TECHNICAL EVALUATION REPORT

HYDROLOGICAL CONSIDERATIONS

COMMONWEALTH EDISON COMPANY

DRESDEN STATION UNIT 2

NRC DOCKET NO. 50-237

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

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1. INTRODUCTION

1.1 PURPOSE OF REVIEW

The purpose of this review is to evaluate the U.S. Nuclear Regulatory Commission's (NRC) Systematic Evaluation Program (SEP) Topics II-3.A (Hydrologic Description), II-3.B (Flooding Potential and Protection Requirements), II-3.B.1 (Capability of Operating Plants to Cope with Design Basis Flooding Conditions), and II-3.C (Safety-Related Water Supply - Ultimate Heat Sink) for Dresden Station Unit 2. This review includes independent analyses by the Franklin Research Center (FRC) as needed to identify various hydrologic conditions. The NRC is reviewing other safety topics within the SEP and intends to coordinate an integrated assessment of plant safety after completion of the review of all applicable safety topics and design basis events (DBEs).

1.2 GENERIC BACKGROUND

The SEP was established to evaluate the safety of 11 of the older nuclear power plants. An important element of the program is the evaluation of the plants against current licensing criteria with respect to 137 selected topics, several of which relate to hydrologic assessments of the site.

In a letter dated January 14, 1981 [1], the NRC agreed to the SEP Owners Group's proposed redirection of the SEP, whereby each licensee would submit evaluations of 60% of the SEP topics in time for a review by the NRC staff to be completed by June 1981. Evaluations of the topics not selected by each licensee were the NRC's responsibility.

1.3 PLANT-SPECIFIC BACKGROUND

This technical evaluation report presents an evaluation of the hydrologic influences at the Dresden Station Unit 2 site. The assessment compares Dresden Station Unit 2 against the criteria currently used by the regulatory staff for licensing new facilities. The Licensee, Commonwealth Edison Company, will be instructed to inform the NRC whether the as-built facility differs from the licensing basis assumed in this assessment.

2. REVIEW CRITERIA

The reference criteria used for all the hydrology topics were based on the Code of Federal Regulations, Volume 10, Section 50 (10CFR50), Appendix A, General Design Criteria, Overall Requirements, Criterion 2, entitled "Design Bases for Protection Against Natural Phenomena." Specific topic review criteria were taken from the following documents:

Standard Review Plan (SRP)

2.4.1	Hydrologic Description
2.4.2	Floods
2.4.3	Probable Maximum Flood (PMF) on Streams and Rivers
2.4.4	Potential Dam Failures
2.4.5	Probable Maximum Surge and Seiche Flooding
2.4.6	Probable Maximum Tsunami Flooding
2.4.7	Ice Effects
2.4.8	Cooling Water Canals and Reservoirs
2.4.9	Channel Diversions
2.4.10	Flooding Protection Requirements
2.4.11	Low Water Considerations
2.4.13	Groundwater

Regulatory Guides

1.27	Ultimate Heat Sink for Nuclear Power Plants
1.59	Design Basis Floods for Nuclear Power Plants
1.102	Flood Protection for Nuclear Power Plants
1.127	Inspection of Water Control Structures Associated with Nuclear Power Plants
1.135	Normal Water Level and Discharge at Nuclear Power Plants

American National Standards Institute N170-1976

Standards for Determining Design Basis Flooding at Power Reactor Sites.

3. TECHNICAL EVALUATION

3.1 HYDROLOGIC DESCRIPTION (TOPIC II-3.A)

3.1.1 Topic Background

An independent review of information pertaining to Systematic Evaluation Program (SEP) Topic II-3.A, Hydrologic Description, for the Dresden Power Station Unit 2 is presented in this section.

Information presented in this section was derived from several sources, including NRC docketed information, NRC staff files, communication with the U.S. Army Corps of Engineers, Sargent & Lundy Engineers, Illinois Waterway Commission, and local and state contacts.

3.1.2 Evaluation

Introduction

The Dresden Unit 2 Power Station is located at the extreme northeast corner of Section 35 of Township 34N, Range 8E in Grundy County, Illinois, as shown in Figure 1.

The Kankakee and Des Plaines watershed drains approximately 7300 square miles in northern Indiana and Illinois, as shown in Figure 2. The Kankakee and the Des Plaines Rivers join to form the Illinois River. Dresden Station is situated just below this junction, on the south bank of the Illinois River at river mile 273 [2]. Approximately 1 mile downstream from the plant is the Dresden Island Lock and Dam, one in a series of locks on the river system for navigational purposes.

The normal water level of the river above the Dresden Island Lock and Dam is 505 ft mean sea level (msl) [3]. The maximum historical flow at Dresden Island is 81,870 cubic ft per second (cfs), which results in a water level of 506.6 ft msl [4]; the river stage at the site is about one foot higher.

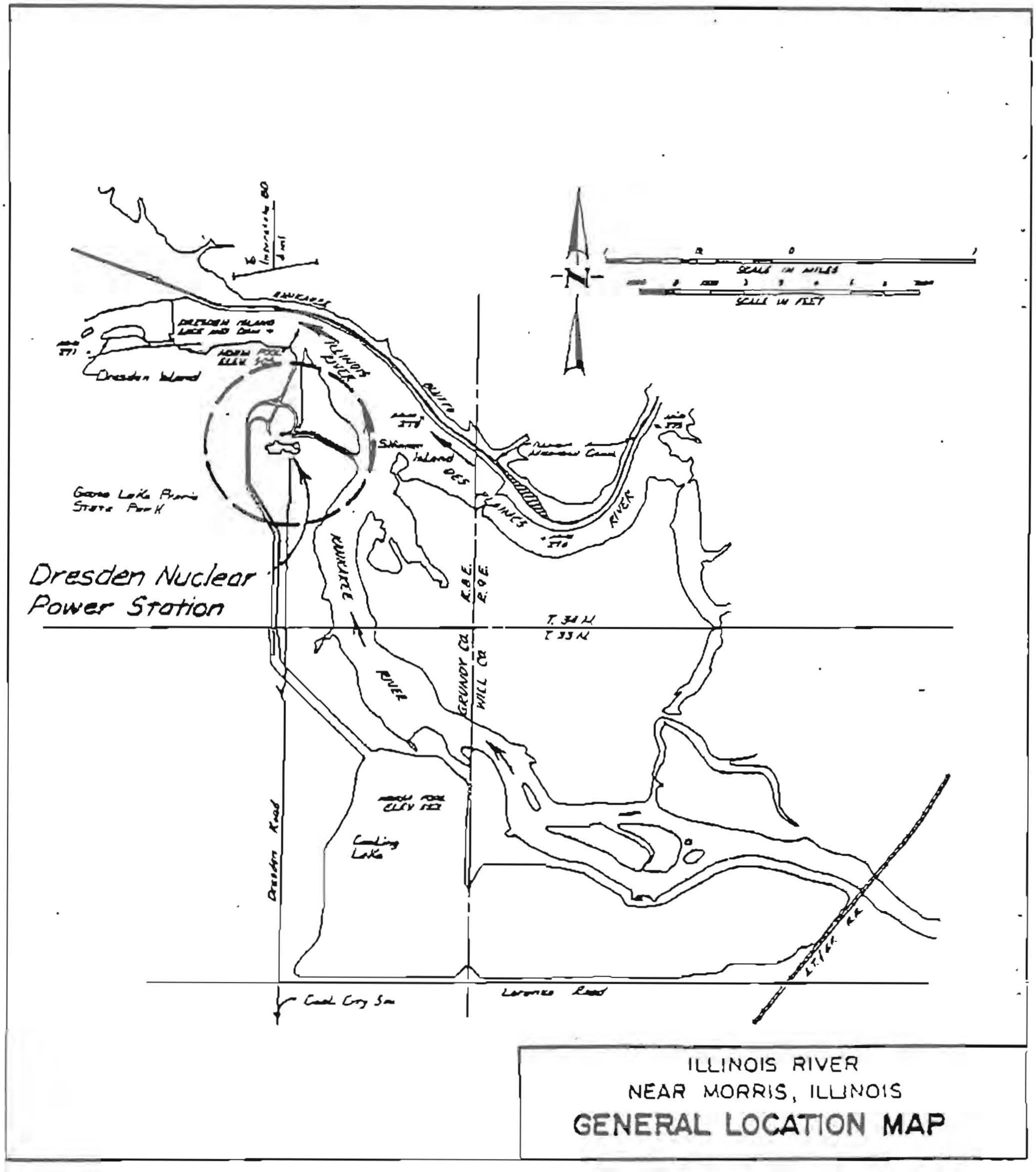

Figure 1. General Location Map for the Hydraulic Analysis of the Illinois River near Dresden Nuclear Power Station

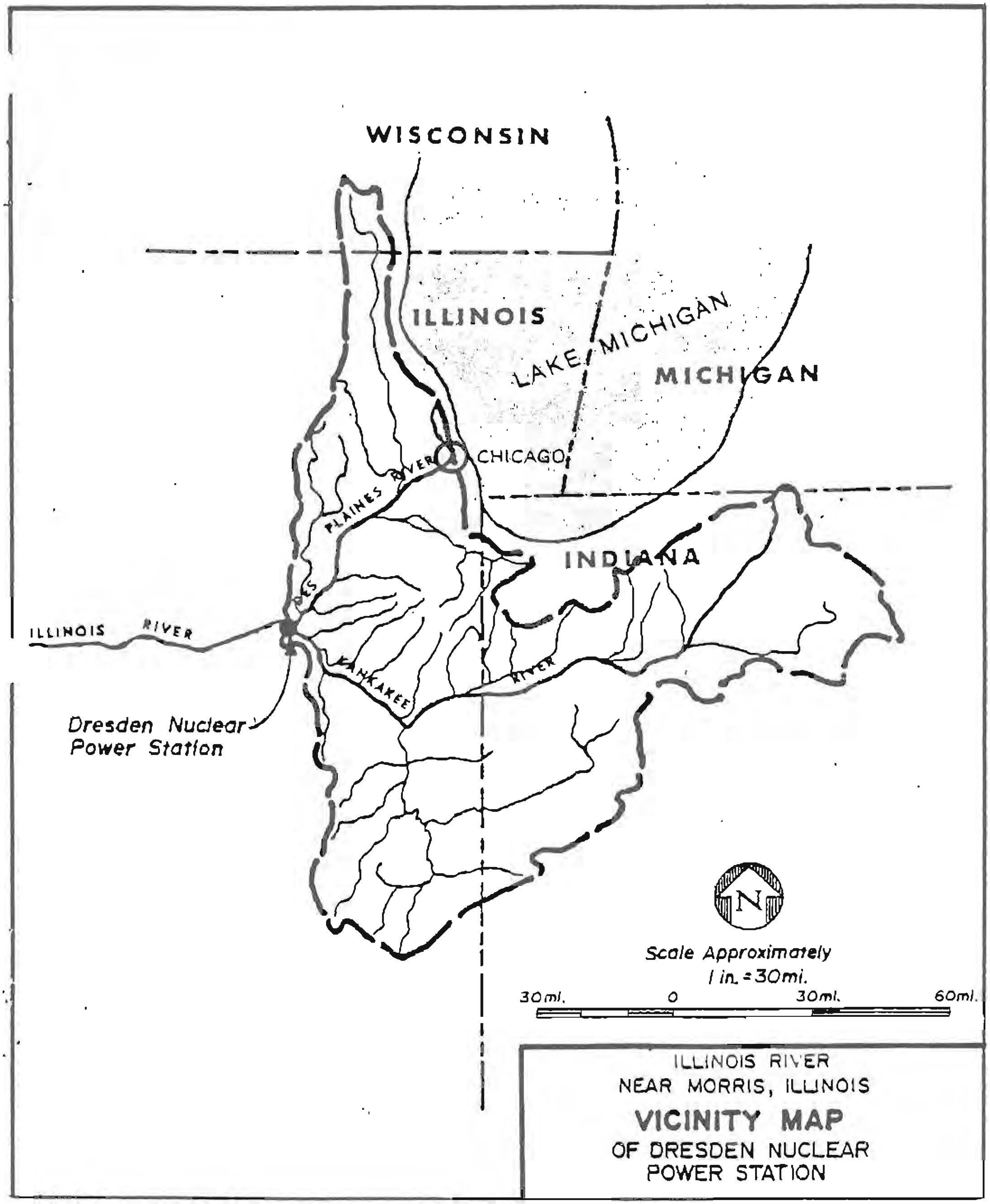

Figure 2. Map of Vicinity of Dresden Nuclear Power Station

Design Bases

Plant Grade Flood Design Basis

The design basis flood level at the Dresden Station is 517 ft msl, which is ground level at the plant site; the lowest non-watertight opening in the walls of Category I safety-related structures is 517 ft 6 in msl. These structures were designed to resist hydrostatic pressure to the level of 517 ft msl. Wave runup was not considered in the design [5].

Intake Structure Limiting Elevation

The emergency service water pump motors are set on floor elevation 509 ft msl and are unprotected from flooding above this elevation. The traveling screen bays are located immediately adjacent to the emergency service water (ESW) pumps and there are no flood protection structures between the traveling screen bays and the ESW pumps above elevation 509 ft msl.

Roof Loading

The roof of the turbine building will support a live load of 35 lb/sq ft, the reactor building roof 70 lb/sq ft, and the crib house roof 60 lb/sq ft [6]. The roof downspouts are designed to drain 4 inches of rainfall hourly [7].

Groundwater

The design basis groundwater level is 514 ft [6]. The seismic design conditions used in the evaluation of design basis groundwater elevation have not been identified.

Emergency Procedure

The Licensee uses, as protection from the probable maximum flood (PMF), an emergency procedure as an "active" flood protection measure (EPIP 200-11) and considers this procedure adequate to protect the plant from the consequences of a PMF. The acceptability of this emergency procedure has been addressed under SEP Topic II-3.B.1 within this TER.

Site Orientation

Rivers

The Kankakee River flows through northern Indiana west to Illinois. Its drainage area is approximately 5895 square miles [8], which is mostly farm and pasture land [9]. Less than 1% of the watershed is urbanized. At the United States Geological Survey (USGS) gage near Wilmington, Illinois, 6 miles upstream from the site on the Kankakee River, the lowest recorded flow was 204 cfs [10], and the highest was 75,900 cfs.

The Des Plaines River originates in northeast Illinois near Lake Michigan, to which it is connected by the Chicago Sanitary and Ship Canal. Through this channel, the effluent from the Chicago water supply system and diversions from Lake Michigan (which are limited by the U.S. Supreme Court to an annual mean of 1,500 cfs) are added to the natural flow of the Des Plaines River. These additions are regulated to maintain between 3000 and 4000 cfs in the canal [10]. The natural watershed of the Des Plaines River is 1,370 square miles [8], of which 18% is urbanized. Its highest recorded discharge is 44,280 cfs at the Brandon Road Lock and Dam, 14 miles upstream from the Dresden site [4].

The nearest gage on the Illinois River is 25 miles downstream from the Dresden site at Marseilles, Illinois. Upstream, the Des Plaines River is gaged at Riverside and the Kankakee River is gaged near Wilmington, Illinois, all operated by the USGS.

The Illinois Waterway is composed of eight dams with adjacent locks between the junction of the Illinois River with the Mississippi at Grafton, Illinois, and the Chicago River outlet at Lake Michigan [11]. These dams were built to facilitate navigation and do not store significant amounts of water. The Dresden Island Lock and Dam impounds water with a normal pool level of 505 ft msl. Below the dam, the water level is 483 ft 4 in msl [3].

The Dresden Lock and Dam is operated by the Rock Island office of the U.S. Army Corps of Engineers. Its construction was planned by the State of Illinois in 1927, but was not completed by the Corps of Engineers until after the Federal Government assumed responsibility for the project in 1930. It was opened to navigation with the newly completed Illinois Waterway in 1933 [12]. The riverbed elevation above the dam varies from about 480 ft msl in the center to almost 500 ft msl by the banks [13]; the top of the dam is at 506.5 ft msl [14]. The dams were not designed to meet any seismic standards, but were designed to withstand forces from large chunks of ice on the river, flood waters, and impact from runaway tows [3].

The Dresden Dam is constructed of 11 reinforced concrete piers measuring 10 ft by 45 ft at the top and 10 ft by 60 ft at the bottom. Each is socketed 5 ft into bedrock and anchored. Between the piers are concrete rollways. Above the dam are the nine tainter gates which control pool level; they are supported by the piers. The dam is anchored on the north bank of the river to bedrock which rises toward the Kankakee Bluffs. On the south end, the dam is anchored to the lock structure, which is 800 ft long and 110 ft wide. The lock walls are 10 ft wide at the top and 20 ft wide at the bottom [3]. Fully opened, each tainter gate opening is 60 ft wide [4] and about 18.5 ft high.

Peoria is the closest point downstream from Dresden Station where the Illinois River is used as a public water supply [14]. Approximately 25,800,000 gallons per day are used for domestic and commercial purposes. In Mapleton, Illinois, the Caterpillar Foundry draws water from the Illinois River for use throughout its plant. Water quality on the Illinois River is poor, due in part to the effluent discharged at Chicago into the Des Plaines River, necessitating all other private and public water users along the Illinois River to use wells as their water supply.

Site Drainage and Water Control Structures

The plant site is 2500 acres and is relatively flat [15]. Elevation ranges from 509 ft msl by the river to 526 ft msl [11] in the southwest area of the site. Plant grade is 517 ft msl. The Dresden Station is about 2000 ft from the shore of the Kankakee River, and natural drainage is north and east toward the Kankakee River [7]. The water in the discharge canal flows into the Illinois River, due north of the plant.

Circling the site is a road with a grade of 517 ft msl. A storm drain system of corrugated metal pipes and catch basins serves the area inside the road, including the roofs. Drainage ditches are provided outside the peripheral road [7].

The roof downspout system is designed to drain at the rate of 4 inches per hour [7]. Parapets around the turbine and reactor buildings roofs are 3 ft 6 in high, and the crib house parapets are 1 ft 6 in above the roof level [6]. Scuppers have not been stated to exist in parapet walls or safety-related buildings.

The Kankakee River supplies coolant water to the plant site through two intake canals, each about 1800 ft long. One canal serves Dresden Unit 1, and the other, Units 2 and 3. The entrance to both canals is protected from debris by floating booms. At a distance of 123 ft beyond the booms is the highest point of both canal floors, 495 ft msl. From this level, the canal floors slant downward to 482 ft 6 in msl at the forebay of the crib houses [3].

There are two discharge canals, one leading from Unit 1, the other from Units 2 and 3 to the Illinois River. Near the outlet, the invert level reaches its highest point, 498 ft msl, and slopes downward between there and the discharge head works to 489 ft msl. Both canals are about 2000 ft long [3]. Following a postulated failure of the Dresden Lock and Dam, 9 million gallons of water will be trapped in the intake and discharge canal. This volume of water acts as the ultimate heat sink (UHS).

The Dresden cooling lake, about 2 miles south of the plant, has an area of 1275 acres at normal pool level of 522 ft msl. The tops of the dikes which retain the water on the north, south, and west sides are at 527 ft msl. There is no dike on the east side. The lake bottom elevation varies from 507 to 517 ft msl, averaging 510 ft msl. The lake contains about 12,750 acre-feet of water [16].

The cooling lake is connected to Unit 2 intake and discharge flumes by an intake canal and a discharge canal, each 11,000 ft long. Between the intake canal and the lake is a lift station with a series of six pumps; beside it is a concrete spillway used to maintain the lake water level [16]. The spillway discharges to the discharge canal which carries water toward the regulating structure.

The flow regulating station distributes the cooled water coming from the lake via the plant. It is routed through the discharge flume to the river in open-cycle operation, or to the inlet of the Units 2 and 3 crib house for closed-cycle operation. Depending on the flow and temperature of the water, a combination of both destinations may be employed. Open-cycle operation is the intended method, but adjustment to closed-cycle operation is possible.

Across the road, which runs parallel to the south edge of the cooling lake, the land rises, preventing drainage southward. Natural drainage is from east to west, toward the Goose Lake School, and a drainage channel at the toe of the south dike leads water to the area west of the lake, which is enclosed between the access road and the west dike. This area drains to the north, where flow is routed into a discharge channel leading into a siphon that goes under the plant discharge canal and leads to the Goose Lake Pumping Station on the Kankakee River. Drainage north of the lake is toward the same channel. Should the lake overflow, water would drain north toward the Kankakee River, through or around the several residences on the river bank [17]. East of the lake, the land is higher and drains directly into the Kankakee River.

In the vicinity of the cooling lake are large areas of abandoned strip mines, with confused topographic and drainage patterns, swamps, and standing water [2]. There is a possibility that some abandoned coal mines extend under the north dike [17].

Groundwater

Groundwater is the source for public and private water supplies in the area of the Dresden Station. The principal aquifers are in the St. Peter and Galesville sandstones, at a depth of more than 500 ft. A few wells also tap the Galena Dolomite of Ordovician age [10].

The normal groundwater levels at the site are between 505 and 508 ft msl. Groundwater levels are controlled by the water levels in the rivers and the canals on the site [18]. Reference 6 implies that the original design basis groundwater elevation is 514 ft msl. No well hydrograph data are available to verify that 514 ft msl is a conservative design elevation; thus, it is recommended that plant grade (elevation 517 ft msl) be used as a conservative value. The effects of groundwater rising to plant grade should be addressed in SEP Topic III-3.A, Effects of High Water Level on Structures.

Ice

The Kankakee and Illinois Rivers freeze in the winter. A log boom is located at the entrance of the intake canals to protect against floating chunks of ice [18]. The reach of the Kankakee River located immediately upstream from the confluence of the Des Plaines is kept free from icing to ensure a clear ship channel. Historically, no flooding problems have been encountered as a result of ice floes. During the last five winters, a hovercraft has been used to break up river ice in the ship channel. This broken ice has passed easily through the tainter gates of Dresden Dam.

An 8-ft-diameter deicing line is used to prevent freezing of the water supply. It connects the discharge head works of Units 2 and 3 and the forebay of the Units 2 and 3 crib house. Its bottom elevation varies from 495 ft msl at the head works to 489 ft msl at the forebay [13].

3.1.3 Conclusion

The information presented under SEP Topic II-3.A identifies the original hydrologic design basis for structures interfacing with the hydrosphere and supplements existing Licensee-presented information.

3.2 FLOODING POTENTIAL AND PROTECTION REQUIREMENTS (TOPIC II-3.B)

3.2.1 Topic Background

An independent review of information pertaining to SEP Topic II-3.B was conducted for the Dresden site. The findings are presented in this section and were developed using several sources of information, including NRC docketed information, NRC staff files, communication with the U.S. Army Corps of Engineers, Sargent & Lundy Engineers, Illinois Waterway Commission, United States Geological Survey, the National Weather Service, and state and local contacts.

The purpose of this topic is to identify, under current licensing criteria, the plant and site design basis flood level resulting from all potential flood sources external to the plant and site. It includes the evaluation of submitted documentation and the determination of significant differences between the values of parameters used for design and construction and those derived in accordance with current licensing criteria. The evaluation addresses the effects of flood and other changes in hydrostatic and hydrodynamic loads on safety-related structures, systems, and equipment, and the adequacy of existing or proposed flood protection measures such as revetments, flood walls or doors, and emergency or administrative procedures.

Specifically, the review focuses on the following topics:

- Groundwater
- Probable Maximum Flood
- Site Drainage
- Roof Drainage.

Regulatory Guides 1.59 and 1.102 have been specifically identified by the NRC's Regulatory Requirements Review Committee for their application to the SEP program. These guides are used to determine whether the facility design complies with current criteria or has some equivalent alternatives acceptable to the staff. The acceptability or nonacceptability of any deviations identified in this evaluation and the need for further action will be judged during the integrated assessment for this facility.

3.2.2 Topic Review Criteria

The following references were used as review criteria for this topic:

- o Standard Review Plan Sections 2.4.2, 2.4.3, 2.4.10, and ~~2.4.13~~ 2.4.12
- o Regulatory Guides 1.59 & 1.102
- o ANSI Standard N170-1976.

3.2.3 Evaluation

Groundwater

Dresden Unit 2 was designed to be protected from a combination 0.1 g load and groundwater elevation to 514 ft msl. No well hydrograph data are available to verify that 514 ft msl is conservative, thus ground elevation (517 ft msl) should be used in evaluation of wall structural integrity. Evaluation of the wall should be performed using SSE ([redacted] and normal maximum groundwater elevation (517 ft msl) under SEP Topic III-3.A., Effects of High Water Level on Structures.

Probable Maximum Flood Analysis

Dresden Unit 2 was not designed to be passively protected from a PMF. The NRC PMF design criteria requirement was promulgated subsequent to the development of the Dresden site. For reference purposes, the PMF discharge elevation developed for this report is presented here.

Water Surface Profiles

The Standard Step Method was used to calculate the stage-discharge relationship for the reach of the Illinois River between the Dresden Island Lock and Dam and the confluence of the Kankakee and Des Plaines Rivers. The computation was made with the 1981 version of the USCE HEC-2 program (19) and a CDC 7600 computer.

The geometric shape of the river channel was determined from a USCE topographic and river sounding map (20) having a 2-ft contour interval. Delineation of overbank areas and contours was made from 7.5-minute USGS topographic maps (21).

Particular attention was given in defining the cross section representing the Dresden Island Lock and Dam due to its control on the upstream water surface for river discharges below 300,000 cfs. The hydraulic configuration of the nine tainter gates and lock was based on oral communication [22] and written reports by personnel of the U.S. Corps of Engineers [23]. The left and right overbank configurations at the lock and dam were taken from the previously mentioned USCE topographic map [20].

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The location of the representative cross section used in the hydraulic analysis is shown in the plan view of Figure 3 where station 18+00 represents the Dresden Island Lock and Dam. The shape of the digitized cross sections starting with station 17+90 and continuing upstream to cross section 92+80 can be seen on Figures 4 through 10. Note that the tainter gate configuration, shown in Figure 5, includes presumed clogging of the gate or orifice by debris.

Calibration of the hydraulic model was based on recorded high water marks from the 1947 and 1957 floods. The July 1957 flood, the largest of record, had a recorded discharge of 94,000 cfs and a water surface elevation of 506 ft msl at Dresden Island Lock and Dam [23]. Recorded high water levels for the Illinois River below Dresden [23] were also incorporated into the model calibration.

Water surface profiles in the vicinity of Dresden Island were independently determined based on background information provided by Harza Engineering Company [51].

The Harza study involved an 8-mile reach of the Illinois River between the Morris Highway Bridge (Route 47) and a cross section located immediately upstream from Dresden Island Lock and Dam. The hydraulic analysis was extended 1 mile upstream from a cross section located about 900 ft below the dam to the confluence of the Kankakee and Des Plaines Rivers. Harza provided two sets of profiles for discharges from 100,000 to 600,000 cfs. The higher profile was used for the range of discharges tested.

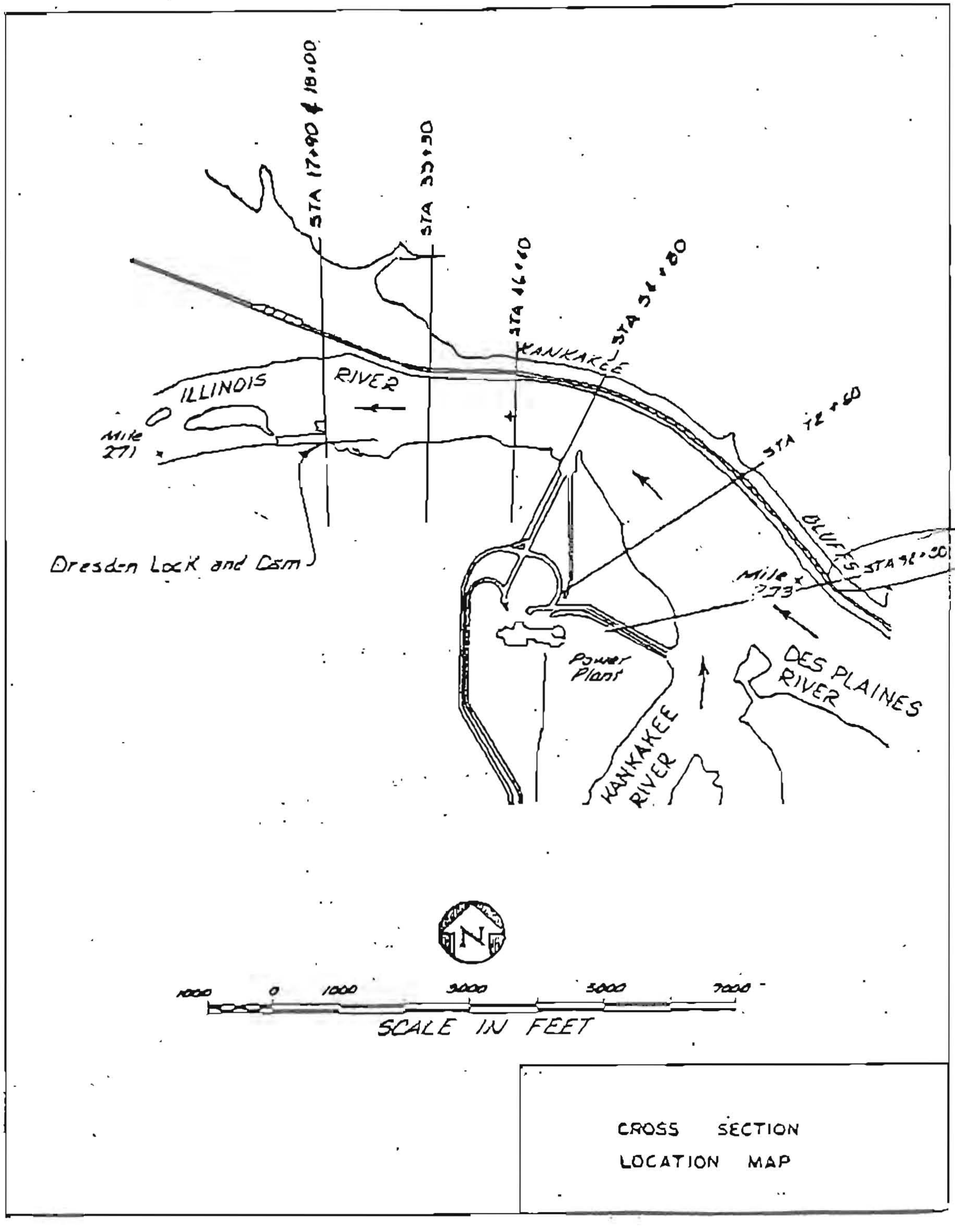


Figure 3. Cross Section Location Map

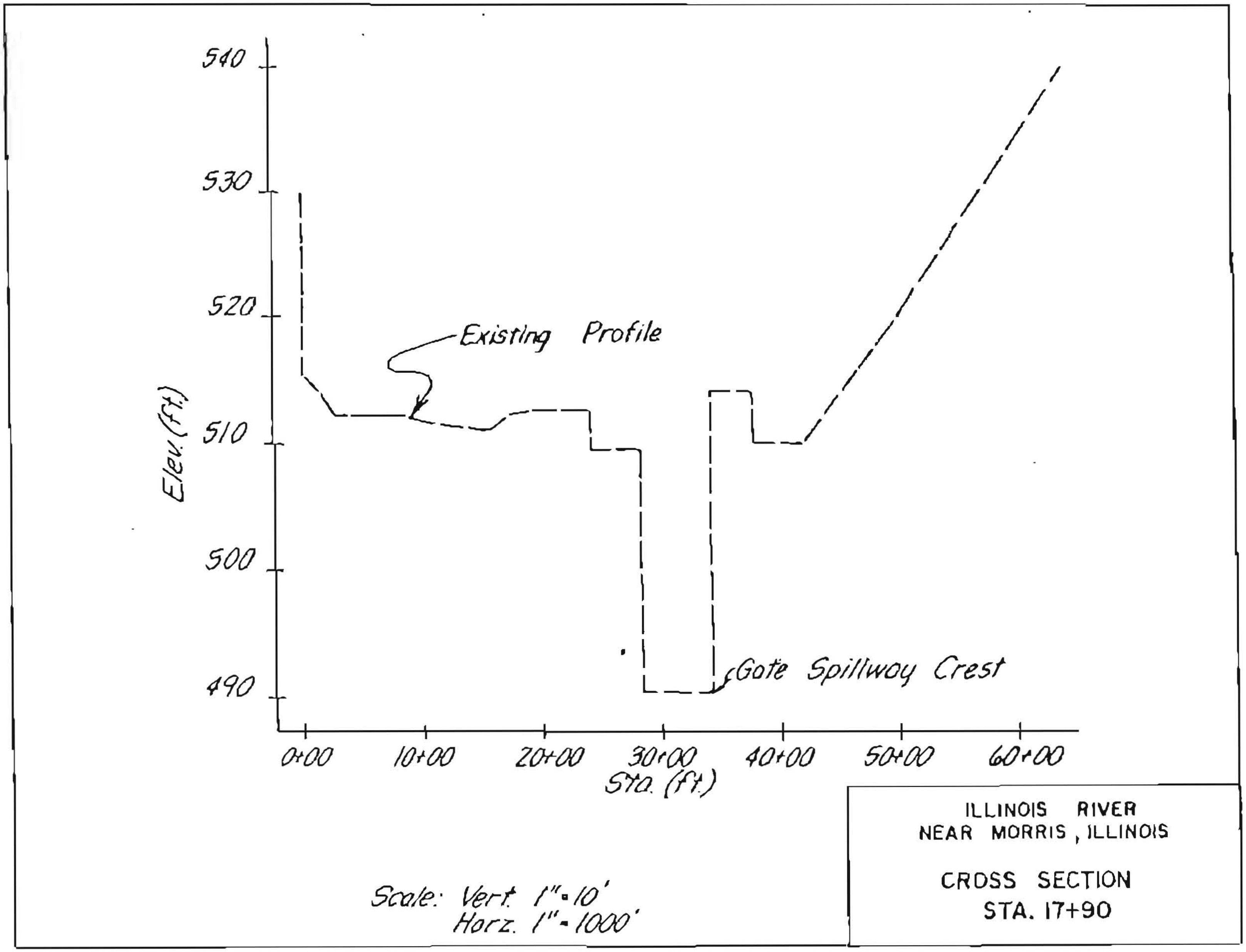


Figure 4. Cross Section Station 17+90

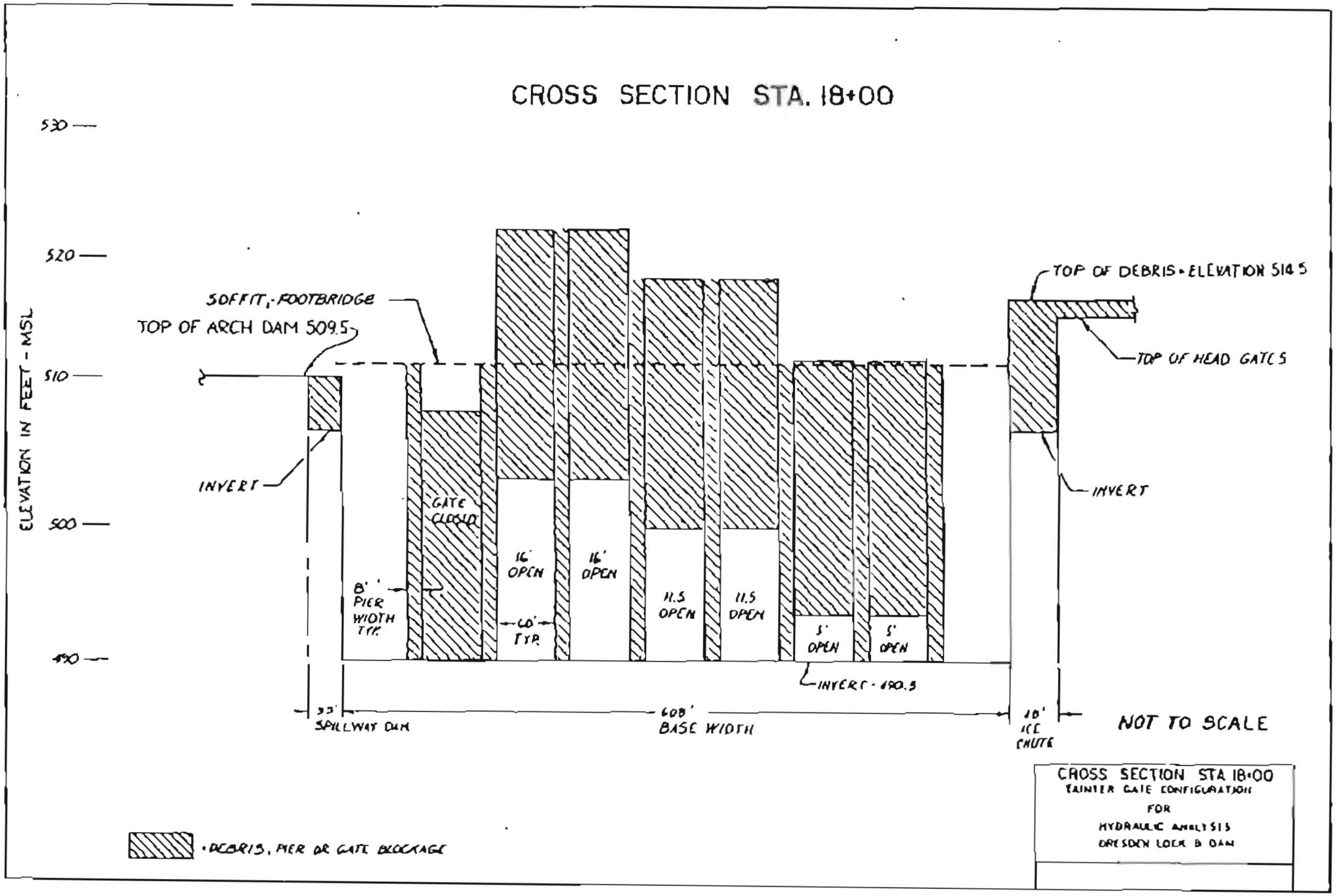


Figure 5. Tainter Gate Configuration for Hydraulic Analysis, Dresden Lock and Dam Station 18+00

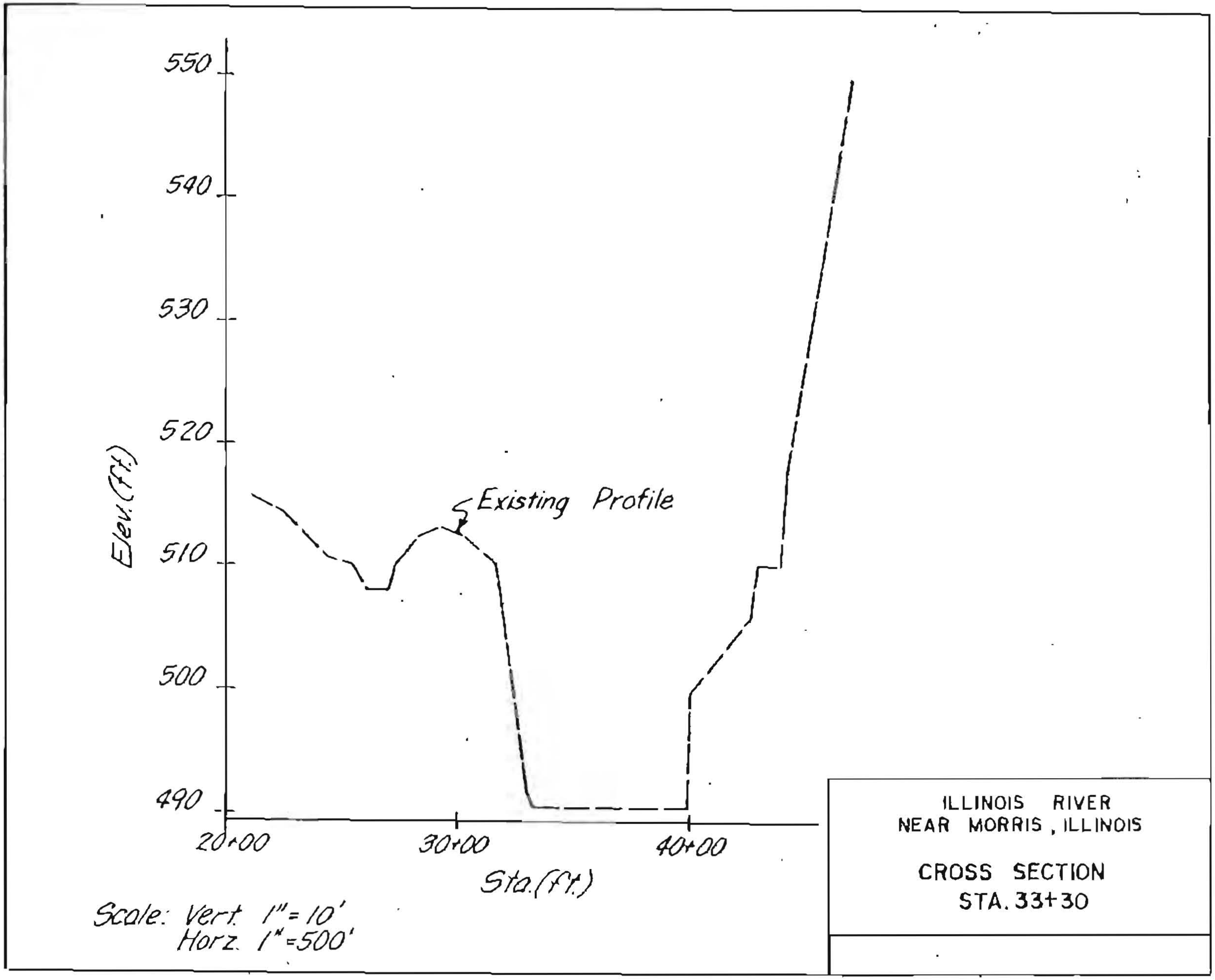


Figure 6. Cross Section Station 33+30

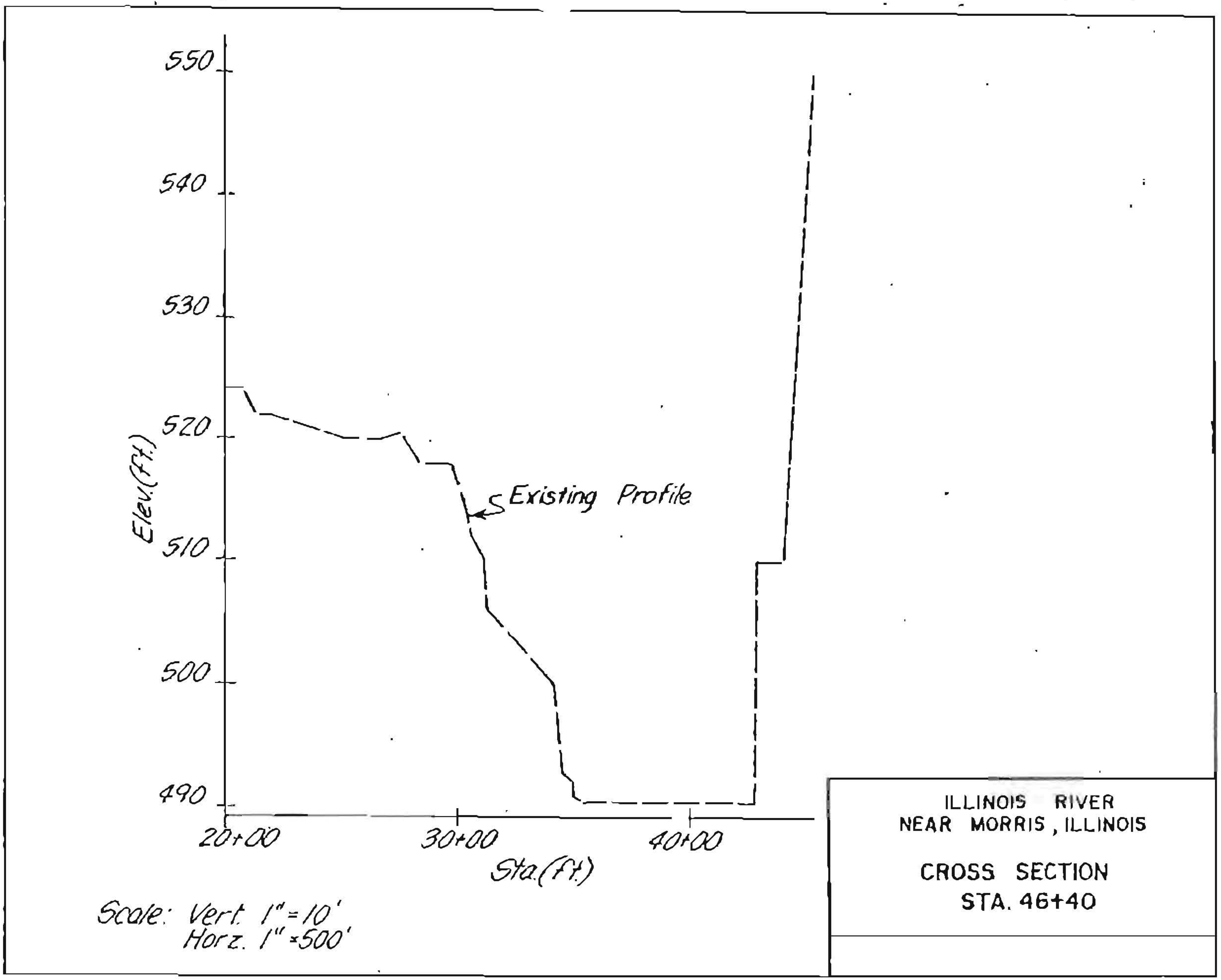


Figure 7. Cross Section Station 46+40

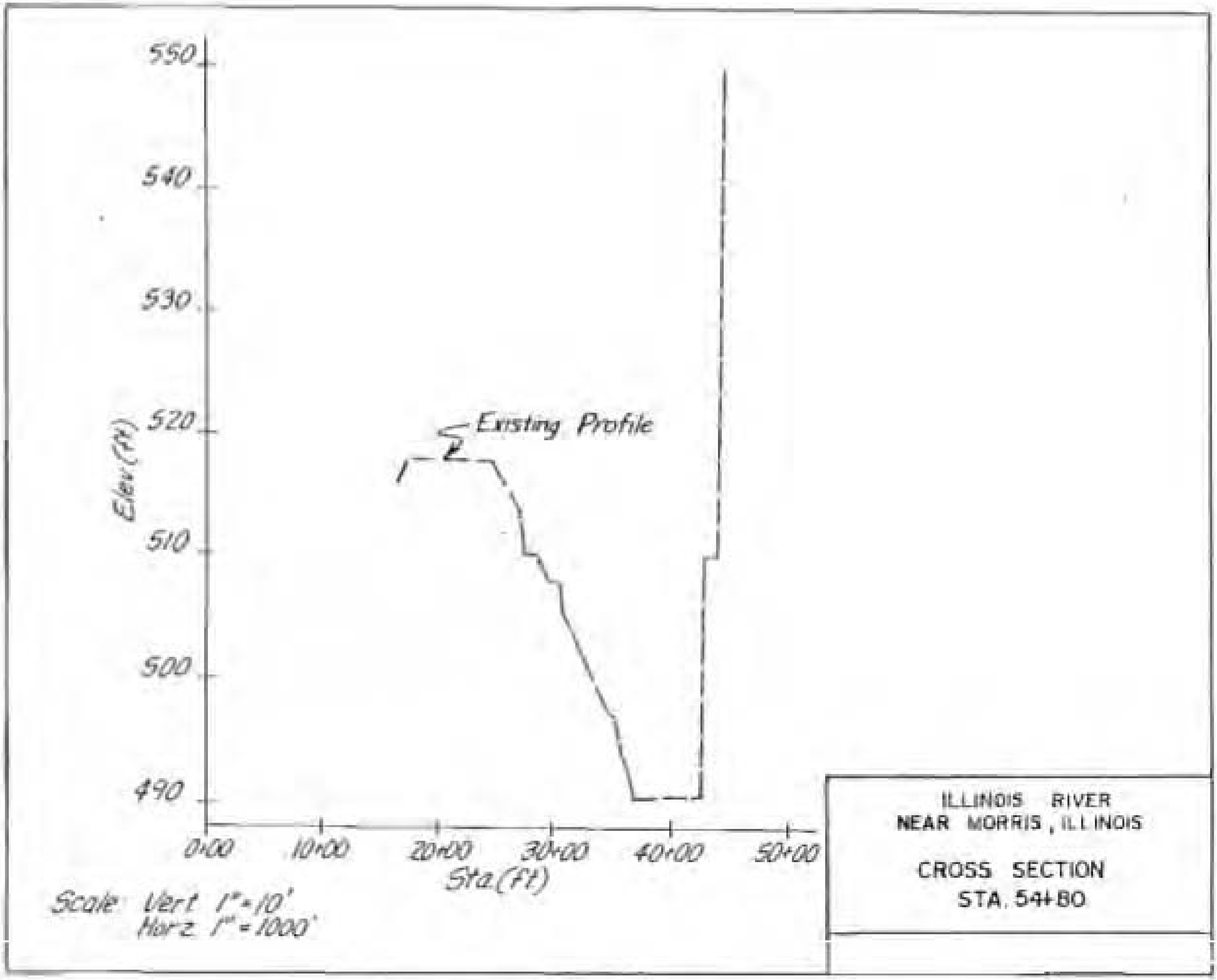


Figure 8. Cross Section Station 54+80

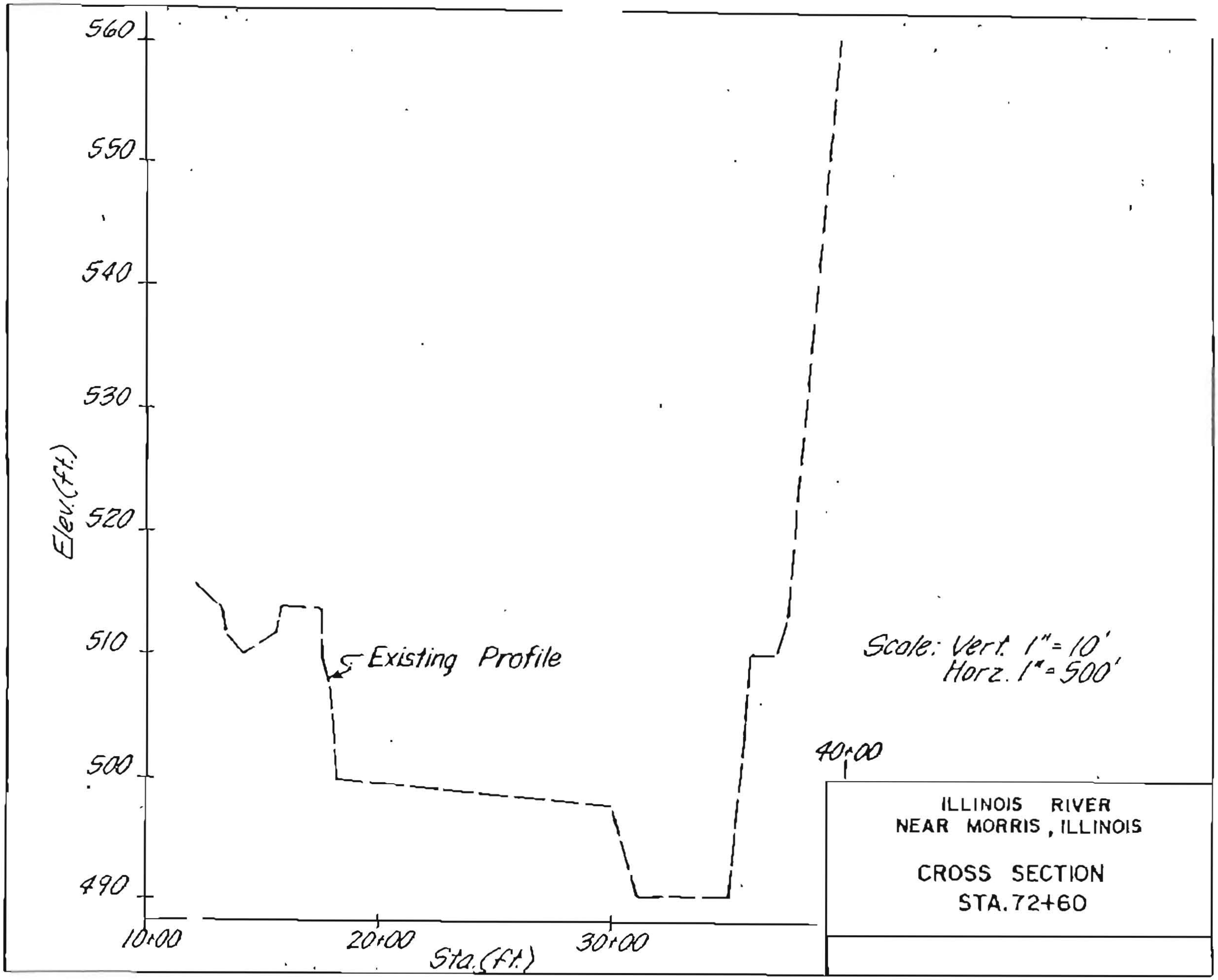


Figure 9. Cross Section Station 72+60

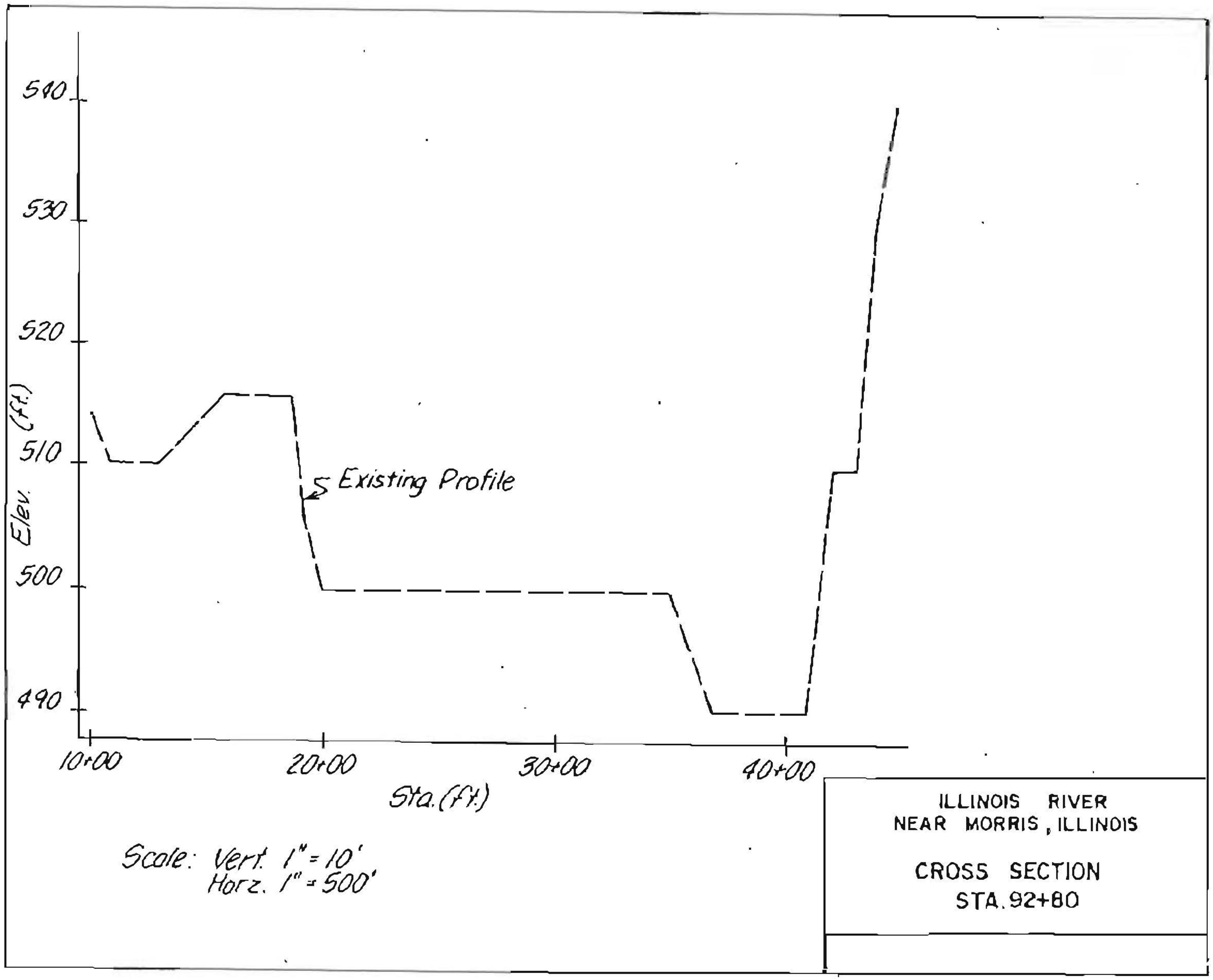
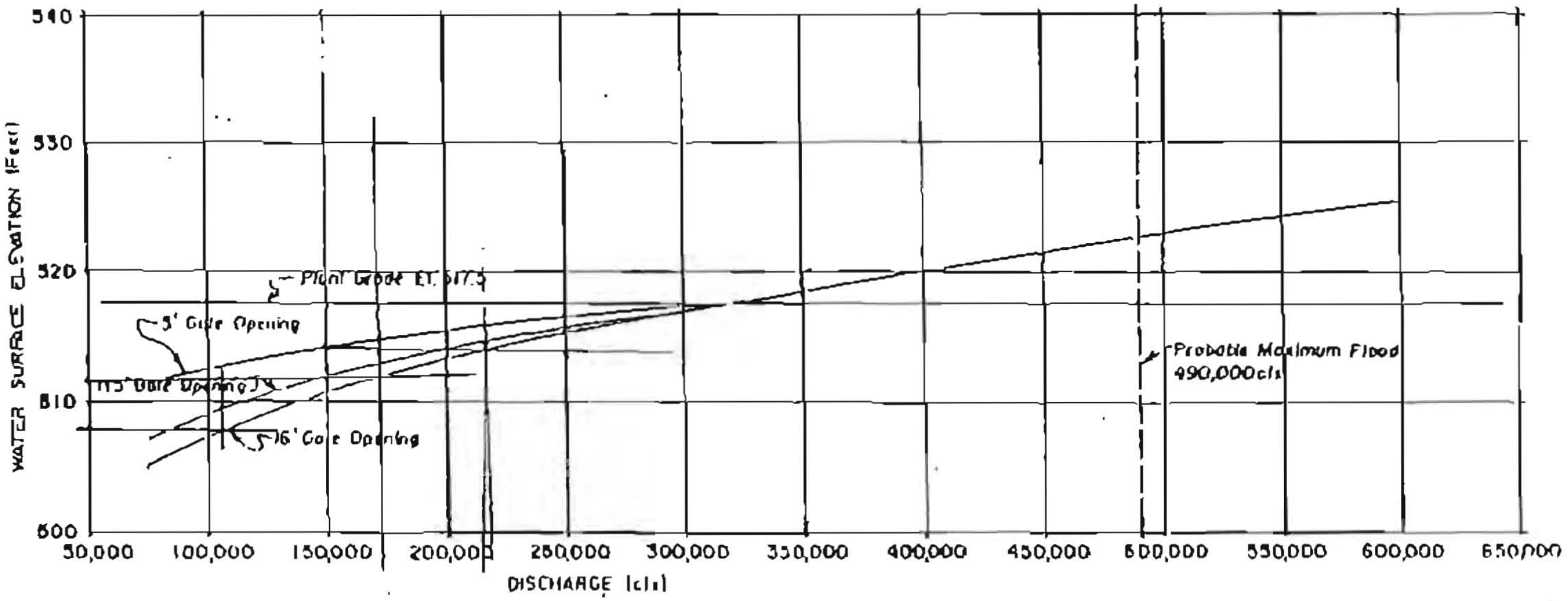


Figure 10. Cross Section Station 92+80



$\frac{1}{6} = 1.6$ 508.5

ILLINOIS RIVER
NEAR MORRIS, ILLINOIS
STAGE VS. DISCHARGE CURVE
STA. 18+00
DRESDEN LOCK AND DAM

Figure 11. Stage vs. Discharge Curve at Dresden Lock and Dam Station 18+00

The lock and dam was simulated by the HEC-2 program as a bridge with eight piers for the tainter gate portion of the structure, as a weir for the portion of flow over the gates, as a weir for both the left and right portion of the structure beyond the tainter gate section, including the left and right overbanks. Weir coefficients were assigned according to discharge and were given the following values: 3.09 for discharges up to 200,000 cfs, 2.8 from 200,000 cfs to 500,000 cfs, and 2.7 for flows of 500,000 cfs and above. The piers were considered to be square, both nose and tail. Coefficients of contraction and expansion were set at 0.3 and 0.5, respectively, as recommended in the 1981 HEC-2 manual.

After the hydraulic model was sufficiently calibrated, the model was used to estimate the response of the river system to flood flows ranging from 100,000 cfs to 600,000 cfs while acting under three separate tainter gate configurations (5 ft, 11.5 ft, and 16 ft open). For each of these three configurations, the evaluation assumed that the lock was closed, the ice chute clogged to 514.5 ft msl, and the spillway dam clogged to elevation 509.5 ft msl.

Water surface profiles were computed by the HEC-2 model from the station 900 ft downstream through the dam and lock structure upstream to station 92+80 as seen in Figures 11 through 16.

The hydraulic analysis resulted in a set of stage-discharge curves; one set of curves was generated per cross section in the study reach. Figures 11 through 16 contain the resultant rating curves for the Illinois River near Dresden Island. The river flow at station 92+80 that would result in a water surface at plant grade (517.5 ft msl) would range between 240,000 cfs and 290,000 cfs, depending on downstream tainter gate openings. Station 92+80 represents the most limiting conditions. This limiting discharge represents approximately 49% of the PMF discharge.

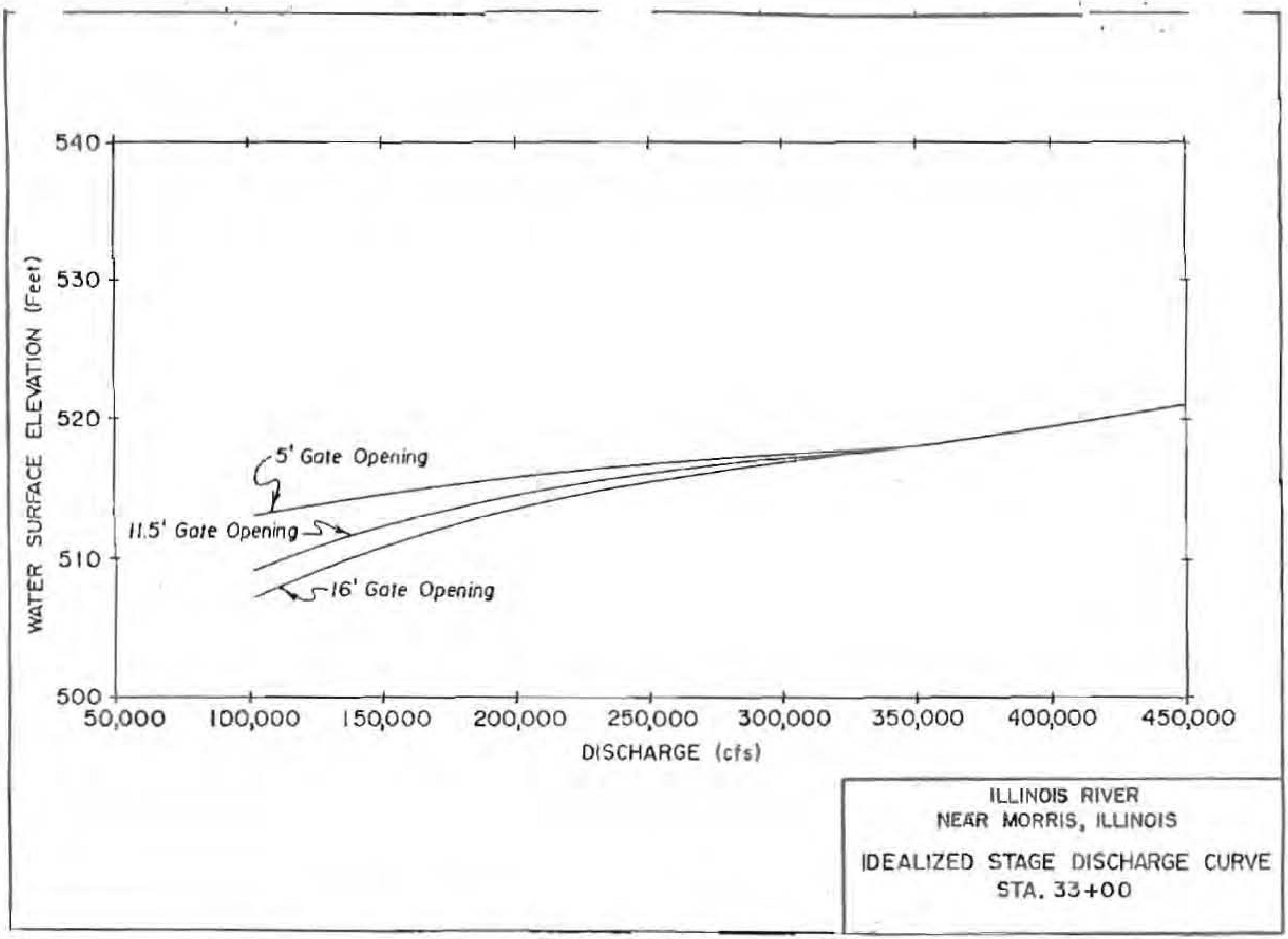


Figure 12. Idealized Stage Discharge Curve Station 33+00

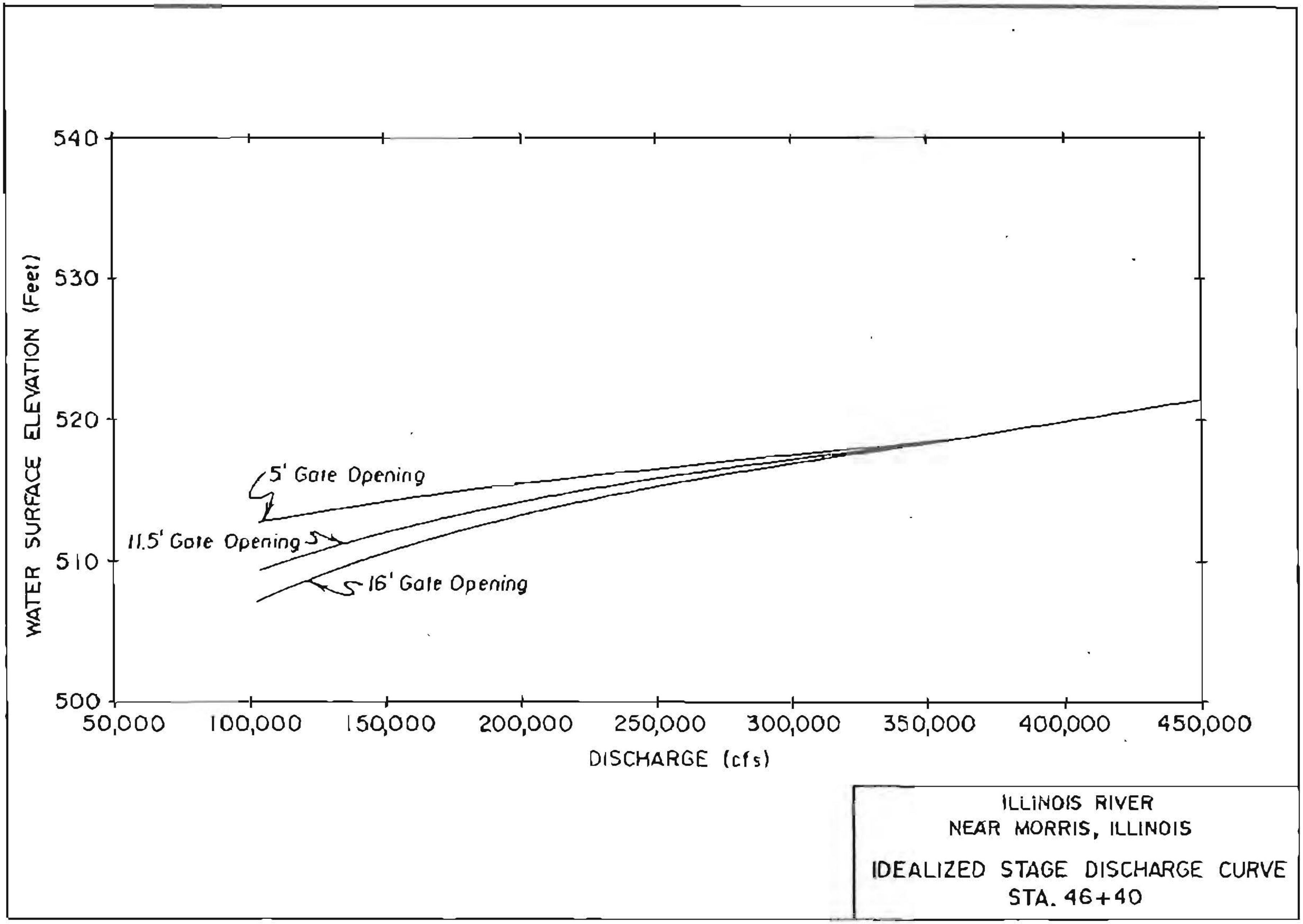
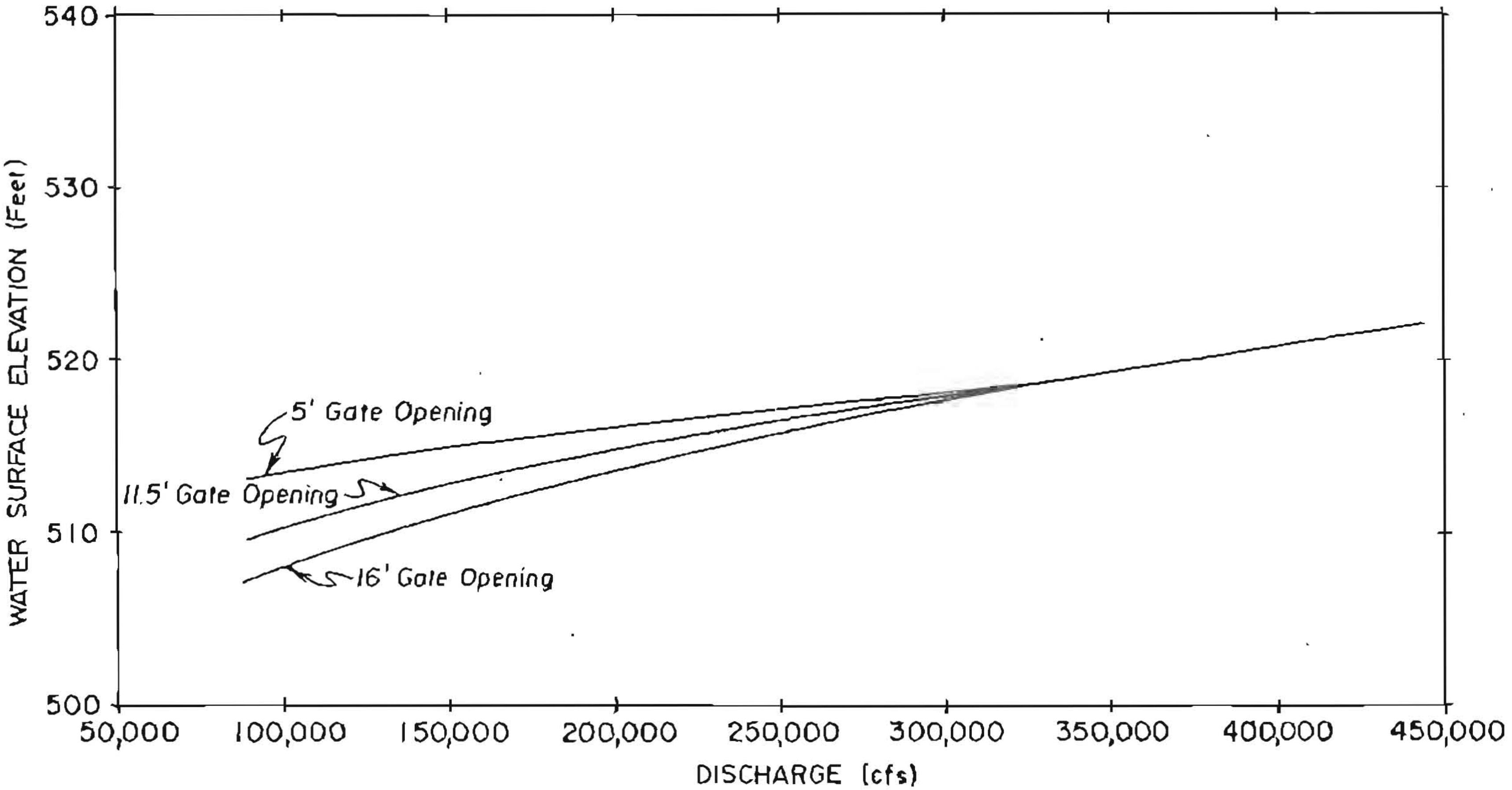


Figure 13. Idealized Stage Discharge Curve Station 46+40



ILLINOIS RIVER
NEAR MORRIS, ILLINOIS

IDEALIZED STAGE DISCHARGE CURVE
STA. 54+80

Figure 14. Idealized Stage Discharge Curve Station 54+80

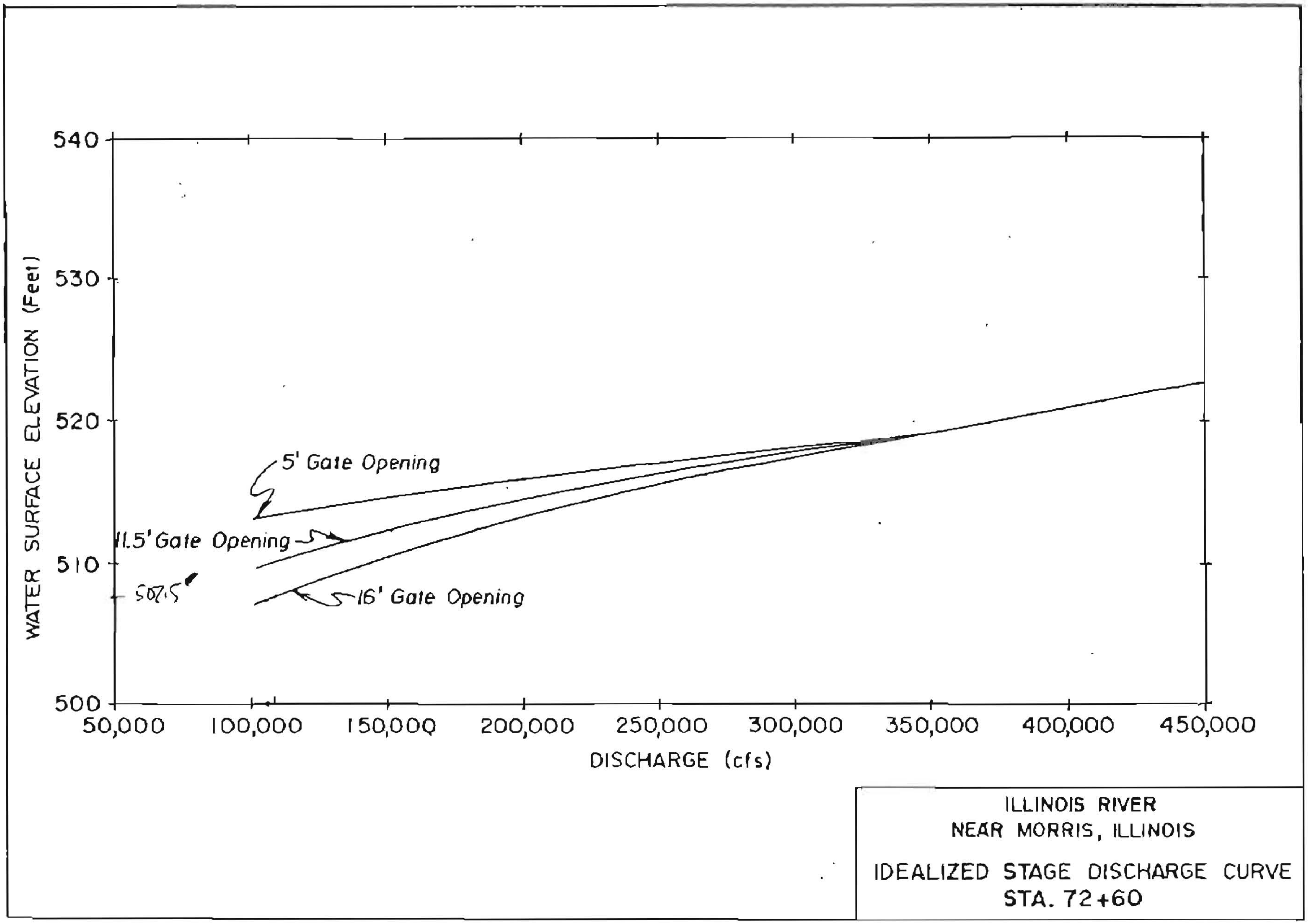


Figure 15. Idealized Stage Discharge Curve Station 72+60

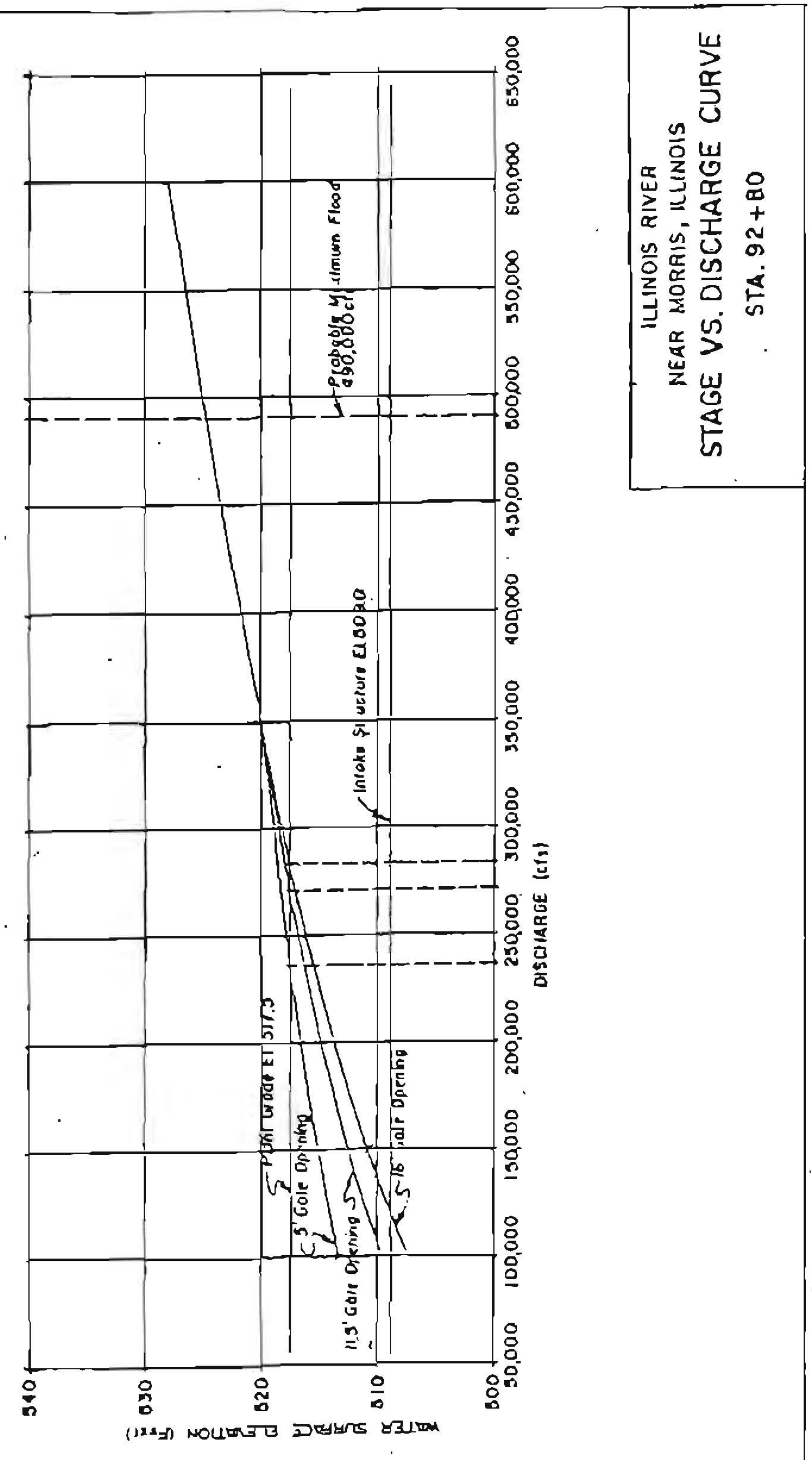


Figure 16. Idealized Stage Discharge Curve Station 92+80

The Manning's roughness coefficients used in the study were 0.03 for the main river channel and 0.05 for the overbanks. Values from 0.1 to 0.4 were assigned to the expansion and contraction coefficients.

When the water surface at station 18+00 is above the top of the arch dam (elevation 509.5 ft msl), weir flow begins. This produces a point of discontinuity or an abrupt change in the slope of the rating curve. Similar changes in the shape of the rating curve occur when the water level is above the top of the elevated tainter gates. In addition, the elevation 512.4 ft msl marks a point at station 18+00 where the river begins to encroach upon the overbank of the main channel. The rating curves reported herein have been idealized to enhance readability. Note that, for discharges above about 300,000 cfs, the position of the tainter gates is no longer a primary control of the water surface elevation above Dresden Island Lock and Dam.

Probable Maximum Flood Determination

The PMF discharge for the combined Kankakee and Des Plaines watershed was simulated by the HEC-1 program [24]. This computer program uses the rainfall/runoff algorithm found in the Corps of Engineers, EM 1110-2-1411.

The model simulated the runoff from the approximately 7300-square-mile watershed that was divided into 13 subbasins according to hydrologic characteristics. The area of the watershed was independently evaluated. Four of the subbasins, two from the Kankakee and two watersheds from the Des Plaines, were calibrated based on reported storm rainfall and flood hydrographs [25, 26]. A model combining the watersheds, and accounting for the connecting waterways, was then calibrated using the July 1957 flood at Dresden Island. This is the largest flood of record at Dresden Island. The published flood hydrograph [27] and rainfall distribution [28] for the 1957 flood were used as model input during calibration.

After suitable agreement was found between the recorded and the simulated hydrographs, the model was used to simulate the PMF resulting from the combined runoff from the Kankakee and Des Plaines watersheds. The probable maximum precipitation (PMP) used in this study for the 7300-square-mile watershed was based a 23.25-inch, 24-hour index storm distributed over 72 hours [29] in accordance with procedures identified in EM 1110-2-1411.

Figure 17 contains the PMF hydrographs for the Des Plaines, Kankakee, and Illinois Rivers. The peak discharge for the Des Plaines River was 145,000 cfs, and the peak flow for the Kankakee River was 375,000 cfs. The combined flood peak for the Illinois River hydrograph was computed to be 490,000 cfs. Base flow was not incorporated in the computer model since river flow is less than 10,000 cfs for 80% of the year [31].

The rising limb of the PMF hydrograph for the Illinois River at Dresden is steep and has a lag time of approximately 75 hours. This is the time from the beginning of rainfall to the hydrograph peak. There is also a delay of about 24 hours before the hydrograph rises. It must be recognized that a theoretical hydrograph such as that shown in Figure 17 should be used with caution in evaluations of emergency procedure timing since actual vs. theoretical hydrographs can differ by several hours in either direction.

For a tainter gate opening of 16 ft per gate, there will be 8 hours between the time when the flood waters reach an elevation of 509 ft msl and the plant grade elevation of 517.5 ft msl during the PMF event.

The PMF for the Illinois River at Dresden was based on a computer model calibrated from the 1957 data. Urbanization since 1957, which is localized in the greater Chicago area, might result in a peak discharge different than calculated for the Des Plaines River. The Kankakee River Basin seems to have changed very little since 1957. Therefore, the simulated Kankakee hydrograph is considered valid. The PMF for the Illinois River at Dresden, for present-day conditions, may peak sooner and higher than predicted because of postulated change in the peak discharge for the Des Plaines River. However, it is expected that any such change in the reported PMF hydrograph would be within the range of uncertainty of the model itself. Extensive recalibration of the runoff model, based on data for current hydrologic conditions, would be

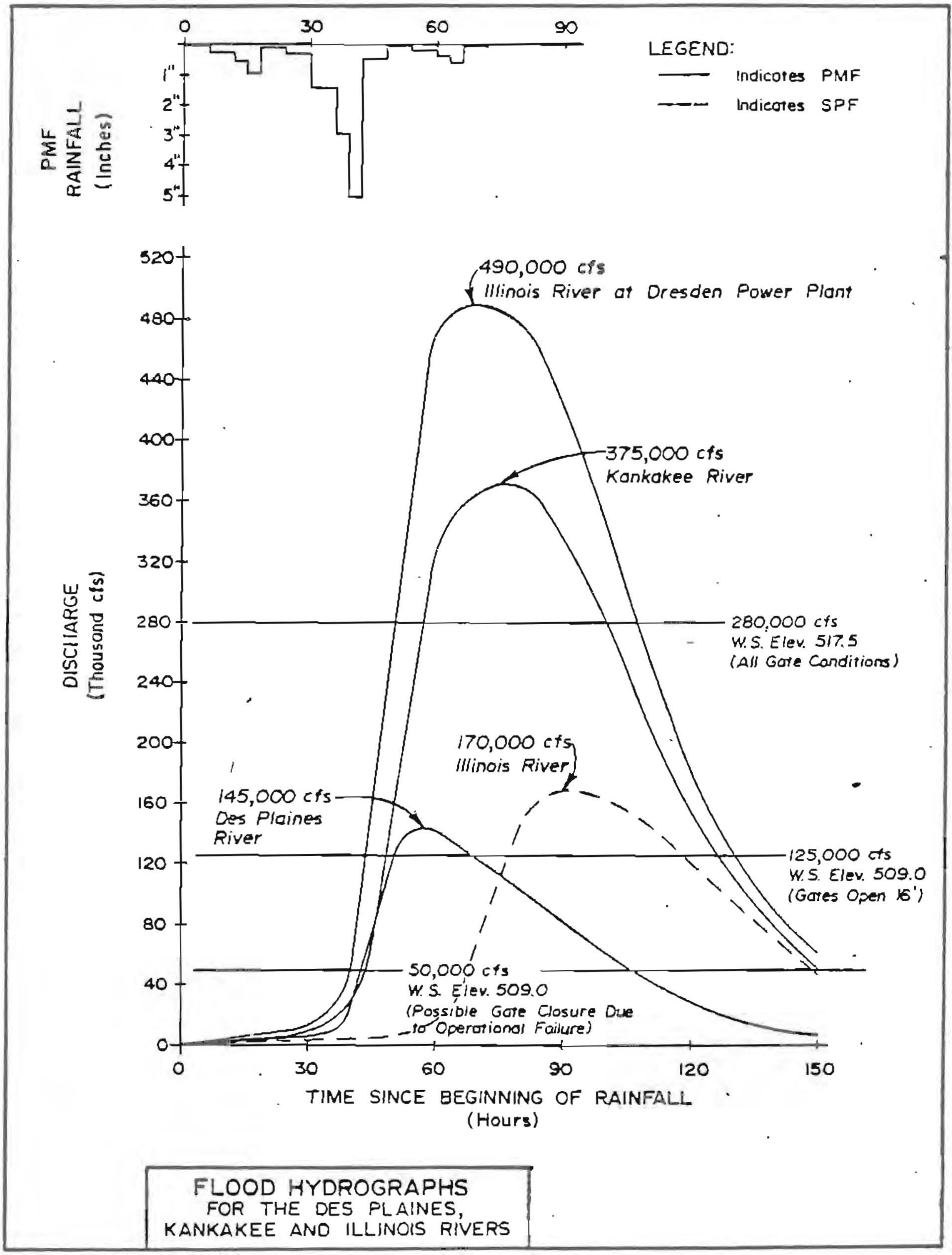


Figure 17. PMF Hydrographs for the Des Plaines, Kankakee, and Illinois Rivers

necessary before the change in the PMF hydrograph due to urbanization would be discernible.

Wave Height

The highest wind speed with a 2-year frequency of occurrence is 50 miles per hour. Two fetches were investigated: one to the southeast of the plant in the Kankakee River (designated A in Figure 18) and the other directly east of the plant across the Kankakee and into the Des Plaines River (labeled B in Figure 18). The critical condition is produced by waves generated on the Kankakee River, which would be 2.6 ft high when they reached the Unit 2 safety-related structures. Wave runup reaches 3 feet above stillwater level. This calculation is a conservative estimate based on procedures outlined in the Shore Protection Manual [32]. A PMF stillwater level of 524.5 ft plus a 3 ft wave runup results in a PMF level of 528 ft.

Standard Project Flood

For reference purposes, the standard project flood discharge of the Illinois River at the Dresden site was calculated using the U.S. Army Corps of Engineers procedure EM1110-2-1411, March 1965 revision. The standard project flood discharge of 170,000 cfs represents approximately 35% of the PMF discharge. The elevation of flood waters at station 92+80, which corresponds to the standard project flood discharge, ranges between 512 and 516 ft msl depending on tainter gate configuration.

Plant Grade Flood Frequency Analysis

The following flood frequency analysis was performed in order to estimate the return frequency of a flood which initiates the Dresden emergency flood procedure (509 ft msl, Emergency Procedure EPIP 200-11, Revision 0, August 1980 [33]). The input data consisted of the published 37-year record of annual peak discharges at Dresden Station for the period 1940 through 1977 [31]. Most of the points of this flood series plot as a straight line on log-normal probability paper. The log-normal distribution was used to extend the data set beyond the length of record.

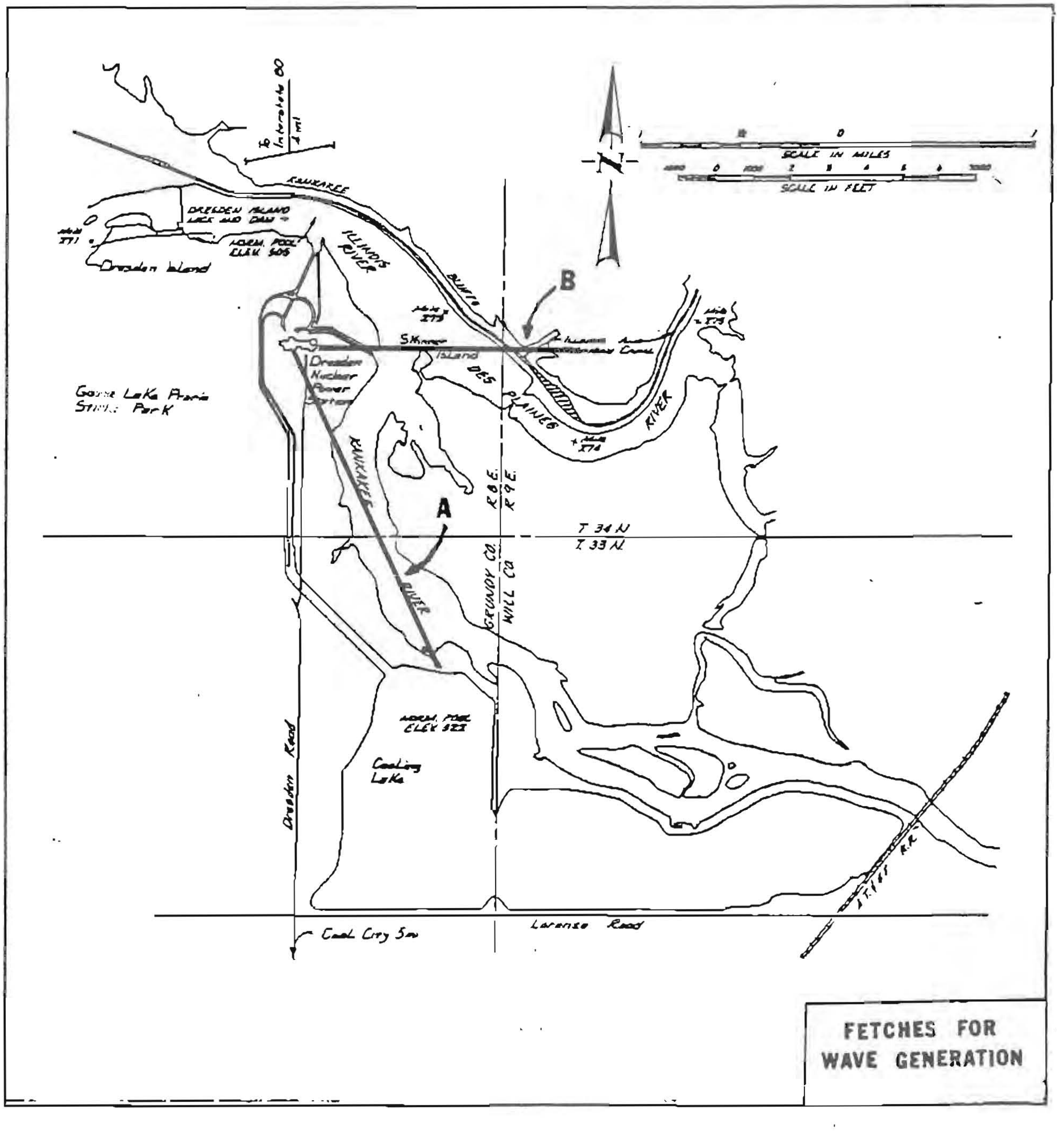


Figure 18. Fetches for Wave Generation

Figure 19 contains the annual flood record plotted with the theoretical log-normal distribution for comparison. Due to the brevity of the record, the upper and lower 95% confidence limits are also plotted to show the degree of uncertainty in the stochastic analysis. Statistically, there is a 95% chance that the upper and lower confidence bounds contain the expected value of peak discharge for a given return period [34].

For comparison, a log-Pearson Type III distribution was used to estimate the return period for extreme events. This theoretical distribution is another standardized method for determining flood flow frequencies [35], and is often recommended for use in analysis of streams in the Eastern United States.

Results of the log-normal and log-Pearson Type III frequency analyses are presented in Table 1. Note that the log-Pearson Type III frequency data fall below the lower confidence bound for return periods greater than 100 years.

It is recognized that a frequency distribution based on a short record is relatively unreliable [36, 37, 38]. In general, as the length of hydrologic record increases, estimations of population statistics, based on sample data, become more reliable, as reflected in the decreasing width of computed confidence bands. The flood record for Dresden Station is relatively short; therefore, estimated extreme flood magnitudes will contain an indeterminate amount of error, particularly for extreme return periods.

Flood Stage Frequency

The return period associated with a given flood stage or water surface elevation was determined by combining the flood stage rating curve for station 92+80 and the theoretical flood frequency distribution for the Illinois River at Dresden. Because the nine tainter gates control the water surface elevation, the stage frequency analysis included three possible gate configurations. The openings were set at 5, 11.5, and 16 ft per gate. The maximum height to which the gate can be raised is approximately 18.5 ft; however, at that height, the lowered counterweight minimizes the area of opening. Thus, a 16-ft gate was considered the maximum gate possible. Station 92+80 was

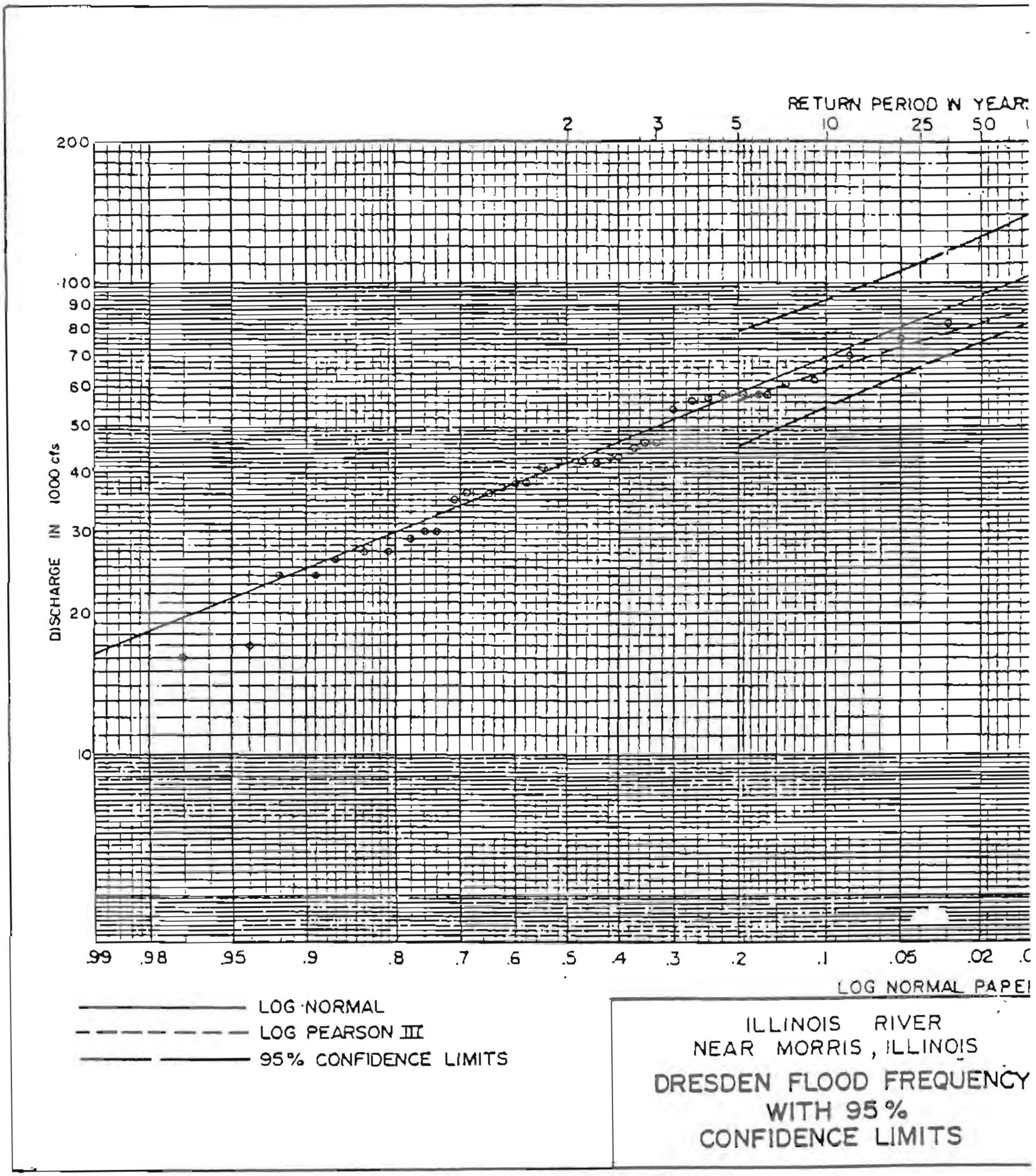


Figure 19. Dresden Flood Frequency with 95% Confidence Limits

Table 1. Flood Frequency Distribution with 95% Confidence Limits

Return Period (years)	Log-Normal Expected Peak (cfs)	Corresponding Water Surface Elevation (msl)*	Log-Normal Lower 95% Confidence Discharge (cfs)	Log-Normal Upper 95% Confidence Limits (cfs)	Log-Pearson Type III Expected Peak Discharge (cfs)
50	95,130	----	74,709	130,913	82,135
100	104,855	509.8	82,347	144,296	88,638
500	135,048	511.6	106,059	185,846	102,375

---

*Stage at station 92+80 for a tainter gate opening of 11.5 ft.

selected for presentation because it was the farthest upstream cross section for which a rating curve was developed and because upstream stations have a relatively higher water surface elevation for a given discharge.

Based on the flood frequency analysis, the 1% or 100-year flood has an expected water surface elevation of 509.8 ft msl. This information indicates that the frequency of flooding to elevation 509 ft msl (limiting elevation for operation of ESW pump motors) occurs, on the average, once every 100 years.

Site Drainage Analysis

The plant site was analyzed for its ability to drain during an intense localized thunderstorm having a total rainfall depth equivalent to the (PMP). The rate of runoff was determined by the Rational Method and the flood routing was calculated using the Manning's formula.

Three representative watersheds within the plant boundaries were delineated for the runoff analysis as seen in Figure 20. These drainages were small in size and were located adjacent to and including the reactor buildings and ancillary facilities. The surface area ranged between 6.7 and 12.4 acres, and the time of concentration for the three basins ranged from 11 to 14 minutes. Idealized flow lines are also shown in Figure 20.

The largest of the three watersheds drains in a southwesterly direction toward the cooling lake canals. Cross sections of this watershed were digitized and used in the flood routing procedure for the local runoff. The 24-hour maximum probable point precipitation is 31.2 in [30] and the maximum 13-minute intensity is 58.3 in per hour [39]. The 13-minute time of concentration was found to be the average for the three onsite drainage areas delineated and was used to calculate the precipitation rate of 58.3 in per hour.

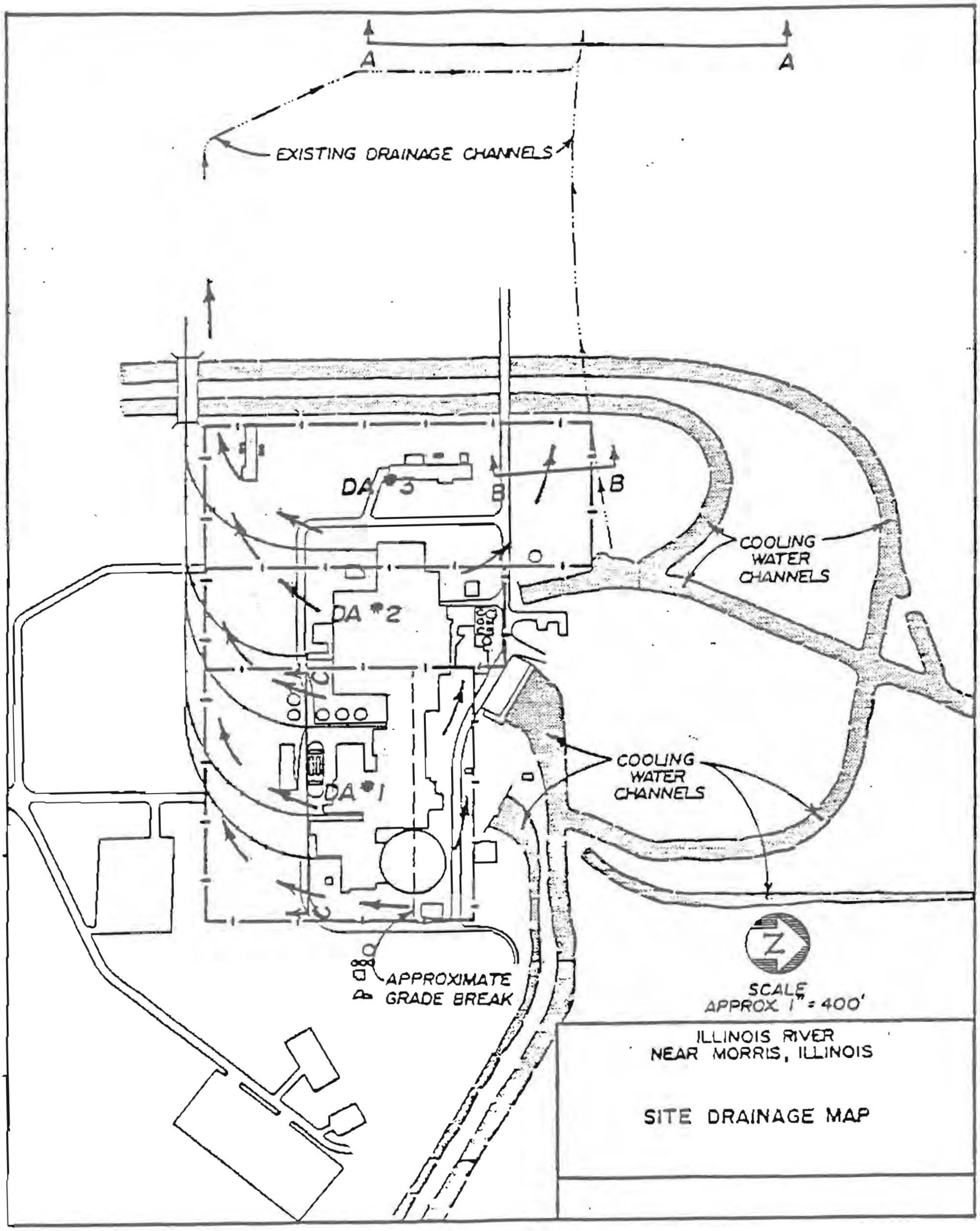


Figure 20. Site Drainage Map

The site drainage analysis assumed that the three adjacent watersheds had simultaneous flood peaks. Furthermore, these flood peaks were summed as though the watersheds were hydraulically connected. This resulted in an estimated flood peak of 1230 cfs.

Two site drainage analyses were performed to determine the depth of flooding adjacent to plant buildings resulting from point precipitation equivalent to the PMP. The first analysis investigated the influence of the downstream cross section on the conveyance in the vicinity of the buildings. The depth of water at the base of the building was estimated from the second set of calculations.

The first site drainage analysis assumed that the PMF from the three designated drainage areas occurred simultaneously and, therefore, could be combined and routed through a single drainage channel located on the south and west sides of the plant. This represents a conservative estimate of both maximum discharge and runoff volume. This channel was analyzed to determine its capacity to convey flood waters, which showed that for a water surface at plant grade the channel can carry twice the flood generated by the PMP.

The second analysis was performed to describe the runoff characteristics of the area between the buildings and the flood channel. This set of calculations was limited to conditions in drainage area No. 1 since it had the largest surface area, shallowest slopes, largest computed peak discharge, and the longest travel distance to the flood channel of the three delineated drainages. Drainage area No. 1 represents the most conservative conditions.

Drainage area No. 1, in actuality, drains both to the north and to the south rather than just to the south as modeled in the first set of calculations. The drainage divide is located north of the east-west midline of the buildings as shown in Figure 20. Approximately 3.1 acres drain to the north and 9.3 acres drain to the south.

The Rational Method was used in the first set of analyses to compute the peak discharge from the total area of drainage area No. 1. This discharge of

520 cfs then was divided on the basis of area to provide a peak discharge of 130 cfs flowing to the north and 390 cfs flowing to the south. Further refinement in the division of the flood peak is limited by available topography.

A cross section was placed on an east-west line located south of and adjacent to the plant buildings in area No. 1. The location of the section, seen as Section C-C on Figure 20, was selected for several reasons including its proximity to the buildings, the large surface area adjacent the section occupied by the buildings, and the lack of defined drainage swales or channels. The cross section can be described as a broad, flat, flood plain and represents the worst-case situation.

An average ground slope between the buildings and the flood channel was determined from available topography to be 0.0022 ft/ft. The average Manning "n" value of 0.022 was assigned to the channel reach. This "n" value represents a combination of values for concrete, earth, asphalt, and grass.

The capacity of the channel section at a normal depth of 0.5 ft, is 510 cfs. This represents about 130% of the total discharge generated by the southern portion of the drainage area. However, the PMF discharge of 390 cfs was found to have a depth of 0.45 ft at cross section C-C. The difference in elevation between the building pad or land surface and the finished floor of the buildings is 0.50 ft or about 0.05 ft of freeboard during the onsite PMF.

The hydraulic analyses show that the water surface elevations created by the onsite PMF will not exceed the finished floor elevation of the plant. The analysis revealed that the slope of the land surface was sufficient to carry away runoff generated from high intensity rainfall equivalent to the PMP without the flood level exceeding elevation 517.5 ft msl.

Roof Drainage Analysis

The probable maximum 6-hour point precipitation for the Dresden site is 26 inches. This would fall in hourly increments of 12.48, 4.16, 3.12, 2.34, 2.08, and 1.82 inches, in any order [40]. The roof downspout system for the power station was designed to drain 4 inches per hour [7]. Parapets around the roofs of the turbine and reactor buildings are 3 ft 6 in high, and the crib house parapets are 1 ft 6 in high [6]. Structural capacities of the roofs are given by the Licensee as follows: turbine building, 35 lb/sq ft equal to 6.73 in of water; reactor building, 70 lb/sq ft or 13.46 in of water; and crib house, 60 lb/sq ft or 11.54 in of water [6].

The parapets of all three buildings are of sufficient height to pond water to depths which will exceed the roof structural capacities.

The Licensee states, and review confirms, that if the roof drains on the turbine building, the reactor building, and crib house are inoperable, then ponded water from the PMP will cause heavier loads than the specified structural capacities of all three roofs. The hour of heaviest rainfall, 12.48 in, would exceed the capacities of the turbine building (6.73 in) and the crib house (11.54 in). In 2 hours (the heaviest hour, 12.48 inches, plus the lightest hour, 1.82 in), the capacity of the reactor building (13.46 in) would be exceeded.

If the drains are fully functional, then the hour of heaviest rainfall would cause a buildup of 8.48 in on the roofs. The rainfall in this 1 hour would exceed the structural capacity specified for the turbine building, 35 lb/sq ft or 6.73 in of water. With drains unblocked and operable, the rainfall load on the reactor building and crib house roofs would not surpass the given structural capacities during the PMP.

Assuming 50% occlusion of the rainfall discharge system of the reactor building and crib house, the rainfall load resulting from the 6-hour PMP would be greater than the roof structural capacities. The following table shows incremental ponding with roof drains 50% blocked:

Hourly Rainfall (inches)	Drainage Capacity (inches)	Ponding (inches)
12.48	2	10.48
4.16	2	2.16
3.12	2	1.12
2.34	2	0.34
2.08	2	0.08
		14.18 total

Ponding caused by the five heaviest hours of the 6-hour PMP would total 14.8 inches, which is 0.72 inches above the capacity of the reactor building, and 2.64 inches above the capacity of the crib house roof, as stated by the Licensee.

Structural modifications, such as removal of portions of the parapets around the roofs, should be considered for the turbine building.

The Licensee states that an inservice inspection of the roof drainage system is indicated and will be described in SEP Topic III-3.C, Inservice Inspection of Water Control Structures [6]. A reasonable alternative to structural modifications of parapets on the reactor building and crib house would be the initiation of a comprehensive inservice inspection program which would preclude the blocking of the discharge system.

3.2.4 Conclusion

Groundwater Elevation

The effects of high normal groundwater elevation (elevation 217 ft msl) in combination with a SSE (0.2 g) should be evaluated for walls and foundations of safety-related structures.

Probable Maximum Flood

The PMF discharge of 490,000 cfs corresponds to a stillwater elevation of 524.5 ft. Wave runup added to the stillwater elevation yields a site PMF elevation of 528 ft msl.

Plant Grade Flood

For a gate opening of 16 ft, where 18.5 ft is the widest possible, the expected 100-year water surface elevation will be 509.8 ft. Depending on tainter gate position, the standard project flood discharge results in a stillwater elevation of between 512 and 516 ft msl.

Site Drainage

The plant site was analyzed for its ability to drain during the 24-hour PMP. The probable maximum point precipitation was 31.2 inches in 24 hours and had a maximum 13-minute intensity of 58.3 inches per hour. The 29.1-acre study area can produce an estimated peak discharge of 1230 cfs from the intense localized storm. The slope of the land surface and position of discharge and intake canals is adequate to convey the large volumes of flood waters generated during the localized PMP. The local drainage configuration, therefore, protects the plant from the localized PMP, and the site conforms to criteria presented in 10CFR50, Appendix A, GDC-2.

Roof Drainage

None of the roofs of safety-related structures (turbine building, reactor building, and crib house) were designed to sustain PMP loading with the drains clogged.

For the turbine building, assuming the drains are open, the PMP event will cause loading in excess of the roof structural capacity. Structural modifications, such as removal of portions of the parapets or the addition of scuppers, are recommended.

For the reactor building and crib house, assuming the drains are fully operational, the PMP event does not cause loading in excess of the roof structural capacities. With partial blockage, however, rainfall loads are in excess of roof structural capacities. Structural modifications are recommended. An appropriate inservice inspection program may mitigate the consequences of severe rainfall events. An example of a program which may be acceptable is presented in Regulatory Guide 1.127, Inspection of Water Control Structures Associated with Nuclear Power Plants.

3.3 CAPABILITY OF OPERATING PLANTS TO COPE WITH DESIGN BASIS FLOOD CONDITIONS (SEP TOPIC II-3.B.1)

3.3.1 Topic Background

Protection against postulated floods can be accomplished by implementing emergency procedures and technical specifications. The purpose of this evaluation is to focus on the adequacy and efficacy of the Dresden plant emergency procedures to preclude flooding of safety-related equipment necessary for maintaining the safe operation and cooldown of the reactor system. Further, this evaluation addresses the existence of technical specifications for flood control systems and procedures.

The following evaluation used information obtained during a Dresden plant site visit, Docket 50-237 [41,42,43], and the PMF hydrograph developed in Section 3.2 of this report.

3.3.2 Topic Review Criteria

- ANSI N170-1976
- Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants"
- Standard Review Plan Sections 2.4.3, 2.4.4, 2.4.5, 2.4.7, 2.4.10, and 2.4.4.14.

3.3.3 Evaluation

Background

The PMF and certain other floods of higher frequency have been determined to reach elevations which jeopardize equipment used in the normal operation of the Dresden plant. Consequently, the Licensee has adopted a flood emergency procedure (EPIP 200-11, Revision 0, August 1980 [33]) which provides guidance for operating personnel in the event of the forecast of a flood elevation reaching 509 ft msl or higher.

This evaluation focuses on the acceptability and efficacy of EPIP 200-11 as a mechanism to protect the equipment needed for reactor cooldown and control. This evaluation considers the timing of storm precipitation and runoff, the reactor cooldown time constraints, the timely availability of staff and necessary specialized equipment, the identity of safe shutdown systems and components, and the acceptability of procedures identified in EPIP 200-11.

The locations and elevations of safety-related components are presented in Table 2. The elevations were taken from the Dresden Station Units 2 and 3, "Fire Protection Systems and Programs," Docket 50-237 and 50-249 [44]. The information contained in Table 2 is presented to enable an identification of systems and components affected by flood water at various elevations. Two critical flood elevations exist at the site. The service water pumps in the crib house are affected at elevation 509 ft, while a number of other systems are affected as flood waters top doorway entrances to the turbine building above plant grade at elevation 517.5 ft.

Focus

The focus of the following discussion is the timing of the cooldown procedure concomitant with the rising of Illinois River flood waters. This background presents the temporal requirements for shutdown and cooldown to a "cold shutdown" condition. Further, this background presents the temporal characteristics of rising river water through the discussion of the critical time flood hydrograph (i.e., that graph which compares the river discharge to absolute time from the initiation of the critical time rainfall event). The critical-time flood is defined for this evaluation as the flood during which water level rises to elevation 509 ft and subsequently to 517.5 ft in the shortest possible time. The time frame in which safe shutdown must be achieved is determined by this critical flood.

Reactor Shutdown Cooling (Normal Operation)

Initial cooldown from the operating temperature of approximately 550°F to 350°F is accomplished using the main condensers and occurs over approximately 4 hours. The design objective of the reactor shutdown cooling system is to continue cooling of the reactor water when the temperature and pressure in the

Table 2

Locations and Elevations of Safety-Related Components

Building	Elevation* (ft)	Equipment Item	Equipment No.
Crib House	509	Diesel Generator Cooling Water Pumps	2-3903-A 2-3903-B
	509	Service Water Pump Motors	
Reactor Building	476.5	Core Spray Pumps	2-A-1503 2-B-1401
	476.5	LPCI/Emergency Air Cooler	2-5746-A 2-5746-B
	476.5	LPCI/Containment Cooling (heat exchanger)	2-A-1503 2-B-1503
		(pumps)	2-A-1502 2-B-1502 2-C-1502 2-D-1502
	517.5	Shutdown Cooling Pumps	2-A-1002 2-B-1002 2-C-1002
	545.5	Shutdown Heat Exchangers	2A-1003 2B-1003 2C-1003
		Reactor Building Closed Cooling Water Pumps	2A-3701 2B-3701 2C-3701
		Reactor Building Closed Cooling Water Heat Exchanger	2A-3702 2B-3702 2C-3702
	570	Reactor Building Closed Cooling Water Expansion Tank	2-3703
	589	Standby Liquid Control System Tank	2-1105
		Standby Liquid Control System Pumps	2A-1102 2B-1102
		Isolation Condenser	2-1302

---

*These elevations are not necessarily the lowest elevations occupied by these equipment items. They represent only the existence of that item at the specified elevation.

reactor fall below the point at which the main condenser can no longer be used as a heat sink following reactor shutdown. Once the reactor water has been cooled to approximately 350°F by the main condenser, the shutdown cooling system is capable of cooling reactor water to 125°F within 24 hours [45].

Flood Elevation Timing

The critical-time flood hydrograph shown in Figure 21 graphically depicts the relationship of flood elevation to time (hours) since the beginning of the limiting rainfall event. The following infomation can be obtained from the critical-time hydrograph.

- For low elevations (i.e., small discharges), the configuration of tainter gates at Dresden Dam has a great effect on stream elevations.
- Assuming gates open to 16 ft, 22 hours will be available from the onset of rain until the Illinois River reaches the elevation of the service water pumps (509 ft msl).
- Assuming gates open to 16 ft, 33 hours will be available from the onset of rain until the Illinois River reaches elevation 517.5 ft msl (plant grade).
- Assuming gates open to 16 ft, flood waters will be above elevation 509 ft msl for approximately 64 hours (2.75 days), and for a longer time during the PMF.
- Assuming gates open to 16 ft, flood waters will rise from elevation 509 to 517 ft in approximately 7 hours during the PMF.

Discussion

A flood emergency procedure should anticipate a flood which threatens the site sufficiently in advance of the occurrence of the flood to allow adequate time to place the plant in a safe shutdown condition (cold shutdown). Ideally, this shutdown procedure should be accomplished using normal shutdown procedures within approximately 28 hours (4 hours condenser cooling plus 24 hours reactor shutdown cooling system). However, presuming a rapid rise of water which hampers the operation of normal cooldown mechanisms, the emergency procedure should also identify the alternate cooldown plan and elaborate upon the mechanisms and equipment used in the alternate cooldown procedure.

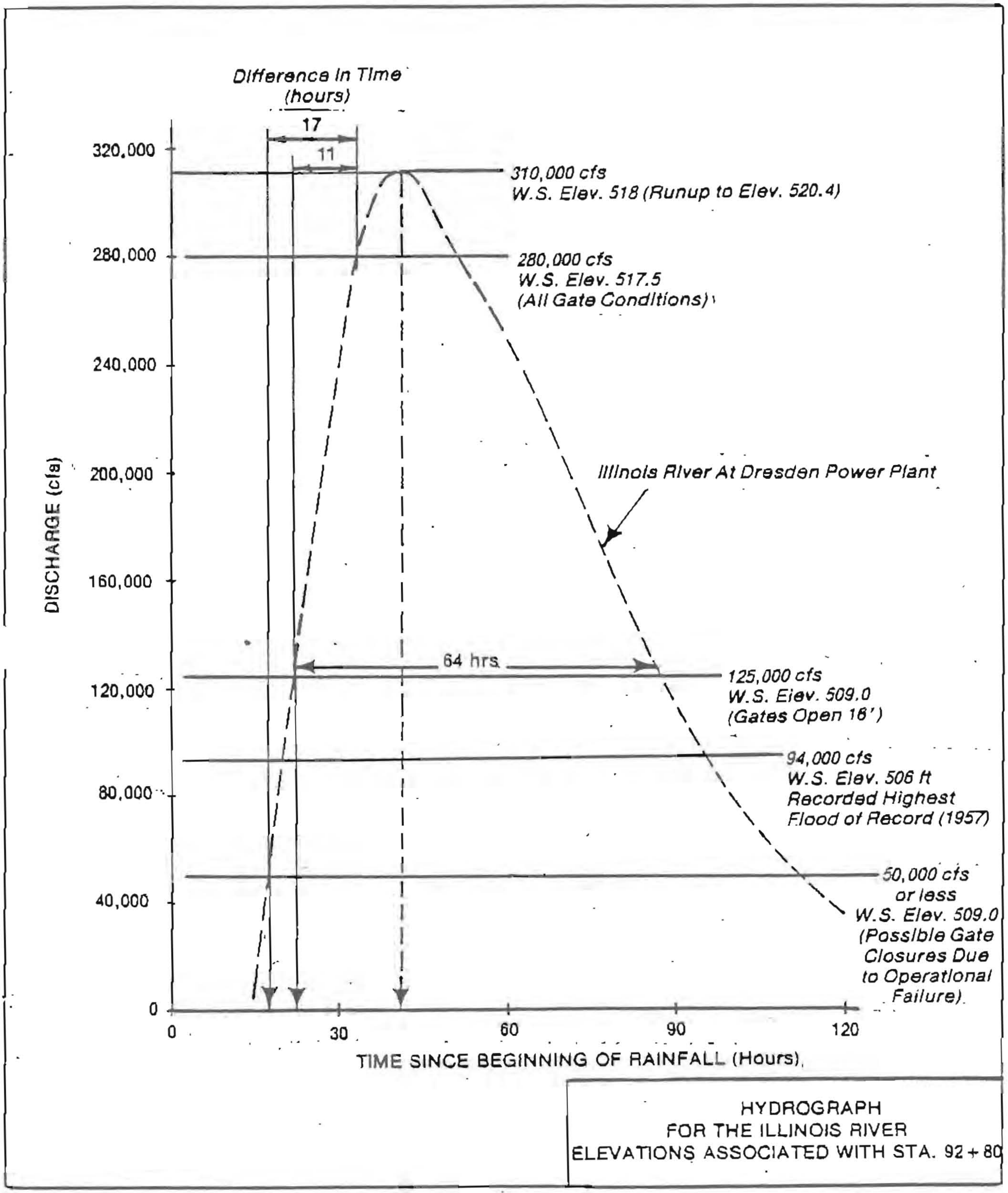


Figure 21. Critical-Time Hydrograph for the Illinois River

63
$\frac{5}{8.5}$ 11 85|550
510
40

EPIP 200-11 (flood emergency procedure) specified that, if river levels are forecast to exceed 509 ft elevation, reactor systems will "be cooled to the lowest legal temperature as quickly as possible." The rate of cooldown of the reactor system and the lowest temperature limit are established by technical specification.

In order to accomplish an ideal normal cooldown, the receipt of a forecast of water elevation exceeding 509 ft msl should be received by the Operations Director 6 hours in advance of the onset of rain (28 hours shutdown time minus 22 hours from onset of rain to water level of 509 ft msl). This is an unlikely situation since meteorological prediction is not sufficiently accurate. Consequently, for each hour lost due to late flood prediction, an hour of normal cooldown procedure will be lost.

Once the flood reaches elevation 509 ft, the normal cooldown system will be activated. The service water pump and diesel-driven fire pumps are located at elevation 509.5 ft msl. According to EPIP 200-11, the cooling of the reactor will be transfered to the isolation condensers. The isolation condensers will be fed with coolant water by the condensate transfer and clean demineralized water pump from the time flood waters rise from elevation 509 ft to 517 ft. Following system deenergizing and loss of ac power at flood elevation 517 ft, gasoline-driven pumps will supply the isolation condensers with coolant water from the intake canal via the fire system. If, for some reason, the gasoline-driven pumps cannot feed the isolation condensers through the fire protection system, direct suction will be taken from flood waters above elevation 517 ft.

When flood water has receded below elevation 509 ft, the Dresden flood emergency procedure directs that the previously moved service water pump motors be replaced to their original mounting, enabling normal operation of the cooldown system. Power for the service water motors is to be supplied by onsite emergency power systems.

Itemized Review of Emergency Procedure

The Dresden Flood Emergency Plan, EPIP 200-11, attempts to present acceptable procedures for maintaining the plant in a safe shutdown condition throughout the duration of a flood which prevents normal plant operation. This plan, in its present form, lacks sufficient specificity and is untested. Deficiencies in the procedure are identified below in chronological and alphabetical order corresponding to the same sections of EPIP 200-11. The Licensee text is presented within quotation marks.

> "A. PURPOSE
>
> This procedure delineates actions to be taken in the event a maximum flood of Units 2 and 3 is anticipated."

It should also be recognized that this procedure will be initiated for floods exceeding elevation 509 ft, not only maximum floods or the PMF. Thus, this procedure should delineate actions to be taken in the event a flood is predicted or anticipated to reach elevation 509 ft. For reference, it has been determined that the frequency of flooding up to elevation 509 ft msl with all lock gates open to the 16-ft gate is in the once-in-100-year range.

> "F. PROCEDURE
>
> 1. Obtain from the U.S. Weather Bureau, the current list of recording precipitation stations in the Des Plaines River Basin and Kankakee River Basin, when extremely heavy rains (approximately three inches per hour) are predicted for the Des Plaines and Kankakee River Basins simultaneously."
>
> 2. Obtain from each of the recording precipitation stations in the Des Plaines River Basin and Kankakee River Basin, the accumulated rainfall since the beginning of the storm and the time the storm began."

The procedural steps identified above need to be streamlined to enable the Operations Director or Station Director to more expeditiously accumulate information pertaining to rainfall intensity, duration, and time of initiation.

"4. If the river levels are forecast to exceed 509' elevation (traveling screen elevation in Unit 2/3 crib house),"

It is not clear who is providing the forecast of exceeding the 509 ft elevation.

"The Station Director or Operations Director will direct the Station in accomplishing the following steps:

a. Units 2 and 3 will be shut down, the drywells will be deinerted and the reactor vessels flooded.

b. Reactor systems will be cooled to the lowest legal temperature as quickly as is practical."

Item 4b should read "reactor systems will be cooled as quickly as possible within the constraints of reactor operation technical specifications."

"c. Two of the Service Water System Pump Motors will be removed to an elevation above 530'. Protection for other motors should be provided as time permits."

As Commonwealth Edison representatives explained during an NRC site visit that addressed this issue [44], the service water pump motors will be lifted and moved using an overhead hoist. The motors will be disconnected, lifted, transferred to another hoist at a higher elevation, and held there for the duration of the flood. After the flood has receded, the service water pump motors will be replaced, thus enabling normal reactor cooling to take place.

An inspection of the service water pump motors during the site visit [44] indicated that the previously identified procedure could take considerably more time than that available for water levels rising to the 509 ft elevation. Also, no protection equipment was readily available to protect other motors. Further, the procedure identified has never been executed on a trial basis.

"d. A level gauge will be installed in the Unit 2/3 crib house intake canal. Readings will be taken on this gauge on a frequency specified by the Operations Director."

This gauge should be permanently installed in the Units 2 and 3 crib house intake canal.

"e. At least four gasoline-driven pumps will be obtained and at least two of them will be installed with the suction taken from the intake canal and discharging into the fire system."

The exact onsite location of four gasoline-driven pumps could not be identified by Licensee representatives during the NRC site visit [46]. The Licensee defended the acceptability of this deficiency by stating that within a matter of hours the central Commonwealth Edison supply division could fly in several pumps at the request of the Station Director. Although this is a reasonable scenario, it should be recognized that there will be great demand for pumps throughout the Commonwealth Edison electrical supply area throughout the duration of this severe flood. Consequently, it is recommended that dedicated pumps be available on the site for this specialized purpose.

Further, the procedure used and equipment needed to perform the connection of gasoline-driven pumps to the fire system was not immediately obvious to Licensee representatives during the NRC site visit. Specialized equipment, attachments, and accessories should be stored on the site for the sole purpose of supporting the flood emergency procedure.

"g. The cooling of the reactors will be transferred to the isolation condensers."

The appropriate station procedure for isolation condenser cooling should be identified for the operator's reference.

"5. If the river levels are forecast to exceed elevation 517', the following steps will be implemented:"

This statement fails to identify personnel responsible for flood prediction and the manner in which the prediction will be made.

"d. The vents on the Below-Ground Diesel Oil Storage Tanks will be sealed or extended to 25' above the ground."

The Licensee has no specialized equipment readily available on the site which will enable the storage tank vents to be extended 25 ft above the ground. Such a vent extension should be capable of withstanding the lateral forces of moving flood water. Specialized equipment should be available and dedicated to the sole purpose of protecting the tank from flood waters.

"f. Boats with motors will be obtained to provide transportation between plant and higher ground as well as around the plant."

Several boats should be available on the site, since boats will be in short supply during severe flood occurrences.

"h. A pressure gauge will be installed on the reactor level instrument line to monitor reactor water level after power is lost."

It is not clear how this pressure gauge will be used to directly measure reactor water level. An appropriate alternative should be devised which enables the plant staff to directly determine reactor water level during the flood event.

No procedure has been identified which would enable the water level to be increased if necessary.

No mention is made of the mechanism which will provide reactor vessel temperature indication. Monitored temperature information is extremely important, as are pressure and level indication.

"6. When the water reaches elevation 517' de-energize all transformers and motor control centers on elevation 517'.

   a. When power is lost to Condensate Transfer and Clear Demineralized Water Pumps, use the fire system to supply make-up water to the isolation condensers.

   b. OPEN all doors to permit free flow of water through the plant.

   c. If the gasoline-driven pumps cannot continue to supply water through the fire system to the isolation condensers, they will be moved inside of the Reactor Building and connected to the make-up line to each isolation condenser. Suction for the pump will be from the local area. There should be several feet of water above elevation 517' by this time."

It is recommended that consideration be given to permanent installation of gasoline-driven pumps at elevations high enough to preclude their being affected by the PMF. This would prevent both lost cooling time during transfer of pump location and general disarray during an already complicated maneuver.

"d. Two of the gasoline pumps will be used to pump river water into the fuel pools to supply make-up water for steaming in the pools."

The function of the spent fuel pool cooling system is to keep the spent fuel assemblies cooled and covered with water. The Licensee's procedure has only addressed the loss of water level and not maintenance of spent fuel temperature. Flood water to elevation 517 ft will affect the normal operation of the spent fuel coolant system resulting in an escalation of pool water temperatures.

The acceptability of this procedure should be addressed in SEP Topic IX-1, "Fuel Storage," and is outside of the scope of this hydrologic review.

> "9. Power from off-site sources will established as soon as possible after the water recedes."

As indicated in this statement, normal reactor cooling procedures will not ensue immediately following the time flood waters drop below elevation 509 ft. Consequently, the operation of gasoline-driven pumps will be required for a significant period of time, i.e., more than 3 days. It is recommended that an adequate supply of fuel for the gasoline-driven pumps be available, thus enabling long-term uninterrupted operation of these pumps throughout the flood emergency.

> "G. CHECKLISTS
>
> None."

It is recommended that comprehensive work item checklists be developed for each procedure identified in the flood emergency plan to prevent a misinterpretation of procedure. Checklists containing the names of equipment items used in each of the procedures should also be developed. Specifically, procedures F.4.c, F.4.e, F.5.d, F.5.g, F.5.h, and F.6.c should be supported by work item and equipment checklists.

3.3.4 Conclusions

Emergency Procedure

In sum, the flood emergency procedure EPIP 200-11 needs to be modified to address the multitude of operational and mechanical problems which will ensue during a flood exceeding plant grade. The flood emergency procedure has never been exercised, an experience which would identify problems to be encountered in an actual emergency. A dedicated isolation condenser feed pump should be installed (to act as hardened protection) at a flood protected elevation, and procedure EPIP 200-11 should be exercised and updated. This type of active protection is a reasonable alternative to passive protection (flood walls, doors, etc.).

Technical Specifications

There are presently no plant technical specifications which incorporate flood emergency procedures at the Dresden Nuclear Power Station Unit 2. Technical specifications which limit the operation of the plant when water level exceeds approximately 508 ft msl are recommended. This elevation was chosen because the limiting elevation for continuous normal operation of the circulation water system is approximately 509 ft msl.

3.4 SAFETY-RELATED WATER SUPPLY (SEP TOPIC II-3.C)

3.4.1 Topic Background

This topic reviews the acceptability of a particular feature of the cooling water system, namely, the ultimate heat sink (UHS). The review is based on current criteria contained in Regulatory Guide 1.27, Rev. 2, which is an interpretation of General Design Criterion (GDC) 44, "Cooling Water," and GDC 2, "Design Bases For Protection Against Natural Phenomena," of 10CFR50, Appendix A.

GDC 44 requires, in part, that suitable redundancy of features be provided for cooling water systems to ensure that they can perform their safety function. GDC 2 requires, in part, that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena without loss of ability to perform their safety functions. Regulatory Guide 1.27 has been specifically cited by the NRC's Regulatory Requirements Review Committee as applicable to the SEP review of operating reactors. This guide is used in judging whether the facility design complies with current criteria.

The UHS, as reviewed under this topic, is the complex of water sources, including necessary retaining structures (e.g., a pond with its dam or a cooling tower supply basin), and the canals or conduits connecting the sources to the cooling water system intake structures, but excludes the intake structures themselves. The UHS performs two principal safety functions: (1) dissipation of residual heat after reactor shutdown and (2) dissipation of residual heat after an accident.

Availability of an adequate supply of water for the UHS is a basic requirement for any nuclear power plant. Since there are various methods of satisfying the requirement, UHS designs tend to be unique to each nuclear plant, depending upon its particular geographical location. Regulatory Guide 1.27 provides UHS examples that the NRC staff has found acceptable.

The UHS must also be able to dissipate the maximum possible total heat, including the effects of a loss-of-coolant accident (LOCA) under the worst combination of adverse environmental conditions. The maximum tolerable temperature of an UHS such as a cooling pond may significantly limit its ability to dissipate the heat load following a LOCA or plant shutdown, while for a UHS such as a large lake, river, or ocean, maximum temperature may not be a significant concern.

Because of the importance of the UHS, it should be able to perform its safety function during and following the most severe natural phenomena or accidents postulated at the site. In addition, the sink safety functions should be ensured during other applicable site-related events that may be caused by less severe natural phenomena and accidents in reasonable combination.

3.4.2 Topic Review Criteria

The criteria by which the UHS was evaluated in this topic review are taken from Regulatory Guide 1.27, "Ultimate Heat Sink For Nuclear Power Plants." Regulatory Guide 1.27 criteria are as follows:

"1. The ultimate heat sink should be capable of providing sufficient cooling for at least 30 days (a) to permit simultaneous safe shutdown and cooldown of all nuclear reactor units that it serves and to maintain them in a safe shutdown condition, and (b) in the event of an accident in one unit, to limit the effects of that accident safely, to permit simultaneous and safe shutdown of the remaining units, and to maintain them in a safe shutdown condition. Procedures for ensuring a continued capability after 30 days should be available.

2. The ultimate heat sink complex, whether composed of single or multiple water sources, should be capable of withstanding, without loss of the sink safety functions specified in regulatory position 1, the following events:

   a. the most severe natural phenomena expected at the site, with appropriate ambient conditions, but with no two or more such phenomena occurring simultaneously,

   b. the site-related events (e.g., transportation accident, river diversion) that historically have occurred or that may occur during the plant lifetime,

   c. reasonably probable combinations of less severe natural phenomena and/or site-related events,

   d. a single failure of manmade structural features.

3. The ultimate heat sink should consist of at least two sources of water, including their retaining structures, each with the capability to perform the safety functions specified in regulatory position 1, unless it can be demonstrated that there is an extremely low probability of losing the capability of a single source.

4. The technical specifications for the plant should include provisions for actions to be taken in the event that conditions threaten partial loss of the capability of the ultimate heat sink or the plant temporarily does not satisfy regulatory positions 1 and 3 during operation."

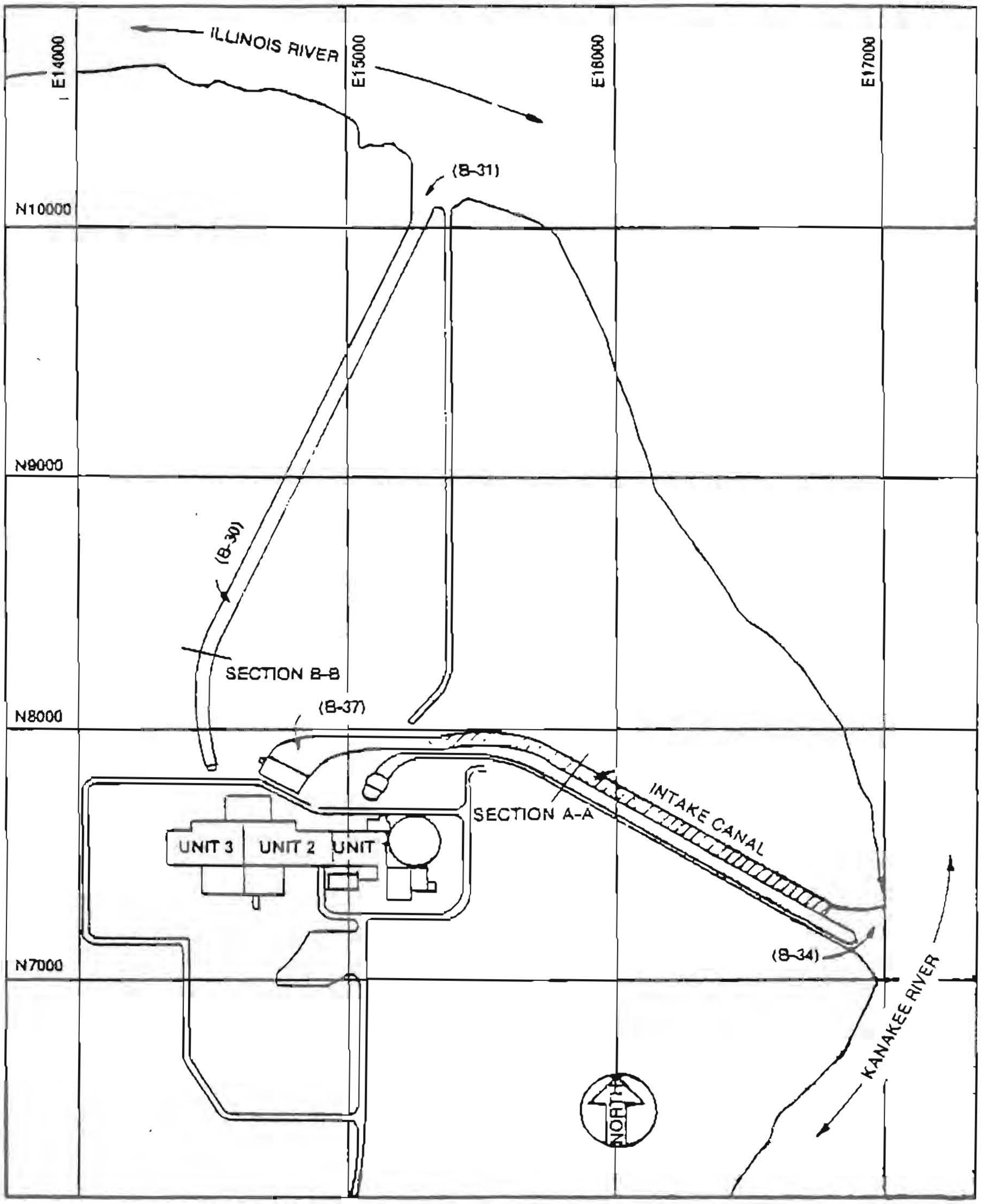
In addition to Regulatory Guide 1.27, clarifications are contained in Standard Review Plan (SRP), Sections 2.4.11, "Low Water Considerations," and 9.25, "Ultimate Heat Sink."

3.4.3 Evaluation

The Des Plaines and Kankakee Rivers provide the normal heat sink for the disposal of unusable energy from the thermodynamic cycle of Dresden Units 2 and 3. The rivers also provide the principal means for removal of the fission product decay heat of the nuclear core following a unit shutdown (see Figure 22).

The normal pool water level above the Dresden Island Lock and Dam is 505 ft 0 in msl. The pool level can vary from a low of 503 ft 0 in to a high of 506 ft 5 in msl. The pool level below the Dresden Dam is 483 ft 4 in msl. Units 2 and 3 share a common intake canal approximately 1,800 ft long (see Figure 23). The high point on the floor of the intake canal is 495 ft 0 in and is located 123 ft downstream of the floating booms which protect the entrance to the canal from floating debris. The canal floor then decreases in elevation until a low point of 482 ft 6 in is reached at the forebay of the crib house. There is a discharge canal approximately 2,000 ft long. One canal serves both Units 2 and 3. The high point of 498 ft 0 in, on the floor of the discharge canal, is located near the discharge flume, the point where the canal joins the river. Between this high point and the discharge head works, the floor of the canal decreases to an elevation of 489 ft 0 in. Connecting the discharge head works of Units 2 and 3 and the forebay of Units 2 and 3 cribhouse is an 8-ft diameter deicing line. The bottom of the deicing line in the head works has an elevation of 495 ft 0 in. A slide gate valve is used to isolate this line when not in use. The low point of the deicing line in the forebay is 489 ft 0 in msl.

In Reference 47, the Licensee identified the isolation condenser as an alternate UHS source. The isolation condenser system provides for cooling of the reactor core in the event that reactor feedwater capability is lost and other heat removal systems become inoperative. This alternate source of cooling water is a once-through system and operates by natural circulation without the need for driving power other than the dc electrical power needed to put the system into operation. Substantial makeup capacity is provided from diverse sources. Water stored in the isolation condenser and kept at full level during standby operation can be supplemented during condenser



KEY PLAN

Figure 22. Plot Plan Showing Intake and Discharge Canals

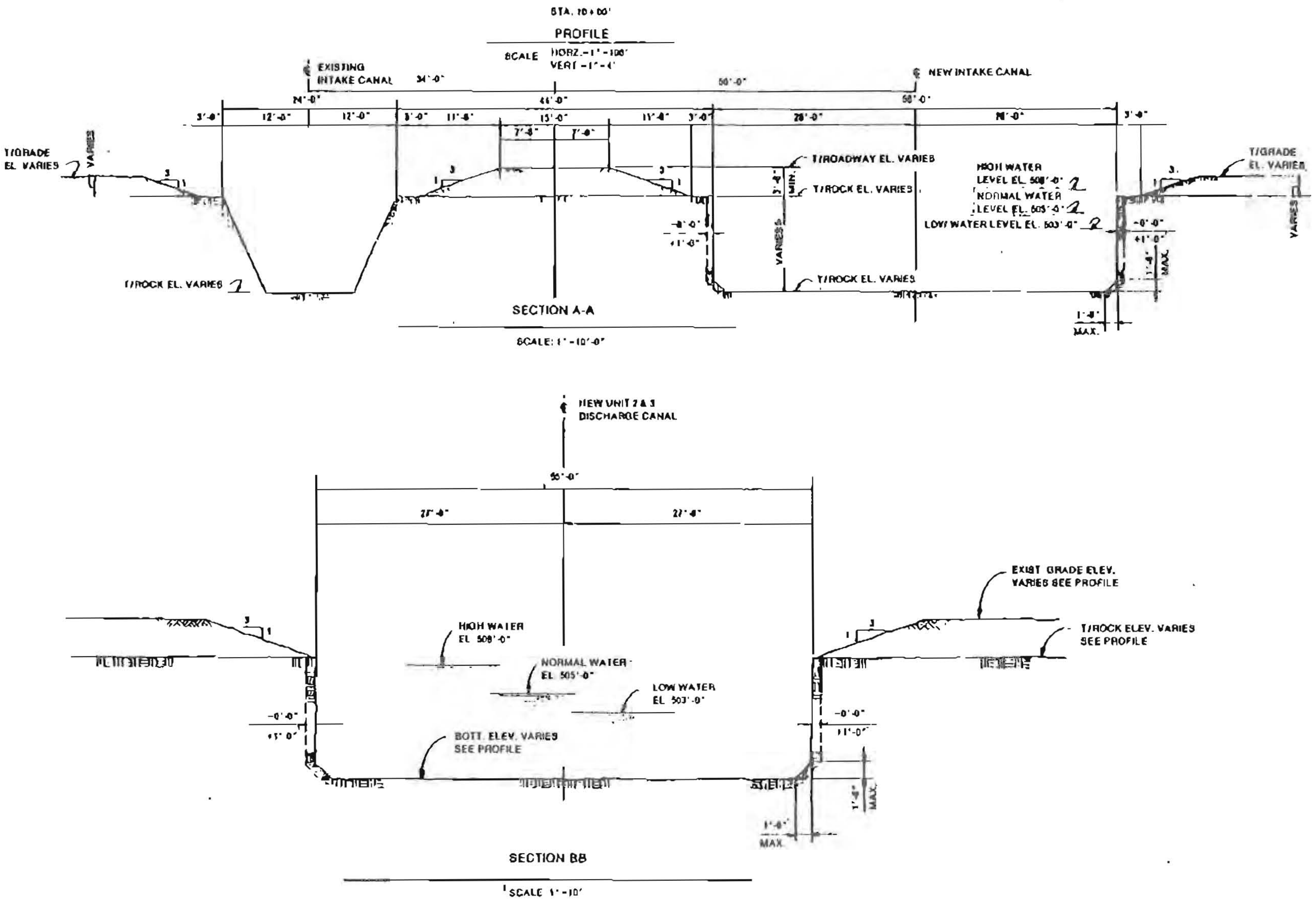


Figure 23. Sections Across Intake and Discharge Canals

operation from the 200,000-gallon demineralized water tank, the 700,000-gallon contaminated demineralized water tanks, and the fire water system. Reference 48 identifies that the contaminated demineralized water systems provide a source of water following a loss of offsite ac power.

The most severe challenges to the UHS function at Dresden Units 2 and 3 occur when a failure is postulated to the Dresden Lock and Dam or when a PMF is postulated at the site. The vulnerability of the UHS complex to these two events is discussed in Section 3.4.3.1.

3.4.3.1 Vulnerability of the UHS to Failure of the Dresden Lock and Dam

The failure of the Dresden Lock and Dam can be postulated to occur due to catastrophic structural failure or to seismically induced structural failure. Although both of these events are considered by the Licensee to be low probability events, consideration of these events is consistent with topic review criteria. In Reference 47, the Licensee provided an evaluation of a catastrophic failure of the Dresden Lock and Dam. That evaluation concluded that Dresden Units 2 and 3 can be safely shut down and maintained in that condition. As described by the Licensee, the first control room indication of trouble would be a drop in the power requirements of the circulating water pumps and service water pumps. The vacuum on each unit condenser would decrease and the reactors would scram on condenser low vacuum. With the loss of the main heat sink, reactor pressure would increase and the isolation condenser on each unit would go into service. Following the reactor scram on Units 2 and 3, the relief valves from the primary system to the suppression chamber would open to maintain a fixed pressure. Level in the reactor would be maintained by reactor feed pumps, control rod drive pump, or, in the case of loss of auxiliary power, the HPCI. With the initiation of the isolation condenser, depressurization of the primary system would start. Each of the reactors could now be depressurized at a controlled rate by use of its isolation condenser. By using the isolation condenser, the primary system temperature could be reduced to 212°F in 8 to 12 hours and held at this point. The temperature could not be reduced below this point since the system depends on steam flow to remove the core decay heat.

The availability of makeup water to the isolation condensers is dependent upon the nature of the initiating event. If the dam failed due to catastrophic structural failure, then makeup could be provided by any of the three sources previously mentioned. If the dam failure was caused by seismic phenomena with concomitant effects such as failure of other non-seismic structures and loss of offsite power, then makeup water must come from a seismically qualified source. In Reference 47, the Licensee indicated that the demineralized water tank and the contaminated demineralized water tank were not designed to withstand seismic phenomena and therefore would not be available. For Units 2 and 3 the Licensee states:

> "River water would be pumped to the isolation condensers by use of the diesel-driven fire pumps or by using a local city fire truck taking suction from the area in front of the Unit 1 intake structure and pumping into the fire system. The fire system is considered a Class II system, however parts of this system can meet the requirements of a Class I system. By use of existing valves, it is possible to sectionalize the system to isolate the failed parts."

In Reference 48, the water capacity of the isolation condenser was described as sufficient for approximately 20 minutes without makeup water. Taking into account the limitations that may be imposed on freedom of movement following the occurrence of a severe earthquake, it can be concluded that the time available is not sufficient to isolate failed parts of the fire system or to rely on the use of a fire truck.

The UHS as reviewed under this topic is the complex of water sources and the canals or conduits connecting the sources to the cooling water system intake structures, but excludes the intake structure and interconnections to the plant cooling systems. The following discussion is provided to aid in understanding the design capability of systems which interface with the UHS. In Reference 49, a seismic review team concluded that, in the case of Dresden Unit 2, there is strong reason to believe that the systems required for safe shutdown will remain funtional under the design hazard (i.e., a SSE of 0.2 g). This conclusion was predicated upon the redundancy of safety systems and components within safety systems and on the premise that a comprehensive equipment maintenance program has been carried out. The seismic review team concluded that the isolation condenser would withstand the 0.2 g SSE without loss of function. An assessment of the seismic capability of the intake structure or the fire system was not identified.

With respect to the UHS complex itself, the effect of earthquakes on the Kankakee and Des Plaines Rivers is not considered to pose a significant threat to the availability of the water source. In addition, the canals were constructed by excavating bedrock to the desired depth. Regolith situated on top of the bedrock was cut back from the canal edges, which precludes canal blockage resulting from a seismic event. The topography of the circulating water canals enables approximately 9,000,000 gallons of river water to be trapped within the intake and discharge canals when water in the rivers drop below the mouth of the intake and discharge canals. This is due to the high points in both the intake and discharge canals. As the Dresden Dam pool level would fall, backflow from the discharge canals would stop at 498 ft 0 in, and from the intake canals at 495 ft 0 in. In References 47 and 50, the Licensee describes how the impounded river water would be used as a heat sink for long-term cooling. Specifically, the Licensee stated:

> "The suctions of the service water pumps for Units 2 and 3 are below elevation 495 feet 0 in; therefore, a service water pump could be valved to supply cooling water to the reactor building closed cooling system which, in turn, could be valved to cool the reactor shutdown heat exchangers. The heated service water would be discharged to the discharge canal to dissipate its heat to the environs. The water in the discharge canal would then be recirculated back to the intake canal through the deicing line. Operation of the Units 2 and 3 diesel generators is assured since the suction for their cooling water pumps are at 487 feet 8 inches. The diesel fire pump of Units 2 and 3 has its suction at 492 feet 0 in. Loss of impounded river water, due to evaporation, could be made up by use of portable low head, high volume, engine-driven pumps. Commonwealth Edison has six 1500 gpm engine-driven pumps on standby at various fossil fuel generating stations. These pumps could be moved to Dresden within 6 hours. Pumps are also available from large Contractors in the northern Illinois area."

The Licensee's description implies that the impounded canal water is used essentially as a cooling pond following failure of the Dresden Lock and Dam. During an October 29, 1981 site visit, the Licensee was requested to augment this description by providing transient analyses of supply and/or temperature which demonstrate the capability of the water impounded in the canals to support simultaneous safe shutdown on Units 2 and 3. In response to that request, the Licensee submitted an analysis [6] that calculated the amount of water required to remove decay heat produced by one 2577 MWt (102% of rated power) reactor for 30 days. Approximately 2,500,000 gallons per reactor are required. The Licensee stated that "this water would not be returned but would be boiled off" within the isolation condenser. In addition, the Licensee indicated that an additional small amount of water would be needed to cool the pumps and diesels that are required to supply the water to the isolation condenser.

The analysis provided in Reference 6 calculated the total integrated fission product decay heat generated for 30 days after shutdown. The analysis assumed that the reactor continuously operated for 5 years at 102% of rated power. This is conservative since approximately one-third of the core is reloaded each refueling outage. Other conservatism in the analysis includes an assumption that the makeup water entering the isolation condenser is at 100°F and that the boiling takes place in the isolation condenser at the rated shell pressure of 25 psig. Both of these assumptions result in minimal heat removal per pound of water.

The analysis assumed that all of the water (i.e., 9,000,000 gallons) trapped within the intake and discharge canals would be available for makeup to the isolation canal. Scoping calculations were performed to estimate the amount of water available to the suction of the diesel-driven fire pump for Dresden Units 2 and 3, whose intake suction elevation is 492 ft. Approximately 2,500,000 gallons are available to elevation 492 ft in the intake canal and 3,000,000 gallons are available to elevation 495 ft in the discharge canal if the deicing line is operational. This estimate of water available does not consider the loss of water due to evaporation. The Licensee's analysis in Reference 6 also did not consider the dissipation of sensible heat from the two reactors. The justification for not including sensible heat was not provided; however, the amount of sensible heat is small compared to the integrated fission product heat over a 30-day period. The Licensee also did not identify the amount of water required to cool plant auxiliary equipment such as the diesel-driven fire pump or the emergency diesel generators.

Instead, the Licensee stated that this amount of water would be small. Nonetheless, the water used to cool the plant auxiliary equipment would be removed from the intake canal and returned to the discharge canal. If the deicing line fails due to the seismic event or the deicing line slide valve cannot be opened, the water in the discharge canal would not be available unless an alternate dumping mechanism were used.

Based upon the above discussion and the assumption of no mechanism by which the water in the discharge canal may be made available, it can be concluded that the available capacity of the intake canal is insufficient to cool both reactors for 30 days. It is hardly conceivable, however, that a mechanism cannot be found to make the discharge canal water available. Although a time-history analysis of water consumption was not performed, the water consumption rate is a decreasing function associated with the fission product decay heat. Because the amount of water available in the intake canal is large, it can be expected that a significant period of time would pass before makeup would be required. It can be conservatively estimated to be several days to a week or more. The Licensee has stated that loss of impounded river water could be made up by use of portable low head, high volume, engine-driven pumps. Six of these pumps are on standby at various fossil fuel generating stations. Based upon the time available, it can be reasonably concluded that replenishment can be effected to ensure the continuous capability of the sink to perform its safety function, taking into account the availability of replenishment equipment and limitations that may be imposed on freedom of movement following the occurrence of severe natural phenomena.

3.4.1.2 Vulnerability of the UHS to Probable Maximum Flood

The PMF at the Dresden Unit 2 site presents a challenge to maintaining the heat sink function; however, the high water levels do not have an effect on the UHS complex. As previously stated, the UHS complex is defined as the complex of water sources and the canals or conduits connecting the source to the cooling water system intake structures, but excludes the intake structure and interconnections to the plant cooling systems. The intake structure and the service water pumps are affected at elevation 509 ft, and a number of other interconnections to plant cooling systems are affected as flood waters top doorway entrances at elevation 517.5 ft. Nonetheless, the UHS complex is not affected by flooding. The effects of the PMF on the plant's capacity to maintain the heat sink function is described in detail in Secton 3.3.

3.4.1.3 Comparison of Dresden Unit 2 UHS to the Topic Review Criteria

Criterion 1 of Regulatory Guide 1.27 was established for heat sinks where the supply may be limited and/or the temperature of plant intake water from the heat sink may become critical. The most limiting challenge to the UHS complex at Dresden Unit 2 occurs when a failure is postulated to the Dresden Lock and Dam due to either catastrophic structural failure or seismically induced structural failure. Based upon the discussion in Subsection 3.4.1.1, the ability to dissipate the total essential heat load, the effect of environmental conditions on the ability of the UHS to furnish the required quantities of cooling water for extended times after shutdown, and the sharing of cooling water with other units can be demonstrated by the Dresden Unit 2 UHS. Although the UHS does not have a 30-day water capacity, it can be reasonably concluded that replenishment can be effected to ensure the continuous capability of the sink to perform its safety function.

Similarly, Criterion 2 of Regulatory Guide 1.27 was established to ensure that the heat sink function would not be lost due to natural phenomena, site-related events, or a single failure of manmade structural features. A large river is cited as acceptable in Regulatory Guide 1.27. The heat sink function at Dresden Unit 2 would be seriously affected but not precluded by failure of Dresden Lock and Dam. These effects are discussed in detail in Section 3.4.1.1. The effect of earthquakes on the Kankakee and Des Plaines Rivers is not considered to pose a significant threat to the availability of the water source. In addition, the canals were constructed by excavating bedrock to the desired depth. Regolith situated on top of the bedrock was cut back from the canal edges which preclude canal blockage resulting from a seismic event.

Other natural phenomena such as tornadoes and severe storms do not endanger the heat sink function. The UHS complex is not affected by flooding. The effects of floods are discussed in detail in Subsection 3.4.3.2.

Low water level caused by prolonged drought or icing is also not considered a threat to the water source at Dresden Unit 2. The Dresden Lock and Dam will maintain the water levels in the canals at about 505 ft msl. The head works of the discharge canal is connected to the forebay of the Units 2 and 3 crib house by an 8-ft-diameter deicing line. The bottom of the deicing line in the head works has an elevation of 495 ft. The low point of the deicing line in the forebay is 489 ft. Therefore, during periods of extreme cold, the thermal effluent can be directed to the intake structure to prevent ice formation.

The effect on site-related events (e.g., a transportation accident) on the UHS complex is being reviewed under Topic II-1.C, "Potential Hazards Due to Nearby Industrial, Transporation, and Military Facilities," and Topic III-4.D, "Site Proximity Missiles." Site-related events are not considered a threat to the availability of the Dresden Unit 2 water source.

A single catastrophic failure of the Dresden Lock and Dam would result in the partial loss of cooling capacity, but no single-active failure within the UHS complex will prevent the performance of its cooling function. The consequences of a passive failure resulting in the loss of the heat sink would be mitigated by the plant's ability to remove reactor decay heat through the isolation condenser. Although the makeup water supply for the isolation condenser is limited, sufficient time would be available to replenish onsite tanks or to provide alternate makeup from the intake canal. An unlikely single catastrophic failure of the Dresden Lock and Dam would not result in a total loss of the heat sink.

Criterion 3 of Regulatory Guide 1.27 was established to provide a high level of assurance that a plant's UHS would be available when needed. For a once-through cooling system such as Dresden Unit 2, the Regulatory Guide suggests at least two aqueducts connecting the river (in this case) with the intake structure and at least two discharge aqueducts to carry the cooling water away to preclude plant flooding, unless it can be demonstrated that the probability is extremely low that a single aqueduct will fail to function as a result of natural or site-related phenomena. A failure of the Dresden Lock and Dam would not preclude use of the isolation condenser. The ability of the Dresden Unit 2 facility to maintain the heat sink capability following an earthquake is discussed in Subsection 3.4.1.1.

Criterion 4 requires that the plant technical specifications include provisions for actions to be taken in the event that conditions threaten partial loss of the UHS. This criterion was established to ensure that the manner in which plant technical sepcifications were written was such that the plant would be placed in a safe condition or provisions would be implemented if a condition existed which threatened the availability of the UHS. An example of such a condition might be the prediction of a severe flood which would jeopardize a UHS dike or retaining structure, a severe drought with the potential to reduce the capacity of a cooling pond, or a prediction of severe river icing conditions which could preclude or inhibit water flow for a once-through cooling system. In each of these situations, technical specifictions requiring the plant to be placed in a safe condition or implementation of procedures to mitigate the consequence of a threatened partial loss of the UHS would be prudent.

As described previously, the Dresden Unit 2 UHS, including the river, Dresden Lock and Dam, and the intake and discharge canals, is not susceptible to damage from natural phenomena and most site-related events. The UHS complex is potentially susceptible to damage from single catastrophic failures and earthquakes. It is critical that impounded water remain in the intake canal to ensure the safe shutdown of Dresden Units 2 and 3. An earthquake or dam failure are events which cannot be predicted sufficiently in advance to allow the plant to be placed in a safe shutdown condition; however, plant operation following such events cannot be continued. Therefore, it would be prudent to include a requirement in the technical specifications stipulating that Dresden Units 2 and 3 be shutdown and cooled down whenever the river level falls below elevation 495 ft.

Although the UHS complex is not affected by flooding, other safety-related components and structures are affected. A discussion of protection against postulated floods by implementing emergency procedures and technical specifications is provided in Section 3.3.

3.4.4 Conclusion

The following is a summary of the degree of conformance of the Dresden Station Unit 2 UHS to the criteria of Regulatory Guide 1.27:

Criterion 1 -	complies, with the clarification that the UHS does not have a 30-day capacity following all postulated events, but sufficient capacity is available to reasonably conclude that replenishment can be effected.
Criterion 2 -	complies, with the clarification that the isolation condenser augments the UHS complex to further reduce the likelihood of a total loss of heat sink function.
Criterion 3 -	complies, with the clarification that the isolation condenser augments the UHS complex to reduce further the likelihood of a total loss of heat sink function.
Criterion 4 -	does not comply because plant operation is not prohibited by extreme low river levels.

In summary, the UHS at Dresden Unit 2 is a dependable design that partially complies with the intent of Regulatory Guide 1.27.

4. CONCLUSIONS

4.1 FLOODING POTENTIAL

The Dresden site is not "flood dry," i.e., the site is shown to be inundated by a probable maximum flood (PMF) event, and consequently must be protected by structural or other (emergency procedures) measures. The effects of the PMF on the plant are significant.

The PMF elevation for the Dresden site is 528 ft msl where plant grade is 517 ft. The lowest elevation of safety-related equipment is 509 ft. The safe operation of the plant during the PMF occurrence is to be accomplished using flood emergency procedure EPIP 200-11.

The roofs of buildings housing safety-related equipment were not designed to shed the probable maximum precipitation (PMP). Modifications are recommended.

Local flooding due to the occurrence of a localized PMP event will not affect safety-related equipment at the site. The site is protected from local flooding in accordance with 10CFR50, Appendix A, GDC-2.

Groundwater fluctuations up to plant grade (517 ft) should be considered in further evaluation of safety-related plant structures (SEP Topic III-3.A, Effects of High Water Level on Structures).

4.2 EMERGENCY PROCEDURE AND TECHNICAL SPECIFICATIONS

Although deficient in its present form, the Dresden flood emergency procedure (EPIP 200-11) outlines a plan for maintaining control of critical safety operations. The efficient execution of this emergency procedure will be impaired because of inadequate direction provided by EPIP 200-11.

There are presently no plant technical specifications which incorporate flood emergency procedures. Technical specifications which limit the operation of the plant under low water conditions in the intake structure are recommended in Section 3.4.4.

4.3 ULTIMATE HEAT SINK

The Dresden Unit 2 UHS partially complies with the intent of Regulatory Guide 1.27. Specific areas of deviation are discussed in Section 3.4.3. Technical specifications which preclude operation of the plant during low water conditions are recommended.

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