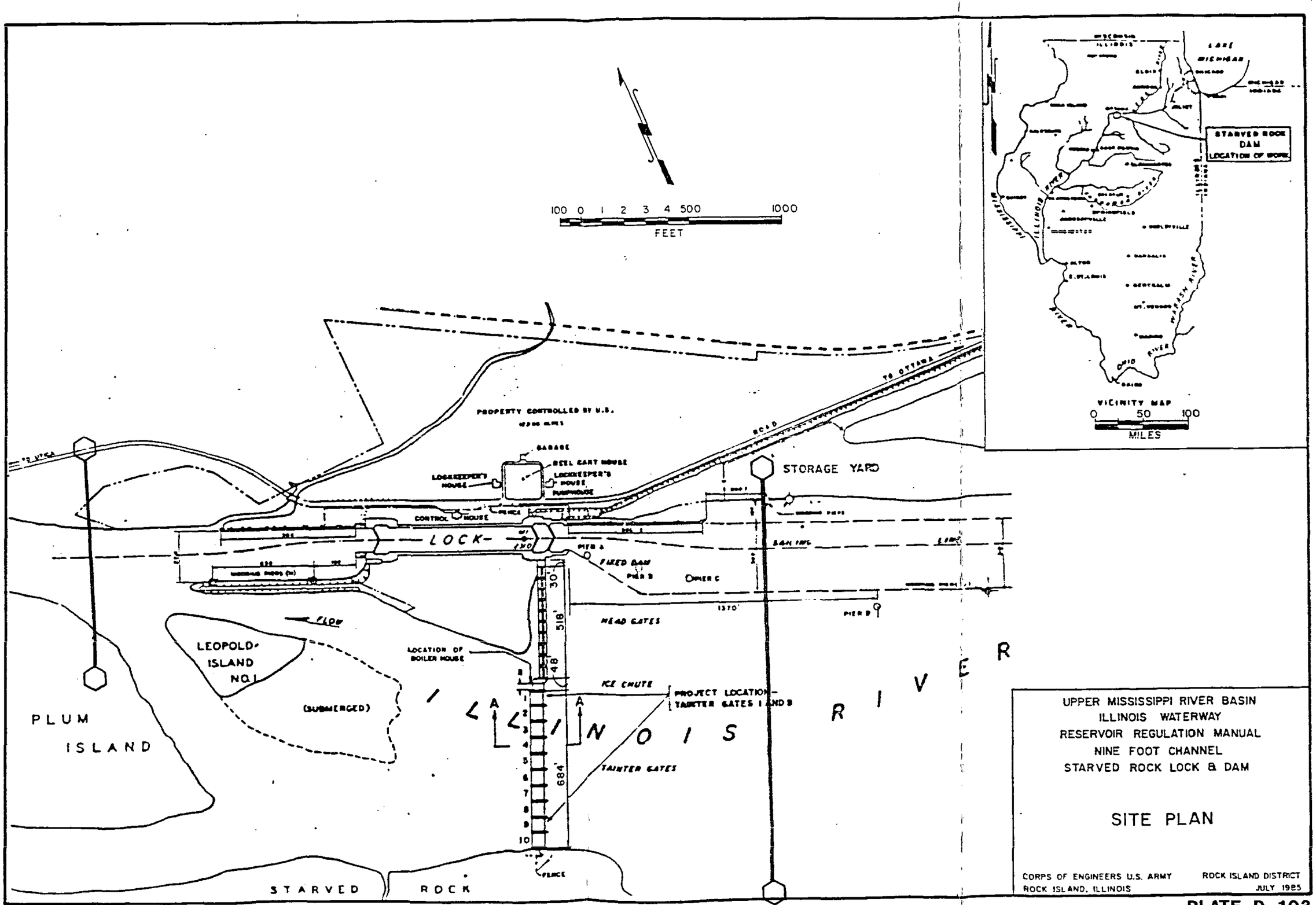
US Army Corps of Engineers

Designed by:
Drawn by:
Checked by:

PLATE D-102

Submitted by:
CHIEF, DESIGN BRANCH
Approved by:
CHIEF, ENGINEERING DIVISION

Scale:
Date:
Drawing number:
Sheet _ _ of _



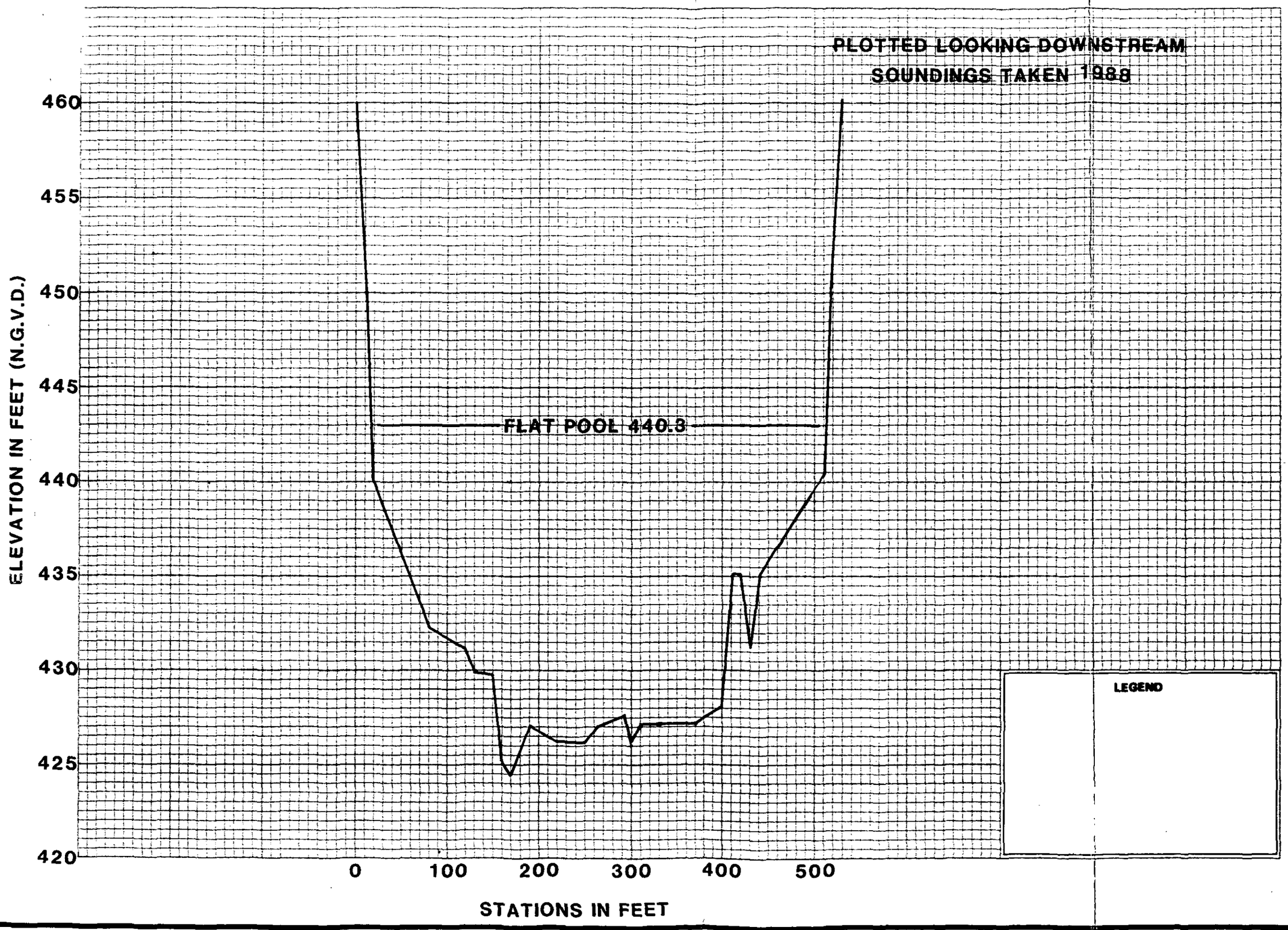
UPPER MISSISSIPPI RIVER BASIN
ILLINOIS WATERWAY
RESERVOIR REGULATION MANUAL
NINE FOOT CHANNEL
STARVED ROCK LOCK & DAM

SITE PLAN

CORPS OF ENGINEERS U.S. ARMY
ROCK ISLAND, ILLINOIS

ROCK ISLAND DISTRICT
JULY 1985

PLATE D-103

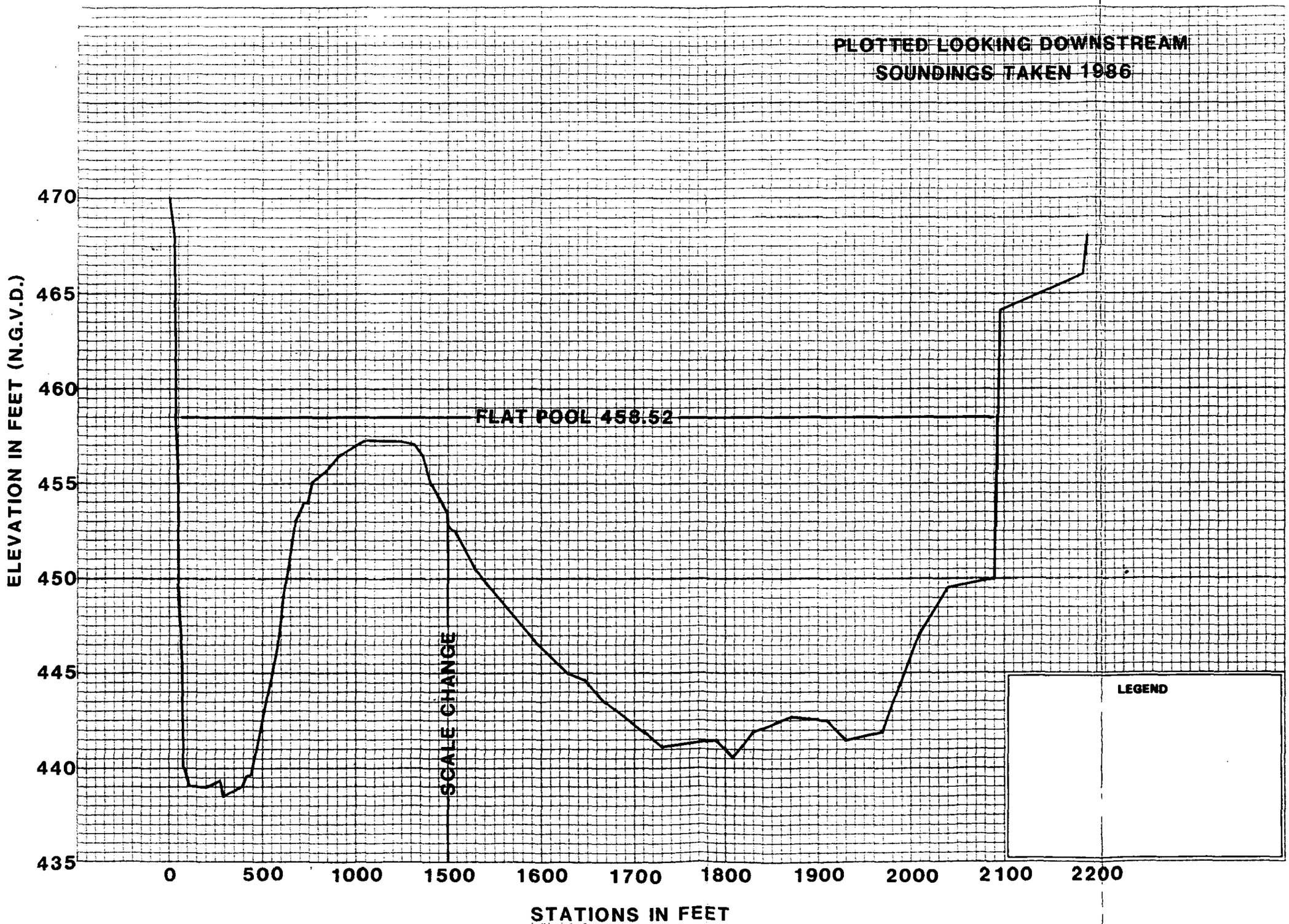


CHANNEL SECTION RIVER MILE 230.64

ILLINOIS RIVER

STARVED ROCK TAIL

PLATE D-104

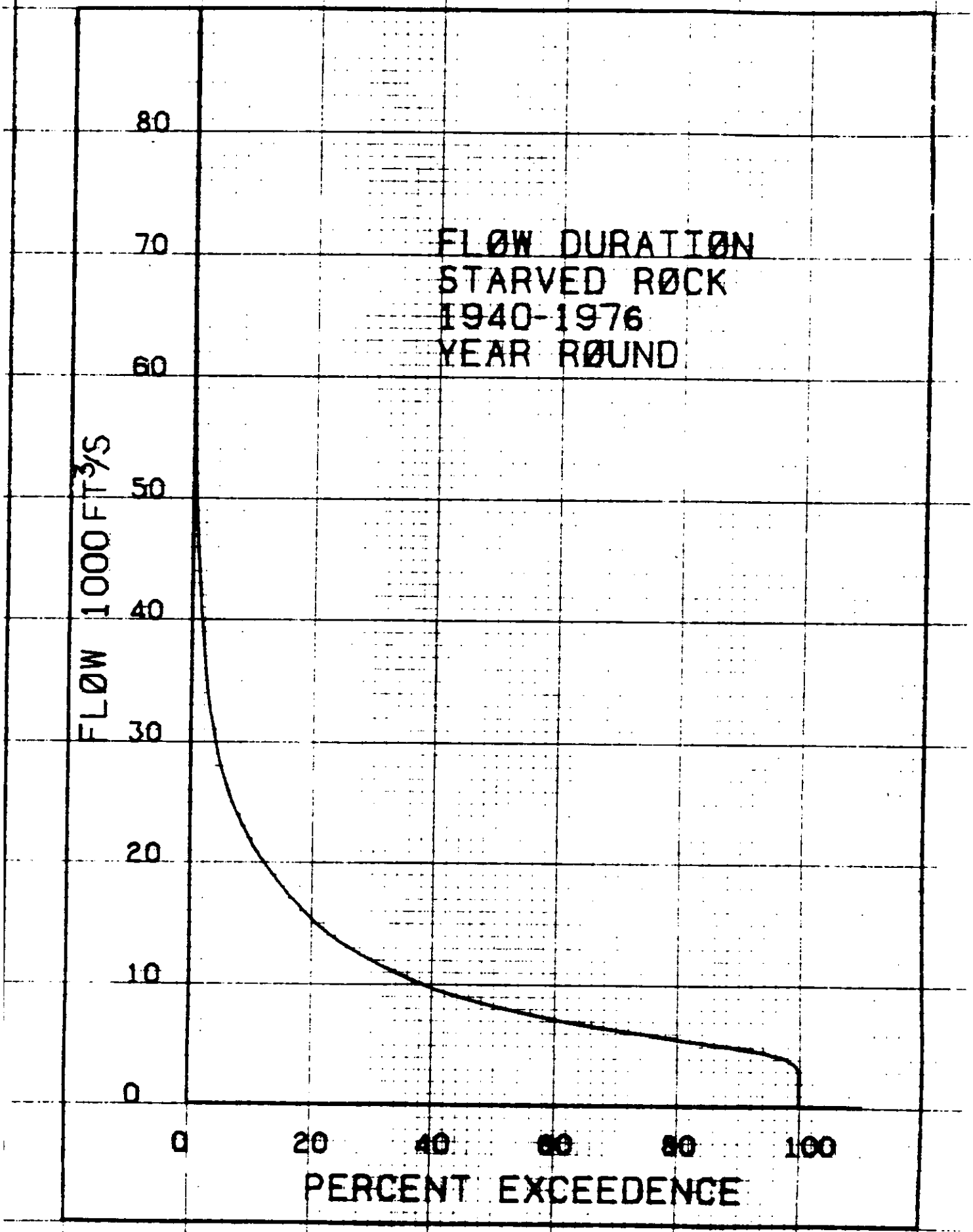


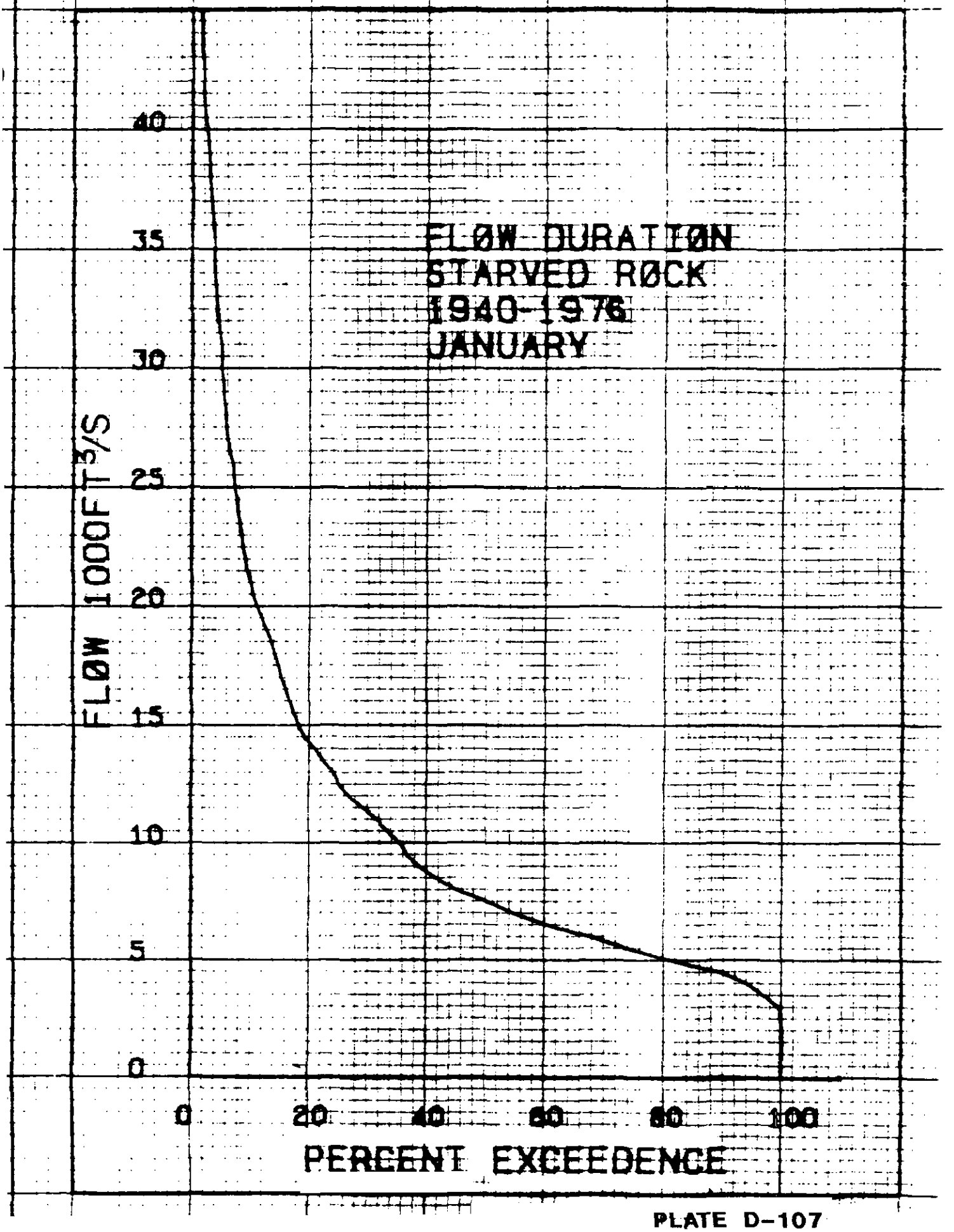
CHANNEL SECTION RIVER MILE 231.42

ILLINOIS RIVER

STARVED ROCK POOL

PLATE D-105


FLØW DURATIØN
STARVED RØCK
1940-1976
YEAR RØUND
FLØW 1000 FT³/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE


FLØW DURATIØN
STARVED RØCK
1940-1976
JANUARY
FLØW 1000FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

CORPS OF ENGINEERS U.S. ARMY

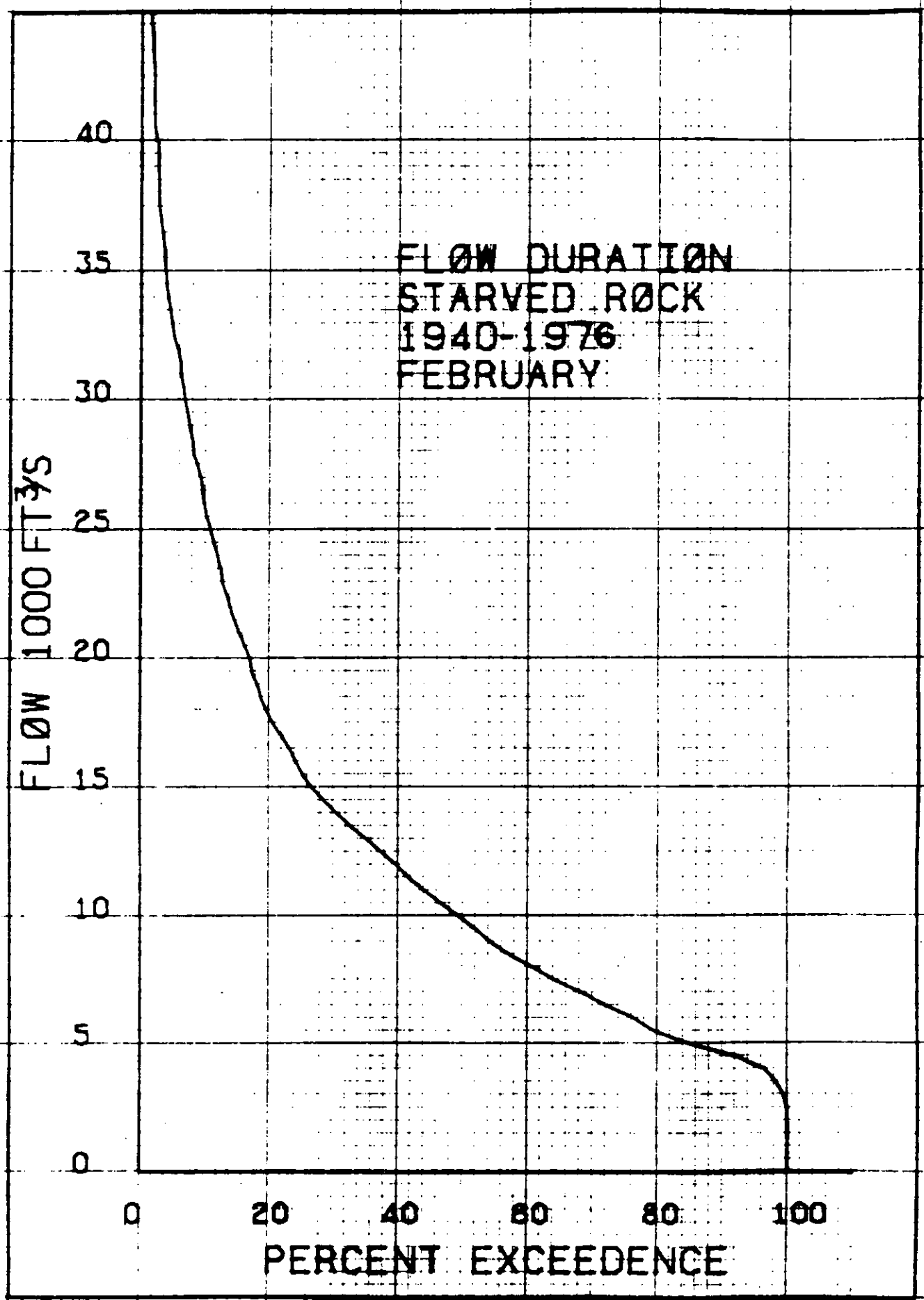
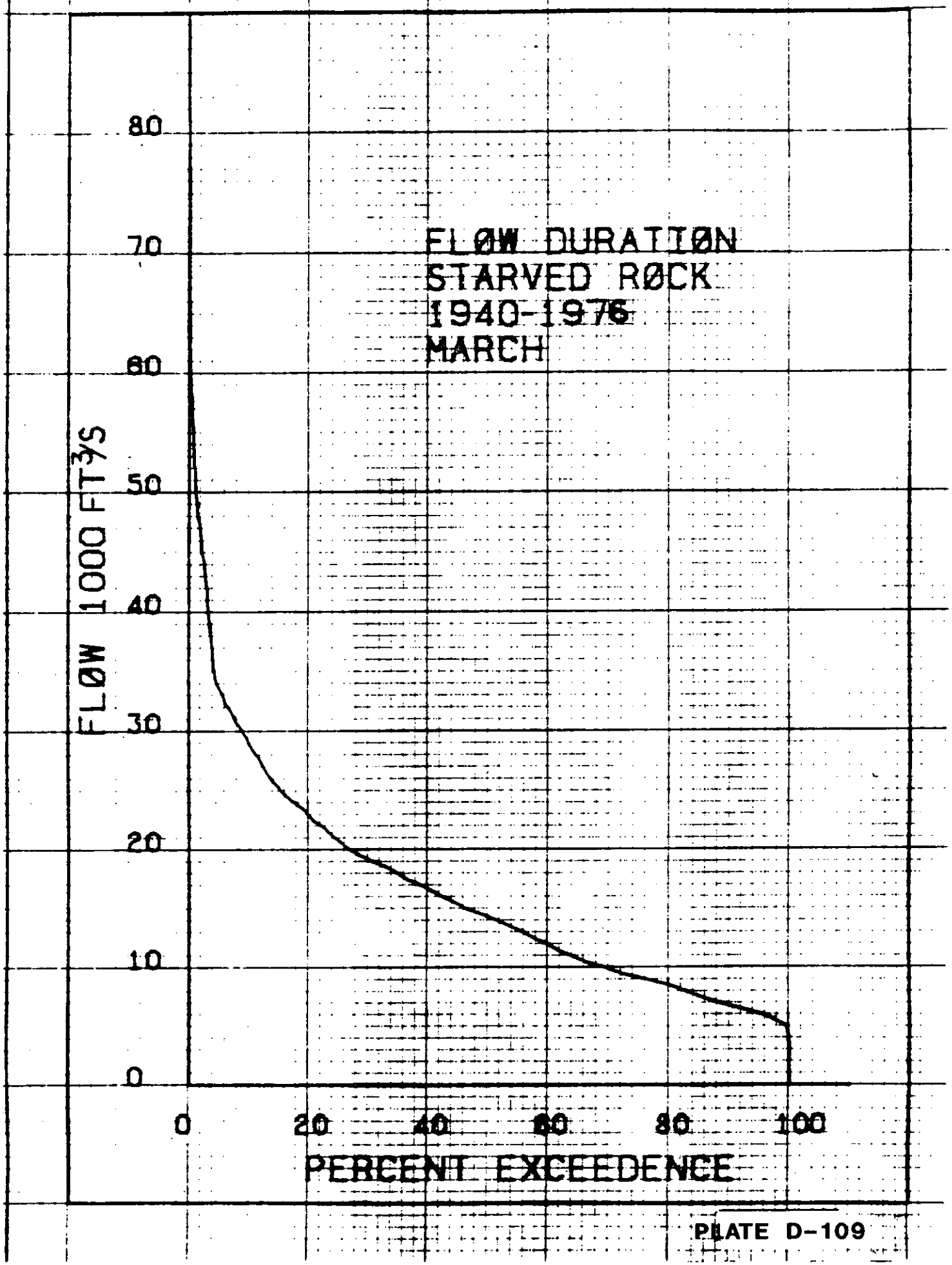
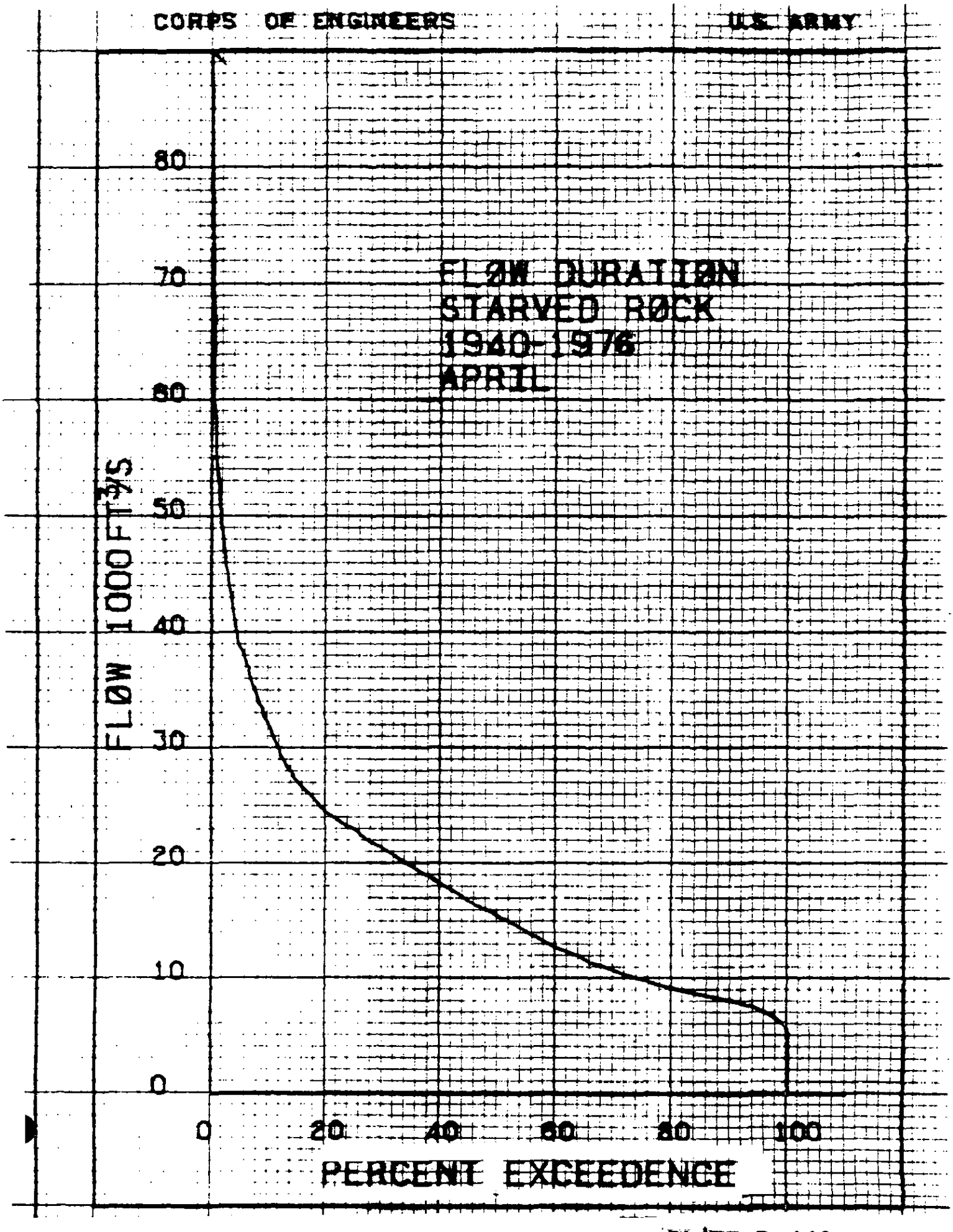
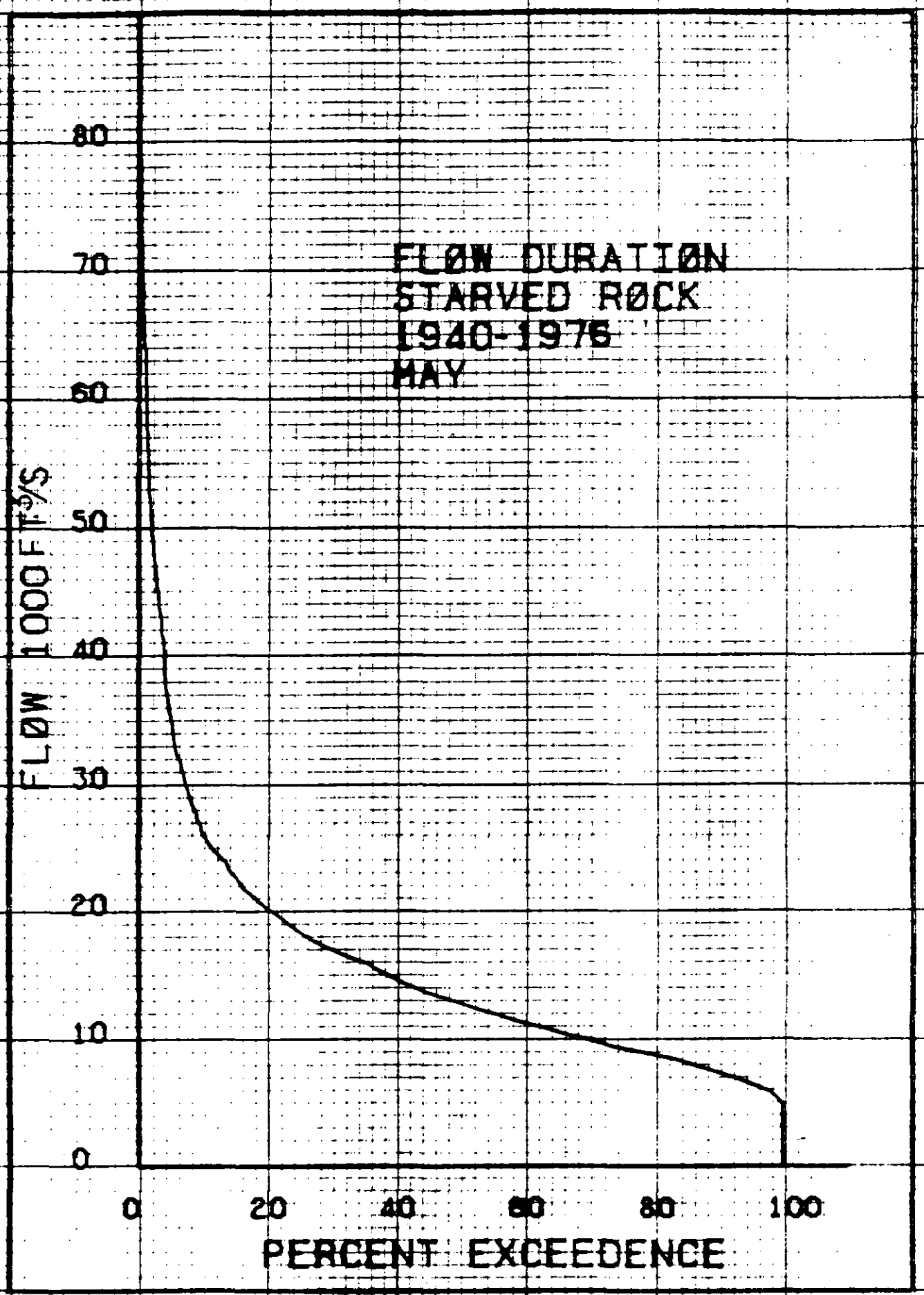
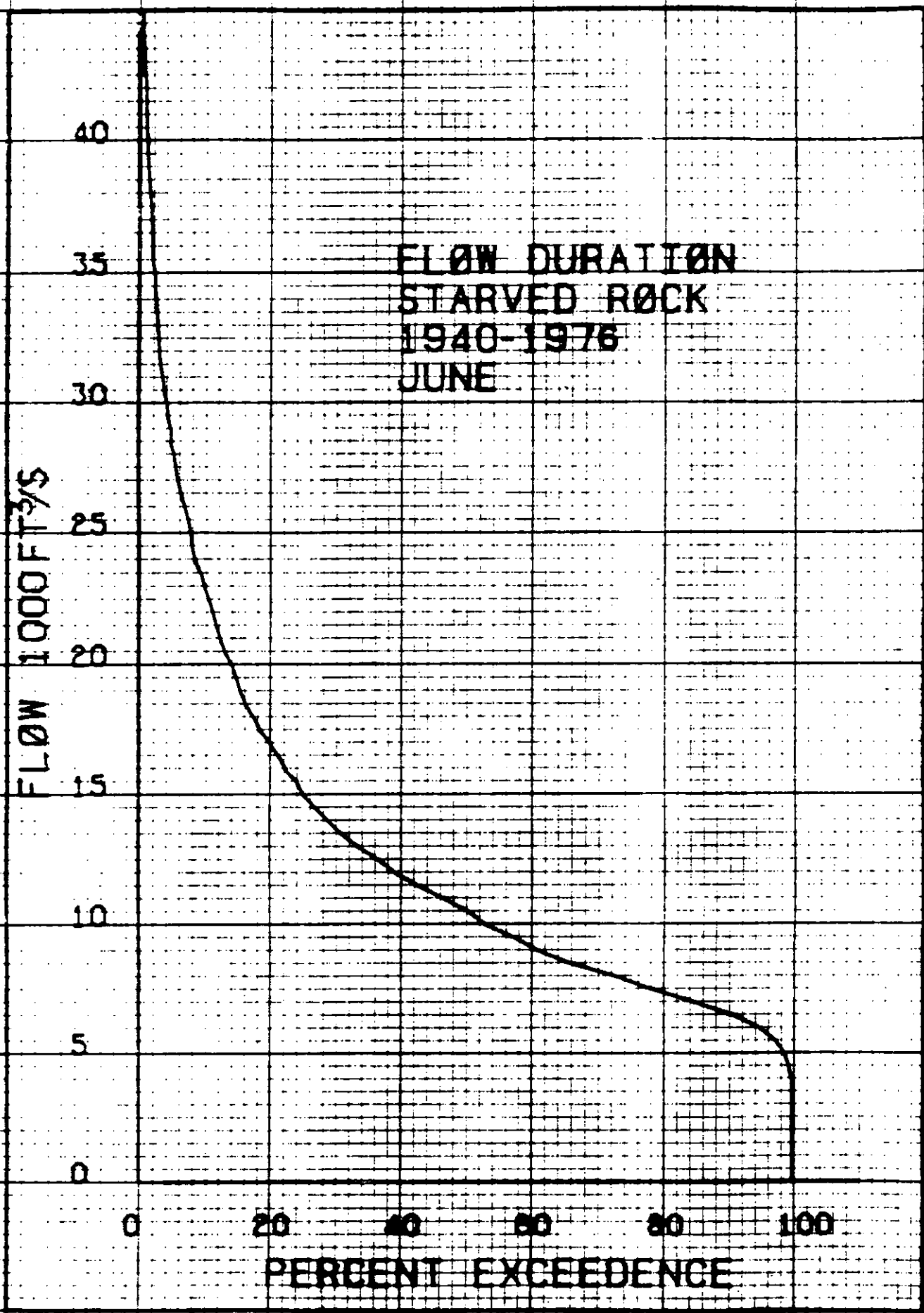


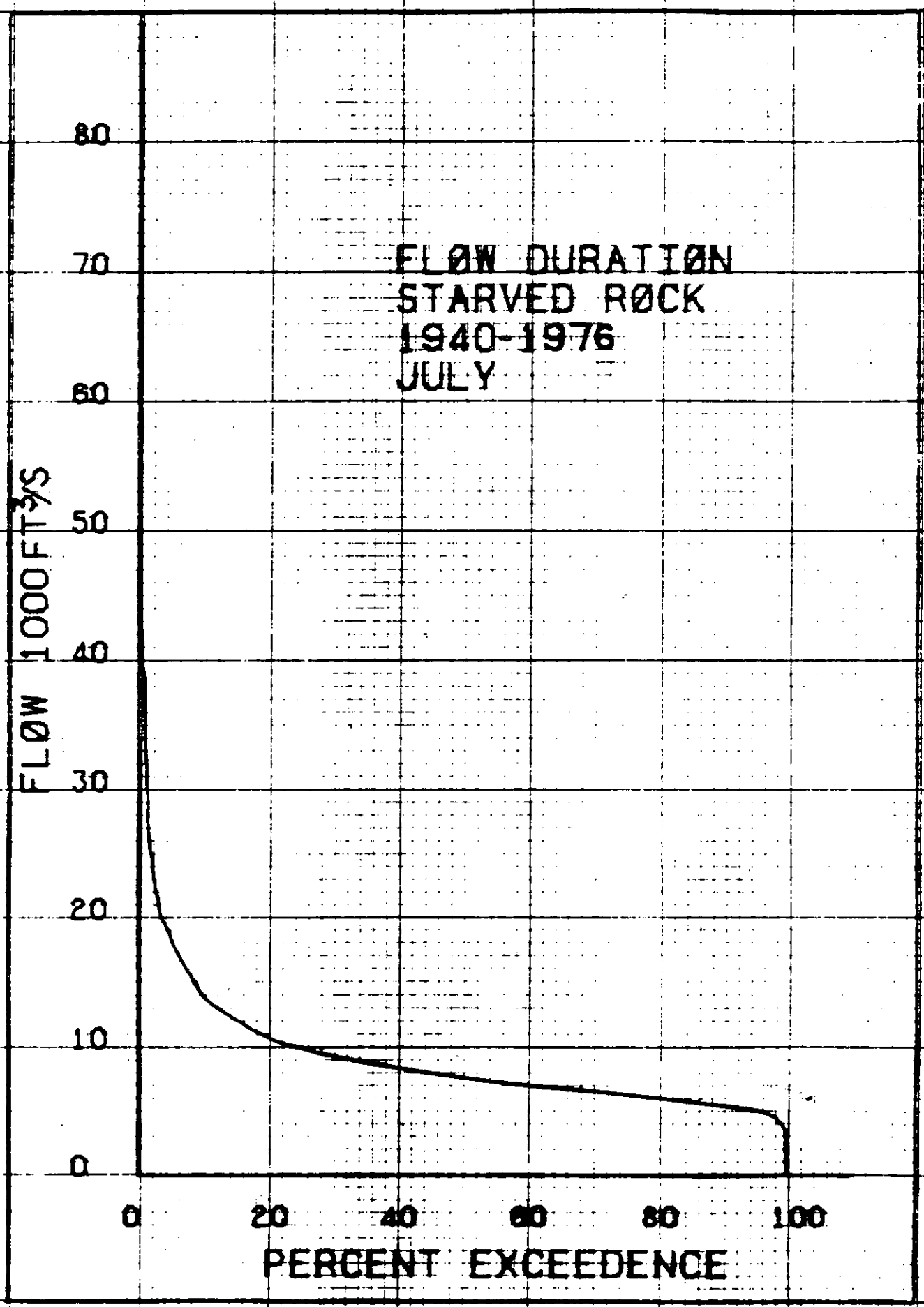
PLATE D-108

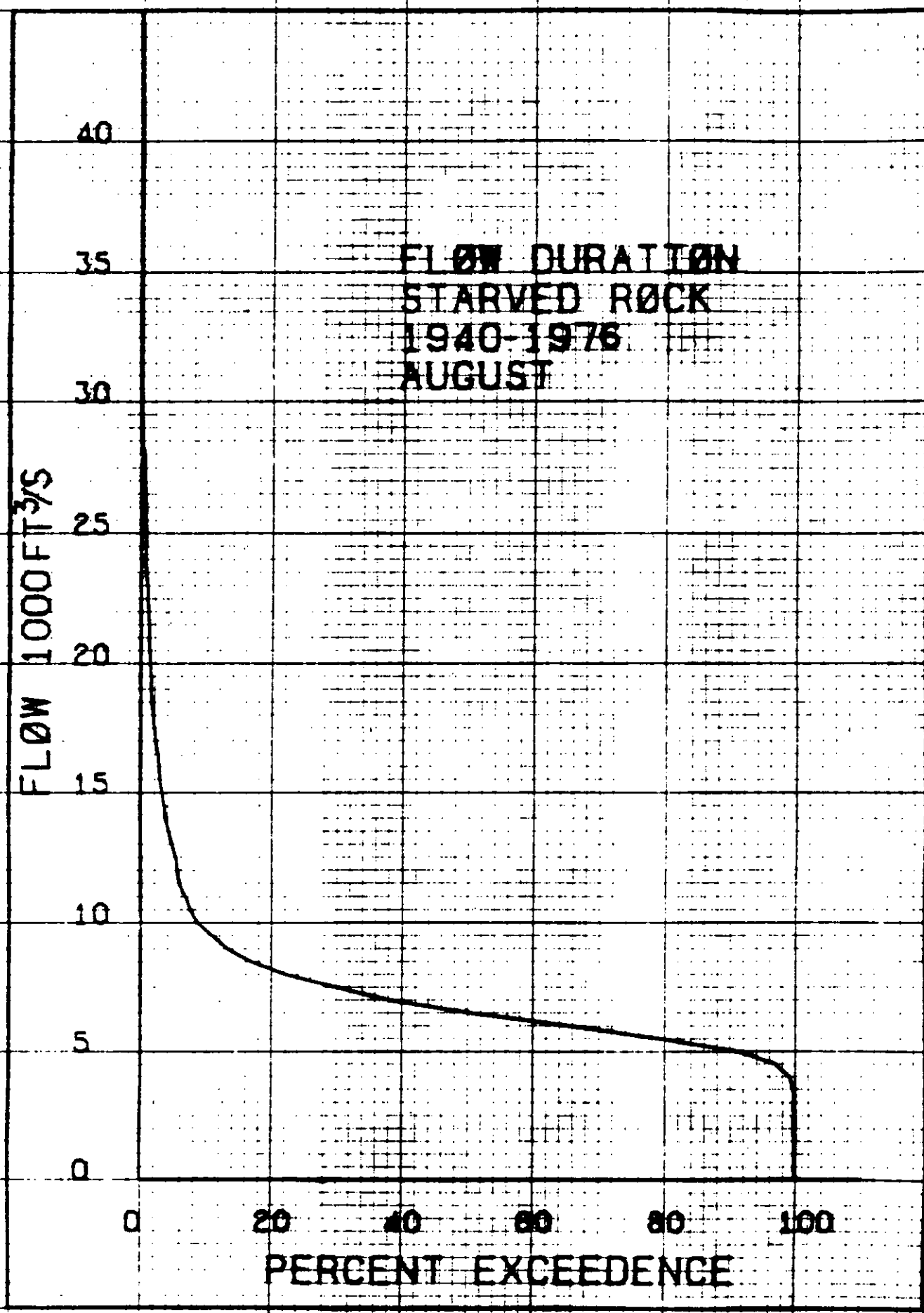

FLØW DURATIØN
STARVED RØCK
1940-1976
MARCH
FLØW 1000 FT³/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

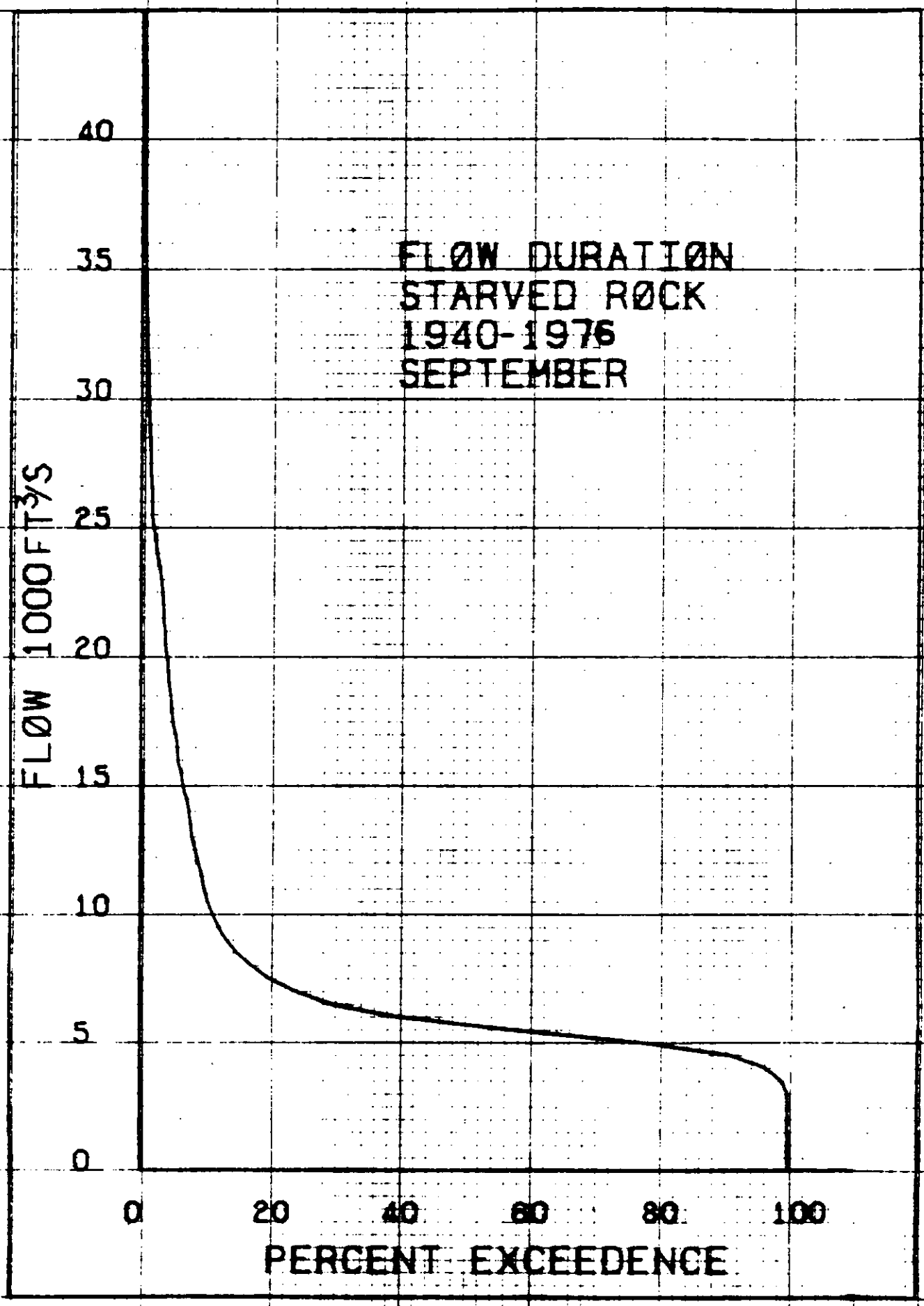

FLØW DURATIØN
STARVED RØCK
1940-1976
APRIL
FLØW 1000FT³/S
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
PERCENT EXCEEDENCE

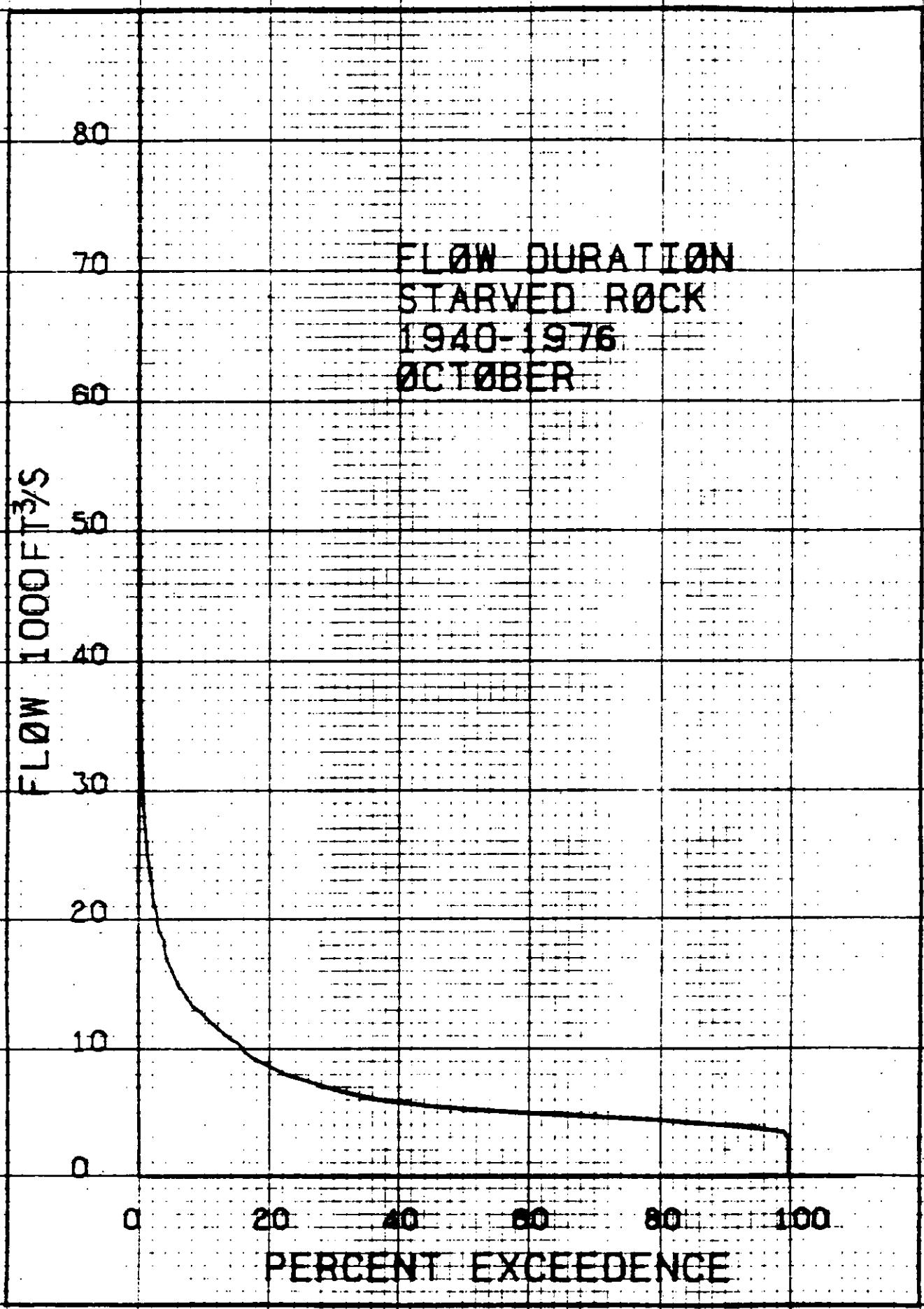

FLØW DURATIØN
STARVED RØCK
1940-1976
MAY
FLØW 1000 FT³/S
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
PERCENT EXCEEDENCE

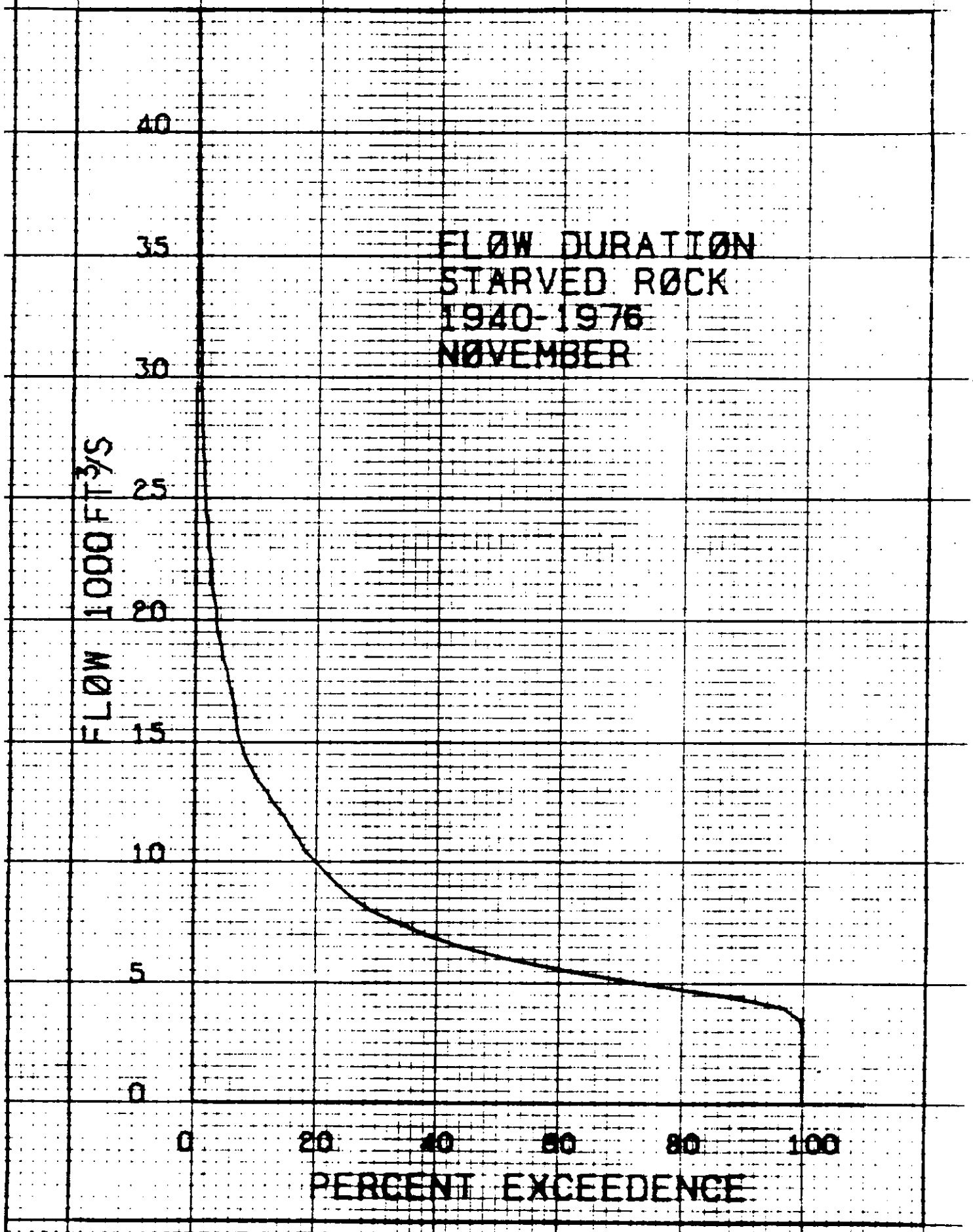

FLØW DURATIØN
STARVED RØCK
1940-1976
JUNE
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

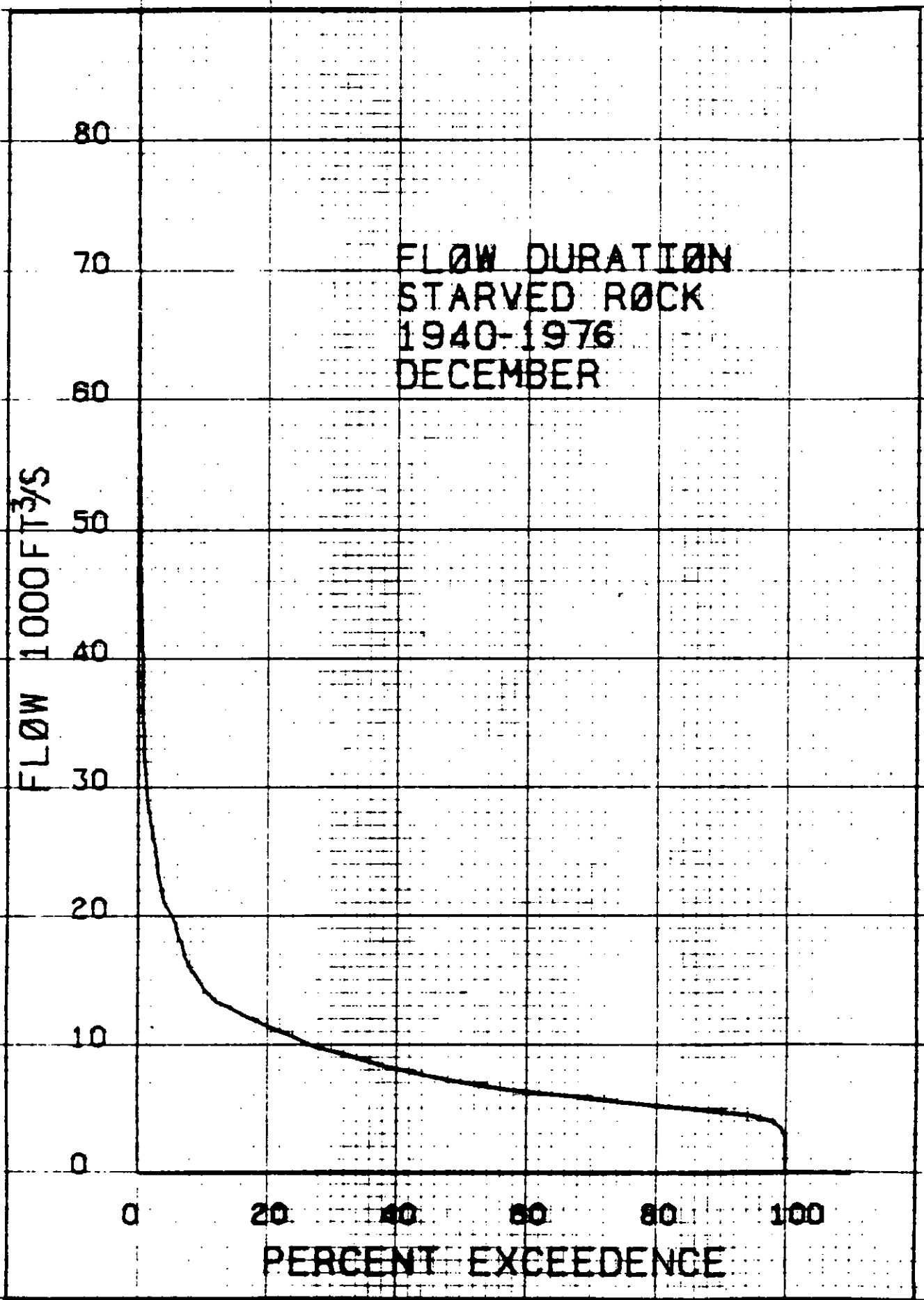

FLØW DURATIØN
STARVED RØCK
1940-1976
JULY
FLØW 1000 FT³/S
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
PERCENT EXCEEDENCE

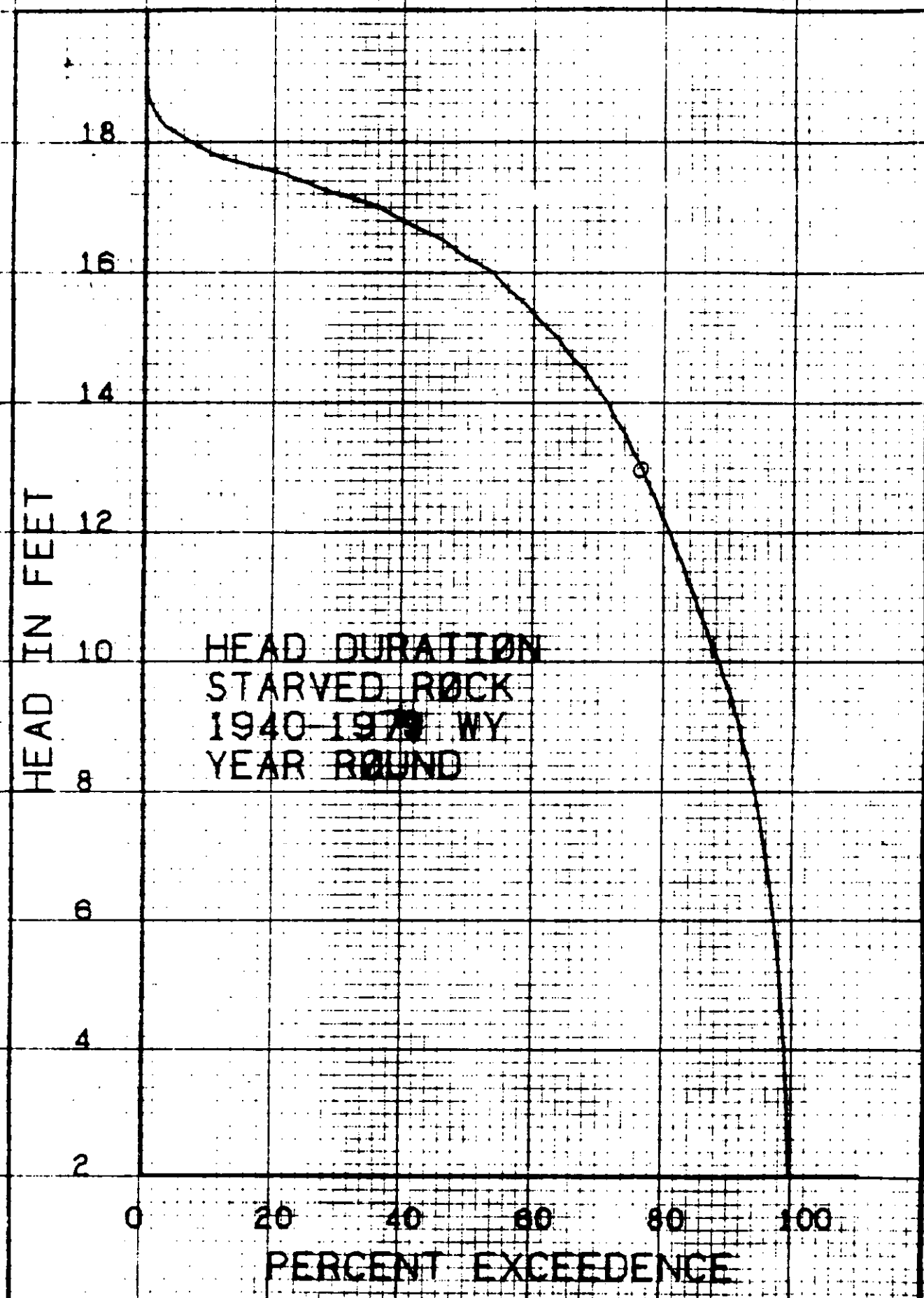

FLØW DURATIØN
STARVED RØCK
1940-1976
AUGUST
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

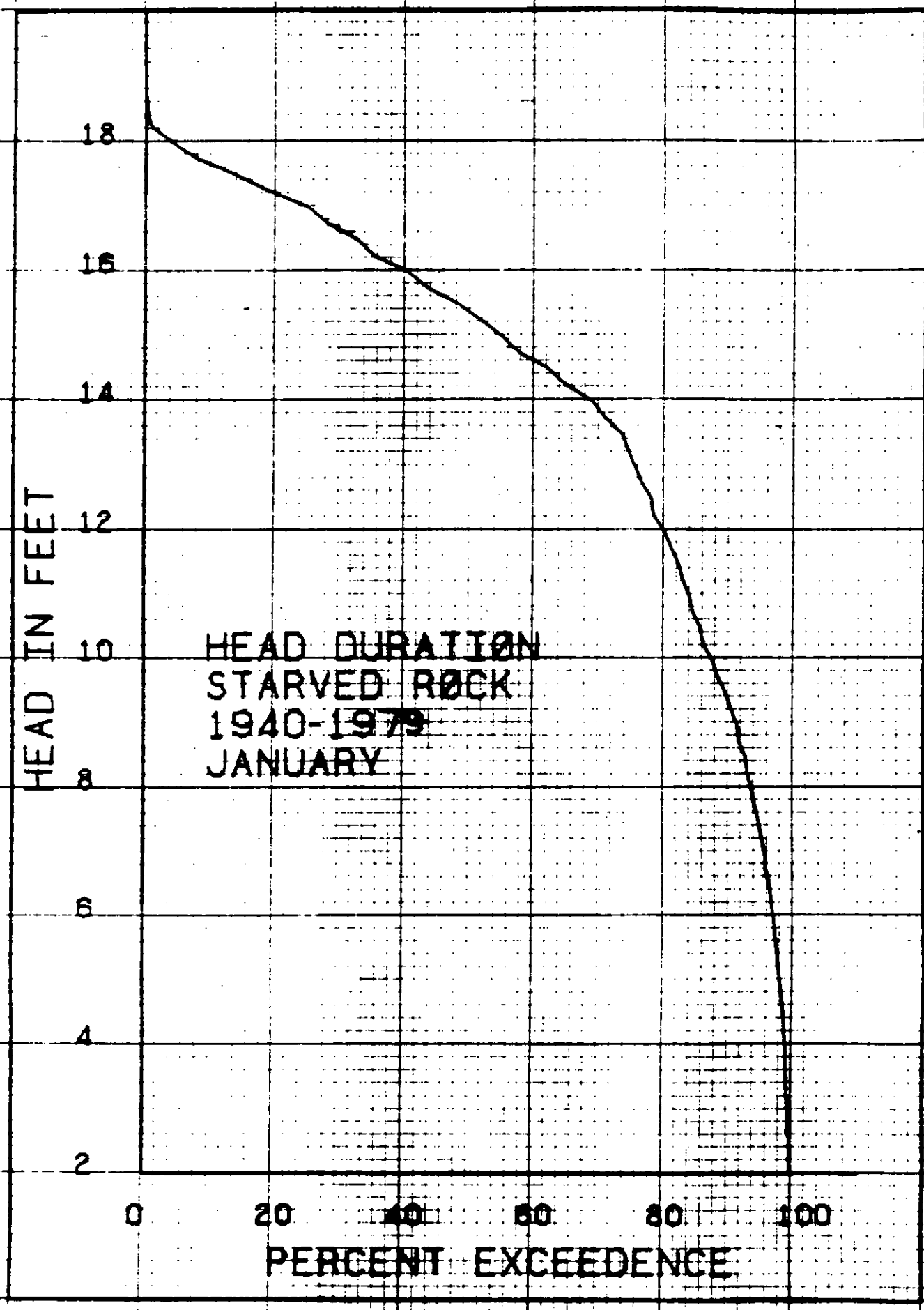

FLØW DURATIØN
STARVED RØCK
1940-1976
SEPTEMBER
FLØW 1000FT3/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

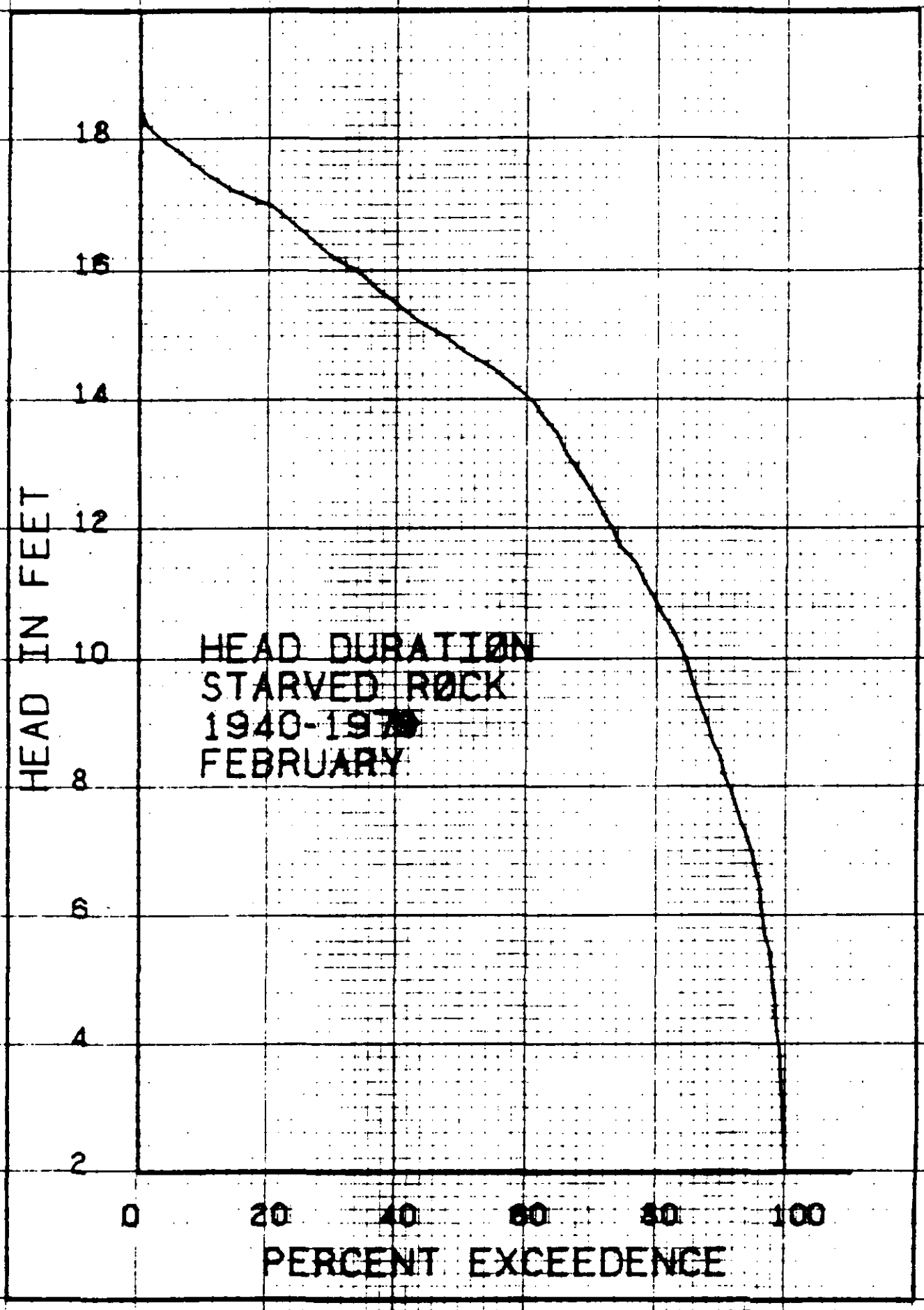

FLØW DURATIØN
STARVED RØCK
1940-1976
ØCTØBER
FLØW 1000FT3/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

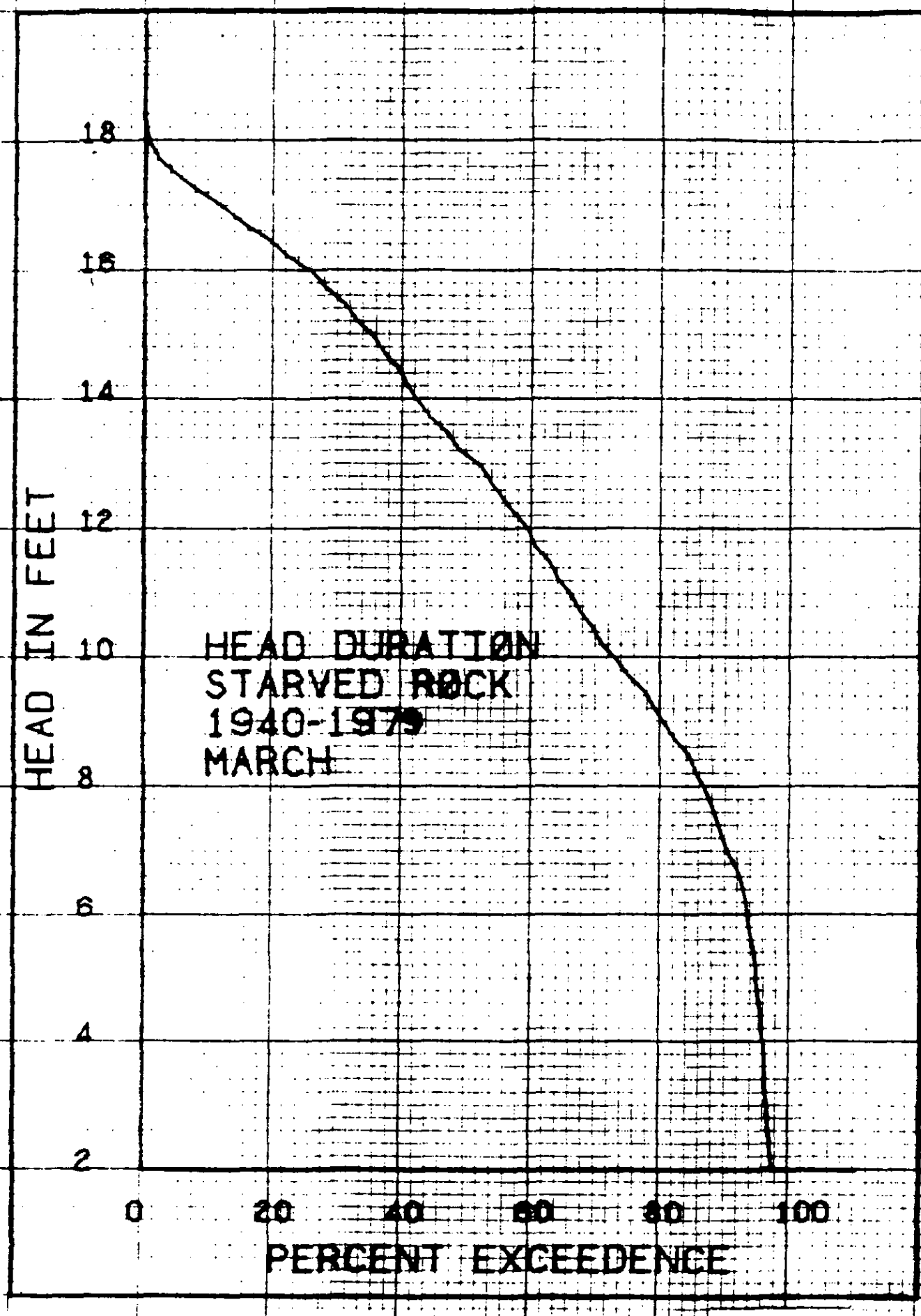

FLØW DURATIØN
STARVED RØCK
1940-1976
NØVEMBER
FLØW 1000 FT³/S
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

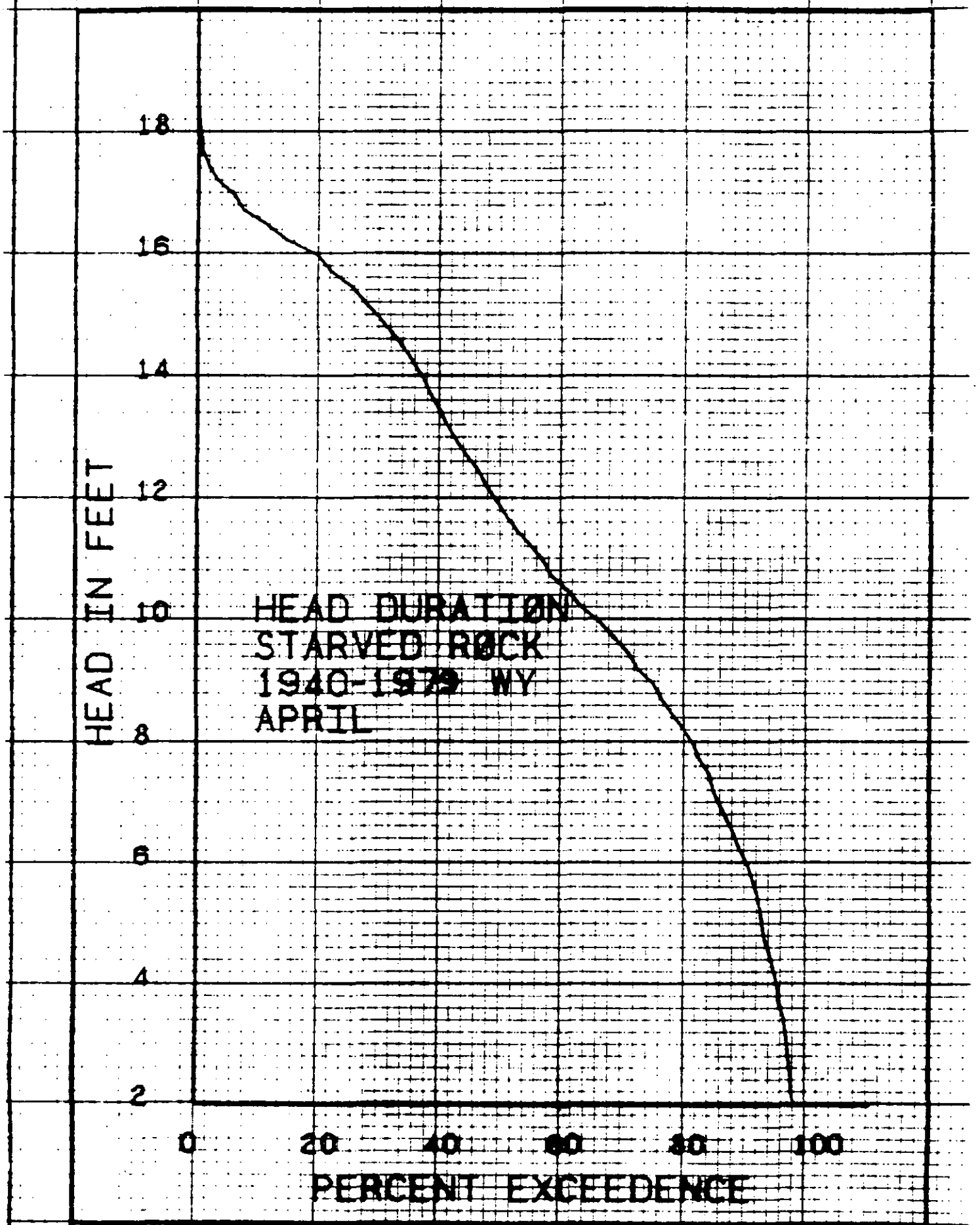

FLØW DURATIØN
STARVED RØCK
1940-1976
DECEMBER
FLØW 1000FT3/S
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PERCENT EXCEEDENCE

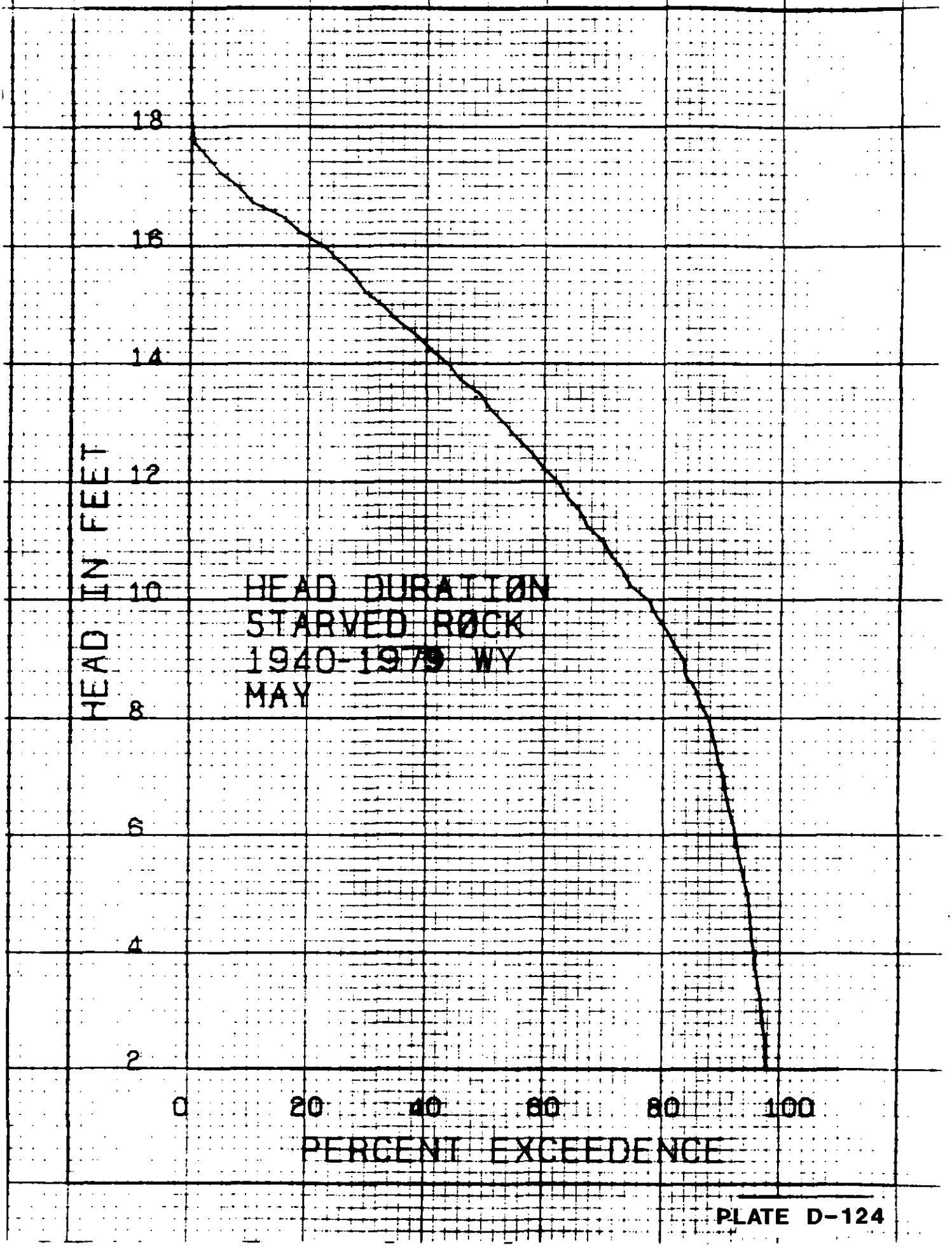

HEAD DURATION
STARVED ROCK
1940-1970 WY
YEAR ROUND
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

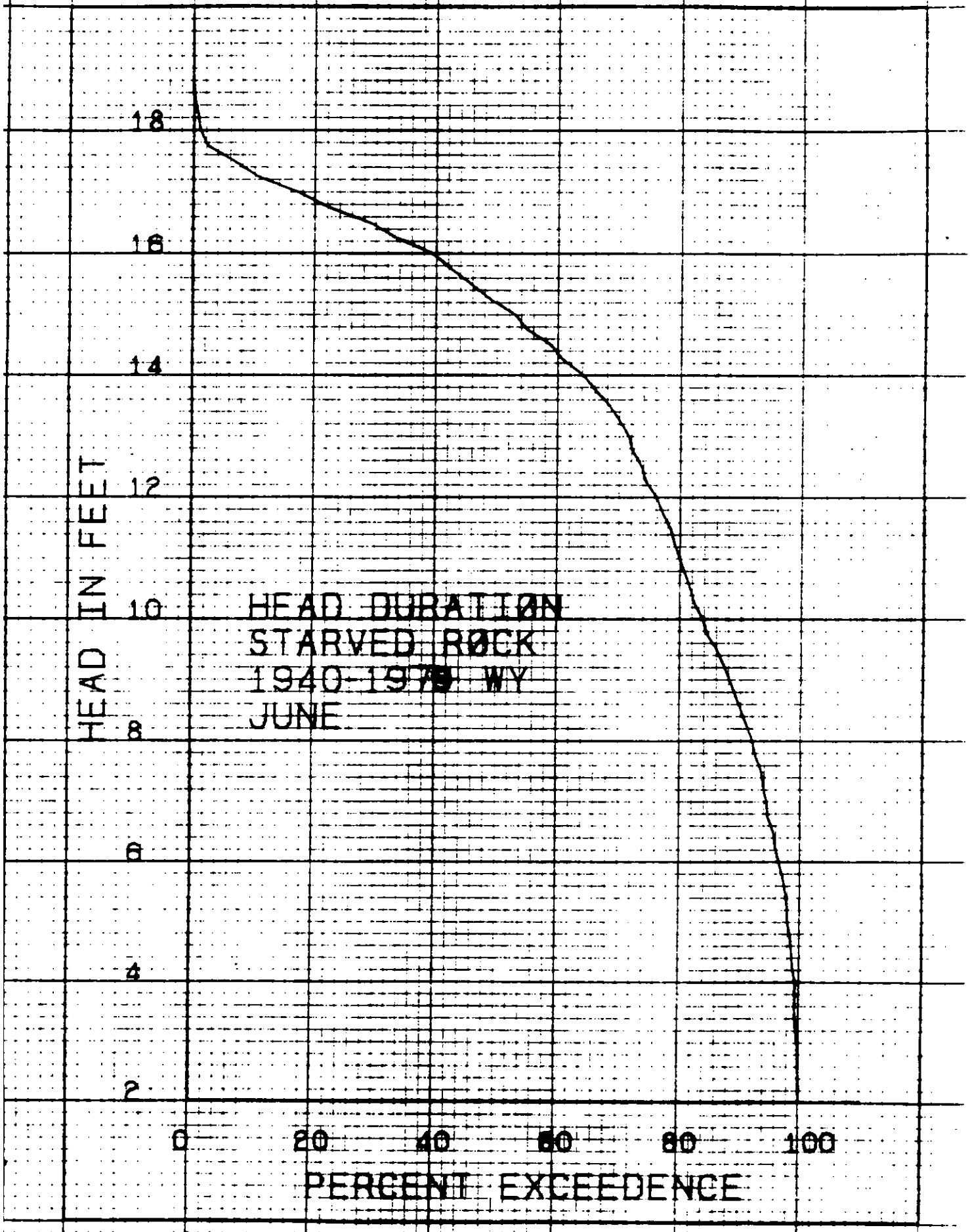

HEAD DURATIØN
STARVED RØCK
1940-1979
JANUARY
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

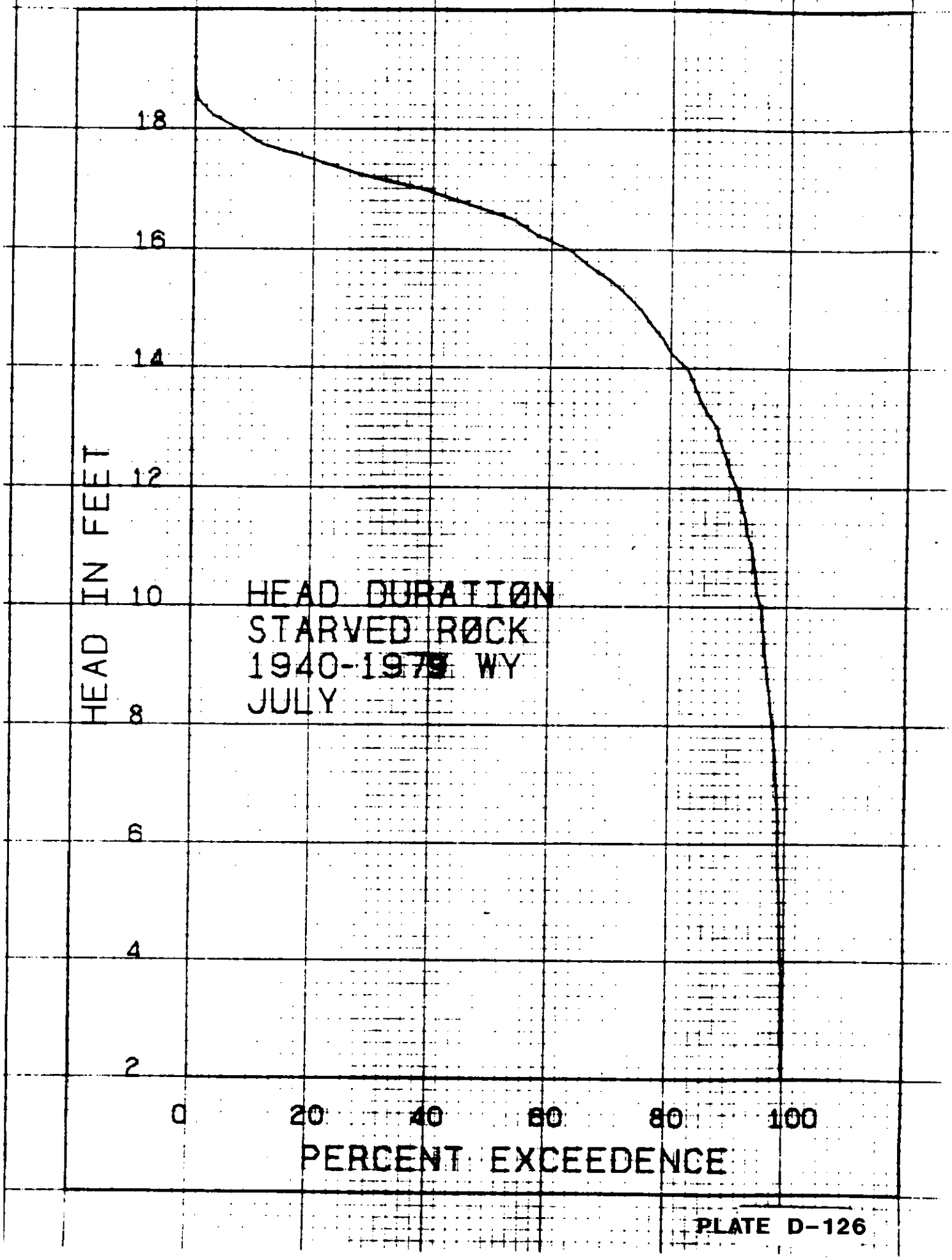

HEAD DURATION
STARVED ROCK
1940-1970
FEBRUARY
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

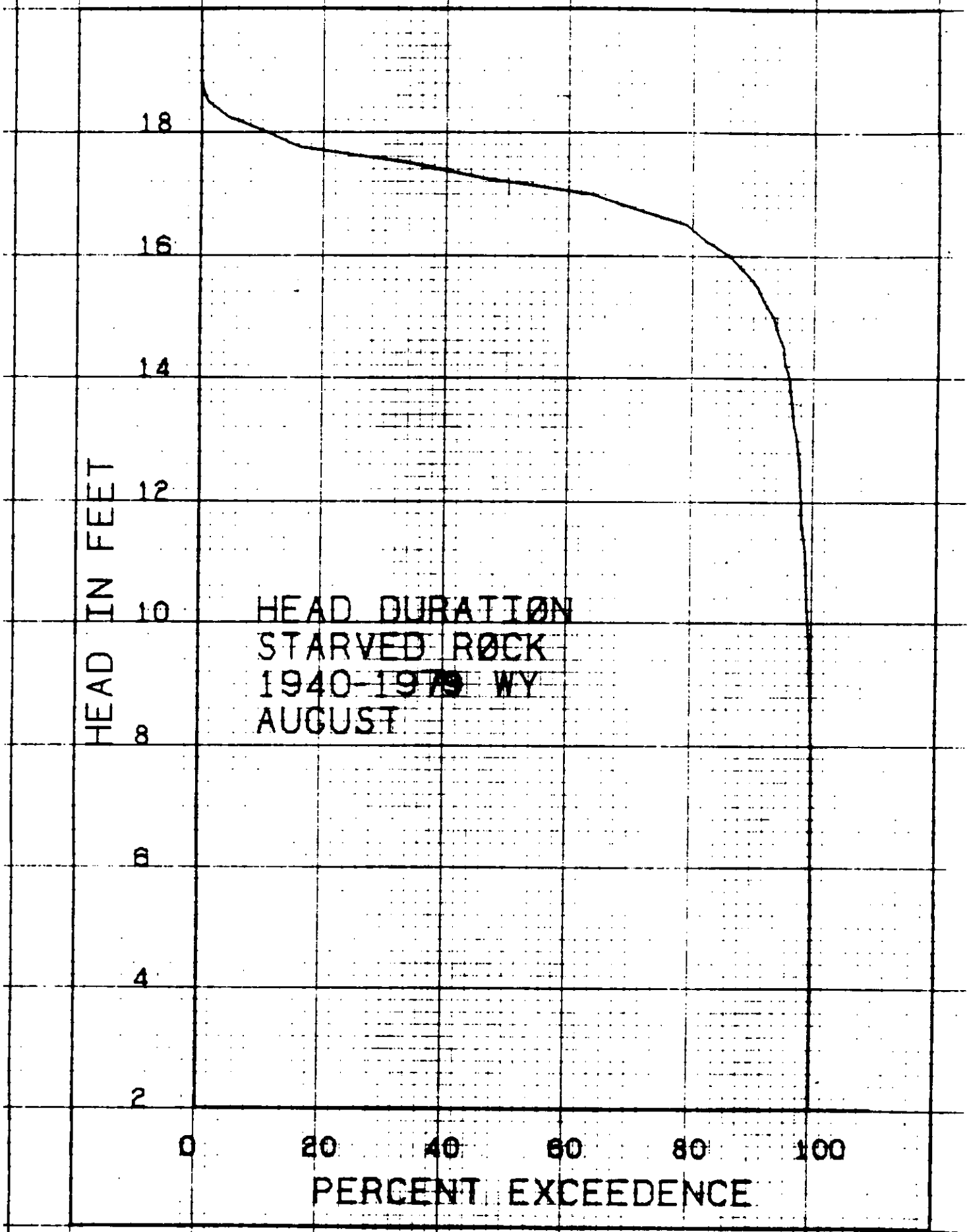

HEAD DURATION
STARVED ROCK
1940-1979
MARCH
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

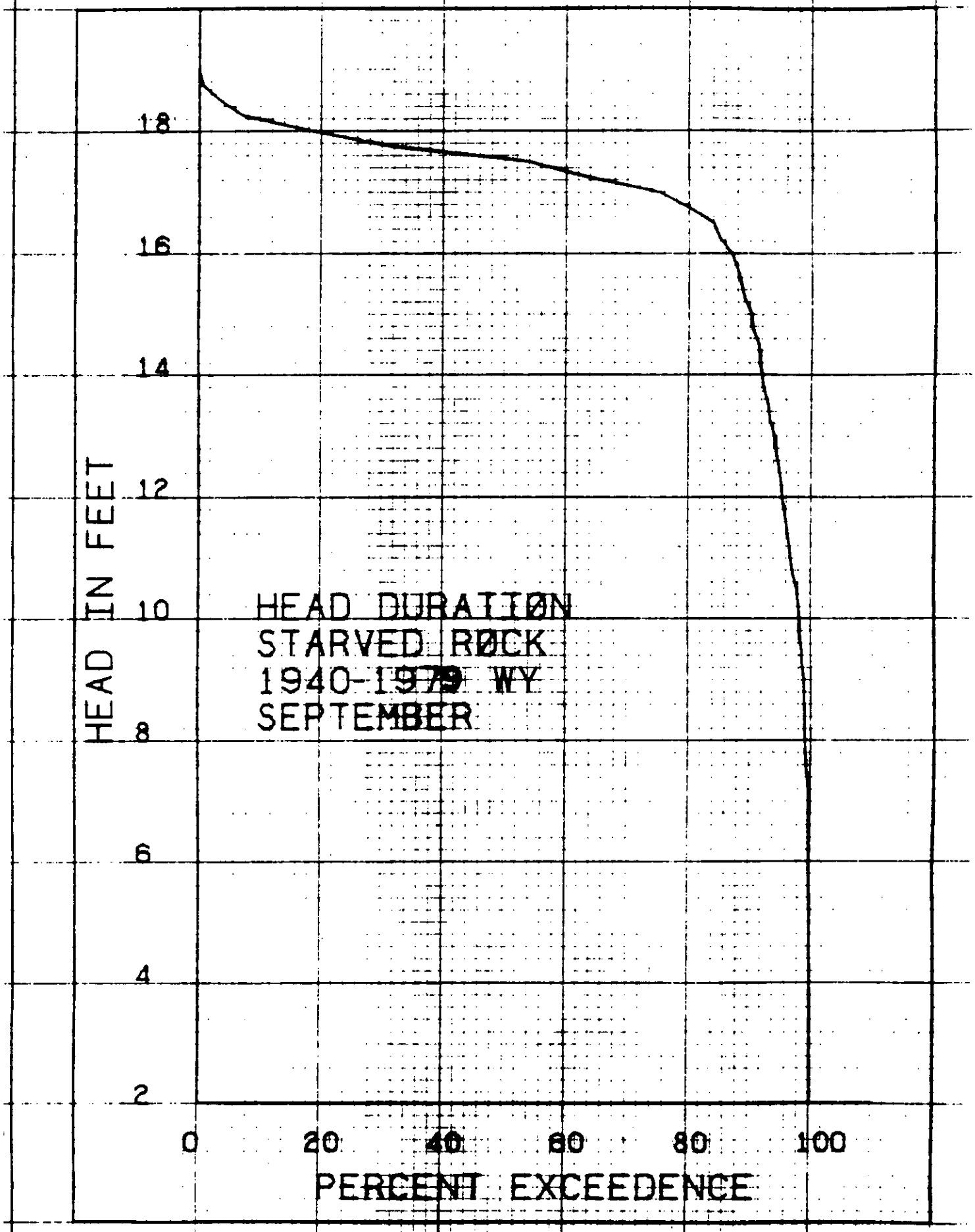

HEAD DURATION
STARVED ROCK
1940-1979 WY
APRIL
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

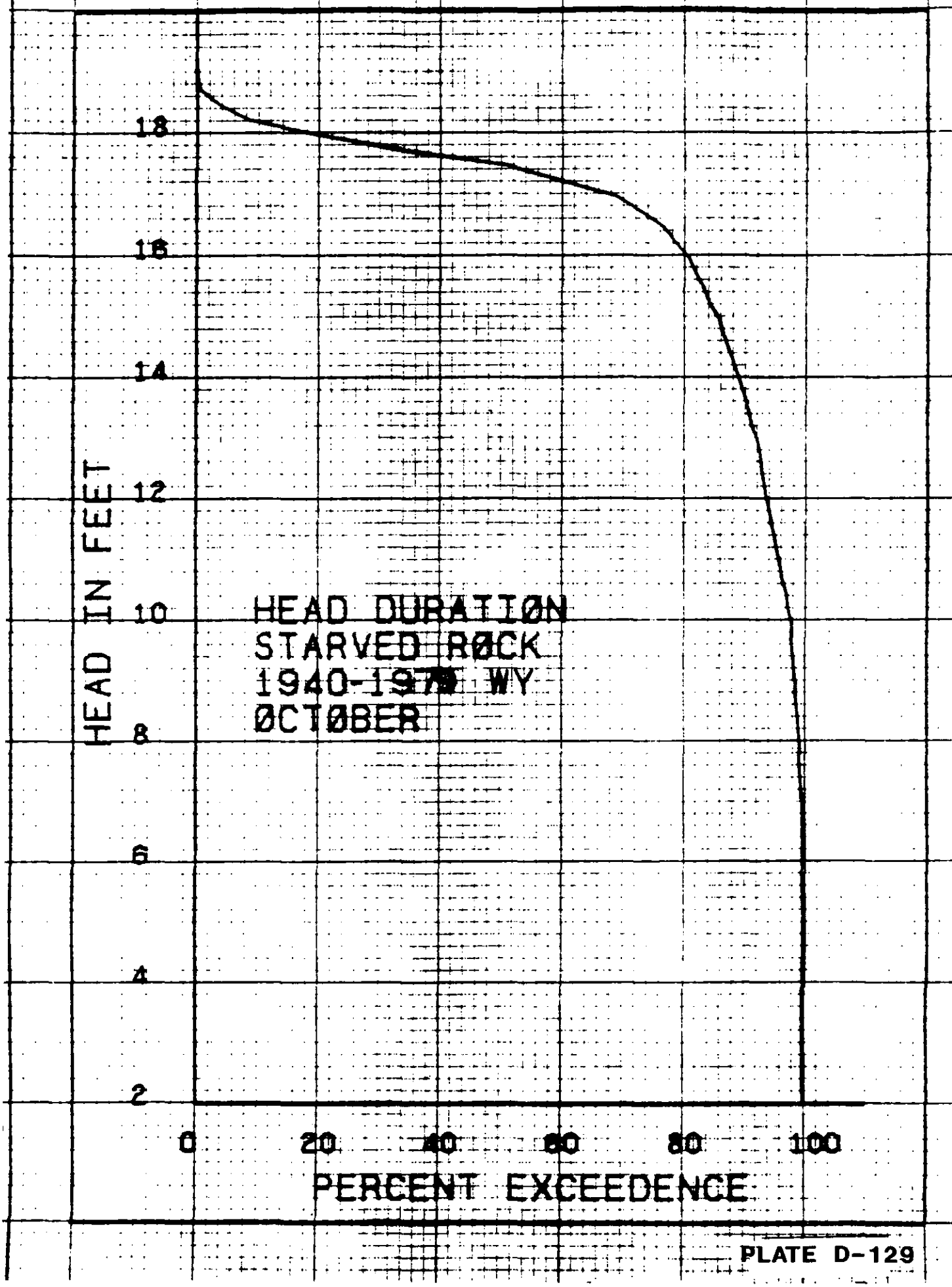

HEAD DURATION
STARVED ROCK
1940-1979 WY
MAY
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

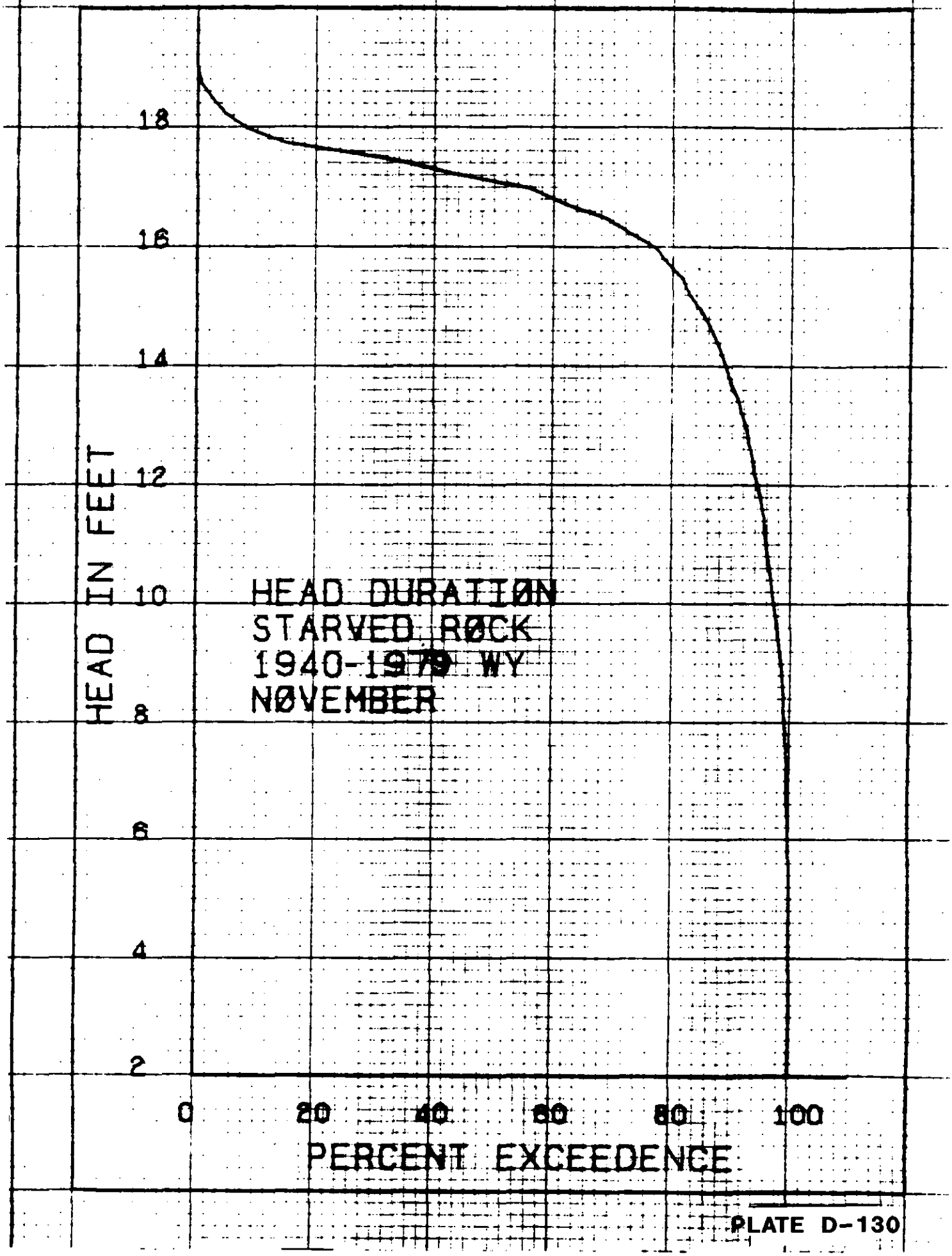

HEAD DURATION
STARVED ROCK
1940-1979 WY
JUNE
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

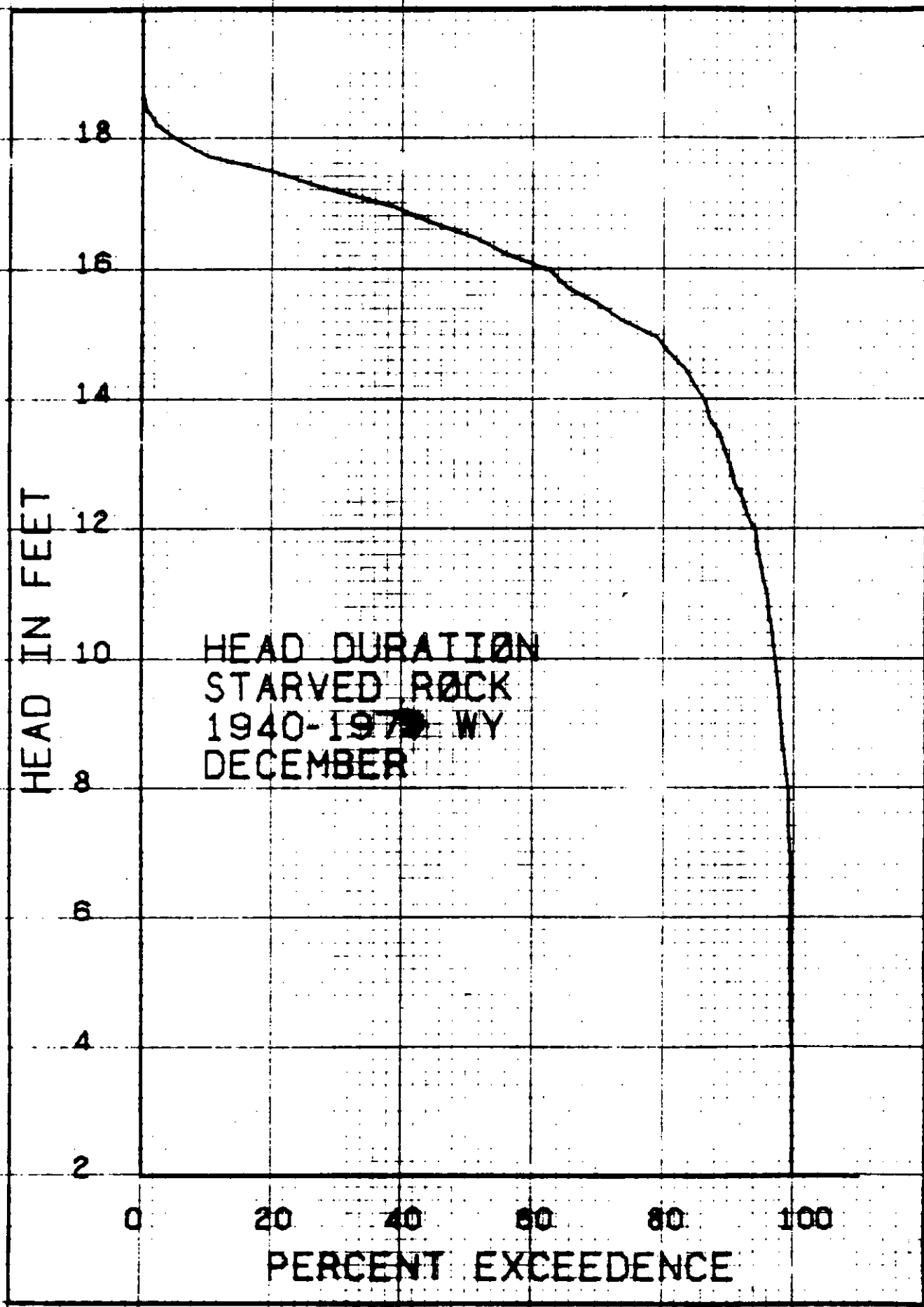

HEAD DURATIØN
STARVED RØCK
1940-1979 WY
JULY
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE

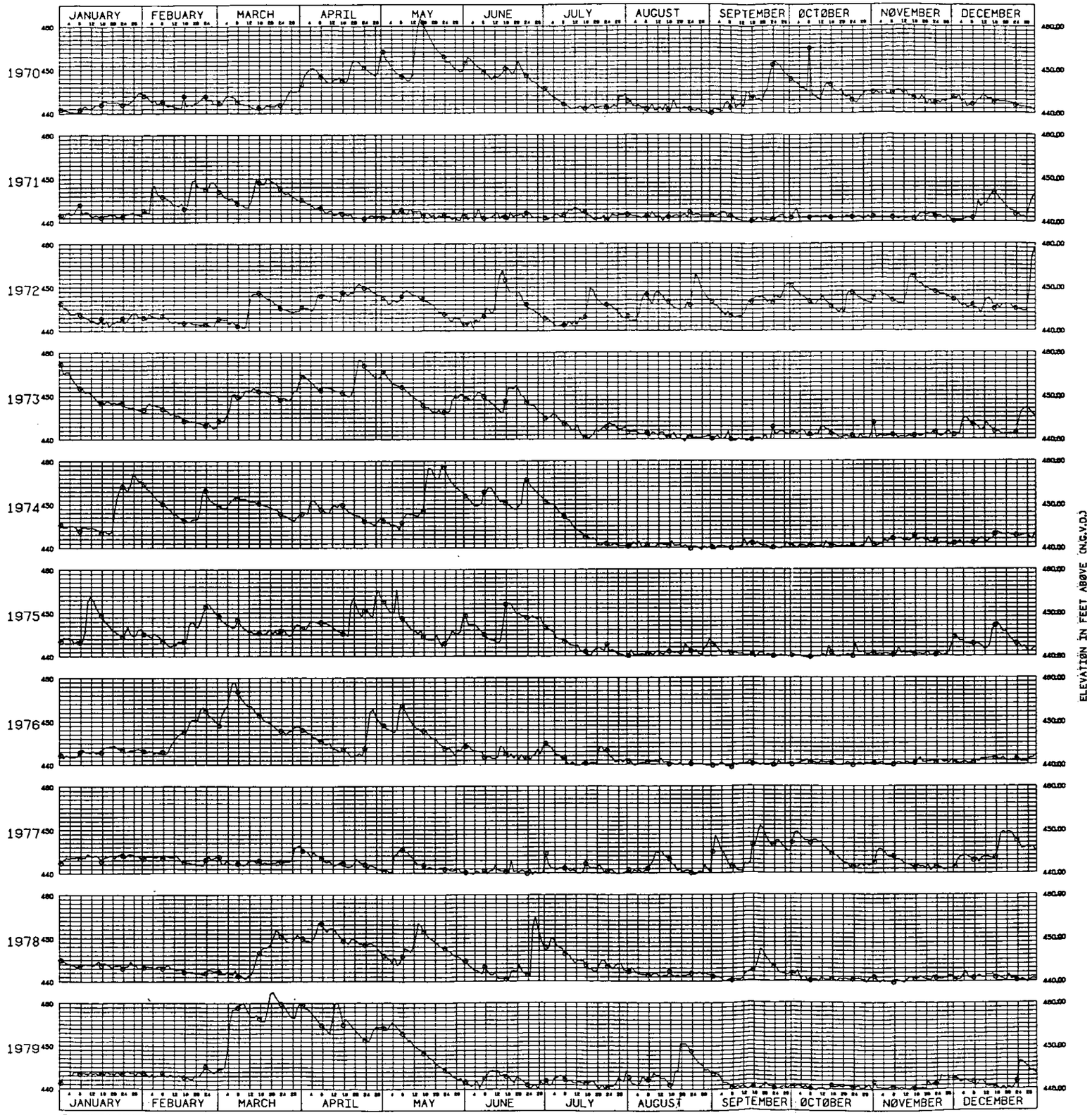

HEAD DURATION
STARVED ROCK
1940-1979 WY
AUGUST
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DURATION
STARVED ROCK
1940-1979 WY
SEPTEMBER
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DURATIØN
STARVED RØCK
1940-1970 WY
ØCTØBER
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DURATION
STARVED ROCK
1940-1979 WY
NOVEMBER
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE


HEAD DURATIØN
STARVED RØCK
1940-1970 WY
DECEMBER
HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
PERCENT EXCEEDENCE



ILLINØIS RIVER.

NØTE-

HYDRØGRAPH
STARVED RØCK'S TAILWATER

Symbol	Description of Revisions	Date	Approved

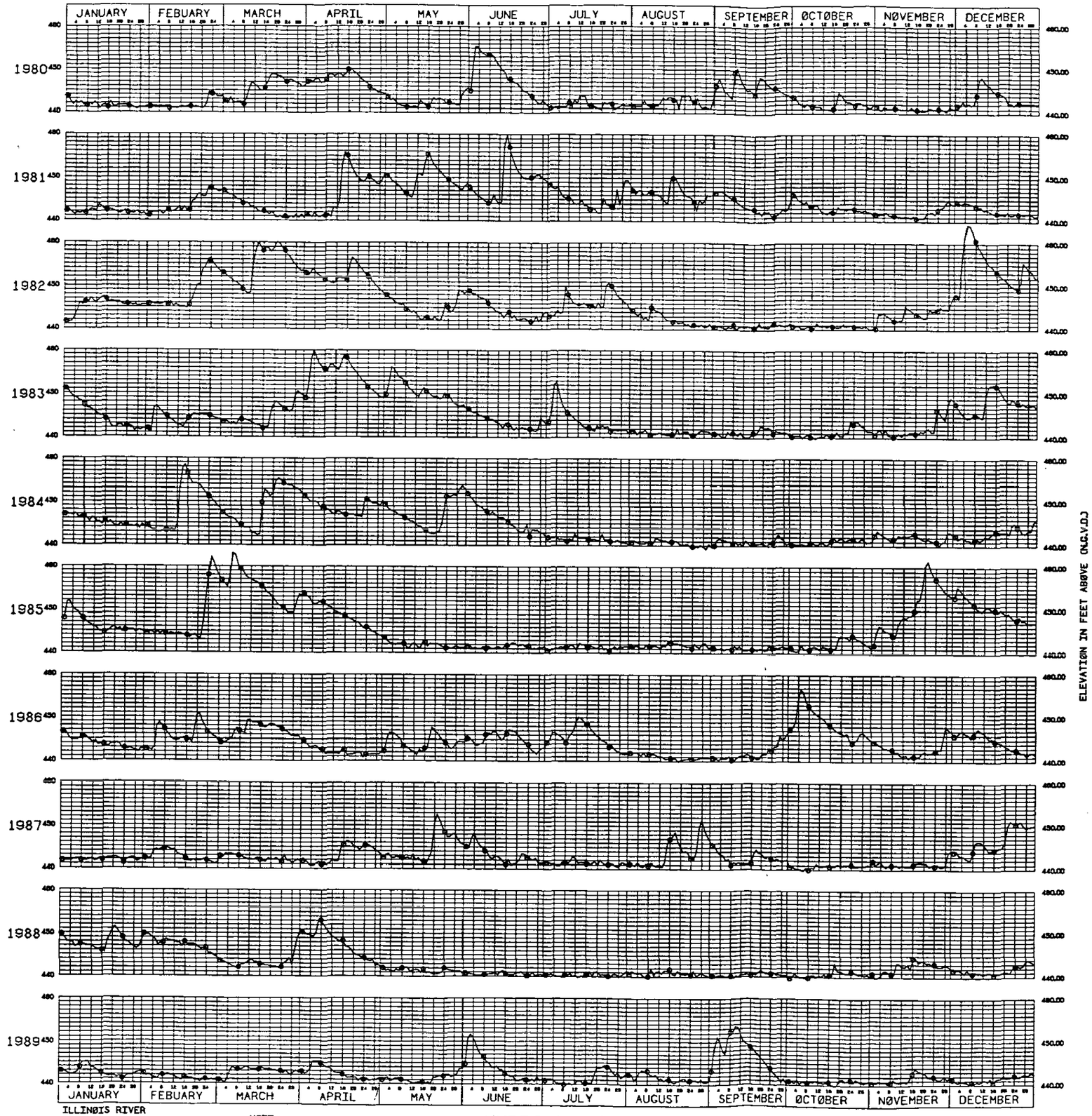
US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:
Submitted by:
CHIEF, DESIGN BRANCH
Approved by:

PLATE D-132

Scale:
Date:



NØTE-

HYDRØGRAPH
STARVED RØCK'S TAILWATER

Symbol	Description of Revisions	Date	Approved

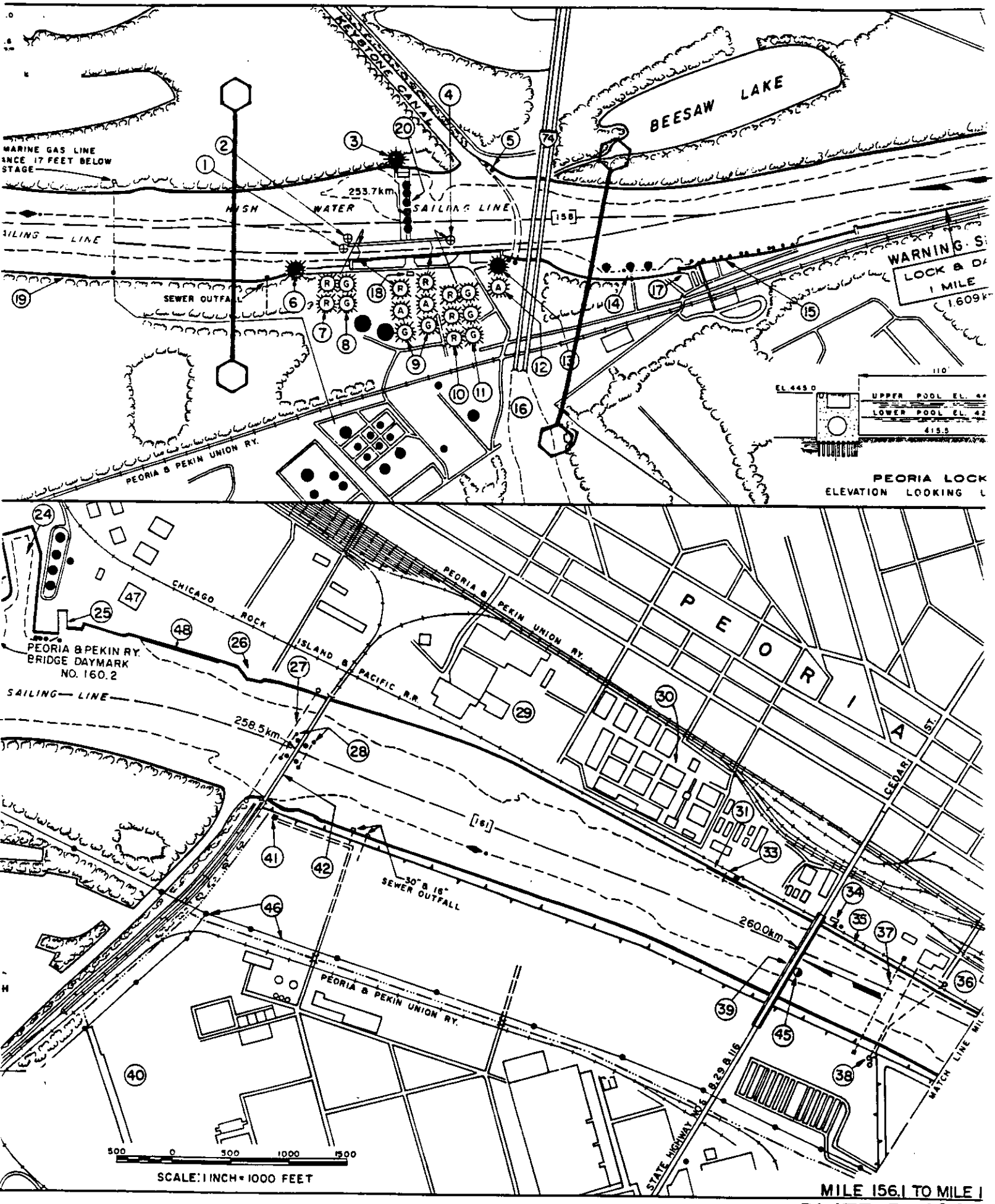
U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

US Army Corps of Engineers

Designed by:
Drawn by:
Checked by:
Submitted by:
CHIEF DESIGN BRANCH
Approved by:

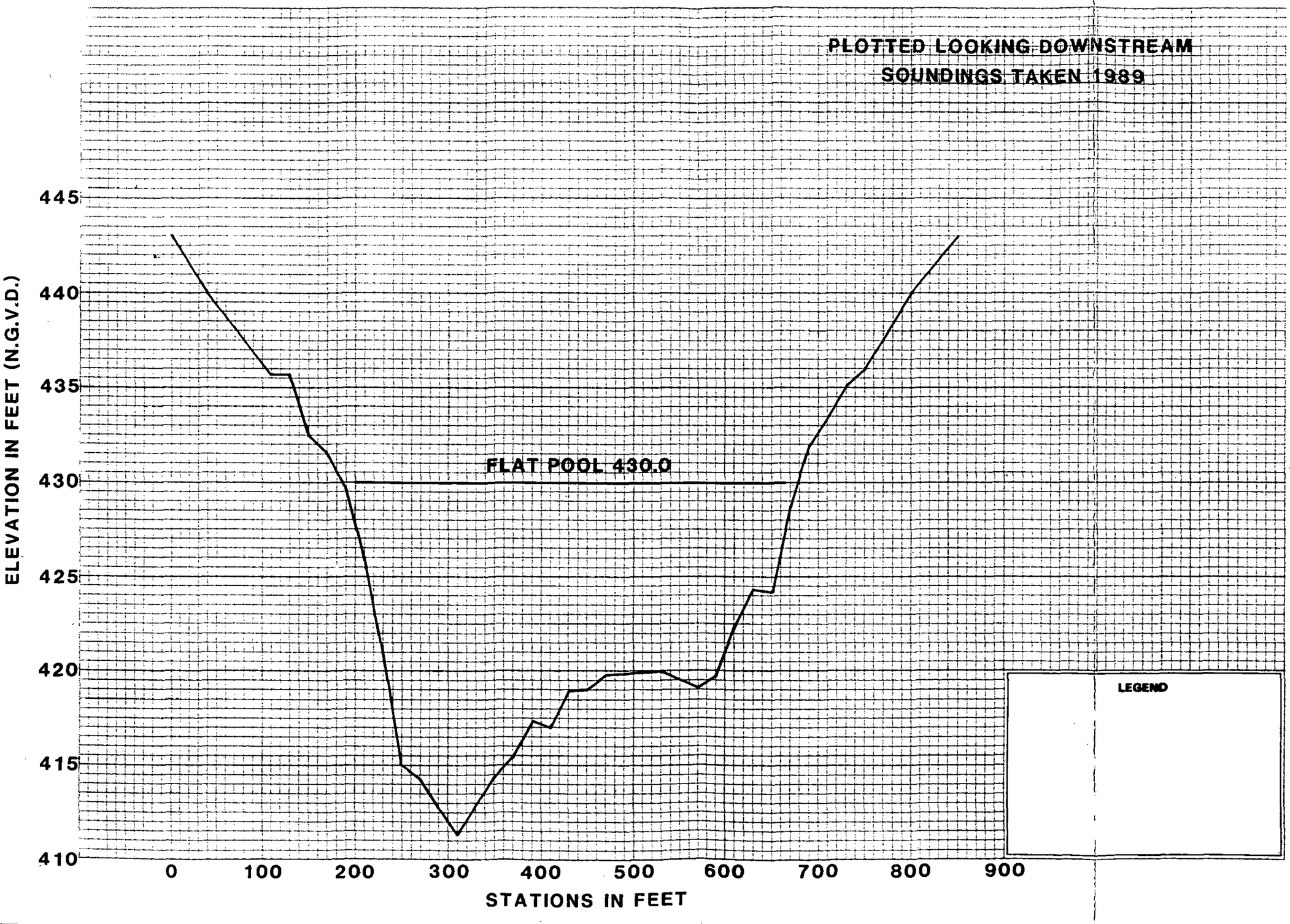
PLATE D-133

Scale:
Date:



MILE 156.1 TO MILE

PLATE D-134

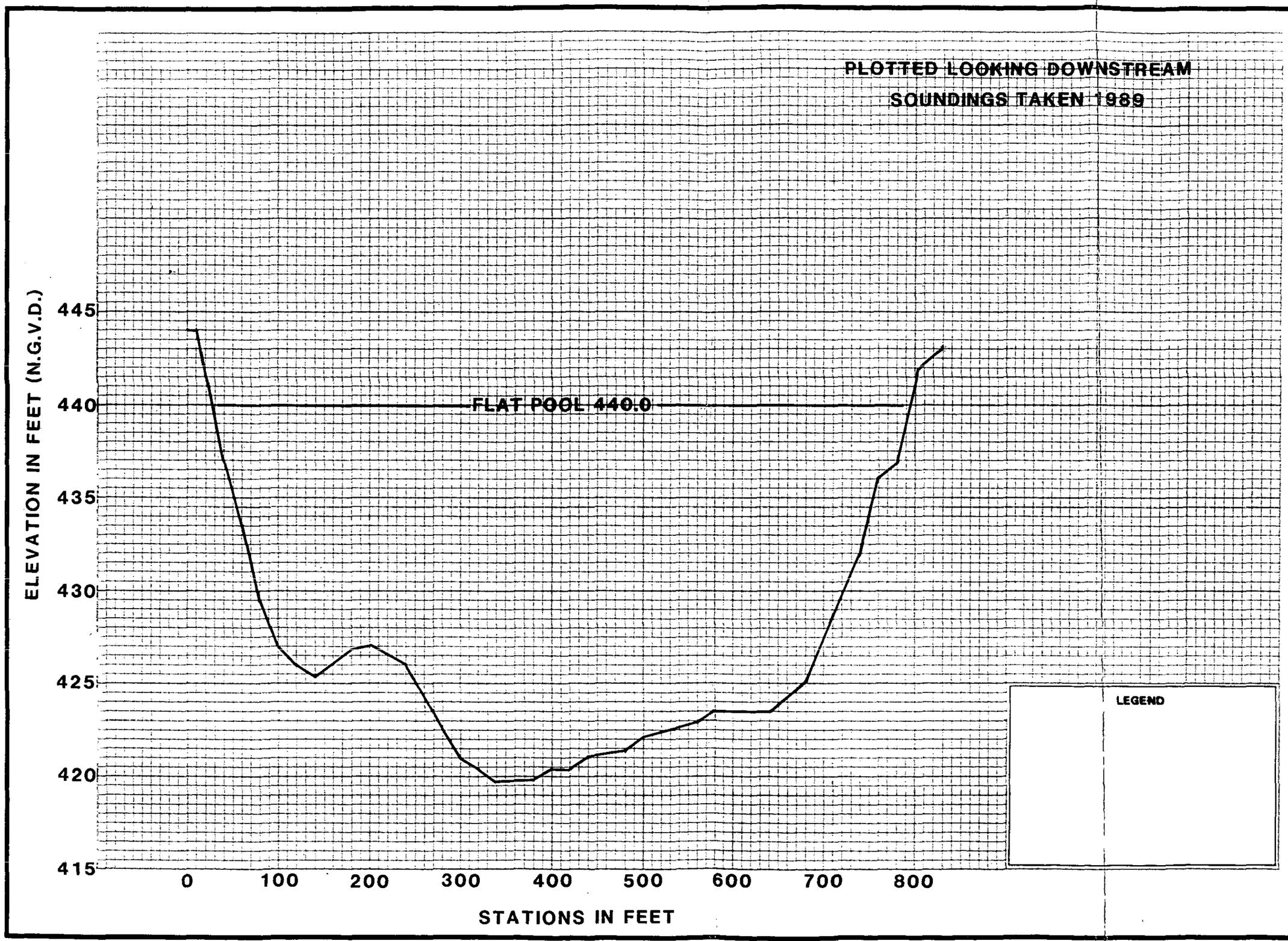


CHANNEL SECTION RIVER MILE 157.47

ILLINOIS RIVER

PEORIA TAIL

PLATE D-135



CHANNEL SECTION RIVER MILE 158.13

ILLINOIS RIVER

PEORIA POOL

PLATE D-136

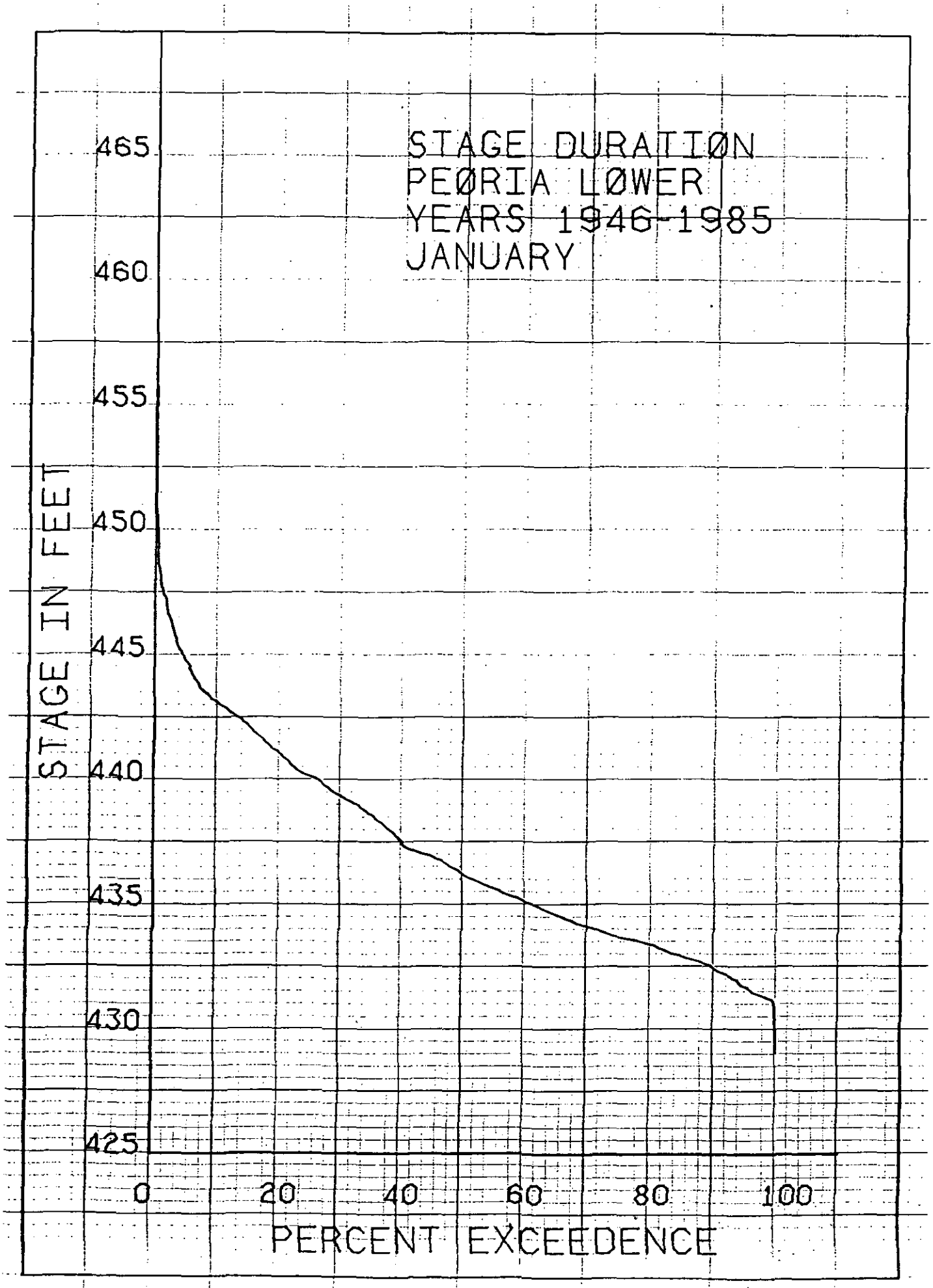
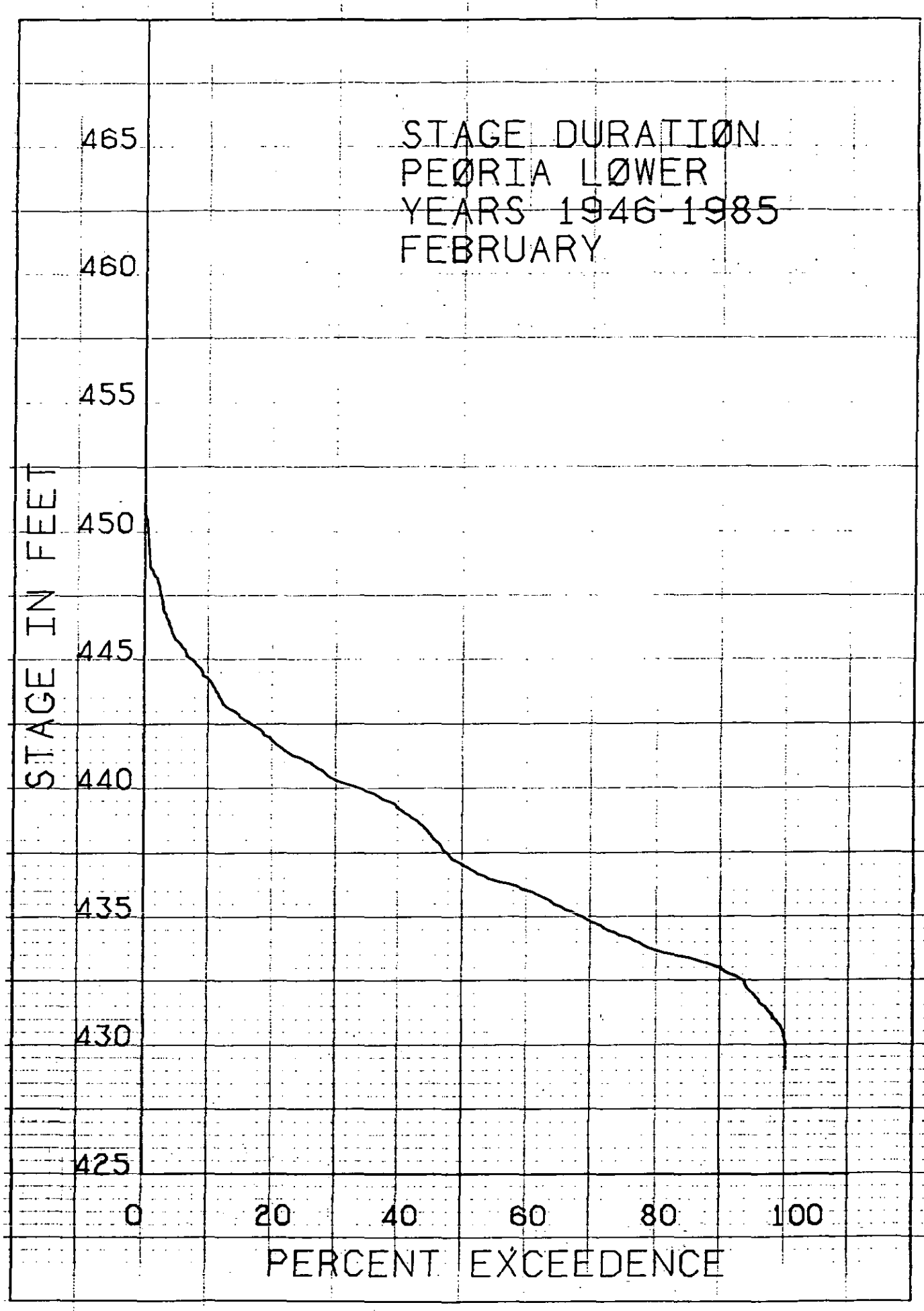

STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
JANUARY
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE B-107


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
FEBRUARY
STAGE IN FEET
465
460
455
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445
440
435
430
425
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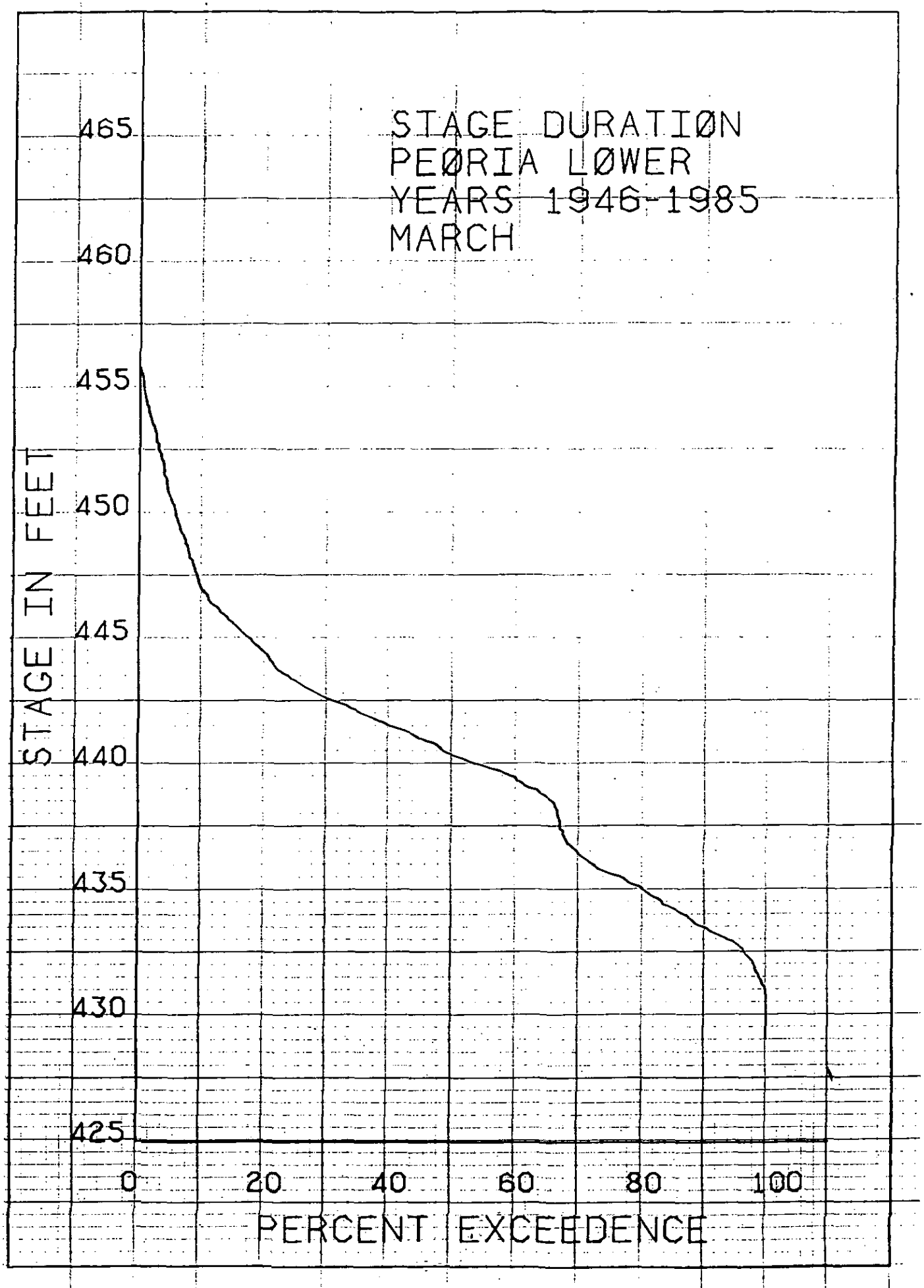
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
MARCH
465
460
455
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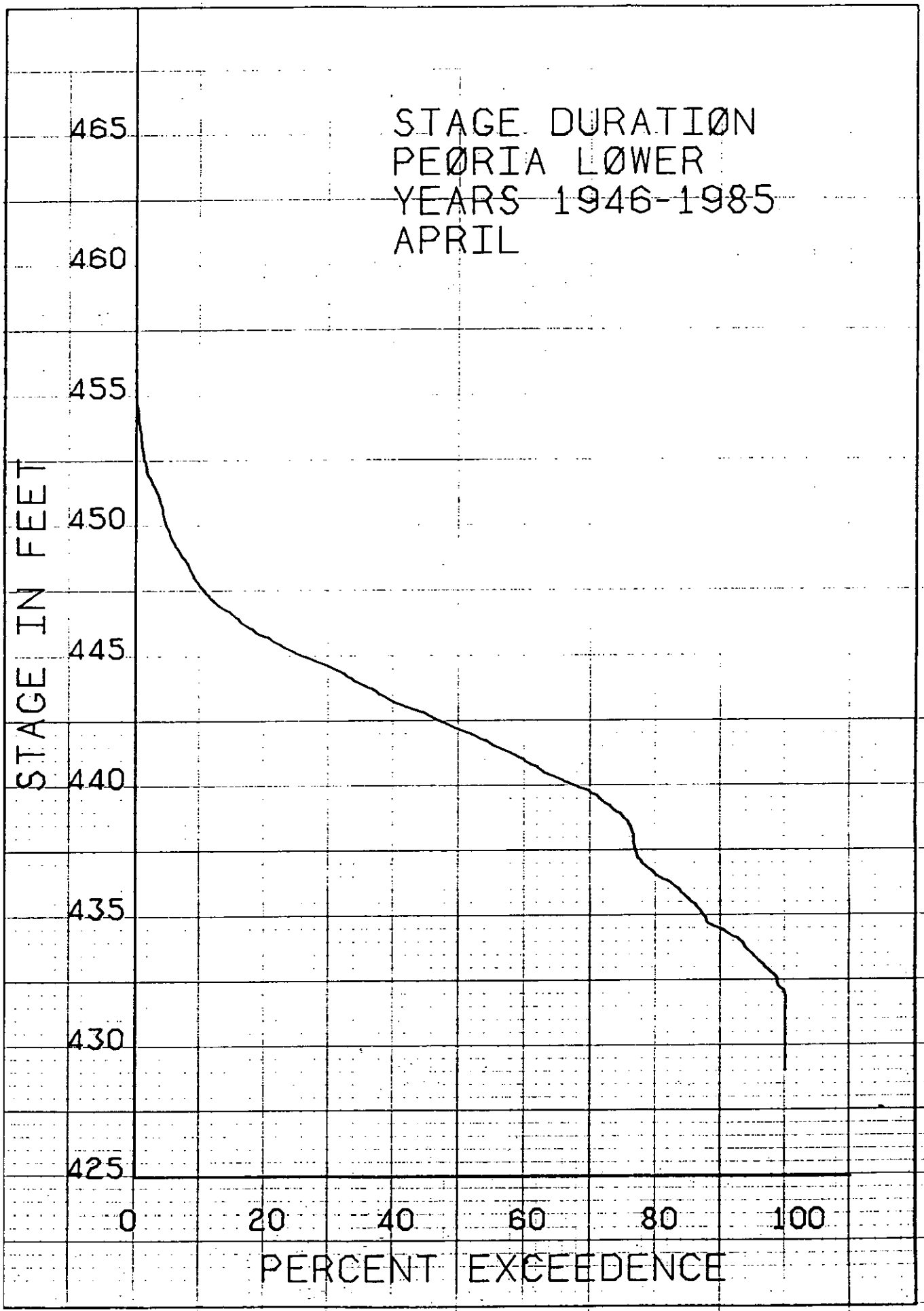
445
440
435
430
425
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
APRIL
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE

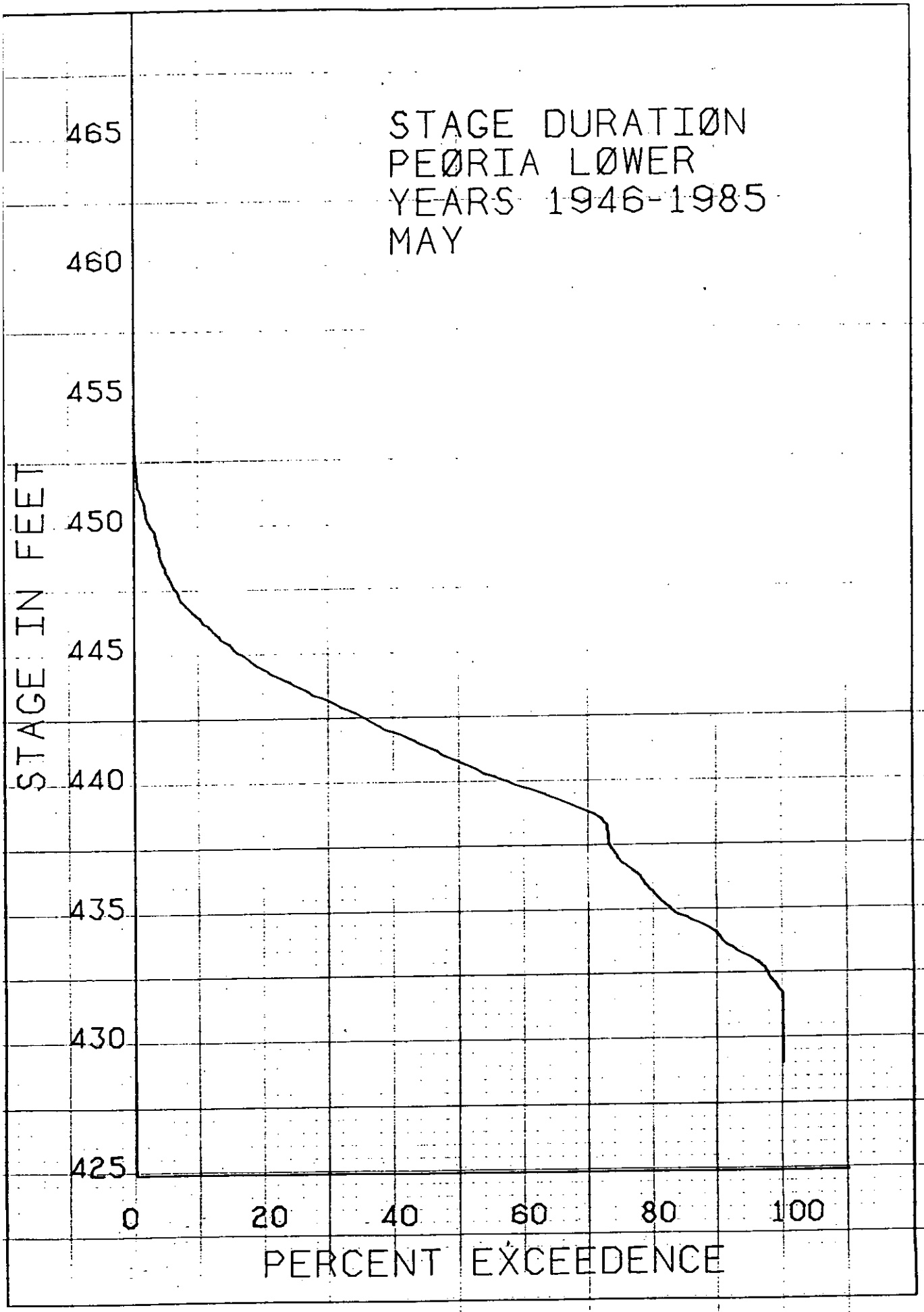
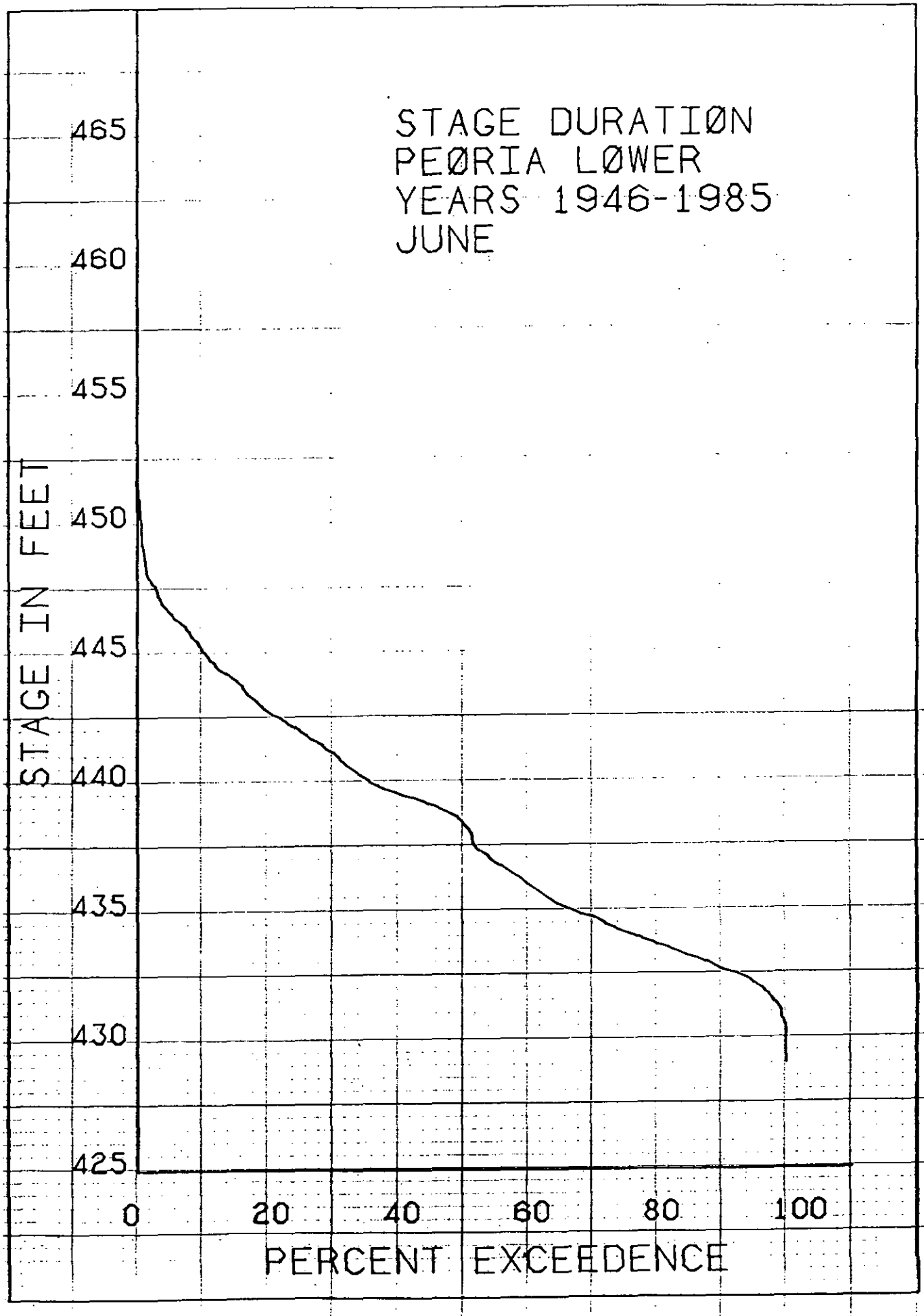
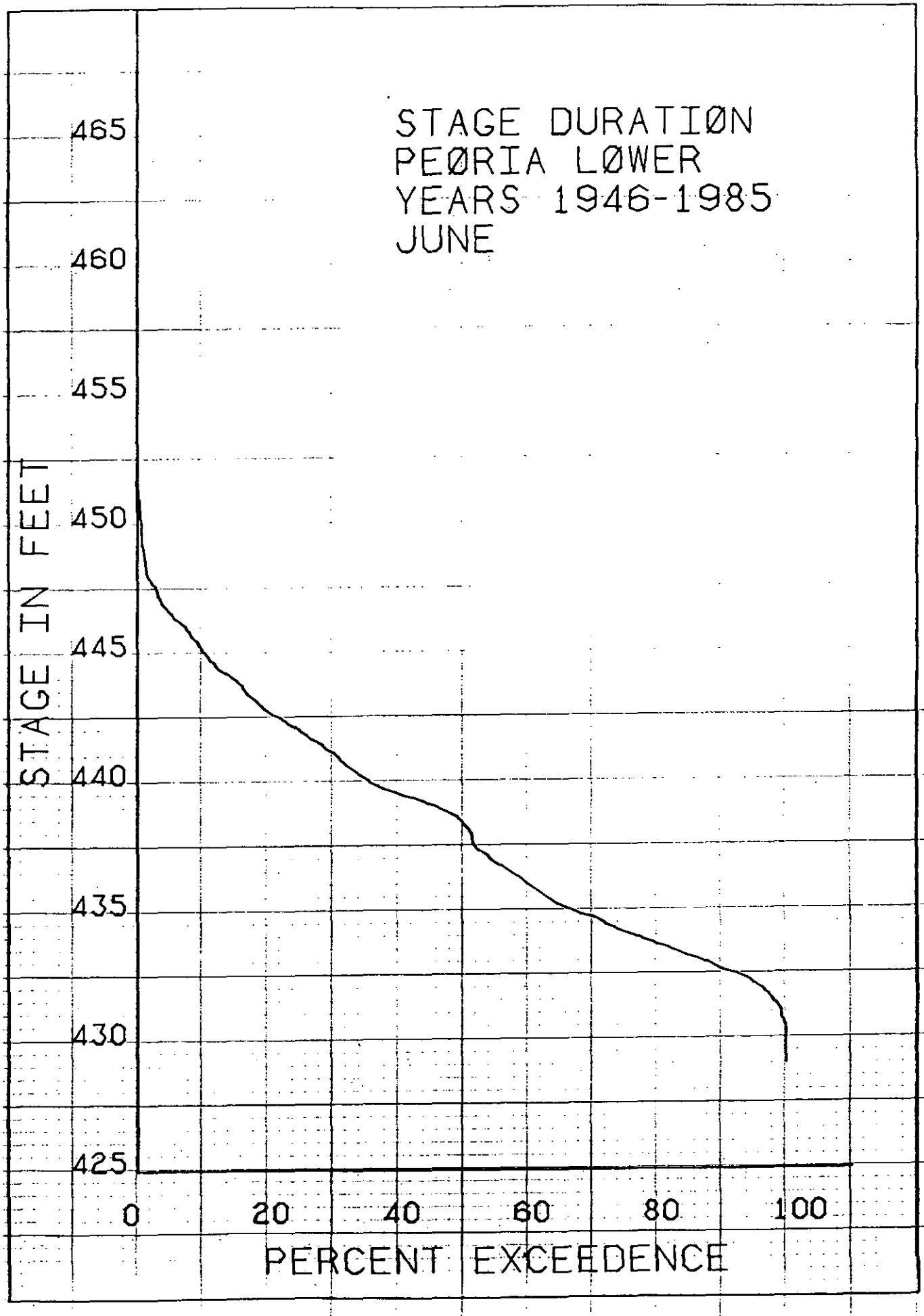
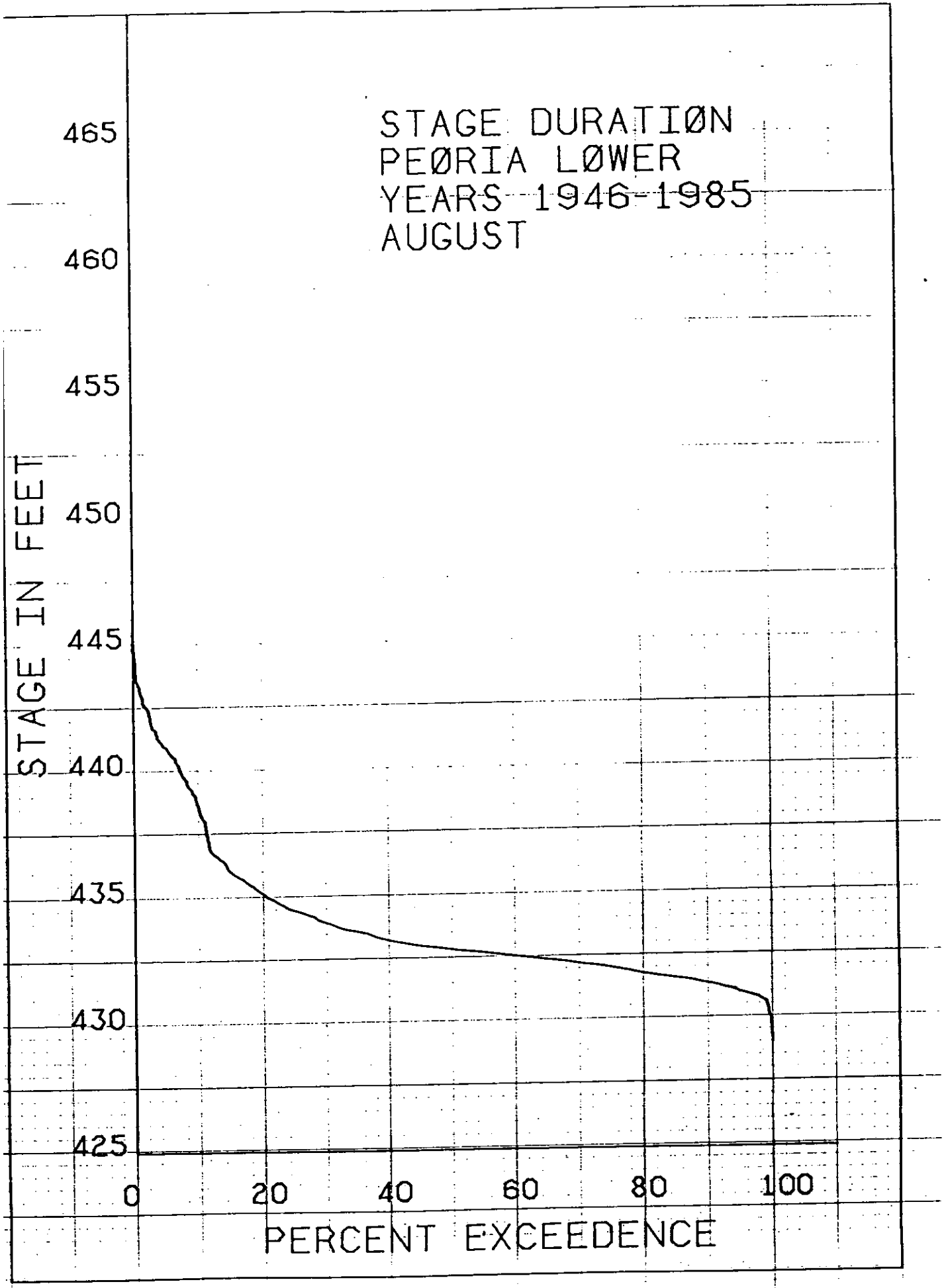

STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
MAY
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-141


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
JUNE
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
JUNE
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
AUGUST
465
460
455
450
445
440
435
430
425
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE

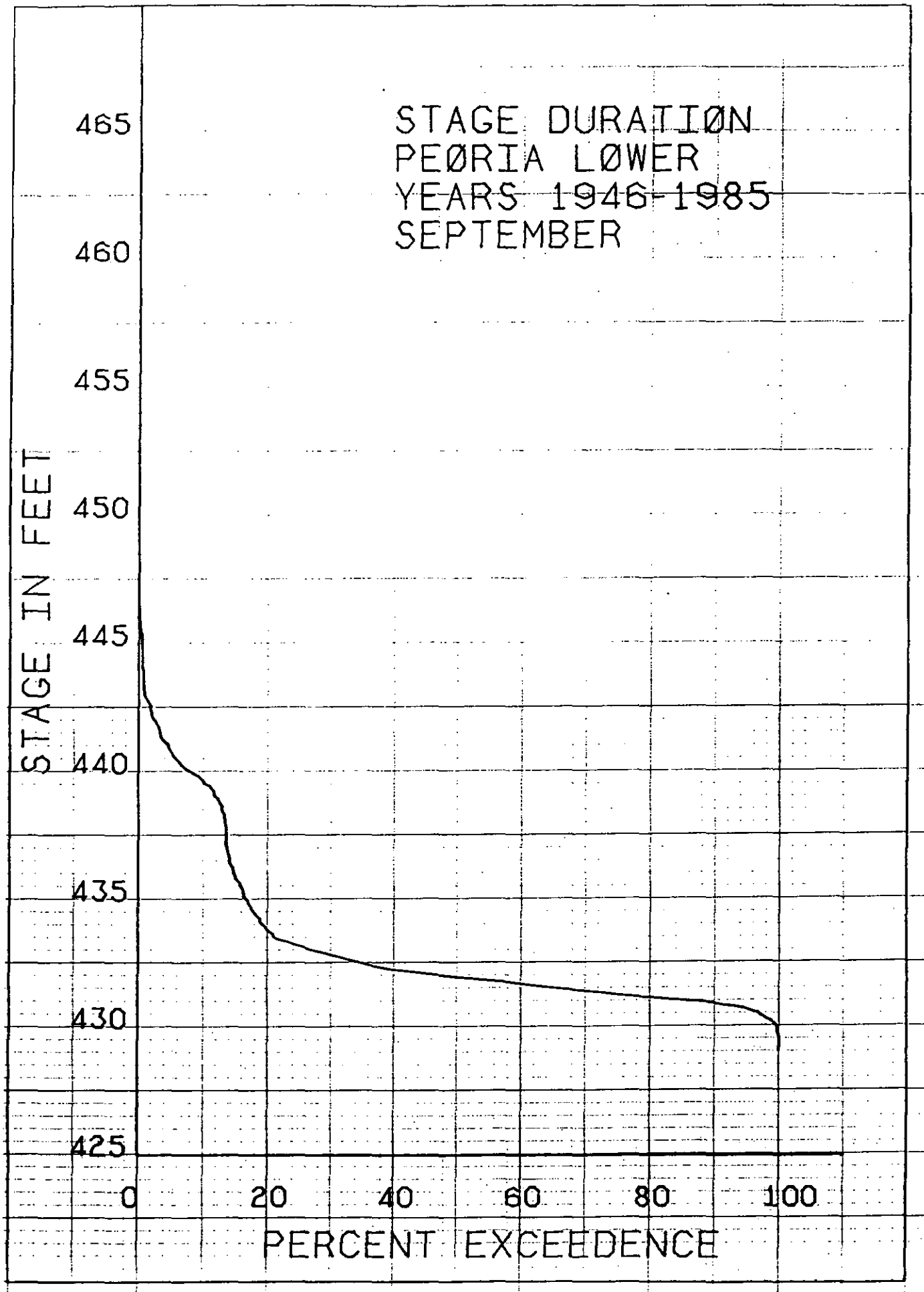
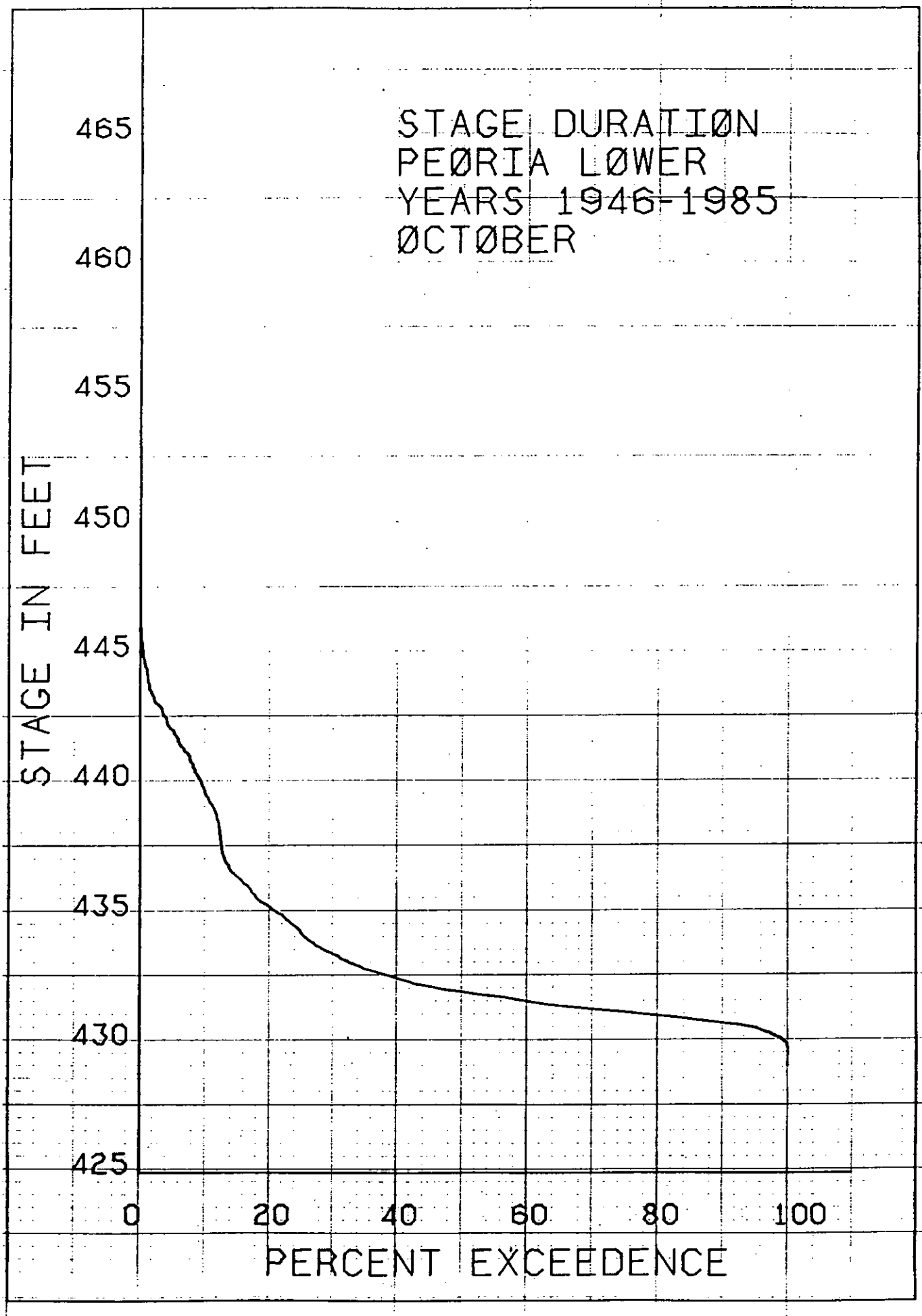
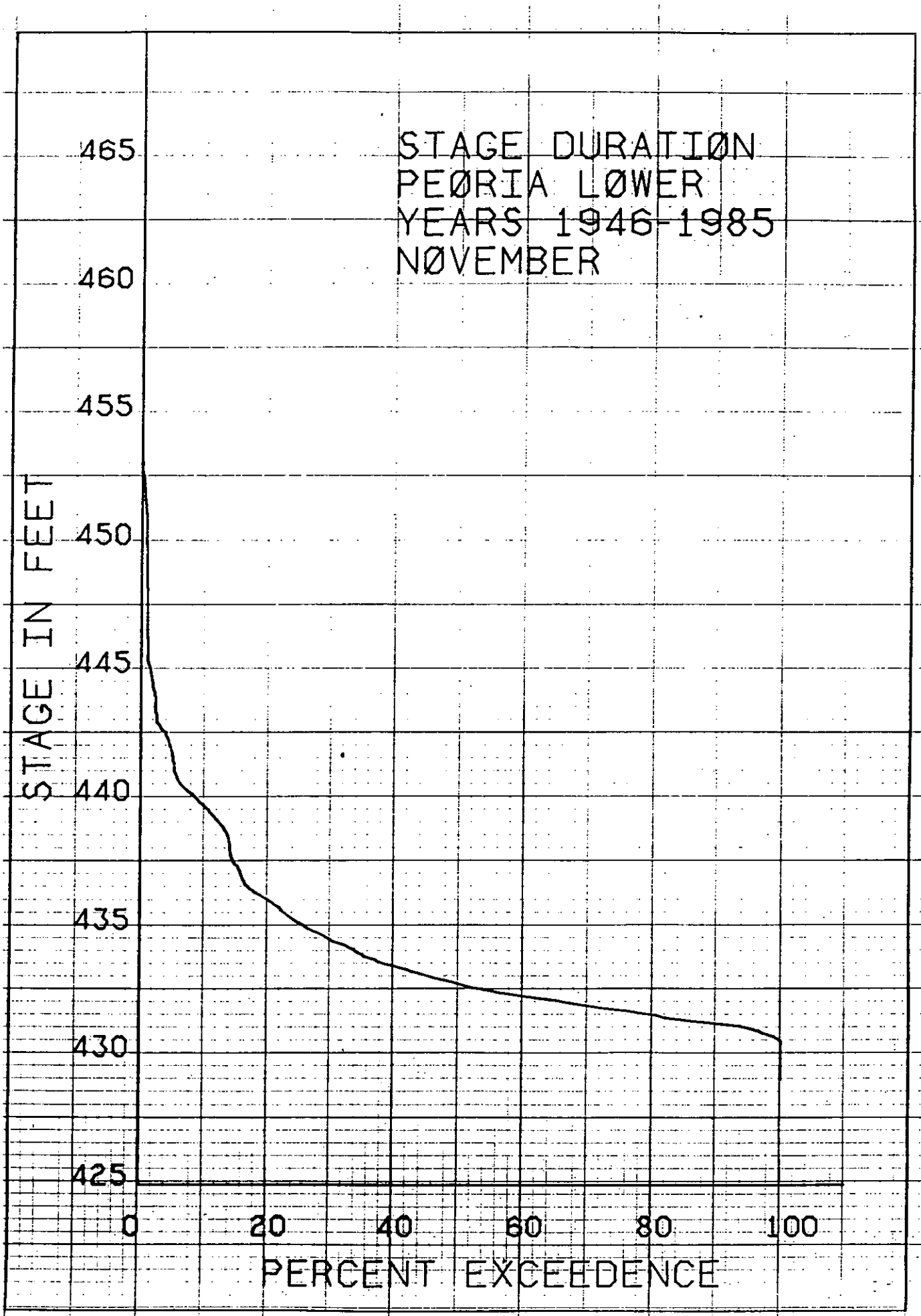

STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
SEPTEMBER
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-145


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
ØCTØBER
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
NØVEMBER
465
460
455
450
445
440
435
430
425
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE

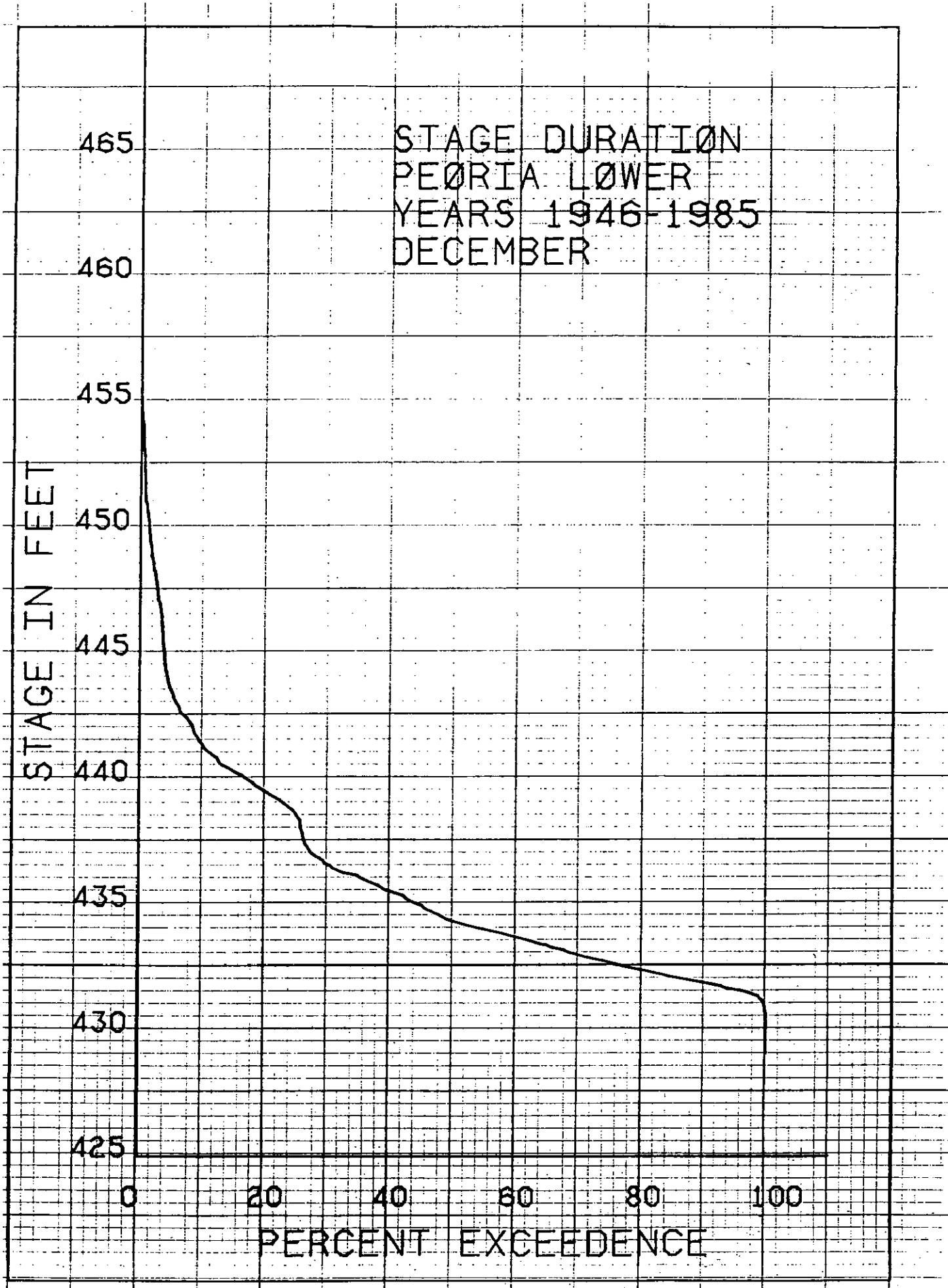
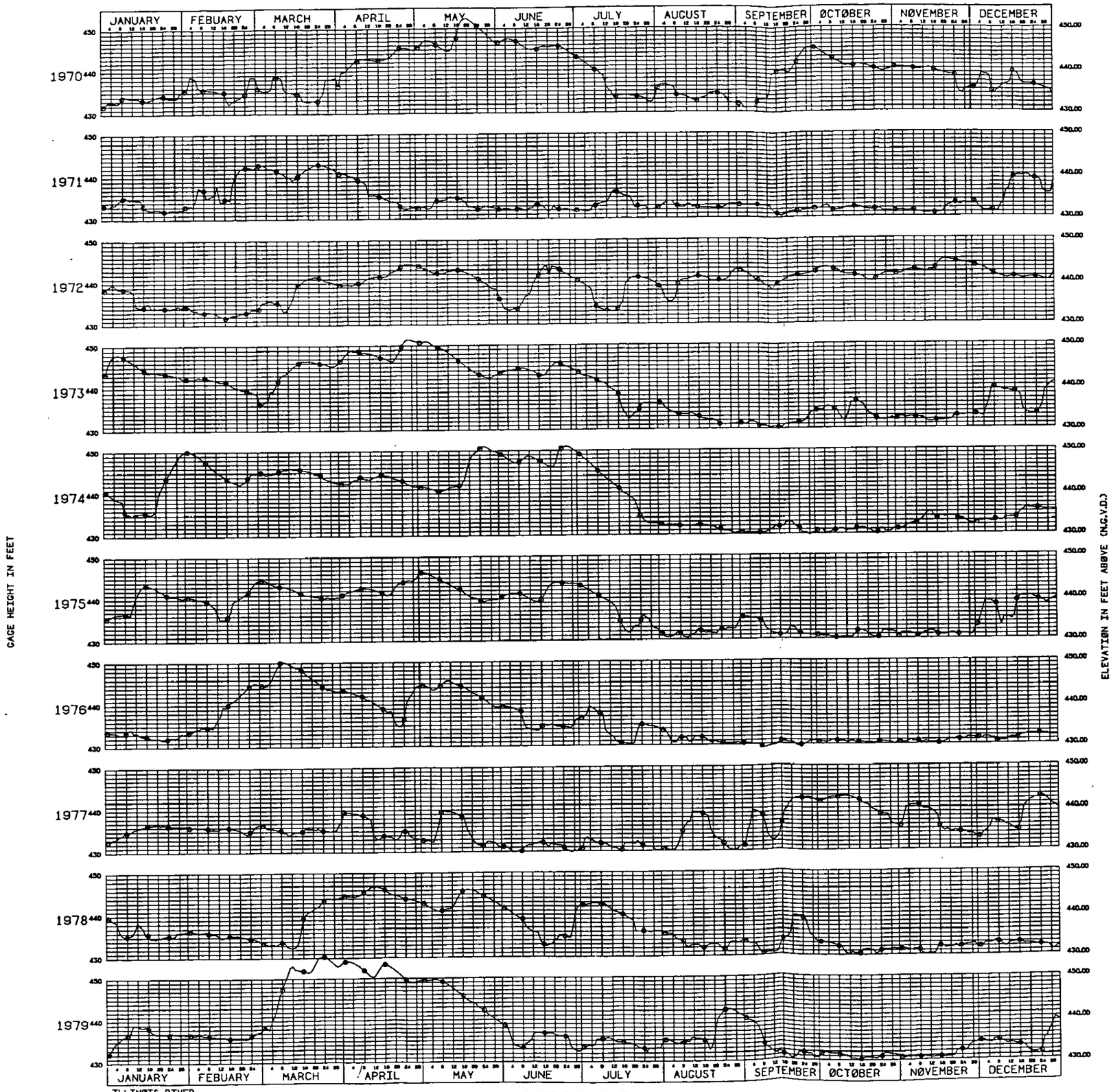

STAGE DURATIØN
PEØRIA LØWER
YEARS 1946-1985
DECEMBER
STAGE IN FEET
465
460
455
450
445
440
435
430
425
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-148



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
PEØRIA'S TAILWATER

Symbol	Description of Revisions	Date	Approved

US Army Corps of Engineers

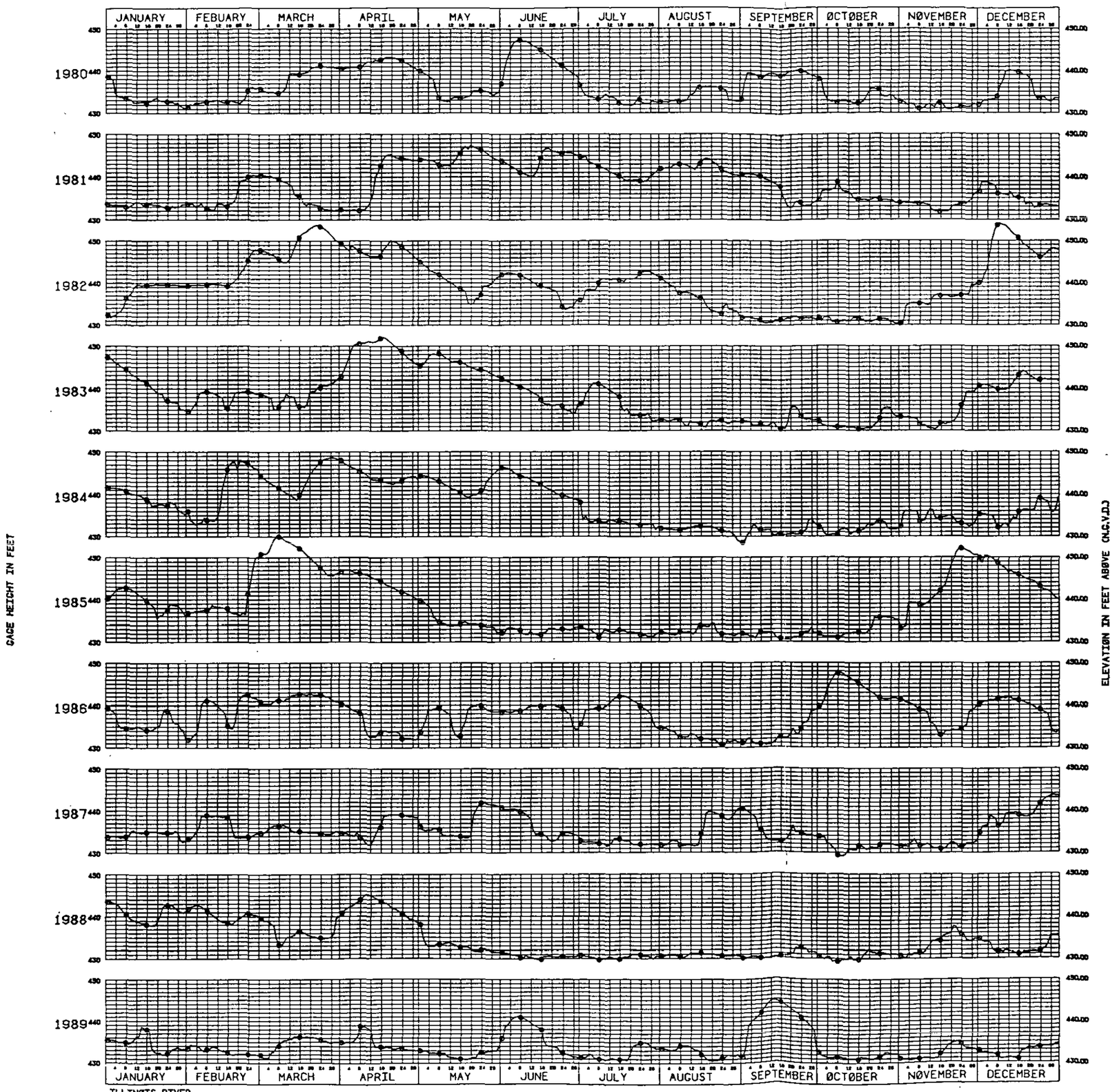
U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:
Drawn by:
Checked by:

PLATE D-149

Submitted by:
CHIEF DESIGN BRANCH
Approved by:
CHIEF, ENGINEERING DIVISION

Scale:
Date:
Drawing number:
Sheet _ of _



ILLINØIS RIVER

NØTE-

HYDRØGRAPH

DEØRTA'S TATI WATER

Symbol	Description of Revisions	Date	Approved

US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

Designed by:

Drawn by:

Checked by:

Submitted by:

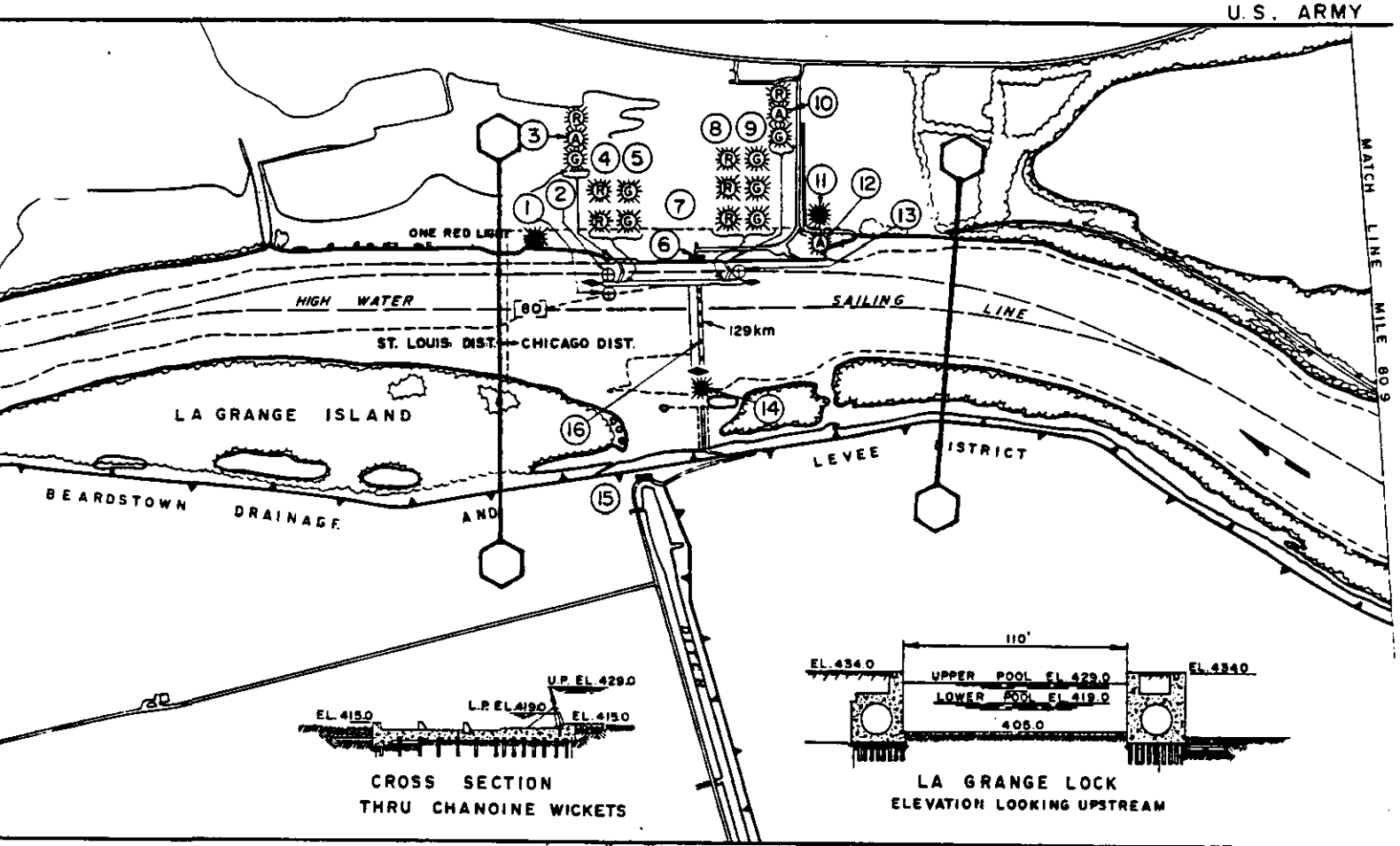
CHIEF, DESIGN BRANCH

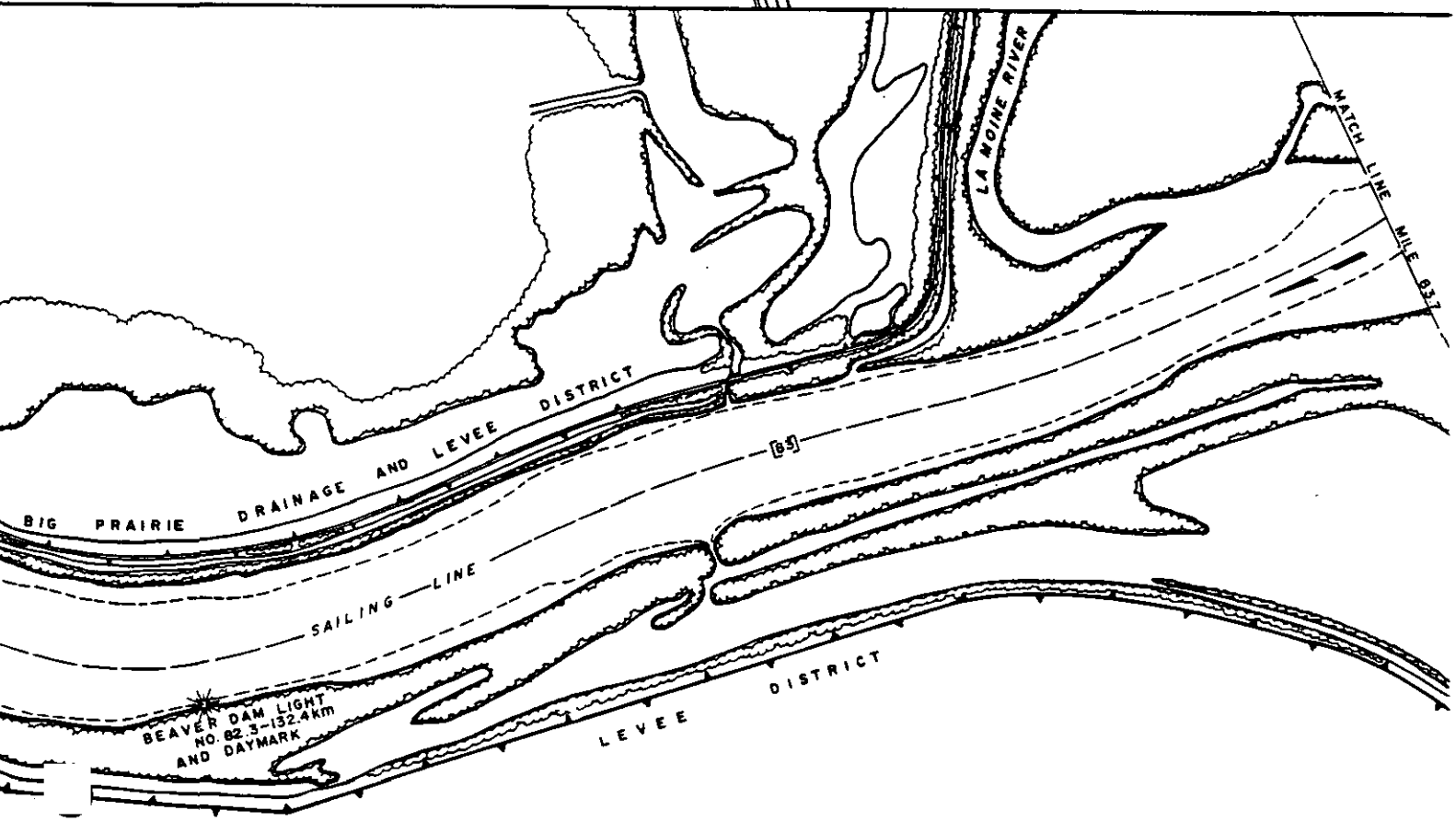
Approved by:

Scale:

Date:

PLATE D-150



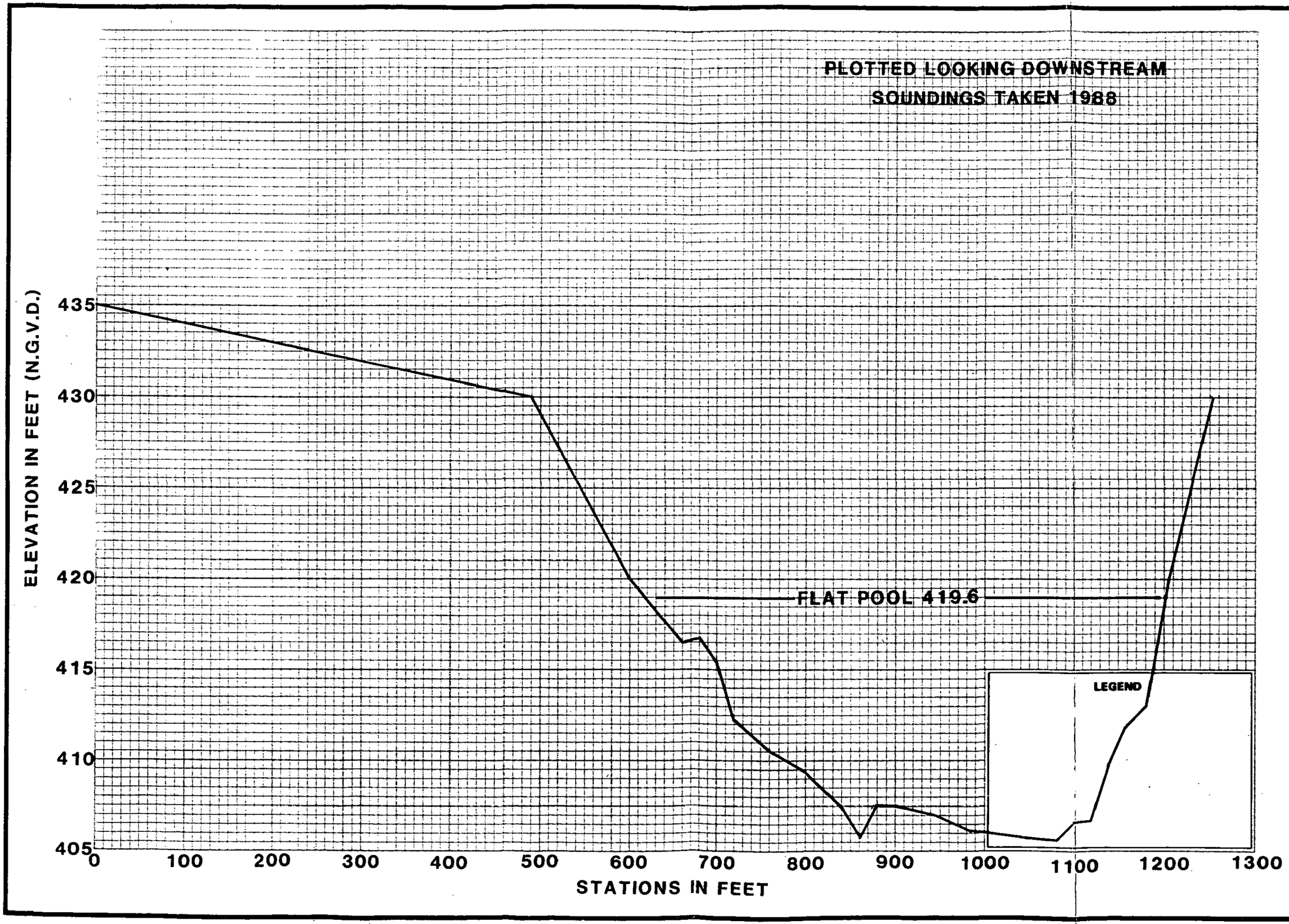


100 200 300 400 500 600 700
SCALE 1000m = 1km

SCALE 1 INCH = 1000 FEET
500 0 500 1000 1500

MILE 78.1 TO MILE 83.7

PLATE D-151

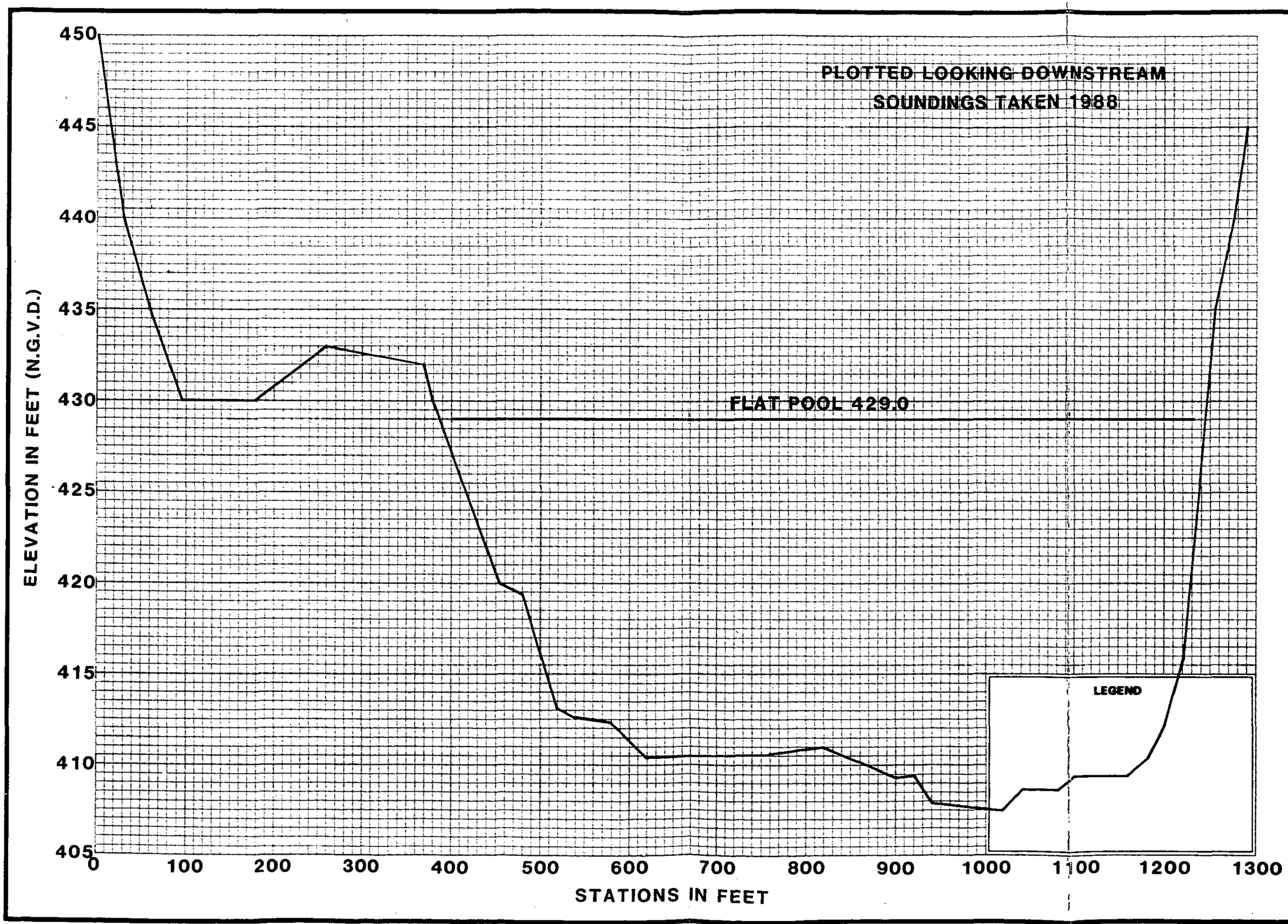


CHANNEL SECTION RIVER MILE 79.78

ILLINOIS RIVER

LA GRANGE TAIL

PLATE D-152

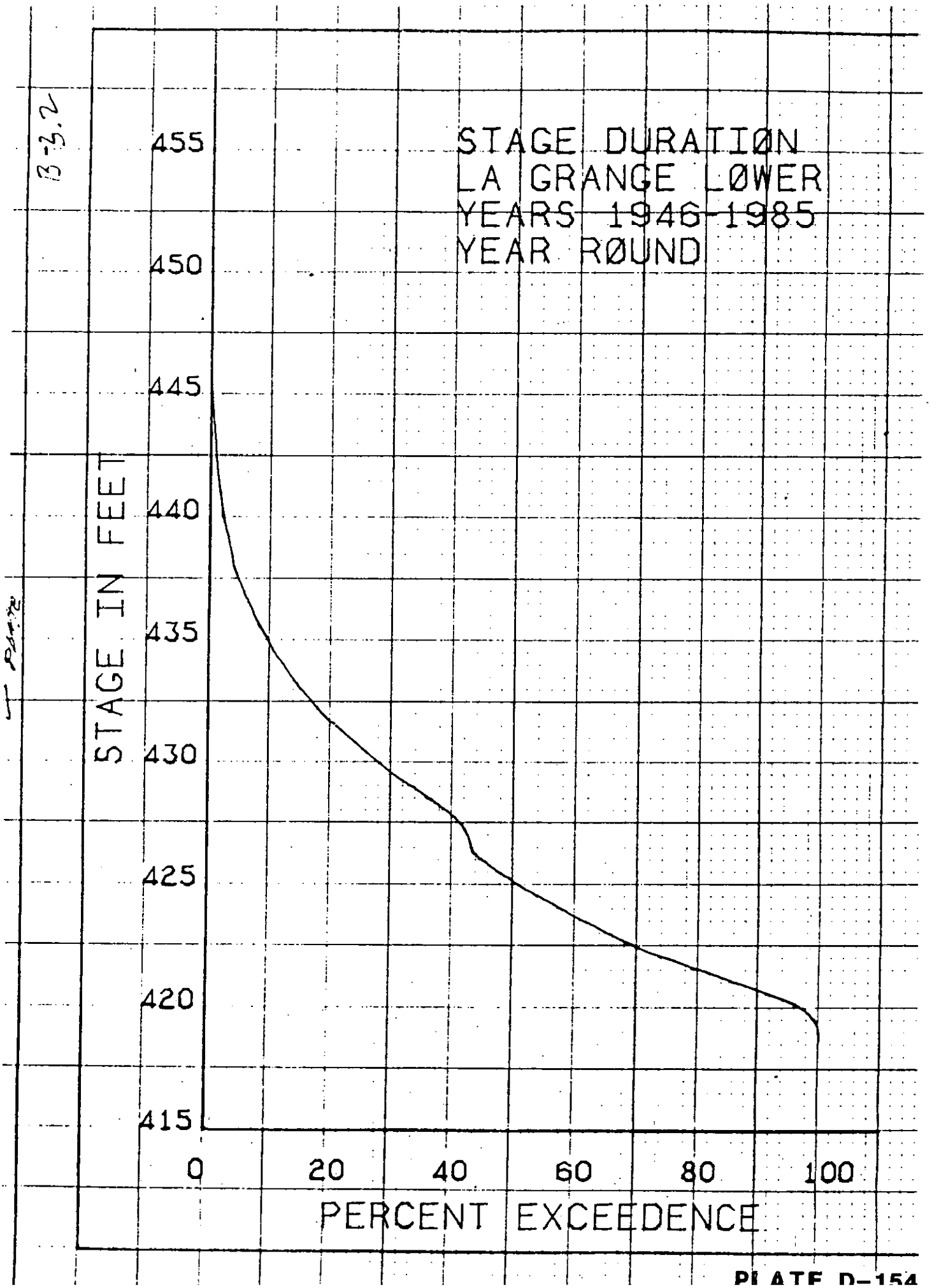


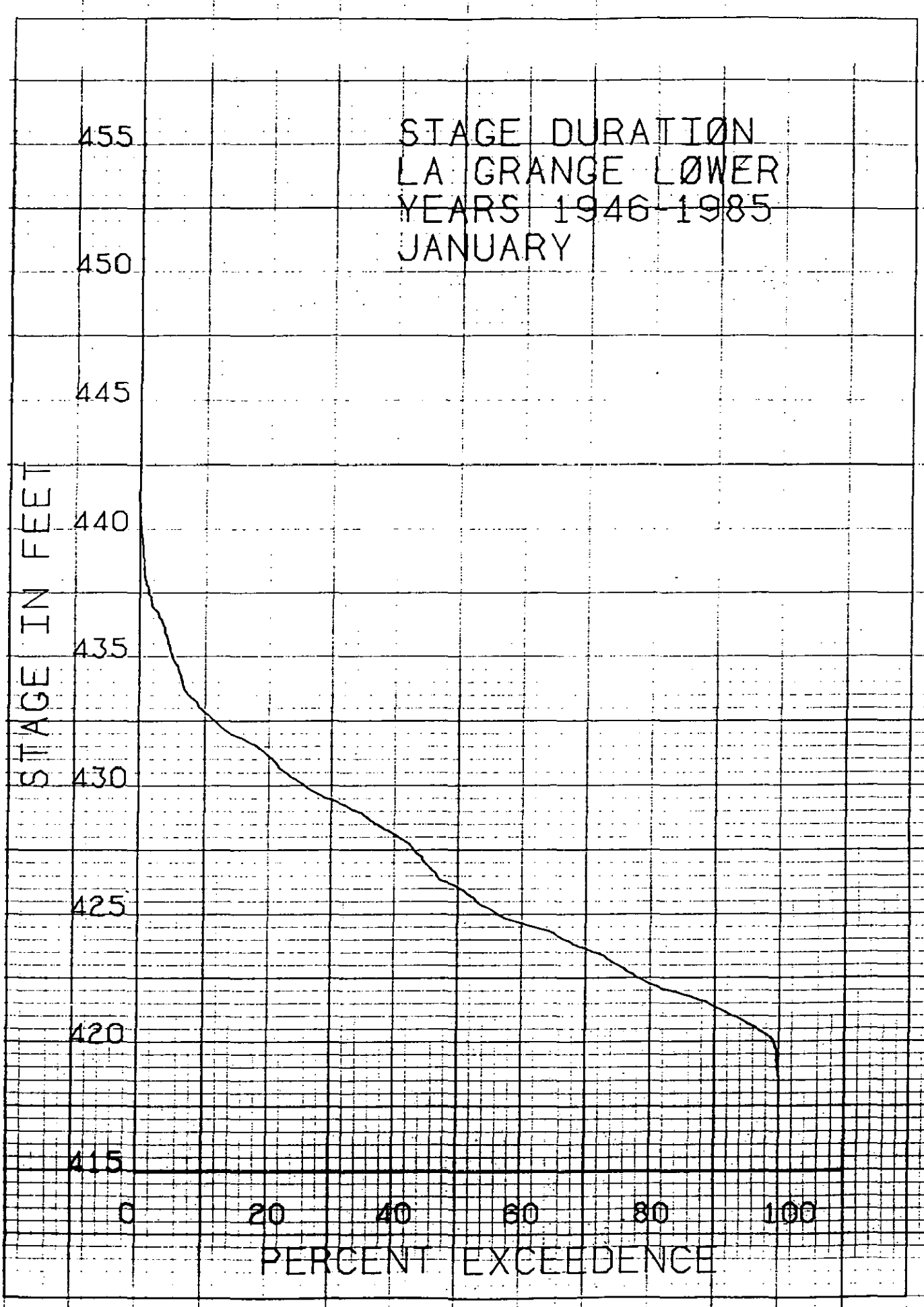
CHANNEL SECTION RIVER MILE 80.52

ILLINOIS RIVER

LA GRANGE POOL

PLATE D-153


B-3.2
STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
YEAR RØUND
455
450
445
440
435
430
425
420
415
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATION
LA GRANGE LOWER
YEARS 1946-1985
JANUARY
STAGE IN FEET
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450
445
440
435
430
425
420
415
0
20
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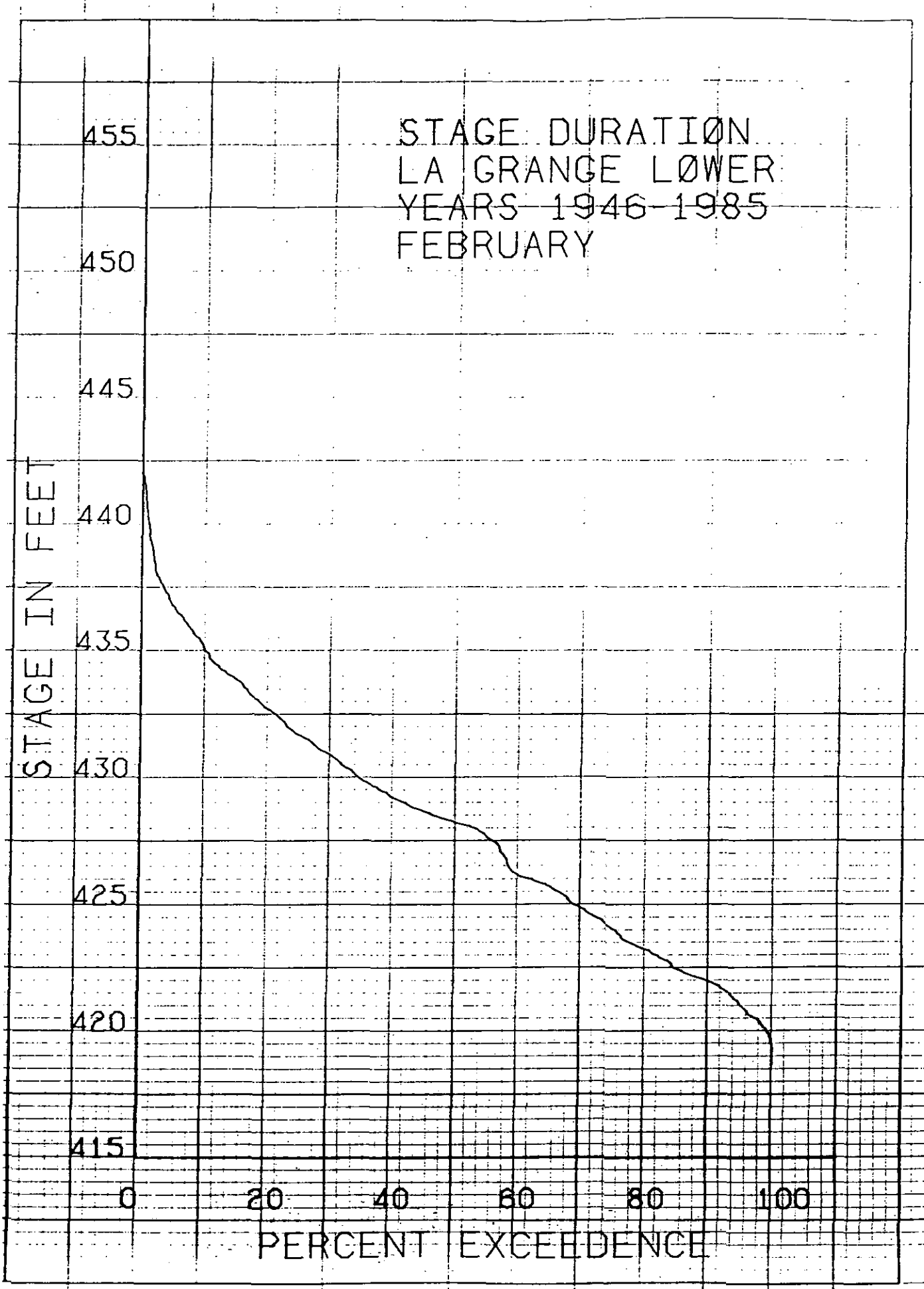
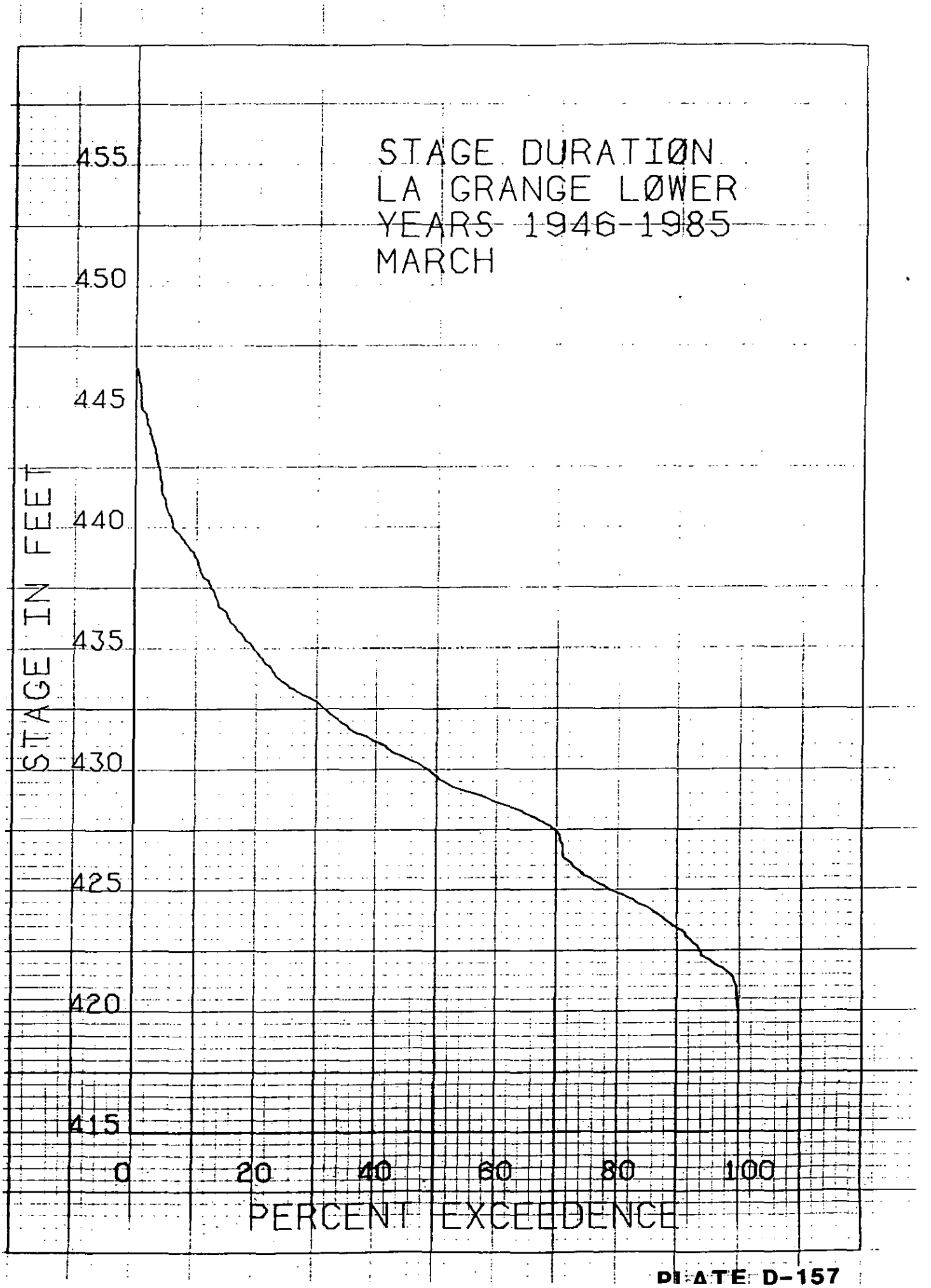
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
FEBRUARY
STAGE IN FEET
455
450
445
440
435
430
425
420
415
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
MARCH
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445
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435
430
425
420
415
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE

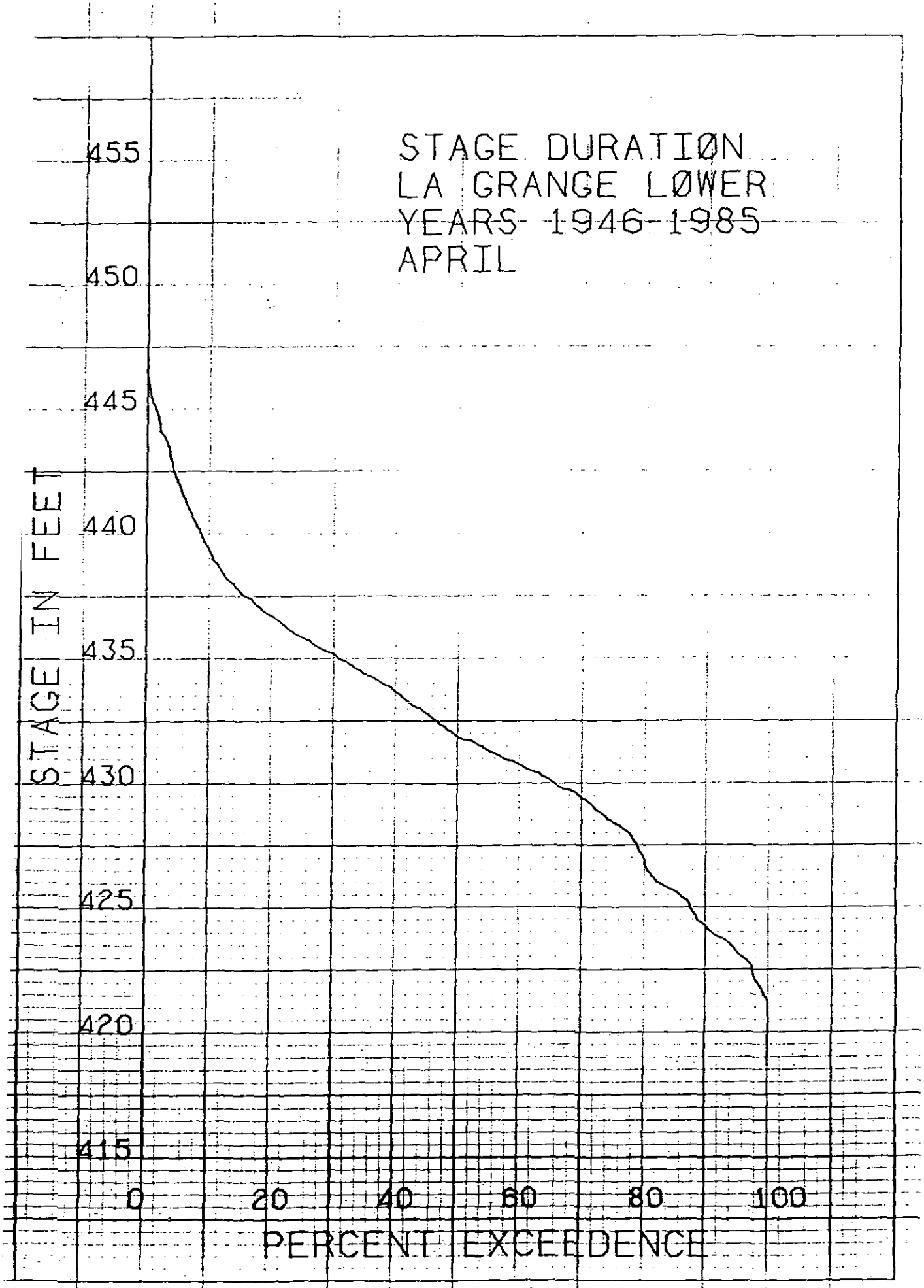
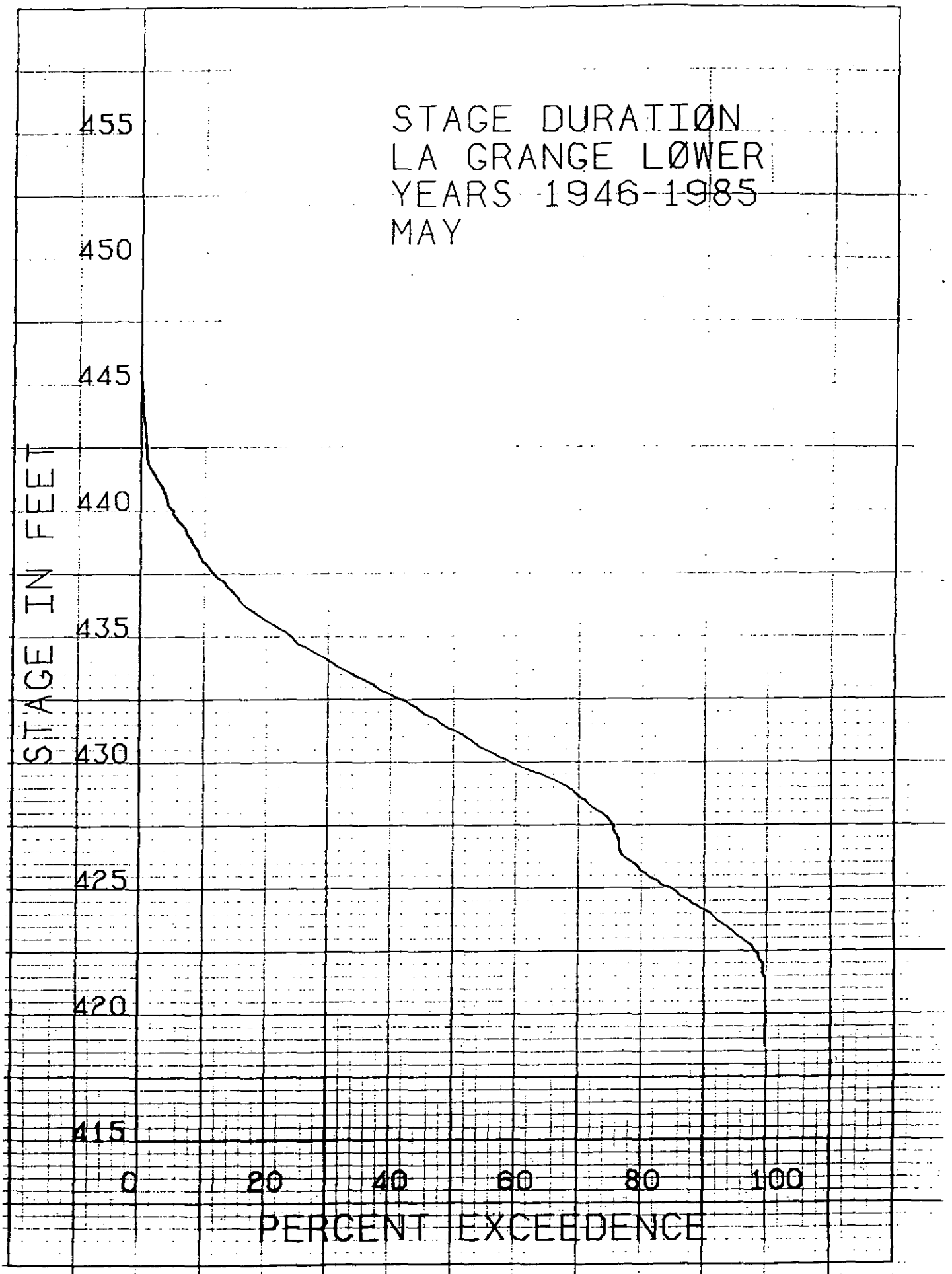

STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
APRIL
455
450
445
440
435
430
425
420
415
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-158


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
MAY
455
450
445
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435
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425
420
415
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-159

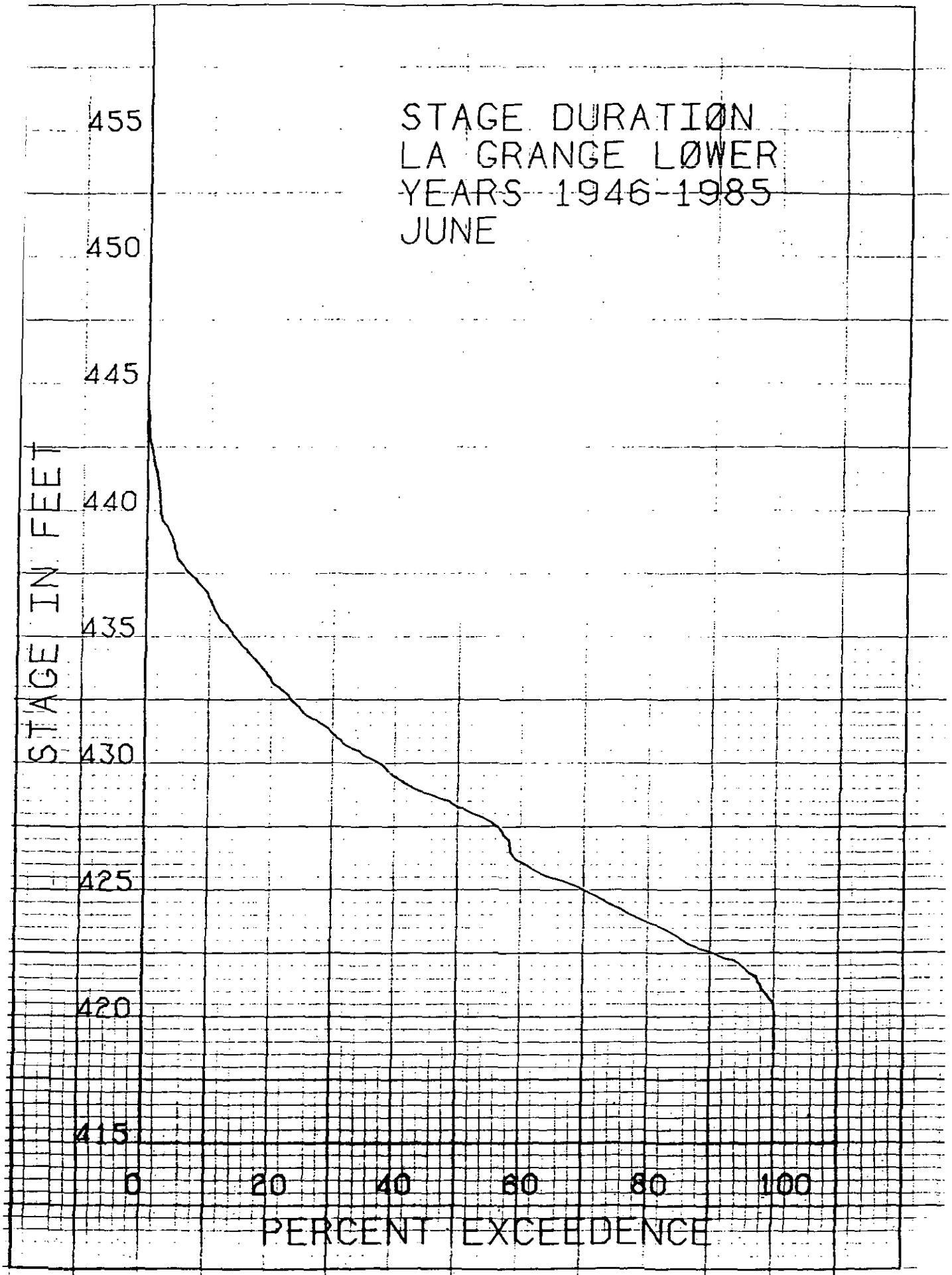
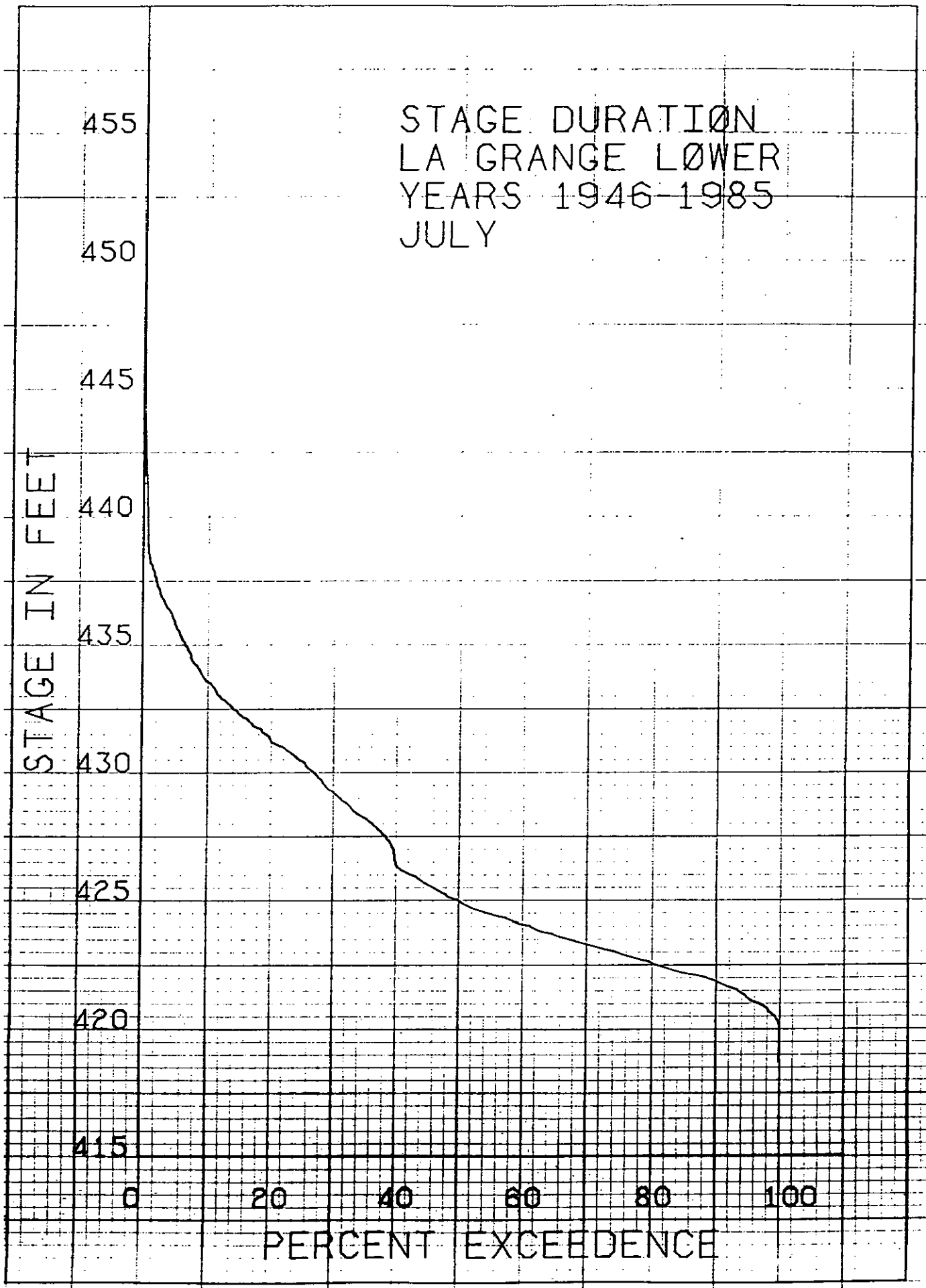

STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
JUNE
455
450
445
440
435
430
425
420
415
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE

PLATE D-160


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
JULY
STAGE IN FEET
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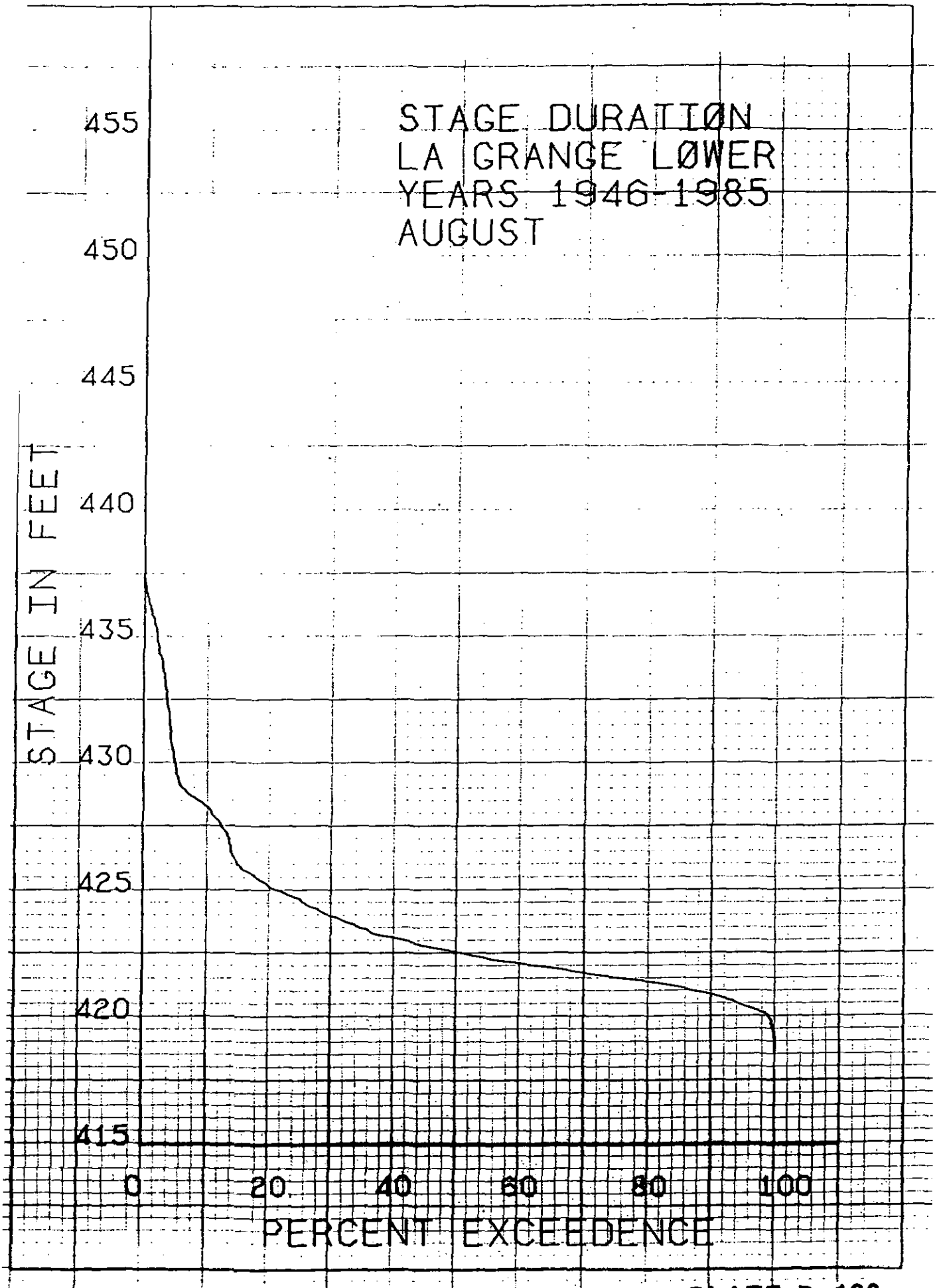
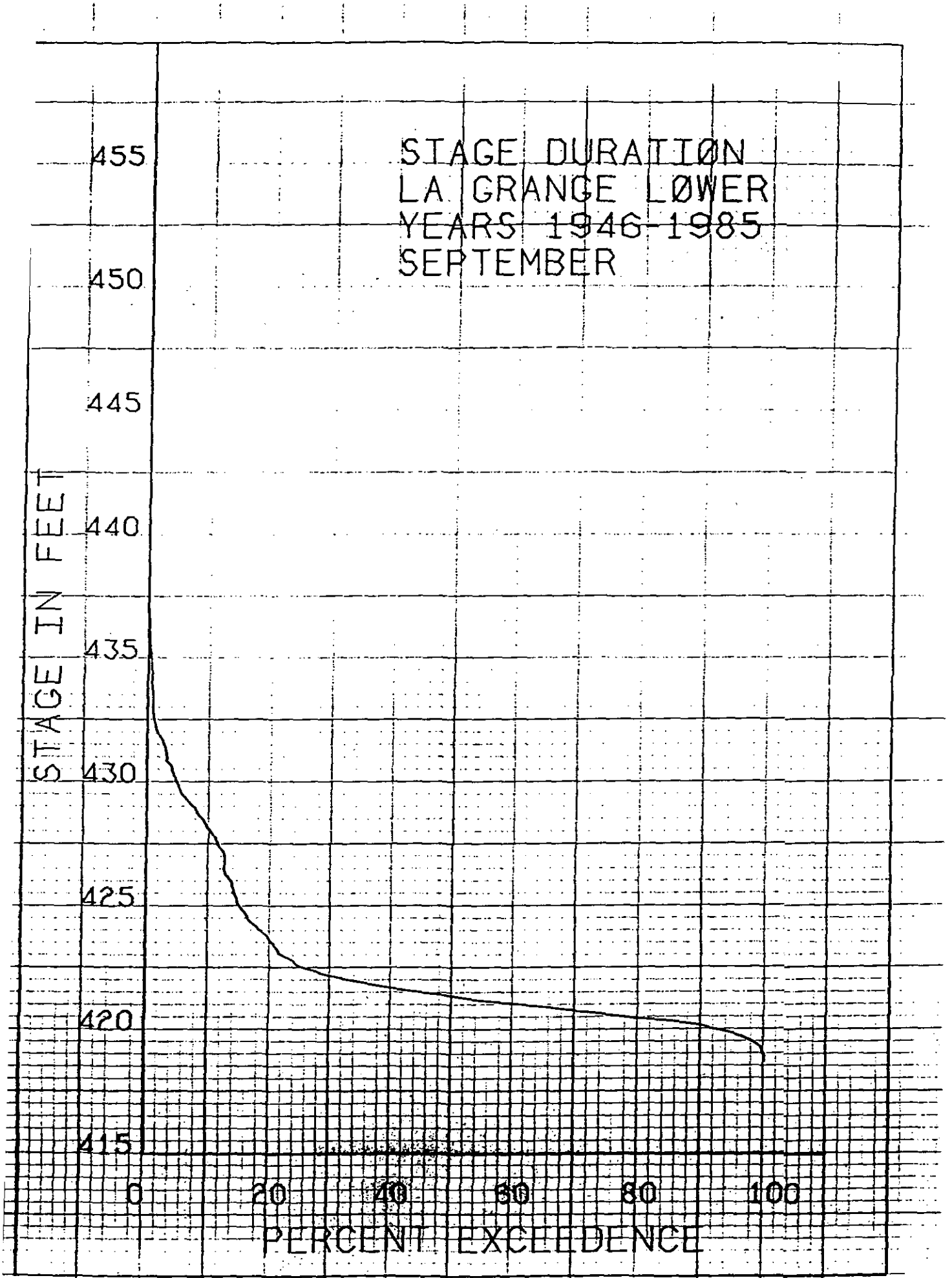
450
445
440
435
430
425
420
415
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
AUGUST
STAGE IN FEET
455
450
445
440
435
430
425
420
415
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
SEPTEMBER
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450
445
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435
430
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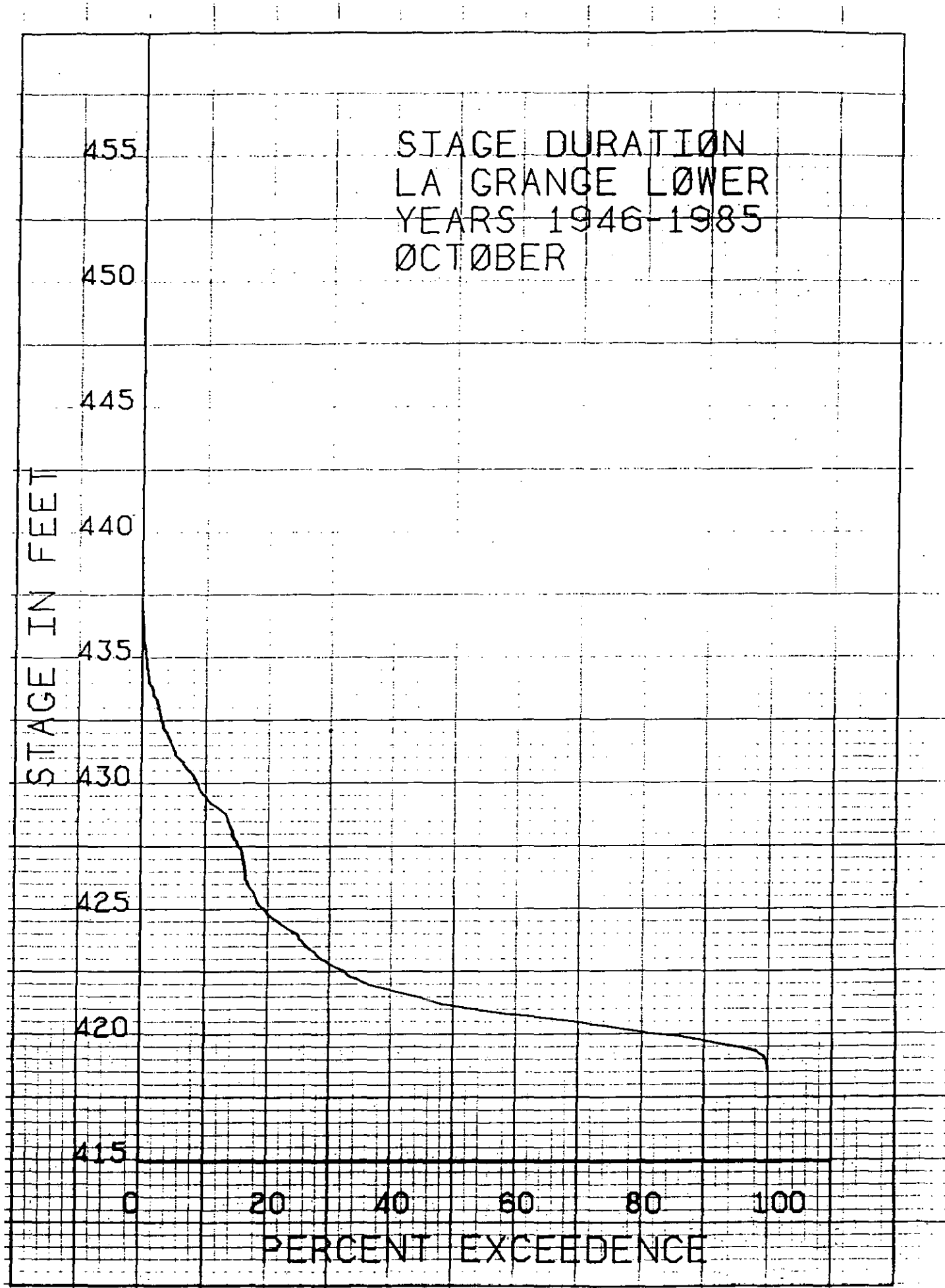
420
415
STAGE IN FEET
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
ØCTØBER
STAGE IN FEET
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425
420
415
0
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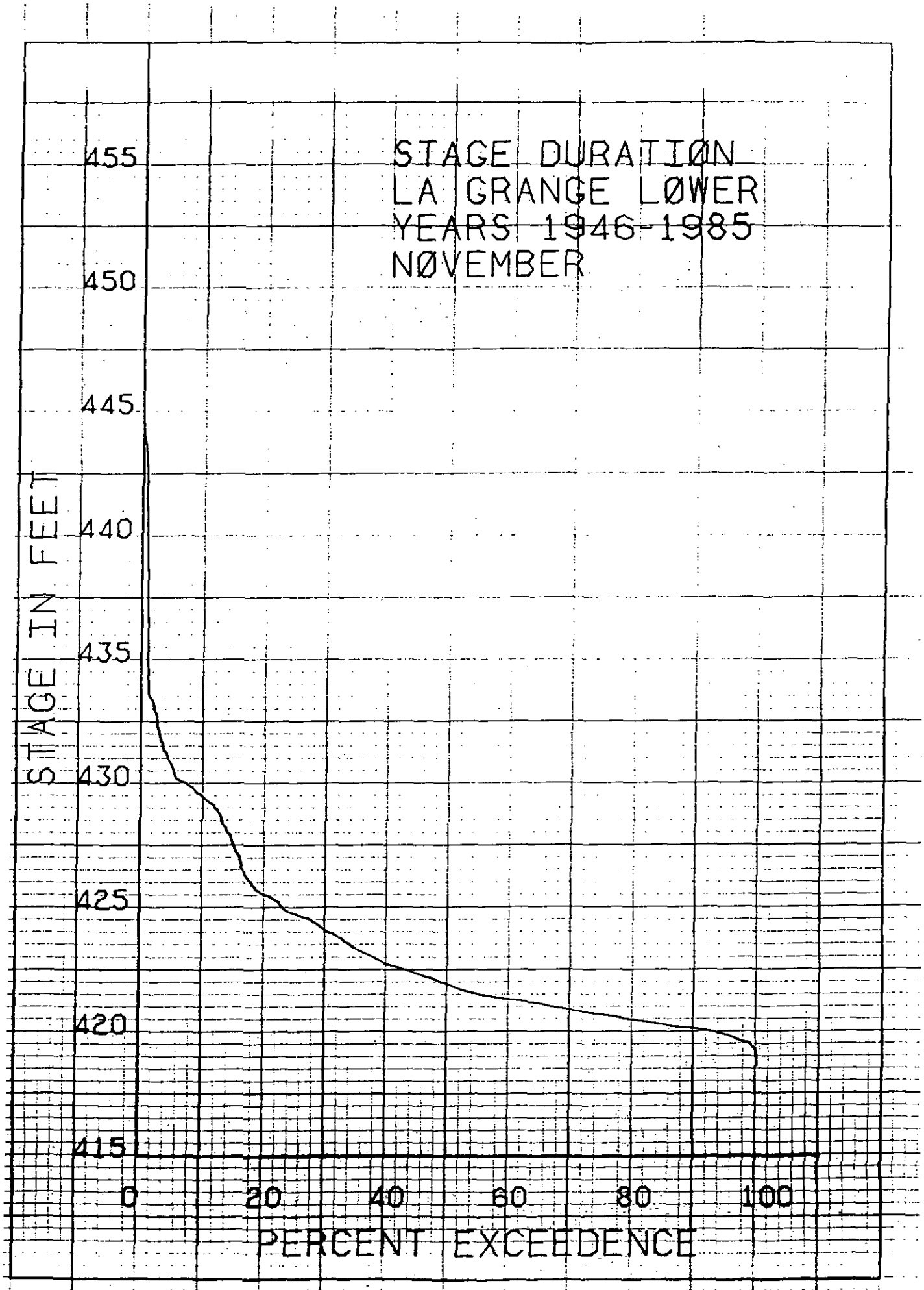
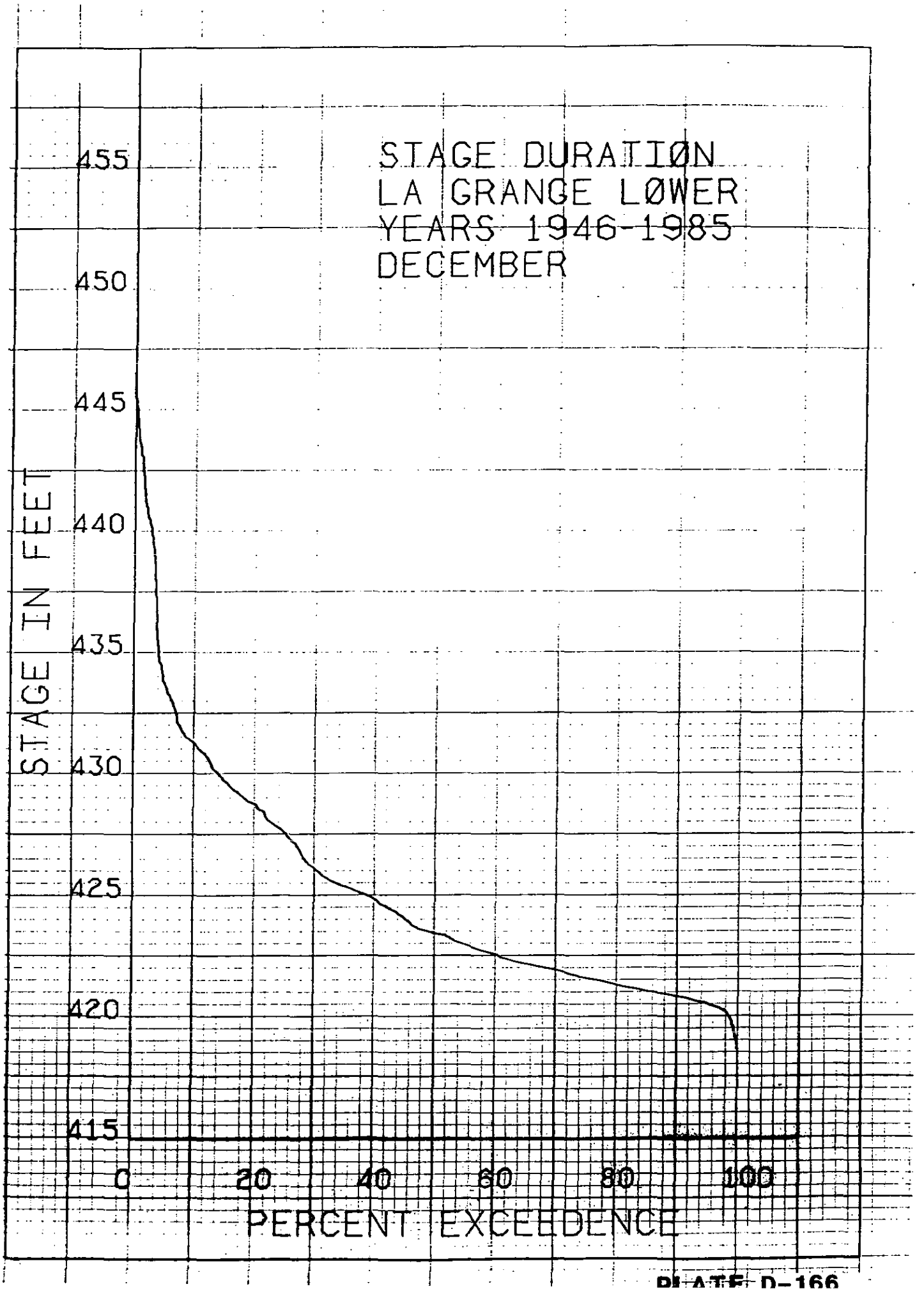
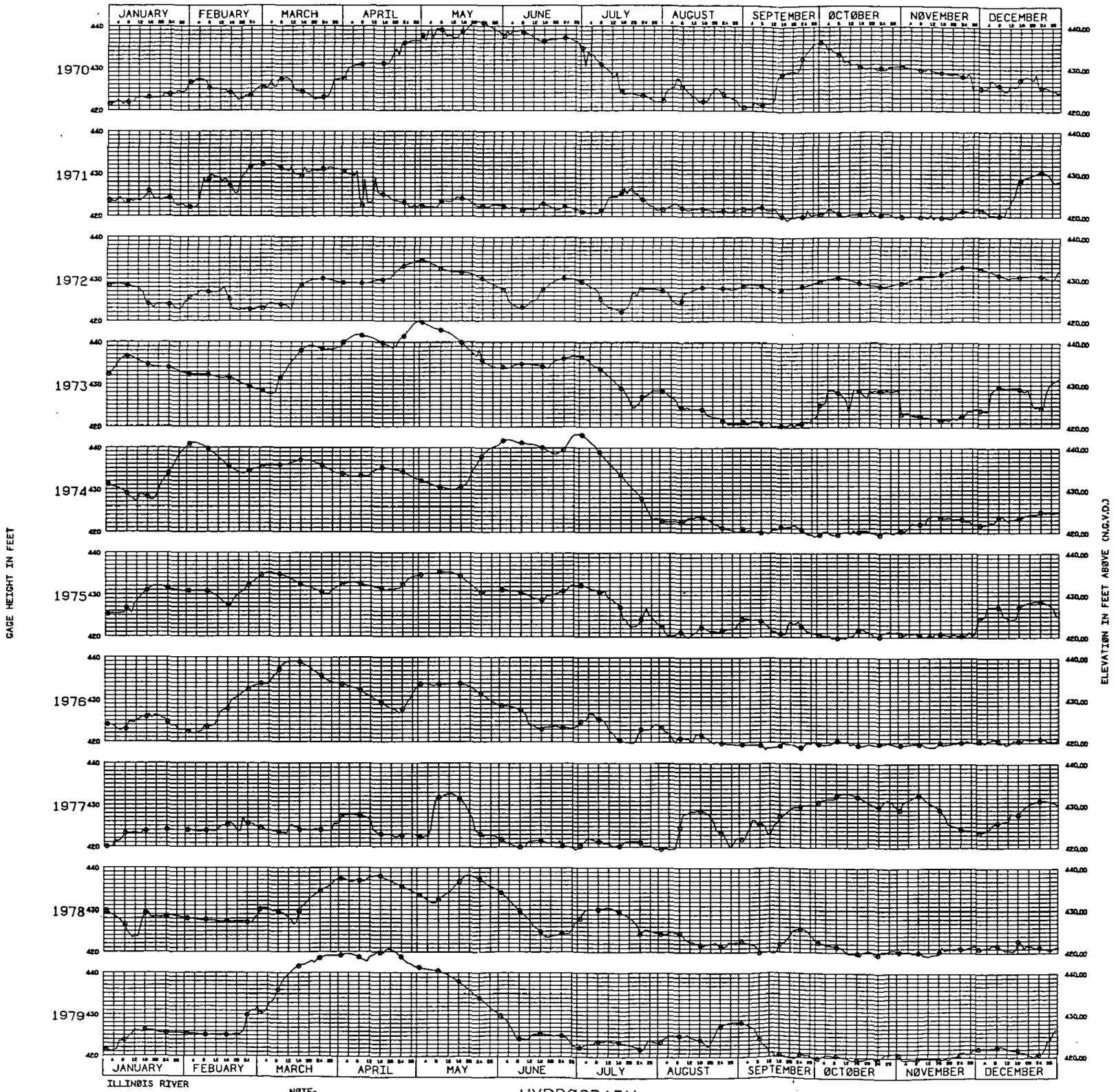
60
80
100
PERCENT EXCEEDENCE

PLATE D-164


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
NØVEMBER
STAGE IN FEET
455
450
445
440
435
430
425
420
415
0
20
40
60
80
100
PERCENT EXCEEDENCE


STAGE DURATIØN
LA GRANGE LØWER
YEARS 1946-1985
DECEMBER
STAGE IN FEET
455
450
445
440
435
430
425
420
415
0
20
40
60
80
100
PERCENT EXCEEDENCE



NØTE-

HYDRØGRAPH
LA GRANGE'S TAILWATER

Symbol	Description of Revisions	Date	Approved

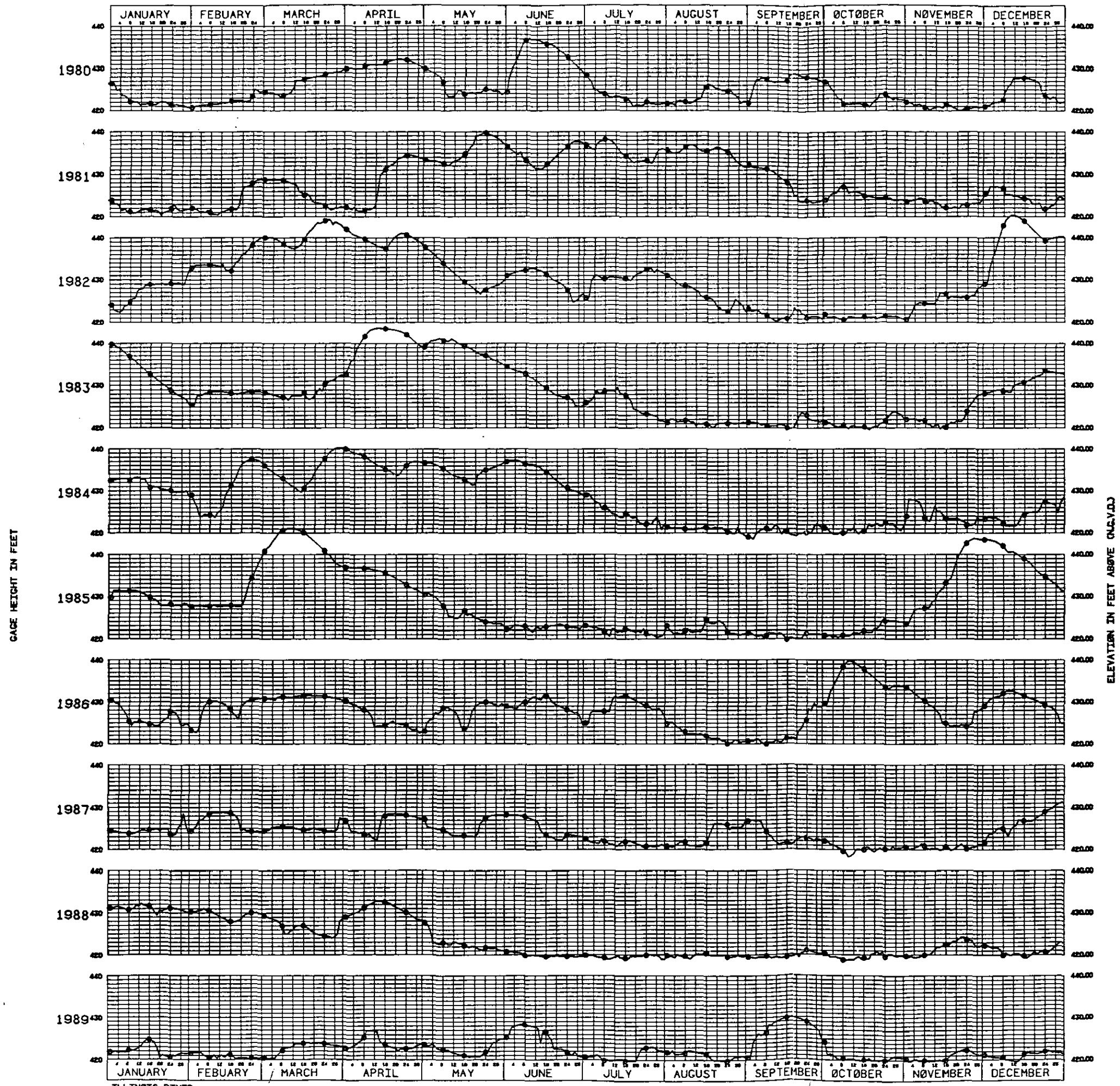
U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

US Army Corps of Engineers

Designed by:
Drawn by:
Checked by:
Submitted by:
CHIEF, DESIGN BRANCH
Approved by:

PLATE D-167

Scale:
Date:



ILLINØIS RIVER

NØTE-

HYDRØGRAPH
LA GRANGE'S TAIL WATER

Symbol	Description of Revisions	Date	Approved

U. S. ARMY ENGINEER DISTRICT, ROCK ISLAND
CORPS OF ENGINEERS
ROCK ISLAND, ILLINOIS

US Army Corps of Engineers

Designed by:
Drawn by:
Checked by:

PLATE D-168

Submitted by:
CHIEF, DESIGN BRANCH
Approved by:

Scale:
Date: