Upper Mississippi River System
Flow Frequency Study

Hydrology & Hydraulics
Appendix D
St. Louis District
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UPPER MISSISSIPPI RIVER SYSTEM FLOW FREQUENCY STUDY
ST. LOUIS DISTRICT
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INTRODUCTION

PURPOSE

The purpose of the Upper Mississippi River System Flood Frequency Study is to update the discharge frequency relationships and water surface profiles for the Mississippi River and Illinois River above Cairo, Illinois, and the Missouri River downstream from Gavins Point Dam (see Plate D-1). Five Corps Districts are participating in this study effort—Omaha, Kansas City, St. Paul, Rock Island, and St. Louis. The purpose of this appendix is to present the technical effort of the St. Louis District (MVS) in performing discharge and stage-frequency studies for the Mississippi and Illinois Rivers within the District boundaries (see Plate D-2). These studies were performed during the 1998-2003 period. The work is part of a five District effort to update frequency estimates following the Great Flood of 1993 and several lesser events during the mid-1970's to mid-1990's.

SCOPE

The scope of the MVS effort encompassed 300 miles of the Mississippi River, from the mouth of the Ohio River to Lock and Dam 22 tailwater (mile 300) and the first 80 miles of the Illinois River, from its mouth at Grafton to the LaGrange Lock and Dam tailwater (mile 80). In conjunction with the Kansas City District, the work also included the reach of the Missouri River from its mouth to the Hermann, MO gage (mile 97.9). This study was amended by the more than 20 years of additional discharge and stage data now available since the last development of stage-frequency relationships, as well as the occurrence of the Great Flood of 1993. The 1993 event was large enough that its impact on discharge and stage-frequency relationships required evaluation.

OBJECTIVES

This study was designed to re-evaluate the existing stage-frequency profiles for those portions of the Mississippi and Illinois Rivers within the boundary of MVS. The current estimate of the stage-frequency relationships along the Mississippi River in the MVS was developed following the previous flood of record (1973). The 1973 flood set records for stage along most of the Mississippi River and the lower half of the Illinois River in MVS. Since that study, the two rivers have experienced moderate to severe flooding in 1979, 1982, 1983, 1985, 1993, 1994 and 1995. The Great Flood of 1993 broke all the stage and discharge records for the entire MVS reach of the Mississippi River from Thebes, IL (mile 43.7) upstream. Mississippi backwater up the Illinois also broke all previous stage records for the lower reach of the Illinois River from the mouth to the Florence, IL gage at mile 56.0. Following the 1993 flood, the Rock Island District compared existing stage-frequency data to the 1993 flood and other events. These comparisons indicated that the adopted discharge and stage-frequency relationships for the Mississippi River were no longer appropriate over a portion of their District. In early 1996, Rock Island District proposed a feasibility study to update stage and discharge frequency relationships for St. Paul, Rock Island and St. Louis Districts. Since these relationships cannot be evaluated for the MVS without data from the Missouri River, the study was expanded to include the Kansas City and Omaha Districts in late 1996. An initial discussion and scoping meeting was held in March 1997 among concerned Districts and Divisions. The balance of FY97 effort was used to develop a work plan, schedule and detailed cost estimates. Technical studies in MVS began in force in March 1998.

PREVIOUS STUDIES

The St. Louis District has developed stage frequency estimates on the Mississippi River on two occasions: in the early 1950's for the Alton-to-Gale levee study and in the 1970's, following the occurrence of the 1973 flood of record. The former analysis concentrated on only the 2% and 0.5% chance exceedance probability profiles, which were used for development of levee profile grades. This study did not include any reservoir impacts. The update, carried out following the 1973 flood, included a statistical analysis of discharge records, an estimated adjustment for the impacts of upstream reservoirs, and the development of water surface profiles for steady flow conditions using the Mississippi Basin Model at Clinton, MS. These results have been utilized since the mid-1970's. The Mississippi River profiles are published in Reference 12. The current MVS stage frequency estimates on the Illinois River from mile 0.0 to mile 80.0 are based on a coincident frequency analysis performed in the late 1970's (ref. 13).

ELEVATION DATUM

All elevation data at gages plus previous and new ground or hydrographic survey data uses the National Geodetic Vertical Datum (NGVD) of 1929.

REPORT FORMAT

All tables are placed within the text of this appendix and all plates are located at the end of the appendix.

ACKNOWLEDGEMENTS

This Appendix is the result of the dedicated efforts of a number of current and retired St. Louis District employees: Rich Astrack, Project Management; Joel Asunskis, John Boeckmann, Ron Dieckmann, Don Duncan, and Dennis Stephens, Hydrologic and Hydraulics Branch; and Gary Dyhouse, retired Chief of Hydrologic Engineering Section.

Also, the coordination and cooperation provided by Corps' study members, Joe McCormick (retired), Bob Occhipinti, and Don Flowers from Mississippi Valley Division, David Goldman of HEC and all Corps' members involved with the study were outstanding. Independent technical review was provided by Lyn Richardson from the Corps of Engineers Great Lakes and Ohio River Division Hydraulics Branch, and Don Flowers of the Water Control Team, Technical Directorate, Mississippi Valley Division.

BASIN DESCRIPTION

WATERSHED CHARACTERISTICS

The Mississippi River rises in the lake-forest country of north central Minnesota near the Village of Bemidji, and flows north, east, and then south through this timbered landscape to Minneapolis-St. Paul. At this point, it leaves the northern woodlands and lakes, and meanders southward past fertile prairies and many villages and cities. Along the way, tributaries to the east and west join the Mississippi River and add to its flow. The upper Mississippi River flows 1,370 miles from its headwaters to the confluence with the Ohio River (the downstream limit of this study). Then it flows another 964 miles to the Gulf of Mexico. The St. Louis District is at the southern end of the upper Mississippi River basin and covers 27,000 square miles. MVS includes 300 miles of the Mississippi River from the tailwater at L & D 22 at Saverton, MO to the mouth of the Ohio River, and the lower 80 miles of the Illinois River from the tailwater at LaGrange L & D to the mouth of the Illinois River.

CLIMATOLOGY

Nearly all surface water runoff in the Upper Mississippi River basin results from precipitation falling within its watershed boundaries. The average annual precipitation over the basin is 32 inches. Of this amount, an estimated 24 inches returns to the atmosphere by means of evaporation and/or transpiration. The remaining 8 inches pass out of the basin as surface water runoff via the Mississippi River. Runoff is subject to seasonal variations of temperature and precipitation. The months of highest runoff are generally March through June, roughly paralleling the monthly precipitation pattern. The average monthly flows then generally taper off, reaching minimum values during the winter months. The March and April flows in the northern half of the basin are augmented by the melting snow, which accumulated during the winter months. Monthly flows in the southern portion of the basin are relatively high during the winter months as compared to the northern portion because annual precipitation is more evenly distributed and temperatures are more moderate. The annual runoff as a percentage of the annual precipitation varies greatly over the basin. The basin-wide ratio of average runoff to average precipitation is about 25 percent.

FLOOD HISTORY

Mississippi River

Flood of 1973. In March and April of 1973, the section of the Mississippi River within the St. Louis District was swollen to unprecedented levels by a combination of heavy rainfall, and melting ice and snow in the north. During the second week of March 1973, a very severe storm system developed over Kansas and moved northeastward over the upper Mississippi basin. The first major crest reached St. Louis on March 17, 1973, with a stage of 35.2 feet. A second crest developed in late March and peaked at St. Louis at 39.8 feet on April 5. By April 8 the stage was falling at St. Louis and by April 10, the Mississippi River was falling at most gages within the St. Louis District boundary. A cloudburst across Missouri, Illinois, and Iowa on April 19-21 caused a third crest. This third crest established record stages at every gage between Louisiana, MO to the north and Cape Girardeau, MO to the south. The third crest reached St. Louis on April 28th and registered a peak stage of 43.31 feet. The maximum measured discharge was 852,000 cfs. During this long duration flood, the Mississippi River at St. Louis was above flood stage a total 77 days and above a 40-foot stage (10 feet above flood stage) for 8 days.

Flood of 1993. The Great Flood of 1993 was unique in its aerial extent as well as its duration. Excessive precipitation during April through July produced record flooding in a nine-state area within the upper Mississippi River basin. Every gaging station along the main stem of the Mississippi River below Lock and Dam No. 15 to Thebes, Illinois experienced a new flood of record. Although, typically, floods occur in the spring, this flood occurred throughout the summer along the Mississippi River. Flooding and water levels remained above the flood stage from April through September in many regions along the Mississippi River. The St. Louis gage crested on August 1 with a peak stage of 49.58 feet. The peak discharge of 1,070,000 cfs was the highest recorded discharge ever measured at St. Louis. The Mississippi River at St. Louis exceeded flood stage a total of 80 days, breaking by 3 days the record set during the 1973 flood. The 1993 flood also exceeded a 40-foot stage at St. Louis for 38 days. Standard hydrometeorological techniques applied to the 1993 precipitation amounts from periods from 2 months up to 12 months, estimated return period of the 1993 precipitation values exceeds 200 year (Kunkel et al., 1994).

Flood of 1995. From April 1995 through early June 1995, many areas of the central United States received more than twice their normal precipitation. An abnormally strong and persistent southwesterly flow of air at the jet stream level pushed a series of major storm systems across the country, resulting in repeated episodes of heavy rainfall. May 1995 was the wettest May on record in both Kansas City and St. Louis. This excessive rainfall, coupled with nearly saturated soil moisture conditions over much of the region, resulted in flooding along the lower and middle Missouri River, along the middle and lower Mississippi River, and along the lower Illinois River. The peak discharge at the Louisiana gage was about 325,000 cfs, at the Grafton gage 377,000 cfs, at the St. Louis gage 800,000 cfs, and at the Chester gage 857,000 cfs. The Mississippi River was at or above flood stage at Louisiana, Grafton, St. Louis, and Chester for 44 days, 52 days, 40 days, and 55 days, respectively. The crest stage at St. Louis gage was the third highest since records have been maintained. The peak stage for the 1995 flood at the Thebes gage was the highest stage recorded because of the influence of the backwater from the Ohio River.

Illinois River

Flood of 1943. The record breaking flood of May 1943 was produced by rainfall of more than twice the amount that normally occurs during the month. Rainfall over the Illinois River Basin during May totaled about 8.5 inches, as compared with the normal of 3.95 inches. The heaviest precipitation was recorded during the period of May 7th through May 20th. The peak flow of 123,000 cfs at Meredosia, IL occurred on May 26. The Illinois River was above flood stage at Meredosia for 70 consecutive days.

Flood of 1982. The December 1982 flood resulted from a prolonged spell of abnormally warm weather and moderate rainfall through late November. Saturated conditions and intense rainfall in early December produced a high percentage of runoff in many areas of Illinois. The resulting peak flow of 112,000 cfs was the third highest recorded flow at Meredosia and occurred on December 12.

Flood of 1985. Rainfall on frozen ground in late February caused the Illinois River to rise above flood stage. Then, on 3-4 March, about two inches of rain fell throughout the Illinois River basin on the already saturated soil. Record stages were recorded upstream of Peoria and near record stages at Beardstown and Meredosia. This spring flood produced the second largest peak flow at Meredosia of 122,000 cfs on March 10th.

Flood of 1993. The great flood of 1993 on the Mississippi River caused the Illinois River to swell to record-breaking stages at Hardin, Illinois, Pearl, Illinois and Florence Illinois gages.

Flood of 1995. The flood of 1995 on the Illinois River recorded a peak discharge of 109,000 cfs at Valley City, Illinois. This flood was 14,000 cfs and 2 feet lower than the record breaking flood of May 1943 at Valley City, Illinois.

HYDROLOGIC WATERSHED MODELING

BASIN HYDROLOGY FOR WATERSHED MODELS

General

The primary objective of the hydrologic engineering effort for this study was to establish the stage and discharge frequency relationships for the Mississippi River and the Illinois River. Another objective was to maximize the use of all hydrologic and hydraulic models for future studies and for water control management purposes. The initial planning thus focused on developing hydrologic (HEC-HMS, ref. 1) models of all watersheds in MVS, except for the St. Francis River Basin, which does not enter the Mississippi within the boundaries of the MVS. The output from these hydrologic models provided daily discharge data to an unsteady flow hydraulic (UNET, ref. 2) model of the Mississippi, Illinois and Missouri Rivers. Watershed models were developed for the main tributaries of the Mississippi River and the Illinois River using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). HEC-HMS models were built for six major Mississippi tributary rivers in the MVS and for 22 local inflow areas to the Mississippi, Missouri and Illinois Rivers. See the HEC-HMS basin outlines on the St. Louis District map (Plate D-2).

Analysis Steps

The building of each HMS model included the following tasks: GIS watershed delineation and routing reach definition; precipitation and flow data acquisition; estimation of missing or unrecorded precipitation data; and model calibration to obtain unit hydrograph, infiltration, and routing parameter estimates. The design of the HMS watershed models included features that are compatible with the Modified Clark unit hydrograph technique to estimate runoff with NEXRAD precipitation data for later applications in water control forecasting. Sub-basins were delineated corresponding to the location of the Corps and USGS stream gaging stations, Corps reservoirs, and major tributary inflow points. The HMS models each contain from one to 15 sub-basins (See Plate D-3). Plate 3A shows an example of the detailed sub-basin delineation for the HEC-HMS model of the Kaskaskia River basin.

GIS Watershed Delineation

This activity was accomplished using ARCINFO and a series of arc macros (GRIDPARM) developed by HEC. MVS hydrologic engineers and water control managers, with assistance from HEC personnel, developed basin work maps and sub-area delineations that were utilized to setup a grid cell database for later computation of precipitation data. Sub-basin drainage areas were based on Corps of Engineers (COE) and USGS published information.

Rainfall Synthesis

The period of record simulation required the input of daily rainfall totals for all subareas for the full 100-year period of record from 1898 to 1997. Unfortunately, daily rainfall data was not collected for the portion of Illinois in the MVS prior to 1901 or prior to 1918 in Missouri. Consequently, these missing data periods had to be estimated. In addition, for most rainfall gages, periods of missing rainfall data were common within the record, although most missing periods were only from one to several days in length. These missing data also required estimation and inclusion in the overall record. Finally, actual and simulated rainfall data for the full period had to be adjusted from a point source at each gage site to represent average rainfall for each sub-basin. This engineering effort was accomplished by using 71 rainfall gages within and near the MVS to extend the missing record back to the start of daily data records. Simulation of daily rainfall, prior to the start of record (1901 in Illinois and 1918 in Missouri), was accomplished by researching historic monthly rainfall records and developing monthly rainfall totals for the desired regions in the two states. Daily rainfall gage data in nearby Illinois areas prior to 1918 were also used to estimate daily rainfall data in adjacent Missouri areas. Monthly rainfall totals for each missing year (three in Illinois, 21 in Missouri) were distributed in time using an actual pattern hyetograph from the same month for an "analog" year during the actual period of record. Monthly totals were distributed into daily values by proportioning the monthly ratios with the known daily precipitation for the "analog" year. When daily rainfall totals at all gages had been computed, a grid network with 5-mile vertices was overlain on a map of the MVS. A "synthetic" rain gage was simulated at each vertex by weighting the rainfall values at nearby rain gages in inverse proportion to the distances, using the HEC program PRECIP (ref. 3). Sub-basin average precipitation values were then computed by averaging the values computed at each vertex within the sub-basin. The number of vertices per sub-basin ranged from 2 to 37. Crosschecks of the PRECIP-computed data with actual data averages were incorporated to insure the appropriateness of the final computations. Reference 4 is a complete report detailing the work required for precipitation simulation for the full period of record. While 24-hour values of precipitation were synthesized, rainfall values in 6-hour increments were later applied to the HMS models to develop period of record runoff. A simple division by four of the 24-hour values was used to achieve the 6-hour increments required.

Discharge Data

Observed discharge data was identified, located and converted to HEC-DSS files for all tributaries to the Mississippi and Illinois in the MVS with sufficient drainage area size to use in HMS calibration. Most major tributaries had 60-75 years of daily discharge data, although several exhibited non-homogenous data due to reservoir construction during the period. Gages that were impacted by reservoirs were split into separate data sets for pre- and post-reservoir conditions.

Infiltration Parameters

As a period of record simulation was necessary, the infiltration process required definition throughout both wet and dry periods. The simple continuous infiltration process in HEC-HMS (deficit/constant loss rate) was used to compute losses throughout the period of record. This technique requires a constant infiltration loss rate (in/hr), an initial deficit (in) and a monthly basin recovery factor (in/day) to simulate the wetting and drying out process. Initial and constant losses were obtained from earlier hydrology studies for a selected watershed, or through optimization to flood hydrographs from gage records, if available. The initial deficit ranged from about 0.1-1.0, with an average of about 0.5 often used. The infiltration values ranged from 0.01-0.1, with infiltration losses of about 0.02 in/hr generally giving good results for flood simulations. While these values gave generally good reconstitution of various flood events, both in terms of peak flow and hydrograph shape, results were somewhat less satisfactory for a period of record simulation. Monthly basin recovery factors varied by basin but were generally in the 0.1-0.4 in/day range for the January-June period and from 0.4-2.5 in/day in the July-December period. Where continuous simulations with HEC-HMS were compared to gage results, the comparison of average annual discharge was generally good. However, simulated discharge during the first half of the year was usually much greater than recorded, while simulated discharges in the latter half of the year were typically lower than actual. Significant variations of the basin recovery factors, within reasonable limits, had only small impacts on the annual and monthly average discharge values. However, flood discharge simulations were usually reasonable, both in timing and in peak daily values. The main factors believed to cause the poor period of record simulations are: (1) a constant infiltration loss for the entire year, (2) the simulated rainfall values applied to the HMS model and (3) size of the basin. A constant loss for all periods of the year and for widely differing wetness conditions is judged to be a significant weakness. The ability to vary the uniform loss rates by month or at least by season would undoubtedly improve the simulation. While the uniform loss rate used is likely appropriate for rainy conditions with the basin partially to fully saturated, loss rates higher than those applied are probably the norm for dryer periods. Rainfall applications are based on the basin-average values computed from nearby gages with PRECIP. These values are certainly different than the actual rainfall amounts that resulted in the recorded discharges. The size of the watershed also impacted the period of record results, with the better simulations occurring for the larger watersheds. Flood simulations for the Big Muddy and Kaskaskia Rivers (>2000 square miles) were quite reasonable, whereas local area flood runoff from 100-800 square miles watersheds was not as well simulated. For the latter situation, the use of average daily rainfall and the 6-hr computation interval often did not define the runoff hydrograph in sufficient detail to capture the actual shape and peak flow. However, since the end purpose of the HMS simulation was the development of period of record Mississippi, Missouri and Illinois River discharges, the discharges simulated with HMS were considered satisfactory.

Base Flow Parameters

For the continuous simulation, a minimum monthly base flow was established for each watershed. These estimates were based on minimum monthly flow values for the period of record at various gage sites. The applied value was somewhat greater than the minimum monthly average value to improve month-to-month consistency, based on the modeler's experience and judgment. Monthly values ranged from less than one cfs for small areas to several hundred cfs for larger areas.

Unit Hydrograph Parameters

Clark TC and R parameters were used for each subarea in the HMS modeling. Values were taken from earlier regional studies performed by the MVS, other agencies, or from computing TC through the Kirpich Formula and then estimating R from ratios of TC and R found appropriate for nearby regions in the MVS. Examples of TC and R-values used can be found in the reports documenting the HMS analysis for the Big Muddy and Kaskaskia River basins (ref. 5 and 6).

Routing Parameters

Routing parameters were applied with available data from earlier models and studies, from examination of historical flow records and from observed flood travel times between gages. The travel time between gages varies with the magnitude of the event and the mode of flow (i.e., in or out of bank). The routing methods used were primarily the Modified Puls method when storage-outflow data was available from previous studies, or the Muskingum techniques when no data was available for a more precise estimate.

Model Calibration

Calibration of HMS models included (depending on data availability): (a) simulated vs. actual flood hydrograph comparisons for individual events, (b) comparison of hypothetical peak discharge for selected events using the HMS model vs. the results of regression equations, (c) simulated vs. actual comparisons of a “typical” high flow year, (d) simulated vs. actual comparisons of a “typical” low flow year, and (e) comparison of discharge frequency results, average flows and flow-duration relationships of the simulated vs. actual data using HEC’s STATS program (ref. 7). Calibration was performed on the Big Muddy, Kaskaskia and Salt River Basins for events and years under both pre- and post-reservoir conditions. Other MVS basins did not have reservoirs impacting flood runoff and only the no-reservoir scenario was required. For gaged locations, all methods but (b) were generally used, whereas ungaged locations generally relied on (b) for calibration. Calibration results can be found in the reports documenting the HMS analysis for the Big Muddy and Kaskaskia River basins (ref. 5 and 6).

IMPACTS OF MAN-MADE STRUCTURES - MVS TRIBUTARY RESERVOIRS

Following calibration of individual HMS basin models, the period of record rainfall data was used for both with and without reservoir HMS models for the Salt, Kaskaskia and Big Muddy Basins to evaluate the impact of flood reduction structures on the outflow. The “with reservoir” simulation used the current schedule of reservoir releases, based on pool elevation, inflow and time of year, with no deviations for any specific flood event. This is not the general rule as minor deviations are normally requested and approved, depending on the actual flood situation. Consequently, the simulated period of record could not closely match the actual record, which often reflected deviations from reservoir releases. Reservoir impacts on tributary and main stem water levels are therefore somewhat conservative, with actual reservoir reductions likely to be somewhat greater than shown from this analysis.

Salt River Basin

The Salt River Basin in northeast Missouri has a total drainage area of about 2,700 square miles and enters the Mississippi River at river mile 284.2. The Clarence Cannon Dam/Mark Twain Lake (Salt River mile 63.0) went into operation in 1984 and regulates upstream runoff from 2,318 square miles. Mark Twain Lake generally controls the great majority of runoff from the basin, with the only significant downstream tributary being Spencer Creek. Reservoir releases are generally maintained at 12,000 cfs, or less, resulting in a high level of flood reduction on the Lower Salt, along with moderate reductions on the Mississippi. One hundred years of daily rainfall values were supplied to both with and without reservoir models. The reservoir simulation showed the structure successfully contained all floods during the period to releases of 12,000 cfs or less until after the crest on the Mississippi had passed the mouth of the Salt. The impacts of Mark Twain Lake on Mississippi River flood levels are part of the total reduction including the three Rock Island District (RID) reservoirs.

Kaskaskia River Basin

This basin, the second largest watershed in Illinois, is located in southwestern Illinois. It has a total drainage area of about 5,800 square miles and enters the Mississippi River at river mile 118. The MVS has constructed two multi-purpose reservoirs on the main stem of the Kaskaskia River: Lake Shelbyville, at river mile 221.8, was completed in 1970 and Carlyle Lake, at river mile 106.6, was completed in 1967. The two lakes together control runoff from about 2,717 square miles and give significant flood reduction to areas downstream. The two reservoirs control just less than 50% of the overall watershed. Comparisons of reservoir impacts are shown at the Shelbyville and Carlyle gages, downstream of each project, and at the Venedy Station gage, (river mile 57.2), the only discharge site downstream of Carlyle Lake. The drainage area at the Venedy Station gage is 4,393 square miles, including about 1,676 square miles of uncontrolled inflow downstream of Carlyle Lake. The Kaskaskia River reservoirs can impact stages on the Mississippi River at the Chester and Thebes gages.

Big Muddy River Basin

The basin encompasses about 2,360 square miles and is located in extreme southern Illinois. The river joins the Mississippi at river mile 75.5 above the mouth of the Ohio River. Rend Lake, a multi-purpose reservoir with a non gated outlet, was built by the MVS on the main stem of Big Muddy River at mile 103.7 and started operation in 1971. The upstream drainage area of the reservoir is 488 square miles. Rend Lake has limited flood reduction potential and partially regulates only about 20% of the total basin. Consequently, downstream flood reductions on the Big Muddy River range from a few feet near the dam for common events to less than one foot near Murphysboro, the last discharge gage on the Big Muddy.

HYDRAULIC MODELING USING UNET

GENERAL

Hydraulic modeling was performed using UNET, a one-dimensional unsteady flow hydraulic model capable of capturing the dynamics of flood wave movement in the Mississippi River (ref. 2). The dynamic wave characteristics of this flood wave movement are apparent in the observed loop rating curves (the difference in stage occurring for the rising and falling limb of the hydrograph). These characteristics can be captured by UNET, but not by simpler hydrologic routing or steady flow backwater profile models.

STUDY AREA DESCRIPTION

The MVS UNET model was developed for the reach of the Mississippi River from near Hannibal, MO to Cairo, IL, the Missouri River from Hermann, MO to the mouth, and the Illinois River from near Meredosia, IL to the mouth. The Kaskaskia, Big Muddy, Meramec, Cuivre and Salt Rivers hydrographs were inserted at their respective junctions with the Mississippi River. All local tributary inflows entering the Mississippi, Illinois and Missouri Rivers were estimated through individual development of HMS models. A graphical schematic of the overall UNET model is depicted in Plate D-4.

Specific data is necessary to develop the UNET model. These data requirements are used to simulate river geometry and flow conditions. Each is discussed in the following paragraphs.

PREVIOUS MODEL

The St. Louis District developed UNET models for the Mississippi River and tributaries in 1995 and has used these models for river forecasting and period of record flow modeling. These models were built using available sounding data for channel geometry from the late 1970's and USGS 7.5-minute quadrangle mapping for the overbank geometry.

SURVEY DATA/ MAPPING

Digital Elevation Models

Aerial photography, airborne GPS control, ground survey control, and aerotriangulation was used in development of digital terrain model (DTM) and digital elevation model (DEM) of the project area for the St. Louis District (Illinois River Grafton, Illinois, river mile 0 to river mile 43.0 and the Mississippi River from the confluence of the Ohio River, river mile 0 to Dam 22 at Saverton, Missouri, river mile 301.2). The DTM data is composed of mass points and breaklines that adequately define elevated roads, railroads, levees (features that would impede flow) and other major topographic changes required for accurate DEM development. The DEM has a 15' posting and a vertical resolution of 0.1 ft. Both the DTM and DEM data collection utilized procedures that met U.S. ARMY CORPS OF ENGINEERS Class I Standards. The aerial mapping is based on surveyed ground control points. These surveyed ground control points are very accurate, but the aerial mapping of well-defined features between the ground control points can vary by as much as 0.67 feet 67% of the time in accordance with the ASPRS Class I mapping standards. Ground surface elevations developed by the aerial mapping will be accurate to within 1.33 feet. This level of accuracy is much better than that used for previous hydraulic models along these rivers and is considered very good for the purposes of hydraulic modeling.

Hydrographic Surveys

Hydrographic survey data taken in 1996 was combined with cross-sectional data cut from the DEM to produce final cross-sections for use in the UNET model.

Survey Data Verification

DTM's were verified using recent top-of-levee as-built elevations and documented structural feature elevations (roadways, lock walls, etc.).

RIVER GEOMETRY

The UNET model cross-section geometry was acquired from digital survey information of the Mississippi and Illinois River channel and floodplain using new profile generating software. Digital cross-sections were cut along the entire reach of the Mississippi River within the MVS from river mile 0.0 to 300.0 and along the Illinois River from the confluence through river mile 43.0. The average distance between cross-sections was between 2000 and 3000 feet. The Digital terrain models (DTM) of the project area were merged with hydrographic survey data of the Mississippi and Illinois River and converted into triangulated irregular network (TIN) data sets. Electronically cut profiles through these TIN data sets generated cross-sections for the Mississippi and Illinois River. The cross-section profiles were imported into HEC-RAS. Cross-section reach lengths, bridge pier data, and Manning's "n" value data were added to the HEC-RAS geometry file. This information was converted into a UNET geometry file. Additional information on the geometry of levee and drainage districts, and crossover storage areas were added to the UNET geometry file. See Plate D-5 for an example of the cross-section locations. Plate D-6 is an illustration of a final UNET geometry file cross-section.

FRICTION VALUES

Manning's "n" values for channel and overbank areas were estimated based on experience gained in calibrating the UNET model. The "n" value is determined from the factors that affect the roughness of channels and flood plains. This "n" roughness value can vary from season to season, and change with depth of water. Channel "n" values for the main stem rivers varied from 0.02-0.04, while the overbank "n" values ranged from 0.035 to 0.15. Manning's "n" values were adjusted in the form of conveyance during the calibration process in UNET to better simulate actual river stages at gaging sites.

MAINSTEM DISCHARGE/ STAGE DATA

There are five discharge gages on the Mississippi River in the MVS, although one (Louisiana) is stage only with occasional discharge measurements made. These sites were used to calibrate the model to recorded discharge data. In addition to the discharge gages, Mississippi River stage data is also available at 33 sites throughout the 300-mile reach of the Mississippi in the MVS. These locations were used for stage calibration. One discharge gage is available on the Illinois River, with five additional stage gages sited on the 80-mile reach. On the Missouri River, the only discharge gage near the MVS boundary is at Hermann, MO with discharge data to 1928 and limited stage data prior to that date. The Kansas City District performed the discharge analysis at the Hermann gage. Stage data is available at the St. Charles gage at river mile 28.2. The stage and discharge data for all river gages were stored into HEC-DSS files for use in the calibration/verification process of the UNET model. Discharge and stage gages are briefly discussed in the following paragraphs and pertinent data for each is shown on Tables D-1, D-2, and D-3.

Louisiana, MO

The Louisiana, MO USACE stage gage (0282A) is located at Mississippi River mile 282.9. Stage data has been collected at the site since 1878, with occasional discharge measurements taken. In recent times, most of the discharge measurements were collected during flood events, since the gage is within the pool created by Lock and Dam 24. Minor to moderate impacts from reservoir regulation occur at the site, due to the three tributary reservoirs in Rock Island District and one MVS reservoir on the Salt River, which enters the Mississippi 1.3 miles upstream from the gage site.

Grafton/Alton, IL

The Grafton, IL USGS gage (05587450) is located at Mississippi River mile 218.0. Prior to September 1986, the gage was located at Alton, IL, river mile 203.0 with essentially the same drainage area. Discharge data has been continuously collected since 1928, and intermittently back to 1880. Minor to moderate impacts are experienced at the gage site, caused by the same reservoirs mentioned in the previous paragraph and also by the numerous Missouri River reservoirs. These latter reservoirs can significantly lower backwater elevations up the Mississippi River occurring at the mouth of the Missouri at river mile 195.0.

St. Louis, MO

The St. Louis, MO USGS gage (07010000) is located at Mississippi River mile 179.60. Discharge has been computed continuously since January 1861. However, this data is non-homogenous and reflect significant changed conditions throughout caused by upstream reservoirs and irrigation diversions. In addition, the quality of the flood discharge data prior to 1931 is considerably lower than the measurements taken after 1931, which marked the continuous use of the Price current meter to measure velocity on the river. Prior to that date, a variety of meters and floats were used from floating plants or from bridges to measure velocity. Earlier studies (ref. 8) have found that flood discharge data was generally overestimated with these techniques, compared to the more-accurate measurements using the Price meter. This early data is therefore of questionable accuracy, especially for flood events. Discharge measurements after 1931 are considered to be accurate, but non-homogenous due to reservoir reductions and irrigation diversions in the Missouri River Basin. Reservoir reductions at St. Louis and for the downstream gages at Chester and Thebes are typically major. Average stage reductions during floods along the 195-mile reach from the mouth of the Missouri to the mouth of the Ohio River are normally several feet.

Chester, IL

The Chester, IL USGS gage (07020500) is located at Mississippi River mile 109.9. Discharge data is available since October 1927, with some intermittent discharge and stage data prior to this date to 1873. Discharges at the Chester and downstream gages are also impacted by the Kaskaskia River reservoirs. The Chester gage is the first gage station downstream of the Kaskaskia River.

Thebes, IL

The Thebes, IL USGS discharge gage (07022000) is located at Mississippi River mile 43.7. Discharge data is available since October 1932 and intermittent stage and discharge data exists back to 1878 at Thebes and two other nearby sites located a few miles upstream. Discharges at the Thebes gage can also be impacted by the Rend Lake Reservoir, which is the first gage station downstream of the Big Muddy River.

Valley City/Meredosia, IL

The Valley City, IL USGS gage (05586100) is located at Illinois River mile 61.3. Prior to 1989, the discharge records were published as "at Meredosia", a stage gage at mile 70.8. Discharge data has been recorded since 1921 and intermittently prior to this date, back to the late 1800's. Additional daily data was estimated for the period prior to 1921 by incorporating stage and discharge records at Beardstown, the nearest gage upstream. The simulated Meredosia daily flows were developed from these records and shifted to the Valley City/Meredosia site. Comparisons of this technique for periods when actual data was available at the latter site showed a good correlation and discharge estimation. There are no significant flood reduction structures upstream of the gage site and Illinois River flows are considered to be completely unregulated.

Stage Gages

More than 30 stage gages along the Mississippi and Illinois Rivers within the MVS were included in the database for later calibration and verification of the UNET model.

TABLE D-1 MISSISSIPPI RIVER USGS DISCHARGE GAGES

RIVER	GAGE SITE	STATE	RIVER MILE	Drainage Area (sq. mi.)	ZERO GAGE DATUM	FLOOD STAGE
MISSISSIPPI	LOUISIANA (DISCONTINUED)	MO	282.90	140,700	437.33	15.00
MISSISSIPPI	GRAFTON	ILL	218.00	171,300	403.79	18.00
MISSISSIPPI	ALTON (DISCONTINUED)	ILL	203.00	171,500	400.00	
MISSISSIPPI	ST. LOUIS	MO	179.60	697,000	379.94	30.00
MISSISSIPPI	CHESTER	ILL	109.90	708,600	341.05	27.00
MISSISSIPPI	THEBES	ILL	43.70	713,200	300.00	33.00
ILLINOIS	MEREDOSIA (DISCONTINUED)	ILL	70.80	26,000	418.00	14.00
ILLINOIS	VALLEY CITY	ILL	61.30	26,600	418.00	8.00
MISSOURI	HERMANN	MO	97.90	528,200	481.56	21.00

TABLE D-2 MISSISSIPPI RIVER STAGE GAGES

RIVER	GAGE SITE	STATE	RIVER MILE	ZERO GAGE DATUM	FLOOD STAGE
MISSISSIPPI	L&D 22 (LOWER)	MO	301.20	446.10	12.00
MISSISSIPPI	MUNDYS LANDING	MO	293.00	441.85	14.00
MISSISSIPPI	LOUISIANA	MO	282.90	437.33	15.00
MISSISSIPPI	L&D 24 (UPPER)	MO	273.50	421.81	
MISSISSIPPI	L&D 24 (LOWER)	MO	273.20	421.81	25.00
MISSISSIPPI	RIP RAP LANDING	MO	265.00	426.03	17.00
MISSISSIPPI	MOSIER LANDING	MO	260.30	400.00	41.00
MISSISSIPPI	STERLING LANDING	MO	250.80	420.48	
MISSISSIPPI	L&D 25 (UPPER)	MO	241.50	407.00	
MISSISSIPPI	L&D 25 (LOWER)	MO	241.20	407.00	26.00
MISSISSIPPI	DIXON LANDING	ILL	228.30	410.62	16.00
MISSISSIPPI	GRAFTON	ILL	218.00	403.79	18.00
MISSISSIPPI	ALTON	ILL	203.00	400.00	
MISSISSIPPI	MELVIN PRICE L&D (UPPER)	ILL	201.10	395.48	
MISSISSIPPI	MELVIN PRICE L&D (LOWER)	ILL	200.50	395.48	21.00
MISSISSIPPI	HARTFORD	ILL	196.80	350.00	67.00
MISSISSIPPI	CHAIN OF ROCKS	MO	190.40	313.91	101.00
MISSISSIPPI	LOCKS 27 (UPPER)	ILL	185.30	350.00	
MISSISSIPPI	LOCKS 27 (LOWER)	ILL	185.10	350.00	
MISSISSIPPI	ST. LOUIS (OFFICIAL - GAGE READER)	MO	179.60	379.94	30.00
MISSISSIPPI	ENGINEERS DEPOT	MO	176.80	379.58	29.00
MISSISSIPPI	JEFFERSON BARRACKS	MO	168.70	377.69	26.00
MISSISSIPPI	WATER'S POINT	MO	158.50	370.39	27.00
MISSISSIPPI	SELMA	MO	145.80	0.00	390.00
MISSISSIPPI	BRICKEYS	MO	136.00	357.78	26.00
MISSISSIPPI	LITTLE ROCK LANDING	MO	125.50	213.79	163.00
MISSISSIPPI	CHESTER	ILL	109.90	341.05	27.00
MISSISSIPPI	BISHOP LANDING	MO	100.80	334.11	29.00
MISSISSIPPI	RED ROCK LANDING	MO	94.10	328.92	31.00
MISSISSIPPI	GRAND TOWER	ILL	81.90	321.93	28.00
MISSISSIPPI	MOCCASIN SPRINGS	MO	66.30	313.89	28.00
MISSISSIPPI	CAPE GIRARDEAU	MO	52.00	304.65	32.00
MISSISSIPPI	GRAYS POINT	MO	46.30	301.18	25.00
MISSISSIPPI	THEBES	ILL	43.70	300.00	33.00
MISSISSIPPI	COMMERCE	MO	39.50	301.83	24.00
MISSISSIPPI	PRICE LANDING	MO	28.20	299.75	24.00

MISSISSIPPI	THOMPSON LANDING	MO	20.20	280.00	39.00
MISSISSIPPI	BIRDS POINT	MO	2.00	274.53	38.00

TABLE D-3 ILLINOIS AND MISSOURI RIVERS STAGE GAGES

RIVER	GAGE SITE	STATE	RIVER MILE	ZERO GAGE DATUM	FLOOD STAGE
ILLINOIS	MEREDOSIA (OFFICIAL: DCP)	ILL	70.80	418.00	14.00
ILLINOIS	VALLEY CITY (OFFICIAL – DCP)	ILL	61.30	418.00	8.00
ILLINOIS	FLORENCE (OFFICIAL – DCP)	ILL	56.00	400.00	24.30
ILLINOIS	HARDIN (OFFICIAL - DCP)	ILL	21.50	400.00	25.00
ILLINOIS	PEARL	ILL	43.20	0.00	424.00
MISSOURI	HERMANN	MO	97.90	481.56	21.00
MISSOURI	ST. CHARLES	MO	27.90	413.59	25.00

BOUNDARY CONDITIONS

For the UNET model, boundary conditions must be specified. For the MVS model, the Hermann Gage on the Missouri River and the Valley City/Meredosia Gage on the Illinois River were used as upstream boundary locations. Two sites were utilized on the Mississippi River as upstream and downstream boundaries.

Hannibal, MO.

This site is located at Mississippi River mile 309.9 in the Rock Island District (RID). The upstream drainage area is 137,000 square miles. This is a stage gage but periodic flow measurements are taken. Stage data is available beginning in 1879. RID hydraulic personnel supplied flow and stage estimates for the full 100-year period of record, including estimated values when actual records were not available.

Birds Point, IL

The gage is located at Mississippi River mile 2.0, with an upstream drainage area of about 717,000 square miles. This stage-only gage has records dating from 1901. It is just upstream from the mouth of the Ohio River and is greatly influenced by Ohio River backwater. The period of record was extended to 1898 using regression analysis with upstream and downstream gages.

BASE CONDITIONS

The hydraulic model was the same for both the “with” and “without” reservoir scenarios. The geometry conditions of the 1990’s were included for the entire 100-year period of record, even though there were changes in overbank “n” values, bridges built, levees constructed, and varying channel conditions throughout much of the first 60 years of the simulation. Consequently, by holding conditions constant, a homogeneous period of record was simulated.

LEVEE DATA

All existing levee units, both Federal and non-Federal or private, were incorporated into the UNET data set.

Federal Levees

The construction of levees along the main stems of the Mississippi and Illinois Rivers has occurred since the late 1890's. However, the construction throughout the MVS was generally by private interests, local drainage and levee districts or municipalities until after World War II. Only a few levees were constructed with Federal funds, prior to the war. These levees protected primarily agricultural areas and were limited to moderate levels of protection (5% chance exceedance or more frequent). Following World War II, Congress authorized numerous MVS levee projects throughout the Mississippi and Illinois River system. Most of these projects were raises to existing levee systems, thereby giving a standard level of protection commensurate to the predominant land use of the interior. Most of the work concentrated on the Alton-to-Gale reach, from Alton, IL at mile 202.6 to Gale, IL at mile 46. Nine existing levee units were raised in the 1950’s and ‘60’s to give a 2% annual chance level of protection to six units downstream of St. Louis and an Urban Flood Protection (estimated 0.2% annual chance minimum) to the remaining three levees across the river from St. Louis. The last levee in the Alton-to-Gale system, Kaskaskia Island, was raised to the 2% chance exceedance level in the late 1980’s. The federal levee on the right bank of the Mississippi River from the Commerce gage (RM 39.5) to the Ohio River is part of the Mississippi River & Tributaries Levee system. Two small urban levee/floodwall units were built in the 1960’s for St. Louis and for Cape Girardeau, MO. At the end of the 1990’s, two small levees were constructed to provide adequate urban protection to the cities of St. Peters, MO (mile 230) and Ste. Genevieve, MO (mile 123.5). An urban levee for the Festus-Crystal City area (mile 148.5) is presently under construction. A few raises to existing levees are in the planning/design process, but all levee modifications will comply with FEMA/State policies concerning minimal impact to unprotected areas. On the portion of the Missouri River that flows through the MVS, only the Chesterfield-Monarch levee (mile 38-46) is being studied for a potential raise.

Non-Federal and Private Levees

There are more levees in this category than there are Federal levees in the MVS. However, most of these projects offer only limited protection against floods, except a few levees along the Missouri River in west St. Louis County protecting urban areas. Most non-Federal or private levees protect farmland from common flood levels, usually no more frequent than a 4% chance exceedance level. The only exceptions are the four levee units in St. Louis County along the Missouri River. Earth City, Riverport, Howard Bend and Chesterfield-Monarch are private or non-Federal levees which are certified by FEMA to have a 1% chance exceedance flood protection or greater. All significant non-Federal and private levees were modeled in UNET.

Levee Parameters

A number of variables were required for the UNET levee simulation. For each storage area/levee unit, a storage-volume relationship was required. The top-of-levee elevation data for the storage area/levee unit was linked to the main channel Two levee connections to the main channel were determined for each levee, one upstream and one downstream of the levee cell. The top-of-levee elevation connection data between adjacent storage areas was developed for overtopping flow between adjacent storage areas if necessary. For extreme flood events, the storage areas may become conveyance areas. Two different methods were employed in the UNET model to model overtopping and failure. The different methods were used because the Mississippi and Illinois levee systems are much larger in acres protected and afford a higher level of protection than the Missouri River levee systems, and the flood gradient for the Missouri River is steeper.
The Mississippi River and the Illinois River levees were designed using the simple levee algorithm while the Missouri River levees used the Kansas City levee algorithm. With the simple levee failure, the flow into the area behind the levee is proportional to the available storage; the flow is greatest at the start of failure and decreases as the levee fills. The UNET simple levee failure algorithm acknowledges the lack of data and applies a simple hydrologic concept that is similar to the filling of a large reservoir system. The Kansas City algorithm models the smaller levee by simulating the levees as a cell during failure and during lower discharges. When a transition discharge is exceeded, the area and conveyance of the cross-section of the floodplain behind the levee are added to the river cross-sections and channel floodplain routing. The Kansas City levee failure requires a detailed description of the levee unit.

Failure of all levees in this analysis was elevation dependent using existing or future design elevations at the two levee connections to the main river. Levees were considered effective until they overtopped. Flood fighting efforts by increasing the levee height were not considered for this analysis.

UNET MODEL CALIBRATION

Following an extensive review of the input data for accuracy, the model was calibrated to reproduce the flows and stages from a high flow year (1993) and a low flow year (1988). The UNET model calibration is based upon stage calibration at more than 40 stage gages and discharge calibration at 5 discharge gages along the Mississippi, Illinois and Missouri Rivers. This total includes most discharge and staff gages operated by the USGS and Corps on the three rivers within or near the MVS boundaries. The comparison of the calibrated model peak stages and flows to the measured stages and flows is shown on Table D-4. The flow results on Table D-4 at Grafton, IL range from 3% for the high flow year (1993) to 10% for the low flow year (1988) and at St. Louis, MO range from 0.5% for the high flow year (1993) to 3% for the low flow year (1988). Flows and stages at Chester and Thebes, IL gages were of similar accuracy. Plates D-7 through D-8A illustrate the actual vs. simulated flows and stages at the St. Louis gage.

UNET MODEL VERIFICATION

After calibration, the model was verified by simulating another flood year. The 1995 record was used as a verification of the calibrated model. The UNET model successfully reproduced recorded discharge and stage at all key MVS locations. Table D-4 and D-5 show the results of the verification simulation at Grafton and St. Louis. Actual and simulated hydrograph comparisons at St. Louis are shown on Plates D9 and D-9A.

TABLE D-4 MISSISSIPPI RIVER STAGE CALIBRATION AND VERIFICATION RESULTS AT ST. LOUIS & GRAFTON GAGES

CALENDAR	MEAN ANNUAL STAGE	MEAN ANNUAL STAGE	OBSERVED	COMPUTED	OBSERVED	COMPUTED
YEAR	DIFFERENCE	DIFFERENCE	PEAK STAGE	PEAK STAGE	PEAK STAGE	PEAK STAGE
	GRAFTON	ST. LOUIS	GRAFTON	GRAFTON	ST. LOUIS	ST. LOUIS
	(FT)	(FT)	(FT)	(FT)	(FT)	(FT)
1988	0.33	2.69	16.92	16.94	19.10	20.19
1993	0.34	0.88	38.01	37.33	49.50	50.29
1995	0.67	0.94	30.38	31.63	41.90	44.00

TABLE D-5 MISSISSIPPI RIVER FLOWS CALIBRATION AND VERIFICATION RESULTS AT ST. LOUIS & GRAFTON GAGES

CALENDAR	MEAN ANNUAL FLOW	MEAN ANNUAL FLOW	OBSERVED	COMPUTED	OBSERVED	COMPUTED
YEAR	DIFFERENCE	DIFFERENCE	PEAK FLOW	PEAK FLOW	PEAK FLOW	PEAK FLOW
	GRAFTON	ST. LOUIS	GRAFTON	GRAFTON	ST. LOUIS	ST. LOUIS
	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)	(CFS)
1988	29,043	30,900	172,000	155,070	311,000	301,889
1993	6,019	9,752	557,000	564,339	1,050,000	1,055,540
1995	11,711	21,777	417,000	373,403	796,000	800,960

HYDROLOGIC FLOW FREQUENCY ANALYSIS

GENERAL

The purpose of the study is to estimate a stage frequency curve at any location on the mainstem rivers in the study area. The stage frequency curve at any location is computed by combining an unregulated frequency curve, a relationship between unregulated and regulated flow values, and a rating curve. The unregulated versus regulated relationship is used to convert the unregulated frequency curve to a regulated frequency curve. The rating curve is then used to transform the regulated frequency curve to a stage frequency curve.

A period of record simulation was selected to obtain annual peak flows for flood frequency analysis. The period of 1898 to 1997 was used as the longest period where flows could be reliably estimated for flood frequency analysis. One hundred years of simulated daily data entering MVS from the upper Mississippi River, the Missouri River and the Illinois River as well as daily data from the major tributaries and local inflow areas within MVS was routed with the UNET model for two scenarios. One scenario would be an “unregulated” condition, which removed the impacts of reservoir regulation. The second scenario would be the current condition of “with reservoir” regulation.

The Corps districts, HEC, Technical and Interagency Advisory Groups selected regional shape estimation methodology from among available statistical methods for estimating the unregulated annual daily maximum flood frequency distributions (see refs. 17 and 18, and Appendix A of this report). The regional shape estimation employs the log-Pearson III distribution estimated from the method of moments as is recommended in the federal guidelines (see Bulletin 17B, IACWD, 1982). This estimation method differs from the guideline method in that a regional skew is used instead of a weighted skew. The regional skew is taken as the average skew for stations within a homogenous flood region.

The unregulated versus regulated relationship is developed by comparing the unregulated and regulated maximum annual daily flows obtained from the period of record simulation. The estimated log-Pearson III distribution describing unregulated annual maximum daily flows is converted to a regulated curve using this relationship. The rating curve used to convert the regulated curve to a stage frequency curve is obtained from the UNET simulations.

UNREGULATED FLOWS FOR PERIOD OF RECORD

The full 100-year period of record, 1898 through 1997, was run for the no-reservoir scenario using the UNET model. Annual peak daily discharge data was determined at the five major discharge gages on the Mississippi River and the one on the Illinois River. The period of record flows for the unregulated flows for the gages at Hannibal and Hermann were received from the Rock Island District and the Kansas City District, respectively. Because of the large drainage area size of the Mississippi basin at each gage, instantaneous peak values are typically only 1-2% greater than mean daily. Therefore, mean daily flows were used throughout the analysis. The unregulated peak daily values are given in Tables D-6 through D-12 for each key gage.

TABLE D-6 UNREGULATED ANNUAL DAILY PEAKS AT LOUISIANA GAGE FROM UNET

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1898	126,000	1923	142,000	1948	287,000	1973	465,000
1899	193,000	1924	182,000	1949	178,000	1974	371,000
1900	155,000	1925	132,000	1950	237,000	1975	293,000
1901	150,000	1926	222,000	1951	298,000	1976	310,000
1902	216,000	1927	229,000	1952	282,000	1977	202,000
1903	335,000	1928	228,000	1953	199,000	1978	226,000
1904	247,000	1929	303,000	1954	193,000	1979	328,000
1905	248,000	1930	174,000	1955	176,000	1980	172,000
1906	187,000	1931	132,000	1956	131,000	1981	224,000
1907	183,000	1932	116,000	1957	119,000	1982	270,000
1908	244,000	1933	178,000	1958	133,000	1983	346,000
1909	238,000	1934	107,000	1959	197,000	1984	261,000
1910	117,000	1935	196,000	1960	329,000	1985	304,000
1911	148,000	1936	149,000	1961	235,000	1986	387,000
1912	254,000	1937	209,000	1962	277,000	1987	133,000
1913	175,000	1938	214,000	1963	147,000	1988	134,000
1914	123,000	1939	223,000	1964	147,000	1989	140,000
1915	216,000	1940	117,000	1965	338,000	1990	370,000
1916	267,000	1941	179,000	1966	187,000	1991	269,000
1917	262,000	1942	216,000	1967	246,000	1992	239,000
1918	218,000	1943	231,000	1968	153,000	1993	541,000
1919	274,000	1944	299,000	1969	340,000	1994	186,000
1920	256,000	1945	257,000	1970	256,000	1995	320,000
1921	130,000	1946	251,000	1971	220,000	1996	362,000
1922	245,000	1947	353,000	1972	219,000	1997	279,000

TABLE D-7 UNREGULATED ANNUAL DAILY PEAKS AT GRAFTON GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1898	172,000	1923	173,000	1948	349,000	1973	505,000
1899	209,000	1924	222,000	1949	217,000	1974	425,000
1900	188,000	1925	177,000	1950	267,000	1975	336,000
1901	187,000	1926	329,000	1951	330,000	1976	317,000
1902	263,000	1927	293,000	1952	335,000	1977	228,000
1903	361,000	1928	237,000	1953	229,000	1978	290,000
1904	290,000	1929	356,000	1954	207,000	1979	437,000
1905	265,000	1930	189,000	1955	213,000	1980	221,000
1906	220,000	1931	159,000	1956	188,000	1981	295,000
1907	236,000	1932	145,000	1957	198,000	1982	359,000
1908	290,000	1933	270,000	1958	193,000	1983	389,000
1909	263,000	1934	140,000	1959	231,000	1984	297,000
1910	149,000	1935	213,000	1960	370,000	1985	381,000
1911	218,000	1936	240,000	1961	273,000	1986	469,000
1912	302,000	1937	239,000	1962	337,000	1987	169,000
1913	244,000	1938	235,000	1963	194,000	1988	155,000
1914	138,000	1939	265,000	1964	193,000	1989	160,000
1915	253,000	1940	157,000	1965	386,000	1990	398,000
1916	289,000	1941	278,000	1966	268,000	1991	325,000
1917	293,000	1942	254,000	1967	280,000	1992	276,000
1918	233,000	1943	322,000	1968	198,000	1993	581,000
1919	305,000	1944	323,000	1969	363,000	1994	239,000
1920	304,000	1945	300,000	1970	311,000	1995	401,000
1921	181,000	1946	299,000	1971	252,000	1996	362,000
1922	351,000	1947	394,000	1972	252,000	1997	320,000

TABLE D-8 UNREGULATED ANNUAL DAILY PEAKS AT ST. LOUIS GAGE FROM UNET MODEL

	ANNUAL		ANNUAL		ANNUAL		ANNUAL
Year	Flow	Year	Flow	Year	Flow	Year	Flow
	(CFS)		(CFS)		(CFS)		(CFS)
1898	407,000	1923	396,000	1948	661,000	1973	880,000
1899	396,000	1924	557,000	1949	421,000	1974	644,000
1900	355,000	1925	435,000	1950	493,000	1975	532,000
1901	318,000	1926	570,000	1951	850,000	1976	507,000
1902	478,000	1927	747,000	1952	724,000	1977	434,000
1903	833,000	1928	530,000	1953	400,000	1978	664,000
1904	662,000	1929	674,000	1954	348,000	1979	768,000
1905	502,000	1930	383,000	1955	338,000	1980	427,000
1906	389,000	1931	416,000	1956	324,000	1981	619,000
1907	516,000	1932	349,000	1957	449,000	1982	696,000
1908	649,000	1933	491,000	1958	569,000	1983	832,000
1909	667,000	1934	238,000	1959	406,000	1984	671,000
1910	400,000	1935	673,000	1960	814,000	1985	734,000
1911	307,000	1936	398,000	1961	582,000	1986	1,026,000
1912	607,000	1937	379,000	1962	575,000	1987	465,000
1913	478,000	1938	461,000	1963	348,000	1988	360,000
1914	350,000	1939	532,000	1964	443,000	1989	379,000
1915	640,000	1940	347,000	1965	581,000	1990	685,000
1916	549,000	1941	555,000	1966	445,000	1991	514,000
1917	694,000	1942	656,000	1967	749,000	1992	589,000
1918	407,000	1943	808,000	1968	408,000	1993	1,216,000
1919	525,000	1944	778,000	1969	703,000	1994	680,000
1920	536,000	1945	619,000	1970	579,000	1995	1,011,000
1921	419,000	1946	504,000	1971	460,000	1996	726,000
1922	719,000	1947	854,000	1972	422,000	1997	655,000

TABLE D-9 UNREGULATED ANNUAL DAILY PEAKS AT CHESTER GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1898	410,000	1923	409,000	1948	686,000	1973	904,000
1899	398,000	1924	563,000	1949	427,000	1974	654,000
1900	356,000	1925	448,000	1950	501,000	1975	556,000
1901	321,000	1926	597,000	1951	859,000	1976	506,000
1902	495,000	1927	757,000	1952	726,000	1977	428,000
1903	819,000	1928	551,000	1953	411,000	1978	669,000
1904	690,000	1929	678,000	1954	350,000	1979	844,000
1905	546,000	1930	379,000	1955	346,000	1980	425,000
1906	405,000	1931	419,000	1956	329,000	1981	622,000
1907	518,000	1932	352,000	1957	554,000	1982	808,000
1908	651,000	1933	571,000	1958	618,000	1983	834,000
1909	698,000	1934	254,000	1959	409,000	1984	678,000
1910	397,000	1935	673,000	1960	811,000	1985	775,000
1911	331,000	1936	394,000	1961	692,000	1986	943,000
1912	611,000	1937	417,000	1962	596,000	1987	478,000
1913	544,000	1938	502,000	1963	376,000	1988	371,000
1914	350,000	1939	604,000	1964	443,000	1989	392,000
1915	678,000	1940	344,000	1965	597,000	1990	715,000
1916	637,000	1941	540,000	1966	444,000	1991	510,000
1917	706,000	1942	708,000	1967	752,000	1992	593,000
1918	406,000	1943	864,000	1968	421,000	1993	1,204,000
1919	536,000	1944	809,000	1969	720,000	1994	733,000
1920	541,000	1945	709,000	1970	598,000	1995	1,024,000
1921	418,000	1946	536,000	1971	464,000	1996	744,000
1922	778,000	1947	894,000	1972	446,000	1997	666,000

TABLE D-11 UNREGULATED ANNUAL DAILY PEAKS AT THEBES GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1898	409,000	1923	410,000	1948	691,000	1973	914,000
1899	405,000	1924	562,000	1949	431,000	1974	653,000
1900	355,000	1925	461,000	1950	504,000	1975	569,000
1901	333,000	1926	600,000	1951	861,000	1976	505,000
1902	492,000	1927	761,000	1952	725,000	1977	424,000
1903	816,000	1928	554,000	1953	410,000	1978	671,000
1904	692,000	1929	675,000	1954	362,000	1979	846,000
1905	543,000	1930	374,000	1955	341,000	1980	423,000
1906	407,000	1931	426,000	1956	327,000	1981	627,000
1907	517,000	1932	351,000	1957	555,000	1982	820,000
1908	651,000	1933	579,000	1958	634,000	1983	848,000
1909	704,000	1934	263,000	1959	416,000	1984	680,000
1910	394,000	1935	672,000	1960	810,000	1985	775,000
1911	334,000	1936	386,000	1961	706,000	1986	939,000
1912	612,000	1937	419,000	1962	597,000	1987	479,000
1913	551,000	1938	498,000	1963	375,000	1988	382,000
1914	349,000	1939	607,000	1964	441,000	1989	399,000
1915	718,000	1940	340,000	1965	597,000	1990	720,000
1916	652,000	1941	533,000	1966	456,000	1991	509,000
1917	707,000	1942	710,000	1967	755,000	1992	596,000
1918	405,000	1943	873,000	1968	420,000	1993	1,187,000
1919	550,000	1944	815,000	1969	729,000	1994	688,000
1920	540,000	1945	708,000	1970	591,000	1995	1,012,000
1921	418,000	1946	543,000	1971	467,000	1996	735,000
1922	778,000	1947	898,000	1972	451,000	1997	630,000

TABLE D-12 UNREGULATED ANNUAL DAILY PEAKS AT MEREDOSIA GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1898	61,000	1923	40,000	1948	74,000	1973	101,000
1899	35,000	1924	57,000	1949	58,000	1974	110,000
1900	50,000	1925	40,000	1950	77,000	1975	55,000
1901	38,000	1926	109,000	1951	77,000	1976	80,000
1902	51,000	1927	93,000	1952	56,000	1977	42,000
1903	46,000	1928	49,000	1953	35,000	1978	72,000
1904	60,000	1929	66,000	1954	33,000	1979	109,000
1905	34,000	1930	50,000	1955	37,000	1980	76,000
1906	40,000	1931	30,000	1956	30,000	1981	75,000
1907	52,000	1932	37,000	1957	66,000	1982	112,000
1908	63,000	1933	94,000	1958	60,000	1983	95,000
1909	39,000	1934	25,000	1959	64,000	1984	76,000
1910	37,000	1935	73,000	1960	73,000	1985	120,000
1911	46,000	1936	59,000	1961	53,000	1986	70,000
1912	55,000	1937	48,000	1962	91,000	1987	33,000
1913	69,000	1938	71,000	1963	41,000	1988	40,000
1914	31,000	1939	69,000	1964	48,000	1989	33,000
1915	37,000	1940	26,000	1965	54,000	1990	77,000
1916	63,000	1941	44,000	1966	65,000	1991	64,000
1917	56,000	1942	74,000	1967	48,000	1992	49,000
1918	39,000	1943	123,000	1968	67,000	1993	88,000
1919	58,000	1944	101,000	1969	62,000	1994	73,000
1920	66,000	1945	63,000	1970	94,000	1995	115,000
1921	36,000	1946	66,000	1971	39,000	1996	85,000
1922	93,000	1947	68,000	1972	51,000	1997	84,000

HYPOTHETICAL FLOOD EVALUATIONS

To extend the regulated versus unregulated curve beyond observed events and to evaluate the impacts of overtopping all Federal and other levees, additional event simulations of the 1993 flood were performed. The discharge hydrographs of the 1993 flood were increased by 10% and 20% to help define an upper limit of flooding. The hydrographs at Herman, Hannibal, and Meredosia were adjusted and routed through the MVS with the UNET model. These events are identified as ratio floods in this report. The ratio floods were used as an indicator of events of higher magnitudes.

ESTIMATING UNREGULATED FLOW FREQUENCY CURVES

The method adopted to estimate the unregulated flow frequency curve at gage locations, regional shape estimation, uses the at-site mean and standard deviation, and a regional skew value to compute a log-Pearson III distribution. An investigation of the variation of skew for the main stem rivers in the study area was performed to obtain the regional skew values. Based on this investigation, the TAG and IAG recommended, and the Corps adopted, average skew estimates for reaches of the Mississippi River main stem affected by similar climate and with similar flood response characteristics. In MVS, -0.1 was determined to be the regional skew for the Mississippi River gages and –0.2 was the regional skew for the gage on the Illinois River at Valley City/Meredosia. The final unregulated flood frequency distribution is computed using the HEC-FFA, Flood Frequency Analysis, computer program from the at-site gage mean and standard deviation combined with the regional skew coefficient used as the adopted skew coefficient. The application of the regional estimation method to the estimated unregulated flows for selected gage locations on the Mississippi and Illinois Rivers is shown in Table D-13 and frequency curve plots are provided in Plates D-15 through D-20.

TABLE D-13 UNREGULATED ANNUAL FREQUENCY STATISTICS

	LOUISIANA	GRAFTON	ST. LOUIS	CHESTER	THEBES	MEREDOSIA
MEAN	5.3345	5.4178	5.7272	5.7417	5.7432	4.7627
STANDARD DEVIATION	0.1495	0.1316	0.1344	0.1352	0.1344	0.1643
REGIONAL SKEW	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2

Notes: Means are peak daily values.
Mean and Standard Deviation are at-site values.
Regional Skew used as adopted skew.

ASSESSMENT OF HISTORIC INFORMATION

Historic information (recording of past stages that are not part of the systematic record) was not included in the data set used to estimate flood frequency curves because: it did not correspond to current land use conditions; the 100-year period of systematic record was considered sufficiently long for estimation purposes; and the final results would not be sensitive to estimated historic discharges. The available historic information on flooding exists during a period where the flood record cannot be considered homogenous. The homogenous period of record available is considered to start in 1898 and extend to present time. Human activities, particularly related to agriculture, during the latter half of the 18th century, have made the flood record during this time not relevant to present land use conditions. Adjusting the record to reflect present day conditions would be at best difficult and would not result in data commensurate in accuracy with the data available post 1898.

Excluding the historic information from the data does not have a large influence on the estimated frequency curves given the 100-years of systematically available information. Table D-14 shows that the maximum difference due to the historic information shown in Table D-15 for the 1% chance exceedance flood is about 6% and for the 0.2% chance exceedance flood is about 7% at St. Louis. Note that this maximum difference is caused by information observed in 1785. Historic information at other gages results in much smaller differences.

Consequently, the Corps Districts, HEC, TAG and IAG agreed (see HEC, 2000) that the historic information was not useful in estimating the flood frequency distributions. The lack of relevance of this data to present day conditions and the relatively long systematic record available made it more likely that the historic data would reduce the accuracy of flood frequency estimates than improve the estimates by extending the period of record. Furthermore, the frequency curve estimate does not seem to be particularly sensitive to this information.

TABLE D-14 COMPARISON OF BULLETIN 17B ESTIMATED QUANTILES OBTAINED FROM SYSTEMATIC PERIOD BEGINNINGIN 1898 AND HISTORIC PERIOD

Location	Area	1%quantile	1% historic	%diff	0.2% quantile	0.2% historic	%diff	Years
Clinton	85600	274300	279252	1.81	322600	326147	1.1	171
Keokuk	119000	371700	374198	0.67	439400	441178	0.4	148
St Louis	697000	1104800	1042080	-5.68	1318200	1222471	-7.26	263

TABLE D-15 ESTIMATED FLOWS IN SENSITIVITY ANALYSIS

Location	Date	Estimated discharge
Clinton	1828	306000
Keokuk	1851	360000
St Louis	1785	1100000

ESTIMATING UNREGULATED FREQUENCY CURVES BETWEEN GAGES

The TAG and IAG recommended based on regional investigations performed by HEC and the Corps Districts (see HEC, 2000) that the log-Pearson III distribution at locations between gages be determined from the regional skew, and by linearly interpolating the mean and standard deviation with drainage area. This method will be used to estimate distributions between gages. To obtain consistent estimates of flow statistics and quantiles for gages that are located relatively close together, such as Hannibal and Louisiana, the average standard deviation of the two gages was used for both gages with the regional skew and their at-site mean. It was felt that this approach satisfies the spirit of the TAG recommendation since the at-site mean is still used. The results of the averaging scheme for Hannibal and Louisiana gages are shown in Table D-16. The application was made because the regional shape estimation procedure resulted in a decrease in the 0.5% and 0.2% chance exceedance flood with increase in drainage area from Hannibal to Louisiana (see Table D-17). This anomalous decrease could be caused by the UNET modeling of the boundary condition at Hannibal, measurement error or some local storage effect at Louisiana. In any case, the averaging procedure resulted in a small change in the log-statistics (see Table D-16) and a reasonable variation in flood flow estimates (see Table D-17).

TABLE D-16 STATISTICS AT HANNIBAL AND LOUISIANA GAGE

Location	Drainage area (sq mi)	[1]at-site mean	[1]at-site standard deviation	[3]average standard deviation
[2]Hannibal	137000	5.3248	0.153	[3]0.1515
Louisiana	141000	5.3345	0.150	[3]0.1515

[1]Statistics of log flows
[2]See Appendix B for Rock Island District analysis at Hannibal
[3]average standard deviation calculated from Hannibal and Louisiana

TABLE D-17 COMPARISON OF ANNUAL MAXIMUM DAILY FLOW QUANTILES FOR HANNIBAL GAGE ESTIMATES AND LOUISIANA GAGE ESTIMATES

Location	1% (cfs)	0.5% (cfs)	0.2% (cfs)
Hannibal (reg. Shape estimate)	468000	508000	559000
Hannibal (ave. Stnd. Deviation)	464000	502000	553000
Louisiana (reg. Shape estimate)	468000	507000	557000
Louisiana (ave. Stnd. Deviation)	474000	513000	565000

REGULATED-UNREGULATED DISCHARGE RELATIONSHIP

The regulated flows from the period of record UNET simulations for each gage are displayed on Tables D-18 through D-22. The period of record used for the regulated simulation started in 1930 instead of 1898 as did the unregulated simulation. The regulated period of record flows for the Missouri River prior to1930 was not provided by the Kansas City District (KCD) because the flows were derived from less reliable stage data. KCD did not have confidence in producing a regulated flow data set prior to1930. The annual maximum daily flows from the unregulated and regulated period of record simulations for each gage site were ranked from largest to smallest. Only the unregulated period of record from 1930 to 1997 could be used, since the regulated data set started at 1930. Then, these equally ranked values were plotted against each other to produce a scatter diagram. Having the additional years of flow from 1898 through 1929 would have been desirable in producing additional data points for the unregulated vs. regulated relationship. However, the omission of data from this early period is less important for the regulated period than the unregulated period, since no frequency analysis was performed using the regulated data set. Rare events are the most critical in defining the upper end of the unregulated-regulated relationship. The period of record regulated flows for the gage at Hannibal, MO on the Mississippi River were supplied by the Rock Island District. The results of the hypothetical floods described previously were incorporated into the scatter diagram to help shape the upper end of the regulated versus unregulated curve where no actual flood events have occurred and to test the statistical results for reasonableness. A best-fit line was then drawn through these points and the relationship was then used to convert the unregulated flow-frequency to regulated flow frequency. The final regulated versus unregulated relationships at each gage are shown on Plates D-10 through D-14. The final regulated flows and their associated unregulated flows for the same return period are listed for each gage on Table D-23. Since there is no significant reservoir operation in the Illinois River basin, no unregulated vs. regulated condition exists. Therefore, the unregulated and regulated flows at Meredosia are identical.

TABLE D-18 REGULATED ANNUAL DAILY PEAKS AT LOUISIANA GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1930	165,000	1947	299,000	1964	146,000	1981	214,000
1931	116,000	1948	261,000	1965	347,000	1982	256,000
1932	112,000	1949	176,000	1966	182,000	1983	305,000
1933	178,000	1950	226,000	1967	245,000	1984	231,000
1934	101,000	1951	278,000	1968	156,000	1985	299,000
1935	184,000	1952	273,000	1969	299,000	1986	339,000
1936	150,000	1953	193,000	1970	239,000	1987	121,000
1937	204,000	1954	187,000	1971	216,000	1988	137,000
1938	210,000	1955	174,000	1972	213,000	1989	135,000
1939	213,000	1956	131,000	1973	412,000	1990	286,000
1940	112,000	1957	119,000	1974	303,000	1991	240,000
1941	167,000	1958	135,000	1975	285,000	1992	222,000
1942	215,000	1959	197,000	1976	283,000	1993	524,000
1943	215,000	1960	266,000	1977	195,000	1994	188,000
1944	244,000	1961	227,000	1978	219,000	1995	290,000
1945	256,000	1962	237,000	1979	311,000	1996	329,000
1946	231,000	1963	148,000	1980	174,000	1997	267,000

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TABLE D-19 REGULATED ANNUAL DAILY PEAKS AT GRAFTON GAGE FROM UNET MODEL

	ANNUAL		ANNUAL		ANNUAL		ANNUAL
Year	Flow	Year	Flow	Year	Flow	Year	Flow
	(CFS)		(CFS)		(CFS)		(CFS)
1930	180,000	1947	343,000	1964	192,000	1981	298,000
1931	144,000	1948	319,000	1965	390,000	1982	345,000
1932	141,000	1949	215,000	1966	265,000	1983	360,000
1933	269,000	1950	258,000	1967	279,000	1984	272,000
1934	137,000	1951	313,000	1968	195,000	1985	378,000
1935	219,000	1952	316,000	1969	332,000	1986	373,000
1936	234,000	1953	224,000	1970	295,000	1987	174,000
1937	233,000	1954	203,000	1971	250,000	1988	157,000
1938	234,000	1955	211,000	1972	248,000	1989	158,000
1939	266,000	1956	187,000	1973	462,000	1990	353,000
1940	155,000	1957	197,000	1974	394,000	1991	321,000
1941	276,000	1958	195,000	1975	333,000	1992	264,000
1942	259,000	1959	231,000	1976	293,000	1993	564,000
1943	330,000	1960	318,000	1977	225,000	1994	240,000
1944	322,000	1961	271,000	1978	268,000	1995	372,000
1945	298,000	1962	309,000	1979	425,000	1996	351,000
1946	288,000	1963	192,000	1980	221,000	1997	301,000

TABLE D-20 REGULATED ANNUAL DAILY PEAKS AT ST. LOUIS GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1930	305,000	1947	661,000	1964	313,000	1981	532,000
1931	378,000	1948	534,000	1965	527,000	1982	678,000
1932	277,000	1949	383,000	1966	375,000	1983	683,000
1933	445,000	1950	401,000	1967	482,000	1984	555,000
1934	218,000	1951	652,000	1968	355,000	1985	660,000
1935	542,000	1952	537,000	1969	599,000	1986	791,000
1936	358,000	1953	339,000	1970	535,000	1987	395,000
1937	321,000	1954	277,000	1971	436,000	1988	303,000
1938	406,000	1955	294,000	1972	395,000	1989	305,000
1939	488,000	1956	234,000	1973	790,000	1990	640,000
1940	269,000	1957	313,000	1974	577,000	1991	472,000
1941	493,000	1958	442,000	1975	480,000	1992	542,000
1942	513,000	1959	362,000	1976	470,000	1993	1,070,000
1943	677,000	1960	586,000	1977	437,000	1994	606,000
1944	675,000	1961	515,000	1978	535,000	1995	790,000
1945	557,000	1962	516,000	1979	660,000	1996	615,000
1946	479,000	1963	294,000	1980	349,000	1997	554,000

TABLE D-21 REGULATED ANNUAL DAILY PEAKS AT CHESTER GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1930	300,000	1947	711,000	1964	316,000	1981	572,000
1931	382,000	1948	560,000	1965	541,000	1982	796,000
1932	282,000	1949	390,000	1966	409,000	1983	756,000
1933	508,000	1950	430,000	1967	489,000	1984	590,000
1934	233,000	1951	665,000	1968	384,000	1985	726,000
1935	544,000	1952	537,000	1969	603,000	1986	820,000
1936	349,000	1953	342,000	1970	540,000	1987	413,000
1937	362,000	1954	280,000	1971	440,000	1988	334,000
1938	458,000	1955	307,000	1972	434,000	1989	316,000
1939	555,000	1956	238,000	1973	804,000	1990	696,000
1940	264,000	1957	401,000	1974	593,000	1991	470,000
1941	480,000	1958	509,000	1975	522,000	1992	539,000
1942	553,000	1959	366,000	1976	469,000	1993	1,021,000
1943	754,000	1960	591,000	1977	430,000	1994	702,000
1944	699,000	1961	615,000	1978	566,000	1995	849,000
1945	658,000	1962	537,000	1979	744,000	1996	625,000
1946	506,000	1963	318,000	1980	349,000	1997	593,000

TABLE D-22 REGULATED ANNUAL DAILY PEAKS AT THEBES GAGE FROM UNET MODEL

Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)	Year	ANNUAL Flow (CFS)
1930	295,000	1947	729,000	1964	314,000	1981	569,000
1931	388,000	1948	569,000	1965	544,000	1982	802,000
1932	287,000	1949	393,000	1966	424,000	1983	766,000
1933	515,000	1950	448,000	1967	493,000	1984	588,000
1934	240,000	1951	667,000	1968	382,000	1985	722,000
1935	540,000	1952	535,000	1969	610,000	1986	822,000
1936	337,000	1953	342,000	1970	536,000	1987	412,000
1937	364,000	1954	286,000	1971	444,000	1988	358,000
1938	461,000	1955	303,000	1972	438,000	1989	325,000
1939	554,000	1956	237,000	1973	811,000	1990	694,000
1940	259,000	1957	473,000	1974	591,000	1991	469,000
1941	471,000	1958	521,000	1975	519,000	1992	538,000
1942	549,000	1959	370,000	1976	469,000	1993	1,001,000
1943	761,000	1960	591,000	1977	424,000	1994	672,000
1944	702,000	1961	623,000	1978	564,000	1995	849,000
1945	658,000	1962	536,000	1979	744,000	1996	646,000
1946	503,000	1963	317,000	1980	346,000	1997	593,000

TABLE D-23 FINAL UNREGULATED VS. FINAL REGULATED FLOW-FREQUENCY AT STREAM GAGES

PERCENT	LOUISIANA GAGE		GRAFTON GAGE		ST. LOUIS GAGE	
CHANCE	UNREGULATED	REGULATED	UNREGULATED	REGULATED	UNREGULATED	REGULATED
EXCEEDANCE	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)
50	217,000	210,000	263,000	254,000	536,000	450,000
20	290,000	269,000	338,000	321,000	693,000	590,000
10	336,000	310,000	385,000	360,000	791,000	670,000
5	380,000	351,000	427,000	393,000	880,000	750,000
4	397,000	370,000	439,000	408,000	910,000	780,000
2	434,000	404,000	480,000	446,000	991,000	850,000
1	474,000	443,000	518,000	488,000	1,070,000	910,000
0.5	513,000	489,000	555,000	529,000	1,150,000	1,000,000
0.2	565,000	545,000	603,000	585,000	1,250,000	1,120,000

TABLE D-23 (CONTINUED) FINAL UNREGULATED VS. FINAL REGULATED FLOW-FREQUENCY AT STREAM GAGES

PERCENT	CHESTER GAGE		THEBES GAGE		MEREDOSIA GAGE	
CHANCE	UNREGULATED	REGULATED	UNREGULATED	REGULATED	UNREGULATED	REGULATED
EXCEEDANCE	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)
50	555,000	480,000	556,000	484,000	59,000	59,000
20	718,000	622,000	719,000	625,000	80,000	80,000
10	819,000	707,000	820,000	709,000	93,000	93,000
5	912,000	780,000	913,000	782,000	106,000	106,000
4	942,000	805,000	943,000	807,000	110,000	110,000
2	1,030,000	893,000	1,030,000	895,000	121,000	121,000
1	1,110,000	948,000	1,110,000	950,000	132,000	132,000
0.5	1,190,000	1,020,000	1,190,000	1,022,000	143,000	143,000
0.2	1,300,000	1,140,000	1,300,000	1,142,000	157,000	157,000

REGULATED FREQUENCY CURVES

The final adopted flow frequency results are shown on Table D-24. This table compares the current St. Louis District existing flow-frequency relationship to the regulated (adopted) flow-frequency values from this study. The plotted regulated flow-frequency curves are shown on Plates D-15 through D-20 and compared to the unregulated flow-frequency values. The approximate frequency of several of the historical events at St. Louis based on the unregulated or regulated (adopted) flow frequency results are shown on Table D-25.

TABLE D-24 EXISTING VS. ADOPTED FLOW-FREQUENCY AT GAGES

PERCENT	LOUISIANA GAGE		GRAFTON GAGE		ST. LOUIS GAGE	
CHANCE	EXISTING	ADOPTED	EXISTING	ADOPTED	EXISTING	ADOPTED
EXCEEDANCE	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)
50	200,000	210,000	230,000	254,000	430,000	450,000
20	260,000	269,000	306,000	321,000	590,000	590,000
10	290,000	310,000	355,000	360,000	690,000	670,000
2	375,000	404,000	460,000	446,000	925,000	850,000
1	410,000	443,000	510,000	488,000	1,020,000	910,000
0.5	450,000	489,000	555,000	529,000	1,125,000	1,000,000
0.2	500,000	545,000	620,000	585,000	1,250,000	1,120,000

TABLE D-24 (CONTINUED) EXISTING VS. ADOPTED FLOW-FREQUENCY AT GAGES

PERCENT	CHESTER GAGE		THEBES GAGE		MEREDOSIA GAGE	
CHANCE	EXISTING	ADOPTED	EXISTING	ADOPTED	EXISTING	ADOPTED
EXCEEDANCE	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)	FLOW (CFS)
50	475,000	480,000	485,000	484,000	62,000	59,000
20	650,000	622,000	665,000	625,000	85,000	80,000
10	760,000	707,000	775,000	709,000	98,000	93,000
2	1,010,000	893,000	1,025,000	895,000	125,000	121,000
1	1,120,000	948,000	1,140,000	950,000	133,000	132,000
0.5	1,220,000	1,020,000	1,250,000	1,022,000	142,000	143,000
0.2	1,380,000	1,140,000	1,395,000	1,142,000	152,000	157,000

TABLE D-25 HISTORIC EVENTS AT ST. LOUIS GAGE

DATE	MEASURED FLOW (CFS)	CONDITION	CONDITIONAL % CHANCE EXCEEDANCE
6/27/1844	1,000,000*	UNREGULATED	1.5
5/19/1892	833,900*	UNREGULATED	7
6/10/1903	875,000*	UNREGULATED	5
10/9/1986	728,000	REGULATED	4
4/28/1973	852,000	REGULATED	2
8/1/1993	1,080,000	REGULATED	.33
5/22/1995	800,000	REGULATED	2.5

* Adjusted flow from Reference 8.

HYDRAULIC ANALYSIS FOR PROFILE DEVELOPMENT

GENERAL

As previously documented, the St. Louis District developed a UNET model to perform unsteady flow period-of-record routing on the Mississippi River from near Hannibal, MO to the mouth, and on the Illinois River from just upstream of Meredosia, IL to the mouth. The results of this routing provided annual peak discharges that were used to generate the unregulated flow frequency relationships and the unregulated-regulated relationships at the main stem discharge gages. The following tasks were required to generate updated water surface profiles for the St. Louis District reaches of the Mississippi River and Illinois River.

1. Extend and update the UNET model that was previously used for the unsteady flow routing.
2. Compute regulated discharge frequency curves for ungaged reaches.
3. Compute rating curves from UNET simulations.
4. Compute regulated stage frequency curves.
5. Special considerations at the junction of the Missouri River with the Mississippi River and the entire Illinois River
6. Compute stage frequency profiles
7. Validate the stage frequency profiles by comparison with historic floods.

EXTEND AND UPDATE UNET MODEL

Refinement of the UNET model was necessary to insure continuous frequency profiles development between districts. A full discussion of the UNET model is found in the Hydrology section of the report. This section will only explain the changes that were made to develop the frequency profiles. The following modifications to the reaches of the UNET model were: 1) Extension of cross-sections on the Illinois River from the Meredosia gage (RM 70.8) upstream to the La Grange L&D (80.2). The upstream boundary condition for the Illinois River was moved from the Meredosia gage to the La Grange L&D. 2) The model extension of the Mississippi River from the Birds Point gage (RM 2.0) to Caruthersville, MO gage on the lower Mississippi River. This was necessary because of the stage boundary condition that existed at the Birds Point gage in the previous model. The downstream boundary condition for the Mississippi River was moved to Caruthersville, MO. 3) Replace cross sections for the Missouri River with the latest Missouri River DTM cross-sections from the mouth (RM 0.0) to Hermann, MO (RM 97.9). 4) Replace cross-sections from L&D 22 (RM 301.1) to the Hannibal gage (RM 309.9) with new DTM cross-sections. 5) Reconfiguration of the Missouri-Mississippi crossover area that constituted changes on the Missouri River from the St. Charles gage (RM 28.2) to the mouth of the Missouri River (RM 0.0), and on the Mississippi River just below the Grafton gage (RM 218.0) to the junction of the Missouri River (RM 195.0). This was accomplished using the Missouri and Mississippi current DTM data.

All existing levee units, both Federal and non-Federal or private, were incorporated into the UNET data set. A full discussion of the levees is found in the Hydrology section of the report. A number of variables were required for the UNET levee simulation. The most critical was the overtopping elevation of the levees. Tables D-26 and D-27 show the critical variables that are used in the levee definition. These tables were modified to reflect changes that were necessary from a public review period during this study. The selection of levee overtopping elevations included the assumption that minor low spots in the levee will be

TABLE D-26 MISSISSIPPI RIVER LEVEES

	Location of	Location of		Maximum	Overtopping Levee	Overtopping Levee
	Levee	Levee		Area	Elevation	Elevation
Aug-00	District	District		Protected	Upstream / Location	Downstream / Location
Name/District	Upstream	Downstream	Bank	(Acres)	or Elevation / Location	or Elevation / Location
	River Mile	River Mile			Connection	Connection
Riverland	293.2	286	R	5878	466.94 @ RM 293.01	464.27 @ RM 286.17
Pettus-Burns-Prewitt-Jaegger P/L	272.3	270.8	R	400	452.20 @ RM 272.22	452.50 @ RM 270.98
Connection Clarksville with Pettis-Burns…..	270.8		R		456.00 @ RM 270.80	456.00 @ RM 270.80
Clarksville P/L	270.8	267.5	R	2340	457.33 @ RM 270.45	455.84 @ RM 267.62
Connection Clarksville with Kissinger	267.4		R		455.84 @ RM 267.40	455.84 @ RM 267.40
Kissinger LD	267.5	265	R	2570	455.81 @ RM 267.22	454.71 @ RM 265.59
Connection Kissinger with Busch - Goose Pasture	264		R		455.84 @ RM 267.40	455.84 @ RM 267.40
Connection Kissinger with Annada - Clarrence Cannon	264		R		454.00 @ RM 264.00	454.00 @ RM 264.00
Busch - Goose Pasture P/L	265.6	263.8	R	410		453.81 @ RM 264.40
Busch P/L	265.6	264.8	R	110		
Goose Pasture P/L	265.5	263.8	R	300		
Connection Busch - Goose Pasture	263.2		R		451.85 @ RM 263.20	451.85 @ RM 263.20
with Annada - Clarence…						
Annada - Clarence Cannon	263.8	260.6	R	6800	455.43 @ RM 263.75	448.10 @ RM 261.98
Clarence Cannon NWR	263.8	260.6	R	3480		
Annada	267 - 265	262.8 – 260.6	R	3320		
Connection Annada - Clarence Cannon with Elsberry	260.1		R		451.00 @ RM 260.10	451.00 @ RM 260.10
Elsberry	260.6	251.3	R	23481	452.24 @ RM 260.17	448.34 @ RM 251.70
Connection Elsberry with Kings Lake	249		R		455.63 @ RM 249.00	455.63 @ RM 249.00
Kings Lake LD	251.3	246.2	R	3300	449.10 @ RM 251.52	447.74 @ RM 246.56
Kings Lake to Sandy Slough	241.23		R		443.00 @ RM 241.23	443.00 @ RM 241.23
Kings Lake to Sandy Creek	246.2		R		443.00 @ RM 246.20	443.00 @ RM 246.20

*RIVER Mile (RM) must represent a modeled cross section.

TABLE D-26 (CONTINUED) MISSISSIPPI RIVER LEVEES

Name/District	Location of Levee District Upstream River Mile	Location of Levee District Downstream River Mile	Bank	Maximum Area Protected (Acres)	Overtopping Levee Elevation Upstream / Location or Elevation / Location Connection	Overtopping Levee Elevation Downstream / Location or Elevation / Location Connection
Sandy Creek	246	245.1	R	944	447.0 @ RM 246.00	448.43 @ RM 245.39
Connection Sandy Creek with Foley	245		R		442.00 @ RM 246.20	442.00 @ RM 246.20
Foley	245.1	243.7	R	1214	449.12 @ RM 244.67	447.23 @ RM 245.39
Connection Foley and Cap Au Gris	263.6		R		439.00 @ RM 263.60	439.00 @ RM 263.60
Cap Au Gris	243.7	239.1	R	3491	446.02 @ RM 243.22	439.19 @ RM 239.09
Connection with Cap Au Gris and Winfield	239.5		R		442.10 @ RM 239.50	442.10 @ RM 239.50
Winfield	241.9	238.7	R	2826		442.09 @ RM 239.09
Connection Winfield and Brevator-Schram	238.7		R		441.00 @ RM 238.70	441.00 @ RM 238.70
Brevator-Schram	238.7	237	R	2121	438.33 @ RM 238.59	438.06 @ RM 237.56
Brevator	238.7	237	R	1841		
Schram P/L	237.5	237	R	280		
Connection Brevator-Schram and Winfield					437.50 @RM 236.90	437.50 @RM 236.90
Old Monroe	237	236.5	R	900	437.77 @ RM 237.00	
Heitman P/L (Cuivre R)	236.3	235.5	R	300	440.39 @ RM 236.39	
Martsan-Portucheck	236.3	235.7	R	755	436.91 @ RM 236.39	438.35 @ RM 235.79
St. Peters (Agric)	230.5	229.5	R	300	*438.10 @ RM 230.O2*	436.81 @ RM 229.49
St. Peters (Urban)	230.5	229.8	R	700	447.10 @ RM 230.02	
Consolidated N County LD	213.8	199.8	R	30000	432.41 @ RM 211.80	430.11 @ RM 200.70
Wood River LD	203	195	L	13700	447.3 @ RM 200.54	445.5 @ RM 195.56
Chouteau Island LD	193.3	189	L	2400	430.04 @ RM 192.91	425.38 @ RM 189.47
Gaberet/Cabrolet Island LD	189	185.8	L	800	424.85 @ RM 188.88	424.19 @ RM 185.76
Chouteau, Nameoki, & Venice LD	194.9	184	L	4800	448.84 @ RM 194.63	443.65 @ RM 185.18

*RIVER Mile (RM) must represent a modeled cross section.

TABLE D-26 (CONTINUED) MISSISSIPPI RIVER LEVEES

Name/District	Location of Levee District Upstream River Mile	Location of Levee District Downstream River Mile	Bank	Maximum Area Protected (Acres)	Overtopping Levee Elevation Upstream / Location or Elevation / Location Connection	Overtopping Levee Elevation Downstream / Location or Elevation / Location Connection
St. Louis Flood Protection	187.4	176.4	R	3160	444.00 @ RM 186.82	430.00 @ RM 176.56
Metro-East Sanitary District	184	175.4	L	61645	440.50 @ RM 182.90	432.50 @ RM 175.80
Praire Du Pont-Fish Lake	175.4	166.3	L	12000	432.00 @ RM 174.38	426.00 @ RM 167.03
Columbia	166.3	156.3	L	14800	418.64 @ RM 165.25	415.00 @ RM 156.52
Connection Columbia with Harrisonville – Stringtown	156.2		L		414.50 @ RM 156.20	414.50 @ RM 156.20
Harrisonville - Stringtown - Fort Chartres & Ivy Landing	156.3	130	L	46500	417.00 @ RM 155.54	405.84 @ RM 130.24
Harrisonville				27800		
Stringtown				2800		
Ft. Chartres & Ivy Landing				15900		
Connection Harrisonville…. with Prarie Du Rocher/Modoc	130		L		406.00 @ RM 130.00	406.00 @ RM 130.00
Prarie Du Roche/Modoc	130	118	L	16000	403.13 @ RM 129.81	397.30 @ RM 119.09
Includes Edgar Lake D&L						
City of Ste. Genevieve (Under Construction)	125	122.5	R	505	403.20 @ RM 124.78	401.68 @ RM 122.72
Ste. Genevieve #2	122.5	115.5	R	7000	395.57 @ RM 122.13	389.06 @ RM 116.88
Kaskaskia Island	115.5	111.5	R	9460	394.90 @ RM 115.24	394.10 @ RM 111.55
Bois Brule	111	94.3	R	26060	392.25 @ RM 110.98	381.80 @ RM 95.45
Degognia - Ground Tower	99.2	75.8	L	51000		
Degognia & Fountain Bluff	99.2	84.2	L	36200	385.13 @ RM 99.00	378.15 @ RM 84.55
Grand Tower	81.8	75.8	L	14800	376.94 @ RM 81.09	374.35 @ RM 76.71

*RIVER Mile (RM) must represent a modeled cross section.

TABLE D-26 (CONTINUED) MISSISSIPPI RIVER LEVEES

Name/District	Location of Levee District Upstream River Mile	Location of Levee District Downstream River Mile	Bank	Maximum Area Protected (Acres)	Overtopping Levee Elevation Upstream / Location Or Elevation / Location Connection	Overtopping Levee Elevation Downstream / Location or Elevation / Location Connection
Big Five	75.5	46	L	51500		
Preston	75.5	65.8	L	20500	370.48 @ RM 75.65	368.79 @ RM 65.84
Includes Miller Pond DD				4300		
Clear Creek	65.8	57	L	18000	364.23 @ RM 65.40	360.71 @ RM 57.09
East Cape Girardeau	57	46	L	13000	360.30 @ RM 56.03	351.50 @ RM 46.90
Includes N. Alexandar County LD				3600		
Cape Girardeau	52.4	52	R	140	359.80 @ RM 52.15	
Powers Island (Memphis District)	39	32.5	R	5740	343.59 @ RM 38.11	337.10 @ RM 33.55
Miller City/Len Small	39	21.2	L	8720	334.20 @ RM 34.00	322.40 @ RM 13.20

*RIVER Mile (RM) must represent a modeled cross section.

TABLE D-27 ILLINOIS RIVER LEVEES

Illinois River Levee System UNET Levee Definition Name/District	Location of Levee District Upstream River Mile	Location of Levee District Downstream River Mile	Bank	Maximum Area Protected (Acres)	Overtopping Levee Elevation Upstream / Location	Overtopping Levee Elevation Downstream / Location
McGee Creek D&L	75.2	67.2	R	12200	452.9 @ RM 70.6	452.2 @ RM 67.8
Meredosia & Willow Cr DL	71	67	L	4000		453.0 @ RM 69.5
Coon Run	71	66.7	L	4600	NOT MODELED	
*** Smith Lake P/L**	67.2	67	L	1500		445.5 @ RM 67.2
Oakes P/L	66.7	65.9	L	400	NOT MODELED	
Mauvaise Terre D&L	67	63.3	L	4000	448.00 @ RM 66.0	447.0 @ RM 63.50
Robertson P/L	64	63.3	L	1000		444.0 @ RM 63.30
Valley City DL	66.6	63	R	4900	447.8 @ RM 66.0	446.6 @ RM 63.5
Scott County DL	63	56.7	L	10500	448.0 @ RM 61.3	444.5 @ RM 57.2
Walnut Creek	56.5	56.1	L	500	NOT MODELED	
Big Swan DL	56.7	50.1	L	12300	444.7 @ RM 56.5	443.5 @ RM 50.60
Hillview DL	50.1	43.1	L	12900	443.0 @ RM 49.70	442.0 @ RM 43.50
Village of Pearl P/L	43.3	43	R	1000	NOT MODELED	
Hartwell DL	43.1	38.3	L	8900	442.00 @ RM 42.7	441.90 @ RM 38.7
Keach	38.3	32.7	L	8400	442.00 @ RM 37.75	440.50 @ RM 32.7
Bluffdale Farms	34	32	L	1000		*437.46 @ RM 32.3*
Schaefer – Farrow P/L	32	30.7	L	800	439.73 @ RM 32.3	
Eldred - Spankey DL	32.7	23.6	L	11300	440.50 @ RM 31.90	440.46 @ RM 24.26
Nutwood DL	23.5	15.3	L	11300	440.12 @ RM 23.20	439.51 @ RM 15.54

*RIVER Mile (RM) must represent a modeled cross section.

fixed during yearly maintenance program of the levee or during flood fighting activities. Major flood fighting was not allowed to be included in the average elevation chosen.

With the minor refinement of the UNET model as discussed in the previous paragraphs, the model was recalibrated to reproduce the flows and stages from the year (1970) through the year (1997). This period included both a high flow event and a low flow event. The results of resulting accuracy of the calibrated model are similar to those discussed in Hydrology section of the report.

REGULATED DISCHARGE FREQUENCY CURVES FOR UNGAGED REACHES

Drainage area was used to interpolate distribution statistics between gages for ungaged reaches. Because of the size and magnitude of the primary river with respect to the tributary drainage areas, river reaches were selected to represent the statistics. Table D-28 shows the final discharge values used for this analysis

COMPUTING RATING CURVES

Rating curves were developed using the period of record analysis from the year 1898 through the year 2000. Tabulations of the maximum flow with its associated stage and maximum stage with its associated flow for each cross section were preformed. The rating curves generated from the unregulated period of record extended the curve beyond the 500-year discharge. A curve was then generated through the data cluster. Ratings curves for St. Louis, Chester, and Thebes on the Mississippi River with their current United States Geological Survey rating curves are displayed in Plates D-21 thru D-23.

STAGE FREQUENCY CURVES

A stage frequency analysis was used in areas influenced by backwater effects. The elevations are both downstream stage and discharge dependent. When the annual stage-discharge data points are applied to a rating curve, a shotgun pattern graph is created with no defined stage-discharge relationship. The stage-probability relationship was created using a Weibull frequency distribution. The annual maximum stages from the 100-year period of record analysis are arranged in descending order and assigned a probability function using the formula n / m+1. The value for n is the event number with the first event as the largest, and the value for m is the total number of events. A best-fit curve is then determined from the data points knowing that the 1993 flood exceeded the 1 % frequency flood. The stage-probability curves were evaluated and blended for reasonableness for each frequency flood for all reaches of the Mississippi and Illinois Rivers in St. Louis District. The curves were adjusted to maintain consistent profiles through the reach.

The stage frequency analysis was used for the Grafton area because of the backwater effects from the Illinois and Missouri Rivers. This paragraph will discuss the development of the stage-probability analysis in detail for the Grafton gage. The stage-probability relationship was created using a Weibull frequency distribution using the 100 year annual peak stages Plate D-24. Stages for probabilities more frequent than 10 % exceedance probability were picked from the plotted points, since there are many plotted points in this range and should be correctly defined. For stages less frequent than the 10 % exceedance probability, a best-fit line was used through the limited plotted points and an extrapolation of this line was used to pick the .5 % and .2% exceedance probability stage. Using a graphical analysis with only 100 years of period of record data, defining the 1%, .5%, and .2% elevations is difficult, since using Weibull plotting positions, there are no points plotted beyond the .99% exceedance probability. Several additional pieces of information were used to help determine the most accurate elevations for these rare events. First, data from a previous analytical coincident frequency analysis done in St. Louis District in 1981 using 40 years of record was used. Plotting of this stage-frequency relationship indicated higher stages than the current best-fit plot, and appeared to be an upper boundary. Several larger floods than the largest event (1993 flood) in the 100-year period of record were computed using the UNET model. Based on these larger events, the highest elevation at Grafton was approximately 443.0 feet NGVD. Secondly, a plot of the current USGS rating curve at Grafton was combined with the regulated frequency flows to produce a stage-frequency relationship, which was also plotted against the coincident curve and the best-fit curve. The stage-frequency curve based on the USGS rating curve is lower than the best-fit curve and would appear to be a lower boundary. The UNET model produces a peak flow for the 1993 flood of 564,000 cfs and a peak elevation of 441.8 feet NGVD. This flow is approximately a .3 % exceedance probability flow, so you would expect the .2 % exceedance probability elevation to be higher than 441.8. As mentioned above, the 1993 flood was the highest in the 100 year period of record and is plotted at the .99% exceedance probability, but the information provided indicates that this event was more likely less frequent than the .3 % exceedance probability. The frequency of the 1993 flood event based on the results from the flood flow frequency study at the St. Louis gage downstream of Grafton and at the Louisiana gage upstream of Grafton is a .33 % exceedance frequency.

SPECIAL CONSIDERATIONS AT JUNCTIONS

The exchange of stage and flow properties of a river system can influence the stage and flow properties on an adjacent river system. The following discussion will examine the junctions on the Mississippi River at the Illinois, the Missouri and the Ohio Rivers and the impact of influence that can result during frequency profile development.

TABLE D-28 DISCHARGE FREQUENCY
FOR THE MISSISSIPPI & ILLINOIS RIVERS

Mississippi River											
Location (Gage)	River Mile	D.A.	2-Year	5-Year	10-Year	20-year	25-year	50-Year	100-Year	200-Year	500-Year
		SQ MI	50%	20%	10%	5%	4%	2%	1%	0.50%	0.20%
L&D 22	301-284.4	137200	209000	261000	306000	342000	354000	399000	442000	485000	537000
Salt River (Louisaina)	284.4-236.4	140700	210000	269000	310000	354000	370000	404000	443000	489000	545000
Cuivre River	236.4-218.0	142000	212000	271000	312000	356000	372000	406000	445000	491000	547000
Illinois River (Grafton)	218.0- 213.3	171300	254000	321000	360000	393000	408000	446000	488000	529000	585000
Crossover Reach	213.3-195.5	*	254000	321000	360000	393000	415000*	486000*	610000*	680000*	720000*
Missouri River (St. Louis)	195.5-160.7	697000	450000	590000	670000	750000	780000	850000	910000	1000000	1120000
Meramec River	160.7-117.4	701400	461000	602000	684000	761000	789000	866000	924000	1008000	1128000
Kaskaskia River (Chester)	117.4-75.6	708600	480000	622000	707000	780000	805000	893000	948000	1020000	1140000
Big Muddy	75.6-43.7	711500	483000	624000	708000	781000	806000	894000	949000	1021000	1141000
Thebes	43.7-0.0	713200	484000	625000	709000	782000	807000	895000	950000	1022000	1142000

Illinois River											
Location (Gage)	River Mile	D.A.	2-Year	5-Year	10-Year	20-year	25-year	50-Year	100-Year	200-Year	500-Year
		SQ MI	50%	20%	10%	5%	4%	2%	1%	0.50%	0.20%
La Grange L&D (Meredosia)	90.0-0.0	26000	59000	80000	93000	106000	110000	121000	132000	143000	157000

*Crossover Flow from the Missouri River

The influences of the backwater on tributaries at junctions can be significant. The effects can be seen on major river systems or minor tributaries. The Illinois River is influenced by the stages of the Mississippi River up to La Grange L&D (RM 80.2). When backwater extends a significant distance upstream of the junction, a total probability theorem can be applied to determine frequencies. This probability theorem would account for all events in the family of stages and discharges to determine the probability. The coincident probability method was used for the current Illinois River profiles using duration at the Grafton gage and frequency discharge at the Meredosia gage. The current Illinois River profiles were developed in early 1980. At that time a comparison of stage frequency and coincident frequency analysis was made at gages having a period of record from 1939-1979. The comparison showed that a reliable reproduction of the coincident frequency was similar up to the 10-year event. The two curves followed the general trend but deviated above the 50-year event. In this current analysis, increasing the period of record to 100-years will improve the graphical frequency curve approach.

The confluence of the Mississippi and the Missouri Rivers is commonly referred to as the crossover area. Flows on the Missouri River exceeding the 20-year discharge overflow the St. Charles peninsula and enter into the Mississippi flows below the Grafton gage. The resultant is that flows are reduced below the levee breach on the Missouri River and flows are increased below the Grafton gage on the Mississippi River. It should be noted that the Mississippi flows backing into the St. Charles peninsula would not produce a crossover situation of Mississippi flows to the Missouri River. This exchange of flows on the Mississippi River has caused backwater effects upstream on the Mississippi and Illinois Rivers. A continuous flow reduction on the Missouri River will occur from the levee breach to the mouth. Along this reach flow will be overtopping the left levee and either enter into Mississippi River by way of overland flow or enter into levee storage available.

The junction of the Middle Mississippi River and the Ohio River is River Mile 953.8 on the Lower Mississippi River or River Mile 981.5 on the Ohio River. The adopted stage-frequency at this location by the Memphis District is shown on Table D-29. This relationship assumes that the New Madrid Floodway goes into operation approximately once in 80 years and reflects that in the stages. A frequency event less than a 1 % exceedance flood for the Ohio River is not available. The stage probability at the junction is fixed, since analysis beyond the junction of the Mississippi and Ohio Rivers was beyond the scope of this study. The Ohio River stages can affect stages on the Mississippi River up to the Cape Girardeau Gage (RM 52.0). Because of the need to match the current profiles at the junction of the Ohio River/Lower Mississippi River, the stage-frequency values shown in Table D-29 were used at the junction and extended upstream until it intersected its respective frequency.

TABLE D-29 STAGE-FREQUENCY AT THE JUCTION OF THE MISSISSIPPI AND OHIO RIVERS

Frequency	Elevation
Ohio/Mississippi River	Ft (NGVD)
50 %	314.0
20 %	319.5
10 %	323.0
5 %	325.6
4 %	326.2
2 %	329.0
1 %	330.3

/

PROFILE COORDINATION AT DISTRICT BOUNDARIES

At the junction of the Ohio River and the Mississippi River, the new St. Louis District profiles were blended into the existing water surface profiles currently published. Close coordination with Kansas City District (NWK) and Rock Island District (MVR), provided for matching profiles at the junction of the Missouri River with the Mississippi River, the Mississippi River at L&D 22, and the Illinois River at LaGrange Lock and Dam.

FLOOD FREQUENCY WATER SURFACE PROFILES

Development of the frequency profile for a free flowing reach of stream is straightforward. The stage for a regulated flow for a given frequency is calculated from the generated rating curve for a given cross section.

The development of the frequency profile for cross sections with backwater influences is a little more complex. This method is especially applicable at the junction of tributaries, which includes the Ohio, Missouri and Illinois Rivers and for the entire reach of the Illinois River. In these areas, the stage-probability curve from the regulated flow period of record simulation is used to determine the frequency elevations for cross sections.

Stage frequency profiles were computed for the 50%, 20%, 10%, 4%, 2%, 1%, .5% and .2 % frequency flood events. They are shown in Plates D-25 through D-32. The .5% and .2 % frequency flood events from the Mississippi River mouth at the Ohio River to Thebes, IL at RM 43.7 were not computed. The frequency profiles at the Ohio and Mississippi Rivers for these events are not available, and the Len Small Levee is being designed and will impact stages to the Thebes gage. Tabular displays of the frequency flood events are shown in Table D-30 for the Mississippi River and Table D-31 for the Illinois River. The gage location identified in Tables D-30 and D-31 are at the nearest tabulated cross section.

TABLE D-30 TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

	MISSISSIPPI RIVER	PERCENT EXCEEDANCE PROBABILITY								
River Mile	Station Name	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
0.00	OHIO RIVER	314.0	319.5	323.0	325.6	326.2	329.0	330.3		
1.39		314.4	319.8	323.2	325.7	326.3	329.0	330.3		
1.40		314.4	319.8	323.2	325.7	326.3	329.0	330.3		
1.41		314.4	319.8	323.2	325.7	326.3	329.0	330.3		
1.42		314.4	319.8	323.2	325.7	326.3	329.0	330.3		
1.47		314.4	319.8	323.2	325.7	326.3	329.0	330.3		
2.00	BIRDS POINT	314.5	319.9	323.3	325.8	326.4	329.0	330.3		
2.67		314.7	320.1	323.4	325.8	326.5	329.0	330.3		
3.52		314.9	320.3	323.5	325.9	326.5	329.0	330.3		
3.92		315.0	320.3	323.6	326.0	326.6	329.0	330.3		
4.58		315.2	320.5	323.7	326.0	326.6	329.0	330.3		
5.11		315.4	320.6	323.8	326.1	326.7	329.0	330.3		
5.64		315.5	320.7	323.9	326.1	326.7	329.0	330.3		
6.25		315.7	320.8	324.0	326.2	326.8	329.0	330.3		
6.86		315.8	321.0	324.0	326.2	326.9	329.0	330.3		
7.50		316.0	321.1	324.1	326.3	326.9	329.0	330.3		
7.50		316.0	321.1	324.1	326.3	326.9	329.0	330.3		
7.51		316.0	321.1	324.1	326.3	327.0	329.0	330.3		
7.52		316.0	321.1	324.1	326.3	327.0	329.0	330.3		
7.60		316.0	321.1	324.2	326.3	327.0	329.0	330.3		
8.23		316.3	321.3	324.3	326.4	327.1	329.1	330.4		
9.00		316.5	321.5	324.4	326.5	327.2	329.2	330.5		
9.60		316.8	321.7	324.5	326.6	327.3	329.2	330.6		
10.14		317.0	321.8	324.6	326.7	327.3	329.3	330.6		

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
10.86		317.2	322.0	324.8	326.8	327.4	329.4	330.7		
11.25		317.4	322.1	324.8	326.8	327.5	329.4	330.7		
11.73		317.5	322.2	324.9	326.9	327.6	329.5	330.8		
12.20		317.7	322.4	325.0	327.0	327.6	329.5	330.8		
12.67		317.9	322.5	325.1	327.1	327.7	329.6	330.9		
13.24		318.1	322.6	325.2	327.1	327.8	329.6	331.0		
13.68		318.2	322.8	325.3	327.2	327.8	329.7	331.0		
14.17		318.4	322.9	325.4	327.3	327.9	329.7	331.1		
14.53		318.5	323.0	325.4	327.3	328.0	329.8	331.1		
14.92		318.7	323.1	325.5	327.4	328.0	329.8	331.1		
15.43		318.8	323.2	325.6	327.5	328.1	329.9	331.2		
15.72		319.0	323.3	325.6	327.5	328.1	329.9	331.2		
16.38		319.2	323.5	325.8	327.6	328.2	330.0	331.3		
16.95		319.4	323.6	325.9	327.7	328.3	330.0	331.4		
17.25		319.5	323.7	325.9	327.7	328.3	330.0	331.4		
17.48		319.6	323.8	326.0	327.8	328.4	330.1	331.4		
17.73		319.7	323.8	326.0	327.8	328.4	330.1	331.4		
18.05		319.8	323.9	326.1	327.9	328.5	330.1	331.5		
18.39		319.9	324.0	326.1	327.9	328.5	330.2	331.5		
18.81		320.1	324.1	326.2	328.0	328.6	330.2	331.6		
19.28		320.2	324.2	326.3	328.1	328.6	330.3	331.6		
19.68		320.4	324.4	326.4	328.1	328.7	330.3	331.7		
20.05	THOMPSON LANDING	320.5	324.5	326.4	328.2	328.7	330.3	331.7		
20.20		320.6	324.6	326.5	328.3	328.8	330.4	331.8		
20.54		320.8	324.8	326.8	328.5	329.1	330.7	332.0		
20.94		321.0	325.1	327.1	328.7	329.3	330.9	332.2		

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
21.37		321.3	325.4	327.4	329.0	329.6	331.2	332.5		
22.03		321.7	325.8	327.8	329.5	330.0	331.6	332.8		
22.71		322.1	326.3	328.3	329.9	330.5	332.0	333.2		
23.28		322.5	326.7	328.7	330.3	330.8	332.4	333.6		
23.63		322.7	326.9	328.9	330.5	331.1	332.6	333.8		
24.03		322.9	327.2	329.2	330.8	331.3	332.9	334.0		
24.49		323.2	327.5	329.5	331.1	331.6	333.2	334.3		
24.83		323.4	327.8	329.8	331.3	331.8	333.4	334.5		
25.40		323.8	328.2	330.2	331.7	332.2	333.7	334.8		
25.96		324.1	328.5	330.5	332.0	332.6	334.1	335.1		
26.64		324.5	329.0	331.0	332.5	333.0	334.5	335.5		
27.34		325.0	329.5	331.5	332.9	333.4	335.0	335.9		
27.96		325.4	329.9	331.9	333.3	333.8	335.3	336.3		
28.20	PRICE LANDING	325.5	330.1	332.1	333.5	334.0	335.5	336.4		
28.57		325.7	330.3	332.3	333.7	334.2	335.7	336.6		
29.09		325.9	330.6	332.6	334.0	334.5	336.0	336.9		
29.92		326.4	331.0	333.0	334.4	334.9	336.4	337.3		
30.40		326.6	331.2	333.2	334.7	335.2	336.7	337.6		
30.82		326.8	331.4	333.5	334.9	335.4	336.9	337.8		
31.28		327.0	331.7	333.7	335.2	335.6	337.2	338.1		
31.65		327.2	331.9	333.9	335.4	335.8	337.4	338.3		
32.08		327.4	332.1	334.1	335.6	336.1	337.6	338.5		
32.55		327.7	332.3	334.4	335.8	336.3	337.8	338.7		
32.84		327.8	332.5	334.5	336.0	336.5	338.0	338.9		
33.21		328.0	332.7	334.7	336.2	336.7	338.2	339.1		
33.61		328.2	332.9	334.9	336.4	336.9	338.4	339.3		

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
34.08		328.5	333.1	335.2	336.7	337.1	338.7	339.6		
34.69		328.8	333.4	335.5	337.0	337.4	339.0	339.9		
35.57		329.2	333.9	335.9	337.5	337.9	339.5	340.4		
35.86		329.3	334.0	336.1	337.6	338.1	339.6	340.5		
36.19		329.5	334.2	336.3	337.8	338.2	339.8	340.7		
36.57		329.7	334.4	336.5	338.0	338.4	340.0	340.9		
37.27		330.1	334.8	336.8	338.4	338.8	340.4	341.3		
37.70		330.3	335.0	337.1	338.6	339.0	340.6	341.5		
38.13		330.5	335.2	337.3	338.9	339.3	340.9	341.8		
38.58		330.7	335.4	337.5	339.1	339.5	341.1	342.0		
39.02		330.9	335.7	337.7	339.3	339.7	341.3	342.2		
39.50	COMMERCE	331.2	335.9	338.0	339.6	340.0	341.6	342.5		
39.72		331.3	336.0	338.1	339.7	340.1	341.7	342.7		
40.09		331.5	336.3	338.3	340.0	340.4	342.0	342.9		
40.60		331.8	336.6	338.6	340.3	340.7	342.3	343.3		
41.10		332.0	336.9	338.9	340.6	341.0	342.6	343.6		
41.70		332.3	337.2	339.3	341.0	341.4	343.0	344.0		
42.30		332.7	337.6	339.6	341.3	341.8	343.3	344.4		
42.70		332.9	337.8	339.8	341.6	342.1	343.6	344.7		
43.20		333.1	338.1	340.1	341.9	342.4	343.9	345.1		
43.70	THEBES	333.4	338.4	340.4	342.2	342.7	344.2	345.4	346.4	348.2
43.70		333.4	338.4	340.4	342.2	342.7	344.2	345.4	346.4	348.2
43.71		333.4	338.4	340.4	342.2	342.7	344.2	345.4	346.4	348.2
43.71		333.4	338.4	340.4	342.2	342.7	344.2	345.4	346.4	348.2
44.29		333.8	338.8	340.9	342.7	343.2	344.7	345.9	346.9	348.7
44.86		334.2	339.2	341.4	343.1	343.6	345.2	346.4	347.3	349.2

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
45.36		334.5	339.6	341.8	343.5	344.0	345.6	346.8	347.7	349.7
45.85		334.9	339.9	342.2	343.9	344.4	346.0	347.2	348.1	350.1
46.30	GRAYS POINT	335.2	340.2	342.6	344.2	344.8	346.4	347.6	348.5	350.5
46.90		335.6	340.7	343.0	344.7	345.2	346.9	348.1	349.0	351.0
47.34		335.9	341.0	343.3	345.0	345.5	347.2	348.4	349.4	351.3
47.95		336.4	341.4	343.7	345.5	346.0	347.6	348.9	349.9	351.7
48.15		336.5	341.6	343.9	345.6	346.1	347.8	349.0	350.1	351.9
48.58		336.8	341.9	344.2	345.9	346.5	348.1	349.4	350.4	352.2
49.28		337.3	342.4	344.7	346.4	347.0	348.6	349.9	351.0	352.7
49.85		337.7	342.8	345.1	346.8	347.4	349.1	350.3	351.5	353.2
50.15		338.0	343.0	345.3	347.1	347.6	349.3	350.6	351.8	353.4
50.51		338.2	343.2	345.6	347.3	347.9	349.6	350.8	352.1	353.7
51.03		338.6	343.6	346.0	347.7	348.2	350.0	351.3	352.5	354.1
51.60		339.0	344.0	346.4	348.1	348.7	350.4	351.7	353.0	354.5
51.60		339.0	344.0	346.4	348.1	348.7	350.4	351.7	353.0	354.5
51.61		339.0	344.0	346.4	348.1	348.7	350.4	351.7	353.0	354.5
51.61		339.0	344.0	346.4	348.1	348.7	350.4	351.7	353.0	354.5
52.00	CAPE GIRARDEAU	339.3	344.3	346.7	348.4	349.0	350.7	352.0	353.4	354.8
52.15		339.4	344.4	346.8	348.5	349.0	350.8	352.1	353.5	354.9
52.62		339.7	344.7	347.0	348.8	349.3	351.1	352.4	353.8	355.2
53.13		340.0	345.0	347.3	349.1	349.7	351.4	352.8	354.1	355.6
53.59		340.2	345.3	347.6	349.4	349.9	351.7	353.1	354.4	355.9
54.04		340.5	345.5	347.9	349.7	350.2	352.0	353.4	354.7	356.3
54.43		340.7	345.8	348.1	349.9	350.5	352.2	353.6	355.0	356.5
55.00		341.0	346.1	348.5	350.3	350.8	352.6	354.0	355.4	356.9
55.47		341.3	346.4	348.8	350.5	351.1	352.9	354.3	355.7	357.3

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
56.03		341.6	346.7	349.1	350.9	351.4	353.3	354.7	356.1	357.7
56.55		341.9	347.0	349.4	351.2	351.8	353.6	355.0	356.4	358.0
57.09		342.2	347.4	349.7	351.5	352.1	353.9	355.4	356.8	358.4
57.67		342.6	347.7	350.1	351.9	352.4	354.3	355.8	357.1	358.8
58.09		342.8	348.0	350.3	352.1	352.7	354.6	356.0	357.4	359.1
58.72		343.2	348.3	350.7	352.5	353.1	355.0	356.5	357.8	359.6
59.15		343.4	348.6	351.0	352.8	353.4	355.2	356.8	358.1	359.9
59.65		343.7	348.9	351.3	353.1	353.7	355.6	357.1	358.5	360.3
60.11		344.0	349.2	351.6	353.4	353.9	355.8	357.4	358.8	360.6
60.52		344.2	349.4	351.8	353.6	354.2	356.1	357.7	359.0	360.9
61.23		344.6	349.8	352.2	354.1	354.6	356.6	358.1	359.5	361.4
61.83		344.9	350.2	352.6	354.4	355.0	356.9	358.5	359.9	361.8
62.42		345.3	350.5	352.9	354.8	355.4	357.3	358.9	360.3	362.2
62.89		345.5	350.8	353.2	355.1	355.7	357.6	359.2	360.6	362.6
63.44		345.9	351.2	353.6	355.4	356.0	358.0	359.6	361.0	363.0
64.08		346.2	351.5	353.9	355.8	356.4	358.4	360.0	361.4	363.4
64.67		346.6	351.9	354.3	356.2	356.8	358.7	360.4	361.8	363.8
65.40		347.0	352.3	354.7	356.6	357.2	359.2	360.9	362.3	364.4
65.84		347.2	352.6	355.0	356.9	357.5	359.5	361.2	362.6	364.7
66.30	MOCCASIN SPRINGS	347.5	352.9	355.3	357.2	357.8	359.8	361.5	362.9	365.0
66.98		347.9	353.3	355.7	357.6	358.2	360.2	361.9	363.4	365.4
67.54		348.3	353.6	356.1	358.0	358.6	360.6	362.3	363.7	365.8
68.09		348.6	354.0	356.4	358.3	358.9	361.0	362.7	364.1	366.2
68.66		348.9	354.3	356.8	358.7	359.3	361.3	363.1	364.5	366.6
69.19		349.3	354.6	357.1	359.0	359.6	361.7	363.4	364.8	366.9
69.75		349.6	355.0	357.5	359.4	360.0	362.1	363.8	365.2	367.3

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
70.27		349.9	355.3	357.8	359.7	360.3	362.4	364.1	365.5	367.6
70.74		350.2	355.6	358.1	360.0	360.6	362.7	364.4	365.9	367.9
71.21		350.5	355.9	358.4	360.3	360.9	363.0	364.7	366.2	368.2
71.78		350.8	356.2	358.7	360.7	361.3	363.4	365.1	366.6	368.6
72.31		351.2	356.5	359.1	361.0	361.7	363.7	365.5	366.9	369.0
72.84		351.5	356.9	359.4	361.4	362.0	364.1	365.8	367.3	369.3
73.56		351.9	357.3	359.9	361.8	362.5	364.6	366.3	367.7	369.8
74.21		352.3	357.7	360.3	362.2	362.9	365.0	366.7	368.2	370.2
74.89		352.7	358.1	360.7	362.7	363.3	365.5	367.2	368.6	370.7
75.65	BIG MUDDY RIVER	353.2	358.6	361.2	363.2	363.8	366.0	367.7	369.1	371.2
75.65		353.2	358.6	361.2	363.2	363.8	366.0	367.7	369.1	371.2
76.20		353.5	358.9	361.5	363.5	364.2	366.3	368.0	369.5	371.5
76.71		353.9	359.2	361.9	363.9	364.5	366.7	368.4	369.8	371.9
77.21		354.2	359.5	362.2	364.2	364.8	367.0	368.7	370.2	372.2
77.86		354.6	359.9	362.6	364.6	365.3	367.4	369.1	370.6	372.6
78.50		354.9	360.3	363.0	365.0	365.7	367.8	369.6	371.0	373.1
78.94		355.2	360.6	363.3	365.3	366.0	368.1	369.8	371.3	373.3
79.22		355.4	360.8	363.5	365.5	366.2	368.3	370.0	371.5	373.5
79.60		355.6	361.0	363.7	365.7	366.4	368.6	370.3	371.8	373.8
80.09		355.9	361.3	364.0	366.0	366.7	368.9	370.6	372.1	374.1
80.55		356.2	361.6	364.3	366.3	367.0	369.2	370.9	372.4	374.4
80.62		356.2	361.6	364.3	366.4	367.1	369.2	371.0	372.4	374.5
81.09		356.5	361.9	364.6	366.7	367.4	369.6	371.3	372.8	374.8
81.60		356.8	362.2	365.0	367.0	367.7	369.9	371.6	373.1	375.1
81.90	GRAND TOWER	357.0	362.4	365.1	367.2	367.9	370.1	371.8	373.3	375.3
82.06		357.1	362.5	365.2	367.3	368.0	370.2	371.9	373.4	375.4

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
82.48		357.3	362.7	365.5	367.5	368.2	370.5	372.2	373.7	375.7
82.99		357.6	363.0	365.8	367.9	368.6	370.8	372.5	374.1	376.1
83.42		357.8	363.3	366.0	368.1	368.8	371.1	372.8	374.4	376.4
83.97		358.1	363.6	366.3	368.4	369.1	371.5	373.2	374.8	376.8
84.55		358.4	363.9	366.7	368.8	369.5	371.9	373.6	375.2	377.2
84.96		358.6	364.2	366.9	369.0	369.8	372.2	373.9	375.5	377.5
85.46		358.9	364.5	367.2	369.3	370.1	372.5	374.2	375.8	377.8
86.00		359.2	364.8	367.5	369.7	370.4	372.9	374.6	376.2	378.2
86.45		359.4	365.1	367.8	369.9	370.7	373.2	374.9	376.5	378.5
86.92		359.7	365.3	368.0	370.2	370.9	373.5	375.2	376.9	378.9
87.44		360.0	365.6	368.3	370.5	371.3	373.9	375.5	377.3	379.3
87.94		360.2	365.9	368.6	370.8	371.6	374.2	375.9	377.6	379.6
88.44		360.5	366.2	368.9	371.1	371.9	374.5	376.2	378.0	380.0
88.96		360.8	366.5	369.2	371.4	372.2	374.9	376.5	378.3	380.3
89.55		361.1	366.9	369.6	371.8	372.5	375.3	376.9	378.8	380.8
90.23		361.4	367.3	370.0	372.2	373.0	375.8	377.4	379.2	381.2
90.77		361.7	367.6	370.3	372.5	373.3	376.1	377.8	379.6	381.6
91.32		362.0	367.9	370.6	372.8	373.6	376.5	378.1	380.0	382.0
91.83		362.3	368.2	370.9	373.1	373.9	376.9	378.5	380.4	382.4
92.38		362.6	368.5	371.2	373.5	374.3	377.2	378.8	380.8	382.8
92.76		362.8	368.7	371.4	373.7	374.5	377.5	379.1	381.0	383.0
93.16		363.0	369.0	371.7	373.9	374.7	377.8	379.4	381.3	383.3
93.97		363.4	369.4	372.1	374.4	375.2	378.3	379.9	381.9	383.9
94.10	RED ROCK LANDING	363.5	369.5	372.2	374.5	375.3	378.4	380.0	382.0	384.0
94.37		363.6	369.6	372.3	374.6	375.4	378.5	380.1	382.1	384.1
94.81		363.9	369.8	372.6	374.8	375.6	378.7	380.3	382.4	384.3

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
95.45		364.2	370.1	372.9	375.1	375.9	379.0	380.6	382.7	384.6
96.06		364.5	370.4	373.2	375.4	376.2	379.2	380.9	383.0	384.9
96.60		364.8	370.6	373.4	375.7	376.5	379.5	381.2	383.3	385.2
97.15		365.1	370.9	373.7	376.0	376.8	379.7	381.4	383.6	385.4
97.70		365.4	371.1	374.0	376.2	377.0	379.9	381.7	383.9	385.7
98.53		365.9	371.5	374.4	376.6	377.4	380.3	382.0	384.3	386.1
99.00		366.1	371.7	374.6	376.8	377.6	380.5	382.3	384.6	386.3
99.58		366.4	372.0	374.9	377.1	377.9	380.7	382.5	384.9	386.5
100.12		366.7	372.2	375.2	377.4	378.2	381.0	382.8	385.1	386.8
100.71		367.0	372.5	375.5	377.7	378.5	381.2	383.1	385.5	387.1
100.80	BISHOP LANDING	367.1	372.5	375.5	377.7	378.5	381.3	383.1	385.5	387.1
101.15		367.3	372.7	375.7	377.9	378.7	381.5	383.3	385.7	387.3
101.66		367.6	373.0	376.0	378.2	379.0	381.8	383.7	386.0	387.6
102.13		367.8	373.3	376.3	378.5	379.3	382.1	384.0	386.3	387.8
102.59		368.1	373.5	376.5	378.8	379.6	382.4	384.3	386.6	388.1
103.11		368.4	373.8	376.9	379.1	379.9	382.8	384.6	386.9	388.4
103.66		368.7	374.1	377.2	379.5	380.3	383.1	385.0	387.3	388.7
104.18		369.0	374.4	377.5	379.8	380.6	383.4	385.3	387.6	389.0
104.73		369.3	374.7	377.8	380.1	380.9	383.8	385.6	388.0	389.3
105.30		369.6	375.1	378.1	380.5	381.3	384.2	386.0	388.3	389.6
105.79		369.9	375.4	378.4	380.8	381.6	384.5	386.3	388.6	389.9
106.23		370.1	375.6	378.7	381.0	381.8	384.7	386.6	388.9	390.1
106.81		370.5	375.9	379.0	381.4	382.2	385.1	387.0	389.3	390.5
107.30		370.7	376.2	379.3	381.7	382.5	385.4	387.3	389.6	390.7
107.78		371.0	376.5	379.6	382.0	382.8	385.7	387.6	389.9	391.0
108.32		371.3	376.8	379.9	382.3	383.1	386.1	388.0	390.2	391.3

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
108.80		371.6	377.1	380.2	382.6	383.4	386.4	388.3	390.5	391.6
109.32		371.9	377.4	380.5	382.9	383.7	386.7	388.6	390.8	391.9
109.90	CHESTER	372.2	377.7	380.8	383.3	384.1	387.1	389.0	391.2	392.2
109.91		372.2	377.7	380.8	383.3	384.1	387.1	389.0	391.2	392.2
109.92		372.2	377.7	380.8	383.3	384.1	387.1	389.0	391.2	392.2
109.93		372.2	377.7	380.8	383.3	384.1	387.1	389.0	391.2	392.2
110.40		372.5	378.0	381.1	383.6	384.4	387.3	389.2	391.4	392.4
110.98		372.8	378.3	381.4	383.9	384.7	387.6	389.5	391.6	392.7
111.55		373.1	378.6	381.7	384.2	385.0	387.9	389.7	391.9	393.0
111.78		373.2	378.7	381.8	384.3	385.1	388.0	389.8	392.0	393.1
112.08		373.4	378.9	381.9	384.5	385.3	388.2	390.0	392.1	393.2
112.68		373.7	379.2	382.3	384.8	385.6	388.5	390.2	392.3	393.5
113.31		374.0	379.5	382.6	385.1	385.9	388.8	390.5	392.6	393.8
113.88		374.4	379.8	382.9	385.4	386.2	389.0	390.7	392.8	394.1
114.54		374.7	380.2	383.2	385.8	386.6	389.4	391.0	393.1	394.4
115.24		375.1	380.6	383.6	386.1	387.0	389.7	391.3	393.4	394.7
115.76		375.4	380.9	383.9	386.4	387.2	390.0	391.6	393.6	394.9
116.41		375.7	381.2	384.2	386.7	387.6	390.3	391.8	393.8	395.2
116.88		376.0	381.5	384.4	387.0	387.8	390.5	392.0	394.0	395.5
117.41	KASKASKIA RIVER	376.3	381.7	384.7	387.3	388.1	390.8	392.3	394.2	395.7
117.41		376.3	381.7	384.7	387.3	388.1	390.8	392.3	394.2	395.7
117.92		376.6	382.0	385.0	387.5	388.4	391.0	392.5	394.4	396.0
118.21		376.7	382.2	385.1	387.7	388.5	391.2	392.6	394.6	396.1
118.64		376.9	382.4	385.4	387.9	388.8	391.4	392.8	394.7	396.3
119.09		377.2	382.6	385.6	388.2	389.0	391.6	393.0	394.9	396.5
119.63		377.5	382.9	385.9	388.4	389.3	391.9	393.2	395.1	396.8

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
120.07		377.7	383.2	386.1	388.7	389.5	392.1	393.4	395.3	397.0
120.65		378.0	383.5	386.4	389.0	389.9	392.4	393.7	395.5	397.2
121.14		378.3	383.7	386.7	389.2	390.1	392.6	393.9	395.7	397.5
121.68		378.6	384.0	387.0	389.5	390.4	392.9	394.1	396.0	397.7
122.13		378.8	384.3	387.2	389.8	390.6	393.1	394.3	396.1	397.9
122.72		379.2	384.6	387.5	390.1	391.0	393.4	394.6	396.4	398.2
123.27		379.5	384.9	387.8	390.4	391.3	393.6	394.8	396.6	398.5
123.93		379.8	385.2	388.1	390.7	391.6	394.0	395.1	396.9	398.8
124.35		380.0	385.5	388.3	390.9	391.8	394.2	395.3	397.0	399.0
124.78		380.3	385.7	388.6	391.2	392.1	394.4	395.5	397.2	399.2
125.24		380.5	385.9	388.8	391.4	392.3	394.6	395.7	397.4	399.4
125.50	LITTLE ROCK LANDING	380.7	386.1	388.9	391.5	392.4	394.7	395.8	397.5	399.5
125.60		380.7	386.1	389.0	391.6	392.5	394.8	395.9	397.6	399.6
126.00		380.9	386.4	389.2	391.8	392.7	395.0	396.1	397.8	399.8
126.48		381.2	386.6	389.5	392.1	393.0	395.3	396.4	398.1	400.1
127.00		381.5	386.9	389.8	392.3	393.3	395.5	396.7	398.4	400.4
127.48		381.7	387.2	390.0	392.6	393.5	395.8	397.0	398.7	400.7
128.00		382.0	387.4	390.3	392.9	393.8	396.1	397.3	399.0	401.0
128.50		382.3	387.7	390.6	393.2	394.1	396.4	397.6	399.3	401.3
129.00		382.6	388.0	390.8	393.4	394.3	396.6	397.9	399.6	401.6
129.39		382.8	388.2	391.0	393.6	394.5	396.8	398.1	399.9	401.8
129.81		383.0	388.4	391.3	393.9	394.8	397.1	398.4	400.1	402.1
130.24		383.3	388.7	391.5	394.1	395.0	397.3	398.6	400.4	402.3
130.78		383.5	388.9	391.8	394.4	395.3	397.6	399.0	400.7	402.7
131.29		383.8	389.2	392.1	394.7	395.6	397.9	399.3	401.0	403.0
131.76		384.1	389.5	392.3	394.9	395.8	398.1	399.6	401.3	403.3

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
132.24		384.3	389.7	392.6	395.2	396.1	398.4	399.8	401.6	403.5
132.77		384.6	390.0	392.9	395.5	396.4	398.6	400.2	401.9	403.9
133.31		384.9	390.3	393.2	395.7	396.6	398.9	400.5	402.3	404.2
133.80		385.2	390.6	393.4	396.0	396.9	399.2	400.8	402.6	404.5
134.37		385.5	390.9	393.7	396.3	397.2	399.5	401.1	402.9	404.8
134.88		385.8	391.2	394.0	396.6	397.5	399.8	401.4	403.2	405.1
135.50		386.1	391.5	394.3	396.9	397.8	400.1	401.8	403.6	405.5
136.00	BRICKEYS	386.4	391.8	394.6	397.2	398.1	400.4	402.1	403.9	405.8
136.48		386.7	392.0	394.9	397.4	398.4	400.6	402.4	404.1	406.0
137.03		386.9	392.3	395.2	397.7	398.7	400.9	402.7	404.4	406.3
137.47		387.2	392.5	395.4	398.0	398.9	401.2	402.9	404.6	406.5
137.97		387.4	392.8	395.7	398.3	399.2	401.4	403.2	404.9	406.7
138.58		387.8	393.1	396.0	398.6	399.5	401.8	403.5	405.2	407.0
139.01		388.0	393.4	396.2	398.8	399.7	402.0	403.7	405.4	407.2
139.48		388.2	393.6	396.5	399.1	400.0	402.3	404.0	405.6	407.4
139.96		388.5	393.9	396.7	399.3	400.2	402.5	404.3	405.8	407.6
140.47		388.8	394.1	397.0	399.6	400.5	402.8	404.5	406.1	407.9
140.96		389.0	394.4	397.2	399.9	400.8	403.1	404.8	406.3	408.1
141.53		389.3	394.7	397.5	400.2	401.1	403.4	405.1	406.6	408.4
142.00		389.6	394.9	397.8	400.4	401.3	403.6	405.4	406.8	408.6
142.50		389.8	395.2	398.1	400.7	401.6	403.9	405.6	407.1	408.8
142.89		390.0	395.4	398.3	400.9	401.8	404.1	405.8	407.3	409.0
143.42		390.3	395.7	398.5	401.2	402.1	404.4	406.1	407.5	409.2
143.80		390.5	395.9	398.7	401.4	402.3	404.6	406.3	407.7	409.4
144.35		390.8	396.2	399.0	401.7	402.6	404.9	406.6	408.0	409.7
144.85		391.1	396.4	399.3	402.0	402.9	405.2	406.9	408.2	409.9

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
145.35		391.3	396.7	399.6	402.2	403.2	405.4	407.2	408.5	410.1
145.81	SELMA	391.6	396.9	399.8	402.5	403.4	405.7	407.4	408.7	410.4
146.27		391.8	397.1	400.0	402.7	403.6	405.9	407.7	408.9	410.6
146.78		392.0	397.4	400.3	402.9	403.9	406.2	407.9	409.2	410.9
147.26		392.3	397.6	400.5	403.2	404.1	406.4	408.2	409.4	411.1
147.77		392.5	397.9	400.8	403.4	404.3	406.6	408.5	409.7	411.4
148.25		392.7	398.1	401.0	403.7	404.6	406.9	408.7	409.9	411.6
148.72		392.9	398.3	401.2	403.9	404.8	407.1	408.9	410.1	411.9
149.24		393.2	398.5	401.5	404.1	405.1	407.4	409.2	410.4	-412.2
149.69		393.4	398.8	401.7	404.4	405.3	407.6	409.4	410.6	412.4
150.19		393.6	399.0	401.9	404.6	405.5	407.9	409.7	410.9	412.6
150.72		393.8	399.3	402.2	404.9	405.8	408.1	410.0	411.1	412.9
151.14		394.0	399.5	402.4	405.1	406.0	408.3	410.2	411.3	413.1
151.51		394.2	399.6	402.6	405.2	406.2	408.5	410.4	411.5	413.3
151.98		394.4	399.8	402.8	405.5	406.4	408.7	410.6	411.8	413.6
152.47		394.6	400.1	403.0	405.7	406.6	409.0	410.9	412.0	413.8
152.94		394.9	400.3	403.3	405.9	406.9	409.2	411.1	412.2	414.1
153.50		395.1	400.6	403.5	406.2	407.1	409.5	411.4	412.5	414.4
154.01		395.4	400.8	403.8	406.5	407.4	409.8	411.7	412.8	414.6
154.60		395.6	401.1	404.1	406.8	407.7	410.1	412.0	413.1	415.0
155.54		396.1	401.5	404.5	407.2	408.1	410.5	412.5	413.5	415.5
156.02		396.3	401.8	404.8	407.4	408.3	410.8	412.7	413.8	415.7
156.52		396.5	402.0	405.0	407.7	408.6	411.0	413.0	414.0	416.0
157.00		396.7	402.2	405.2	407.9	408.8	411.3	413.2	414.3	416.2
157.43		396.9	402.4	405.4	408.1	409.0	411.5	413.4	414.5	416.4
157.79		397.1	402.6	405.6	408.3	409.2	411.6	413.6	414.6	416.6

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
158.21		397.3	402.8	405.8	408.5	409.4	411.9	413.9	414.9	416.8
158.50	WATERS POINT	397.4	402.9	406.0	408.6	409.6	412.0	414.0	415.0	417.0
158.67		397.5	403.0	406.0	408.7	409.6	412.1	414.1	415.1	417.1
159.23		397.8	403.3	406.3	409.0	410.0	412.4	414.4	415.4	417.4
159.73		398.1	403.6	406.6	409.3	410.2	412.7	414.6	415.7	417.7
160.18		398.3	403.8	406.8	409.6	410.5	413.0	414.9	415.9	417.9
160.71		398.6	404.1	407.1	409.8	410.8	413.3	415.1	416.2	418.2
160.71	MERAMEC RIVER	398.6	404.1	407.1	409.8	410.8	413.3	415.1	416.2	418.2
161.24		398.9	404.3	407.4	410.1	411.1	413.6	415.4	416.4	418.5
161.86		399.2	404.7	407.7	410.5	411.4	413.9	415.7	416.8	418.8
162.38		399.5	404.9	408.0	410.8	411.7	414.2	416.0	417.1	419.1
162.99		399.9	405.2	408.3	411.1	412.0	414.5	416.3	417.4	419.4
163.30		400.0	405.4	408.4	411.3	412.2	414.7	416.5	417.5	419.6
163.80		400.3	405.6	408.7	411.5	412.5	415.0	416.7	417.8	419.8
164.20		400.5	405.8	408.9	411.7	412.7	415.2	416.9	418.0	420.1
164.67		400.8	406.1	409.1	412.0	413.0	415.5	417.2	418.3	420.3
165.25		401.1	406.4	409.4	412.3	413.3	415.8	417.5	418.6	420.6
165.81		401.4	406.7	409.7	412.6	413.6	416.1	417.8	418.9	420.9
166.40		401.7	407.0	410.0	412.9	413.9	416.5	418.1	419.2	421.2
167.03		402.1	407.3	410.4	413.3	414.3	416.8	418.4	419.5	421.6
167.52		402.3	407.5	410.6	413.5	414.6	417.1	418.7	419.8	421.8
168.13		402.7	407.8	410.9	413.9	414.9	417.4	419.0	420.1	422.2
168.75	JEFFERSON BARRACKS	403.0	408.2	411.3	414.2	415.2	417.8	419.3	420.4	422.5
168.80		403.0	408.2	411.3	414.2	415.3	417.8	419.3	420.4	422.5
168.81		403.0	408.2	411.3	414.2	415.3	417.8	419.3	420.5	422.5
168.92		403.1	408.3	411.4	414.3	415.3	417.9	419.4	420.5	422.6

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
169.10		403.2	408.4	411.5	414.4	415.4	418.0	419.5	420.6	422.6
169.46		403.4	408.7	411.7	414.6	415.6	418.2	419.7	420.8	422.8
169.79		403.6	408.9	411.9	414.8	415.8	418.3	419.9	421.0	422.9
170.15		403.9	409.2	412.1	415.0	416.0	418.5	420.1	421.2	423.1
170.60		404.1	409.5	412.4	415.2	416.3	418.8	420.4	421.4	423.3
171.01		404.4	409.8	412.7	415.5	416.5	419.0	420.6	421.7	423.4
171.46		404.7	410.1	413.0	415.7	416.8	419.2	420.9	421.9	423.6
171.88		404.9	410.4	413.2	416.0	417.0	419.4	421.1	422.2	423.9
172.41		405.2	410.8	413.6	416.3	417.3	419.7	421.4	422.6	424.4
172.97		405.6	411.2	413.9	416.6	417.6	420.0	421.8	423.0	424.8
173.46		405.9	411.5	414.2	416.8	417.9	420.2	422.1	423.3	425.2
174.00		406.2	411.9	414.6	417.1	418.2	420.5	422.4	423.7	425.6
174.38		406.4	412.2	414.8	417.4	418.4	420.7	422.6	423.9	425.9
175.33		407.0	412.8	415.4	417.9	418.9	421.2	423.1	424.6	426.7
175.80		407.3	413.2	415.7	418.1	419.2	421.5	423.4	424.9	427.1
176.19		407.5	413.5	416.0	418.4	419.4	421.7	423.6	425.2	427.4
176.40		407.7	413.6	416.1	418.5	419.5	421.8	423.8	425.4	427.6
176.56		407.8	413.7	416.2	418.6	419.6	421.8	423.9	425.5	427.7
176.96	ENGINEERING DEPOT	408.0	414.0	416.4	418.8	419.8	422.1	424.1	425.7	428.0
177.44		408.3	414.3	416.8	419.2	420.2	422.4	424.4	426.1	428.5
177.91		408.7	414.6	417.1	419.6	420.6	422.8	424.8	426.5	428.9
178.31		409.0	414.9	417.4	419.9	420.9	423.1	425.1	426.8	429.3
178.86		409.4	415.2	417.8	420.4	421.3	423.5	425.5	427.2	429.8
178.88		409.4	415.2	417.9	420.4	421.3	423.5	425.5	427.2	429.8
178.89		409.4	415.2	417.9	420.4	421.3	423.5	425.5	427.2	429.8
179.00		409.5	415.3	418.0	420.5	421.4	423.6	425.6	427.3	429.9

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
179.12		409.6	415.4	418.0	420.6	421.5	423.6	425.7	427.4	430.0
179.15		409.6	415.4	418.1	420.6	421.5	423.7	425.7	427.4	430.1
179.17		409.6	415.4	418.1	420.6	421.6	423.7	425.7	427.5	430.1
179.53		409.8	415.7	418.3	420.9	421.8	423.9	425.9	427.7	430.4
179.60	ST. LOUIS	409.9	415.7	418.4	421.0	421.9	424.0	426.0	427.8	430.5
180.01		410.1	415.9	418.6	421.2	422.2	424.3	426.3	428.1	430.8
180.02		410.1	415.9	418.6	421.3	422.2	424.3	426.3	428.1	430.9
180.03		410.1	415.9	418.6	421.3	422.2	424.3	426.3	428.2	430.9
180.11		410.1	415.9	418.7	421.3	422.2	424.4	426.4	428.2	430.9
180.20		410.1	416.0	418.7	421.4	422.3	424.4	426.4	428.3	431.0
180.21		410.1	416.0	418.7	421.4	422.3	424.4	426.4	428.3	431.0
180.22		410.1	416.0	418.7	421.4	422.3	424.4	426.4	428.3	431.0
180.77		410.4	416.2	419.0	421.7	422.7	424.8	426.8	428.8	431.5
181.33		410.6	416.5	419.3	422.1	423.0	425.2	427.2	429.2	432.0
181.90		410.8	416.7	419.6	422.4	423.4	425.6	427.6	429.7	432.4
182.44		411.0	417.0	419.9	422.7	423.7	426.0	428.0	430.1	432.9
182.50		411.0	417.0	420.0	422.8	423.8	426.1	428.0	430.2	432.9
182.52		411.0	417.0	420.0	422.8	423.8	426.1	428.0	430.2	433.0
182.53		411.0	417.0	420.0	422.8	423.8	426.1	428.0	430.2	433.0
182.90		411.2	417.2	420.2	423.0	424.0	426.4	428.3	430.5	433.3
183.26		411.3	417.3	420.4	423.2	424.3	426.6	428.6	430.8	433.6
183.27		411.3	417.3	420.4	423.2	424.3	426.6	428.6	430.8	433.6
183.28		411.3	417.3	420.4	423.2	424.3	426.6	428.6	430.8	433.6
183.30		411.3	417.4	420.4	423.3	424.3	426.7	428.6	430.9	433.6
183.38		411.4	417.4	420.4	423.3	424.3	426.7	428.6	430.9	433.7
183.98		411.6	417.7	420.8	423.7	424.7	427.1	429.1	431.4	434.2

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
184.56		411.8	417.9	421.1	424.0	425.1	427.6	429.5	431.9	434.7
185.18		412.1	418.2	421.4	424.4	425.5	428.0	429.9	432.4	435.2
185.76		412.3	418.4	421.6	424.6	425.7	428.2	430.1	432.6	435.4
186.36		412.5	418.6	421.9	424.7	425.9	428.4	430.3	432.8	435.6
186.82		412.7	418.8	422.1	424.8	426.0	428.6	430.4	433.0	435.7
187.41		412.9	419.0	422.3	425.0	426.2	428.8	430.6	433.2	435.9
188.00		413.2	419.2	422.5	425.2	426.4	429.0	430.8	433.4	436.1
188.43		413.3	419.4	422.7	425.3	426.5	429.2	431.1	433.5	436.2
188.88		413.5	419.5	422.9	425.4	426.7	429.4	431.3	433.7	436.3
189.47		413.7	419.8	423.1	425.6	426.8	429.7	431.7	433.9	436.5
190.29		414.1	420.1	423.5	425.8	427.1	430.2	432.2	434.2	436.8
190.32		414.1	420.1	423.5	425.8	427.1	430.2	432.2	434.2	436.8
190.37	CHAIN OF ROCKS	414.1	420.1	423.5	425.8	427.1	430.2	432.2	434.2	436.8
190.46		414.1	420.1	423.5	425.8	427.2	430.2	432.2	434.2	436.8
190.47		414.2	420.1	423.5	425.9	427.2	430.2	432.2	434.2	436.8
190.48		414.2	420.1	423.5	425.9	427.2	430.2	432.2	434.2	436.8
190.50		414.2	420.1	423.6	425.9	427.2	430.2	432.2	434.3	436.8
190.64		414.2	420.2	423.6	425.9	427.2	430.3	432.3	434.3	436.9
190.79		414.3	420.3	423.7	426.0	427.3	430.3	432.3	434.4	436.9
190.81		414.3	420.3	423.7	426.0	427.3	430.4	432.4	434.4	436.9
190.82		414.3	420.3	423.7	426.0	427.3	430.4	432.4	434.4	436.9
190.85		414.4	420.3	423.7	426.1	427.3	430.4	432.4	434.4	436.9
191.36		414.6	420.5	423.9	426.3	427.5	430.6	432.6	434.6	437.1
191.92		415.0	420.7	424.1	426.6	427.8	430.8	432.8	434.9	437.2
192.41		415.2	420.9	424.3	426.9	428.0	430.9	432.9	435.1	437.4
192.91		415.5	421.1	424.5	427.1	428.2	431.1	433.1	435.3	437.5

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
193.28		415.7	421.3	424.6	427.3	428.3	431.2	433.2	435.4	437.6
193.79		416.0	421.5	424.8	427.6	428.5	431.4	433.4	435.7	437.7
194.16		416.2	421.6	425.0	427.8	428.7	431.6	433.6	435.8	437.8
194.63		416.5	421.8	425.1	428.0	428.9	431.7	433.7	436.0	438.0
194.97		416.6	421.9	425.3	428.2	429.0	431.8	433.8	436.2	438.0
195.55	MISSOURI RIVER	417.0	422.2	425.5	428.5	429.3	432.0	434.0	436.4	438.2
195.56		417.0	422.2	425.5	428.5	429.3	432.1	434.1	436.4	438.2
196.09		417.3	422.4	425.7	428.7	429.5	432.2	434.2	436.5	438.2
196.48		417.5	422.6	425.8	428.8	429.6	432.4	434.4	436.5	438.3
196.82	HARTFORD	417.7	422.7	425.9	428.9	429.8	432.5	434.5	436.6	438.3
197.31		417.9	422.9	426.0	429.0	429.9	432.6	434.6	436.8	438.5
197.71		418.2	423.1	426.1	429.1	430.0	432.7	434.7	437.0	438.6
198.28		418.5	423.3	426.2	429.2	430.2	432.8	434.8	437.2	438.8
198.81		418.8	423.5	426.4	429.3	430.3	432.9	434.9	437.4	439.0
199.34		419.1	423.7	426.5	429.4	430.4	433.0	435.0	437.6	439.2
199.83		419.3	423.9	426.6	429.5	430.6	433.1	435.1	437.8	439.3
200.31		419.6	424.1	426.7	429.6	430.7	433.2	435.2	438.0	439.5
200.54	MEL PRICE TW	419.8	424.3	426.9	429.8	430.8	433.3	435.3	438.1	439.6
200.70	MEL PRICE POOL	420.0	424.5	427.0	429.9	430.9	433.4	435.4	438.2	439.7
200.85		420.2	424.6	427.1	430.0	431.0	433.5	435.5	438.3	439.8
201.29		420.6	425.0	427.5	430.3	431.3	433.7	435.7	438.5	440.0
201.85		420.7	425.1	427.7	430.2	431.4	433.9	436.0	438.6	440.0
202.50		420.8	425.2	427.9	430.4	431.5	434.2	436.4	438.7	440.1
202.63		420.8	425.2	428.0	430.5	431.5	434.3	436.5	438.7	440.1
202.66		420.8	425.2	428.0	430.5	431.5	434.3	436.5	438.7	440.1
202.68	ALTON	420.8	425.2	428.0	430.5	431.5	434.3	436.5	438.7	440.1

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
203.04		420.9	425.3	428.1	430.6	431.6	434.4	436.6	438.8	440.2
203.36		420.9	425.4	428.1	430.6	431.6	434.4	436.6	438.8	440.2
203.86		421.1	425.5	428.3	430.7	431.7	434.5	436.7	438.9	440.3
204.38		421.2	425.7	428.4	430.8	431.8	434.6	436.8	439.0	440.4
204.96		421.3	425.8	428.5	430.9	431.9	434.7	436.9	439.1	440.5
205.48		421.4	426.0	428.6	431.0	432.0	434.7	437.0	439.2	440.6
206.07		421.5	426.1	428.7	431.1	432.1	434.8	437.1	439.3	440.7
206.60		421.7	426.3	428.8	431.2	432.2	434.9	437.1	439.3	440.8
207.12		421.8	426.4	429.0	431.3	432.3	435.0	437.2	439.4	440.9
207.72		421.9	426.6	429.1	431.4	432.4	435.1	437.3	439.5	441.1
208.29		422.0	426.8	429.2	431.5	432.5	435.2	437.4	439.6	441.2
208.89		422.2	426.9	429.3	431.6	432.6	435.3	437.5	439.7	441.3
209.46		422.3	427.1	429.5	431.7	432.7	435.4	437.6	439.8	441.4
210.13		422.4	427.3	429.6	431.9	432.8	435.5	437.7	439.9	441.5
210.79		422.6	427.5	429.7	432.0	432.9	435.6	437.8	440.0	441.6
211.39		422.7	427.6	429.9	432.1	433.0	435.7	437.9	440.1	441.7
211.92		422.8	427.8	430.0	432.2	433.1	435.7	438.0	440.2	441.8
212.38		422.9	427.9	430.1	432.3	433.2	435.8	438.1	440.3	441.9
212.86		423.1	428.1	430.2	432.4	433.3	435.9	438.2	440.4	442.0
213.28		423.1	428.2	430.3	432.4	433.4	436.0	438.2	440.4	442.1
213.28		423.1	428.2	430.3	432.4	433.4	436.0	438.2	440.4	442.1
213.87		423.3	428.3	430.4	432.5	433.5	436.0	438.3	440.5	442.2
214.48		423.4	428.5	430.5	432.7	433.6	436.1	438.4	440.6	442.3
215.09		423.5	428.7	430.7	432.8	433.7	436.2	438.5	440.7	442.4
215.60		423.7	428.8	430.8	432.9	433.8	436.3	438.6	440.8	442.5
215.99		423.7	428.9	430.9	432.9	433.8	436.4	438.7	440.9	442.6

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
216.55		423.9	429.1	431.0	433.0	433.9	436.5	438.8	441.0	442.7
216.92		424.0	429.2	431.1	433.1	434.0	436.5	438.8	441.0	442.8
217.47		424.1	429.3	431.2	433.2	434.1	436.6	438.9	441.1	442.9
218.02	GRAFTON	424.2	429.5	431.3	433.3	434.2	436.7	439.0	441.2	443.0
218.03	ILLINOIS RIVER	424.2	429.5	431.3	433.3	434.2	436.7	439.0	441.2	443.0
218.30		424.3	429.6	431.4	433.4	434.3	436.8	439.1	441.2	443.0
218.86		424.6	429.8	431.6	433.6	434.5	436.9	439.2	441.3	443.1
219.43		424.9	430.0	431.8	433.8	434.7	437.1	439.4	441.4	443.2
220.02		425.2	430.3	432.0	434.0	434.9	437.3	439.5	441.5	443.3
220.47		425.5	430.5	432.2	434.1	435.0	437.4	439.6	441.6	443.4
221.05		425.8	430.7	432.4	434.3	435.2	437.6	439.8	441.7	443.4
221.62		426.1	430.9	432.6	434.5	435.4	437.8	439.9	441.8	443.5
222.10		426.3	431.1	432.8	434.7	435.6	437.9	440.1	441.9	443.6
222.55		426.5	431.3	432.9	434.8	435.7	438.1	440.2	441.9	443.7
223.11		426.8	431.5	433.1	435.0	435.9	438.2	440.3	442.0	443.7
223.75		427.2	431.7	433.4	435.3	436.2	438.4	440.5	442.1	443.8
224.25		427.4	431.9	433.5	435.4	436.3	438.6	440.6	442.2	443.9
224.70		427.6	432.1	433.7	435.6	436.5	438.7	440.7	442.3	444.0
225.11		427.9	432.3	433.8	435.7	436.6	438.8	440.9	442.4	444.0
225.70		428.2	432.5	434.1	435.9	436.8	439.0	441.0	442.5	444.1
226.28		428.5	432.7	434.3	436.1	437.0	439.2	441.2	442.5	444.2
226.77		428.7	432.9	434.4	436.3	437.2	439.3	441.3	442.6	444.3
227.23		429.0	433.1	434.6	436.4	437.3	439.5	441.4	442.7	444.3
227.76		429.2	433.3	434.8	436.6	437.5	439.6	441.6	442.8	444.4
228.29	DIXON LANDING	429.5	433.5	435.0	436.8	437.7	439.8	441.7	442.9	444.5
228.50		429.6	433.6	435.1	436.9	437.8	439.9	441.7	442.9	444.5

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
229.00		429.7	433.7	435.2	437.1	438.0	440.0	441.9	443.1	444.7
229.49		429.9	433.8	435.4	437.2	438.1	440.2	442.0	443.2	444.8
230.02		430.1	434.0	435.6	437.4	438.3	440.3	442.1	443.3	444.9
230.29		430.1	434.0	435.6	437.5	438.4	440.4	442.2	443.4	444.9
230.79		430.3	434.2	435.8	437.7	438.6	440.6	442.3	443.5	445.1
231.40		430.5	434.3	436.0	438.0	438.9	440.8	442.5	443.7	445.2
232.01		430.7	434.5	436.2	438.2	439.1	441.0	442.7	443.8	445.3
232.58		430.9	434.6	436.4	438.4	439.3	441.2	442.8	444.0	445.5
233.11		431.1	434.8	436.6	438.6	439.5	441.3	443.0	444.1	445.6
233.59		431.2	434.9	436.7	438.8	439.7	441.5	443.1	444.2	445.7
234.05		431.4	435.0	436.9	438.9	439.8	441.6	443.2	444.4	445.8
234.55		431.5	435.1	437.0	439.1	440.0	441.8	443.3	444.5	445.9
235.16		431.7	435.3	437.2	439.3	440.2	442.0	443.5	444.6	446.0
235.79		431.9	435.5	437.4	439.6	440.5	442.2	443.7	444.8	446.2
236.39	CUIVRE RIVER	432.1	435.6	437.6	439.8	440.7	442.4	443.8	445.0	446.3
236.39		432.1	435.6	437.6	439.8	440.7	442.4	443.8	445.0	446.3
237.00		432.3	435.8	437.8	440.0	440.9	442.6	444.0	445.1	446.5
237.56		432.5	435.9	438.0	440.2	441.1	442.7	444.1	445.3	446.6
238.19		432.7	436.1	438.2	440.5	441.4	442.9	444.3	445.4	446.7
238.59		432.8	436.2	438.3	440.6	441.5	443.1	444.4	445.5	446.8
239.09		433.0	436.3	438.5	440.8	441.7	443.2	444.5	445.6	446.9
239.58		433.2	436.5	438.7	441.0	441.9	443.4	444.7	445.8	447.0
240.10		433.3	436.6	438.8	441.2	442.1	443.5	444.8	445.9	447.1
240.64	L&D 25 LOWER	433.5	436.7	439.0	441.4	442.3	443.7	444.9	446.0	447.3
241.23	L&D 25 UPPER	433.7	436.9	439.2	441.6	442.5	443.9	445.1	446.2	447.4
241.33		434.0	437.2	439.4	441.8	442.7	444.1	445.3	446.4	447.6

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
241.49		434.4	437.6	439.8	442.2	443.1	444.4	445.6	446.7	447.9
242.02		434.6	437.7	440.0	442.4	443.2	444.5	445.7	446.7	448.0
242.65		434.8	437.8	440.1	442.5	443.4	444.6	445.7	446.8	448.0
243.22		435.0	437.9	440.3	442.7	443.5	444.7	445.8	446.8	448.1
244.03		435.3	438.1	440.5	442.9	443.7	444.8	445.8	446.9	448.1
244.67		435.5	438.2	440.7	443.1	443.8	444.9	445.9	446.9	448.2
245.39		435.7	438.5	441.0	443.3	444.0	445.1	446.1	447.1	448.4
246.00		435.9	438.8	441.2	443.5	444.2	445.2	446.2	447.3	448.6
246.56		436.1	439.0	441.4	443.7	444.3	445.4	446.4	447.4	448.7
247.09		436.3	439.2	441.6	443.8	444.5	445.5	446.5	447.6	448.9
247.69		436.5	439.5	441.8	444.0	444.6	445.7	446.7	447.7	449.0
248.22		436.6	439.7	442.0	444.1	444.8	445.8	446.8	447.9	449.2
248.87		436.9	440.0	442.3	444.3	445.0	446.0	447.0	448.1	449.4
249.50		437.1	440.2	442.5	444.5	445.1	446.2	447.2	448.2	449.5
250.00		437.2	440.4	442.7	444.7	445.3	446.3	447.3	448.4	449.7
250.38		437.3	440.6	442.8	444.8	445.4	446.4	447.4	448.5	449.8
250.85		437.5	440.8	443.0	444.9	445.5	446.5	447.5	448.6	449.9
251.22		437.7	441.0	443.1	445.0	445.6	446.6	447.6	448.7	450.0
251.70		437.9	441.2	443.3	445.2	445.8	446.8	447.8	448.9	450.2
252.19		438.1	441.4	443.5	445.4	446.0	447.0	448.0	449.1	450.4
252.67		438.3	441.6	443.7	445.6	446.2	447.1	448.1	449.2	450.5
253.21		438.5	441.8	443.9	445.7	446.3	447.3	448.3	449.4	450.7
253.70		438.8	442.0	444.1	445.9	446.5	447.5	448.5	449.6	450.9
254.18		439.0	442.2	444.3	446.1	446.7	447.7	448.7	449.7	451.1
254.68		439.2	442.5	444.5	446.3	446.9	447.8	448.8	449.9	451.2
255.26		439.5	442.7	444.7	446.5	447.1	448.0	449.0	450.1	451.4

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
255.81		439.7	443.0	444.9	446.7	447.3	448.2	449.2	450.3	451.6
256.40		440.0	443.2	445.1	446.9	447.5	448.4	449.4	450.5	451.8
256.95		440.2	443.4	445.3	447.1	447.7	448.6	449.6	450.7	452.0
257.57		440.5	443.7	445.6	447.3	447.9	448.8	449.8	450.9	452.2
258.00		440.7	443.9	445.7	447.5	448.1	449.0	450.0	451.0	452.4
258.39		440.9	444.1	445.9	447.6	448.2	449.1	450.1	451.2	452.5
258.72		441.0	444.2	446.0	447.7	448.3	449.2	450.2	451.3	452.6
259.18		441.2	444.4	446.2	447.9	448.5	449.4	450.4	451.4	452.8
259.65		441.4	444.6	446.4	448.1	448.7	449.6	450.6	451.6	453.0
260.17		441.6	444.8	446.6	448.3	448.9	449.8	450.8	451.8	453.2
260.30		441.7	444.9	446.6	448.3	448.9	449.8	450.8	451.8	453.2
260.68		441.9	445.1	446.8	448.5	449.1	450.0	451.0	452.0	453.4
261.41		442.3	445.5	447.2	448.9	449.5	450.4	451.4	452.4	453.7
261.98		442.6	445.8	447.5	449.2	449.8	450.7	451.7	452.7	454.0
262.47		442.8	446.1	447.8	449.4	450.0	450.9	451.9	453.0	454.2
263.14		443.2	446.5	448.1	449.8	450.4	451.3	452.3	453.3	454.5
263.75		443.5	446.8	448.5	450.1	450.7	451.6	452.6	453.7	454.8
264.40		443.8	447.2	448.8	450.4	451.0	451.9	452.9	454.0	455.1
264.96	RIP RAP LANDING	444.1	447.5	449.1	450.7	451.3	452.2	453.2	454.3	455.4
265.59		444.4	447.8	449.4	451.0	451.6	452.5	453.5	454.6	455.7
265.98		444.5	447.9	449.5	451.2	451.8	452.7	453.7	454.8	455.9
266.55		444.8	448.2	449.8	451.4	452.0	453.0	454.0	455.0	456.2
267.22		445.0	448.4	450.1	451.7	452.3	453.3	454.3	455.3	456.5
267.62		445.2	448.6	450.3	451.9	452.5	453.5	454.5	455.5	456.7
268.23		445.5	448.9	450.5	452.2	452.8	453.7	454.7	455.8	457.0
268.76		445.7	449.1	450.8	452.4	453.0	454.0	455.0	456.0	457.3

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
269.31		445.9	449.3	451.0	452.7	453.3	454.3	455.3	456.3	457.5
269.91		446.2	449.6	451.3	453.0	453.6	454.5	455.5	456.6	457.8
270.45		446.4	449.8	451.5	453.2	453.8	454.8	455.8	456.8	458.1
270.98		446.8	450.0	451.7	453.4	454.0	455.0	456.0	457.0	458.4
271.66		447.3	450.2	452.0	453.6	454.2	455.3	456.3	457.3	458.8
272.22		447.8	450.4	452.2	453.8	454.4	455.5	456.5	457.5	459.1
272.59		448.0	450.5	452.3	453.9	454.5	455.6	456.6	457.6	459.3
272.98		448.3	450.7	452.5	454.0	454.7	455.8	456.8	457.8	459.5
273.32	L&D 24 LOWER	448.6	450.8	452.6	454.1	454.8	455.9	456.9	457.9	459.7
273.53	L&D 24 UPPER	449.1	451.3	453.1	454.6	455.3	456.4	457.4	458.4	460.2
273.84		449.3	451.5	453.3	454.8	455.5	456.6	457.6	458.5	460.3
274.43		449.6	451.8	453.6	455.1	455.8	457.0	458.0	458.9	460.5
275.00		449.8	452.1	453.9	455.4	456.2	457.3	458.3	459.3	460.7
275.55		450.1	452.4	454.2	455.7	456.5	457.6	458.7	459.6	460.9
276.27		450.4	452.7	454.6	456.1	456.9	458.0	459.1	460.1	461.2
276.86		450.7	453.0	454.9	456.5	457.2	458.4	459.5	460.4	461.6
277.57		451.1	453.4	455.3	456.9	457.6	458.8	459.9	460.9	462.1
278.11		451.3	453.7	455.6	457.2	457.9	459.1	460.3	461.2	462.5
278.67		451.6	454.0	455.9	457.5	458.2	459.4	460.6	461.6	462.9
279.08		451.8	454.2	456.1	457.7	458.5	459.7	460.9	461.8	463.2
279.63		452.0	454.5	456.4	458.0	458.8	460.0	461.2	462.2	463.6
280.18		452.3	454.8	456.7	458.3	459.1	460.3	461.5	462.5	464.0
280.78		452.6	455.1	457.0	458.6	459.4	460.6	461.9	462.9	464.5
281.43		452.9	455.4	457.4	459.0	459.8	461.0	462.3	463.3	464.9
282.03		453.2	455.8	457.7	459.3	460.1	461.4	462.7	463.7	465.4
282.05		453.2	455.8	457.7	459.3	460.1	461.4	462.7	463.7	465.4

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
282.09		453.2	455.8	457.8	459.4	460.1	461.4	462.7	463.7	465.4
282.13		453.2	455.8	457.8	459.4	460.2	461.4	462.7	463.7	465.4
282.69		453.5	456.1	458.1	459.7	460.5	461.8	463.1	464.1	465.8
282.90	LOUISIANA	453.6	456.2	458.2	459.8	460.6	461.9	463.2	464.2	466.0
283.14		453.7	456.3	458.3	459.9	460.7	462.0	463.3	464.3	466.1
283.16		453.7	456.3	458.3	459.9	460.7	462.0	463.3	464.3	466.1
283.20		453.7	456.3	458.3	459.9	460.7	462.0	463.3	464.4	466.1
283.75		454.0	456.6	458.6	460.2	461.0	462.3	463.6	464.6	466.4
284.40	SALR RIVER	454.3	456.9	458.9	460.5	461.3	462.6	463.9	465.0	466.7
284.40		454.3	456.9	458.9	460.5	461.3	462.6	463.9	465.0	466.7
285.00		454.5	457.1	459.2	460.8	461.6	462.9	464.2	465.3	467.0
285.59		454.8	457.4	459.4	461.0	461.8	463.2	464.5	465.6	467.3
286.17		455.0	457.7	459.7	461.3	462.1	463.5	464.8	465.9	467.6
286.72		455.3	457.9	460.0	461.6	462.4	463.7	465.1	466.2	467.9
287.31		455.5	458.2	460.2	461.8	462.6	464.0	465.4	466.5	468.2
287.89		455.8	458.4	460.5	462.1	462.9	464.3	465.7	466.8	468.5
288.47		456.0	458.7	460.8	462.4	463.2	464.6	466.0	467.1	468.8
288.87		456.2	458.9	461.0	462.6	463.4	464.8	466.2	467.3	469.0
289.49		456.5	459.1	461.2	462.8	463.6	465.1	466.5	467.6	469.3
290.20		456.8	459.4	461.6	463.2	464.0	465.5	466.8	468.0	469.6
290.60		456.9	459.6	461.7	463.3	464.1	465.6	467.0	468.2	469.8
291.00		457.1	459.8	461.9	463.5	464.3	465.8	467.2	468.4	470.0
291.56		457.4	460.0	462.2	463.8	464.6	466.1	467.5	468.7	470.3
292.09		457.6	460.3	462.4	464.0	464.8	466.4	467.8	469.0	470.6
292.57		457.8	460.5	462.7	464.3	465.1	466.6	468.0	469.2	470.8
293.01	MUNDYS LANDING	458.0	460.7	462.9	464.5	465.3	466.8	468.2	469.5	471.0

TABLE D-30 CONTINUED TABULAR RESULTS MISSISSIPPI RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
293.37		458.1	460.9	463.0	464.6	465.4	467.0	468.4	469.7	471.2
293.86		458.4	461.1	463.3	464.9	465.7	467.2	468.7	469.9	471.5
294.55		458.7	461.4	463.6	465.2	466.0	467.6	469.0	470.3	471.8
294.97		458.8	461.6	463.8	465.4	466.2	467.8	469.2	470.5	472.0
295.60		459.1	461.8	464.1	465.7	466.5	468.1	469.5	470.8	472.3
296.15		459.3	462.1	464.3	465.9	466.7	468.4	469.8	471.1	472.6
296.80		459.6	462.4	464.6	466.2	467.0	468.7	470.1	471.4	472.9
297.30		459.8	462.6	464.8	466.4	467.2	468.9	470.4	471.7	473.2
297.81		460.1	462.8	465.1	466.7	467.5	469.2	470.6	472.0	473.4
298.17		460.2	463.0	465.2	466.8	467.6	469.4	470.8	472.2	473.6
298.86		460.5	463.3	465.6	467.2	468.0	469.7	471.2	472.5	474.0
299.45		460.8	463.6	465.8	467.4	468.2	470.0	471.5	472.8	474.3
300.04		461.0	463.8	466.1	467.7	468.5	470.3	471.8	473.1	474.6
300.63		461.3	464.1	466.4	468.0	468.8	470.6	472.1	473.4	474.9
301.20	L&D 22 TW	461.5	464.3	466.6	468.2	469.0	470.8	472.3	473.7	475.1

TABLE D-31 TABULAR RESULTS ILLINOIS RIVER FREQUENCY

	Illinois River	PERCENT EXCEEDANCE PROBABILITY								
River Mile	Station Name	50.0%	20.0 %	10.0 %	5.0 %	4.0 %	2.0 %	1.0 %	0.5 %	0.2 %
0.00	GRAFTON	424.2	429.5	431.3	433.3	434.2	436.7	439.0	441.2	443.0
0.80		424.3	429.5	431.4	433.4	434.3	436.7	439.0	441.2	443.0
1.40		424.3	429.5	431.4	433.4	434.3	436.8	439.1	441.2	443.0
1.90		424.4	429.6	431.4	433.5	434.3	436.8	439.1	441.2	443.0
2.80		424.4	429.6	431.5	433.6	434.4	436.9	439.2	441.3	443.0
3.80		424.5	429.7	431.6	433.7	434.5	436.9	439.2	441.3	443.0
4.80		424.6	429.7	431.7	433.7	434.6	437.0	439.3	441.3	443.0
5.10		424.6	429.7	431.7	433.8	434.6	437.0	439.3	441.3	443.0
5.80		424.7	429.8	431.8	433.8	434.7	437.1	439.3	441.3	443.0
6.80		424.8	429.8	431.8	433.9	434.7	437.1	439.4	441.4	443.0
7.80		424.9	429.8	431.9	434.0	434.8	437.2	439.4	441.4	443.0
8.70		424.9	429.9	432.0	434.1	434.9	437.2	439.5	441.4	443.0
9.50		425.0	429.9	432.0	434.2	434.9	437.3	439.5	441.4	443.0
9.90		425.0	429.9	432.1	434.2	435.0	437.3	439.6	441.4	443.0
10.84		425.1	430.0	432.2	434.3	435.1	437.4	439.6	441.5	443.1
11.80		425.2	430.0	432.2	434.4	435.1	437.4	439.7	441.5	443.1
12.47		425.2	430.1	432.3	434.5	435.2	437.5	439.7	441.5	443.1
12.76		425.3	430.1	432.3	434.5	435.2	437.5	439.7	441.5	443.1
13.50		425.3	430.1	432.4	434.6	435.3	437.5	439.8	441.5	443.1
14.00		425.4	430.1	432.4	434.6	435.3	437.5	439.8	441.5	443.1
14.60		425.4	430.2	432.5	434.7	435.4	437.6	439.8	441.5	443.1
15.17		425.5	430.2	432.5	434.7	435.4	437.6	439.8	441.6	443.1
15.54		425.5	430.2	432.5	434.7	435.4	437.6	439.9	441.6	443.1

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
15.90		425.5	430.2	432.6	434.8	435.5	437.7	439.9	441.6	443.1
16.31		425.6	430.3	432.6	434.8	435.5	437.7	439.9	441.6	443.1
16.70		425.6	430.3	432.6	434.9	435.5	437.7	439.9	441.6	443.1
17.30		425.6	430.3	432.7	434.9	435.6	437.7	440.0	441.6	443.1
17.70		425.7	430.3	432.7	434.9	435.6	437.8	440.0	441.6	443.1
17.96		425.7	430.3	432.7	435.0	435.6	437.8	440.0	441.6	443.1
18.25		425.7	430.3	432.7	435.0	435.6	437.8	440.0	441.6	443.1
18.64		425.8	430.4	432.8	435.0	435.7	437.8	440.0	441.6	443.1
19.10		425.8	430.4	432.8	435.1	435.7	437.9	440.1	441.6	443.1
19.40		425.8	430.4	432.8	435.1	435.7	437.9	440.1	441.7	443.1
19.58		425.8	430.4	432.8	435.1	435.7	437.9	440.1	441.7	443.1
20.20		425.9	430.4	432.9	435.2	435.8	437.9	440.1	441.7	443.1
20.50		425.9	430.5	432.9	435.2	435.8	437.9	440.1	441.7	443.1
21.00		426.0	430.5	433.0	435.2	435.9	438.0	440.2	441.7	443.1
21.18		426.0	430.5	433.0	435.3	435.9	438.0	440.2	441.7	443.1
21.52		426.0	430.5	433.0	435.3	435.9	438.0	440.2	441.7	443.1
21.54	HARDIN	426.0	430.5	433.0	435.3	435.9	438.0	440.2	441.7	443.1
21.67		426.0	430.5	433.0	435.3	435.9	438.0	440.2	441.7	443.1
22.05		426.1	430.6	433.1	435.4	436.0	438.1	440.2	441.7	443.1
22.60		426.2	430.7	433.2	435.5	436.1	438.2	440.3	441.8	443.1
23.10		426.3	430.8	433.3	435.6	436.2	438.2	440.3	441.8	443.2
23.20		426.3	430.8	433.3	435.6	436.2	438.2	440.3	441.8	443.2
23.50		426.4	430.9	433.3	435.7	436.2	438.3	440.4	441.8	443.2
24.26		426.5	431.0	433.5	435.8	436.4	438.4	440.4	441.9	443.2
24.70		426.6	431.1	433.5	435.9	436.5	438.5	440.5	441.9	443.2

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
25.10		426.7	431.1	433.6	435.9	436.5	438.5	440.5	441.9	443.2
25.51		426.8	431.2	433.7	436.0	436.6	438.6	440.5	442.0	443.3
25.88		426.8	431.3	433.7	436.1	436.7	438.6	440.6	442.0	443.3
26.20		426.9	431.3	433.8	436.1	436.7	438.7	440.6	442.0	443.3
26.70		427.0	431.4	433.9	436.2	436.8	438.8	440.7	442.0	443.3
27.20		427.1	431.5	434.0	436.3	436.9	438.8	440.7	442.1	443.3
27.70		427.2	431.6	434.1	436.4	437.0	438.9	440.7	442.1	443.4
28.10		427.3	431.7	434.1	436.5	437.1	439.0	440.8	442.1	443.4
28.50		427.3	431.8	434.2	436.6	437.1	439.0	440.8	442.1	443.4
29.00		427.4	431.8	434.3	436.6	437.2	439.1	440.9	442.2	443.4
29.45		427.5	431.9	434.4	436.7	437.3	439.2	440.9	442.2	443.4
29.83		427.6	432.0	434.4	436.8	437.4	439.2	440.9	442.2	443.4
30.20		427.7	432.1	434.5	436.9	437.4	439.3	441.0	442.3	443.5
30.50		427.7	432.1	434.5	436.9	437.5	439.3	441.0	442.3	443.5
30.80		427.8	432.2	434.6	437.0	437.5	439.4	441.0	442.3	443.5
31.30		427.9	432.3	434.7	437.1	437.6	439.4	441.1	442.3	443.5
31.70		428.0	432.3	434.7	437.1	437.7	439.5	441.1	442.4	443.5
31.90		428.0	432.4	434.8	437.2	437.7	439.5	441.1	442.4	443.5
32.30		428.1	432.4	434.8	437.2	437.8	439.6	441.1	442.4	443.5
32.70		428.2	432.5	434.9	437.3	437.9	439.6	441.2	442.4	443.6
33.10		428.2	432.6	435.0	437.4	437.9	439.7	441.2	442.4	443.6
33.50		428.3	432.7	435.0	437.5	438.0	439.8	441.2	442.5	443.6
34.00		428.4	432.7	435.1	437.5	438.1	439.8	441.3	442.5	443.6
34.30		428.5	432.8	435.2	437.6	438.1	439.9	441.3	442.5	443.6
34.70		428.6	432.9	435.2	437.7	438.2	439.9	441.4	442.6	443.6

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
35.20		428.6	433.0	435.3	437.8	438.3	440.0	441.4	442.6	443.7
35.70		428.7	433.0	435.4	437.8	438.4	440.1	441.4	442.6	443.7
36.10		428.8	433.1	435.5	437.9	438.5	440.2	441.5	442.6	443.7
36.30		428.9	433.2	435.5	438.0	438.5	440.2	441.5	442.7	443.7
36.60		428.9	433.2	435.6	438.0	438.5	440.2	441.5	442.7	443.7
37.10		429.0	433.3	435.7	438.1	438.6	440.3	441.6	442.7	443.7
37.50		429.1	433.4	435.7	438.2	438.7	440.4	441.6	442.7	443.8
37.75		429.1	433.4	435.8	438.2	438.7	440.4	441.6	442.7	443.8
38.20		429.2	433.5	435.8	438.3	438.8	440.5	441.7	442.8	443.8
38.70		429.3	433.6	435.9	438.4	438.9	440.5	441.7	442.8	443.8
38.90		429.4	433.6	436.0	438.4	438.9	440.6	441.7	442.8	443.8
39.30		429.4	433.7	436.0	438.5	439.0	440.6	441.8	442.8	443.8
39.50		429.5	433.7	436.1	438.5	439.1	440.7	441.8	442.9	443.8
39.66		429.5	433.8	436.1	438.6	439.1	440.7	441.8	442.9	443.9
39.85		429.6	433.8	436.1	438.6	439.1	440.7	441.8	442.9	443.9
40.04		429.6	433.8	436.2	438.6	439.1	440.7	441.8	442.9	443.9
40.40		429.7	433.9	436.2	438.7	439.2	440.8	441.9	442.9	443.9
40.80		429.7	434.0	436.3	438.8	439.3	440.8	441.9	442.9	443.9
41.40		429.9	434.1	436.4	438.9	439.4	440.9	441.9	443.0	443.9
41.80		429.9	434.1	436.5	438.9	439.5	441.0	442.0	443.0	443.9
42.30		430.0	434.2	436.5	439.0	439.5	441.1	442.0	443.0	444.0
42.70		430.1	434.3	436.6	439.1	439.6	441.1	442.1	443.1	444.0
43.04		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.17		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.19		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
43.19		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.19		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.20		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.20	PEARL	430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.30		430.2	434.4	436.7	439.2	439.7	441.2	442.1	443.1	444.0
43.50		430.3	434.5	436.8	439.3	439.8	441.3	442.2	443.1	444.0
44.00		430.4	434.6	436.9	439.4	439.9	441.4	442.2	443.2	444.1
44.50		430.5	434.7	437.1	439.5	440.0	441.5	442.3	443.3	444.2
45.00		430.6	434.8	437.2	439.6	440.1	441.6	442.4	443.4	444.3
45.40		430.7	434.9	437.3	439.7	440.2	441.6	442.5	443.5	444.3
45.90		430.8	435.0	437.4	439.8	440.3	441.7	442.6	443.5	444.4
46.10		430.8	435.1	437.5	439.8	440.3	441.8	442.6	443.6	444.4
46.30		430.9	435.1	437.5	439.9	440.4	441.8	442.7	443.6	444.4
46.80		431.0	435.2	437.7	440.0	440.5	441.9	442.8	443.7	444.5
47.30		431.1	435.4	437.8	440.1	440.6	442.0	442.9	443.8	444.6
47.60		431.2	435.4	437.9	440.1	440.7	442.1	442.9	443.8	444.6
47.80		431.2	435.5	438.0	440.2	440.7	442.1	443.0	443.9	444.6
48.30		431.3	435.6	438.1	440.3	440.8	442.2	443.1	443.9	444.7
48.75		431.4	435.7	438.2	440.4	440.9	442.3	443.1	444.0	444.8
49.00		431.5	435.8	438.3	440.4	441.0	442.4	443.2	444.1	444.8
49.29		431.5	435.8	438.4	440.5	441.0	442.4	443.2	444.1	444.9
49.70		431.6	435.9	438.5	440.6	441.1	442.5	443.3	444.2	444.9
50.05		431.7	436.0	438.6	440.6	441.2	442.6	443.4	444.2	445.0
50.30		431.8	436.1	438.6	440.7	441.3	442.6	443.4	444.3	445.0
50.80		431.9	436.2	438.8	440.8	441.4	442.7	443.5	444.3	445.1

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
51.30		432.0	436.3	438.9	440.9	441.5	442.8	443.6	444.4	445.1
51.60		432.0	436.4	439.0	441.0	441.5	442.9	443.7	444.5	445.2
52.16		432.2	436.5	439.1	441.1	441.7	443.0	443.8	444.6	445.3
52.60		432.3	436.6	439.3	441.2	441.8	443.1	443.9	444.6	445.3
53.13		432.4	436.7	439.4	441.3	441.9	443.2	444.0	444.7	445.4
53.60		432.5	436.8	439.5	441.4	442.0	443.3	444.0	444.8	445.5
54.10		432.6	437.0	439.7	441.5	442.1	443.4	444.1	444.9	445.5
54.60		432.7	437.1	439.8	441.6	442.2	443.5	444.2	445.0	445.6
55.10		432.8	437.2	440.0	441.7	442.3	443.6	444.3	445.1	445.7
55.50		432.9	437.3	440.1	441.8	442.4	443.7	444.4	445.1	445.7
55.90		433.0	437.4	440.2	441.9	442.5	443.8	444.5	445.2	445.8
55.96		433.0	437.4	440.2	441.9	442.5	443.8	444.5	445.2	445.8
55.96		433.0	437.4	440.2	441.9	442.5	443.8	444.5	445.2	445.8
55.97		433.0	437.4	440.2	441.9	442.5	443.8	444.5	445.2	445.8
55.97		433.0	437.4	440.2	441.9	442.5	443.8	444.5	445.2	445.8
56.00	FLORENCE	433.0	437.4	440.2	441.9	442.5	443.8	444.5	445.2	445.8
56.50		433.1	437.5	440.3	442.1	442.7	443.9	444.6	445.3	445.9
57.00		433.2	437.7	440.4	442.2	442.8	444.0	444.7	445.4	446.0
57.43		433.3	437.8	440.6	442.3	442.9	444.1	444.8	445.5	446.1
57.80		433.3	437.9	440.6	442.4	443.0	444.2	444.9	445.5	446.1
58.00		433.4	437.9	440.7	442.5	443.1	444.3	444.9	445.6	446.2
58.50		433.5	438.1	440.8	442.7	443.3	444.4	445.0	445.7	446.3
58.90		433.5	438.2	440.9	442.8	443.4	444.5	445.1	445.7	446.3
59.10		433.6	438.2	441.0	442.8	443.4	444.5	445.1	445.8	446.4
59.60		433.7	438.4	441.1	443.0	443.6	444.6	445.2	445.9	446.5

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
60.14		433.8	438.5	441.2	443.1	443.7	444.7	445.4	446.0	446.6
60.60		433.9	438.6	441.3	443.3	443.9	444.8	445.5	446.1	446.7
61.00		433.9	438.7	441.4	443.4	444.0	444.9	445.5	446.1	446.7
61.30	VALLEY CITY	434.0	438.8	441.5	443.5	444.1	445.0	445.6	446.2	446.8
61.40		434.0	438.8	441.5	443.5	444.1	445.0	445.6	446.2	446.8
61.40		434.0	438.8	441.5	443.5	444.1	445.0	445.6	446.2	446.8
61.40		434.0	438.8	441.5	443.5	444.1	445.0	445.6	446.2	446.8
61.40		434.0	438.8	441.5	443.5	444.1	445.0	445.6	446.2	446.8
61.42		434.0	438.8	441.5	443.5	444.1	445.0	445.6	446.2	446.8
61.80		434.1	438.9	441.6	443.6	444.2	445.1	445.7	446.3	446.9
62.30		434.2	439.0	441.7	443.8	444.3	445.3	445.8	446.4	447.0
62.80		434.3	439.1	441.8	443.9	444.5	445.4	446.0	446.5	447.1
63.00		434.4	439.1	441.9	443.9	444.5	445.4	446.0	446.6	447.2
63.30		434.4	439.2	442.0	444.0	444.6	445.5	446.1	446.7	447.2
63.50		434.5	439.2	442.0	444.1	444.6	445.6	446.1	446.7	447.3
64.00		434.6	439.3	442.1	444.2	444.8	445.7	446.3	446.8	447.4
64.50		434.7	439.4	442.2	444.3	444.9	445.8	446.4	446.9	447.5
65.00		434.8	439.5	442.4	444.5	445.0	445.9	446.5	447.1	447.6
65.50		434.9	439.6	442.5	444.6	445.1	446.1	446.6	447.2	447.7
66.00		435.0	439.7	442.6	444.7	445.2	446.2	446.7	447.3	447.8
66.60		435.1	439.9	442.7	444.9	445.4	446.3	446.9	447.4	448.0
66.61		435.1	439.9	442.7	444.9	445.4	446.3	446.9	447.4	448.0
67.00		435.2	439.9	442.8	445.0	445.5	446.4	447.0	447.5	448.1
67.20		435.2	440.0	442.9	445.1	445.5	446.5	447.0	447.6	448.1
67.80		435.4	440.1	443.0	445.2	445.7	446.6	447.2	447.7	448.2

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
68.20		435.5	440.2	443.1	445.3	445.8	446.7	447.3	447.8	448.3
68.70		435.6	440.3	443.2	445.4	445.9	446.9	447.4	447.9	448.4
69.20		435.7	440.4	443.3	445.6	446.0	447.0	447.5	448.0	448.5
69.70		435.8	440.5	443.4	445.7	446.1	447.1	447.6	448.1	448.7
70.00		435.8	440.5	443.5	445.8	446.2	447.2	447.7	448.2	448.7
70.20		435.9	440.6	443.6	445.8	446.3	447.2	447.8	448.3	448.8
70.60		436.0	440.7	443.7	445.9	446.4	447.3	447.9	448.4	448.9
70.80	MEREDOSIA	436.0	440.7	443.7	446.0	446.4	447.4	447.9	448.4	448.9
71.00		436.0	440.7	443.7	446.0	446.4	447.4	447.9	448.4	448.9
71.24		436.1	440.8	443.8	446.0	446.5	447.5	448.0	448.5	449.0
71.31		436.1	440.8	443.8	446.0	446.5	447.5	448.0	448.5	449.0
71.32		436.1	440.8	443.8	446.0	446.5	447.5	448.0	448.5	449.0
71.32		436.1	440.8	443.8	446.1	446.5	447.5	448.0	448.5	449.0
71.32		436.1	440.8	443.8	446.1	446.5	447.5	448.0	448.5	449.0
71.44		436.1	440.8	443.8	446.1	446.5	447.5	448.0	448.5	449.0
71.90		436.2	440.9	443.8	446.1	446.5	447.5	448.1	448.6	449.1
72.40		436.4	440.9	443.9	446.2	446.6	447.6	448.2	448.7	449.2
72.70		436.4	441.0	443.9	446.2	446.6	447.6	448.2	448.7	449.3
72.80		436.5	441.0	443.9	446.2	446.6	447.6	448.2	448.7	449.3
73.10		436.5	441.0	444.0	446.2	446.7	447.7	448.3	448.8	449.3
73.20		436.5	441.0	444.0	446.2	446.7	447.7	448.3	448.8	449.4
73.70		436.7	441.1	444.0	446.3	446.7	447.7	448.4	448.9	449.5
74.20		436.8	441.2	444.1	446.3	446.8	447.8	448.5	449.0	449.6
74.70		436.9	441.2	444.2	446.4	446.9	447.9	448.6	449.1	449.7
75.00		436.9	441.3	444.2	446.4	446.9	447.9	448.6	449.1	449.7

TABLE D-31 CONTINUED TABULAR RESULTS ILLINOIS RIVER FREQUENCY

RIVER MILE	STATION NAME	50.0%	20.0%	10.0%	5.0%	4.0%	2.0%	1.0%	0.5%	0.2%
75.50		437.1	441.4	444.3	446.5	447.0	448.0	448.7	449.2	449.8
76.00		437.2	441.4	444.3	446.5	447.0	448.0	448.8	449.3	449.9
76.50		437.3	441.5	444.4	446.6	447.1	448.1	448.9	449.4	450.0
77.00		437.4	441.6	444.4	446.6	447.1	448.1	449.0	449.5	450.1
77.50		437.5	441.6	444.5	446.6	447.2	448.2	449.1	449.6	450.2
78.00		437.6	441.7	444.6	446.7	447.3	448.3	449.1	449.6	450.3
78.50		437.7	441.8	444.6	446.7	447.3	448.3	449.2	449.7	450.4
79.00		437.9	441.8	444.7	446.8	447.4	448.4	449.3	449.8	450.5
79.30		437.9	441.9	444.7	446.8	447.4	448.4	449.4	449.9	450.5
79.50		438.0	441.9	444.7	446.8	447.4	448.4	449.4	449.9	450.6
80.10		438.1	442.0	444.8	446.9	447.5	448.5	449.5	450.0	450.7

FLOOD FREQUENCY PROFILES COMPARED TO HISTORICAL EVENTS

The 10%, 2%, 1% and .2% frequency flood events were compared to recent flood events. The Mississippi and the Illinois Rivers frequency flood events were compared to the 1993 and 1995 observed profiles. The 1993 flood event is the largest regulated flood event on record and the 1995 flood event was a major flood event on the Ohio River for the Mississippi River and the Illinois River. They are shown in Plates D-33 through D-40.

EXISTING AND ADOPTED STAGE FREQUENCY CURVES COMPARISON

The comparisons of the stage frequency results at the gages are shown on Table D-32. This table compares the current St. Louis District existing stage-frequency relationship to the stage-frequency values from this study.

The comparison of the current and adopted 1 % exceedance frequency profile shows differences between the two profiles. The current Mississippi profiles were created using a physical model created by Waterway Experimental Station using the Mississippi Basin Model Study (MBMS) and adopted in November 1979. These Mississippi profiles were developed before computer modeling of this river system was developed or applied. The current Illinois Profiles were developed using a coincident stage frequency analysis and adopted in May 1981.

The differences between the two profiles for the Mississippi River are discussed in this paragraph. The new frequency discharges are different than the current frequency discharges for the Mississippi River. The 1% exceedance frequency discharge from the Ohio River to the Illinois River on the Mississippi River has decreased from the current frequency discharge. The 1% exceedance frequency discharge from the Illinois River upstream to L&D 22 on the Mississippi River has increased when compared to the current frequency discharge value. These changes in discharge values were the results of the extension of the known period of record, ungaged discharges from historical floods were not used, and a regional negative skew in the statistical analysis. The lower Middle Mississippi River frequency profiles from Thebes, IL to the Ohio River were developed using a stage frequency analysis in the new profiles as compared to assigning a stage at the Ohio River with a constant flow in the steady state analysis for the MBMS analysis. Miller City/Len Small Levee Districts (Mississippi River RM 21-39) were modeled to their current higher levee elevations. The Kaskaskia Island Levee District (Mississippi River RM 112-115) was raised. The Ste. Genevieve Urban Levee (Mississippi River RM 122.5-125) was constructed. The Prarie Du Roche levee (Mississippi River RM 118-130) was raised. The St. Peters Urban Levee (Mississippi River RM 229.8-230.5) was constructed. The L-15 Levee on the Missouri River was raised to a 5 % exceedance frequency which will effect the flows in the cross over area. Lock and Dam 26 (RM 202.9) was removed and Melvin Price Lock and Dam (RM 201.1) was constructed. Floods exceeded the 1 % chance exceedance frequency (1993 and 1995) that gave direction to the shape of the adopted profiles. High water marks of these events were used to their fullest to check and verify the adopted profiles.

The differences between the 1 % exceedance frequency profiles for the Illinois River are not significant. The new profile had a longer period of record to develop a better estimate of the stage frequency relationship.

TABLE D-32 EXISTING VS. ADOPTED STAGE-FREQUENCY AT STREAM GAGES

PERCENT	LOUISIANA GAGE		GRAFTON GAGE		ST. LOUIS GAGE	
CHANCE	EXISTING	ADOPTED	EXISTING	ADOPTED	EXISTING	ADOPTED
EXCEEDANCE	ELEVATION	ELEVATION	ELEVATION	ELEVATION	ELEVATION	ELEVATION
	FT (NGVD)	FT (NGVD)	FT (NGVD)	FT (NGVD)	FT (NGVD)	FT (NGVD)
20	455.5	456.2	427.3	429.5	413.4	415.7
10	457.4	458.2	430.2	431.3	416.9	418.4
2	460.5	461.9	437.4	436.7	424.3	424.0
1	462.4	463.2	440.7	439.0	427.0	426.0
0.2	465.0	466.0	445.3	443.0	430.8	430.5

TABLE D-32 (CONTINUED) EXISTING VS. ADOPTED STAGE-FREQUENCY AT STREAM GAGES

PERCENT	CHESTER GAGE		THEBES GAGE		MEREDOSIA GAGE	
CHANCE	EXISTING	ADOPTED	EXISTING	ADOPTED	EXISTING	ADOPTED
EXCEEDANCE	ELEVATION	ELEVATION	ELEVATION	ELEVATION	ELEVATION	ELEVATION
	FT (NGVD)	FT (NGVD)	FT (NGVD)	FT (NGVD)	FT (NGVD)	FT (NGVD)
20	376.1	377.7	338.3	338.4	439.7	440.7
10	379.3	380.8	340.8	340.4	442.6	443.7
2	386.6	387.1	345.2	344.2	446.0	447.4
1	389.5	389.0	346.7	345.4	446.8	447.9
0.2	391.0	392.2	350.3	348.2	448.6	448.9

RISK & UNCERTAININITY FOR THE 100-YEAR

The risk & uncertainty of the 1 percent flood profile is based on a number of variables. These variables can be classified into two categories, the uncertainty of the flow and the stage values. Uncertainty of flow is the function of the analytical tool selected for the analysis, the selected regional skew value for the shape of the frequency distribution, temperature and rainfall patterns. Uncertainty can also be injected into the flow value selected when the translation of the unregulated flow is changed to the regulated flow. Uncertainty in stages of the stream is also very prominent. Levee overtopping or failure, vegetation or Manning's "n", backwater condition, and water temperature are just a few factors that will influence the stage of an event. A separate report will address the risk and uncertainty analysis.

SUMMARY AND CONCLUSIONS

MAJOR FINDINGS OF STUDY

This study reflected the best frequency estimates for the Mississippi and Illinois Rivers to date The stage frequency profiles presented from this study reflected current knowledge of the river system. Reduction or increases of final stage frequency profiles are reflective of the basin current conditions and current hydrologic and hydraulic technology.

STUDY LIMITATIONS & RECOMMENDATIONS

Frequency analysis is dependable on the base data that is being used. Base data includes the discharges and stages at gages on the rivers, the H&H modeling tools and the statistical methods available. The length of the period of record of stream data is necessary to assure a better handle on the true frequency. This current analysis is the best analysis that can be performed at this time but acquisition of additional data in the future will require a new study to capture a better picture of the true frequency of the rivers.

GLOSSARY

Acre – foot	a measure of volume equal to an acre of land uniformly flooded to one foot in depth.
Channel slope	the change in elevation of the channel bottom divided by the distance between the measured elevations
Coefficient of variation	the standard deviation divided by the mean
Cubic-feet-per-second	(cfs) unit of flow
Discharge	the volume of water passing a location in the river per unit time (e.g., cubic feet per second).
Drainage area	the surface area of the watershed contributing runoff to a particular location on the river system.
Exceedance frequency	the exceedance probability multiplied by 100, sometimes interpreted as the number of exceedances per 100 years on the average (e.g. the 1% chance exceedance frequency flood is the 0.01 exceedance probability multiplied by 100)
Exceedance probability	the probability that the annual flood will be equaled or exceeded in a year (e.g., the 0.01 exceedance probability flood has a 1/100 chance of being equal or exceeded in any year)
Flood distribution	a function or graphical curve expressing the relationship between exceedance probability and annual maximum flow (e.g., the log-Pearson III distribution is typically used by federal agencies to represent the peak annual flood distribution)
Flood frequency curve	see flood distribution
Flood population	the true flood distribution describing the likely occurrence of annual floods. An idealization in that it is based on assumptions regarding the random occurrence of floods. The population can never be known, but estimates are made from the observed period of record.
Hydrograph	the variation of river discharge with time at a particular cross section, usually for some period corresponding to a flood event

Flood rank the position in an ordered list from largest to smallest of the observed annual maximum floods (e.g., the largest flood has rank equal to one, the smallest has rank equal to the number of observed floods).

Operating rule the procedures to be followed and/or actions to be taken by dam operators given both reservoir inflows and downstream flow conditions.

Plotting position an estimate obtained of flood exceedance probability from the observed record of annual maximum flow values independent of an assumed distribution. Various plotting position formulas exist for estimating plotting positions (e.g., Weibull annual maximum flood plotting position = flood rank/(number of observations + one))

Probability a number in the range 0 to 1 defining the likelihood of observing future values or magnitudes of a random variable (e.g., the probability of observing a head or a tail from flipping a coin is 0.5)

Quantile the probability distribution quantity corresponding to a particular exceedance probability (e.g., the 0.01 exceedance probability flood is 100000 cfs, where 100000 is the quantile)

Rating curve the relationship between discharge and river stage

Regulated flows river flows affected by the presence of reservoirs and operation of dam outlets (a significant portion of the study area observed period of record was influenced by reservoir regulation)

Regulated flood frequency curve see regulated flood distribution

Regulated flood distribution a flood distribution expressing the relationship between exceedance probability and regulated flows. Generally very non-linear and not describable by an analytic flood distribution, such as the log-Pearson III distribution.

Regulated vs unregulated relationship a relationship between the discharge that would occur without the influence of reservoirs to that occurring with present day reservoir operations.

River Basin (see watershed)

River cross section the area of river defined by the channel bottom, and possibly levees, at right angles to the flow

River main channel the portion of river cross-section carrying flow under normal circumstances.

River overbank the portion of the river cross section conveying additional flow to the main channel during flood periods

Sample estimate a quantity derived from the observed data used to approximate the unknown population value (e.g., sample mean, sample standard deviation, sample skew coefficient, sample flood distribution)

Sample mean an estimate of the central tendency of the data. the average (the sum of the observed values/number of observations)

Sample skew coefficient a measure of the asymmetry of the distribution, for the same mean and standard deviation, a positive value results in a greater 1% exceedance frequency flood than a negative value. The average of the cube deviations from the mean divided by the standard deviation cubed.

Sample standard deviation Both a measure of the range of the observed data and the width of the flood distribution the square root of the average of the sum of squared deviations from the mean of the observations..

Unregulated flows river flows unaffected by the influence of reservoir regulation (a major effort was undertaken by the Corps Districts to adjust the observed records for the influence of reservoir regulation)

Unsteady flow the variation of stream flow with time, a condition always present within a river (note that although flow within a river is always unsteady, the change is gradual enough to be considered approximately steady for analysis purposes).

Volume duration frequency curves curves a set of flood distribution for various annual maximum defined for different durations at a particular location (e.g., flood distributions estimated from the observed 1-day, 3-day, 7-day, 10-day and 30-day maximum flood volumes obtained from the period of record)

Watershed a closed boundary describing the land surface area contributing runoff to a particular location on a river

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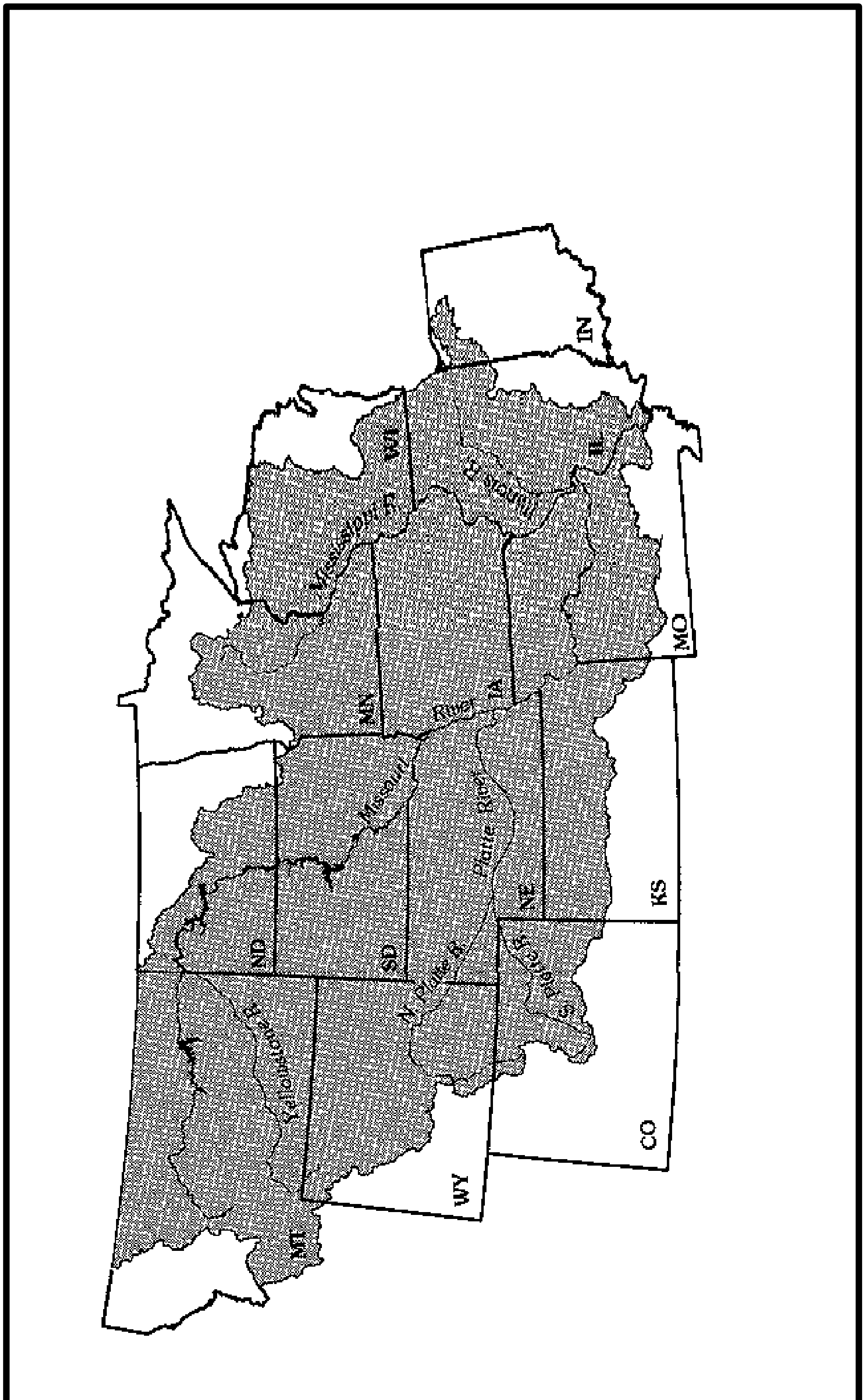
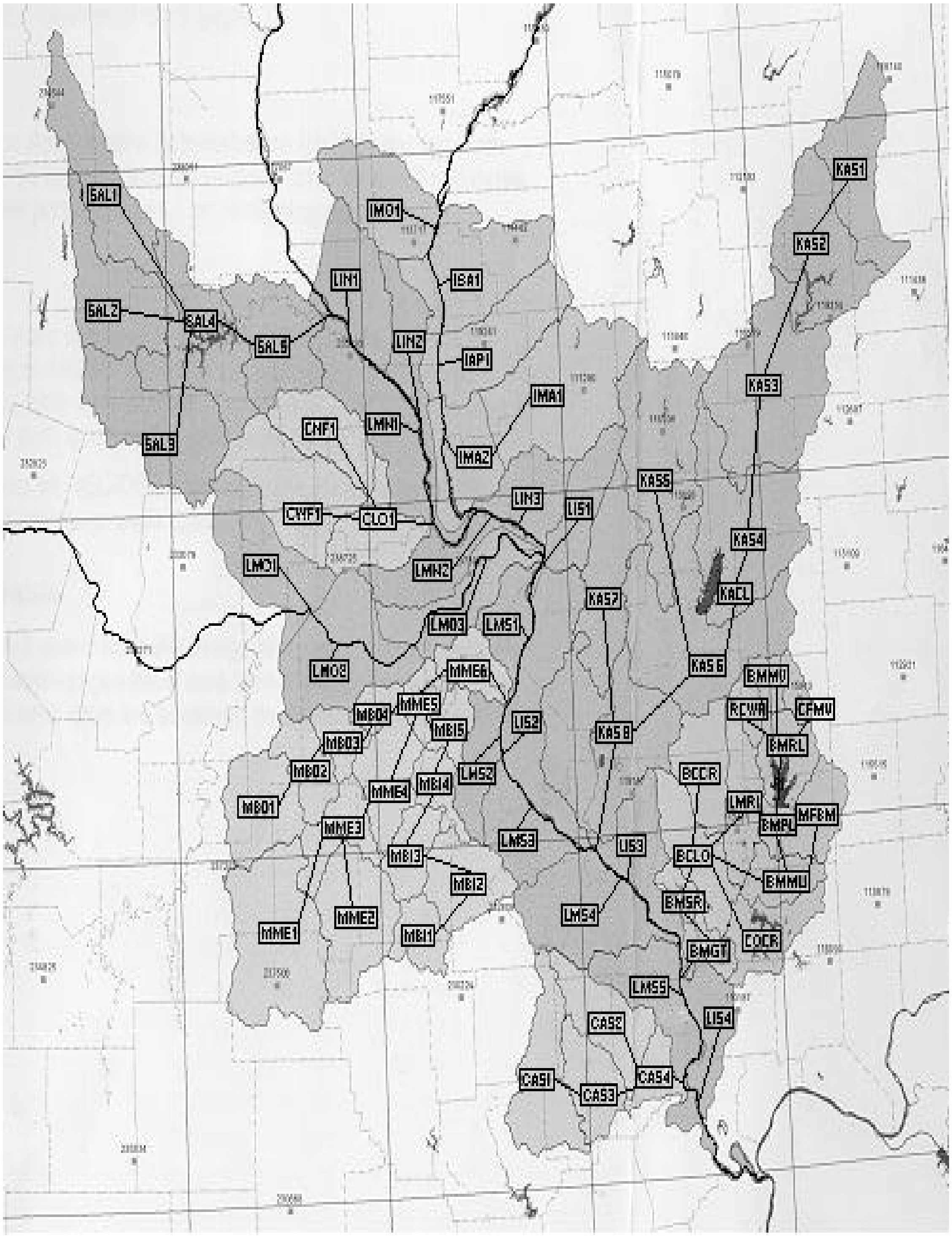


AREA MAP
PLATE D-1

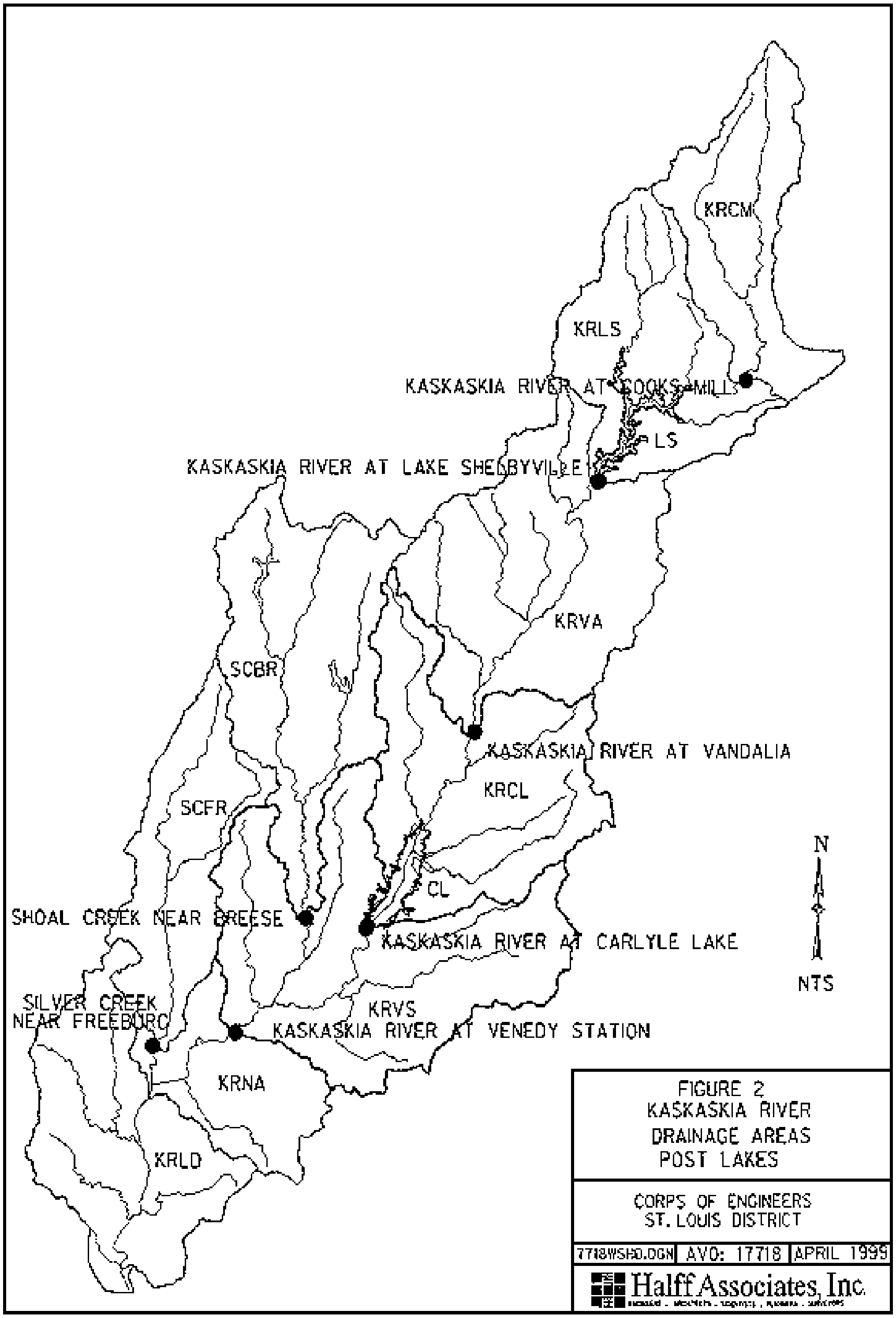
N:\Mark\DISTMAPT.DGN 02/27/01 12:52:59 PM

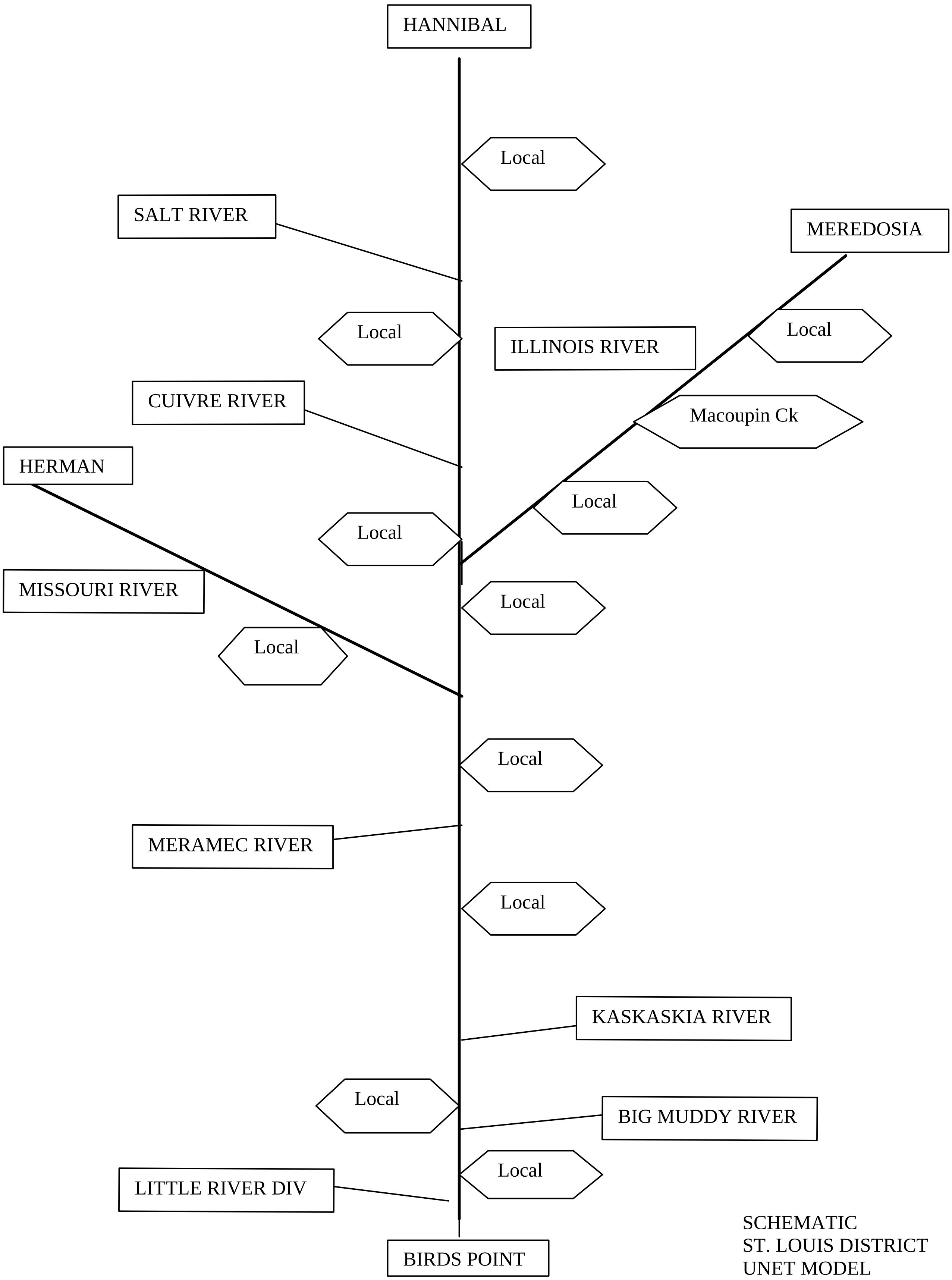
PLATE D-2



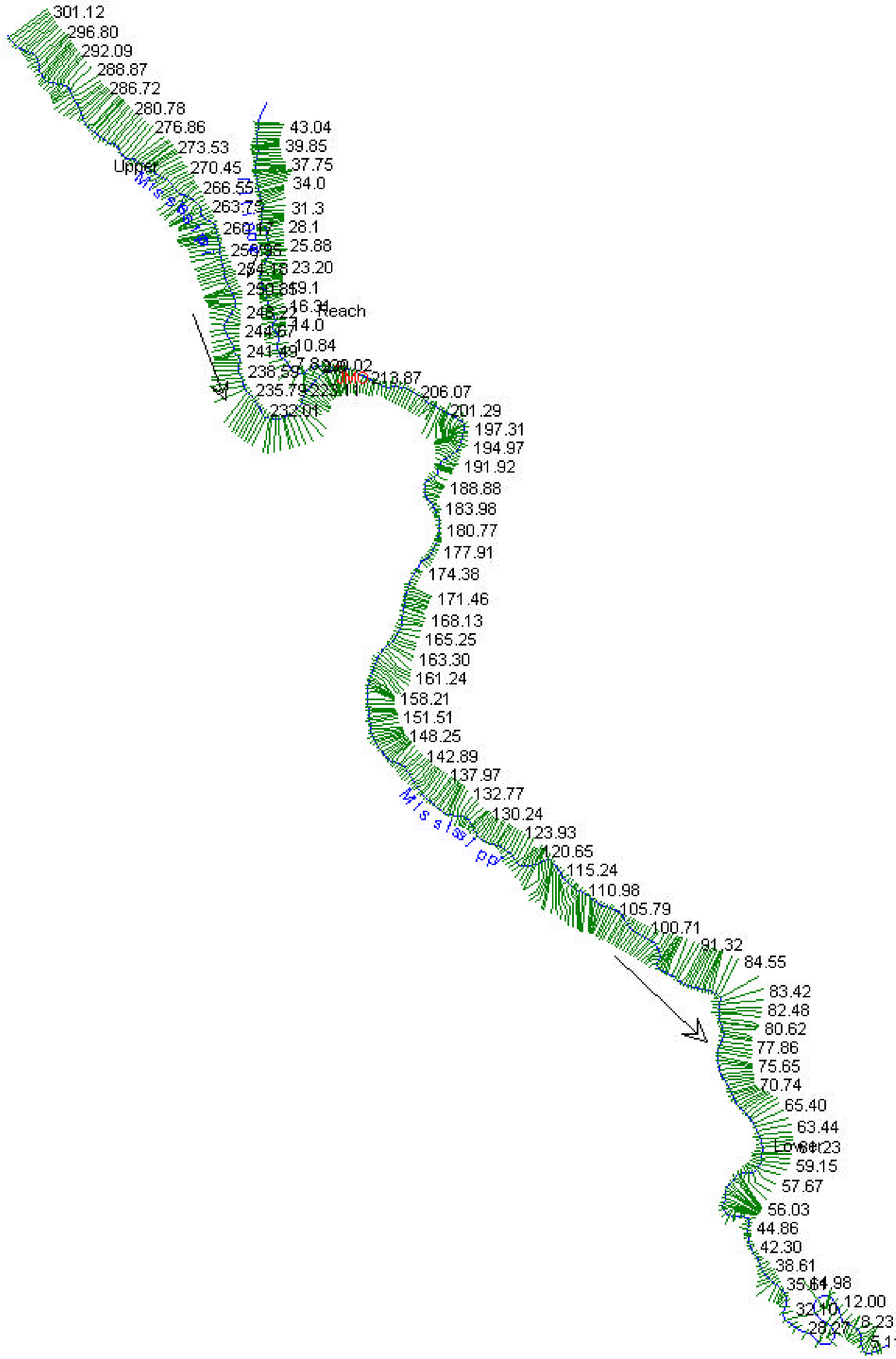
SAL1
SAL2
SAL4
SAL5
SAL3
IMO1
LIN1
ISA1
LIN2
IAP1
IMA1
CNF1
LMN1
IMA2
LIN3
LIS1
KAS1
KAS2
KAS3
KAS5
CWF1
CLO1
LMO1
LMN2
KAS4
KAS7
KACL
LMO3
LMS1
LMO2
MME6
KAS6
BMMU
MME5
MBO4
RCWR
CFMV
MBI5
LIS2
KAS8
BMRL
MBO3
MBO2
LMS2
BCCR
MBI4
MME4
LMRI
MBO1
MME3
BMPL
MFBM
LMS3
LIS3
BCLO
MBI3
BMMU
MBI2
BMSR
LMS4
MME1
MME2
MBI1
COCR
BMGT
LMS5
LIS4
CAS2
CAS1
CAS3
CAS4

PLATE D-3

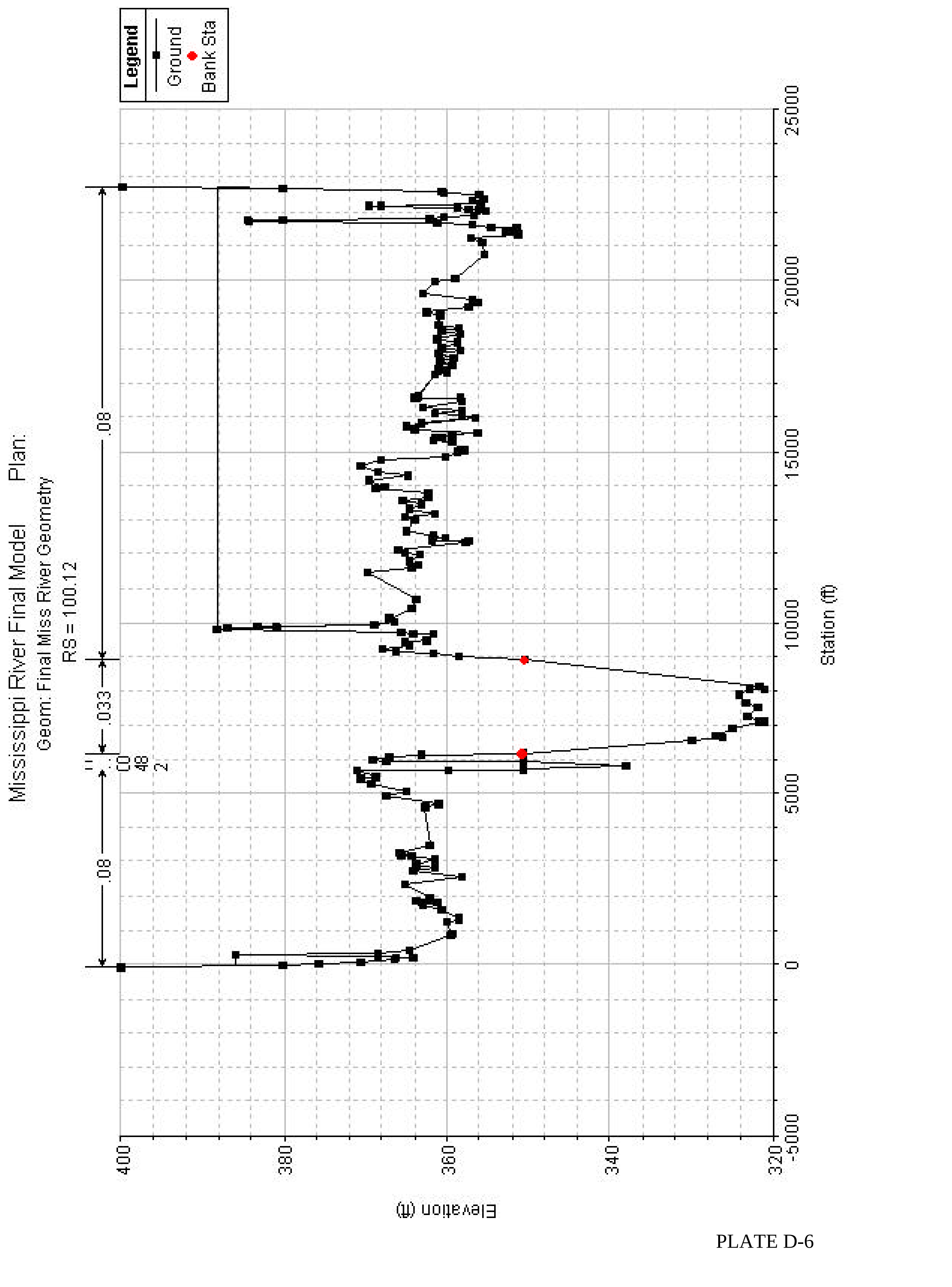

KRCM
KRLS
KASKASKIA RIVER AT COOKS MILLS
LS
KASKASKIA RIVER AT LAKE SHELBYVILLE
KRVA
SCBR
KASKASKIA RIVER AT VANDALIA
KRCL
SCFR
CL
SHOAL CREEK NEAR BREESE
KASKASKIA RIVER AT CARLYLE LAKE
SILVER CREEK
NEAR FREEBURG
KRVS
KASKASKIA RIVER AT VENEDY STATION
KRNA
KRLD
N
NTS
FIGURE 2
KASKASKIA RIVER
DRAINAGE AREAS
POST LAKES
CORPS OF ENGINEERS
ST. LOUIS DISTRICT
7718WSHD.DGN AVO: 17718 APRIL 1999
Halff Associates, Inc.



SCHEMATIC
ST. LOUIS DISTRICT
UNET MODEL
PLATE D-4

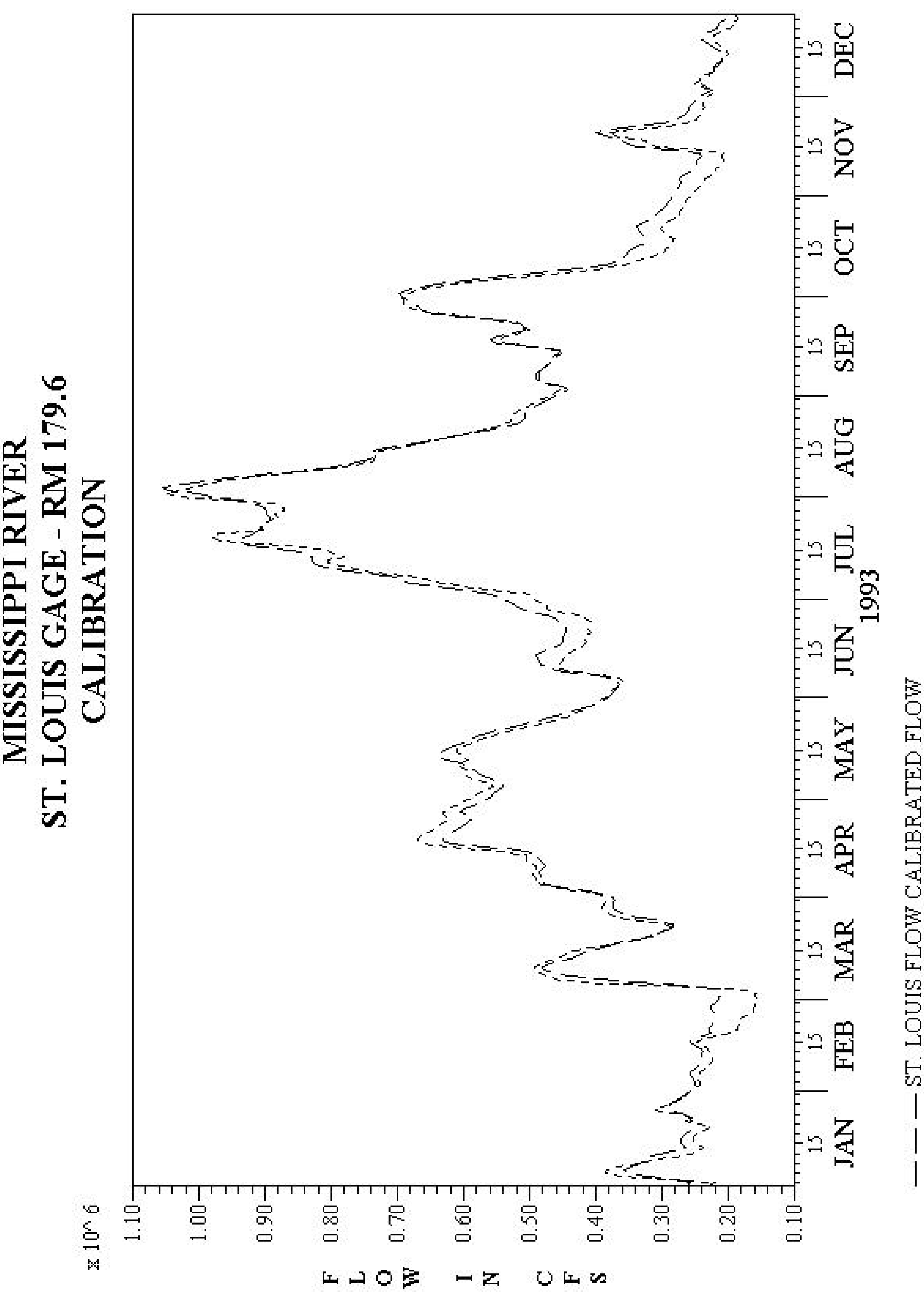


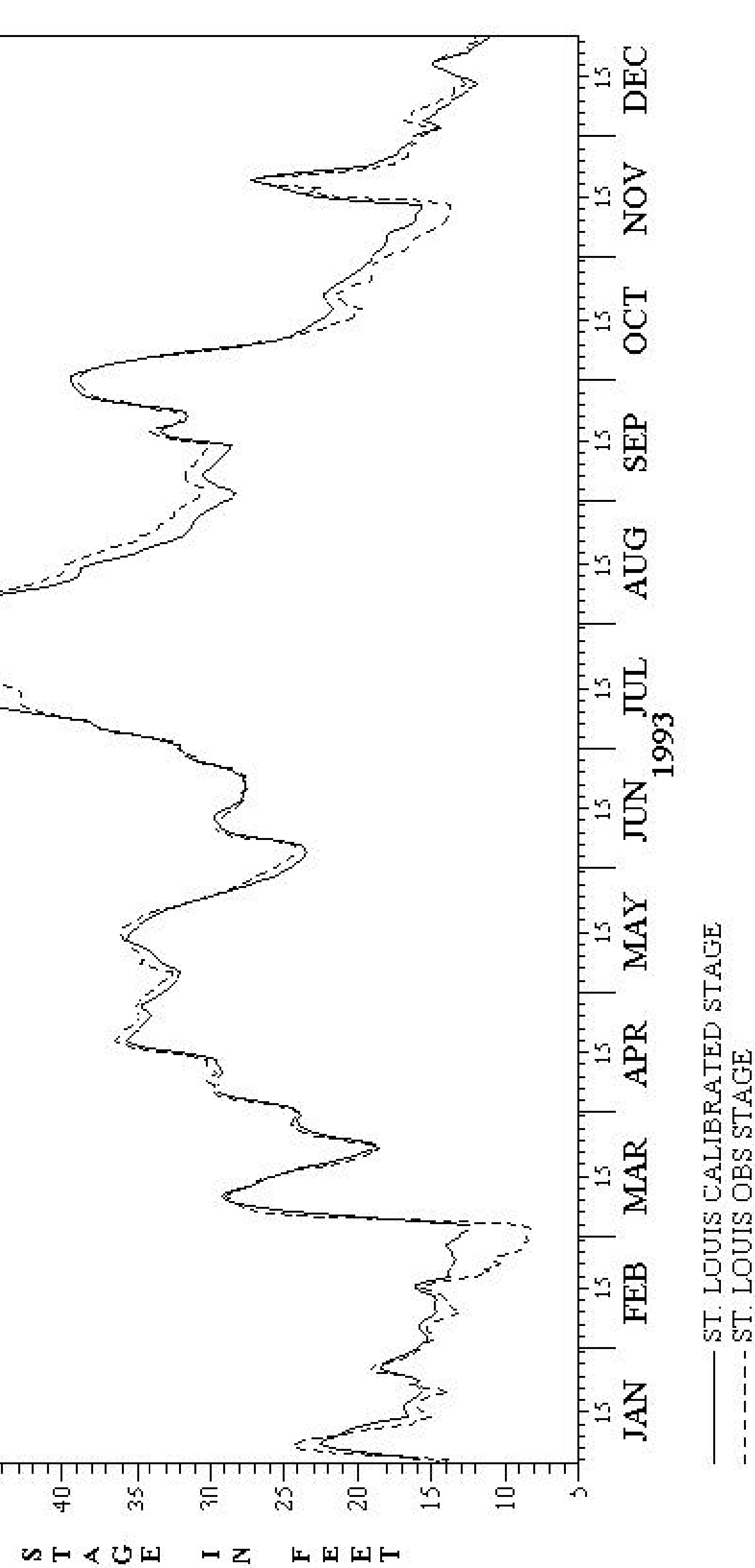
LOCATIONS OF UNET
CROSS SECTIONS
PLATE D-5



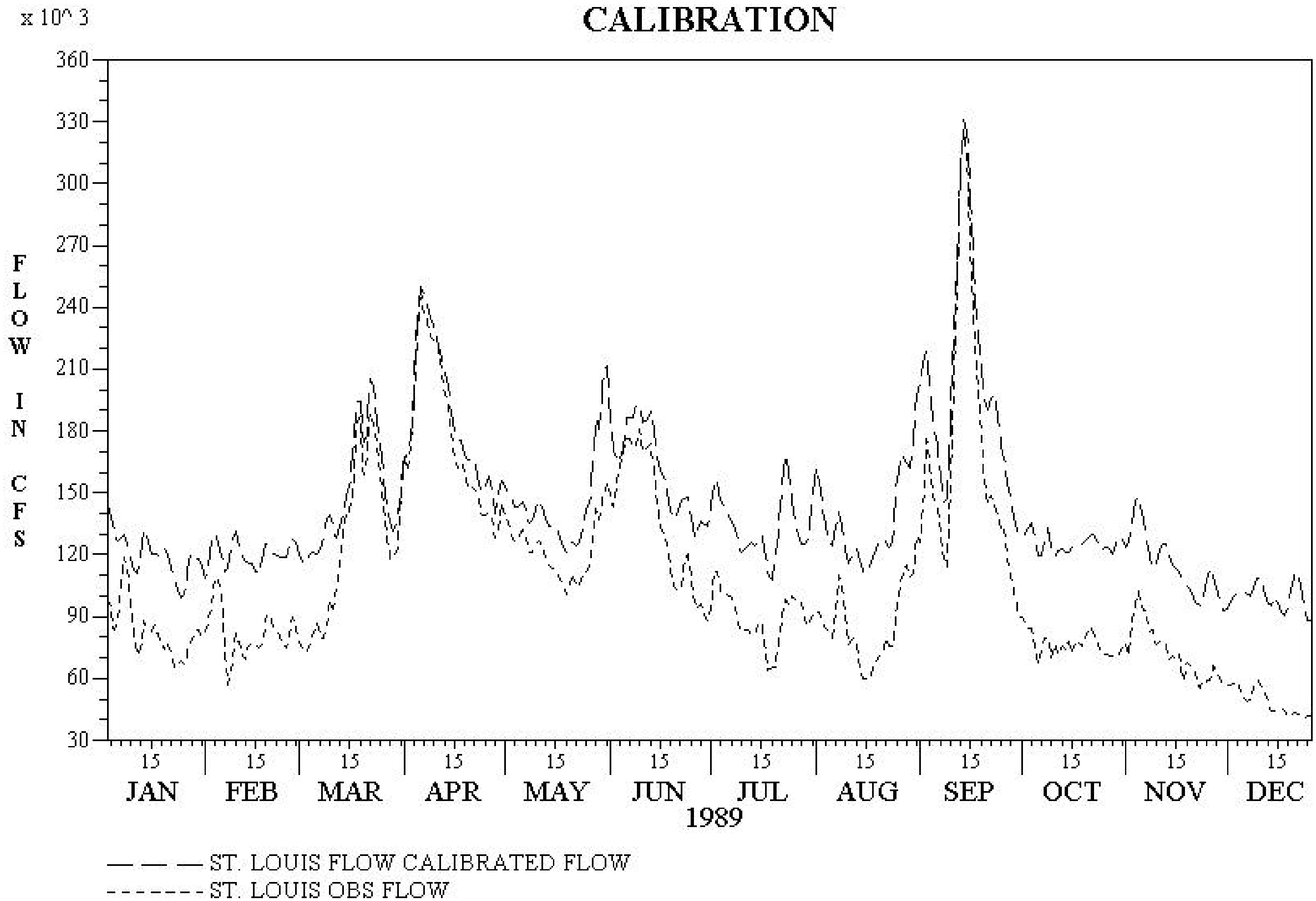
Mississippi River Final Model Plan:
Geom: Final Miss River Geometry
RS = 100.12
Legend
Ground
Bank Sta
.08
.033
.08
Elevation (ft)
Station (ft)
400
380
360
340
320
-5000
0
5000
10000
15000
20000
25000

PLATE D-6

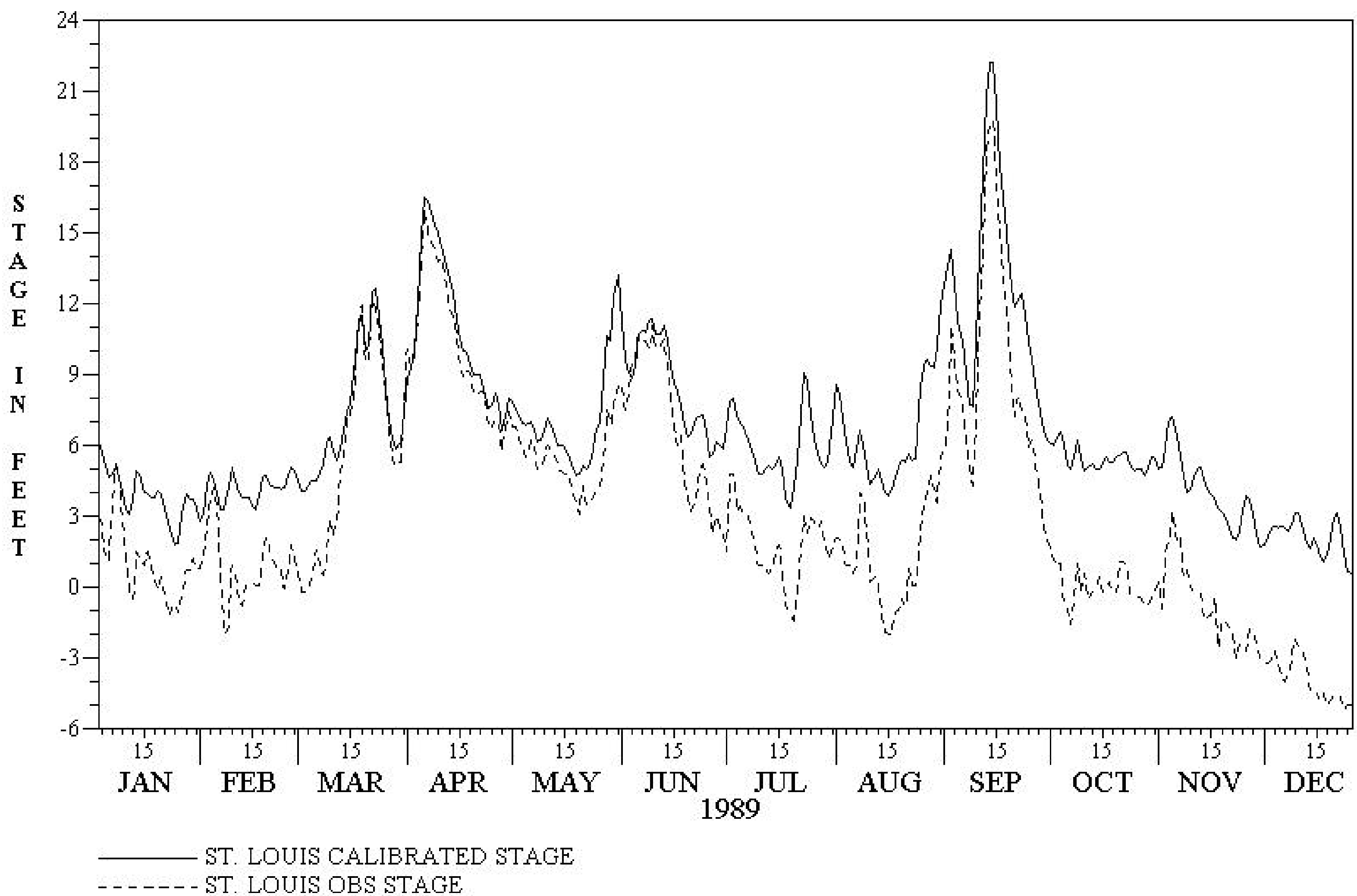

MISSISSIPPI RIVER
ST. LOUIS GAGE - RM 179.6
CALIBRATION
FLOW IN CFS
x 10^6
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1993
ST. LOUIS FLOW CALIBRATED FLOW
ST. LOUIS OBS FLOW

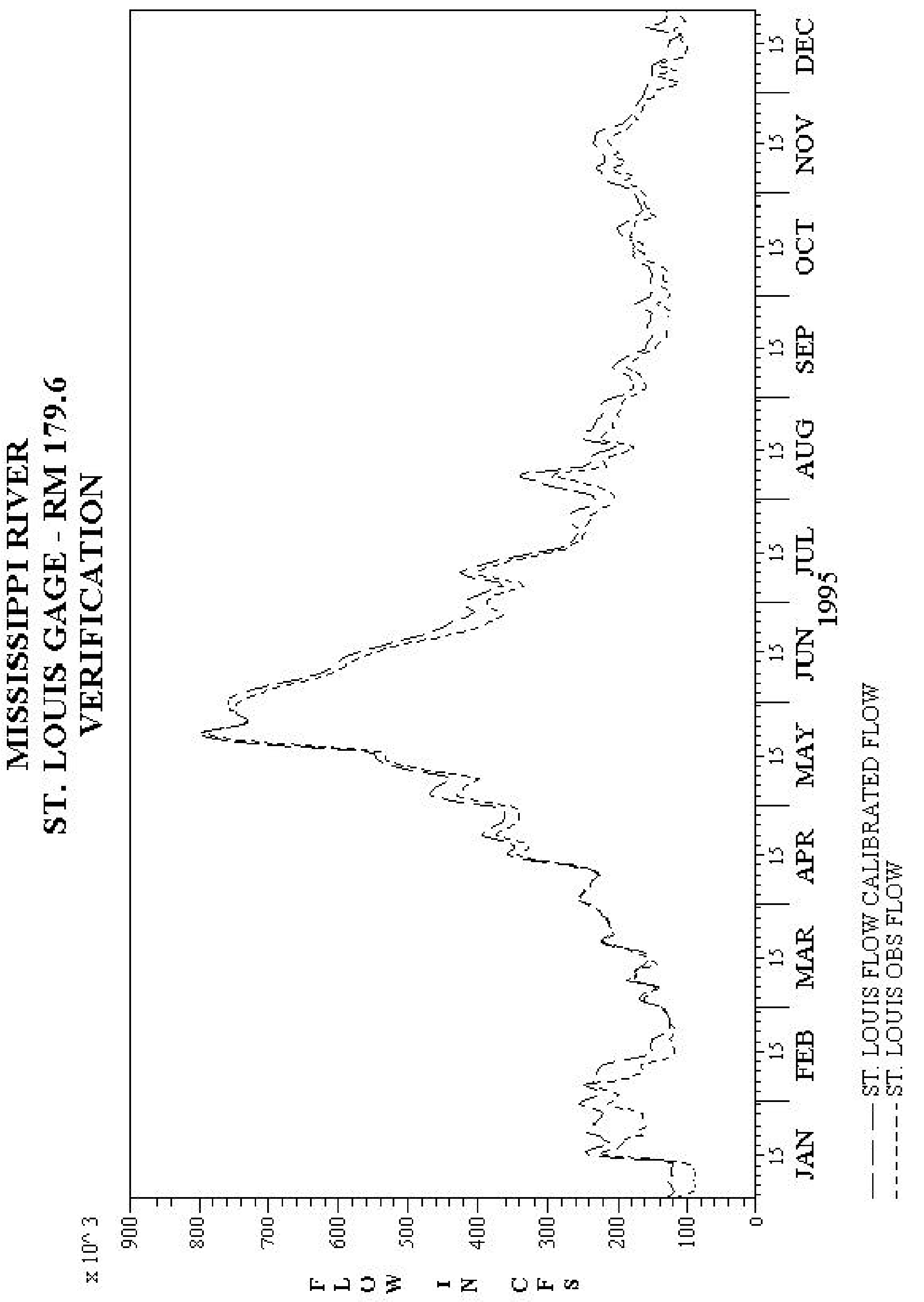

MISSISSIPPI
ST. LOUIS GAGE - RM 179.6
CALIBRATION
STAGE IN FEET
55
50
45
40
35
30
25
20
15
10
5
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
15
1993
ST. LOUIS CALIBRATED STAGE
ST. LOUIS OBS STAGE

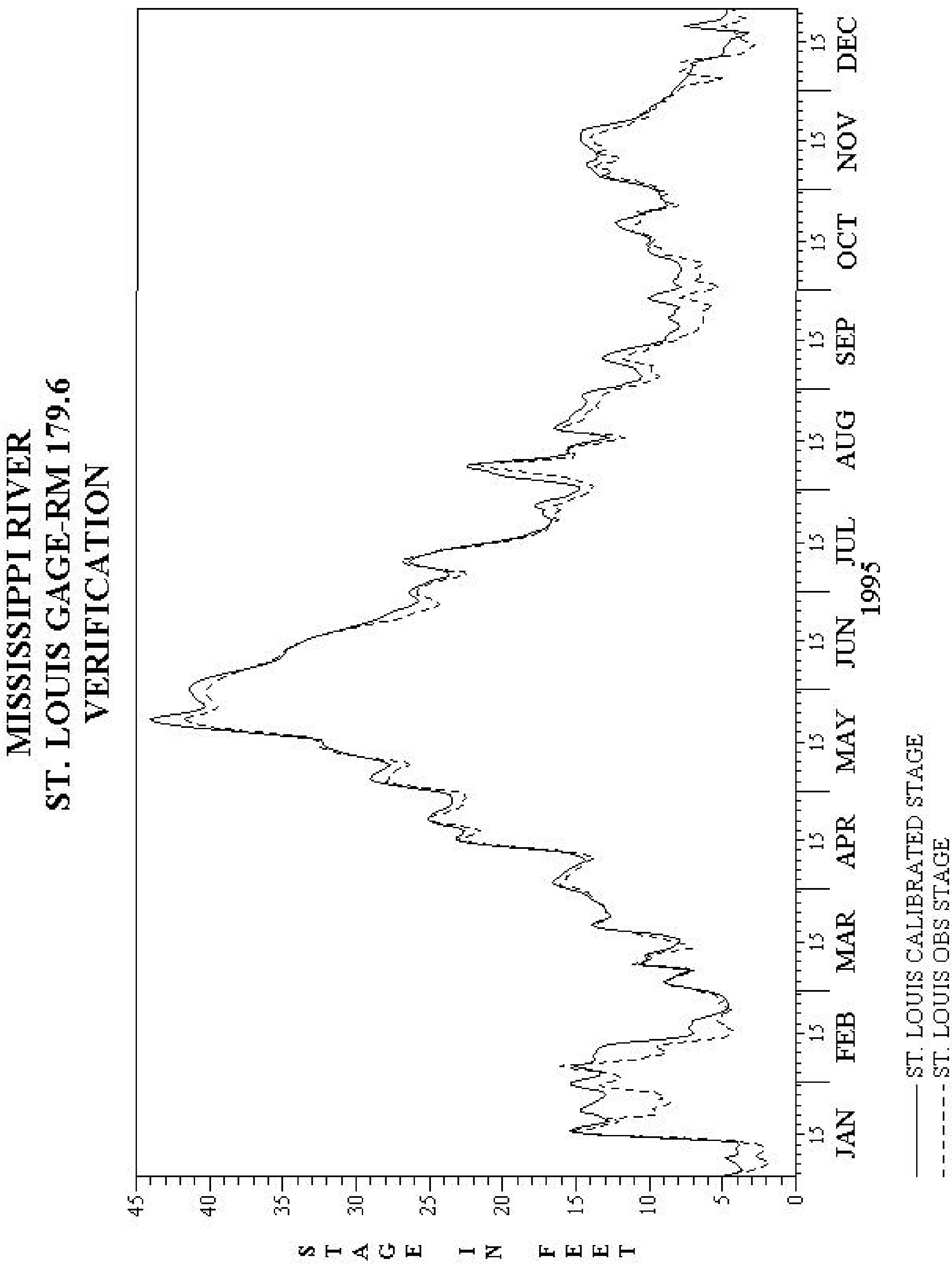
MISSISSIPPI RIVER
ST. LOUIS GAGE - RM 179.6
CALIBRATION

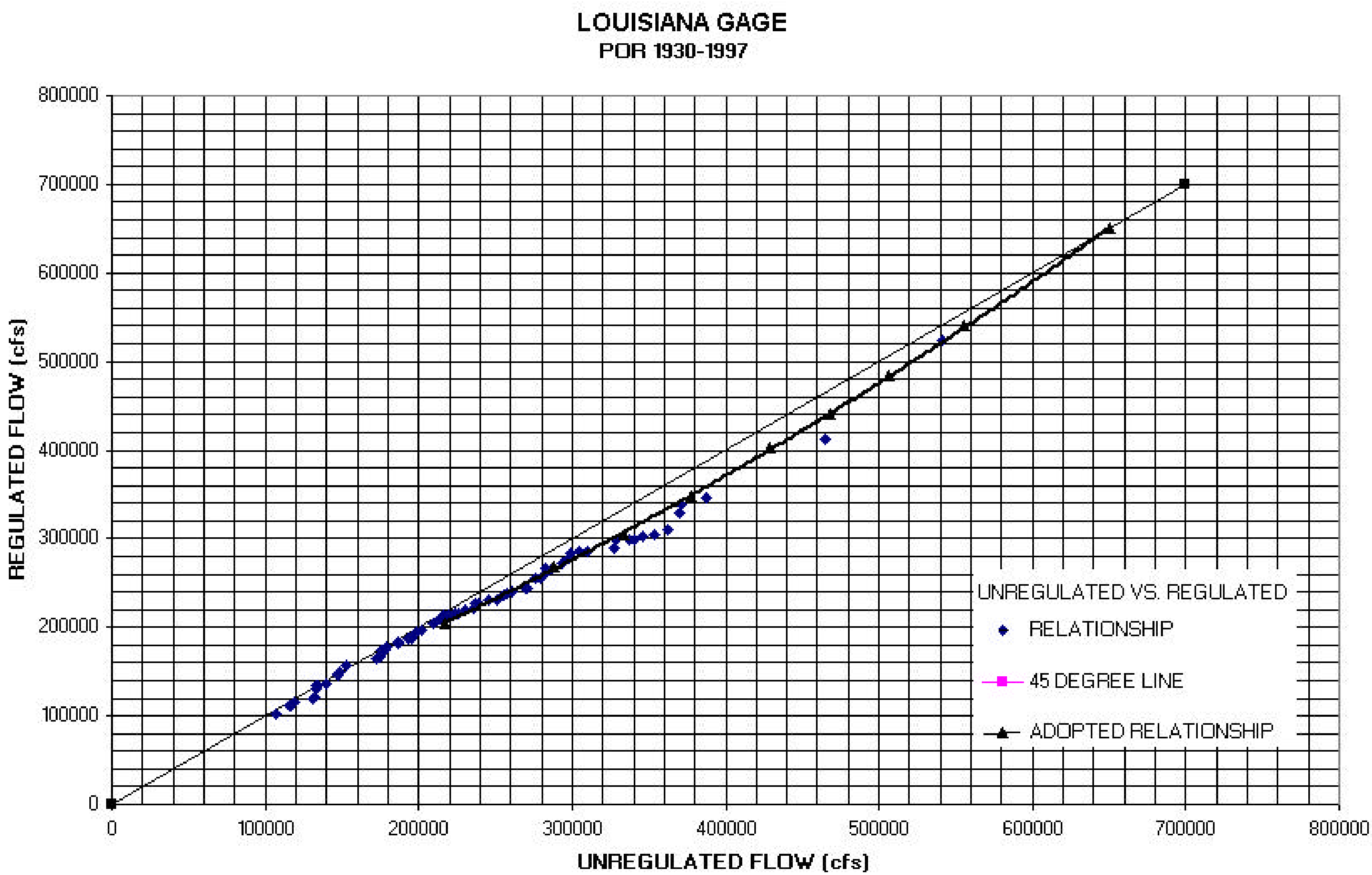


MISSISSIPPI RIVER
ST. LOUIS GAGE-RM 179.6
CALIBRATION




MISSISSIPPI RIVER
ST. LOUIS GAGE - RM 179.6
VERIFICATION
FLOW IN CFS
x 10^3
0
100
200
300
400
500
600
700
800
900
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
15
1995
ST. LOUIS FLOW CALIBRATED FLOW
ST. LOUIS OBS FLOW


MISSISSIPPI RIVER
ST. LOUIS GAGE-RM 179.6
VERIFICATION
STAGE IN FEET
0
5
10
15
20
25
30
35
40
45
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1995
ST. LOUIS CALIBRATED STAGE
ST. LOUIS OBS STAGE


LOUISIANA GAGE
POR 1930-1997
REGULATED FLOW (cfs)
UNREGULATED FLOW (cfs)
0
100000
200000
300000
400000
500000
600000
700000
800000
UNREGULATED VS. REGULATED
RELATIONSHIP
45 DEGREE LINE
ADOPTED RELATIONSHIP

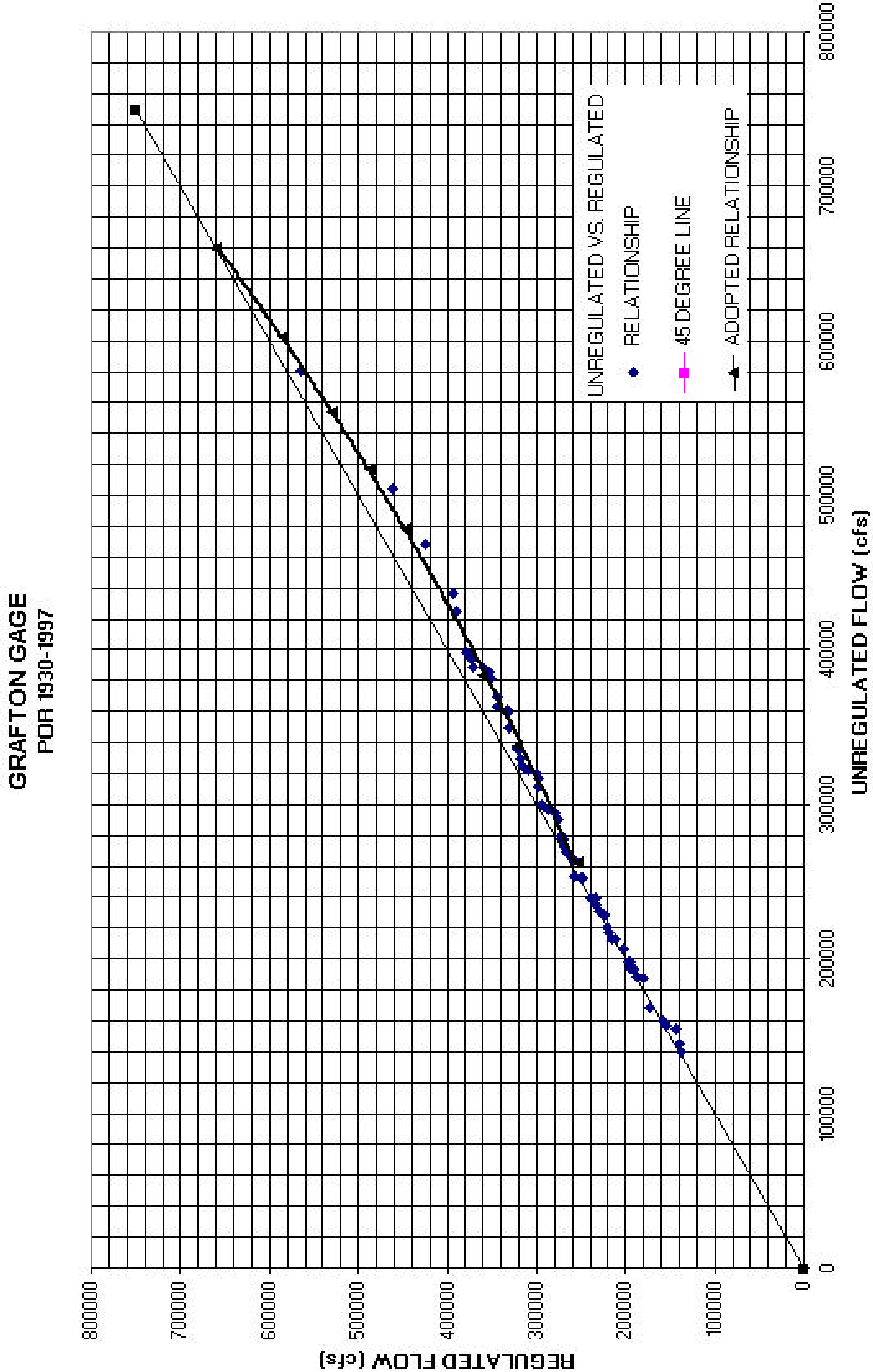

GRAFTON GAGE
POR 1930-1997
UNREGULATED VS. REGULATED
RELATIONSHIP
45 DEGREE LINE
ADOPTED RELATIONSHIP
REGULATED FLOW (cfs)
UNREGULATED FLOW (cfs)
0
100000
200000
300000
400000
500000
600000
700000
800000

PLATE D-11

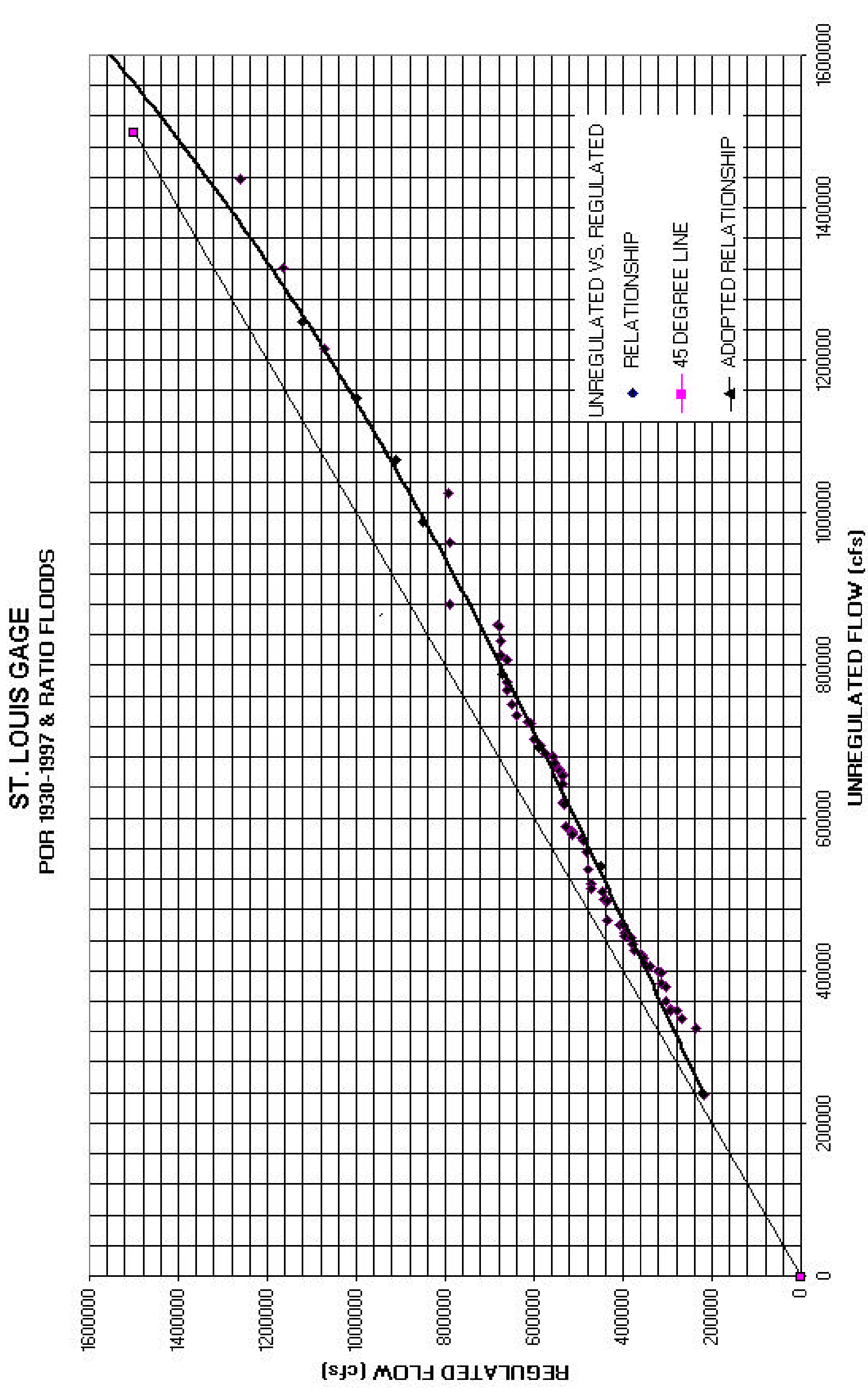

ST. LOUIS GAGE
POR 1930-1997 & RATIO FLOODS
UNREGULATED VS. REGULATED RELATIONSHIP
45 DEGREE LINE
ADOPTED RELATIONSHIP
REGULATED FLOW (cfs)
UNREGULATED FLOW (cfs)
0
200000
400000
600000
800000
1000000
1200000
1400000
1600000

PLATE D-12

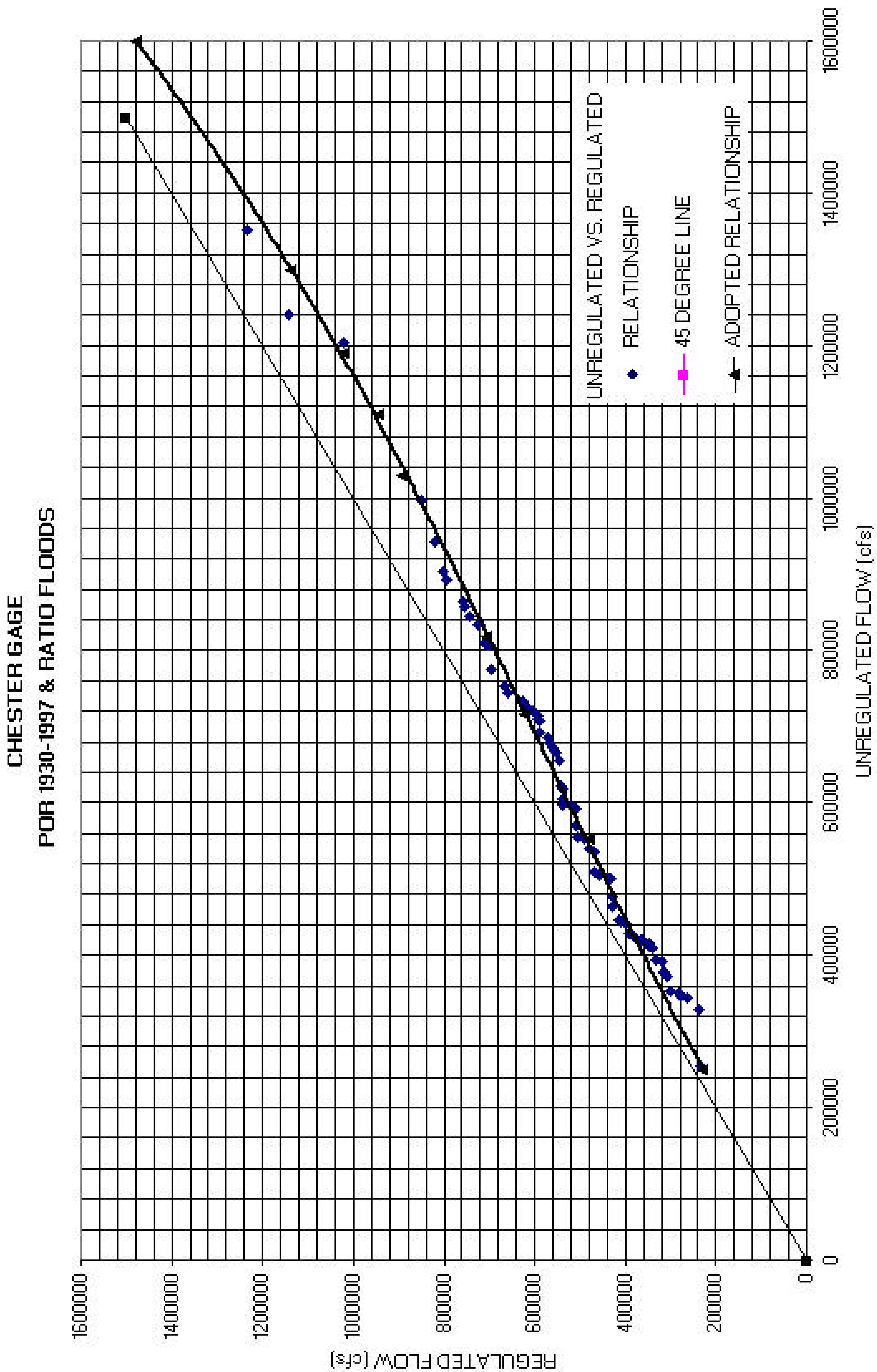
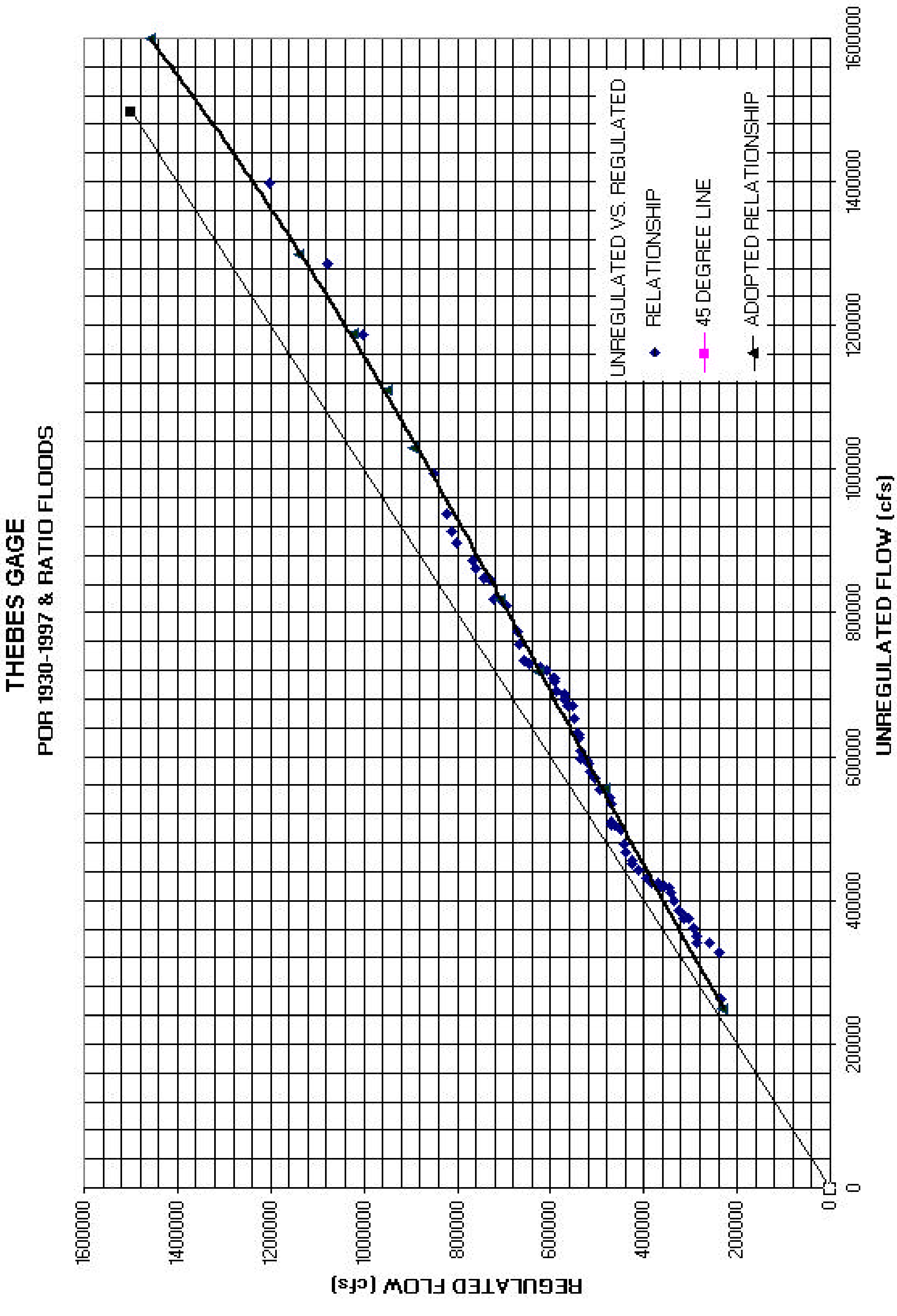
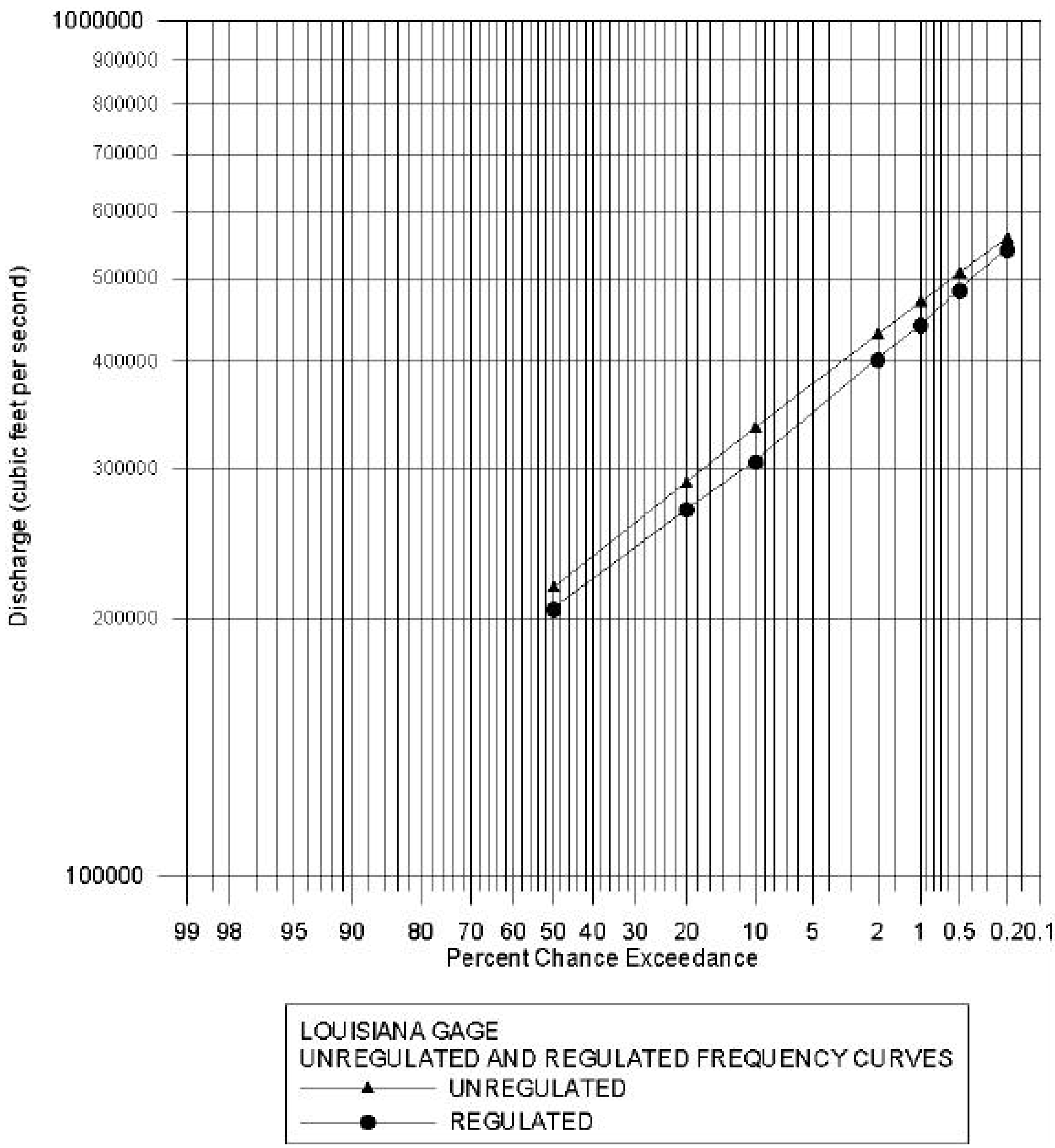
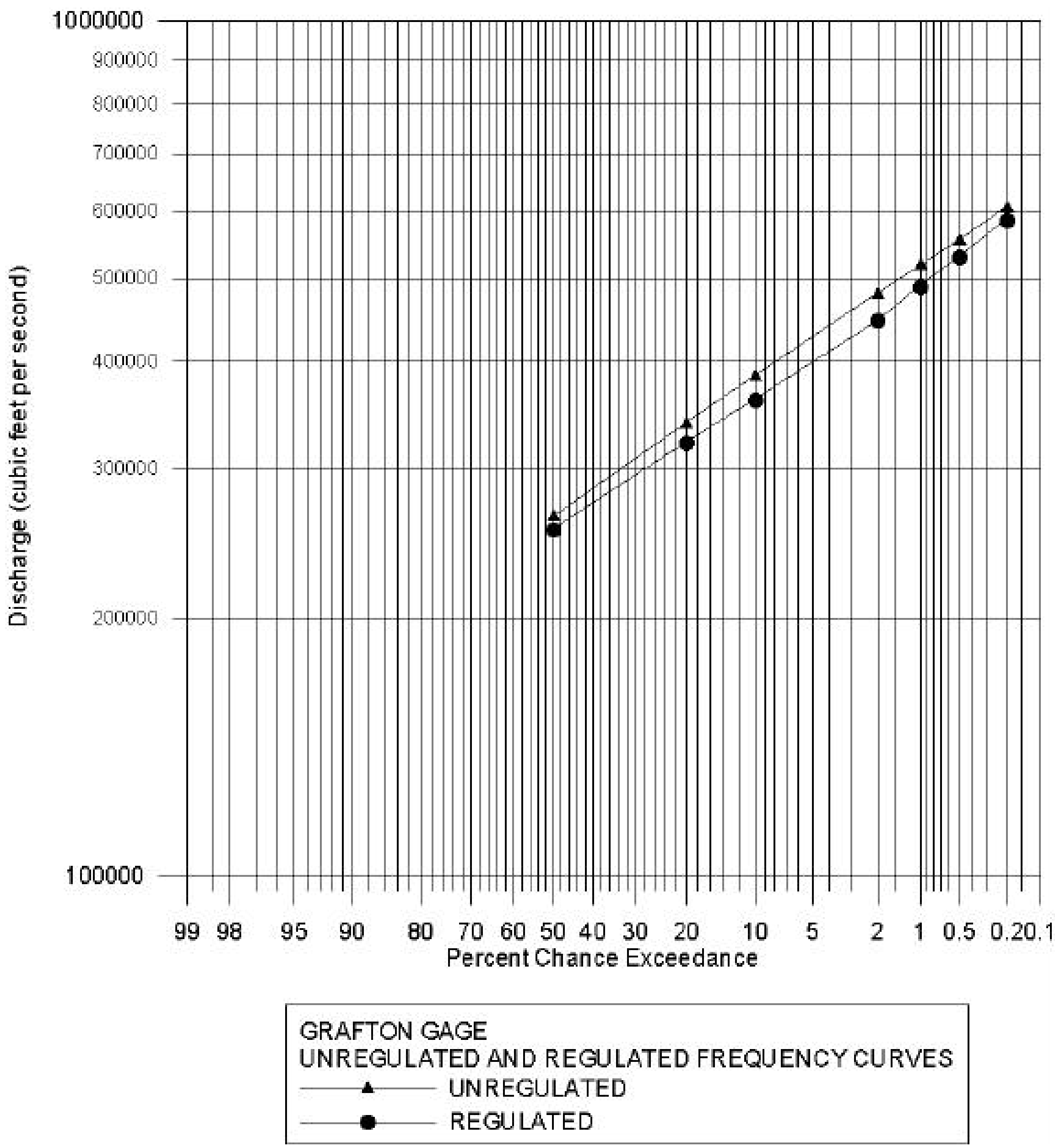

CHESTER GAGE
POR 1930-1997 & RATIO FLOODS
UNREGULATED VS. REGULATED
RELATIONSHIP
45 DEGREE LINE
ADOPTED RELATIONSHIP
UNREGULATED FLOW (cfs)
REGULATED FLOW (cfs)
0
200000
400000
600000
800000
1000000
1200000
1400000
1600000

PLATE D-13


THEBES GAGE
POR 1930-1997 & RATIO FLOODS
UNREGULATED VS. REGULATED RELATIONSHIP
45 DEGREE LINE
ADOPTED RELATIONSHIP
UNREGULATED FLOW (cfs)
REGULATED FLOW (cfs)
0
200000
400000
600000
800000
1000000
1200000
1400000
1600000


1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
Discharge (cubic feet per second)
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1
Percent Chance Exceedance
LOUISIANA GAGE
UNREGULATED AND REGULATED FREQUENCY CURVES
UNREGULATED
REGULATED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900000
800000
700000
600000
500000
400000
300000
200000
100000
Discharge (cubic feet per second)
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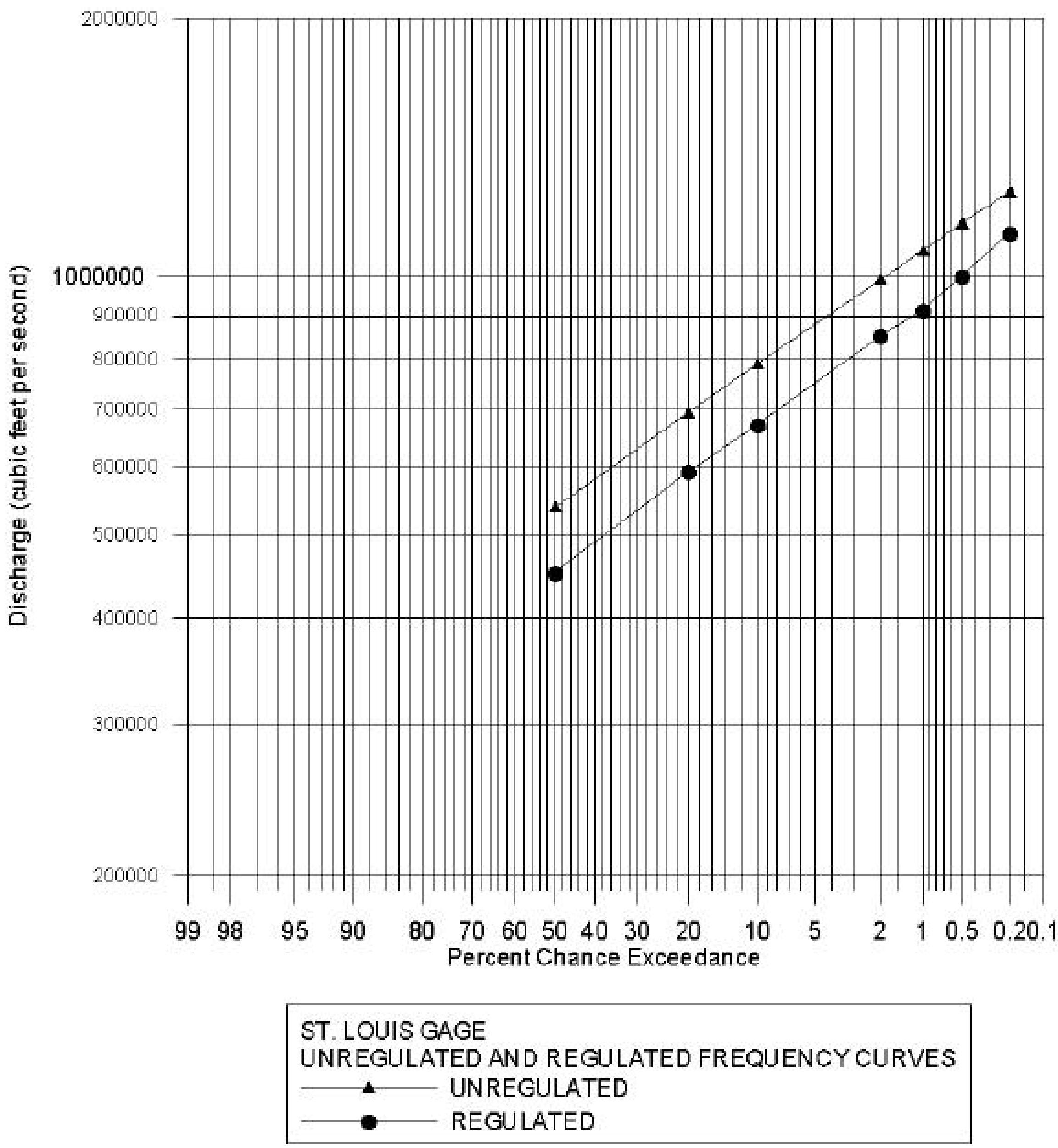
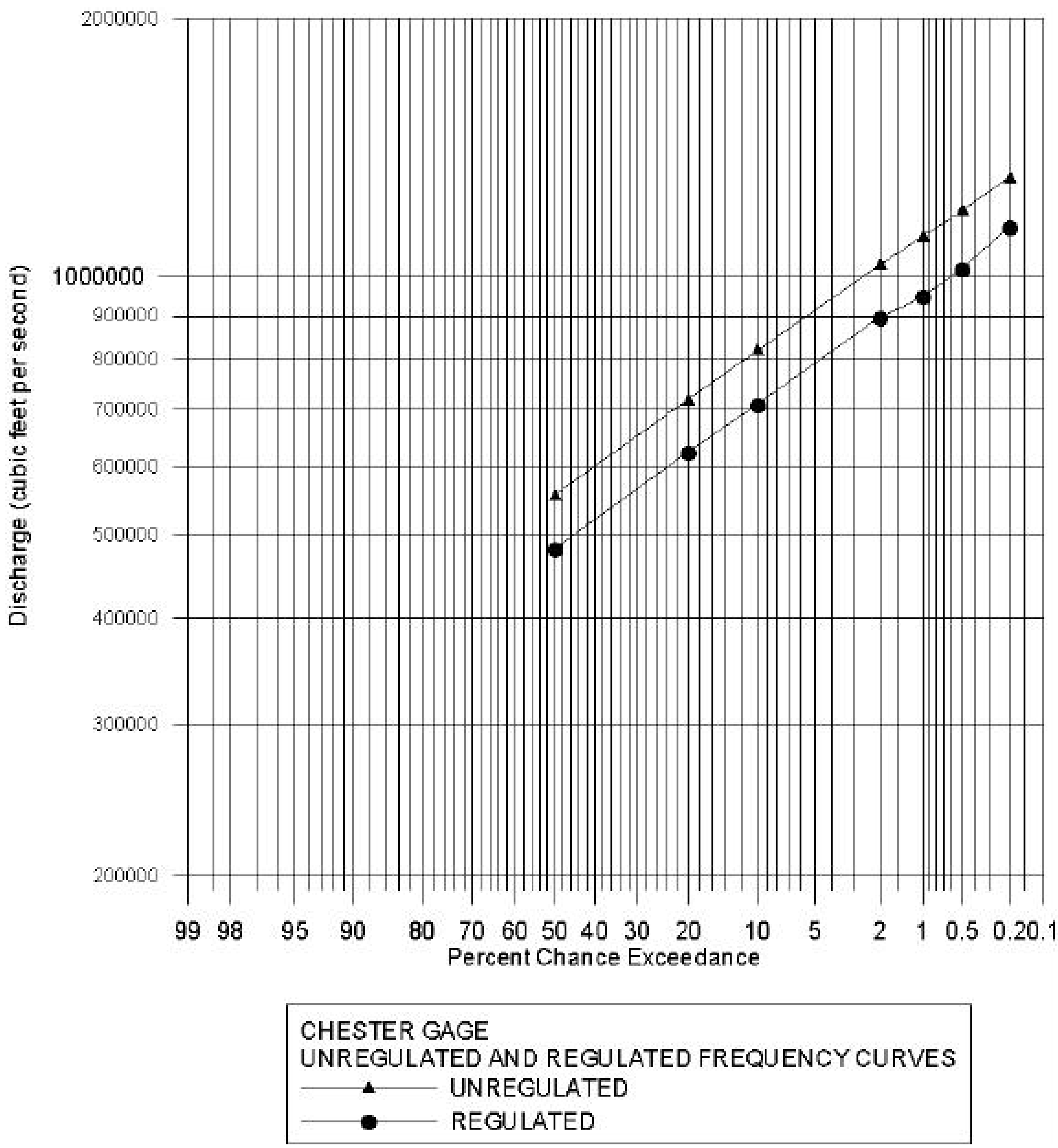
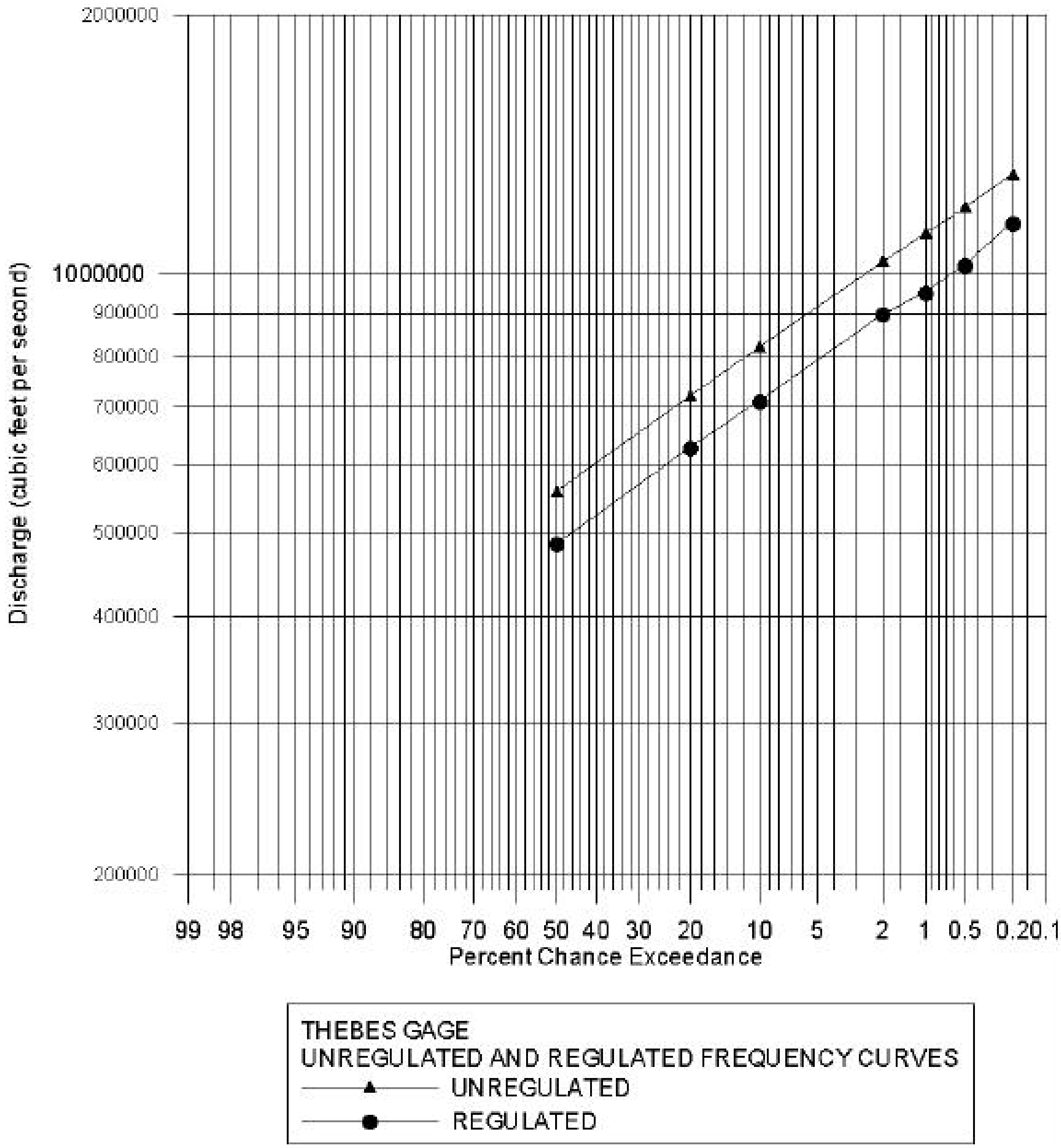
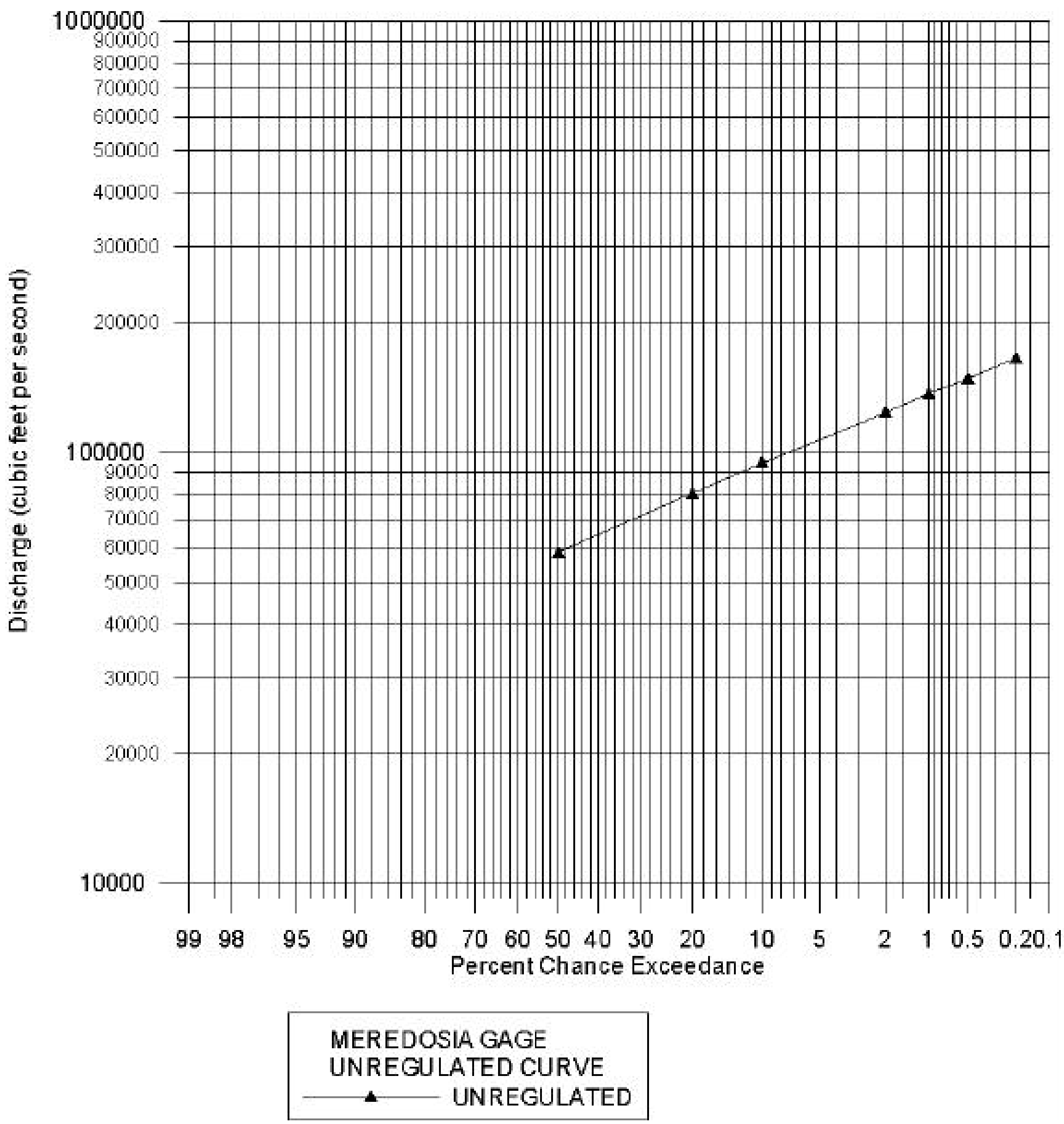
Percent Chance Exceedance
GRAFTON GAGE
UNREGULATED AND REGULATED FREQUENCY CURVES
UNREGULATED
REGULATED


2000000
1000000
900000
800000
700000
600000
500000
400000
300000
200000
Discharge (cubic feet per second)
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.20.1
Percent Chance Exceedance
ST. LOUIS GAGE
UNREGULATED AND REGULATED FREQUENCY CURVES
UNREGULATED
REGULATED


2000000
1000000
900000
800000
700000
600000
500000
400000
300000
200000
Discharge (cubic feet per second)
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1
Percent Chance Exceedance
CHESTER GAGE
UNREGULATED AND REGULATED FREQUENCY CURVES
UNREGULATED
REGULATED


2000000
1000000
900000
800000
700000
600000
500000
400000
300000
200000
Discharge (cubic feet per second)
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1
Percent Chance Exceedance
THEBES GAGE
UNREGULATED AND REGULATED FREQUENCY CURVES
UNREGULATED
REGULATED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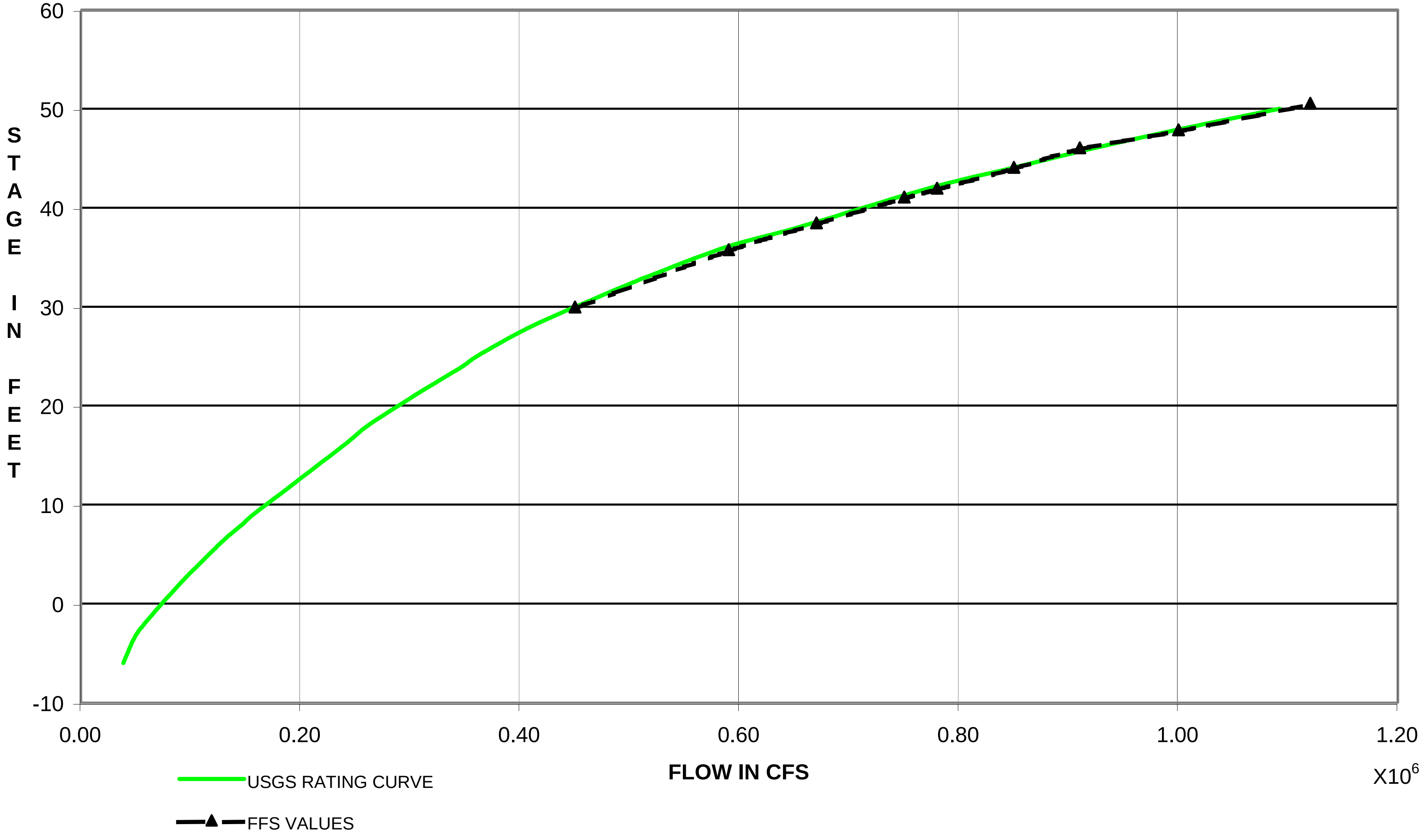
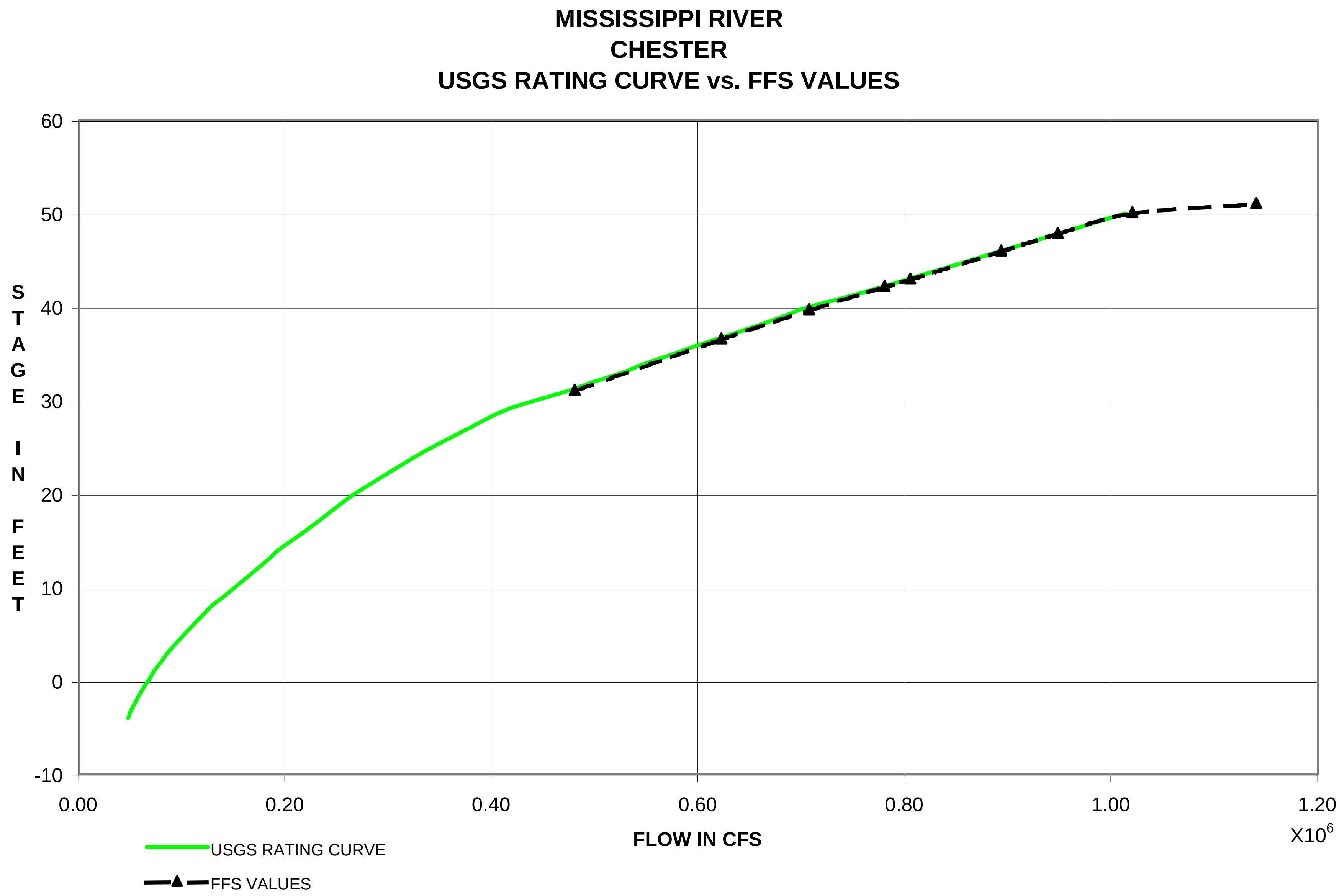
900000
800000
700000
600000
500000
400000
300000
200000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
Discharge (cubic feet per second)
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1
Percent Chance Exceedance
MEREDOSIA GAGE
UNREGULATED CURVE
UNREGULATED

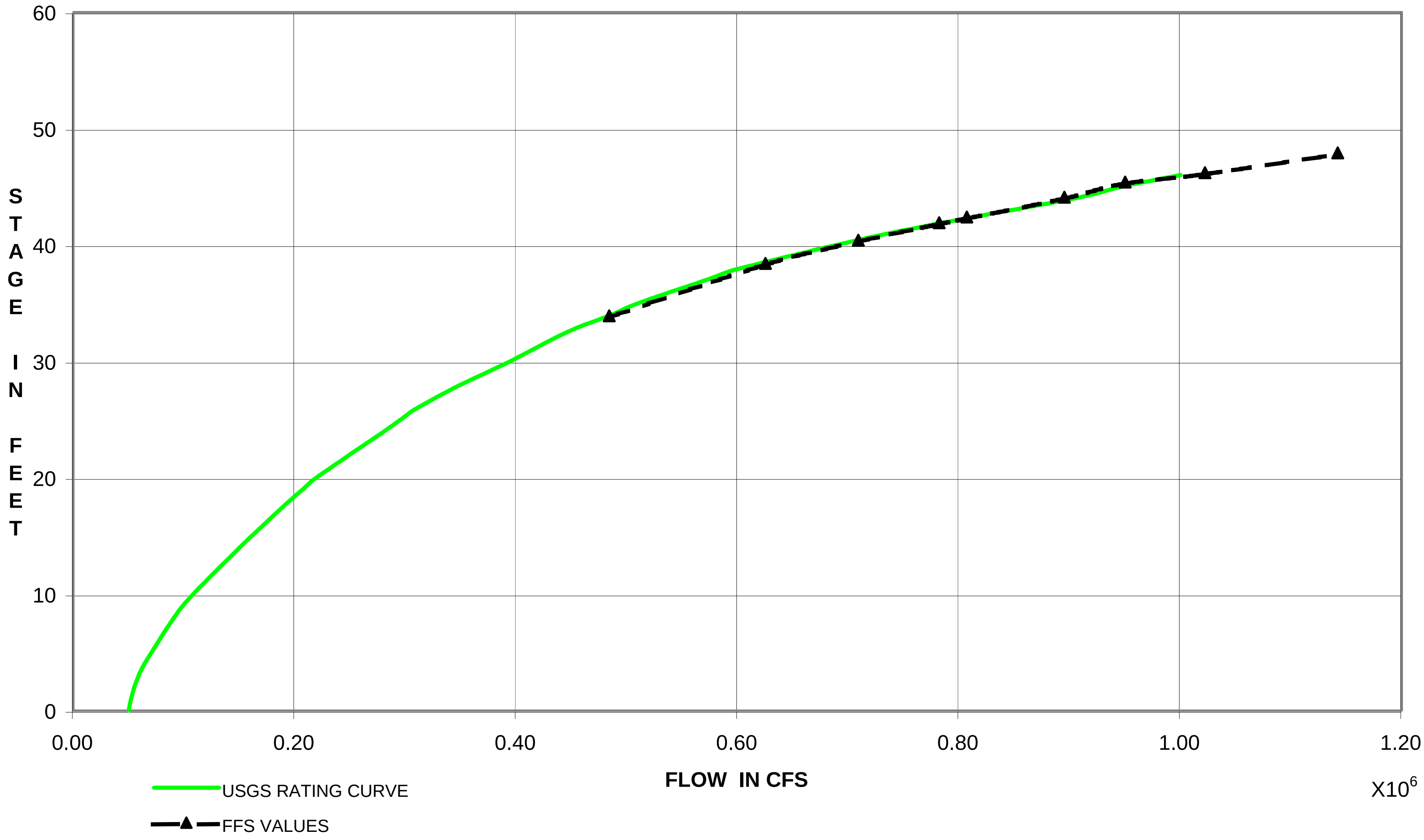
MISSISSIPPI RIVER
ST. LOUIS
USGS RATING CURVE vs. FFS VALUES

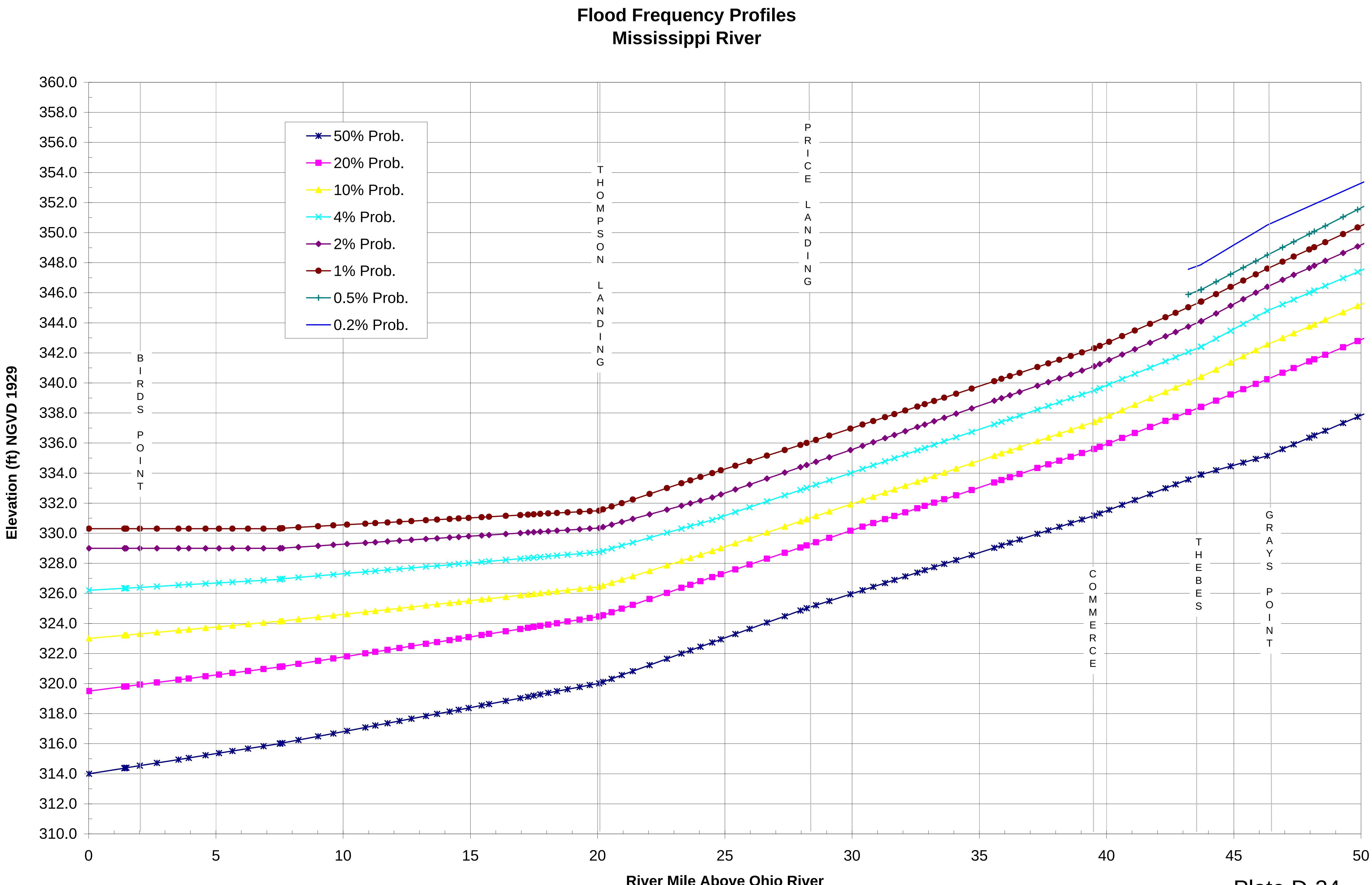




MISSISSIPPI RIVER
CHESTER
USGS RATING CURVE vs. FFS VALUES
STAGE IN FEET
FLOW IN CFS
X10^6
60
50
40
30
20
10
0
-10
0.00
0.20
0.40
0.60
0.80
1.00
1.20
USGS RATING CURVE
FFS VALUES

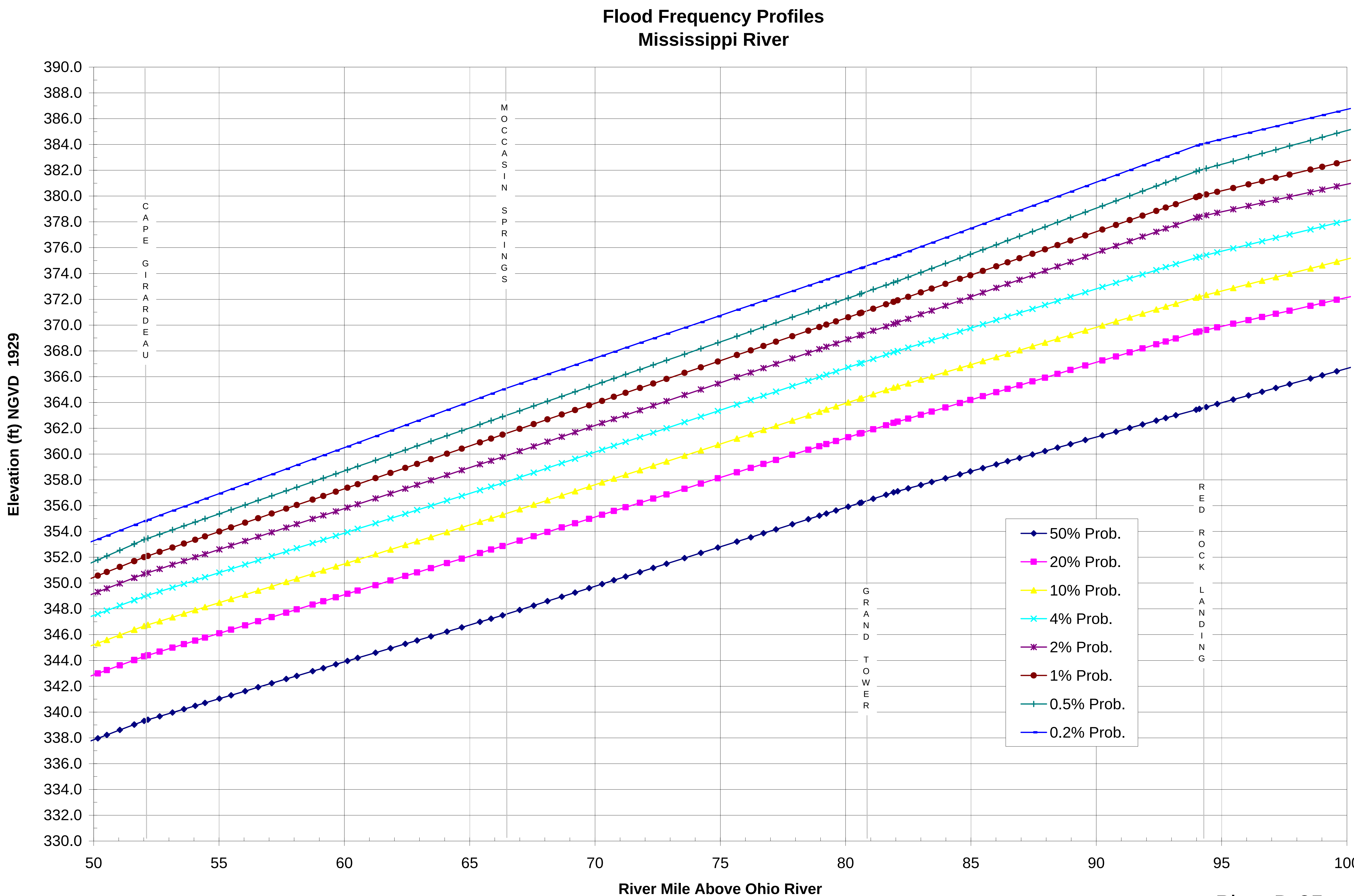
MISSISSIPPI RIVER
THEBES
USGS RATING CURVE vs. FFS VALUES





Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.
BIRDS POINT
THOMPSON LANDING
PRICE LANDING
COMMERCE
THEBES
GRAYS POINT
360.0
358.0
356.0
354.0
352.0
350.0
348.0
346.0
344.0
342.0
340.0
338.0
336.0
334.0
332.0
330.0
328.0
326.0
324.0
322.0
320.0
318.0
316.0
314.0
312.0
310.0
0
5
10
15
20
25
30
35
40
45
50

Plate D-24



Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
390.0
388.0
386.0
384.0
382.0
380.0
378.0
376.0
374.0
372.0
370.0
368.0
366.0
364.0
362.0
360.0
358.0
356.0
354.0
352.0
350.0
348.0
346.0
344.0
342.0
340.0
338.0
336.0
334.0
332.0
330.0
50
55
60
65
70
75
80
85
90
95
100
CAPE GIRARDEAU
MOCCASIN SPRINGS
GRAND TOWER
RED ROCK LANDING
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.

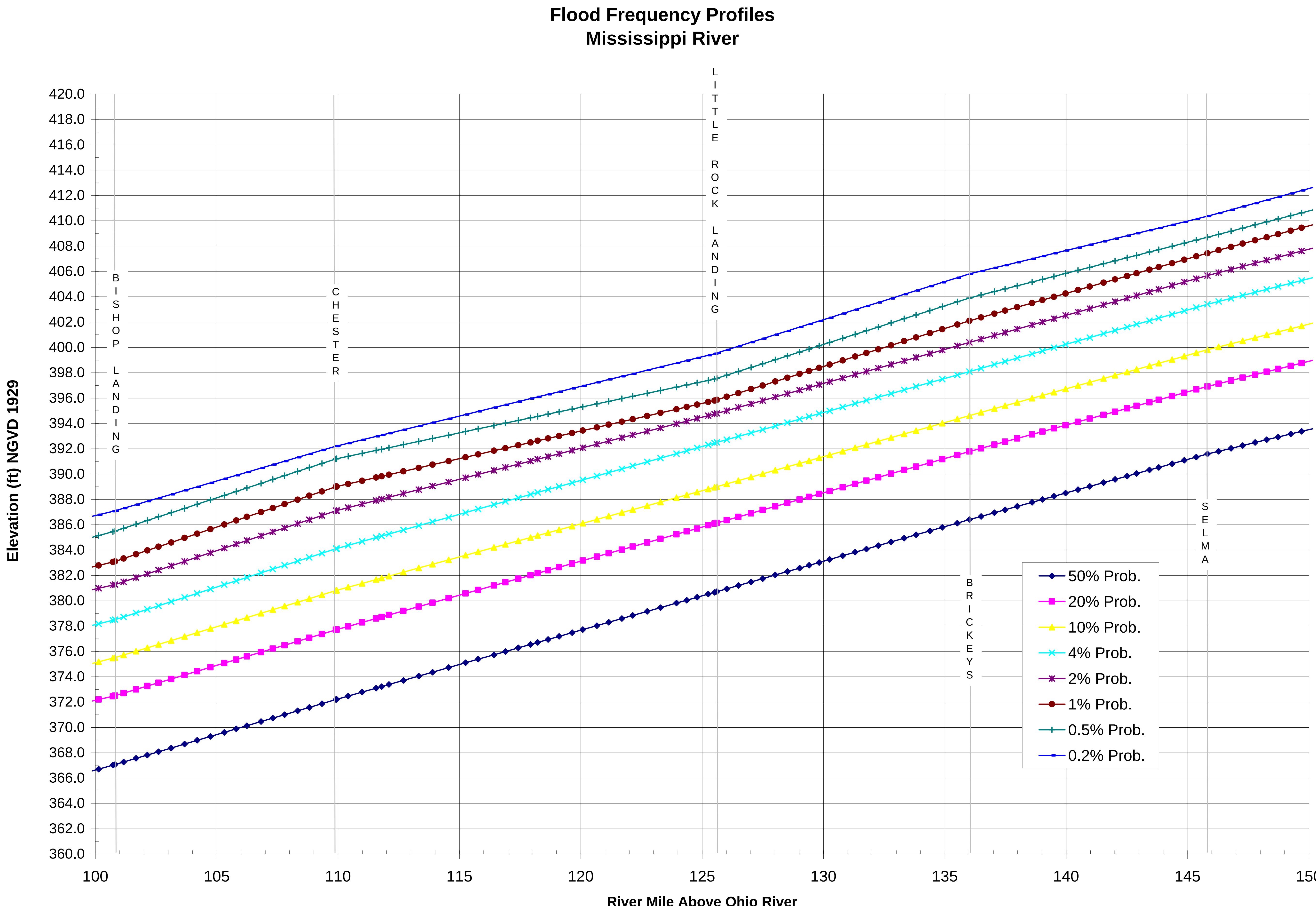

Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
BISHOP LANDING
CHESTER
LITTLE ROCK LANDING
BRICKEYS
SELMA
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.

Plate D-26

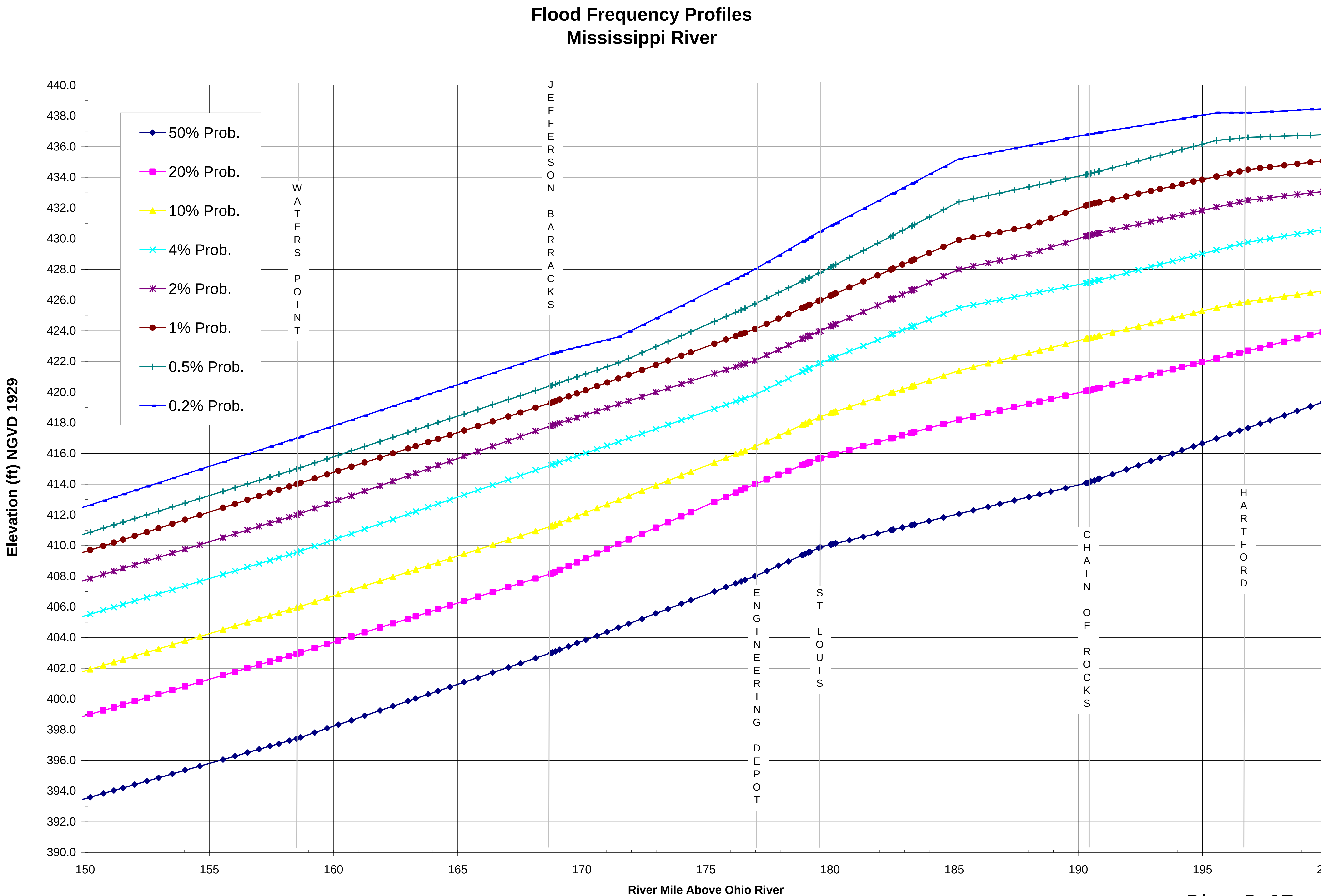
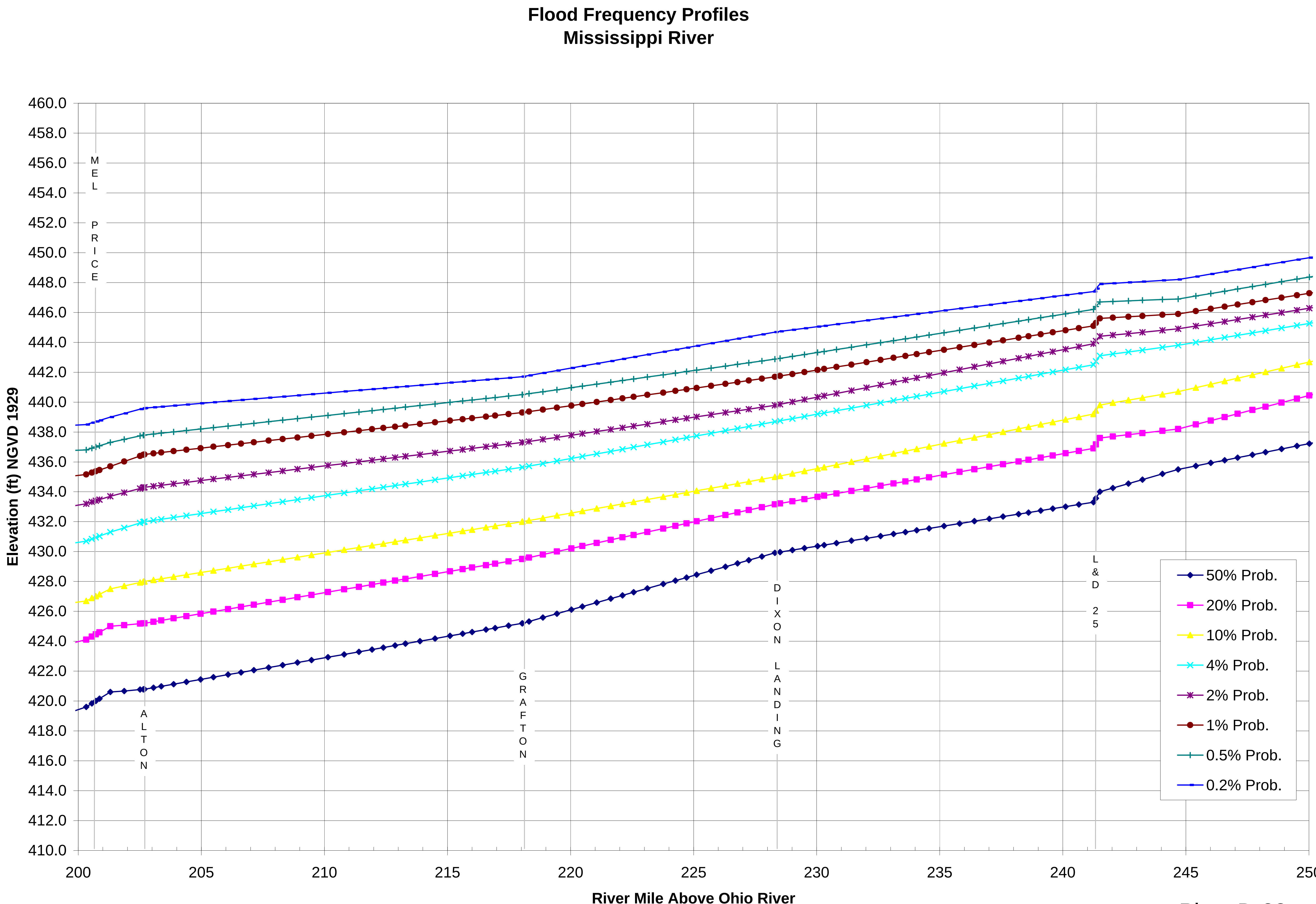

Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.
WATERS POINT
JEFFERSON BARRACKS
ENGINEERING DEPOT
ST LOUIS
CHAIN OF ROCKS
HARTFORD
440.0
438.0
436.0
434.0
432.0
430.0
428.0
426.0
424.0
422.0
420.0
418.0
416.0
414.0
412.0
410.0
408.0
406.0
404.0
402.0
400.0
398.0
396.0
394.0
392.0
390.0
150
155
160
165
170
175
180
185
190
195
200

Plate D-27


Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
MEL PRICE
ALTON
GRAFTON
DIXON LANDING
L&D 25
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.
460.0
458.0
456.0
454.0
452.0
450.0
448.0
446.0
444.0
442.0
440.0
438.0
436.0
434.0
432.0
430.0
428.0
426.0
424.0
422.0
420.0
418.0
416.0
414.0
412.0
410.0
200
205
210
215
220
225
230
235
240
245
250

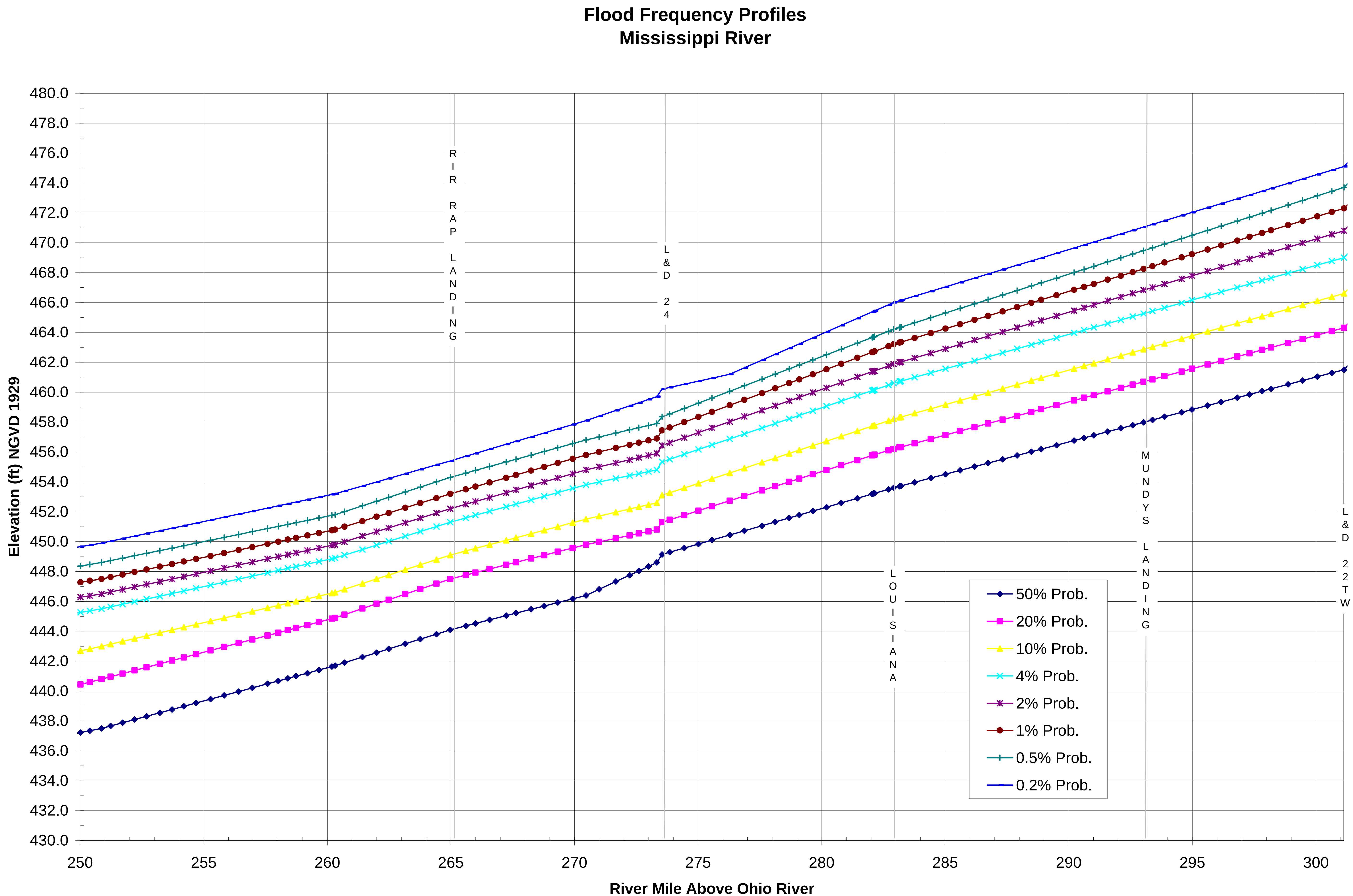
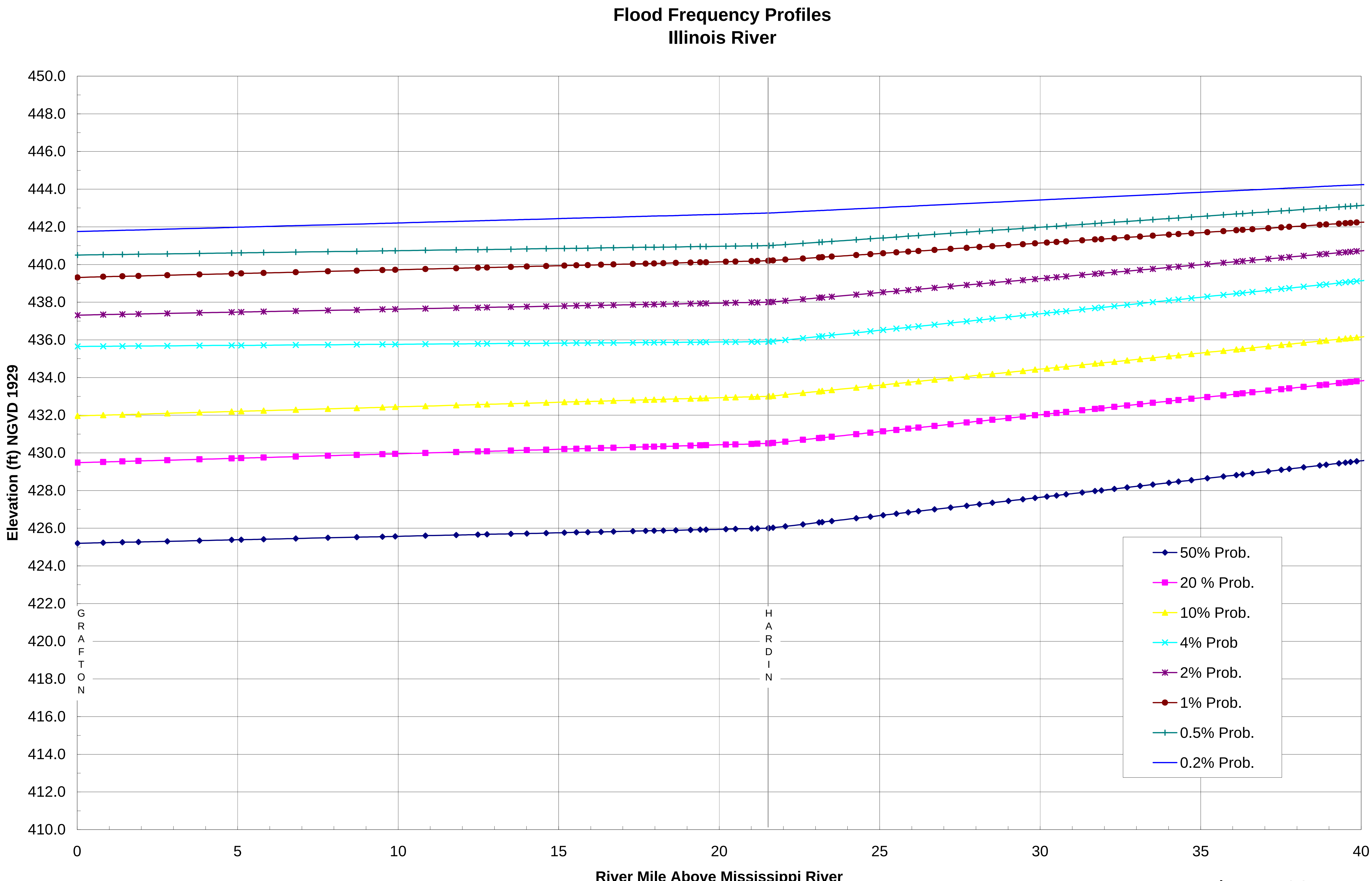
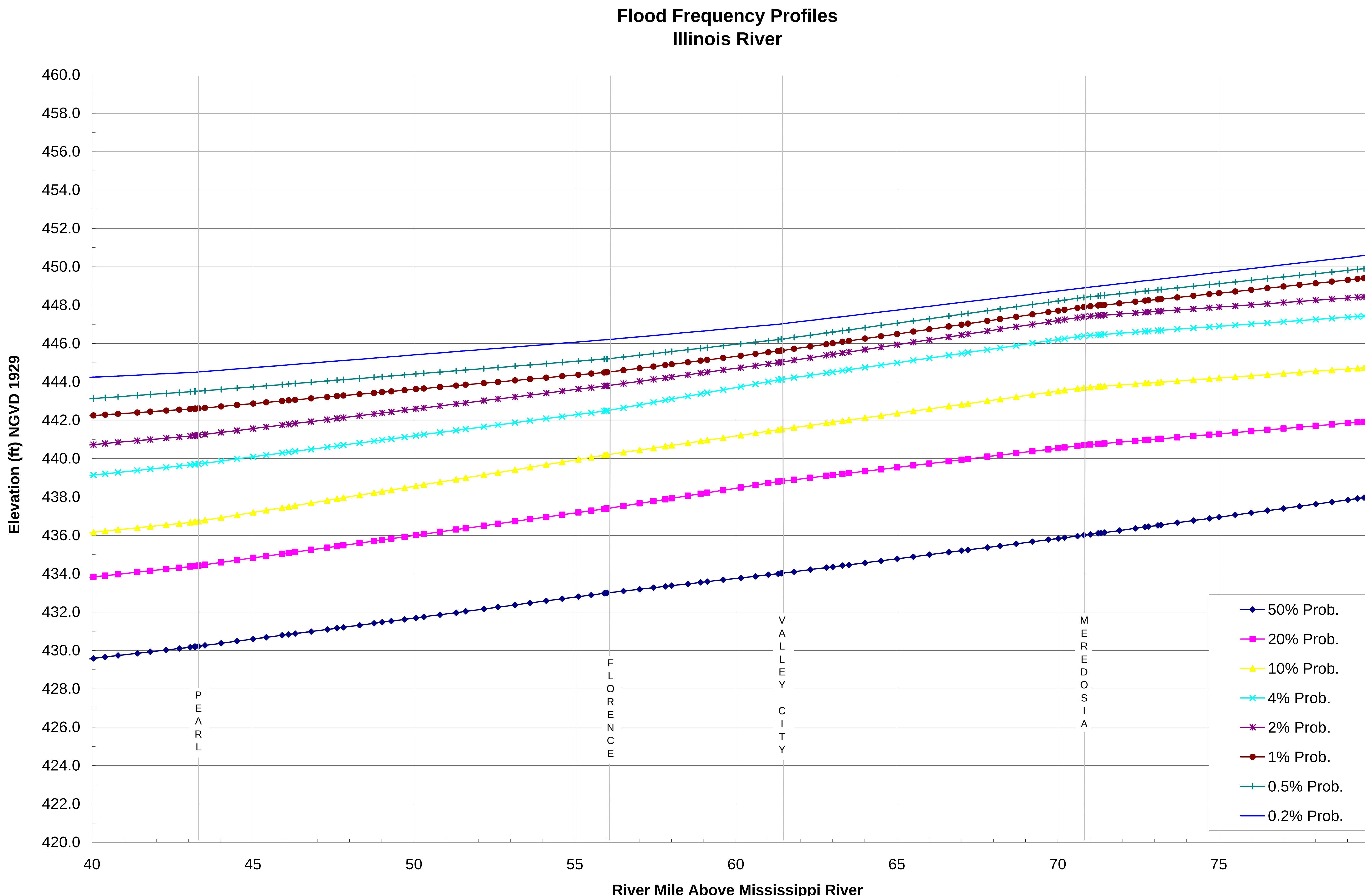

Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
RIR RAP LANDING
L&D 24
LOUISIANA
MUNDYS LANDING
L&D 22 TW
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.

Plate D-29

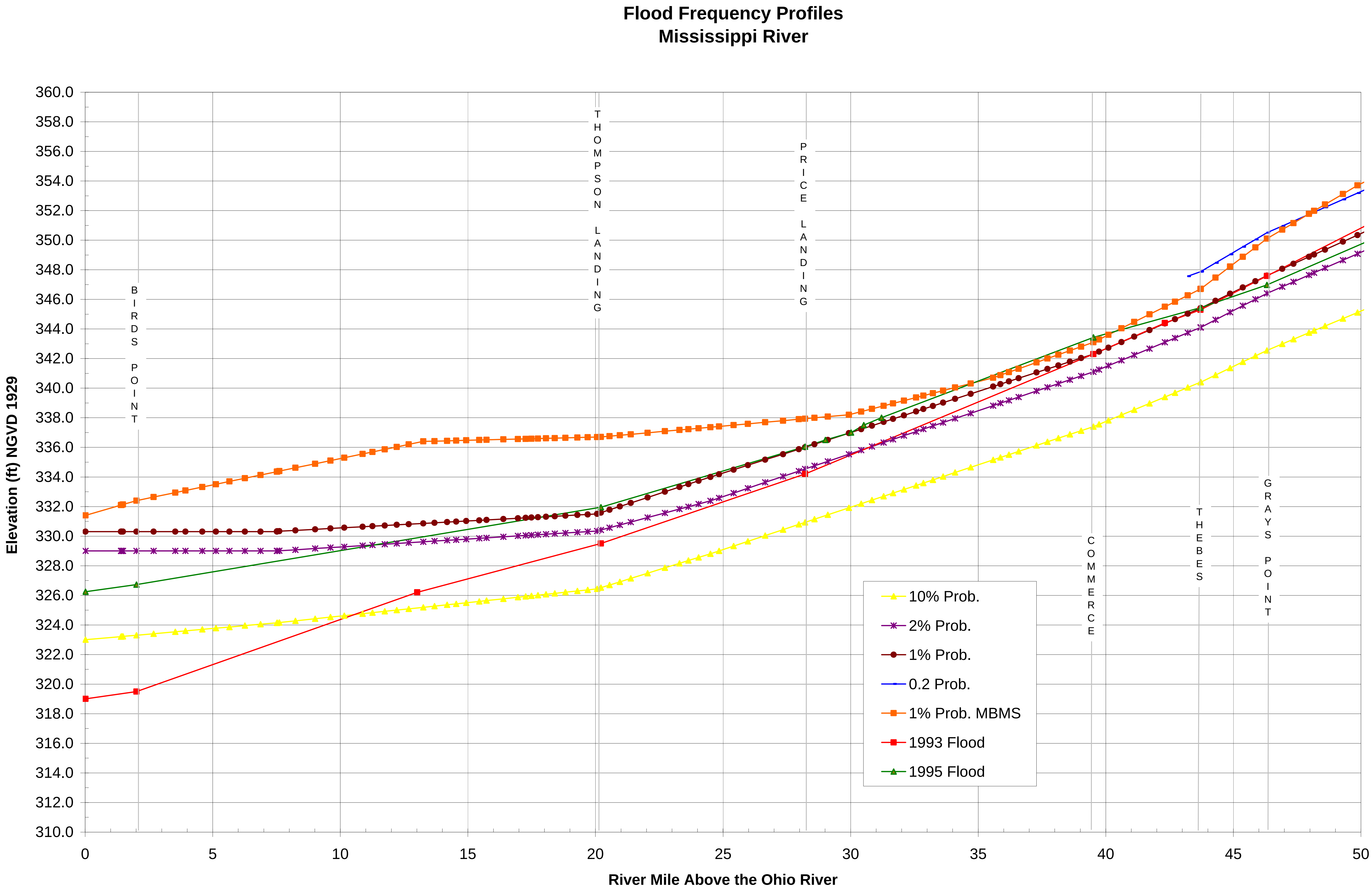


Flood Frequency Profiles
Illinois River
Elevation (ft) NGVD 1929
450.0
448.0
446.0
444.0
442.0
440.0
438.0
436.0
434.0
432.0
430.0
428.0
426.0
424.0
422.0
420.0
418.0
416.0
414.0
412.0
410.0
0
5
10
15
20
25
30
35
40
River Mile Above Mississippi River
GRAFTON
HARDIN
50% Prob.
20 % Prob.
10% Prob.
4% Prob
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.

Plate D-30



Flood Frequency Profiles
Illinois River
Elevation (ft) NGVD 1929
460.0
458.0
456.0
454.0
452.0
450.0
448.0
446.0
444.0
442.0
440.0
438.0
436.0
434.0
432.0
430.0
428.0
426.0
424.0
422.0
420.0
40
45
50
55
60
65
70
75
80
River Mile Above Mississippi River
PEARL
FLORENCE
VALLEY CITY
MEREDOSIA
50% Prob.
20% Prob.
10% Prob.
4% Prob.
2% Prob.
1% Prob.
0.5% Prob.
0.2% Prob.



Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above the Ohio River
BIRDS POINT
THOMPSON LANDING
PRICE LANDING
COMMERCE
THEBES
GRAYS POINT
10% Prob.
2% Prob.
1% Prob.
0.2 Prob.
1% Prob. MBMS
1993 Flood
1995 Flood

Plate D-32

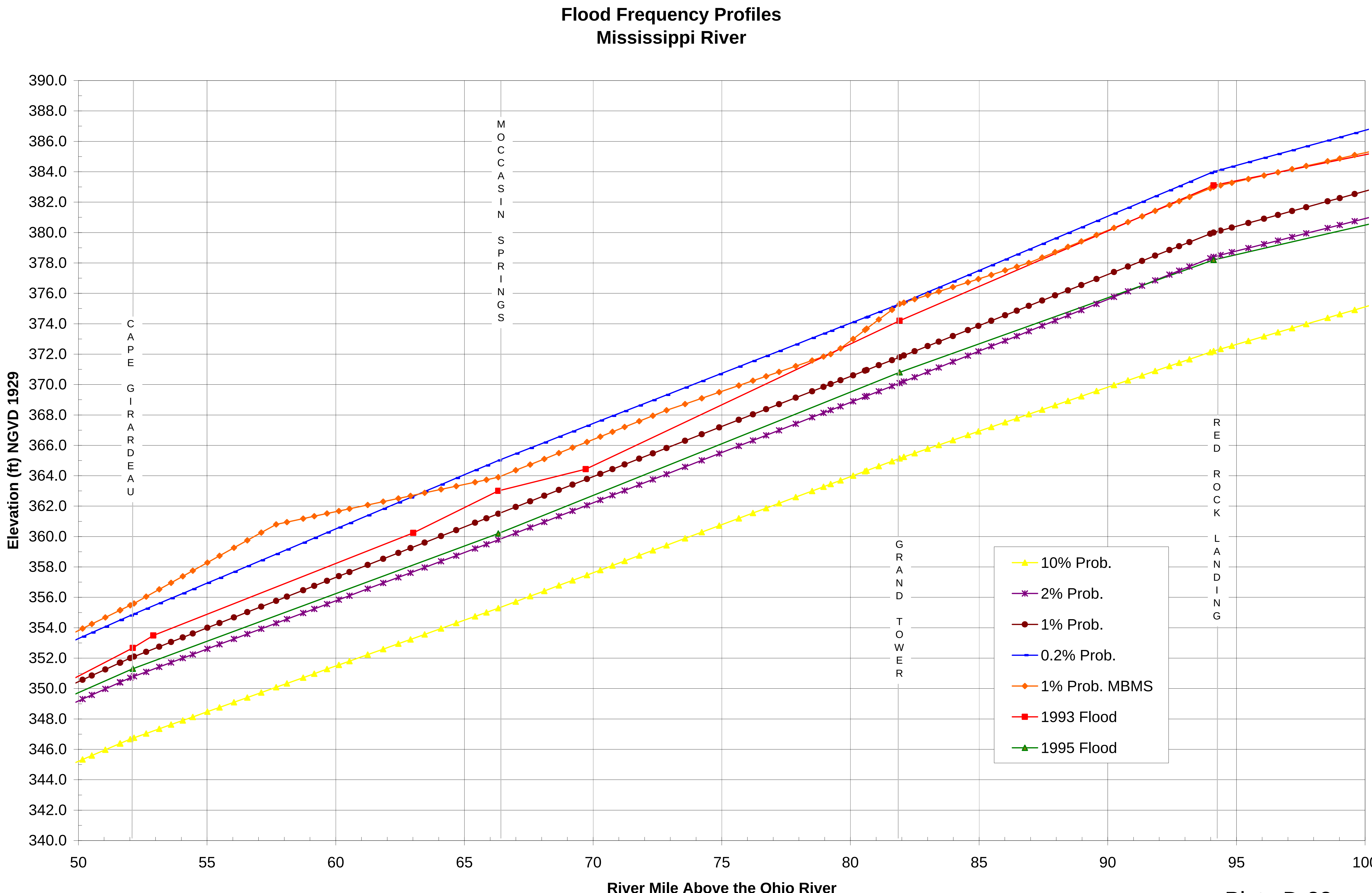

Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above the Ohio River
390.0
388.0
386.0
384.0
382.0
380.0
378.0
376.0
374.0
372.0
370.0
368.0
366.0
364.0
362.0
360.0
358.0
356.0
354.0
352.0
350.0
348.0
346.0
344.0
342.0
340.0
50
55
60
65
70
75
80
85
90
95
100
CAPE GIRARDEAU
MOCCASIN SPRINGS
GRAND TOWER
RED ROCK LANDING
10% Prob.
2% Prob.
1% Prob.
0.2% Prob.
1% Prob. MBMS
1993 Flood
1995 Flood

Plate D-33

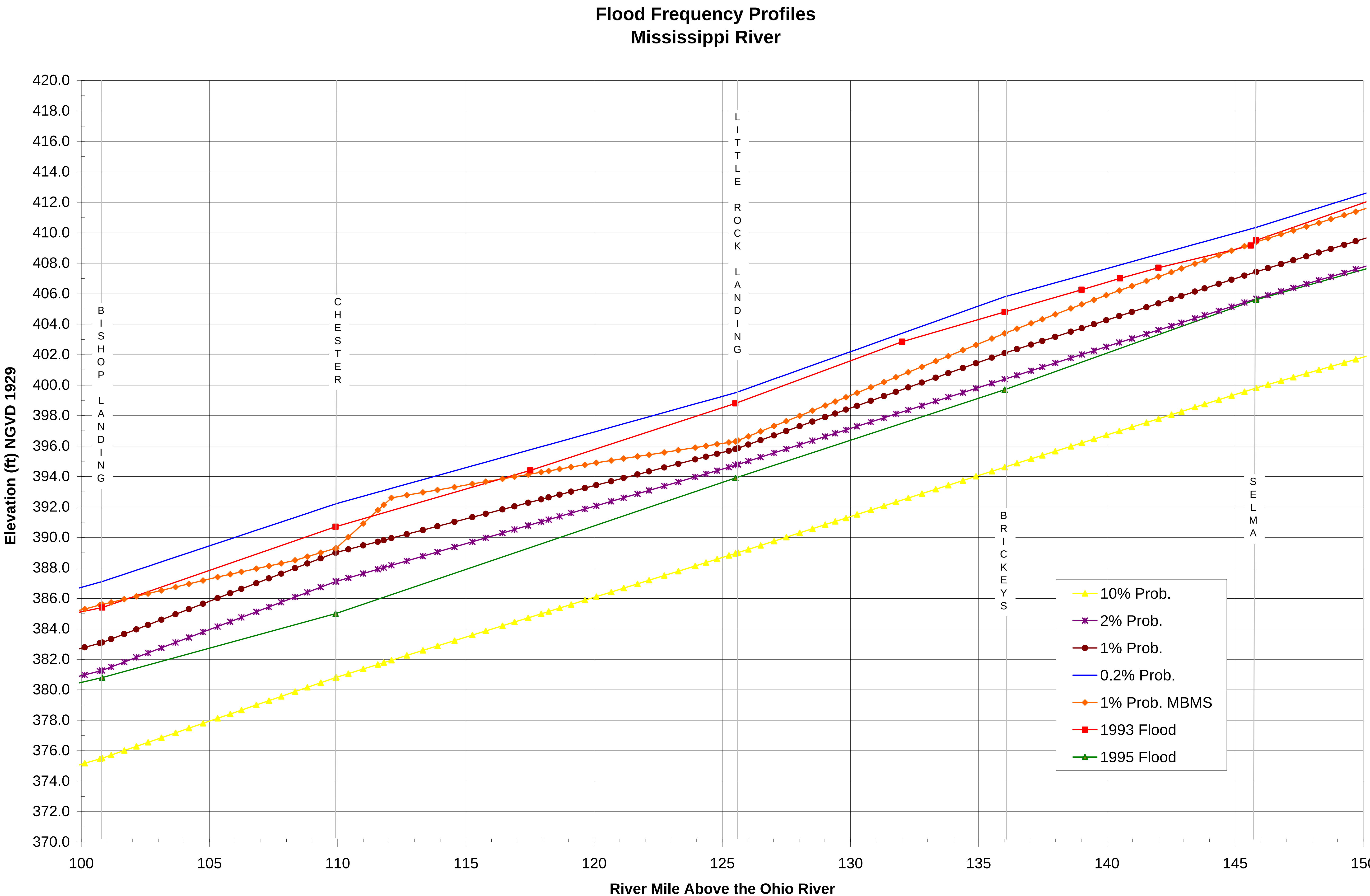

Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above the Ohio River
BISHOP LANDING
CHESTER
LITTLE ROCK LANDING
BRICKEYS
SELMA
10% Prob.
2% Prob.
1% Prob.
0.2% Prob.
1% Prob. MBMS
1993 Flood
1995 Flood

Plate D-34

Flood Frequency Profiles
Mississippi River

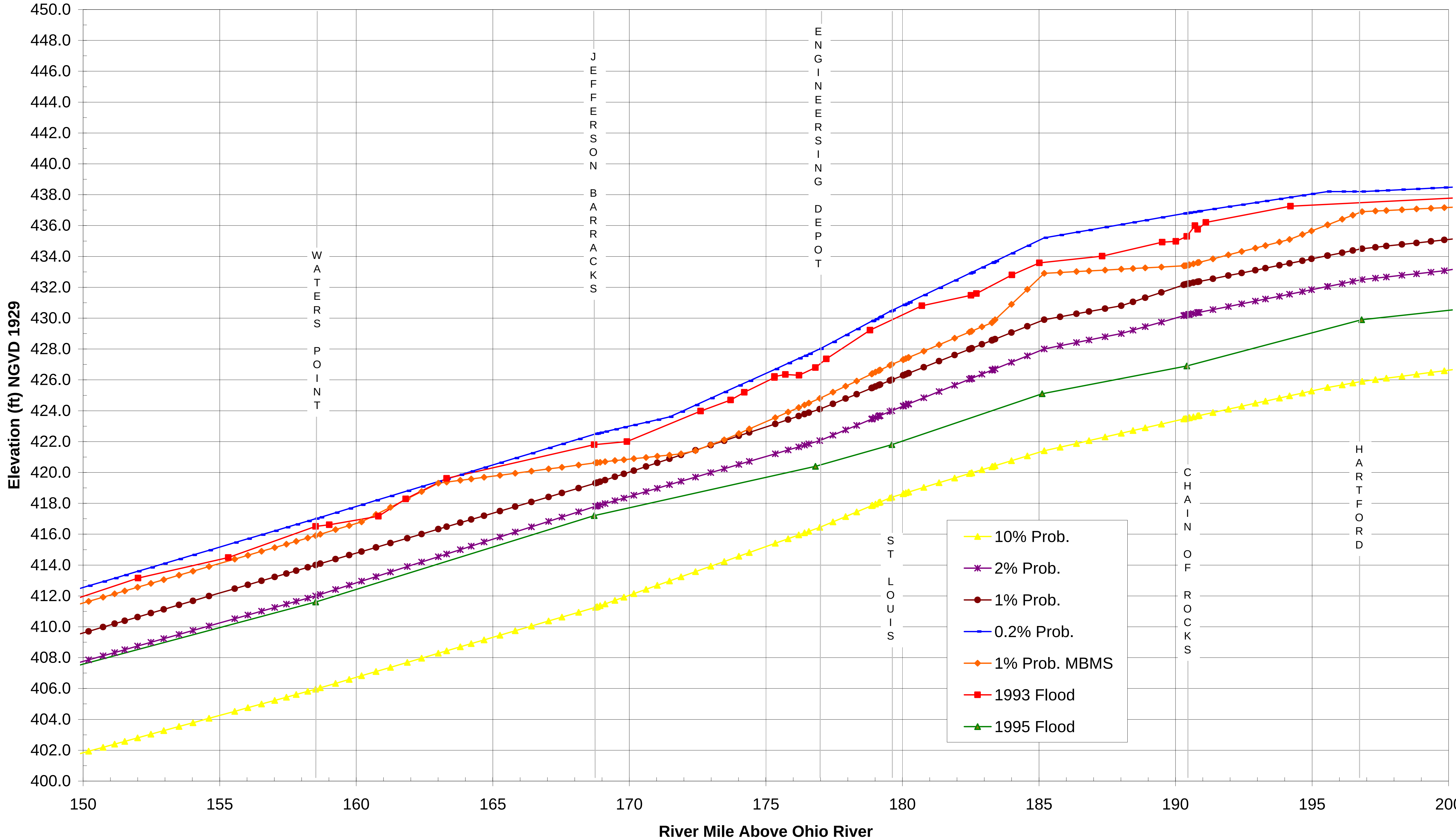
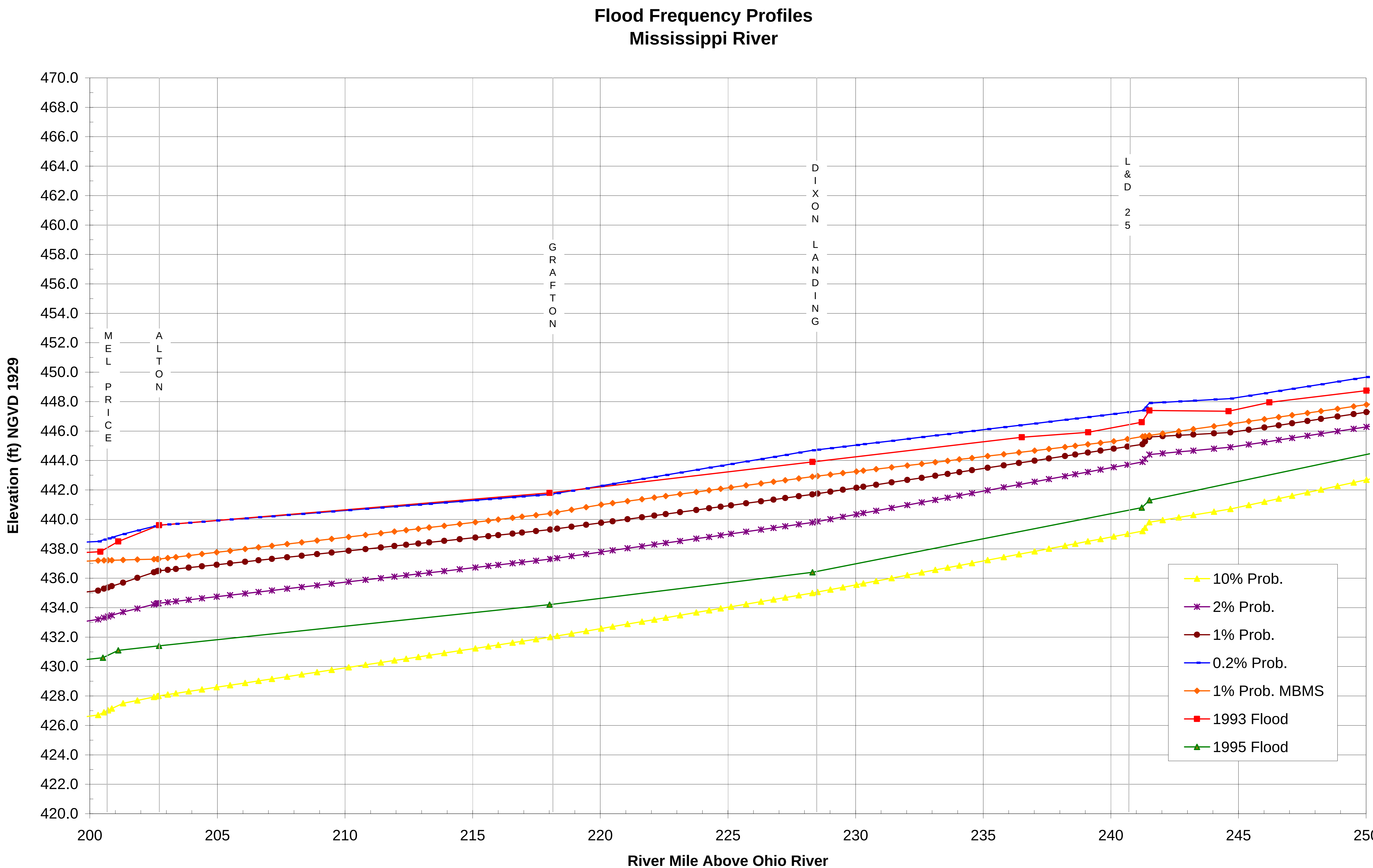
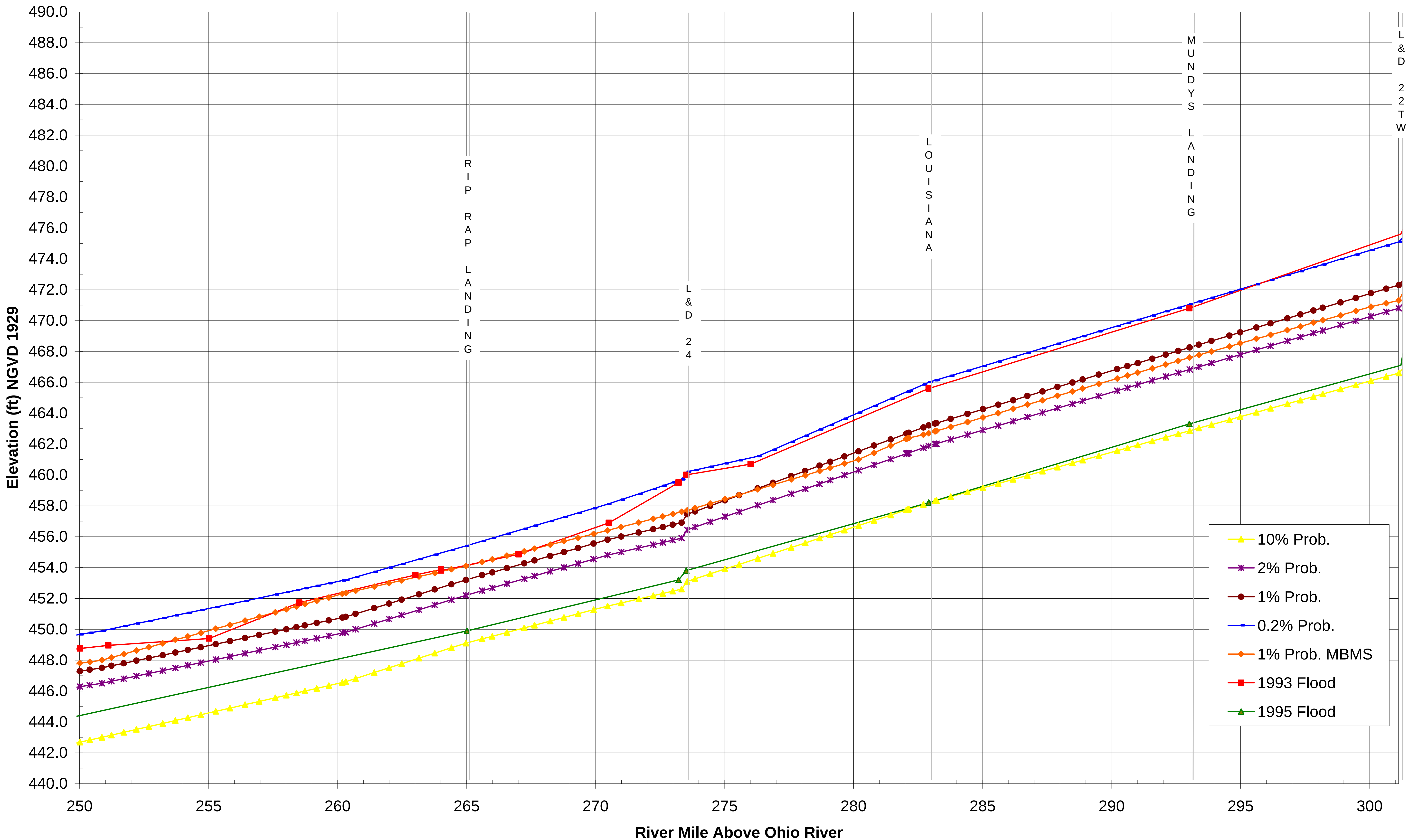


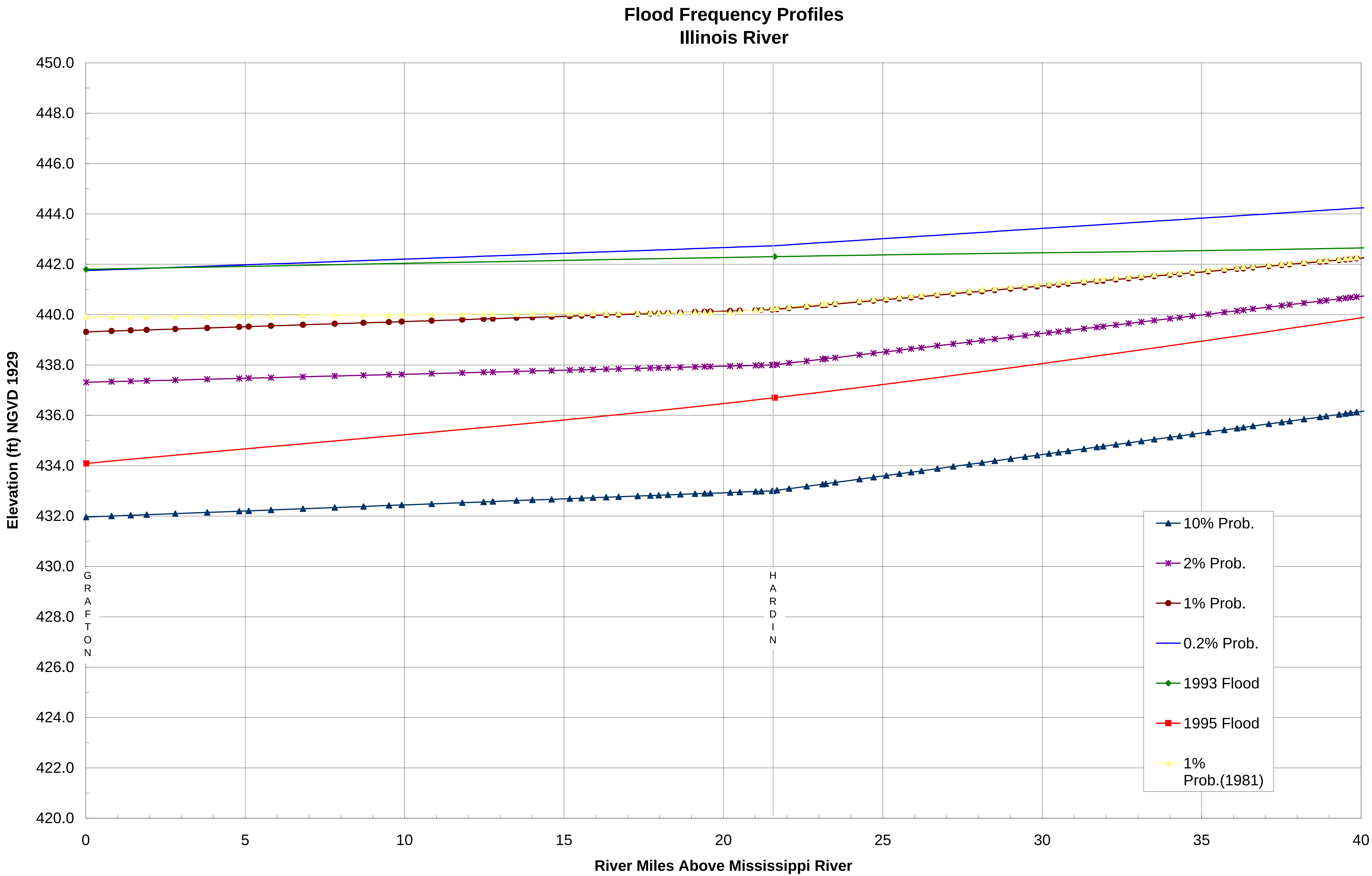
Plate D-35

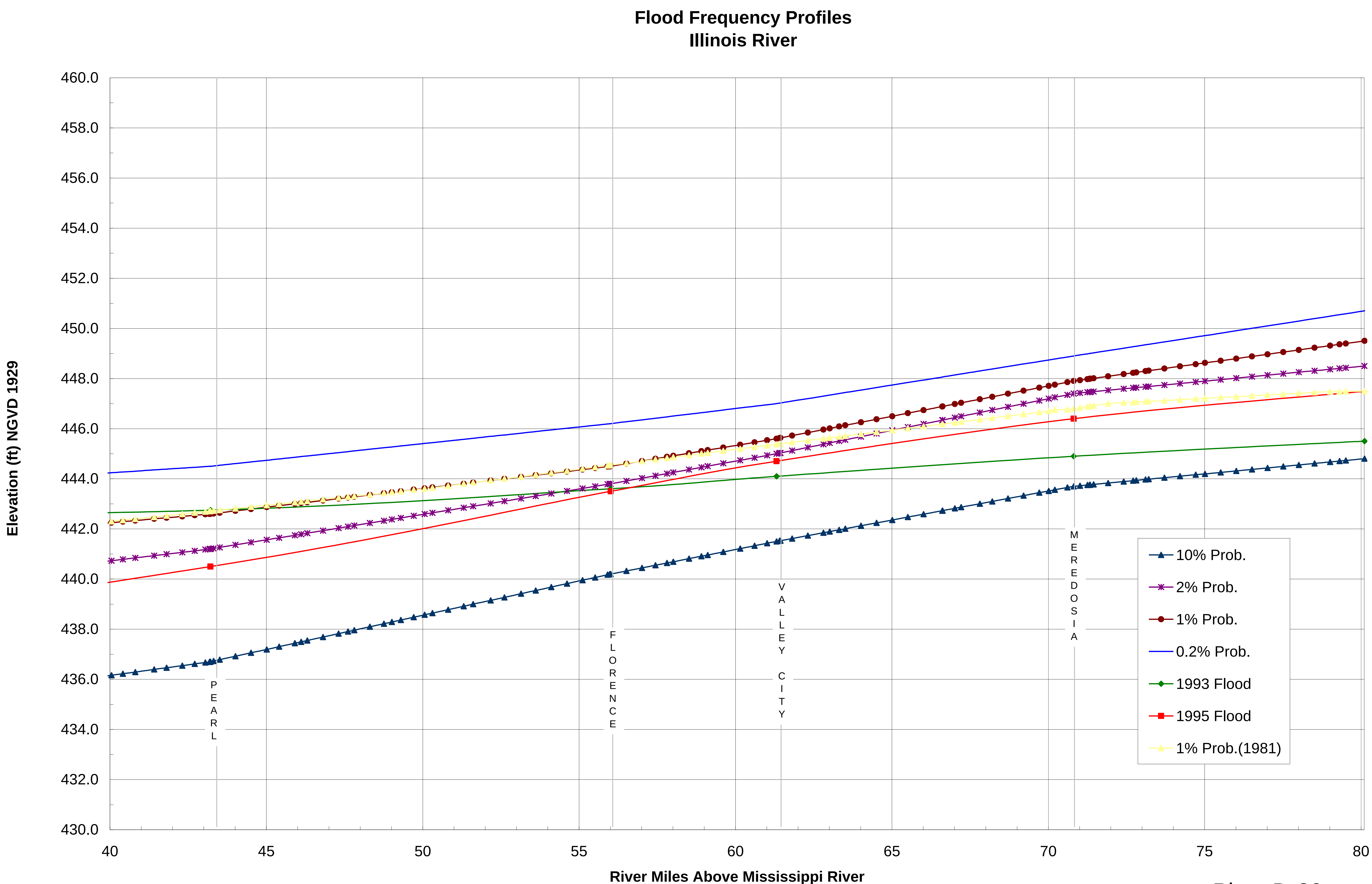


Flood Frequency Profiles
Mississippi River
Elevation (ft) NGVD 1929
River Mile Above Ohio River
MEL PRICE
ALTON
GRAFTON
DIXON LANDING
L&D 25
470.0
468.0
466.0
464.0
462.0
460.0
458.0
456.0
454.0
452.0
450.0
448.0
446.0
444.0
442.0
440.0
438.0
436.0
434.0
432.0
430.0
428.0
426.0
424.0
422.0
420.0
200
205
210
215
220
225
230
235
240
245
250
10% Prob.
2% Prob.
1% Prob.
0.2% Prob.
1% Prob. MBMS
1993 Flood
1995 Flood

Flood Frequency Profiles
Mississippi River




Flood Frequency Profiles
Illinois River
Elevation (ft) NGVD 1929
450.0
448.0
446.0
444.0
442.0
440.0
438.0
436.0
434.0
432.0
430.0
428.0
426.0
424.0
422.0
420.0
0
5
10
15
20
25
30
35
40
River Miles Above Mississippi River
GRAFTON
HARDIN
10% Prob.
2% Prob.
1% Prob.
0.2% Prob.
1993 Flood
1995 Flood
1% Prob.(1981)



Flood Frequency Profiles
Illinois River
Elevation (ft) NGVD 1929
River Miles Above Mississippi River
460.0
458.0
456.0
454.0
452.0
450.0
448.0
446.0
444.0
442.0
440.0
438.0
436.0
434.0
432.0
430.0
40
45
50
55
60
65
70
75
80
PEARL
FLORENCE
VALLEY CITY
MEREDOSIA
10% Prob.
2% Prob.
1% Prob.
0.2% Prob.
1993 Flood
1995 Flood
1% Prob.(1981)

Plate D-39