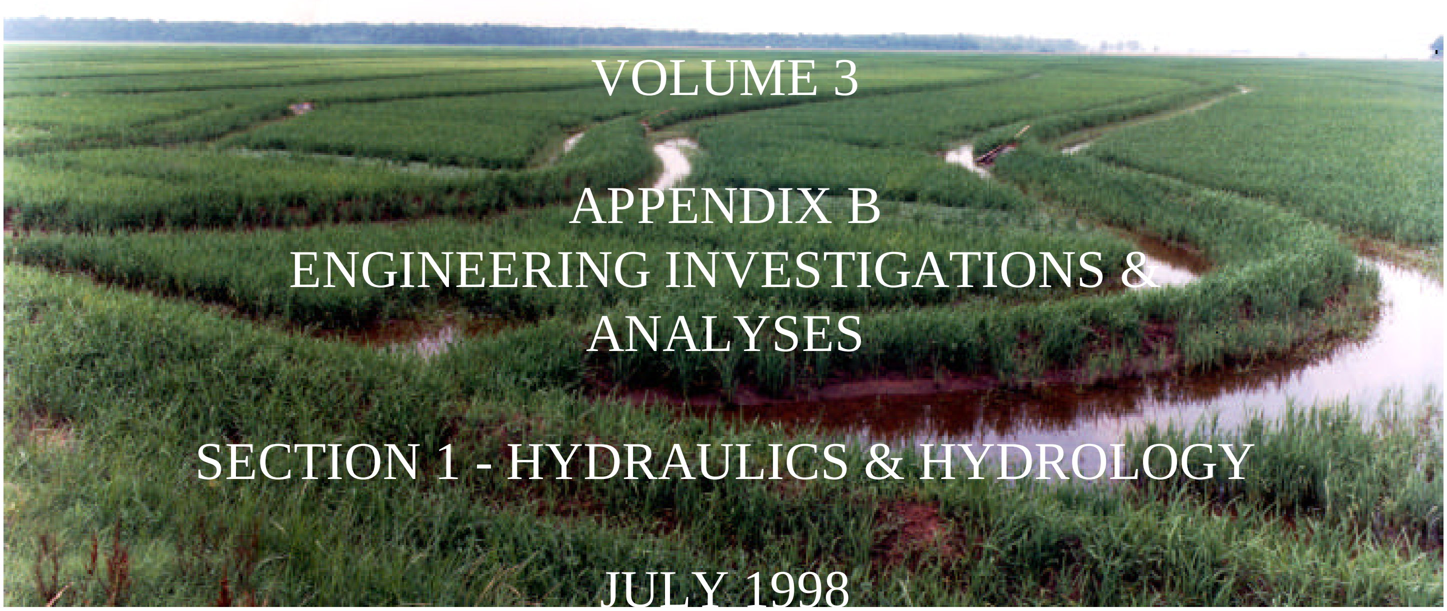
**US Army Corps of Engineers**
Memphis District
Mississippi River Comission

# EASTERN ARKANSAS REGION COMPREHENSIVE STUDY

# GRAND PRAIRIE REGION AND BAYOU METO BASIN, ARKANSAS PROJECT

# GRAND PRAIRIE AREA DEMONSTRATION PROJECT

# GENERAL REEVALUATION REPORT



VOLUME 3

APPENDIX B
ENGINEERING INVESTIGATIONS & ANALYSES

SECTION 1 - HYDRAULICS & HYDROLOGY

JULY 1998

# GRAND PRAIRIE AREA DEMONSTRATION PROJECT
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# SECTION I

# PART A - (1)

# INTRODUCTION

# SECTION I

# HYDROLOGY AND HYDRAULICS

# PART A - (1) - INTRODUCTION

## TOPIC - A GENERAL

Section I presents a full feasibility evaluation of hydrology and hydraulics for the Eastern Arkansas Grand Prairie Demonstration Project. The feasibility design presented herein deals with two water systems occupying the same area: the existing natural drainage system and the proposed man-made irrigation delivery system composed of canals and pipes. A description is provided to explain how water will be pumped from the White River and distributed to water users without harming the natural drainage system or adversely affecting the environment.

This report section is based in part on work performed by the National Resources Conservation Service (NRCS), reported in the *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report, 1992*, and on the Memphis District *Eastern Arkansas Region Comprehensive Study, August 1990.*

## TOPIC B - ORGANIZATION OF VOLUME - II

Section I is divided into nine parts. Part B - (2) describes the agricultural characteristics of the project area that affect project hydrology and hydraulics. Part C (3) presents hydrologic and hydraulic feasibility designs of the project delivery system components. Part D (4) presents the results of a water balance study performed to evaluate the reliability of the White River as the water source for the project. Part E (5) addresses project sediment transport considerations, such as the potential for scour or deposition within the canals. Part F - (6) presents project water quality considerations and expected effects. Part G - (7) is a preliminary system operation plan. Part H - (8) is the hydrology and hydraulics quality control plan used throughout the study. Part I - (9) is a glossary of pertinent irrigation, water supply, and project specific terms.

# SECTION I

# PART B - (2)

# AGRICULTURAL BASIS

# PART B - (2) - AGRICULTURAL BASIS

## TOPIC A - INTRODUCTION

### 2-A-01. BASIS OF PROJECT.

Heavy use of groundwater as a source of irrigation water has resulted in depletion of the Mississippi Alluvial aquifer to extremely low levels in eastern Arkansas. This aquifer is the principal source of irrigation water for most of the farmers within the area. Previous studies of the region have indicated that unless alternative sources of irrigation water are located, the groundwater resource will be severely damaged. This study presents a plan to protect the groundwater resource and to provide a sustained agricultural water supply in a demonstration project in the Grand Prairie area of eastern Arkansas.

The proposed project area includes portions of Arkansas, Prairie, Lonoke, and Monroe Counties in eastern Arkansas. This project area covers 385,500 acres which includes approximately 290,000 acres of cropland. This is a major rice and soybean producing area which relies heavily on groundwater as an irrigation source. The extensive use of the groundwater resource has depleted groundwater reserves to extremely low levels, and continued use at current rates threatens to severely damage the resource. The Eastern Arkansas Region Comprehensive Study (EARCS), the Eastern Arkansas Water Conservation Project (EAWCP), the Arkansas State Water Plan (ASWP), and several US Geological Survey (USGS) studies have reported average annual water level declines of 0.5 to 0.7 feet per year. The aquifer is generally less than 100 feet in saturated thickness with some critical areas at less than 20 feet of saturated thickness [1]. Methods to preserve the groundwater resource while maintaining agricultural outputs must include improvements in irrigation application efficiency, cropping patterns, and alternative sources for irrigation water.

The project water use priority adopted (from most favored to least favored) was 1) direct rainfall, 2) capture of runoff resulting from rainfall or from application of irrigation water, 3) direct use of water imported from the White River, 4) withdrawals from on-farm reservoir storage, and 5) groundwater. This priority stressed conservation and economy and also advanced project goals by placing minimal demand on the aquifer.

### 2-A-02. AGENCY RESPONSIBILITIES.

The agricultural characteristics of the project area not only determine the demand for irrigation water, but also strongly affect the hydrology and hydraulics of the landscape. It was necessary to inventory the agricultural characteristics of individual farm tracts and interpret that information in order to provide a basis for project hydrologic and hydraulic design.

Due to its great size, the project was undertaken as a joint effort between several agencies, which permitted each agency involved to focus on its area of expertise. The Corps of Engineers has extensive expertise in design and operation of large-scale water resource projects. These projects range from water supply to pumping stations for flood control. The NRCS (formerly the Soil Conservation Service (SCS)) has extensive expertise in on-farm level technical assistance for irrigation and soil conservation. The Farm Service Agency (FSA--formerly the Agricultural Stabilization and Conservation Service (ASCS)) maintains comprehensive records containing land use and cropping history for each farm tract participating in USDA farm programs.

Full utilization of each agency's expertise divided analyses and design tasks into two categories: 1) on-farm tract level (NRCS/FSA) and 2) project level (CE).

On-farm activities consisted of all elements associated with the tract level, including cropping patterns, on-farm water distribution and storage, crop water budgets, and irrigation efficiency. On-farm level work also included establishing an ownership tract naming sequence and tract soil data.

Project level activities consisted of delivery system design and operation. Delivery system layout consisted of a conjunctive effort by the CE and the NRCS to develop a system best able to provide the necessary water to each tract.

# TOPIC B - TRACT SPECIFIC DATA

## 2-B-01. TRACT NOMENCLATURE.

Tract nomenclature was developed to facilitate data entry into an Informix database for use in a Geographic Information System (GIS). The tract naming was tied to each tract's geographic location and crop history. The naming included components that represented the county name, the FSA farm number, and the supply point.

## 2-B-02. CROPS.

Primary crops grown in the Grand Prairie are rice, soybeans (late and early), grain sorghum, corn , wheat and oats. The crop history (type of crops planted and acreage) for each tract was combined with climatic data, soils data, and planting/harvest dates to calculate a water budget and consumptive use. The resulting output from the water budget and consumptive use calculations provided a water demand for each tract.

## 2-B-03. IRRIGATION RESERVOIRS.

Surface storage of rainfall has been developed for several decades in the Grand Prairie. Existing reservoirs provide an estimated 14 percent of the water required by crops grown in the Grand Prairie [2]. These existing reservoirs were located using 1991 aerial photography to update USGS quadrangle maps. NRCS District Conservationists (NRCS-DC) provided additional input pertaining to the depth/volume of water that could be stored in these reservoirs. The NRCS-DC's also provided information for potential sites and suitable depths for additional reservoirs.

# TOPIC C - PROJECT-WIDE / AREA-WIDE ADOPTED DATA AND CRITERIA

## 2-C-01. PARTICIPATION.

Adopted requirements were that all tracts within these boundaries with cultivated cropland would participate and use imported surface water. Any tract located adjacent to a delivery segment was considered to have a source of imported surface water. Project boundaries were located consistent with the White River Regional Irrigation Water Distribution District (WRRIWDD) boundaries. The boundaries have been revised twice during the course of this study as the WRRIWDD evolved into the White River Irrigation District (WRID). Appropriate adjustments to the delivery system have been made to reflect the first and second reductions in service areas. The first change in boundary was a slight reduction in area north of US Interstate 40 and resulted in no change in project design. System designs and economic optimization were analyzed for this service area. The final reduction in area occurred when the southern most area south of DeWitt, AR was taken out of the WRID in 1995. This change resulted in a reduction in required irrigation water and slightly reduced canal sizes in several segments of the delivery system.

## 2-C-02. CROPS.

Land use data as reported to the FSA proved to be the most reliable source of information and was utilized for areas where available. Where FSA data was not available, land use was determined by reference to aerial photographs, USGS quadrangle maps, NRCS records and by field inspection [3]. Cropland acreages for 1991 were used as the project cropland acres. Cropland associated with FSA base acres and lands set aside from crop production under the Conservation Reserve Program (CRP) were readily identifiable from FSA records. Cropland not associated with FSA base acres was considered to be planted with early soybeans, since soybeans are not a commodity crop (late soybeans would typically be double-cropped after wheat , which is a commodity crop). Planting and harvest dates for individual crops were held constant throughout the project area. Wheat and oat crops were considered not irrigated, but the double-cropped late soybeans following wheat and oats were considered irrigated. It was assumed that land use would remain the same throughout the project life.

## 2-C-03. SOILS.

NRCS soil mapping indicates that the project area is primarily characterized by soils of the Crowley-Stuttgart-Grenada Association [4]. This soil association consists of poorly drained to moderately well drained, level to gently sloping, loamy soils that formed in windblown silts overlying old alluvium on upland flats and low ridges. The individual soil series comprising the Association exhibit similar farming and irrigation characteristics which include texture, available water holding capacity, and the existence of a compact subsoil. Due to the similarities of the soils located in the Grand Prairie, no distinctions of soil series were made.

## 2-C-04. IRRIGATION RESERVOIRS.

Although the numerous reservoirs in existence are operated by many different individuals, landscape characteristics and crop requirements are so similar across the project area it was considered appropriate to assume uniform operation procedures and schedules, as determined by the NRCS [5]. Locations of existing reservoirs were based on aerial photography, and the volume of these reservoirs was computed by using measured surface areas and an estimated depth. New reservoirs will be constructed on soybean acreage when possible. Where soybean acreage is not available, area required will be taken from rice acreage. All on-farm storage reservoirs will be filled beginning January 1 and filling will be completed by April 30. All existing reservoirs will be utilized throughout the life of the project. All tracts will be capable of capturing tailwater and runoff from the irrigated acres. Evaporation in excess of rainfall on all lakes, storage reservoirs, and fish ponds was considered a demand and was accounted for in water balance computations.

## 2-C-05. FISH RESERVOIRS.

Commercial fish farming operations will utilize imported surface water. Twenty-five percent of the fish pond volume is to be drained annually and refilled during April [6].

## 2-C-06. WATERFOWL.

Water required for flooding waterfowl acreage, in excess of rainfall, will be provided by available surface import water. Flooding of land for winter waterfowl is to occur during October and November. The area to be flooded will be covered by an average depth of three inches [7].

## 2-C-07. DELIVERY SYSTEM.

Peak import requirements will occur during the irrigation season. An initial sizing of the delivery system was based simply on the demand for irrigation water and the assumption that the White River can fulfill this demand. Tract demands and delivery system cumulative demands estimated by the NRCS were based on water budget computations. A water budget is an accounting of water inflows and losses for a system over time. Canal capacity was based on 10-day[1] demands developed for each tract using 10-day climatic conditions and resulting crop budget/consumptive use outputs. At this stage in the design no losses were included for distribution system evaporation and seepage, since these losses depend in part on the actual

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[1] 10-day values are those values that represent 10-day time period averages.

configuration of the delivery system components. At a later stage in the design estimated values of these losses were included to determine the gross capacity required for the delivery system components.

## 2-C-08. EFFICIENCY.

Not all of the water furnished to a tract of irrigated cropland actually benefits the crop. Inevitably some water is lost through processes such as evaporation, runoff, and seepage below the root zone. Although it was not possible to know the actual irrigation efficiency for each individual tract, typical current irrigation efficiency in the project area was estimated at 60 percent, and for design purposes this efficiency was adopted as uniform throughout the project area. Irrigation efficiency projected for the project condition is estimated at 70 percent, due to anticipated installation of water conservation practices and adoption of improved water management techniques [8]. Tailwater recovery and runoff capture was assumed possible for all tracts.

## 2-C-09. GROUNDWATER.

Safe groundwater yield was based on the University of Arkansas Peralta model data [9]. Groundwater was assumed to be uniformly available within a given Peralta cell (3 mile by 3 mile cell grid). Groundwater withdrawal for each tract was prorated among irrigated cropland acreage.

# TOPIC D - IRRIGATION DEMAND MODELING

## 2-D-01. CROP WATER REQUIREMENTS.

Crop irrigation water requirements were determined using a NRCS program called CONUSE. This program is based on the modified Blaney-Criddle method for determining consumptive use for various crops under varying climatic conditions. The specific method is contained in the SCS publication "Irrigation Water Requirements" [10]. This procedure is considered to be the accepted method for determining plant water use in the humid southern US.

The CONUSE program and normal[2] year climatic data were used to compute the monthly consumptive use and net irrigation requirement for the major crops produced in the project area. CONUSE was run for each of the major crops grown in the project area. Rainfall and temperature data was based on monthly totals for 1965 through 1981 at the Stuttgart, AR precipitation station. The results from CONUSE were used in the NRCS water budget program to compute individual tract water needs.

## 2-D-02. GROUNDWATER AVAILABILITY.

The output data from the Peralta model was used to predict future groundwater availability. In order to duplicate, as near as possible, current trends in irrigated agriculture in the Grand Prairie, the Peralta 2030 SMA model runs were selected. The 2030 SMA model run represents a pumping scenario that is limited by a minimum aquifer saturated thickness of 20 feet including any municipal and industrial use. The 2030 pumping demand is approximately equivalent to 1992 conditions and is slightly less than maximum potential demand as expressed in 2040 data. At the present time this is the only groundwater data available and is considered conservative for project planning. Peralta model results are in the form of annual acre-feet of water availability per 9 square mile cell (3 mile by 3 mile cell grid). The resulting ground water availability values from the 2030 SMA model run were used as input for the NRCS water budget model.

A Project Cell Analysis program previously developed by the NRCS was used to confirm and refine data specific to Grand Prairie Demonstration Project Boundaries [11]. This program was based on the 9 square mile cells used by Peralta and uses the surface water and ground water data, water demands, available storage and conservation levels to establish the overall import needs and peak import capacities.

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[2] The normal year used for the CONUSE analyses was defined to have approximately 6 inches of total rainfall occurring during the two consecutive months July and August.

## 2-D-03. NETWORK.

A spreadsheet macro was developed to determine required flow rates for each segment of the delivery system. The spreadsheet accumulated individual tract needs along a canal segment, from downstream to upstream. The accumulation was accomplished along a path specified by the canal segment linked to each tract. Demands were successively added together until all canals (and tracts) were included. Canal branch demands were added at nodes starting at the downstream limits of each canal and increased towards the upstream limits, finally ending at the White River near DeValls Bluff, AR.

# TOPIC E - DETAILS OF NRCS ANALYSES

Detailed descriptions of NRCS project analyses and designs are included in Volume 2, Appendix A - NRCS On-Farm Report.

## REFERENCES


[1] ________. *Eastern Arkansas Region Comprehensive Study--Draft Feasibility Report and Environmental Assessment, Volume 1*, Memphis District Corps of Engineers, August 1990, p 30.

[2] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section D/ General Description of Project", (page unnumbered).

[3] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section G/ Data Collection/ Land Use Data, " (page unnumbered).

[4] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section G/ Data Collection/ Soils Data, " (page unnumbered).

[5] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section I/ Computer Models/ Irrigation Efficiencies, " (page unnumbered).

[6] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section F/ Project Assumptions, " (page unnumbered).

[7] ________. Refer to Environmental volume of this report .

[8] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section I/ Computer Models/ Irrigation Efficiencies, " (page unnumbered).

[9] ________. *Eastern Arkansas Region Comprehensive Study--Draft Feasibility Report and Environmental Assessment, Volume 1*, Memphis District Corps of Engineers, August 1990, p 28.

[10] ________. *Technical Release No. 21, Irrigation Water Requirements*, U.S.D.A.. Soil Conservation Service, 1970.

[11] ________. *Eastern Arkansas Region Comprehensive Study General Reevaluation (Grand Prairie Area)--Documentation Report.* Soil Conservation Service, Little Rock, Arkansas, November, 1992, "Section I/ Computer Models/ Existing Computer Models," (page unnumbered).

# SECTION I

# PART C - (3)

# HYDROLOGY AND HYDRAULICS

# PART C - (3) - HYDROLOGY AND HYDRAULICS

## TOPIC A - INTRODUCTION

This section addresses the hydrology and hydraulics of two water systems, the existing natural drainage system and the project delivery system, occupying the project area landscape. A design was performed that permits water to be pumped from the White River and distributed throughout the project area without adversely affecting the natural drainage system.

Unlike a natural drainage system, which collects water from numerous small streams at various points upstream to form a single large stream at the watershed outlet, this irrigation delivery system distributes water from a single large upstream canal to numerous smaller canals downstream. The fundamental concept of the delivery system design is that the water is to be lifted from the White River to a high point in the project area and then conveyed to remote locations in the project area by gravity flow. The trunk and main branches of the distribution "tree" follow high ground as much as possible in order to take full advantage of opportunities to convey withdrawals by gravity flow.

Part C - (3) is divided into three parts. Topic B describes the hydrology of existing streams within the project area. Hydrologic analysis of these streams was required in order to ensure that the project components would not cause flooding and to confirm that certain existing streams could be incorporated into the delivery system. The hydraulics of delivery system components is described in Topic C. These components include the main pump stations, canals, check structures, existing streams, pipelines, inverted siphons, turnouts, riprap weirs, wasteways, and road crossings.

## TOPIC B - HYDROLOGY OF EXISTING STREAMS

### 3-B-01. GENERAL.

It was necessary to determine how irrigation flows and the man-made canals used to convey these flows might affect the natural runoff characteristics of the Grand Prairie Demonstration Project area. It was also necessary to determine if selected existing streams could be incorporated into the delivery system. A hydrologic study was made of the project area existing streams. The study provided estimates of the magnitude and frequency of natural flows occurring in the existing streams. This information was used in the hydraulic design of inverted siphons and of riprap weirs. The siphons permit natural streams to flow unimpeded across canal alignments , while the riprap weirs modify existing streams to function as irrigation water supply canals. The results of the hydrologic study enabled the siphons and weirs to be designed to function without causing flooding.

The project area boundaries are not limited to one watershed, but instead encompass portions of the watersheds of several small streams and numerous minor drains, as shown in Plate III-B-1. The canal system printed in magenta on the 1:250,000 base map [1] should not necessarily be interpreted as the alignment currently proposed for the canal system.

The topography of the project area is that of a low tableland with streams exiting from all sides. The largest stream within the project area is La Grue Bayou, which originates in the northwest corner of the project area near Carlisle and flows toward the southeast, passing through Peckerwood Lake and exiting the eastern side of the project area near Lookout to join the White River. Most of the project area drains toward the south or to the east, but the area north of a line between DeValls Bluff and Carlisle primarily drains to the north. A narrow fringe of land along the west side of the project area from Carlisle to Stuttgart is drained by minor streams that flow west toward Two Prairie Bayou. Elevations in the project area exceed 230 ft msl in limited areas to the west of DeValls Bluff, and dip below 200 ft msl in bottomlands along the larger streams in the southern portion of the project area.

The climate of the project area is characterized by cool, wet winters and hot, humid summers. Average annual precipitation recorded at the National Weather Service (NWS) gage at Stuttgart, Arkansas was 49.2 inches for the years 1948 through 1986. The lowest and highest recorded NWS temperatures at Stuttgart, Arkansas for the years 1948 through 1986 were -6 degrees and 107 degrees Farenheit [2]. A detailed description of project area climate is presented in the water balance section of this volume.

Project area soils and vegetative cover affect infiltration of rainfall. The soils are primarily silt loams underlain by a compact subsoil [3]. Land use in the project area is primarily agricultural, with most farmland devoted to crop production. Cropland vegatative cover varies throughout the year, depending on the state of crop growth at a given season.

**3-B-02. DATA.**

Because limited gage data is available for existing streams within the project area, the hydrologic analysis focused on estimating discharge-frequency relationships for the streams. Information required to perform the hydrologic analysis included topographic, land use, and rainfall data and unit hydrograph parameters. Unit hydrograph parameters and other pertinent data related to the topography of the individual watersheds is presented in Plate III-B-2.

Rainfall frequency data associated with the centroid of the project area was applied to the entire project area. Data was obtained from the following three rainfall-frequency atlases: (1) HYDRO-35 [4], (2) Technical Paper No. 40 [5], and (3) Technical Paper No. 49 [6]. Partial duration rainfall values were found by interpolation. Values for the 5, 10, 25, and 50 year return periods for the 5- and 15- minute durations were obtained from equations presented in HYDRO-35. The 1.01 and 500 year return period rainfall values were determined by extrapolation on log-log paper as a family of curves, and the 1.01-yr and 500-yr values were obtained for each duration directly from the graph. The partial duration rainfall frequency values are presented in Plate III-B-3. Also, plots of the same information are presented in Plate III-B-4 for 5- through 60 minute durations, and in Plate III-B-5 for 2-hr through 2-day durations.

In addition to the hypothetical rainfall described above, historical rainfall gage data in the project area that fell within the period of 1967 - 1991 was used in the analysis.

**3-B-03. METHOD.**

Due to limited stream gage information, the hydrologic analysis consisted of estimation of peak discharges occurring at key locations along the existing streams. The analysis included estimates based on hypothetical and gaged precipitation events. The HEC-1 computer program was used to model hypothetical events, verified using USGS regression equations, and used as the basis of a long-term historical HUXRAIN model of the streams (HUXRAIN is described below on page III-6) . A statistical analysis was made of the HUXRAIN output to provide discharge-frequency information required to evaluate flooding occurring under existing and project conditions. The HUXRAIN hydrographs were used in an unsteady flow analysis to analyze routing effects on travel time.

The HEC-1 [7] model required data regarding rainfall depths, losses, unit hydrograph parameters, and stream channel routing information. The atlas rainfall depths were used to develop hypothetical rainfall distributions. Runoff was estimated by the method of initial and uniform loss rate. The initial loss ranged from 1.0 to 1.5 inches and the uniform loss rate ranged from 0.1 to 0.15 inches per hour. Unit hydrographs were developed using Snyder's method [8], with "$t_p$" computed from the equation:

$$t_p = C_t (L L_{ca})^{0.3}$$

where "$t_p$" is the lag time from the midpoint of unit rainfall duration to the peak of the unit hydrograph, in hours, "L" is the river mileage from the outflow point of the watershed to upstream limits of the watershed along the longest watercourse," $L_{ca}$" is the river mileage from the outflow point of the watershed to the center of gravity of the watershed following the main watercourse, and "$C_t$" is a coefficient based on drainage basin characteristics such as slope of the watershed.

In order to develop values of $C_t$ and $C_p$ for ungaged basins, an analysis of several gaged basins in the Memphis District was made. From the analysis of these gages, a relationship was developed between $C_t$ and the weighted stream slope, as shown in Plate III-B-7. Values of $C_p$ were found to vary from 0.50 for flat land to 0.7 for hilly land. Snyder's lag time, $t_p$, was calculated for each subarea from measured values of L and $L_{ca}$. Subareas which contained urban development were adjusted to reflect the accelerated runoff associated with urban areas. Using the percent of urbanization obtained from land use maps, the unit hydrograph parameter $t_p$ was adjusted using the following relation:

$$t_{pu} = \frac{t_p}{1 + \frac{\%Urban}{100\%}}$$

This relation is based on the assumption that 100% basin urbanization will result in a 50 % reduction in the time to peak [9] of a subarea hydrograph.

The Modified Puls storage routing method was used in HEC-1 to perform channel routing, following the guidelines of HEC TD-30 [10]. Channel cross-section information and USGS quadrangle maps were used to build a HEC-2 [11] model for storage computations. Storage-outflow relationships were developed by running the HEC-2 model with a range of flows and were the basis of SV and SQ records used in the HEC-1 model.

HEC-1 peak discharge values were compared to values obtained from regression equations developed by the USGS [12]. These regression equations were developed for two regions within the state of Arkansas for recurrence intervals of 2, 5, 10, 25, 50, and 100 years. Region A includes a 30 to 70-mile wide swath of comparatively flat lowlands bordering the Mississippi River in the eastern part of the state. Region B consists of the remainder of the state and includes Crowley's Ridge. Most of the project area is included in Region A, however the northward draining portion of the project area is part of Region B. Highway 70 is the approximate dividing line between the two regions in the project area.

The regression equations for Region A are based on the watershed characteristics of area, channel slope, and channel length. Thirty feet per mile is the maximum slope for which the regression equation is valid, and so if the channel slope is greater than 30 feet per mile, then 30 feet per mile is the slope entered into the equation. The equation for the two year peak is provided below as an example:

$$Q_2 = 107 \ A^{0.83} \ S^{0.28} \ L^{-0.33}$$

where,

$Q_2$ = discharge, cfs, for the 2 year recurrence interval
A = drainage area, sq mile
S = channel slope, feet/ mile

$L$ = channel length, mile.

The average standard error of regression for the $Q_2$ is plus or minus 30%. The lowest standard of error is plus or minus 28% for the $Q_5$, and the greatest standard error is plus or minus 40% for the $Q_{100}$. The standard error is the range of error to be expected about two-thirds of the time [13]. For example, if the $Q_2$ estimated by the regression equation were 1000 cfs, then there is about a 66% probability that the actual $Q_2$ is within the range of 1300 cfs to 700 cfs. There is about a 33% probability that the actual $Q_2$ exceeds 1300 cfs or is lower than 700 cfs.

Region B regression equations are based on watershed area, channel slope, annual precipitation, and mean elevation. Five-hundred ft msl is the minimum elevation for which the regression equation is valid, so if the basin elevation is less than 500 ft msl, then 500 ft msl is used in the equation. The equation for the two year peak is provided below as an example:

$$Q_2 = 0.120\ A^{0.78}\ S^{0.42}\ (P-30)^{0.55}\ E^{0.75}$$

where,

$Q_2$ = discharge, cfs, for the 2 year recurrence interval
$A$ = drainage area, sq mile
$S$ = channel slope, feet/ mile
$P$ = mean annual precipitation, inch
$E$ = mean basin elevation, ft msl

The average standard error of regression for the $Q_2$ is plus or minus 42%, which is also the greatest standard error for the six recurrence intervals. The lowest standard of error is plus or minus 33% for the $Q_{10}$ and the $Q_{25}$,.

The USGS regression equations have large standard errors, as indicated above, and are intended not to provide exact predictions of peak discharge, but to provide guidance in determination of the most likely range of peak discharges. For the project, HEC-1 loss rate input was adjusted until computed peaks were comparable to USGS estimates. For each key location the statistical computer program HEC-FFA [14] was used to produce a flow-frequency curve and associated confidence limits. HEC-1 unit hydrographs were then produced having a six-hour time base.

Historical NOAA rainfall data were matched to project watersheds using the Thiessen weighting method. Also, an analysis was made to determine the antecedent precipitation index (API) for the project watersheds. The equation for API is

$$API_t = API_o\ k^t$$

where "$API_0$" is the initial index value, "k" is a recession factor, "t" is time span in days, and "$API_t$" is the reduced value of the index after time, t [15]. The significance of the API is that it accounts for the amount of soil moisture present at the time of a precipitation event, permitting an estimate of runoff depths over time. Recession factors, k, typically lie within the range of 0.85 to 0.98 [16], and a study of Memphis district watersheds resulted in a typical recession factor of 0.88, which was adopted. To apply the API concept it is necessary to determine a factor, Y, representing watershed recharge (recharge here means all losses ultimately affecting runoff over long time spans, including evapotranspiration), as shown in the following equation:

$$Y = A(2.0 - API)^2 + B,$$

where "A" and "B" are curve-fitting constants used in a graphical technique. The values of "A" and "B" are determined by trial and error, as described in the next paragraph.

The API technique was applied using the HUXRAIN rainfall-runoff computer program developed by the Memphis District [17]. HUXRAIN was originally developed to support hydrologic analyses for the St. Francis River Basin project--specifically the Huxtable Pumping Plant. The program requires rainfall data in 24- or 6-hour intervals, unit hydrographs for selected watershed nodes, the API "A" and "B" coefficients, API monthly runoff coefficients, and node stream rating tables. Program output consists of long-term simulated flow hydrographs and stage hydrographs for the nodes. Six-hour unit hydrographs derived from HEC-1 were input for the nodes for this project. Adjustments of the API "A" and "B" coefficients were made until HUXRAIN peak discharges were comparable to HEC-1 discharges. The final HUXRAIN output was analyzed statistically to provide flow-frequency information and was written to a DSS file for use as input to a UNET unsteady flow computer program model to analyze existing stream hydraulics.

**3-B-04. RESULTS OF ANALYSIS.**

The results of the analysis were HEC-1 estimates of discharge, USGS regression discharge checks, HUXRAIN hydrographs, and flow-frequency relationships. As an example of HEC-1 output flow-frequency curves, three plots for Little La Grue Bayou are provided in Plate III-B-8. The plots correspond to stream channel stations at watershed areas of 39.42, 82.35, and 126.42 square miles. For a given plot, the HEC-1 computed discharges associated with each hypothetical precipitation event are plotted on log-probability paper and are bounded by confidence limits of 95% and 5%. Comparison of HEC-1 results with USGS regression values for La Grue Bayou, Little La Grue Bayou, Caney Bayou, Stuttgart King Bayou, and the Mill Bayou, Elm Prong Bayou, and Hurricane Bayou system is presented in Plate III-B-9. HEC-1 values ranged from as much as 39% greater to as much as 18% lower than the USGS regression values. However, most of the HEC-1 values were confined within a range of only 20% greater to 15% lower than the USGS values. Plate II-B-9 also presents comparisons between HEC-1 peaks and HUXRAIN estimates of peaks for La Grue Bayou, Little La Grue

Bayou, and the Mill Bayou, Elm Prong Bayou, and Hurricane Bayou system. Typically, HEC-1 values were confined within a range of only 25% greater to 25% lower than the HUXRAIN values..

# TOPIC C - HYDRAULICS

## 3-C-01. INTRODUCTION.

A complex system of structural components is required to convey water in a controlled manner through the delivery system. The types, dimensions, and locations of these structures to be included in this system were determined in this study. Ten structure types will be required in the system: pump stations, canals, existing streams, check structures, pipelines, inverted siphons, turnouts, riprap weirs, wasteways, and road crossings.

A main pump station at the White River lifts water to the high point in the project area, where the water is received by a main canal. The main canal branches into smaller canals across the project area. Where advantageous, existing streams are incorporated into the delivery system and are modified by the installation of riprap weirs to function as canals. Water levels are maintained at required elevations in the canals by check structures. Water is directed to minor channels or to individual users through turnout structures. Pipelines are used to deliver water in cases where open channels are not feasible and if gravity flow is not possible, the water is pumped through the pipelines. Inverted siphons are installed where natural streams would be blocked by canals. Wasteways installed on main canals provide for emergency diversion of flow and for maintenance dewatering. Bridge and culvert road crossings direct canal flows across public and private roads.

## 3-C-02. PUMP STATIONS.

Two pump stations are included in the project. The main pump station at DeValls Bluff on the White River lifts water up the bluff to the head of the canal system. All water furnished by the project delivery system passes through this main pump station. A pump (lift) station is required on Canal 3200 to supply water to the northwest portion of the project area. These two pump stations are distinguished from the numerous minor pump installations associated with individual pipelines. Those minor pumps are described in the pipeline portion of this section.

The DeValls Bluff pump station will have a maximum capacity of 1640 cfs. As shown in Plate III-C-1 an inlet channel directs water from the White River to the pump station, and this channel must be able to convey water during low river stages. In order to determine design elevations for the inlet channel, an analysis was made of gage data at Clarendon and at DeValls

Bluff. As shown in Table III-C-1 discharge and stage data available at Clarendon was compared to stage data at DeValls Bluff to obtain estimates of the 0.01 nonexceedance probability water surface elevation at DeValls Bluff. The lowest recorded White River water surface elevation at DeValls Bluff of 153.3 msl was essentially equal to the post-dam 0.01 nonexceedance water surface elevation and was adopted as the basis for the inlet channel design. The pool elevation in Canal 1000 will be approximately 232.8 msl. Therefore the maximum static head the pumps must overcome is approximately 79.5 ft when the White River is at elevation 153.3 msl. Sediment transport was an important consideration in the inlet channel design and is discussed in the sediment transport section of this volume.

Table III-C-1. Low Flow Discharges, Stages, and Elevations for Clarendon and DeValls Bluff Gages

| 0.01 Nonexceedance Probability Discharge at Clarendon cfs | Stage at Clarendon [1] ft | Stage at DeValls [2] Bluff ft | Elevation at DeValls Bluff ft-msl |
|---|---|---|---|
| 4446 [3] | 6.5 | 0.4 | 153.36 |
| 3243 [4] | 5.5 | -0.7 [5] | 152.26 |
| 4238 [6] | 6.5 | 0.4 | 153.36 |

[1] Based on the 1988 rating table at Clarendon gage.
[2] Based on a stage vs. stage relationship developed between Clarendon and DeValls Bluff; DeValls Bluff gage zero = 152.96 ft-msl.
[3] Period of record 1965-80, annual basis, post-dam.
[4] Period of record 1940-80, annual basis, pre- and post-dam.
[5] Estimated.
[6] Period of record 1965-1980, monthly basis (October), post dam.

Table III-C-2 presents the relationship between exceedance frequency and water surface elevation at DeValls Bluff. Since the pump station must be protected from flooding, the frequency-elevation relationship was used as a guide in setting minimum elevations of pump station components.

Table III-C-2. Frequency vs. Flowline Elevation for White River at DeValls Bluff, Arkansas [1]

| Exceedance Frequency | Computed Water Surface Elevation ft-msl |
|---|---|
| 1 | 172.6 |
| 2 | 175.1 |
| 5 | 177.8 |
| 10 | 180.3 |
| 25 | 183.6 |
| 50 | 186.1 |
| 100 | 188.4 |

[1] Source of information White River Navigation Study.

The Canal 3200 lift station has a maximum capacity of 100 cfs. The upstream and downstream canal bed elevations are 220.8 and 231.8 ft. msl respectively, creating a step-up in the canal bed of 11.0 ft. As shown in plan view on Plate III-C-2, an earthen embankment separates the upstream and downstream canals. An intake pipe directs water from the upstream canal to the reinforced concrete lift station structure where the water is lifted and released into the downstream canal. Plate III-C-3 shows the lift station structure in longitudinal section, with intake pipe and pump bay shown. Plate III-C-4 shows the lift station in transverse section, with 5 pump bays.

The DeValls Bluff pump station and the Canal 3200 lift station have only been described to the extent necessary to demonstrate feasibility and to show the relationship between hydraulic structures in the delivery system. A more detailed description of pump station design is provided in the Mechanical and Electrical portion of the project report.

## 3-C-03. CANALS.

a. General. The White River pump station at DeValls Bluff will force water through a 6000 ft long pipeline to a location on high ground where it can be released into the canal system. Although not an open canal, this pipeline functions as the first segment of the canal system and therefore is described in this portion of the report. A canal receives the water from the pipeline and branches to distribute it across the project area. The canals have very small slopes and average flow velocities of 2 fps or less, essentially forming a series of pools. Check structures serve to form and to control the canal pools.

b. Design Data. Information required to design the pipeline included total design discharge, difference between inlet and outlet water surface elevations, pipeline length, and loss characteristics. The design discharge used for the pipeline was 1800 cfs, which reflects demands for some areas which have been withdrawn from the project. The design inlet water surface elevation was 153.3 ft msl (corresponding to the lowest river stage on record) [18]. The canal design water surface elevation at the pipeline outlet was 232.8 ft msl for a lift of 79.5 feet. The length of the pipeline was determined to be 6000 feet. Loss characteristics were dependant on the pipeline material selected and the dimensions of the pipeline cross-section. Although a concrete box-culvert section was considered, a circular steel pipe section was selected for evaluation. For the steel pipe a Darcy-Weisbach roughness of 3 mm was selected to allow for development of rust and general tuberculation over time [19]. Minor loss coefficients were determined to be 0.5 for entrance loss, 0.3 for bend loss, and 1.0 for exit loss [20].

Information required to design the canals included demand data, geographical data, soils data, losses, and hydraulic data. To develop demand and geographical data, tract irrigation demands were provided by the NRCS, while aerial photography and USGS 7.5 minute mapping provided project area topography and locations of improvements.

Soil properties affected canal design with respect to slope stability, channel regime, seepage, and earthwork balance. The Memphis District Geotechnical Section recommended 3H:1V canal sideslopes for stability. The silty texture of the soil was a factor in determination of the proper silt factor, f, used in the Lacey regime computations; a silt factor of 0.357 was published for "Lower Mississippi silt" [21]. Delivery system water loss due to seepage, evaporation, and operational waste was estimated at 30% of the demand. This value was based on USBR guidelines for preliminary estimation of losses in unlined earthen canals [22] and on consideration of the silty texture of project area soils, which will not seep excessively. Adopting recommendations of the Geotechnical Section, a shrinkage value of 1.3 was used for computation of earthwork balance, such that 1.3 cubic feet of channel excavation was equated to 1.0 cubic feet of earthfill.

Canal hydraulic computations required values for roughness, slope, canal depth limits, and required freeboard. A manning channel roughness of 0.035 was selected for design, which is appropriate for a maintained earthen canal [23]. Since the delivery system is designed to operate essentially as a series of pools, small channel slopes were assumed in the range of 0.001 ft/ft to 0.00005 ft/ft. Minimum desired flow depth for the smaller canals was determined to be about 3.0 feet, based on turnout inlet submergence requirements. Due to maintenance considerations, a maximum canal depth of 13 feet was adopted. USBR [24] canal freeboard guidelines were followed, which express freeboard as a function of canal discharge. As shown in Plate III-C-5 , the recommended height of the canal bank above the water surface increases slowly with increasing discharge. For example, freeboard of 3.55 ft is recommended for a canal discharging 1000 cfs, and a canal discharging 2000 cfs requires only an additional 0.55 feet of freeboard.

c. Design Method. Important considerations in design of the pipeline were to (1) avoid high flow velocity, and (2) to determine a readily available pipe diameter that provided a reasonable balance between material cost and pumping cost. A conceptual profile drawing of the pipeline is given in Plate III-C-6.

A maximum flow velocity of about 10 fps was selected to guide the design process. This approximate limit on velocity was intended to prevent damage to the pipeline and also to prevent high head loss. The design discharge and maximum velocity dictated a total pipeline cross-section area of about 180 sq ft. It was determined that two parallel pipes each 10 ft in diameter would provide 78.5 sq ft of area each, for a total cross-sectional area of 157.0 sq ft. This amounted to a flow velocity of 11.46 fps. Since the calculated velocity was close to the approximate limit of 10 fps, the calculated velocity was deemed acceptable.

The pair of 10 ft diameter steel pipes was further analyzed to determine head losses. Losses were comprised of friction losses generated along the length of the pipe and minor losses occurring at the entrance, at one bend immediately upstream of the exit, and at the exit itself. Regarding friction loss, the pipe roughness of 3 mm resulted in a relative roughness of 0.001 and a friction factor of 0.02. From the Darcy-Weisbach equation and assuming design flow conditions of 1800 cfs, the head loss due to friction was determined to be 24.64 feet, which corresponds to a friction slope of 0.00411 ft/ft. Minor losses totaled 3.70 feet, for a total pipeline head loss of 28.34 feet due to flow. Combining the 28.34 ft of head loss with the 79.5 feet of lift resulted in a total head of 107.84 ft of head for the pumps to overcome in forcing the design discharge through the pipeline. The computation described is also presented in the form of computations on Plate III-C-7.

The design process described above was intended to indicate approximate pipeline diameter and head losses in order to demonstrate the feasibility of the pipeline approach. Steel pipe can be obtained in this size range; optimization and specification of a particular pipe product will be performed in the design for construction stage.

Important canal design considerations were (1) to provide service to all irrigated tracts within the project area, (2) to maximize gravity flow distribution, (3) to determine stable canal proportions required to convey the design discharge, and (4) to obtain balanced earthwork quantities.

Preliminary canal alignments were established considering location of irrigated tracts, topography, and location of roads, utilities, buildings, and other improvements. The canals were located along ridges where possible in order to permit withdrawals by gravity flow. In most cases the preliminary canal alignments were found to be feasible and were adopted. In a few cases land rights concerns resulted in changes of alignment or in substitution of pipelines for open channels. Since loses were estimated at 30 percent, the actual design discharge of a canal exceeded demand discharge.

With canal alignment and design discharge known, canal dimensions were determined in the following manner: First, a value of canal bed slope was assumed. With slope assumed and the manning n-value of 0.035 selected, the remaining factor to determine was canal cross-section. A satisfactory canal cross-section simultaneously satisfied the requirements of sideslope stability, required hydraulic radius and area, and an appropriate width/depth ratio for channel regime stability. By adding freeboard to maximum pool depth the overall depth of the canal section was determined.

The Lacey regime method was used to determine stable channel cross-section proportions. Unlike sideslope stability, which addresses the structural ability of sloping earth to support its own weight, regime stability is a sediment transport concern. In general, for a given discharge and soil type there is a combination of bed slope and cross section dimensions for which the quantity of sediment transported into the reach is equaled by the quantity transported out of the reach. If this balance does not exist the channel will alter its boundaries until balanced sediment transport (regime) is achieved [25].

The basic Lacey equation is, [26]:

$$U = 1.17\,(Rf)^{0.5}$$

where U = velocity, fps
R = hydraulic radius, ft
f = silt factor.

The equation states that for a stable channel the average velocity is equal to a constant times the square root of the product of hydraulic radius and a silt factor. Recommended silt factors vary from a low of 0.357 for "Lower Mississippi silt," to 1.00 for "Standard Kennedy silt," to a high of 39.60 for "massive (24") boulders". Lacey manipulated the basic stability equation to provide solutions for channel area, perimeter, and bed slope. For project conditions, using a silt factor of 0.4 and a maximum allowable velocity of 2.0 fps, the Lacey equations resulted in the following two relationships:

$$2 \leq W/D \leq 3 \quad \text{for } Q \leq 400 \text{ cfs}$$
$$3 \leq W/D \leq 5 \quad \text{for } Q > 400 \text{ cfs}$$

where W = canal bottom width, ft
D = canal flow depth, ft
Q = design discharge, cfs.

The maximum velocity of 2 fps was selected in order to minimize erosion, to minimize head loss, and to produce a controllable pool-like canal system. For a given channel width, maximum downstream and minimum upstream values of flow depth were calculated for the regime proportions. The calculated depths were large enough to provide the turnout inlet heads required. The allowable range in canal depth divided by the assumed slope length yielded the maximum permissible length for that canal, to be established by installation of check structures.

An invert elevation intended to result in balanced earthwork quantities was assumed for the canal, and hydraulic computations were performed using the calculated cross-section dimensions. A check was then performed to ensure that the Lacey W/D proportions were satisfied all along the length of the canal, particularly at locations where a change in channel dimensions occurred. Earthwork balance was checked by use of the Memphis District computer program PROF3500. If earthwork quantities were not in balance, either a new slope was assumed or a new starting elevation was assumed and the canal design cycle was repeated.

Additional considerations in canal design included the elevation of the canal water surface, the maximum drop across check structures, and design details for small canals. It was desired that the water surface in the canal be above the elevation of natural ground in order to facilitate gravity flow for withdrawals and also to minimize excavation quantities. The drop across check structures was limited to about 5 or 6 feet from upstream bed to downstream bed. For small canals conveying 20 cfs or less, a minimum depth of about 3 feet was maintained and stable canal proportions were selected to minimize pool surface area and associated evaporation loss. However, in locations where excavated material was needed for fill, stable canal dimensions were selected to provide the material even if pool surface area was not minimized.

Canal hydraulics were modeled using the UNET one-dimensional unsteady flow computer program [27]. UNET was well suited for this modeling effort, since the canal system is essentially a series of pools through which transient flows pass as check structure gate settings are adjusted. The UNET model was used to calculate water surface profiles and also the lag time required for downstream demands to be satisfied by the passage of discharges through the series of canals. Since the water surface profiles change with respect to both space and time, the UNET model provided multiple flowlines as output. By identifying the maximum enveloping water level at a station and adding freeboard the total required depth of the canal was determined for that station.

Erosion control was also considered in canal design. Types of erosion evaluated were general scour due to flow, wave-induced erosion, and localized erosion due to sudden changes in canal configuration. Due to the selection of design flow velocities of 2 fps or less and the use of regime canal design principles, canals were found to require no general riprap protection against flow-related scour. Since the canal pools will be maintained at an essentially constant elevation and the long, straight canals have significant fetch, there is potential for long-term wave-induced erosion similar to that occurring along lake shorelines. Wave-induced erosion will be resisted somewhat by vegetation on the embankment, but near the water line the growth of vegetation will be suppressed. In an extreme case wave erosion could seriously damage canal embankments, but the most likely extent and rate of wave erosion is difficult to estimate. Although lining the canal waterlines with riprap is physically possible, this approach was not seriously considered due to the high cost. In the expectation that wave erosion will not be a significant problem, it was decided to recommend provision for occasional wave erosion repair in project operating costs and for coverage of the topic in the O&M manual. Regarding local scour, velocities are low enough that even sharp canal bends or abrupt changes in dimensions are not expected to require riprap protection against flow. It is possible, however, that certain exposed locations in bends may require protection from direct wave attack. During design for construction, if it should become apparent that isolated canal locations require riprap protection for whatever reason, design of localized riprap protection will be performed at that time.

d. Design Results. The main pipeline design process resulted in a feasibility design featuring two parallel pipes each 10 feet in diameter and 6000 feet long.

The canal design process resulted in a system of canals and of pipelines with canal designations. The canal-designated pipelines are described under the pipeline portion of this report. The canals were trapezoidal in cross section except for a few triangular cross-sections for small canals. As shown in Plate III-C-8 three typical canal cross-sections were designed. The first is a full-fill cross-section, where the bed elevation of the canal matches the natural ground elevation. The second type is the partial cut cross-section, where the canal bed elevation is below natural ground but the water surface elevation is above natural ground. The third type is the full cut cross-section, where both the canal bed and the water surface are below natural ground. Main canal levees were designed with 15 ft topwidths, while the minor canal levees were designed with topwidths 10 ft wide on one side and 5 ft wide on the other side. Both the partial cut and the full cut cross-sections were designed with a minimum levee height of 2.0 ft above natural ground. All cut slopes and fill slopes were designed at 3H:1V.

Six main canals were designed, designated as Canal No. 1000, 2000, 3000, 4000, 5000, and 6000; subsidiary canals were designed for each of these main canals. The alignment of canals was strongly influenced by La Grue Bayou, which crosses the project area from the northwest near Carlisle to the southeast near Ulm. Canal 1000 is the largest and most upstream canal in the system, receiving water from the outlet of the pump station pipeline. It has a capacity of **1790** cfs, a bottom width of 60 ft, and a slope of 0.00005 ft/ft. With a length of about four miles, Canal 1000 is much shorter than the other main canals and terminates at Highway 70 about two miles west of DeValls Bluff. Canal 1000 leads into Canal 2000, which serves the north-east portion of the project area north of La Grue Bayou near Hazen and Roe. Canal 2000, leads into Canal 3000, which serves the north-west portion of the project area near Hazen, Carlisle, and Slovak. After crossing to the south side of La Grue Bayou near the west boundary of the project area, Canal 3000 delivers the water used by Canals 4000, 5000, and 6000. Canal 3000 leads into Canal 4000, which serves the west portion of the project area near Slovak. Canal 4000 leads into Canal 5000, which serves both the west and east portions of the project area near Stuttgart and Ulm. Canal 5000 leads into Canal 6000, which serves the project area south of Stuttgart. For comparison with Canal 1000, Canal 6000 begins with a bottom width of 42.5 ft, a design discharge of **816** cfs, a bed slope of 0.00005 ft/ft, and terminates with a 5 ft bottomwidth, a design discharge of 150 cfs, and a bed slope of 0.0002 ft/ft.

Results of canal design are presented in two plates. Plate III-C-9 presents canal information for selected stations, including bottom elevation, design discharge, slope, bottom width, and remarks concerning associated control and withdrawal structures. Plate III-C-10 presents freeboard related information for selected stations, including maximum water surface elevation, minimum levee grade elevation, and minimum required operation range. In this plate the main canals 1000 through 6000 are represented as one continuous "main" canal.

In addition, Plate III-C-11 presents a plan view of a canal transition from Laterals 6215 and 6216 into Little La Grue Bayou. Unlike the canals described above, this canal transition does not function as a pool, but instead simply conveys flow under conditions approximating normal depth. However, the design techniques used for the other canals were applicable to the design of the canal transition and were applied.

## 3-C-04. CHECK STRUCTURES.

a. General. Check structures feature gates which are used to regulate the water surface elevation in the canal pool upstream of the structure and to release flow to the downstream canal pool. The details of check structure operation depend on the canal system operation concept being applied, i.e. downstream or upstream operation [28]. Check structures are operated dependant on flow volumes to maintain the canal water surface elevations required for deliveries at turnout structures. The structure design varies according to the maximum discharge capacity. Main canal sites with high flow rates are controlled with large open channel gated check structures, while sites with lower discharges may be controlled with closed conduit check structures.

b. Design Data. Design data included design discharge, loss coefficients and conduit roughness, and upstream and downstream water surface elevations.

c. Design Method of Main Canal Check Structures. Main canal gated check structures were required on Canals 1000-5000, due to the magnitude of discharge, which ranged from 817 cfs to 1407 cfs. A typical gated check structure is shown in plan view in Plate III-C-12. The structure features the gates themselves, a stilling basin, and overflow weirs to either side of the gates. Plate III-C-13 shows the structure in longitudinal section, depicting a gate and the stilling basin. Plate III-C-14 shows a half-transverse section of the structure, depicting a gate and the sheet piling which serves as an overflow weir in the event that the upstream water surface elevation rises too high.

The types of gate typically used for check structures are the sluice gate (vertical lift) and the tainter (radial) gate. Sluice gates were selected by the Mechanical Engineering section for this project because, unlike tainter gates, gate operator mechanisms for sluice gates are prefabricated and can be easily obtained, and the smaller structural members supporting the gates tend to make vertical lift gates more cost effective than tainter gates. Gate sizes are dependant on the required demand flows in the downstream canal under maximum water surface elevation conditions. Gate discharges were computed using the standard orifice equation for free flow conditions, as shown below:

$$Q=cA(2gH)^{0.5}$$

where "c" is the contraction coefficient for sluice gates, "A" is the cross sectional area of the gate opening in square feet, "g" is the acceleration of gravity in feet per second squared, and "H" is the difference between the upstream water surface elevation and the centerline of the gate opening in feet. Sluice gate contraction coefficients as presented in reference [29] ranged from 0.598 to 0.611. Based on this range, a coefficient of 0.60 was selected to analyze free flow conditions at each check structure.

Under submerged conditions, the contraction coefficient is a function of the tailwater depth, $h_s$, and gate opening, $g_o$ [30]. Head, H, is the difference between the upstream and downstream water surface elevations. The submergence adjustment was made following U.S. Army Corps of Engineers guidance [31],[32]. The submerged contraction coefficient, $c_s$, and its relationship with tailwater depth and gate opening are shown below:

$$c_s=c(h_s/g_o),$$

where $c_s$ would substitute for “c” in the equation above for “Q”.

Stilling basin design was conducted following U.S. Bureau of Reclamation (USBR) guidance [33] as Type-I hydraulic jump stilling basins without baffle blocks. EM 1110-2-1605 suggests the stilling basin should be designed for a single gate fully open with normal headwater and minimum tailwater. An array of gate openings and tailwater conditions were analyzed for stilling basin design to ensure all ranges of velocities anticipated during operations were considered. The initial condition analyzed was a 1.0 ft. gate opening assuming no tailwater in the receiving canal. Subsequent gate openings were increased until the gates were eventually clear of the water surface. Maximum stilling basin lengths resulted with the maximum gate openings. Riprap protection and limits were designed both upstream and downstream of the structures using procedures outlined in EM-1110-2-1605. Approach riprap limits were set at

50 feet for all checks and the downstream limits were set at 10 times the conjugate depth, $y_2$ as outlined in the EM.

d. Design Method for Gated Conduit Check Structures. Gated conduit check structures are corrugated metal pipes used for flows of approximately 300 cfs and less. The gated conduit check structures consist of pipes installed under in-channel earth dams separating the upstream and downstream canal pools. As shown in Plate III-C-15, the horizontal conduit conveys water from the upstream pool to the downstream pool. A riser houses the vertical lift gate, which regulates flow to the downstream canal. Gate operation will maintain desired upstream pool elevations and the required flows released to the downstream canal.

Conduit sizes were determined using the CULVERW program developed by the St. Louis District, Corps of Engineers [34]. This program calculates a headwater rating curve at the entrance to either box or circular culverts. It has the capability to analyze multiple culverts and computes a headwater rating curve for submerged outlet conditions. The horizontal conduit was sized to pass the maximum required flows downstream with maximum pools or tailwater conditions in the receiving canal. Riser dimensions 1.5 times the horizontal conduit diameter were adopted. This adopted proportion may be altered during design for construction if necessary to accommodate specific gate products.

Riprap protection was designed for the conduit check structure outlets. Riprap gradations and thicknesses were determined as outlined in EM-1110-2-1601 [35]. The length of riprap protection was determined using the following equation found in Report H-74-9 [36]:

$$L_{sp}=D_o3(Q/D_o^{5/2})$$

where "$L_{sp}$" is the length of protection in feet, "$D_o$" is conduit diameter in feet, and "Q" is flow in cfs.

e. Design Results. A complete list of main canal check structures is provided on Plate III-C-16, including the identification of each structure, minimum upstream pool elevations, bottom elevation, and explanatory remarks. Likewise, a complete list of conduit check structures is provided in Plate III-C-17.

## 3-C-05. EXISTING STREAMS.

a. General. A number of existing streams are intersected by the canal system, therefore, some selected existing streams were designed to convey irrigation water from the canals to the landowners. Streams were selected based on the considerations of advantageous access to irrigated tracts and on available stream conveyance. Computer hydraulic models were built for Barnes Creek, Caney Bayou, East Stuttgart King Bayou, Elm Prong of Mill Bayou, Hurricane Bayou, Hurricane Creek, Little LaGrue Bayou, Lost Island Bayou, Mill Bayou, Peckerwood

Lateral, Sherrill Creek, South Mill Bayou, Stuttgart King Bayou, Upper LaGrue Bayou, and Wolf Island Slash. These models were used to determine frequency flowline information and to aid in locating and sizing riprap weirs which are necessary to adapt the existing streams to serve as delivery system components.

b. Design Data. Field survey cross-section data was used to build HEC-2 models for the natural streams. This survey information was also used to build the UNET unsteady flow models to represent the distribution system and to determine lag times in the natural streams by analyzing the conveyance capabilities of each stream. Discharges for input to these models were derived using HEC-1 models for each of the natural stream's watershed, which is discussed in Topic B. Manning's roughness coefficients were determined through field reconnaissance, guided by standard references [37], [38]. Road crossing information for bridges or culverts was obtained from survey information and was coded into the HEC-2 model using the special bridge routine.

c. Design Method. The existing stream computer models were executed to estimate the magnitude of the frequency flows compared to bankfull discharge and to predict how small increases in discharge due to the addition of irrigation flows would affect the frequency flowline elevation. The largest irrigation flows introduced into the channels were only about 10% of the 1.01-year event, which is above bankfull. This resulted in very small changes to frequency flowlines, which were depicted by plotting stage-frequency curves. Since the bankfull elevation is also the zero flood damage elevation, changes in flowlines were considered in the design of the riprap weirs. This was a critical concern, because the weirs must pool water in the existing streams without significantly increasing water surface elevations at bankfull discharge.

d. Design Results. Because the additional irrigation water is a small percentage of the 1.01 year event, changes to 1.01 year event and other frequency events are not significant. The effects on bankfull capacity are addressed in the riprap weir section of the report. Results of the hydraulic study of the existing streams are presented in three sets of plates. Plate III-C-18 presents flowlines for the streams under existing conditions for eight frequencies ranging from the annual to the 500-year event. Plate III-C-19 presents flowlines for the streams for with-project conditions for the same eight frequencies. Plate III-C-20 presents the stage frequency relationship for both existing and with-project conditions at selected stations along thirteen streams. This plate shows that the estimated elevation difference between the existing and with-project conditions is less than 0.4 feet for all plotted streams over all frequencies considered. Most of the elevation differences are less than 0.1 feet with greater elevation difference predicted for the less frequent events.

**3-C-06. PIPELINES.**

a. General. At certain locations within the project area it is more practical and/or efficient to deliver water through pipelines than through open channels. In some instances pipelines fit into right-of-way restrictions better than open channels. Some reaches feature unfavorable depths of cut for an open channel, and some reaches have an adverse grade requiring pumped conduit flow. The pipelines are also typically used near the end of a branch in the delivery system where discharges are low enough to be readily conveyed through a conduit of economical size. However, in some cases pipelines were substituted for segments that had been originally planned for canals due to right-of-way limitations. Discussion of the design for the pipeline between the DeValls Bluff pump station and canal 1000 is presented in 3-C-03.

b. Design Data. Data required to design the pipelines included topography, irrigation flow demands, head losses, and pump characteristics. Table III-C-3 presents the values of minor losses associated with pipeline fittings and appurtenances. The recommended loss values were increased 10 percent to allow for variances in materials, construction, and future conditions. Table III-C-4 presents values of Hazen-Williams pipe roughness for PVC and concrete pipelines. These values were also adjusted 10 percent to allow for variances in materials, construction, and future conditions. Pumped pipeline criteria are presented in Table III-C-5. The motor and pump efficiencies were provided by Mechanical and Electrical Branch to be used as a generalization for the size of pumps used in this project. The minimum pipe diameter and motor horsepower requirements were from SCS recommendations based on actual field practices. The maximum pipe velocity, kinematic viscosity, and roughness coefficient were taken from design guidelines.

Table III-C-3 Minor Loss Coefficients [39]

| **Fitting** | **Coefficient** | |
|---|---|---|
| | Recommended | Used (10% increase) |
| 45° Elbow | 0.40 | 0.44 |
| 90° Elbow | 0.50 | 0.55 |
| Tee, Line Run | 0.30 | 0.33 |
| Tee, Branch Run | 1.80 | 1.98 |
| 45° Wye, Line Run | 0.30 | 0.88 |
| 45° Wye, Branch Run | 0.80 | 0.88 |
| Coupling | 0.33 | 0.33 |
| Squared Entrance | 0.50 | 1.1 |
| Exit | 1.0 | 1.1 |

Table III-C-4 Hazen-Williams Discharge Coefficients [40]

| **Pipe Material** | **Factor** | |
|---|---|---|
| | Recommended | Used (w/10% decrease)* |
| Poly-Vinyl Chloride Pipe (PVC) | 130 | 117 |

| | | |
|---|---|---|
| Reinforced Concrete (RCP) | 100 | 90 |

* A decrease in the coefficient corresponds to an increase in roughness.

Table III-C-5 Pumped Pipeline Criteria [41]

| | |
|---|---|
| Motor Efficiency | 90% |
| Pump Efficiency | 75% |
| Minimum Pipe Diameter | 6" |
| Minimum Motor Horse Power | 5 hp |
| Maximum Velocity in Pipe | 5 fps |
| Kinematic Viscosity | $1 \times 10^{-5}$ |
| Roughness Coefficient ($\epsilon$) | 0.0018 |

c. Design Method. Due to the large number of pipelines, depth, outlet head, and velocity limits were standardized to aid in design. The pipelines were designed at a pipe invert depth of 5 feet below natural ground in order to obtain adequate cover. Final design of pipelines will provide at least one pipe diameter of cover or the minimum cover specified by the manufacturer. The pipelines were sized to deliver water at design discharge to an elevation 5 feet above natural ground elevation at the pipeline outlet as a design safety factor to ensure that adequate head was provided at the ground level. The minimum design velocity desired in the pipe network was 2 fps in order to prevent settling of sediment. The maximum desired design velocity was 5 fps in order to protect the pipe from flow-related damage. In several cases the calculated velocities exceed 5 fps and appropriate measures, according to manufacture's specifications, should be taken to adequately protect these pipelines against surge. These pipelines can be identified by referring to the "velocity delivered" column in Plate III-C-22. Pipes were sized to minimize pumping horsepower requirements.

The scale and complexity of the pipeline system warranted analysis aided by specialized computer software. Pipe and pump sizes were determined using the CYBERNET AutoCAD add-in program developed by Haestad Methods. This process consisted of graphically constructing a pipe network schematic for each site. Once the schematic was completed, various components such as static nodes, junction nodes, pumps, pressure regulating valves (PRV), pressure sustaining valves (PSV), flow control valves (FCV), check valves, and minor loss components were added by snapping to their desired location on a schematic. Pull down menus for each type of component were accessed, and values added for pipe lengths, diameters, and roughness coefficients, static node water surface elevations, junction node elevations, and pump work horse power (whp). Values for minor loss coefficients were assigned to each type of fitting and were applied to the network calculations when a fitting was inserted into the schematic. The basic editing environment of CYBERNET consists of numerical models which yield a complete and accurate simulation of the system network pressures, pipe flow rates, hydraulic grades, and pumping rates using Hazen Williams or Darcy-Weisbach friction equations. These numerical models incorporate the algorithms contained in the standard KYPIPE2™ computer program. A sample computation and sample network schematics are shown in Plate III-C-21.

Motor efficiencies of 90% and pump efficiencies of 75% recommended by the Mechanical and Electrical section were adopted. These efficiencies were used to distinguish the nominal horsepower of the pump from the lesser work horsepower effective in moving water through the pipeline. For example, if a pump is listed on Plate III-C-22 as 10 hp, the work horsepower (whp) would be 10 x 0.90 x 0.75 = 6.75. The work horsepower was the value entered in the CYBERNET program. Results from CYBERNET pump routine were cross-checked using manual methods and found to correlate well.

d. Design Results. Pipeline design results for the project area are presented in three plates. Plate III-C-22 summarizes pipelines that are identified by the standard project numbering system for pipelines. The plate presents pipeline length, required capacity, material selected, pipe diameter, pump horsepower, actual capacity, and velocity.

Some segments of the delivery system were originally designated to be served by canals, but due to unfavorable site conditions such as limited right-of-way or unfeasible depth of cut found during design, were converted to pipeline systems. These new pipelines retain the original canal numbering convention. Plate III-C-23 presents design results for such pipelines that are designed as in-line dual pipes. All these dual pipelines are made of reinforced concrete pipe (RCP). Plate III-C-24 presents results for in-line single conduits. The in-line single conduits are made of either PVC or RCP.

## 3-C-07. INVERTED SIPHONS.

a. General. It is necessary to keep delivery system flow separate from natural stream flow (except where the natural streams are intentionally used to receive canal flow as components of the delivery system). The alignment of the delivery system canals would block intersecting natural streams if no provision were made to reroute flow in either the canal or the stream. Locations were identified on USGS 7.5' quadrangle maps where this would occur, and inverted siphons were sized for these locations. A conceptual drawing of an inverted siphon is provided in Plate III-C-25. In most cases the design discharge for the natural stream was less than the design discharge for the canal, and a smaller siphon resulted by passing the natural stream under the canal. However, in a few instances canal design discharge is less than that for the natural stream, so the canal was passed under the natural stream.

Where the canal was passed under the natural stream, the required capacity of the siphon was known. For the typical case where natural streams were routed under canals, it was necessary to determine the required capacity. Therefore, the natural stream drainage areas were delineated in order to determine runoff for the design storm. Based on a 50 year project design life, a 100-year design event was selected to size the siphons. A head of 0.3 foot on the siphons was adopted as the allowable head that would produce insignificant increases in upstream water elevations. Using the design event and maintaining this minimum head on the siphons, a spreadsheet was built in order to analyze each of the structures using the SCS equation for time of concentration, the rational method for predicting peak discharge, and the Hazen-Williams head loss equation for flow in pipes.

b. Design Data. The inverted siphon design procedure required the following parameters as input: drainage basin area, either the runoff coefficient and rainfall intensity for the rational method (C and i) or the $Q_{100}$ from a previous study if available, and energy loss coefficients for entrance, exit, bend, and friction losses. Based on previous studies using the rational method to compute runoff for a basin, small subbasins (1 square mile or less) produced peak discharges that were comparable with gage records. Larger subbasins tended to yield peak discharges that were higher than gage records. Because most of the subbasins were small, it was decided that the rational method would be used for runoff determination and that larger than recommended subbasins would be slightly over designed to account for inaccuracies in quadrangle maps used in the design.

Drainage basin areas for each siphon were planimetered from USGS quadrangle maps. In the cases where one basin drained into another, the value entered in the spreadsheet reflected the total combined area.

The runoff coefficient selected for the rational method was C=0.5, which is suitable for flat, cultivated land with clay and silt loam [42 ]. In order to approximate rainfall intensity, five representative siphon locations were selected for their catchment characteristics. The time of concentration was calculated for each drainage area according to the SCS equation [43], which was developed for agricultural watersheds. The equation is:

$$t_c = \frac{100(L)^{0.8}\left(\frac{1000}{CN}-9\right)^{0.7}}{1900(S)^{0.5}}$$

where "L" is the length of the watercourse in feet, "S" is the average slope in percent, and "CN" is the SCS runoff curve number. The time of concentration ,$t_c$, is equal to 1.67 times the basin lag.

The runoff curve number, CN, depends on soil properties and vegetative cover [44].

Each soil series identified by the SCS is classified in one of four hydrologic soil groups: A, B, C, and D. High infiltration rates are associated with hydrologic soil group A, while very low infiltration rates are associated with group D. The principle soil series in the project area are Grenada, Stuttgart, and Crowley, which are classified respectively in hydrologic soil groups C, D and D [45] and have low to very low infiltration rates. For a soil in a given hydrologic soil group, heavy vegetative cover such as pasture produces lower curve numbers, while sparse vegetative cover produces higher curve numbers. A project curve number of 90 was adopted, which is representative of fallow hydrologic soil group C and D soils.

Values for time to concentration were calculated for the five areas and were averaged to obtain a single value of 3.2 hours. Based on a time of concentration of 3.2 hours, a rainfall intensity of 1.66 inches/hour was derived. Using the TP-40 rainfall maps [46], this was found equivalent to a 100-year, 3 hour storm.

As mentioned above, the rational method is considered applicable to catchments smaller than 1 square mile, but some siphon locations had drainage areas that exceeded this limit. Since the values given by the rational method could overestimate the design discharge, design discharges determined from any previous studies were used for design if available.

Tailwater depth for the siphons was assumed to equal the diameter of the selected pipe size unless a flowline elevation was available for use from a previous study.

The effect of minor head losses was included in design computations. An entrance loss coefficient of K=0.8 was adopted for pipes projecting from fill [47]. The exit loss coefficient used was K=1.0 [48]. The value adopted for a 45 degree bend was equal to K=0.16 [49]. All energy losses mentioned above were calculated by using:

$$h_L = K\left(\frac{V^2}{2g}\right)$$

The conduit friction loss was estimated by the Hazen-Williams head loss equation:

$$h_L = 3.02(L)(D)^{-1.167}\left(\frac{V}{C}\right)^{1.85}$$

where "L" was set equal to 250 feet, "D" was the pipe diameter in feet, and "V" was the velocity in fps. The length, L, was standardized at 250 ft in order to provide for head losses associated with the longest siphon lengths expected in the project area. The coefficient "C" for a corrugated metal pipe (CMP) was C=60 [50].

The data used to design each inverted siphon is presented in two plates. Plate III-C-26 presents a summary of design data, as well as resultant siphon dimensions, for the inverted siphons that convey natural stream flows under a canal. Design data includes drainage area, rational method "C" value, the reference discharge determined during the previous study if available, the design discharge, head and tailwater, and loss coefficients. Plate III-C-27 presents comparable information for inverted siphons conducting canal flow under natural streams. No hydrologic data appears in this plate, since the design discharge was known.

c. Design Method. The design was based on the criterion that headwater would be limited to 0.3 feet above the top of the pipe when passing the $Q_{100}$ through the siphon. Based on the largest canal size in the water delivery system, the inverted siphons were assumed to have a total length of 250 feet, a conduit slope of 1%, and four 45 degree bends. This configuration translates to vertical drop of about 2.34 feet between the entrance and the exit. For conditions where no tailwater was available or tailwater is equal to the diameter of the pipe, the following equation was used:

$$HW = (h_{entrance} + h_{exit} + h_{bends} + h_{friction}) - 2.34$$

where "HW" is headwater in feet above the top of the pipe, and head losses are expressed in feet. Where a tailwater was available and not equal to the diameter, the equation for headwater was modified to the following:

$$HW = TW - D + (h_{entrance} + h_{exit} + h_{bends} + h_{friction}) - 2.34$$

where "TW" is tailwater above the downstream invert in feet, "D" is the diameter of the pipe in feet, and all other values remain as previously defined. Values of available diameter CMP were 24, 30, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, and 96 inches. An iteration was performed by checking the capacity of single or dual pipelines of progressively increasing diameters until the above mentioned 0.3 ft criterion was obtained.

d. Design Results. Design results are presented in the two plates mentioned above, Plate III-C-26 and Plate III-C-27. Design results consist of a conduit diameter and the number of parallel conduits required.

## 3-C-08. TURNOUTS.

a. General. Turnouts are used to divert water from a segment of the delivery system toward one or more water users. Water may be diverted from a canal, from an existing stream, or from a pipeline. Typically the water exiting a turnout enters a smaller receiving channel, but some turnouts divert water into pipelines. The USBR publication "Design of Small Canal Structures" was used as a guide in designing project turnouts [51].

Five types of project turnouts are provided for, as described below:

Type-1. This gravity flow corrugated metal pipe structure is the most typical turnout, where water is drawn from the side of a canal and is diverted through the canal bank into the upstream end of a receiving channel. As shown in Plate III-C-28, a horizontal inlet conduit conveys water to a gate housed in a riser. Flow passes through the gate and horizontal outlet conduit to the receiving channel. The plate also shows the riprap outlet protection, which protects the channel from scour. Plate III-C-29 is a plan view of a Type-1 turnout, showing the relationship between the canal embankments and the embankments of the receiving channel.

Type-2. This type differs from Type-1 in that the water is diverted into a buried pipeline instead of an open channel, as shown in Plate III-C-30. No riprap protection is required.

Type-3. This type differs significantly from Types-1 and -2, due to the presence of a pump for forcing diverted flow through a buried pipeline. It is used at locations where a high pipe outlet elevation or intervening high ground prevents gravity flow from the turnout. As shown in Plate III-C-31, no gate is required in this type, since control is provided by the pump itself.

Type-4. This type is identical to Type-2, except the turnout is located at the very end of a canal, rather than being located along the side of a canal, as shown if Plate III-C-32.

Type-5. Unlike all previously described types, this turnout receives water from a buried pipeline and diverts flow into an open channel. As shown in Plate III-C-33, the construction is very similar to the Type-1 turnout, except no riprap protection is provided.

b. Design Data. Data required for turnout design included design discharge, inlet head, and tailwater depth. Also required were estimated values of minor loss coefficients and pipe roughness.

c. Design Method. For Type-1 turnouts pipe flow velocity affects outlet stability and also affects design pipe diameter. It was necessary to select a typical velocity in order to proceed with other aspects of turnout design. The USBR recommends that structures discharging into an unlined channel should have a maximum pipe velocity of approximately 3.5 feet per second [52]. Alternatively, turnouts with protected outlets have a maximum permissible pipe velocity of approximately 5 feet per second. Given the erodible project area soils, it was believed that scour would occur even at the lower velocity, so riprap protection and a velocity of 5.0 feet per second was selected. The USBR recommends a minimum turnout pipe diameter of 18 inches [53], which was adopted as the minimum diameter for the project.

Turnout types 1, 2, and 4 draw water by gravity directly from a canal and must have sufficient inlet head in order to function at design discharge. The coordination of canal pool elevations with turnout inlet invert elevations was therefore a prime design requirement. Once the pipe size was determined, the turnout elevations were designed to overcome the head loss for the required maximum delivery discharge and minimum upstream pool elevation. Total energy (head) loss through a turnout is comprised of pipe entrance loss, friction loss, and exit loss. The equation for head loss is shown below:

$$h_l=0.78h_v+LS_f+h_v$$

where $h_l$ is total head loss in feet, $h_v$ is the velocity head in feet, L is the length of the horizontal conduit, $S_f$ is the friction slope in feet per feet. A factor of 1.78 times the velocity head was added to the total energy loss and subtracted from the control water surface to set the final turnout invert. The USBR recommends this factor be used to ensure proper submergence of the turnout to promote smoothness of flow and accuracy of water measurement devices incorporated into the structure [54].

Main canal turnouts diverting flow into secondary canals were analyzed where tailwater elevation was known, and sized using the CULVERW computer program developed by the St. Louis District Corps of Engineers. CULVERW was written to permit analysis of tailwater effects on conduit capacity.

For gravity flow turnouts, the gate and appurtenances used to control flow rate are housed in a corrugated pipe riser. In order to house the vertical gate and to facilitate attachment to the horizontal conduit, it is desirable for the riser to have a greater diameter than the horizontal conduit. A riser diameter 1.5 times the diameter of the horizontal conduit economically provides the needed enlargement and was selected as a standard proportion in the turnout design. Gate sizes were approximated as equal to the horizontal conduit diameter. The length of riprap protection was determined using the equation:

$$L_{sp}=Do3(Q/_o{}^{5/2})$$

where "$L_{sp}$" is the length of protection in feet, "$D_o$" is conduit diameter in feet , and "Q" is demand flow in cfs [55].

d. Design Results. The results of turnout design are presented in Plate III-C-34, including associated canal number, length and diameter of conduit, gate size, turnout type, and number of parallel conduits.

**3-C-09. RIPRAP WEIRS.**

a. General. As described in 3-C-08, it is essential that a sufficient depth of water be pooled at the inlet of each turnout in order for the turnout to attain its design discharge. This requirement applies along existing streams, as well as along canals. Weirs were designed to create the necessary pools along the existing streams.

Under existing conditions, the natural streams in the project area convey flows resulting from rainfall-runoff events. At any given point along an existing natural stream a maximum bankfull discharge capacity exists, and landowners conduct their farm operations accordingly. Since the with-project natural streams will continue to convey storm runoff flows, a reduction in storm runoff capacity would tend to cause more frequent out of bank flows and consequently increase flood damages. Therefore, the goal of the weir design process was to establish a pool for irrigation operations without significantly reducing the storm runoff capacity.

Riprap weirs were the structure type selected. A riprap weir is an in-channel trapezoidal chute made entirely of rock riprap, as shown in Plate III-C-35. In profile, at the upstream end, the weir inlet apron matches the stream bed elevation. The inlet apron forms a level entrance transition protecting the upstream end of the weir from scour caused by eddies and by drawdown of the water surface profile immediately upstream of the weir crest. Proceeding downstream, the weir bed profile rises on an adverse 6H:1V slope to a design elevation a few feet above the stream bed, and runs level in the downstream direction for ten feet. This level portion forms the actual weir that pools water upstream of the structure. The profile next descends on a 10H:1V slope to an elevation below the steam bed elevation and then runs level downstream for a certain distance. This level portion below the stream bed elevation forms a stilling basin to dissipate the energy released by water flowing over the 10H:1V slope. The stilling basin is terminated by a 2H:1V adverse slope that tops out at the stream bed elevation. Continuing downstream from this point, an outlet apron runs level at the stream bed elevation. The outlet apron protects the weir from scour and forms an outlet transition.

To further describe the shape of the structure, riprap extends up the sideslopes of the weir to approximately the top bank elevation. The side slopes of the weir are typically held somewhat constant, at a slope no steeper than 3H:1V, and otherwise conforming reasonably with the existing stream cross-section. In plan view, the riprap weir typically maintains a constant topwidth overall, with the width of the bottom varying. For example, the bottom widths of the inlet and outlet aprons are essentially equal and are also about equal to the bottom width of the natural stream. The width of the ten-foot level area is wider than the stream bottom, due to its contact with the weir sideslopes at the higher elevation. The width of the stilling basin is less than the stream bed, due to the narrowing of the sideslopes at the lower elevation. Typically, the structure is no wider than the topwidth of the existing stream in order to minimize right-of-way requirements.

b. Design Data. Data required for design of riprap weirs included topography, weir height, irrigation flow demands, existing bankfull channel capacity, and the ten year design discharge. At some locations survey data was available to establish topography, but at other locations no survey data was available, so reference was made to comparable surveyed streams in order to produce a feasibility-level design for each weir.

From survey information taken in 1988, HEC-1 and HEC-2 models were constructed and used to analyze rip-rap weir hydraulics. Irrigation water flows were added to the flows used in the HEC-2 models to show with-project conditions. The following table, Table III-C-6, shows bankfull discharges (< 1.01 year) and irrigation flows for each existing waterway modeled in the project:

Table III-C-6

| STREAM NAME | FILE NAME | BANK-FULL Q | IRRIGATION ADDED (CFS) | STREAM NUMBER |
|---|---|---|---|---|
| Little LaGrue Bayou | LLBREV | 1250<br>940<br>680<br>600 | 35 @ 6000<br>27 @ 5505<br>30 @ 6215<br>70 @ 6216 | 6100 |
| Wildcat Ditch | WD | 480 | 14 | 6210 |
| Caney Bayou (Dropped Out) | CB | 700 | 8 | 6270 |
| Buck Creek (Dropped Out) | | | | 3260 |
| East Stuttgart King Bayou | ESKB | 420 | 12 | 6410 |
| Elm Prong Mill Bayou | EPMB | 650 | 22 | 6500 |
| Hurricane Bayou | HB | 600 | 10 | 6610 |
| Mill Bayou | MB | 1070 | 100 | 6300 |
| South Mill Bayou | SMB | 180 | 23.5 | 6310 |
| Stuttgart King Bayou Ditch | SKB | 670 | 130 | 5300 |
| LaGrue Bayou (Upper) | LB | 730 | 17 | 3300 |
| LaGrue Bayou (Lower) | LBEX | 1770 | 87 | 2210 |
| Lost Island Bayou | LIB | 700 | 23 | 5100 |
| Sherill Creek | SC | 820 | 16 | 5510 |
| Wolf Island Slash | WIS | 620 | 45 | 3510 |
| Barnes Creek | BC | 180 | 6 | 3230 |
| Hurricane Creek | HUC | 500 | 7 | 3210 |
| Honey Creek | HON | 1110 | 10 | 2100 |

Site specific water demand and changes in the project boundaries affected the process of riprap weir design. Buck Creek in the northwest portion of the project was deleted from the project area before weirs were designed. Removal of a southern portion of the project area deleted Caney Bayou after its weirs had been designed, but those designs were used as a reference to design weirs for other streams that lacked survey data. Although Almyra Creek (6220--located north and east of the bend in Canal 6200 in the southern portion of the project) and South Branch (no number--located north of Canal 3500A) both lie within the project limits, no demands are placed on them, and so no weirs were designed for these two streams.

Those streams for which riprap weir designs were based on estimated topography instead of surveys are listed below in Table III-C-7:

Table III-C-7

| STREAM NAME | STREAM NUMBER | DESIGN BASED ON SURVEYED STREAM |
|---|---|---|
| Miller Creek | 1300 | 3210 |
| | 1400 | 3210 |
| Pate Branch | 1500 | 2100 |
| | 1510 | 2100 |
| | 1520 | 2100 |
| | 2200 | 2100 |
| Washington Creek | 2220 | 2100 |
| | 2230 | 5100 |
| | 2240 | 2100 |
| | 2250 | 2100 |
| | 2260 | 2100 |
| South Fork of Hurricane Creek | 2300 | 3210 |
| Oak Creek | 2410 | 5100 |
| Little Hurricane Creek | 2500 | 3210 |
| | 3110 | 5100 |
| | 3200 | 3210 |
| Payne Creek | 3221 | 3210 |
| Buck creek (Dropped from project) | 3260 | 3210 |
| Johnson Branch | 3261 | 3210 |
| | 5310 | 5300 |
| Clearpoint Creek | 5311 | 5300 |
| Little LaGrue Lateral | 5520 | 6210 |
| | 5530 | 5100 |
| | 6220 | 6270 |
| Holt Branch | 6230 | 6270 |
| (Dropped from project) | 6240 | 6270 |

| | | |
|---|---|---|
| (Dropped from project) | 6250 | 6270 |
| (Dropped from project) | 6260 | 6270 |
| (Dropped from project) | 6280 | 6270 |
| (Dropped from project) | 6290 | 6270 |

Data required to size the riprap weir stilling basins included the absolute drop height, H, and the critical depth, $Y_c$, for the design discharge. These values for each weir location are included in the plates summarizing design results.

c. Design Method. Riprap weirs were sited in the following locations: (1) locations along the natural waterway that would provide service to tracts not serviced by a canal or by a major pipe system, (2) locations upstream of bridges, (3) intermediate locations providing the deepest pool to as many tracts as possible, and (4) locations where the pool from the next downstream weir ends, provided that location is not in the middle of a tract already supplied.

In order to obtain maximum benefit from each weir, it was desirable to set weirs at the highest possible elevation. It was decided to set weir elevations by determining the highest elevation that can convey the existing bankfull discharge with no significant increase in flowline elevation. More specifically, weir height was determined in the following manner: First, HEC-2 was used to determine the bankfull discharge at the location chosen. Then, the top of weir elevation was set at a trial value of one foot below the top of bank, using the sedimentation option in HEC-2. Next, the bankfull discharge at the weir location was run through the model with and without the weir in place, and the difference in water surface elevations was compared. If the difference was essentially zero, then the trial weir height was accepted; if not, the weir height was lowered, and the cycle was repeated.

Structure dimensions were based in part on a standard design for the Agricultural Research Service (ARS) low drop grade control structures installed under the Demonstration Erosion Control (DEC) Project in North Mississippi [56]. The ARS low drops typically have a drop of about five feet, and are used to stabilize channels. Unlike the Grand Prairie project riprap weirs, ARS low drops do not form a localized "hump" in the channel bed, but instead form a step in the channel bed profile. The ARS low drop structure has been designed and installed in various configurations, typically including sheet piling to support the downstream edge of the weir crest and including a baffle plate in the stilling basin. However, an early version of the ARS low drop closely resembles the riprap weir profile, and therefore equations to size this ARS stilling basin were adopted to size the riprap weir stilling basin.

The length of the stilling basin was established using a range of discharges up to the ten year event, determining the most critical discharge/tailwater condition, and using the following equations:

$$X_b = [\ 3.54\ +\ 4.26\ (H/Y_c)\ ]\ Y_c$$

and

$$L_b = 2\ (X_b)$$

where "$L_b$" is the length of the stilling basin, measured from the weir to the beginning of the downstream channel. "$X_b$ " is defined as the distance between the weir and the baffle pier or plate. Although baffle piers and plates are not used on the project stilling basins, because of low velocities, it was necessary to calculate the $X_b$ value to be used in the $L_b$ calculations. "H" is the absolute drop height and "$Y_c$ "is the critical depth for the design discharge.

Velocity of flow over the riprap weir was calculated using a standard step backwater approach in order to determine the riprap size required for stability. The flow was considered subcritical when the computed water surface elevation (CWSEL) was greater than the critical water surface elevation (CRIWS), and/or the channel Froude number (FRCH) was less than unity, while for supercritical flow the converse was true. The occurrence of supercritical flow affects the solution technique for determination of flow lines, but also from an operational standpoint the significance of supercritical flow is that it typically has more potential to cause erosion or to displace riprap than does subcritical flow. Supercritical flow was calculated at points along the nappe region (the 10H:1V slope on the downstream side of the weir crest), but only for low flow events with tailwater at normal depth for that flow condition. Velocities in the upstream and downstream regions of the weir were found to be between 0.50 and 2.50 feet per second respectively and typically about one foot per second.

Rip-rap thickness and gradations were designed using to Standard LMVD Gradation Tables [57], Hydraulic Design Criteria [58], and EM-11-2-1601[59], using velocities based on a range of low and high flows in an HEC-2 model. According to the Standard Gradation Table, for a specific weight of stone of 155 pounds per cubic foot, and using the Isbach Equation for highly turbulent flow, a rip-rap layer 18" thick and a median stone weight within the range of 20 to 40 pounds will sustain velocities as high as 6.7 feet per second. This far exceeds any velocities encountered in the HEC-2 runs, but it is standard Corps practice to use an 18" minimum thickness and this thickness was adopted.

d. Design Results. The project-wide results of riprap weir design are presented in three plates. Plate III-C-36 presents riprap weir locations, as well as controlling elevations, dimensions, and discharges. Plate III-C-37 presents stilling basin lengths and supporting data, such as the ten year critical water surface elevation and critical depth. Plate III-C-38 presents detailed dimensions of the riprap weirs, including aprons and riprap thicknesses.

## 3-C-10. WASTEWAYS.

a. General. USBR guidelines stress the importance of including protective structures in canal systems [60]. In particular, damage could result if the water level in a main canal pool were to rise too high above design elevation. At locations where the canal is higher than natural ground, an inadvertent overtopping could breech the canal embankment. Excessively high water levels could result from mechanical failure or from operator error. Also, a provision should be made to permit dewatering of an individual canal pool for maintenance. Wasteways were included in the design both to protect main canals from unintentionally high water levels and to permit dewatering for maintenance. A project wasteway is a gated conduit structure similar in design to a turnout, as shown in Plate III-C-39. Main Canals 2000, 3000, 4000, and 5000 were each provided with one wasteway structure, while Canal 6000 was provided with three wasteways. The wasteways were located where the flow will discharge into an existing stream.

b. Design Data. Information required for design included discharge and conduit characteristics. The design flows for the wasteways were determined using maximum demand flows for the reach. Since the design of the wasteways was based on demands within a particular reach, and the demands remain constant regardless of the optimal size of the White River pump station (1640 cfs, 1800 cfs, etc.), design of the wasteways was not dependant on pump size. Corrugated metal pipe was selected, with a Manning's roughness coefficient of 0.024 [61], a length of 100 feet, and an assumed entrance loss of 0.5 feet.

c. Design Method. Wasteway design included sizing of the conduits, evaluation of flooding potential, and provision for outlet protection. The conduits were sized using the CULVERW program, and equal diameter conduits in parallel were designed where required for capacity.

Although the emergency release of water from the wasteways will be infrequent, such a release under critical conditions conceivably has the potential to flood adjacent lands. For example, the maximum emergency discharge released from Wasteway #5 will be about 450 cfs, and the duration of a maintenance drawdown through the same wasteway will be about 7 hours. Typically, the maximum discharge through a wasteway will be about one-third of the bankfull capacity of the receiving natural stream. Critical conditions for flooding will exist when the natural streams are conveying high flows originating from runoff and an emergency wasteway release is added to the flow. However, since the delivery system will experience peak demand when the existing streams are normally at very low natural flow, the probability of a release during critical conditions is quite low. Regarding maintenance dewatering, the discharge rate used will typically be less than the emergency discharge and will have little potential to cause flooding.

Because outlet velocities were estimated as high as 12.6 fps at full flow conditions, protection against scour is required. If loose riprap were installed on the stream bed immediately below the conduit outlets, 5000 pound stones would be required due to the high flow velocity [62]. To avoid use of such large stone, 12 inch thick gabion splash pads with the dimensions specified in Table III-C-8 below were designed. The equation below [63] was used to size the length of the splash pad:

$$L_{sp}=D_o\left[3\left(\frac{Q}{D_o^{\frac{5}{2}}}\right)\right]$$

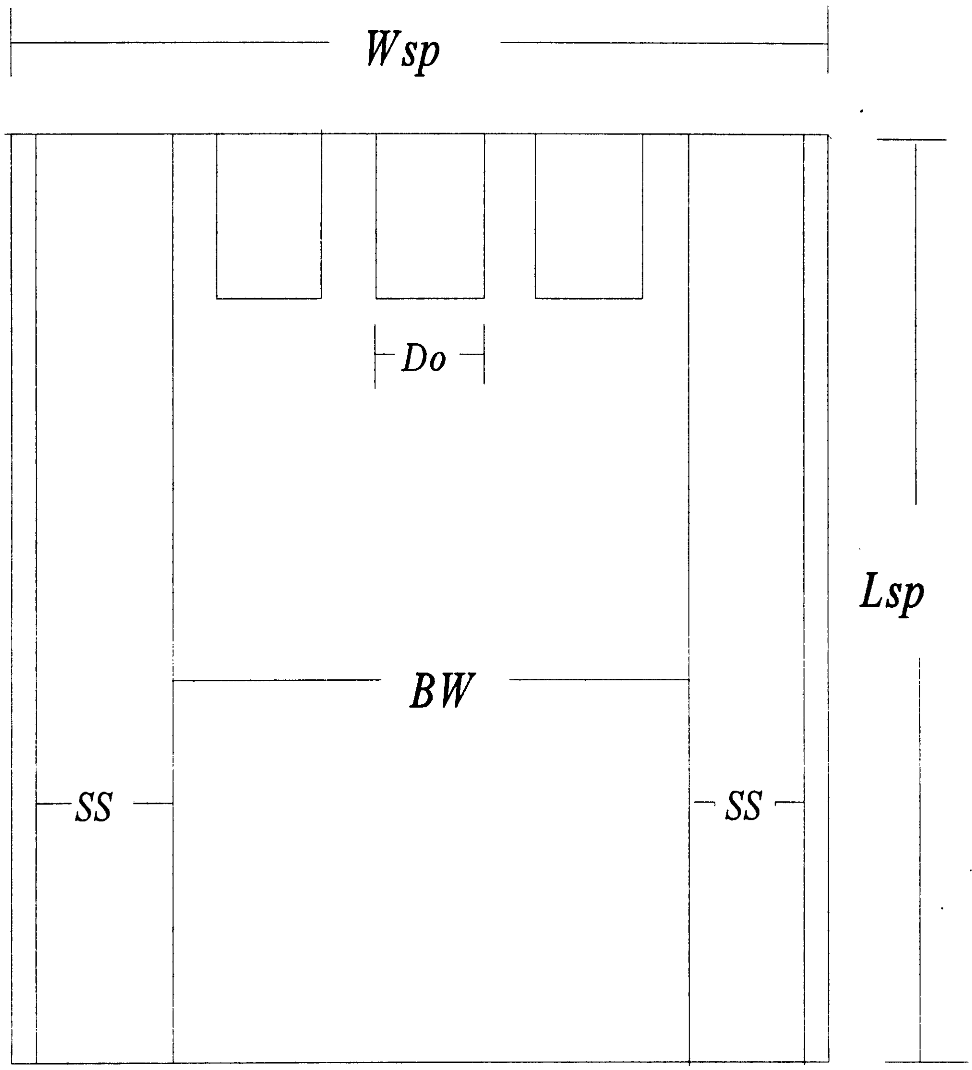
where, Lsp = length of splash pad, ft
Do = conduit diameter, ft
Q = discharge, cfs.

For the feasibility design stage it was assumed that wasteways would empty into natural channels with a bottom width of 20 feet and side slopes of 1V:2.5H. Splashpad width (Wsp) was based on this assumed bottom width. The extent of protection with mattress wrapping around the conduit outlets themselves will protect the wasteway outlets from undermining

d. Design Results. Design values for each wasteway are shown in Table III-C-8, including design discharge, pipe size, and length of the gabion splash pad. Figure III-C-1 shows a typical plan view of a riprap splash pad, with three parallel conduits overhanging and discharging onto the pad.

Table III-C-8

| **Structure Name** | **Reference Name** | **Pool Elev. (NGVD)** | **Flow (cfs)** | **Pipe Size** | **Length of Splash Pad** |
|---|---|---|---|---|---|
| | | | | | |
| Wasteway #1 | WW2000.01 | 229.2 | 366 | 3-42" CMP | 60' |
| Wasteway #2 | WW3000.01 | 226.5 | 127 | 1-42" CMP | 60' |
| Wasteway #3 | WW4000.01 | 223.0 | 167 | 1-48" CMP | 65' |
| Wasteway #4 | WW5000.01 | 220.9 | 312 | 2-48" CMP | 60' |
| Wasteway #5 | WW6000.01 | 216.3 | 449 | 3-48" CMP | 60' |
| Wasteway #6 | WW6000.02 | 206.3 | 143 | 1-48" CMP | 55' |
| Wasteway #7 | WW6000.03 | 198.5 | 87 | 1-36" CMP | 50' |




Key

Wsp = Width of splash pad
BW = Bottom width of channel
SS = Sideslope (Horizontal / Vertical)
Do = Conduit diameter
Lsp = Length of splash pad

Figure III-C-1
Typical Riprap Layout for Wasteways
(plan view)

## 3-C-11. ROAD CROSSINGS.

a. General. The open channel portion of the delivery system intersects many roadways, including state highways, county roads, and private on-farm roads. It was necessary to provide for the conveyance of canal flows past these roadways. Either box culverts or circular culverts were found to be suitable crossing structures at most sites, due to the moderate depth, topwidth, and flow rate in most canal pools. Thirteen sites, however, require bridges. Plate III-C-40 is a half-section of a circular culvert. As indicated, provision has been made for the invert of the culvert to sag if necessary to pass under the roadway. Road-ditch drainage is provided by the triangular section which passes above the conduit. Similarly, Plate III-C-41 is a half-section of a box culvert. Plate III-C-42 is a plan and profile view of a typical bridge road crossing. At bridges, siphons are required to direct road-ditch drainage past the canal.

b. Design Data. The information required to design the road crossing culverts included the maximum demand discharge of the canal, tailwater elevation, culvert head loss characteristics, and the amount of canal freeboard available on the upstream side of the culvert. Bridge hydraulic design required low chord elevations and pier dimensions, and loss coefficients.

c. Design Method. Following the determination of canal alignment, design freeboard, and flowlines, the road crossings were designed. Road crossings were designed to have very low head losses, such that the effect on canal hydraulics would be negligible and the previously computed flowlines would remain valid.

Culvert design was conducted using the CULVERW computer program [64], which calculates a headwater rating curve at the entrance to a box or circular culvert. Downstream tailwater conditions were considered in the analysis for submerged conditions. The effect of the culverts and bridges on freeboard and water travel time was checked by inputting structure data into the channel geometry file of the UNET [65] computer model.

Culvert exit velocities require riprap outlet protection. Riprap protection was designed following the guidelines of EM-1110-2-1601[66].

d. Design Results. The UNET computer model of the canal system with road crossings included showed that the bridges and culverts had been successfully sized to have minimal effect on canal hydraulics. The results of design are presented on Plate III-C-43. The plate provides the identification number of each structure and a brief description of the road crossed. For culverts, the structure is identified as either a box or a circular culvert, the preliminary design length of the culvert is indicated, and the number of parallel barrels or boxes is indicated. For bridges, the low chord elevation is provided.

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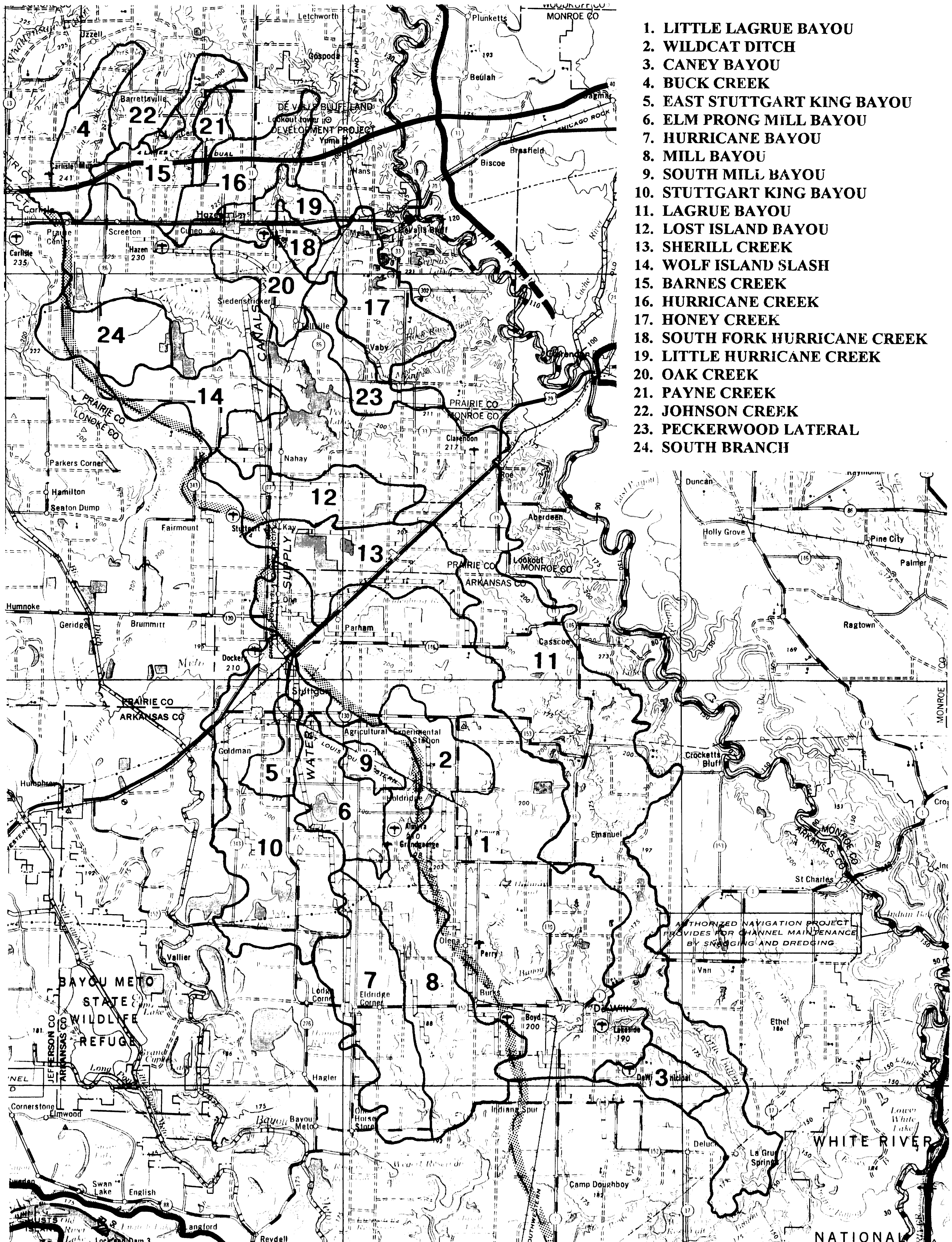



EASTERN ARKANSAS WATER SUPPLY STUDY
GRAND PRAIRIE DEMONSTRATION PROJECT

**STUDY AREA WATERSHEDS**

U. S. ARMY CORPS OF ENGINEERS
MEMPHIS DISTRICT

PLATE III-B-1

EASTERN ARKANSAS COMPREHENSIVE STUDY
GRAND PRAIRIE AREA

Delivery Order Number 0004 -- LaGrue Bayou (Main Stem)

| Subarea Name | L (mi) | Lca (mi) | WSS (ft/mi) | Tp | Ct | AREA | LAKE AREA | EFFECTIVE AREA |
|---|---|---|---|---|---|---|---|---|
| LB1 | 2.36 | 1.33 | 3.8611 | 4.02 | 2.85 | 2 | 0 | 2 |
| LB2 | 6.27 | 3.28 | 3.5946 | 6.86 | 2.77 | 9.64 | 0.63 | 9.01 |
| LB3 | 3.53 | 1.73 | 2.8443 | 5.33 | 3.1 | 3.71 | 0.03 | 3.68 |
| LB4 | 4.62 | 2.49 | 3.3277 | 5.98 | 2.87 | 6.26 | 0.05 | 6.21 |
| LB5 | 4.21 | 1.55 | 2.7292 | 5.55 | 3.16 | 4.71 | 1.18 | 3.53 |
| LB6 | 6.28 | 2.07 | 1.4741 | 9.18 | 4.25 | 8.54 | 0 | 8.54 |
| LB7 | 3.62 | 1.57 | 3.0754 | 5.03 | 2.98 | 6.29 | 0 | 6.29 |
| LB8 | 6.94 | 2.77 | 0.93235 | 12.86 | 5.3 | 18.81 | 0 | 18.81 |
| LB9 | 6.31 | 2.88 | 0.23669 | 21.48 | 9 | 9.79 | 0 | 9.79 |
| LB10 | 2.87 | 1.2 | 3.2066 | 4.24 | 2.93 | 3.04 | 0 | 3.04 |
| LB11 | 3.02 | 1.86 | 3.242 | 4.88 | 2.91 | 1.95 | 0 | 1.95 |
| LB12 | 8.47 | 3.47 | 1.403 | 12 | 4.35 | 13.64 | 0 | 13.64 |
| LB13 | 7.65 | 2.79 | 2.1097 | 8.96 | 3.58 | 7.17 | 0.09 | 7.08 |
| LB14 | 9.83 | 3.23 | 3.3774 | 8.05 | 2.85 | 13.53 | 0.256 | 13.274 |
| LB15 | NO LB15 | | | | | | | |
| LB16 | 8.28 | 2.7 | 3.7572 | 6.89 | 2.71 | 15.1 | 0.175 | 14.925 |
| LB17 | 7.89 | 1.45 | 4.4848 | 5.17 | 2.49 | 9.31 | 0.054 | 9.256 |
| LB18 | 5.68 | 1.06 | 0.4452 | 12.95 | 7.56 | 10.28 | 0.011 | 10.269 |
| LB19 | 7.29 | 2.64 | 3.5438 | 6.77 | 2.79 | 11.8 | 0.235 | 11.565 |
| LB20 | 7.16 | 3.17 | 1.7424 | 10.01 | 3.92 | 6.49 | 0.122 | 6.368 |
| LB21 | 8.57 | 3.74 | 3.444 | 8 | 2.83 | 7.78 | 0.02 | 7.76 |
| LB22 | omit | | | | | | | |
| | | | | | Basin A= | 169.84 | | 166.987 |
| SC1 | 5.07 | 1.88 | 2.5182 | 6.46 | 3.29 | 6.55 | 1.48 | 5.07 |
| SC2 | 2.76 | 1.34 | 3.5081 | 4.15 | 2.8 | 3.17 | 0 | 3.17 |
| SC3 | 9.67 | 3.12 | 2.1797 | 9.79 | 3.52 | 10.25 | 0 | 10.25 |
| | | | | | Basin A= | 19.97 | | 18.49 |
| OC1 | 1.79 | 0.72 | 6.5517 | 2.24 | 2.07 | 1.73 | 0 | 1.73 |
| OC2 | 2.06 | 0.82 | 8.0288 | 2.2 | 1.88 | 1.82 | 0 | 1.82 |
| OC3 | 3.98 | 2.1 | 2.2981 | 6.49 | 3.43 | 4.05 | 0 | 4.05 |
| | | | | | Basin A= | 7.6 | | 7.6 |
| WIS1 | 1.8 | 0.69 | 4.7278 | 2.53 | 2.43 | 2.08 | 0 | 2.08 |
| WIS2 | 4.22 | 0.97 | 2.3824 | 5.15 | 3.37 | 6.04 | 0.056 | 5.984 |
| WIS3 | 3.26 | 1.54 | 1.725 | 6.4 | 3.94 | 3.35 | 0.14 | 3.21 |
| | | | | | Basin A= | 11.47 | | 11.274 |

| Subarea Name | L (mi) | Lca (mi) | WSS (ft/mi) | Tp | Ct | AREA | LAKE AREA | EFFECTIVE AREA |
|---|---|---|---|---|---|---|---|---|
| LIB1 | 5 | 1.6 | 3.7641 | 5.05 | 2.71 | 6.85 | 0.12 | 6.73 |
| LIB2 | 3.95 | 1.98 | 3.7216 | 5.05 | 2.72 | 5.77 | 0.16 | 5.61 |
| LIB3 | 5.57 | 3.15 | 2.2413 | 8.21 | 3.48 | 8.05 | 0 | 8.05 |
| | | | | | Basin A= | 20.67 | | 20.39 |
| SB1 | 1.81 | 0.45 | 2.6185 | 3.03 | 3.22 | 0.73 | 0 | 0.73 |
| SB2 | 3.81 | 1.25 | 2.5627 | 5.2 | 3.26 | 5.6 | 0.066 | 5.534 |
| SB3 | 3.18 | 1.74 | 1.3785 | 7.3 | 4.39 | 5.94 | 0.21 | 5.73 |
| | | | | | Basin A= | 12.27 | | 11.994 |
| P1 | 2.18 | 1.01 | 1.0372 | 6.38 | 5.03 | 2.17 | 0 | 2.17 |
| P2 | 2.46 | 1.42 | 0.909 | 7.81 | 5.36 | 2.75 | 0 | 2.75 |
| P3 | 2.24 | 1.1 | 4.4932 | 3.26 | 2.49 | 1.47 | 0 | 1.47 |
| P4 | 3.92 | 1.44 | 2.1282 | 5.99 | 3.56 | 2.64 | 0 | 2.64 |
| | | | | | Basin A= | 9.03 | | 9.03 |
| | | | | | Total All Areas = | 250.85 | | 245.765 |

EASTERN ARKANSAS COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DO #: 0003

MILL, CANEY, AND STUTTGART KING BAYOU WATERSHEDS
FINAL WATERSHED PARAMETERS

| SUBAREA NAME | LENGTH MILES | LENGTH CA MILES | WSS FT/MI | Tp | Ct | AREA SQ MI. |
|---|---|---|---|---|---|---|
| | | | | | | |
| MB1 | 4.32 | 2.02 | 2.7816 | 5.69 | 3.13 | 3.56 |
| MB2 | 5.36 | 2.98 | 1.6272 | 9.31 | 4.05 | 4.36 |
| MB3 | 5.18 | 1.71 | 1.3356 | 8.58 | 4.46 | 3.66 |
| MB4 | 6.59 | 3.62 | 3.2108 | 7.57 | 2.92 | 4.91 |
| MB5 | 5.63 | 2.13 | 2.8152 | 6.56 | 3.11 | 6.73 |
| MB6 | NA | NA | NA | NA | NA | NA |
| MB7 | 3.93 | 2.25 | 3.4904 | 5.4 | 2.81 | 4.47 |
| MB8 | 3.75 | 2.16 | 4.2423 | 4.79 | 2.56 | 5.98 |
| MB9 | 5.85 | 2.84 | 1.0318 | 11.72 | 5.05 | 9.44 |
| MB10 | 6.88 | 3.54 | 1.3921 | 11.39 | 4.37 | 6.74 |
| | | | | | | |
| EPMB1 | 3.38 | 1.73 | 3.5518 | 4.73 | 2.79 | 4.99 |
| EPMB2 | 6.45 | 3.16 | 2.998 | 7.46 | 3.02 | 8.3 |
| | | | | | | |
| HB1 | 3.17 | 1.82 | 3.9613 | 4.47 | 2.64 | 3.12 |
| HB2 | 5.32 | 1.97 | 2.1879 | 7.11 | 3.52 | 6.95 |
| HB3 | 5.09 | 2.4 | 2.5562 | 6.91 | 3.26 | 9.84 |
| HB4 | 4.6 | 1.99 | 3.6106 | 5.37 | 2.76 | 4.21 |
| HB5 | 6.41 | 2.94 | 2.3543 | 8.19 | 3.39 | 3.84 |
| | | | | | | |
| SKB1 | 4.44 | 2.92 | 2.0691 | 7.79 | 3.61 | 6.88 |
| SKB2 | 4.89 | 3.09 | 4.0997 | 5.87 | 2.6 | 5.28 |
| SKB3 | 2.23 | 1.29 | 0.8979 | 7.41 | 5.39 | 4.14 |
| SKB4 | 6.56 | 2.79 | 2.2608 | 8.28 | 3.46 | 16.37 |
| SKB5 | 4.31 | 3.07 | 1.5416 | 9.03 | 4.16 | 4.29 |
| | | | | | | |
| ESKB1 | 5.76 | 1.76 | 4.2955 | 5.09 | 2.54 | 5.28 |
| | | | | | | |
| CB1 | 5.17 | 3.41 | 5.2696 | 5.45 | 2.3 | 6.1 |
| CB2 | 6.65 | 2.98 | 6.2488 | 5.2 | 2.12 | 7.68 |
| | | | | | | |

# CATCHMENT CHARACTERISTICS (OFFLINE POND, NET, AND TOTAL AREA, L, Lc, SLOPE, Ct, Tpu, %URBAN)

DRAINAGE AREA — LITTLE LA GRUE BAYOU (LLB), WILDCAT DITCH (WD)

DATE: 8/10/93
COMPLETED BY: DSS

| DRAINAGE BASIN | NO. | TOTAL AREA (in^2) | OFFLINE POND AREA (in^2) | NET AREA (in^2) | NET AREA (mi^2) | L (in) | L (mi) | Lc (in.) | Lc (mi) | SLOPE (ft./mi.) | Ct | Tpu | %URBAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LLB | 1 | 16.98 | 0.12 | 16.86 | 2.42 | 9.34 | 3.54 | 6.60 | 2.50 | 3.76 | 2.71 | 5.21 | 0.0 |
| LLB | 2 | 35.20 | 0.70 | 34.50 | 4.95 | 7.66 | 2.90 | 3.20 | 1.21 | 4.97 | 2.37 | 3.45 | 0.0 |
| LLB | 3 | 30.40 | 1.49 | 28.91 | 4.15 | 7.95 | 3.01 | 4.40 | 1.67 | 1.87 | 3.79 | 6.15 | 0.0 |
| LLB | 4 | 24.47 | 3.19 | 21.28 | 3.05 | 7.48 | 2.83 | 3.95 | 1.50 | 1.52 | 4.19 | 6.47 | 0.0 |
| LLB | 5 | 29.80 | 6.87 | 22.93 | 3.29 | 9.48 | 3.59 | 5.40 | 2.05 | 3.21 | 2.92 | 5.32 | 0.0 |
| LLB | 6 | 38.38 | 0.00 | 38.38 | 5.51 | 17.42 | 6.60 | 9.42 | 3.57 | 1.74 | 3.93 | 10.13 | 0.0 |
| LLB | 7 | 18.30 | 0.20 | 18.10 | 2.60 | 7.90 | 2.99 | 4.66 | 1.77 | 5.14 | 2.33 | 3.84 | 0.0 |
| LLB | 8 | 58.13 | 4.34 | 53.79 | 7.72 | 14.78 | 5.60 | 7.29 | 2.76 | 3.03 | 3.01 | 6.84 | 0.0 |
| LLB | 9 | 45.45 | 5.51 | 39.94 | 5.73 | 9.68 | 3.67 | 4.04 | 1.53 | 3.63 | 2.76 | 4.63 | 0.0 |
| LLB | 10 | 37.65 | 4.00 | 33.65 | 4.83 | 13.33 | 5.05 | 5.47 | 2.07 | 0.69 | 6.11 | 12.35 | 0.0 |
| LLB | 11 | 39.80 | 2.45 | 37.35 | 5.36 | 8.78 | 3.33 | 4.74 | 1.80 | 4.40 | 2.51 | 4.30 | 0.0 |
| LLB | 12 | 41.02 | 0.16 | 40.86 | 5.86 | 17.33 | 6.56 | 6.55 | 2.48 | 1.30 | 4.52 | 9.97 | 4.7 |
| LLB | 13 | 24.94 | 0.26 | 24.68 | 3.54 | 10.61 | 4.02 | 5.21 | 1.97 | 3.29 | 2.89 | 5.38 | 0.0 |
| LLB | 14 | 37.31 | 1.27 | 36.04 | 5.17 | 14.82 | 5.61 | 6.85 | 2.59 | 2.77 | 3.14 | 6.73 | 4.0 |
| LLB | 15 | 32.18 | 1.00 | 31.18 | 4.47 | 12.89 | 4.88 | 7.87 | 2.98 | 3.05 | 3.00 | 6.69 | 0.0 |
| LLB | 16 | 14.64 | 0.42 | 14.22 | 2.04 | 4.79 | 1.81 | 2.61 | 0.99 | 10.16 | 1.68 | 2.00 | 0.0 |
| LLB | 17 | 22.00 | 0.00 | 22.00 | 3.16 | 6.30 | 2.39 | 2.83 | 1.07 | 7.31 | 1.97 | 2.61 | 0.0 |
| LLB | 18 | 31.79 | 0.34 | 31.45 | 4.51 | 11.48 | 4.35 | 6.62 | 2.51 | 1.79 | 3.87 | 7.92 | 0.0 |
| LLB | 19 | 12.55 | 0.89 | 11.66 | 1.67 | 6.16 | 2.33 | 2.56 | 0.97 | 4.13 | 2.59 | 3.31 | 0.0 |
| LLB | 20 | 38.13 | 0.40 | 37.73 | 5.41 | 14.71 | 5.57 | 4.90 | 1.86 | 1.14 | 4.80 | 9.54 | 1.5 |
| LLB | 21 | 30.60 | 0.00 | 30.60 | 4.39 | 10.88 | 4.12 | 5.38 | 2.04 | 2.26 | 3.46 | 6.56 | 0.0 |
| LLB | 22 | 46.58 | 0.00 | 46.58 | 6.68 | 13.11 | 4.97 | 6.51 | 2.47 | 5.85 | 2.19 | 4.65 | 0.0 |
| LLB | 23 | 20.20 | 0.77 | 19.43 | 2.79 | 12.94 | 4.90 | 6.60 | 2.50 | 2.83 | 3.11 | 6.59 | 0.0 |
| LLB | 24 | 30.40 | 0.19 | 30.21 | 4.33 | 11.88 | 4.50 | 6.25 | 2.37 | 6.54 | 2.08 | 4.22 | 0.0 |
| LLB | 25 | 28.55 | 0.00 | 28.55 | 4.10 | 11.23 | 4.25 | 4.98 | 1.89 | 9.10 | 1.77 | 2.65 | 25.0 |
| LLB | 26 | 45.69 | 0.25 | 45.44 | 6.52 | 16.67 | 6.31 | 8.85 | 3.35 | 6.55 | 2.08 | 4.40 | 17.7 |
| LLB | 27 | 25.60 | 0.00 | 25.60 | 3.67 | 10.43 | 3.95 | 5.25 | 1.99 | 1.66 | 4.02 | 7.46 | 0.0 |
| WD | 1 | 21.37 | 0.21 | 21.16 | 3.04 | 6.15 | 2.33 | 2.32 | 0.88 | 1.68 | 3.99 | 4.95 | 0.0 |
| WD | 2 | 8.64 | 0.00 | 8.64 | 1.24 | 4.72 | 1.79 | 1.65 | 0.63 | 6.29 | 2.12 | 2.19 | 0.0 |
| WD | 3 | 19.42 | 1.16 | 18.26 | 2.62 | 7.83 | 2.97 | 4.28 | 1.62 | 4.85 | 2.40 | 3.84 | 0.0 |
| WD | 4 | 11.42 | 0.24 | 11.18 | 1.60 | 4.70 | 1.78 | 1.90 | 0.72 | 4.43 | 2.51 | 2.70 | 0.0 |

I:\PROJECTS\MEMPHCOE\EASTARK\LENGTHS.WQ1

PRINTING DATE: 31-Aug-93 11:11 AM

TOTAL AREA: 131.66 mi^2
NET AREA: 126.43 mi^2

2/24/94

EASTERN ARKANSAS COMPREHENSIVE STUDY
GRAND PRAIRIE AREA

Delivery Order Number 0005 -- "Northern Watersheds"
Barnes, Buck, and Hurricane Creeks

| Subarea Name | L mi | Lca mi | WSS ft/mi | Tp | Ct | AREA mi**2 | LAKE AREA | EFFECTIVE AREA |
|---|---|---|---|---|---|---|---|---|
| BC1 | 4.86 | 2.74 | 4.2479 | 5.56 | 2.56 | 5.35 | 0 | 5.35 |
| BC2 | 2.22 | 1.7 | 6.3122 | 3.15 | 2.11 | 2.78 | 0 | 2.78 |
| BC3 | 2.08 | 1.39 | 4.6912 | 3.35 | 2.44 | 1.53 | 0 | 1.53 |
| BC4 | 2.63 | 1.27 | 3.7759 | 3.88 | 2.7 | 1.24 | 0 | 1.24 |
| BC5 | 2.95 | 1.27 | 12.0045 | 2.3 | 1.55 | 3.32 | 0.04 | 3.28 |
| BC6 | 2.38 | 1.39 | 13.0427 | 2.13 | 1.49 | 1.66 | 0 | 1.66 |
| | | | | | | Basin Area = | | 15.84 |
| PC1 | 3.99 | 1.5 | 7.3796 | 3.35 | 1.96 | 3.87 | 0.21 | 3.66 |
| | | | | | | Basin Area = | | 3.66 |
| BK1 | 3.6 | 2.1 | 2.3201 | 6.27 | 3.42 | 2.55 | 0 | 2.55 |
| BK2 | 3.96 | 1.95 | 3.5962 | 5.11 | 2.77 | 4.47 | 0 | 4.47 |
| | | | | | | Basin Area = | | 7.02 |
| HUC1 | 3.46 | 1.42 | 6.7672 | 3.29 | 2.05 | 3.35 | 0 | 3.35 |
| HUC2 | 1.71 | 0.67 | 11.041 | 1.68 | 1.61 | 1.98 | 0 | 1.98 |
| HUC3 | 2.52 | 1.41 | 9.4116 | 2.55 | 1.74 | 1.39 | 0 | 1.39 |
| HUC4 | 6.67 | 2.78 | 4.4828 | 5.98 | 2.49 | 6.34 | 0 | 6.34 |
| | | | | | | Basin Area = | | 13.06 |
| SFH1 | 2.86 | 0.89 | 6.5628 | 2.74 | 2.07 | 3.18 | 0.02 | 3.16 |
| SFH2 | 1.52 | 1 | 8.1191 | 2.12 | 1.87 | 0.69 | 0 | 0.69 |
| | | | | | | Basin Area = | | 3.85 |
| LHU1 | 4.18 | 2.09 | 6.1166 | 4.11 | 2.14 | 4.57 | 0 | 4.57 |
| LHU2 | 3.43 | 1.73 | 7.1303 | 3.4 | 1.99 | 2.3 | 0 | 2.3 |
| LHU3 | 2.32 | 1.35 | 2.1122 | 5.04 | 3.58 | 0.66 | 0 | 0.66 |
| | | | | | | Basin Area = | | 7.53 |
| | | | | | | Total Area = | | 50.96 |

# Partial Duration Rainfall Table

Catchment Centroid: 34 25'05" Lattitude
91 24'18" Longitude

Date: 6/30/93
Completed By: DSS

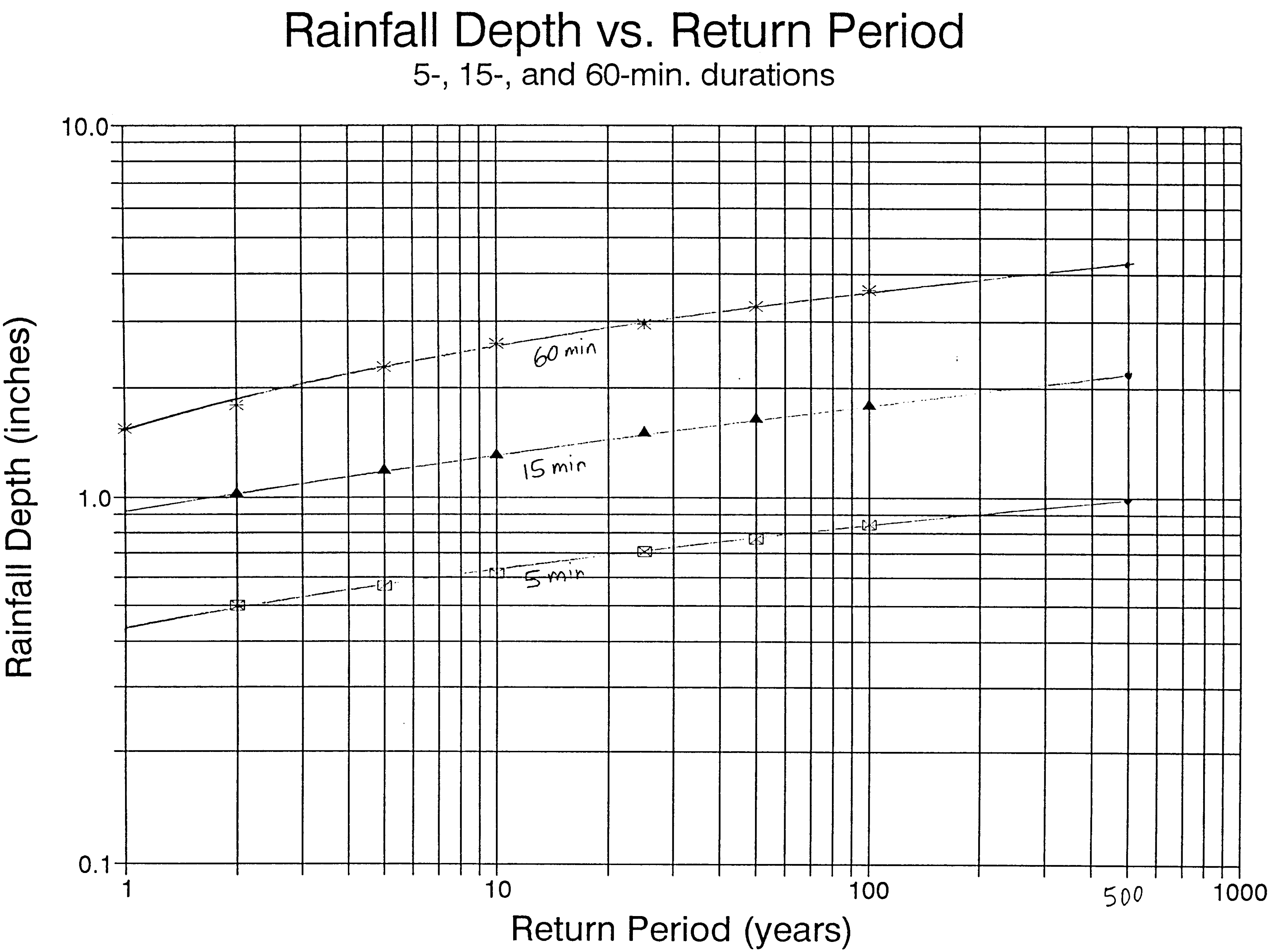
**From rainfall maps (exceptions are noted with asterisks):**

| | Duration Periods | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Return Period | 5 min.* | 15 min.* | 60 min. | 2 hr. | 3 hr. | 6 hr. | 12 hr. | 24 hr. | 2 day |
| 1 yr. | -- | -- | 1.54 | 1.88 | 2.07 | 2.51 | 3.04 | 3.54 | -- |
| 1.01 yr.** | 0.43 | 0.93 | 1.55 | 1.89 | 2.08 | 2.52 | 3.05 | 3.55 | 4.01 |
| 2 yr. | 0.50 | 1.04 | 1.79 | 2.25 | 2.44 | 2.97 | 3.58 | 4.13 | 4.84 |
| 5 yr. | 0.57 | 1.20 | 2.27 | 2.78 | 3.11 | 3.75 | 4.52 | 5.21 | 6.08 |
| 10 yr. | 0.62 | 1.33 | 2.61 | 3.21 | 3.55 | 4.31 | 5.10 | 6.04 | 6.96 |
| 25 yr. | 0.71 | 1.52 | 2.96 | 3.67 | 4.04 | 4.94 | 5.93 | 6.91 | 8.08 |
| 50 yr. | 0.77 | 1.66 | 3.30 | 4.03 | 4.50 | 5.52 | 6.58 | 7.67 | 9.60 |
| 100 yr. | 0.84 | 1.81 | 3.63 | 4.48 | 4.98 | 6.00 | 7.24 | 8.35 | 10.60 |
| 500 yr.** | 0.97 | 2.09 | 4.33 | 5.36 | 6.28 | 7.49 | 8.80 | 9.98 | 13.40 |

*Values for the 5, 10, 25, and 50 yr. floods were obtained from eqns. 9, 10, 11, and 12 from NOAA Technical Memorandum NWS HYDRO-35 (p. 28)

**Extrapolated from a plot on log-log paper.

I:\PROJECTS\MEMPHCOE\EASTARK\RAINTABL.WQ1



Rainfall Depth vs. Return Period
5-, 15-, and 60-min. durations
Rainfall Depth (inches)
10.0
1.0
0.1
60 min
15 min
5 min
1
10
100
500
1000
Return Period (years)


PLATE III-B-4

# Rainfall Depth vs. Return Period

2-hr. through 2-day durations

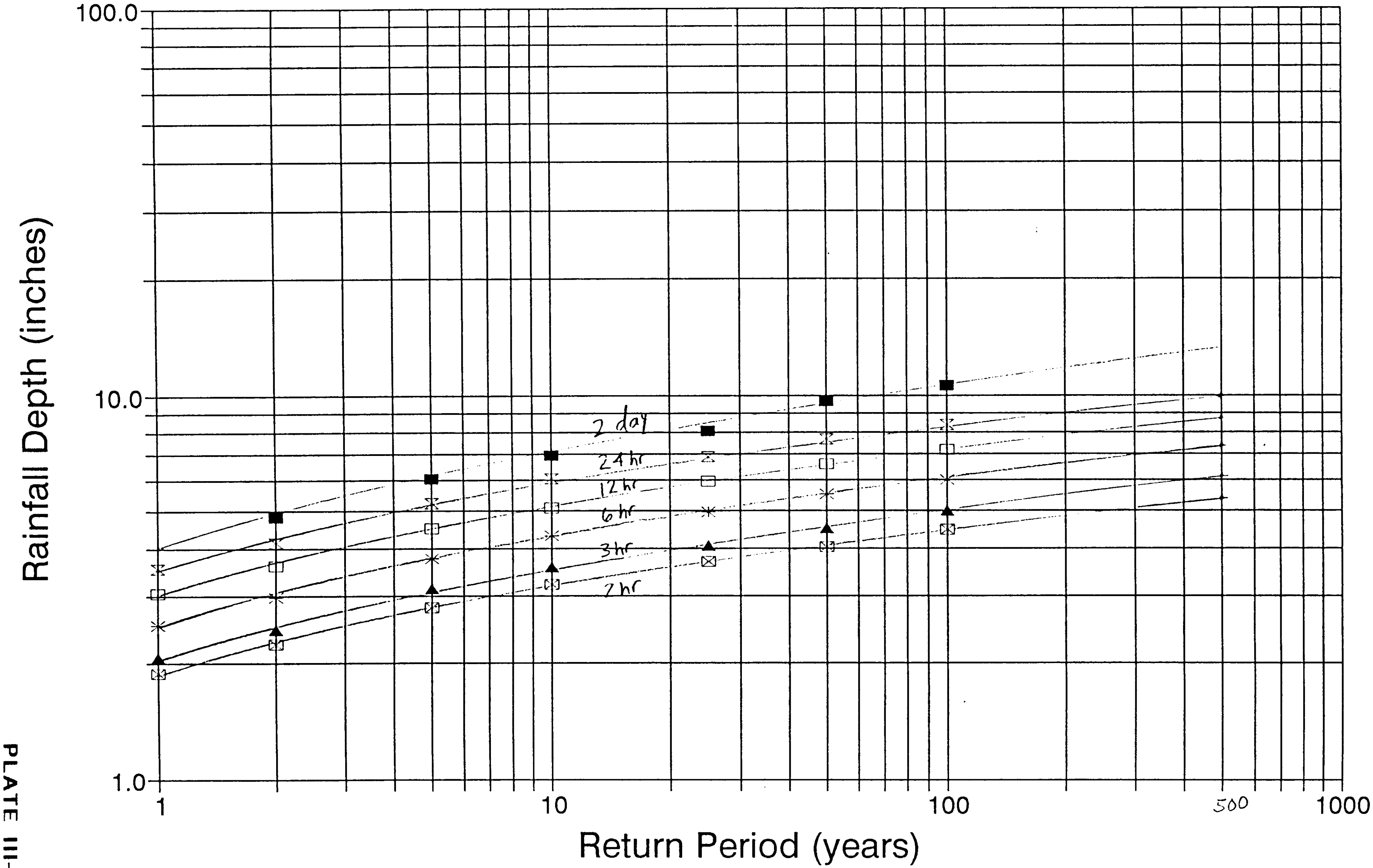
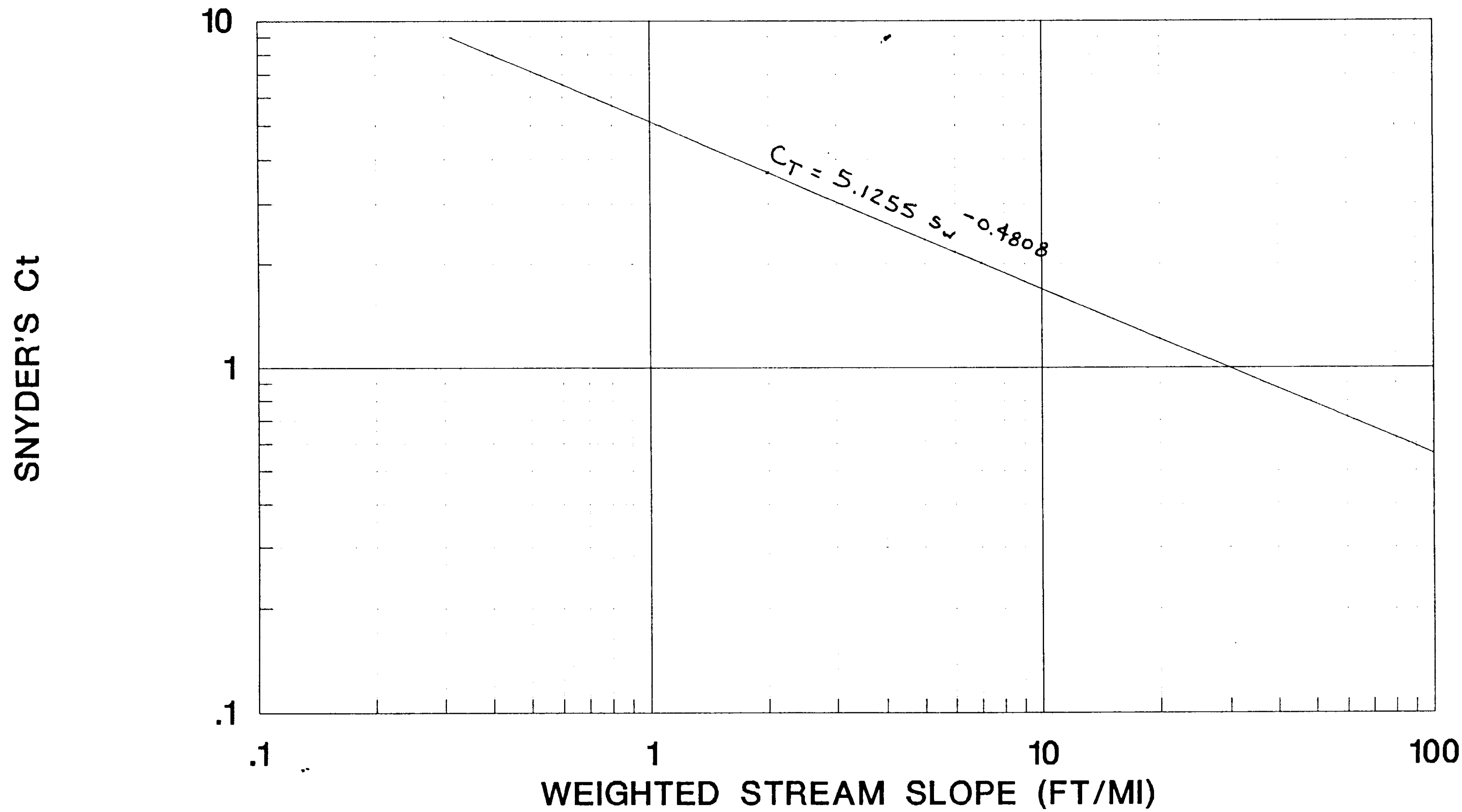
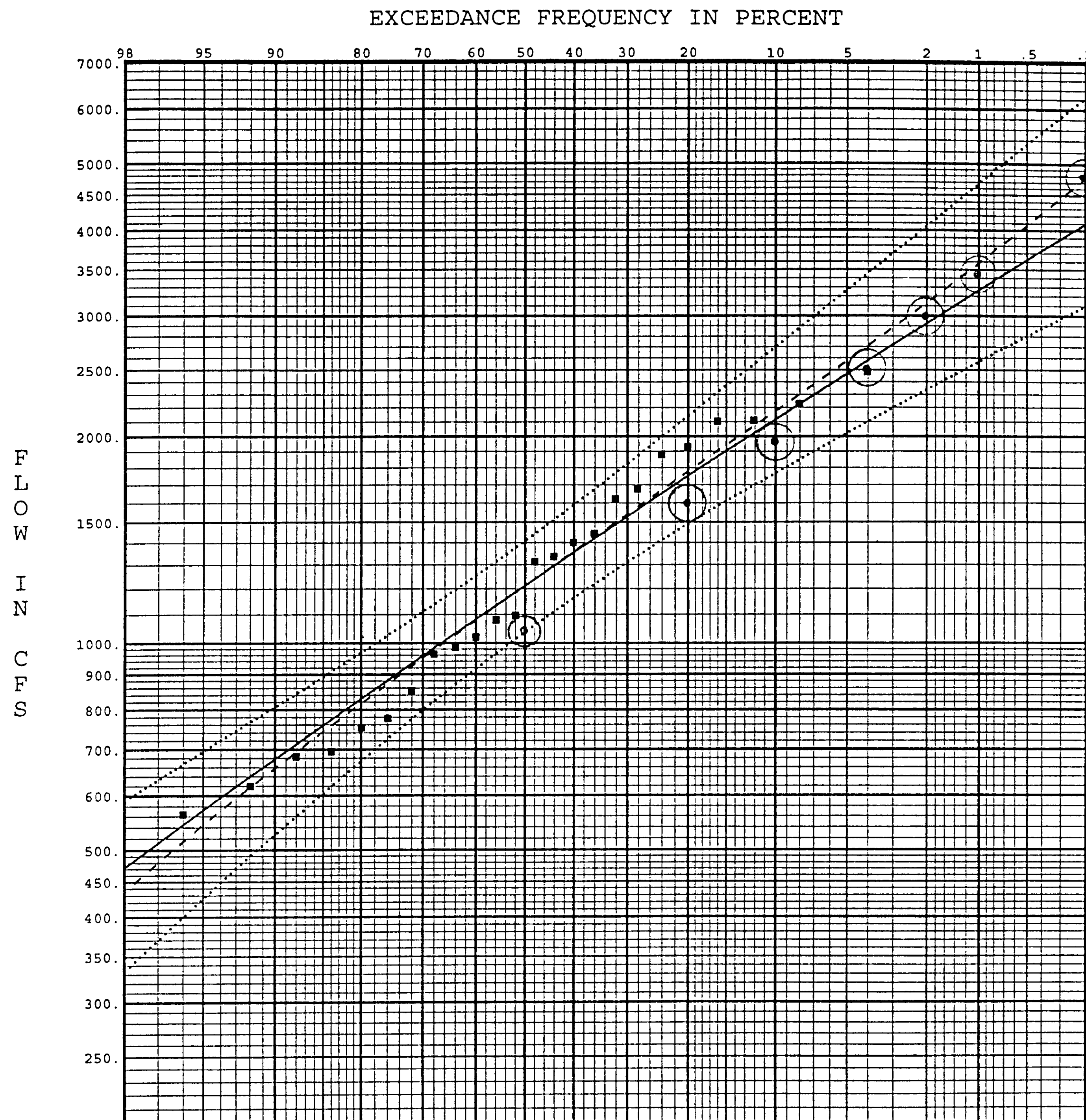



PLATE III-B-5

# Ct vs. WEIGHTED STREAM SLOPE
# MEMPHIS DISTRICT





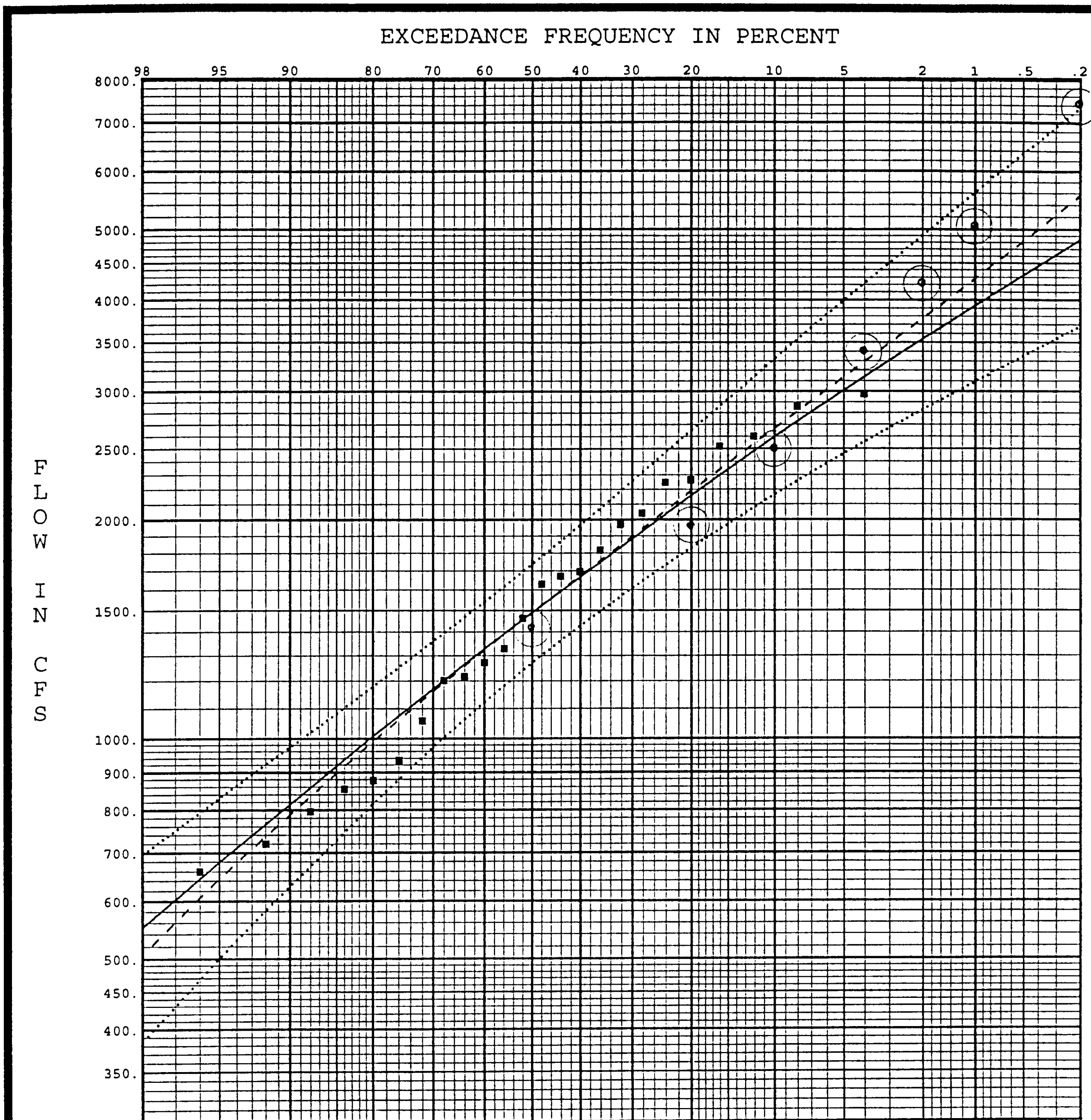

—— Flow Frequency (without Exp. Prob.)
- - - Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
........ 5% and 95% Confidence Limits

FREQUENCY STATISTICS
LOG TRANSFORM OF FLOW, CFS

| | | NUMBER OF EVENTS | |
|---|---|---|---|
| MEAN | 3.0806 | HISTORIC EVENTS | 0 |
| STANDARD DEV | .1928 | HIGH OUTLIERS | 0 |
| SKEW | -.0373 | LOW OUTLIERS | 0 |
| REGIONAL SKEW | -.3000 | ZERO OR MISSING | 0 |
| ADOPTED SKEW | -.1000 | SYSTEMATIC EVENTS | 24 |

(•) HEC-1 Results

Little LaGrue Bayou
Node 2050 (1/3 point)
API "A" Range: .6000 to .7500
BASIN AREA = 39.42 SQ MI
WATER YEARS IN RECORD
1967-1968,1970,1970-1971,1973,
1973-1977,1979,1979-1986,
1988-1989,1989,1991



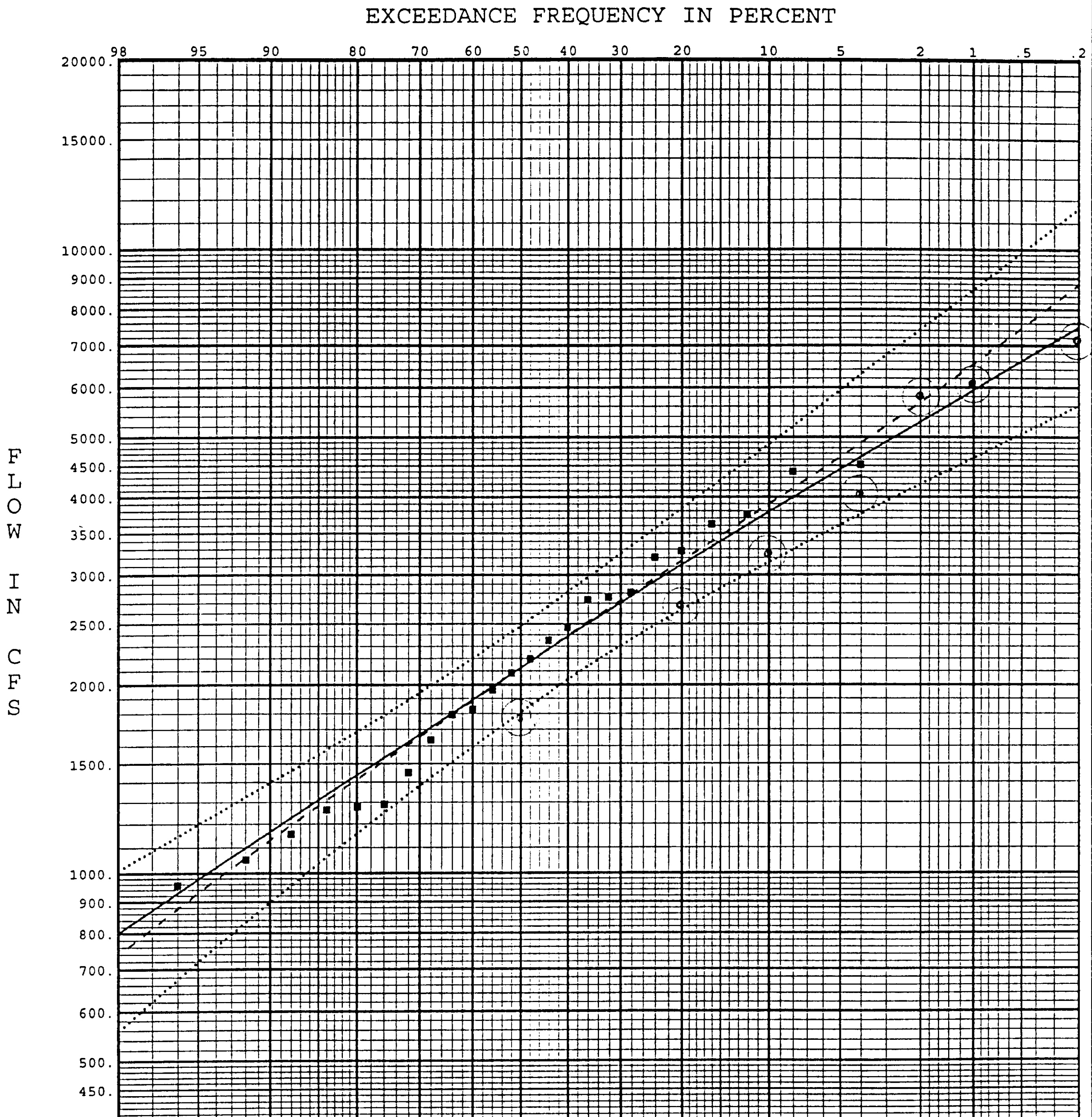

—— Flow Frequency (without Exp. Prob.)
- - - Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
........ 5% and 95% Confidence Limits

FREQUENCY STATISTICS

| LOG TRANSFORM OF FLOW, CFS | | NUMBER OF EVENTS | |
|---|---|---|---|
| MEAN | 3.1668 | HISTORIC EVENTS | 0 |
| STANDARD DEV | .1966 | HIGH OUTLIERS | 0 |
| SKEW | -.1504 | LOW OUTLIERS | 0 |
| REGIONAL SKEW | -.3000 | ZERO OR MISSING | 0 |
| ADOPTED SKEW | -.2000 | SYSTEMATIC EVENTS | 24 |

HEC-1 Results

Little LaGrue Bayou
Node 2080 (2/3 point)
API "A" Range: .6000 TO .7500
BASIN AREA = 82.35 SQ MI
WATER YEARS IN RECORD
1967-1968,1970,1970-1971,1973,
1973-1977,1979,1979-1986,
1988-1989,1989,1991




—— Flow Frequency (without Exp. Prob.)
- - - Flow Frequency (with Exp. Prob.)
■ Weibull Plotting Positions
........ 5% and 95% Confidence Limits

FREQUENCY STATISTICS

| LOG TRANSFORM OF FLOW, CFS | | NUMBER OF EVENTS | |
|---|---|---|---|
| MEAN | 3.3247 | HISTORIC EVENTS | 0 |
| STANDARD DEV | .1997 | HIGH OUTLIERS | 0 |
| SKEW | -.0410 | LOW OUTLIERS | 0 |
| REGIONAL SKEW | -.3000 | ZERO OR MISSING | 0 |
| ADOPTED SKEW | -.1000 | SYSTEMATIC EVENTS | 24 |

⊙ HEC-1 Results

Little LaGrue Bayou
Node 2120 (3/3 point)
API "A" Range: .6000 TO .7500
BASIN AREA = 126.42 SQ MI
WATER YEARS IN RECORD
1967-1968,1970,1970-1971,1973,
1973-1977,1979,1979-1986,
1988-1989,1989,1991

EASTERN ARKANSAS WATER SUPPLY STUDY

NOV. 22, 1993

MILL BAYOU, ELM PRONG, AND HURRICANE BAYOU WATERSHED SYSTEM.

## C-1 COMPARED TO USGS REGRESSION EQUATIONS

Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 | Loss Rates Initial/Uniform |
|---|---|---|---|---|---|---|---|---|---|---|
| 4035 | HEC-1 | 450 | 650 | 1000 | 1240 | 1960 | 2560 | 3090 | 4215 | 1.3/0.15 |
| | USGS EQ. | --- | 840 | 1200 | 1450 | 1770 | 2000 | 2220 | --- | |
| | DIFF. | | -23% | -17% | -14% | 11% | 28% | 39% | | |
| | | | | | | | | | | |
| 4070 | HEC-1 | 570 | 770 | 1120 | 1360 | 1690 | 1960 | 2230 | 3080 | |
| | USGS EQ. | --- | 1150 | 1600 | 1940 | 2360 | 2660 | 2940 | --- | 1.2/0.11 |
| | DIFF. | | -33% | -30% | -30% | -28% | -26% | -24% | | |
| | | | | | | | | | | |
| 4080 | HEC-1 | 1070 | 1490 | 2100 | 2550 | 3160 | 3730 | 4290 | 5800 | |
| | USGS EQ. | --- | 1590 | 2240 | 2730 | 3330 | 3750 | 4150 | --- | 1.4/0.14 |
| | DIFF. | | -6% | -6% | -7% | -5% | -1% | 3% | | |

## HEC-1 AND USGS AT OUTLET COMPARED TO LA GRUE BAYOU GAUGE DATA

Mill Bayou — Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 4080 | HEC-1 | 1070 | 1490 | 2100 | 2550 | 3160 | 3730 | 4290 | 5800 |
| | cfs/sq.mi. | 11.9 | 16.5 | 23.3 | 28.3 | 35.1 | 41.4 | 47.6 | 64.4 |
| | | | | | | | | | |
| | USGS EQ. | --- | 1590 | 2240 | 2730 | 3330 | 3750 | 4150 | --- |
| | cfs/sq.mi. | | 17.6 | 24.9 | 30.3 | 37.0 | 41.6 | 46.1 | |
| | | | | | | | | | |

Area = 90.1 Square miles net

La Grue Bayou Gauge Data — Discharge in cfs — From Table 1, p. 22, WRIP 86-4335

| | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| | GAUGE | --- | 2400 | 3990 | 5070 | 6440 | 7440 | 8420 | --- |
| | cfs/sq.mi. | | 13.7 | 22.8 | 29.0 | 36.8 | 42.5 | 48.1 | |
| | | | | | | | | | |

Area = 175 Square miles

## HEC-1 AT OUTLET UNIT DISCHARGE COMPARED TO LA GRUE BAYOU GAUGE DATA

Unit discharge in cfs/sq.mi.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4080 | HEC-1 | 11.9 | 16.5 | 23.3 | 28.3 | 35.1 | 41.4 | 47.6 | 64.4 |
| | GAUGE | --- | 13.7 | 22.8 | 29.0 | 36.8 | 42.5 | 48.1 | --- |
| | DIFF. | | 21% | 2% | -2% | -5% | -3% | -1% | |

Notes: NSTPS = 1 for all reaches

DT= 10 minutes, base flow = 1 cfs for all streams.

QDIFFMB

EASTERN ARKANSAS WATER SUPPLY STUDY
LAGRUE BAYOU WATERSHED SYSTEM

FEB. 9, 1994

## .1EC-1 COMPARED TO USGS REGRESSION EQUATIONS

Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 | Loss Rates Initial/Uniform |
|---|---|---|---|---|---|---|---|---|---|---|
| 1040 | HEC-1 | 728 | 964 | 1343 | 1703 | 2305 | 2931 | 3463 | 4843 | 1.0/0.07 |
| | USGS EQ. | --- | 1123 | 1609 | 1962 | 2396 | 2704 | 3000 | --- | |
| | DIFF. | | -14% | -17% | -13% | -4% | 8% | 15% | | |
| 1080 | HEC-1 | 1243 | 1696 | 2447 | 2962 | 3771 | 4549 | 5284 | 7862 | |
| | USGS EQ. | --- | 2059 | 2788 | 3330 | 3955 | 4384 | 4779 | --- | 1.0/0.09 |
| | DIFF. | | -18% | -12% | -11% | -5% | 4% | 11% | | |
| 1150 | HEC-1 | 1774 | 2196 | 2876 | 3366 | 4038 | 4726 | 5478 | 7957 | |
| | USGS EQ. | --- | 2464 | 3335 | 4010 | 4810 | 5366 | 5887 | --- | 1.0/0.09 |
| | DIFF. | | -11% | -14% | -16% | -16% | -12% | -7% | | |

## HEC-1 AT NODE 1080 COMPARED TO FREQUENCY ANALYSIS OF GAUGE DATA

La Grue Bayou Gauge Data — Discharge in cfs

| 1080 | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| | HEC-1 | 1243 | 1696 | 2447 | 2962 | 3771 | 4549 | 5284 | 7862 |
| | GAUGE | 424 | 2400 | 3990 | 5090 | 6480 | 7500 | 8510 | 10800 |
| | DIFF. | 193% | -29% | -39% | -42% | -42% | -39% | -38% | -27% |

## HEC-1 AT NODE 1080 COMPARED TO LOWER CONFIDENCE LIMIT FROM FREQUENCY ANALYSIS OF GAUGE DATA

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1080 | HEC-1 | 1243 | 1696 | 2447 | 2962 | 3771 | 4549 | 5284 | 7862 |
| | GAUGE | 211.0 | 1870 | 3090 | 3840 | 4730 | 5360 | 5960 | 7260 |
| | DIFF. | 489% | -9% | -21% | -23% | -20% | -15% | -11% | 8% |

Notes: NSTPS = 1 for all reaches
DT= 10 minutes, base flow = 1 cfs for all streams.

QDIFFLB

EASTERN ARKANSAS WATER SUPPLY STUDY
LITTLE LA GRUE BAYOU WATERSHED

AUG. 31, 1993

## EC-1 COMPARED TO USGS REGRESSION EQUATIONS

Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 2050 | HEC-1 | 737 | 1042 | 1599 | 1983 | 2534 | 3004 | 3461 | 4815 |
| | USGS EQ. | --- | 1134 | 1642 | 2013 | 2475 | 2803 | 3122 | --- |
| | DIFF. | | -8% | -3% | -1% | 2% | 7% | 11% | |
| 2080 | HEC-1 | 1082 | 1423 | 1970 | 2509 | 3431 | 4262 | 5079 | 7487 |
| | USGS EQ. | --- | 1535 | 2153 | 2611 | 3166 | 3555 | 3927 | --- |
| | DIFF. | | -7% | -8% | -4% | 8% | **20%** | **29%** | |
| 2120 | HEC-1 | 1169 | 1764 | 2693 | 3249 | 4045 | 5846 | 6055 | 7146 |
| | USGS EQ. | --- | 1909 | 2667 | 3243 | 3947 | 4444 | 4919 | --- |
| | DIFF. | | -8% | 1% | 0% | 2% | **32%** | **23%** | |

## HEC-1 AND USGS AT OUTLET COMPARED TO LA GRUE BAYOU GAUGE DATA

Little La Grue Bayou — Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 2120 | HEC-1 | 1169 | 1764 | 2693 | 3249 | 4045 | 5846 | 6055 | 7146 |
| | cfs/sq.mi. | 9.2 | 14.0 | 21.3 | 25.7 | 32.0 | **46.3** | **47.9** | 56.5 |
| | | | | | | | | | |
| | USGS EQ. | --- | 1909 | 2667 | 3243 | 3947 | 4444 | 4919 | --- |
| | cfs/sq.mi. | | 15.1 | 21.1 | 25.7 | 31.2 | **35.2** | **38.9** | |
| | | | | | | | | | |

Area = 126.4 Square miles net

La Grue Bayou Gauge Data — Discharge in cfs — From Table 1, p. 22, WRIP 86-4335

| | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 19 yrs. | GAUGE | --- | 2400 | 3990 | 5070 | 6440 | 7440 | 8420 | --- |
| record | cfs/sq.mi. | | 13.7 | 22.8 | 29.0 | 36.8 | **42.5** | **48.1** | |
| | | | | | | | | | |

Area = 175 Square miles

## HEC-1 AT OUTLET UNIT DISCHARGE COMPARED TO LA GRUE BAYOU GAUGE DATA

Unit discharge in cfs/sq.mi.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2120 | HEC-1 | 9.2 | 14.0 | 21.3 | 25.7 | 32.0 | 46.3 | 47.9 | 56.5 |
| | GAUGE | --- | 13.7 | 22.8 | 29.0 | 36.8 | 42.5 | 48.1 | --- |
| | DIFF. | | 2% | -7% | -11% | -13% | **9%** | **-0%** | |

Notes: Loss = 1.2 initial to node 2090 then 1.5 inch initial, 0.10 inch/hr constant
NSTPS = 1 for all reaches
DT= 10 minutes, base flow = 5 cfs LLB mainstem, 1 cfs Wildcat Ditch

HEC-1 and USGS regression equation results differ by 20% to 32% for 50-yr and 100-yr flood; however, HEC-1 results agree more closely with La Grue Bayou (nearby stream) gauge station analysis.

QDIFF.WQ1

EASTERN ARKANSAS WATER SUPPLY STUDY
STUTTGART KING BAYOU WATERSHEDS.

NOV. 21, 1993

## HEC-1 COMPARED TO USGS REGRESSION EQUATIONS

Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 3020 | HEC-1 | 660 | 910 | 1160 | 1320 | 1530 | 1730 | 2010 | 2800 |
| | USGS EQ. | --- | 767 | 1115 | 1363 | 1672 | 1892 | 2106 | --- |
| | DIFF. | | 19% | 4% | -3% | -8% | -9% | -5% | |
| | | | | | | | | | |
| 3040 | HEC-1 | 670 | 910 | 1230 | 1460 | 1770 | 2060 | 2320 | 2980 |
| | USGS EQ. | --- | 911 | 1245 | 1484 | 1764 | 1958 | 2138 | --- |
| | DIFF. | | -0% | -1% | -2% | 0% | 5% | 9% | |

## HEC-1 AND USGS AT THE OUTLET

Stuttgart King Bayou — Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 3040 | HEC-1 | 840 | 1000 | 1310 | 1530 | 1820 | 2070 | 2330 | 3040 |
| | cfs/sq.mi. | 19.9 | 23.7 | 31.0 | 36.2 | 43.1 | 49.0 | 55.2 | 72.0 |
| | | | | | | | | | |
| | USGS EQ. | --- | 911 | 1245 | 1484 | 1764 | 1958 | 2138 | --- |
| | cfs/sq.mi. | | 21.6 | 29.5 | 35.1 | 41.8 | 46.4 | 50.6 | |
| | | | | | | | | | |

Area = 42.24 Square miles net

Notes: Loss = 1.5 initial and 0.10 inch/hr constant
NSTPS = 1 for all reaches
DT= 10 minutes, base flow = 1 cfs for all streams.

QDIFFSKR.WQ1

EASTERN ARKANSAS WATER SUPPLY STUDY
CANEY BAYOU WATERSHED.

NOV.15, 1993

## :C-1 COMPARED TO USGS REGRESSION EQUATIONS

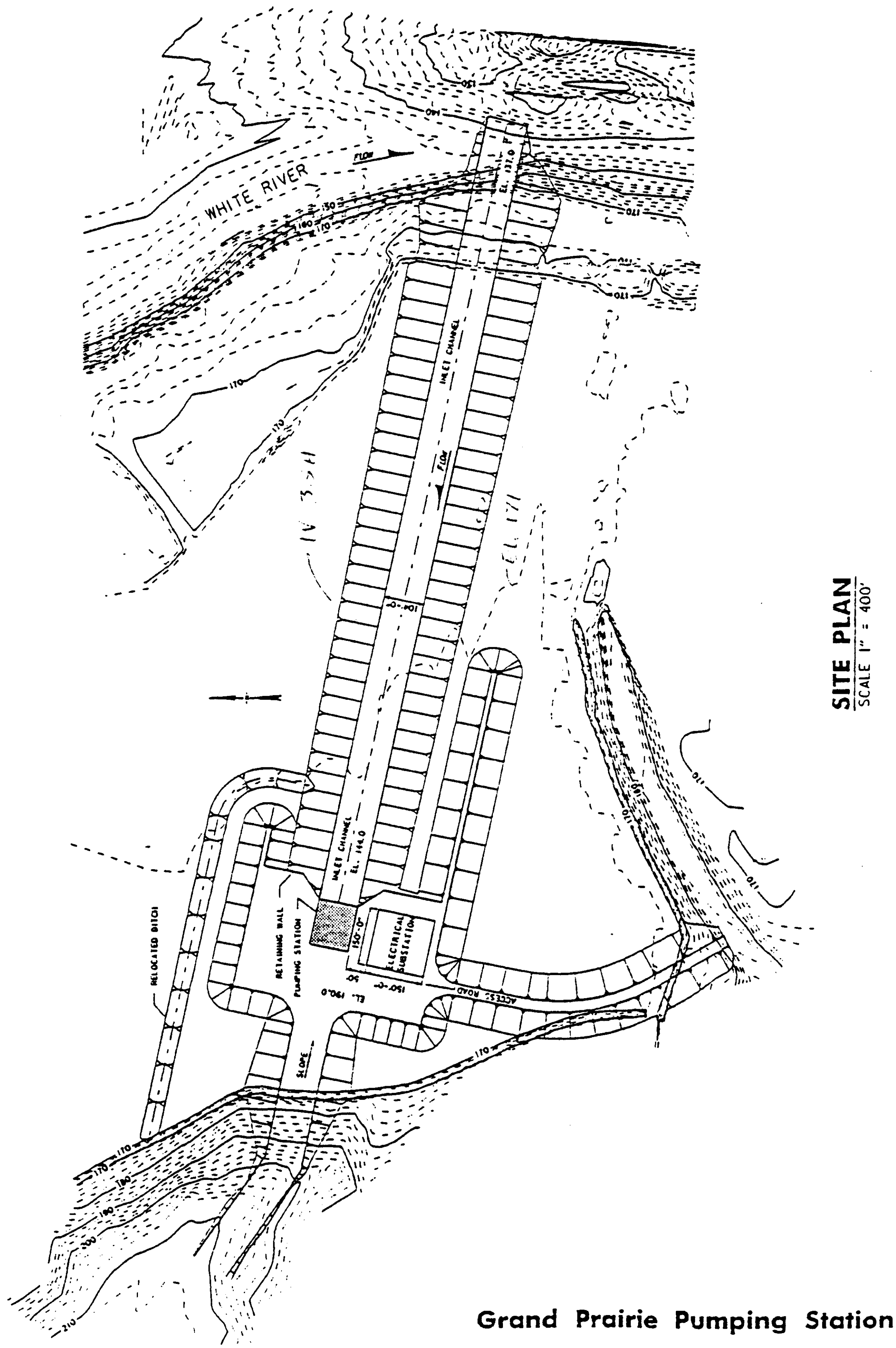
Discharge in cfs

| NODE | Freq. (yr) | 1.01 | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
|---|---|---|---|---|---|---|---|---|---|
| 1150 | HEC-1 | 740 | 1040 | 1546 | 1890 | 2290 | 2670 | 2990 | 3830 |
| | USGS EQ. | --- | 750 | 1170 | 1490 | 1920 | 2240 | 2560 | --- |
| | DIFF. | | 39% | 32% | 27% | 19% | 19% | 17% | |

Notes: Loss = 1.5 initial and 0.12 inch/hr constant
NSTPS = 1 for all reaches
DT= 10 minutes, base flow = 1 cfs for all streams.

COMPUTATION SHEET

| | | | |
|---|---|---|---|
| PROJECT Grand Prairie Demostration Project Eastern Arkansas | PAGE OF | COMPUTED BY MSW | DATE 9/20/96 |
| SUBJECT Grand Prairie Pumping Station | | CHECKED BY | DATE |




Grand Prairie Pumping Station

# COMPUTATION SHEET

PROJECT Grand Prairie Demonstration Project
Eastern Arkansas

SUBJECT Lift Station Design

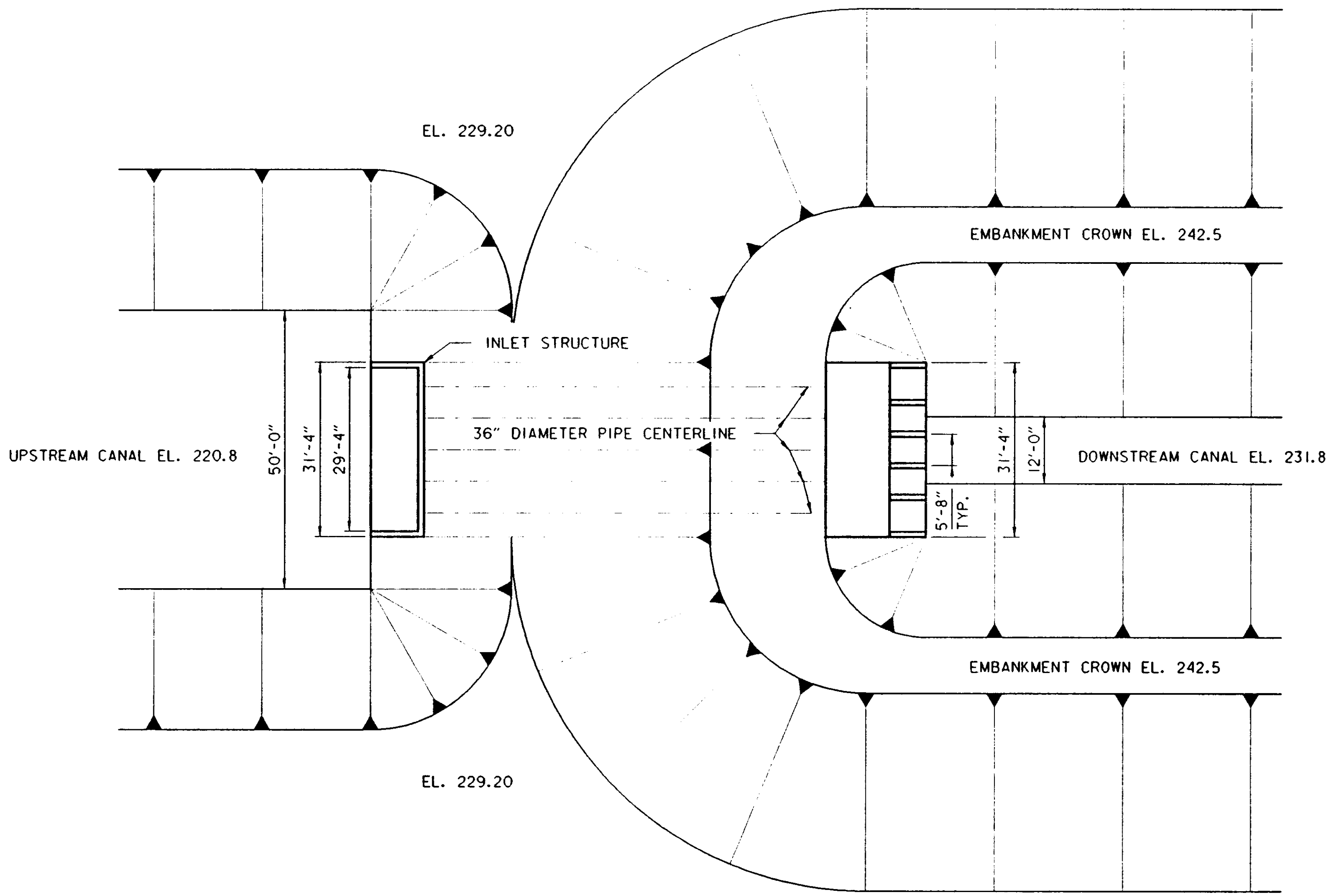
PAGE OF

COMPUTED BY MSW

CHECKED BY

DATE 9/2096

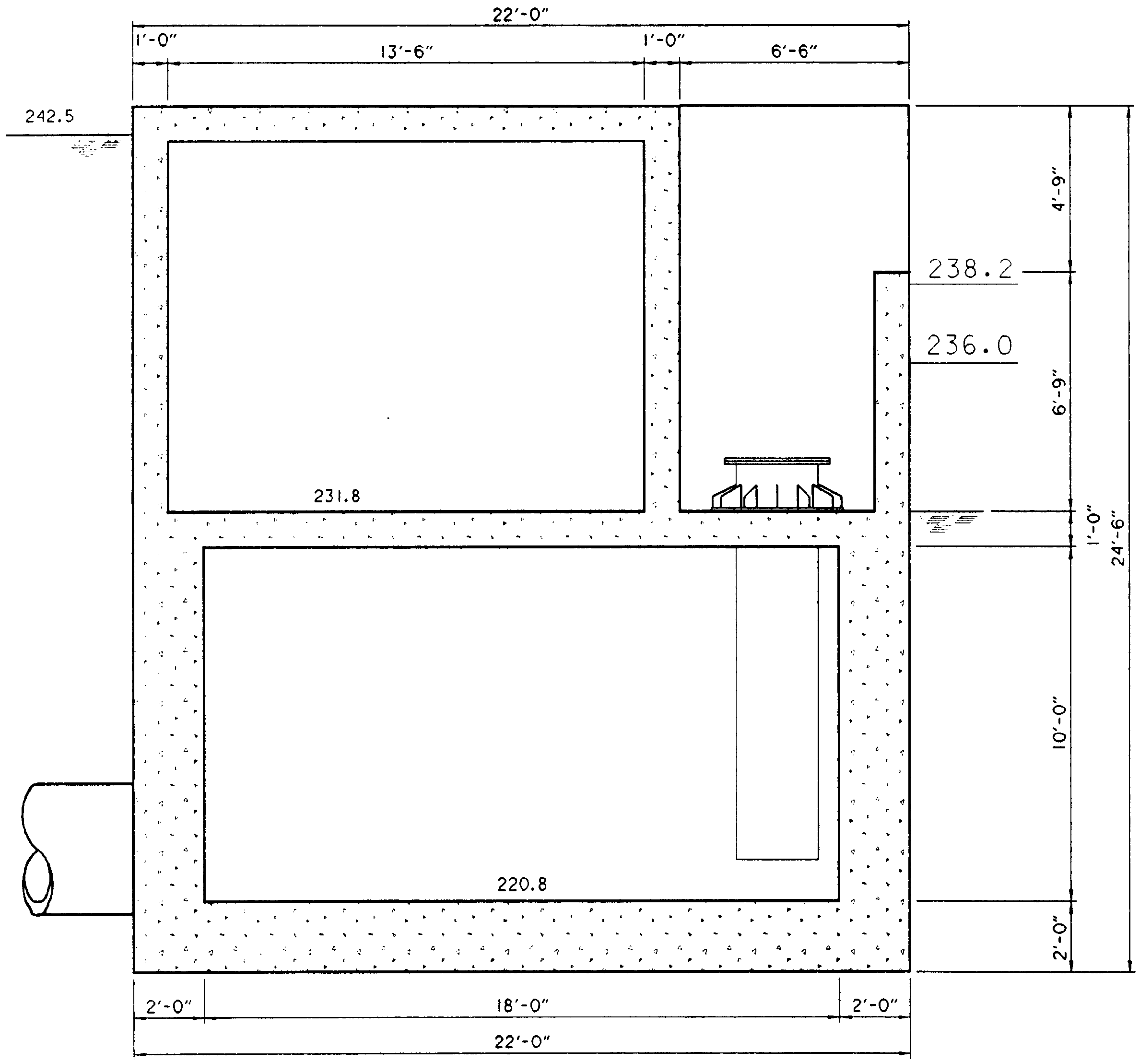
DATE




**Lift Station**
SCALE 1" = 30'-0"

## COMPUTATION SHEET

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | **Grand Prairie Demostration Project**<br>**Eastern Arkansas** | PAGE OF | COMPUTED BY **MSW** | DATE **9/20/96** |
| SUBJECT | **Lift Station Design** | | CHECKED BY | DATE |




**LONGITUDINAL SECTION**
SCALE 3/16" = 1'-0"

# COMPUTATION SHEET

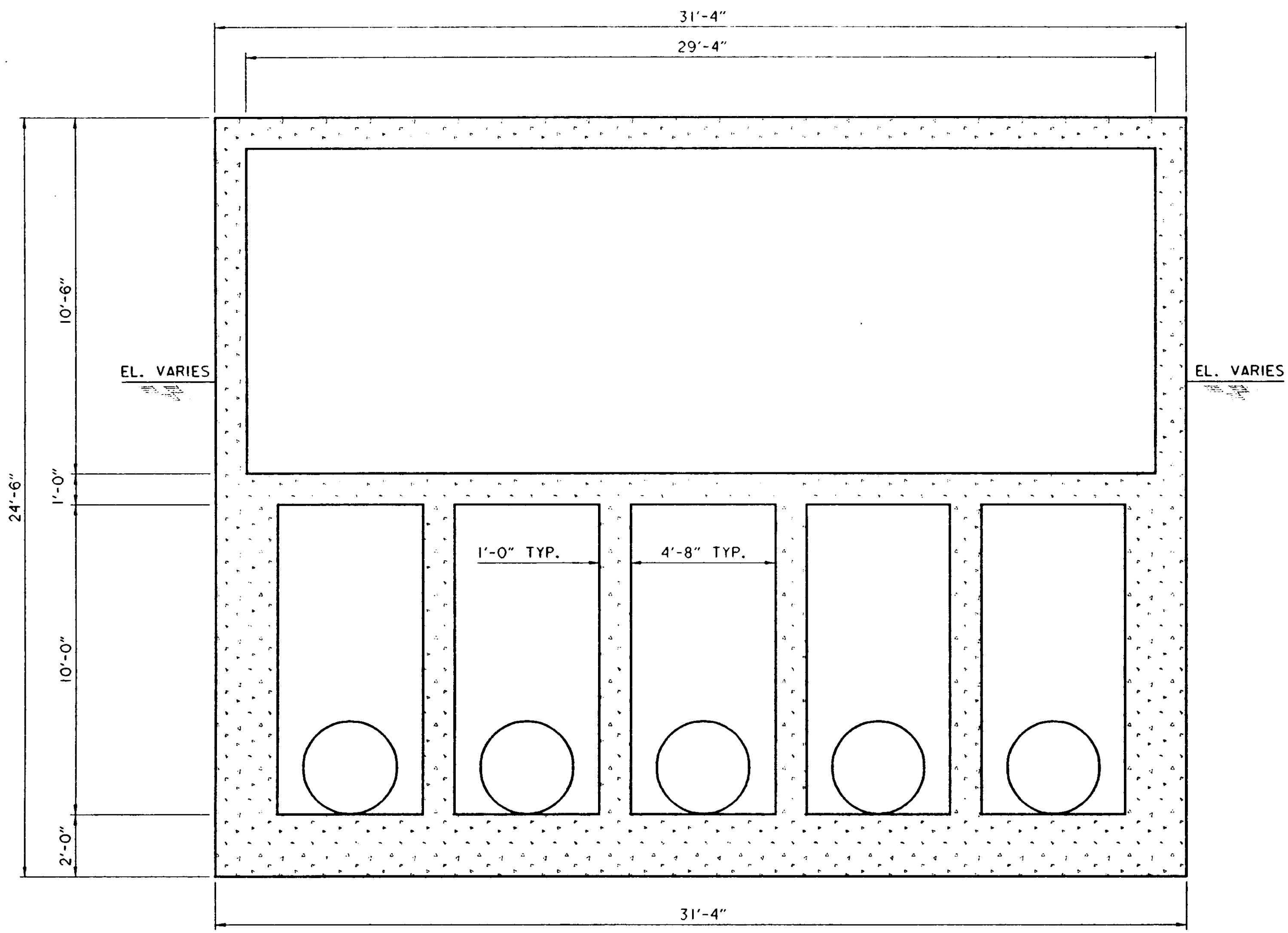
PROJECT **Grand Prairie Demonstration Project Eastern Arkansas**

SUBJECT **Lift Station Design**

PAGE OF

COMPUTED BY **MSW** DATE **92096**

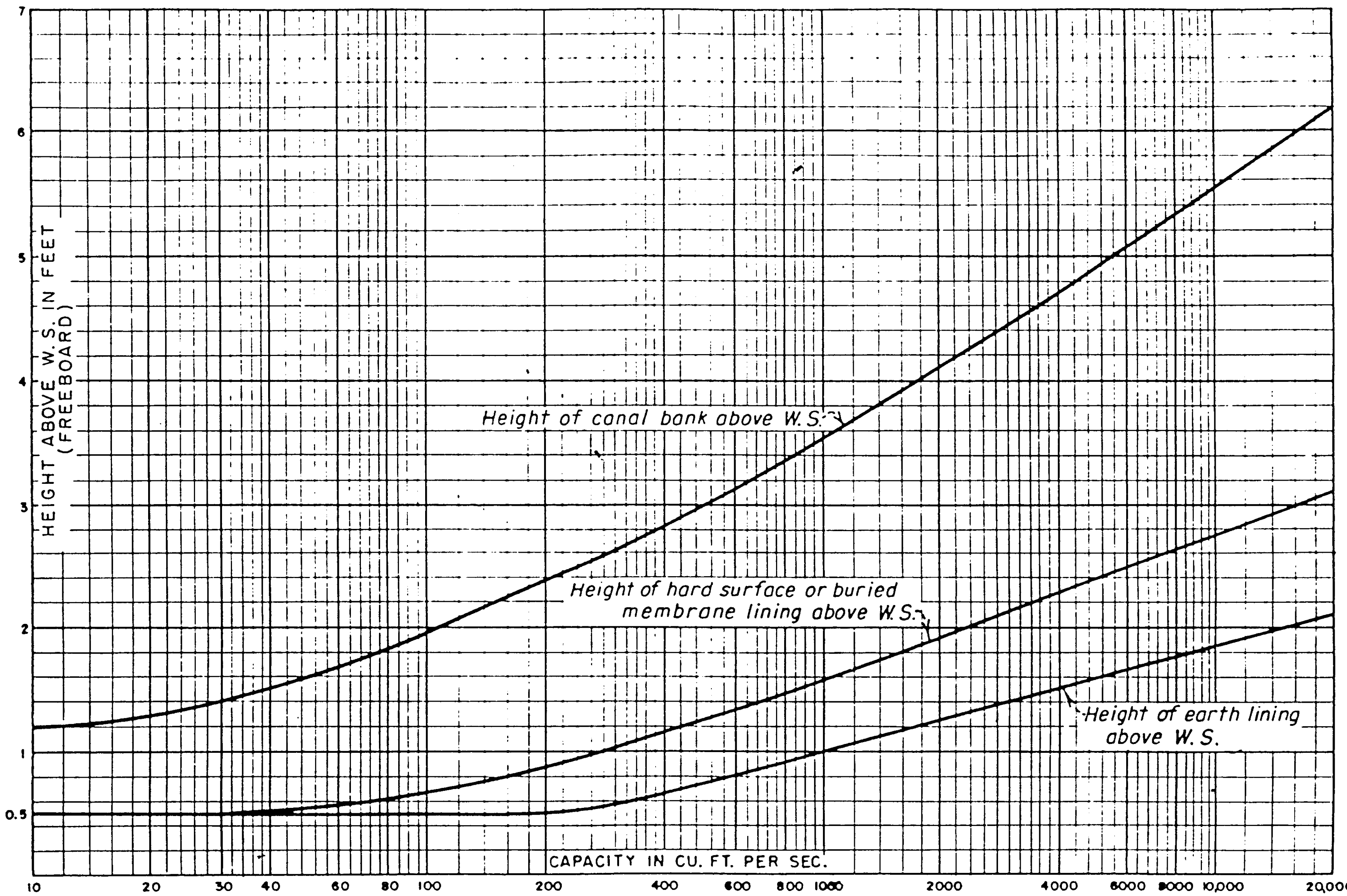
CHECKED BY DATE




**TRANSVERSE SECTION**

SCALE 3/16" = 1'-0"

PLATE III-C-4


HEIGHT ABOVE W.S. IN FEET
(FREEBOARD)
0.5
1
2
3
4
5
6
7
Height of canal bank above W.S.
Height of hard surface or buried membrane lining above W.S.
Height of earth lining above W.S.
CAPACITY IN CU. FT. PER SEC.
10
20
30
40
60
80
100
200
400
600
800
1000
2000
4000
6000
8000
10,000
20,000

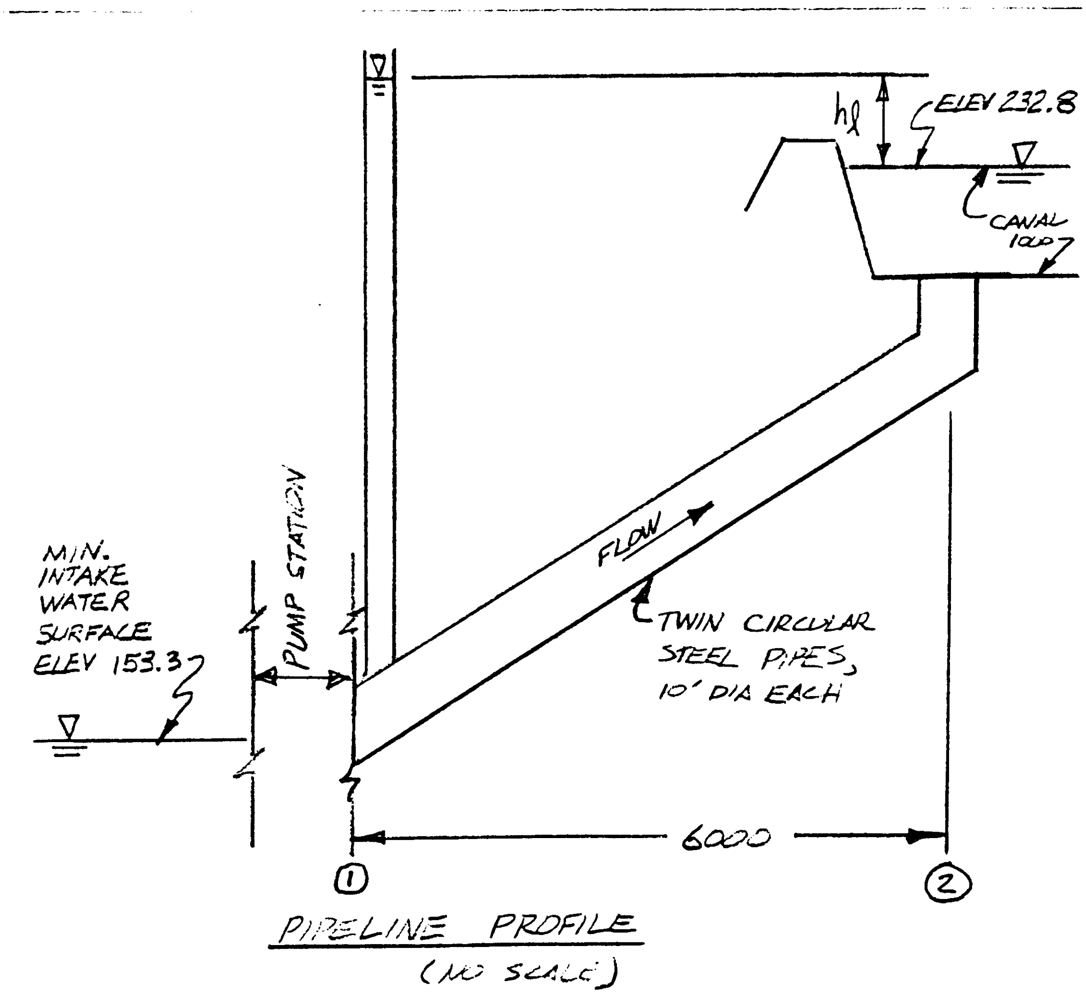

hl
ELEV 232.8
CANAL
1000
MIN.
INTAKE
WATER
SURFACE
ELEV 153.3
PUMP STATION
FLOW
TWIN CIRCULAR
STEEL PIPES,
10' DIA EACH
6000
1
2
PIPELINE PROFILE
(NO SCALE)

Plate III-C-7 Main Pipeline Sizing Computations

The computations presented below were used to develop a feasibility design for the pipeline which conveys water from the main pump station to the head of Canal 1000. In these computations a design discharge of 1800 cfs was assumed.

1. Maximum velocity of flow desired approximately 10 fps.

2. Consider two circular steel pipes, 10 ft diameter.

3. Cross-sectional area of one such pipe

$$A=\frac{\pi}{4}D^2=0.785(10ft)^2=78.5sqft$$

4. Velocity

$$V=\frac{Q}{A}=\frac{900cfs}{78.5sqft}=11.46fps$$

5. Since 11.46 fps is comparable to the desired maximum velocity of 10 fps, use the 10 ft diameter and continue with computations.

6. Bernoulli equation from pump station (1) to head of Canal 1000 (2), with consideration of head loss due to friction in the pipe .

$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+h_{l_{12}}$$

7. Darcy-Weisbach equation to determine head loss in pipe due to friction.

$$h_l=f\frac{l}{D}\frac{V^2}{2g}$$

8. The friction factor, f, in the Darcy-Weisbach equation is a function of the Reynolds number and the relative roughness and is determined using a Moody diagram.

Reynolds number:

$$Re = \frac{VD}{\nu} = \frac{(11.5fps)(10ft)}{(1.217x10^{-5}sq-ft/\sec)} = 9.45x10^6$$

relative roughness:

$$\frac{\epsilon}{D} = \frac{3.0mm}{(10ft)(304.8mm/ft)} = 0.00098$$

from Moody diagram, f = 0.0197, use f= 0.02

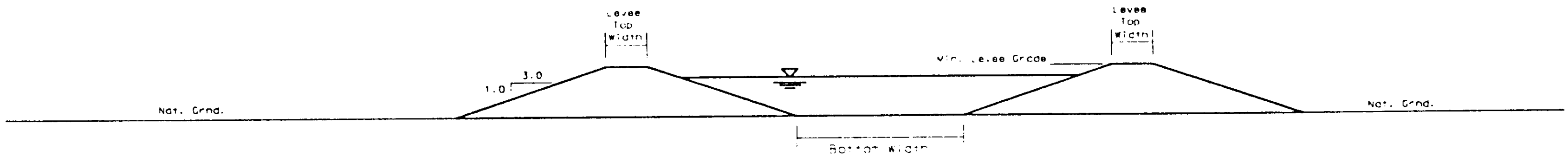
$$h_l = f\frac{l}{D}\frac{V^2}{2g} = 0.02\frac{(6000ft)}{(10ft)}\frac{(11.5fps)^2}{2g} = 24.64ft$$

friction slope = 0.00411 ft/ft

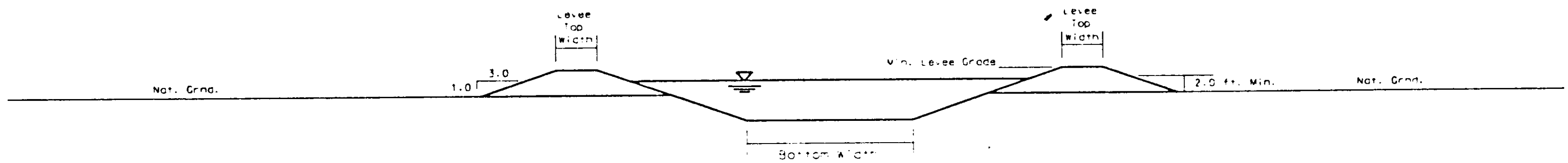
9. Minor loss coefficients include an entrance loss coefficient, $K_{en}$=0.5, a bend loss coefficient, $K_b$= 0.3, and an exit loss coefficient, $K_{ex}$= 1.0. Adding the minor losses to the friction loss determined by the Darcy-Weisbach equation results in the sum of the head losses, Σh.

$$\Sigma h = h_l + (K_{en} + K_b + K_{ex})\frac{V^2}{2g}$$

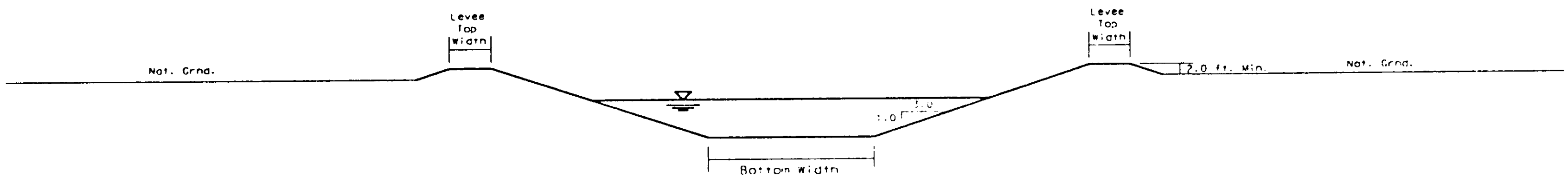
$$\Sigma h = 24.64ft + (0.5 + 0.3 + 1.0)\frac{(11.5fps)^2}{2g} = 28.34ft$$




Typical Full Fill Section




Typical Partial Cut Section




Typical Full Cut Section

NOTES:

1. Bottom Width and Min. Levee Grade as noted in Canal Table.
2. Levee Top Width Varies as follows: Main Canal - 15 feet
   All other Canals - 10 feet on one side
   5 feet on the other
3. Min. Levee Grade shown in Canal Table not Applicable to Full Cut section. A minimum berm height of 2.0 feet is required.
4. All volume calculations based on Levee Top Width of 15 feet for the Main Canal, and 7.5 feet for all other canals (the average of 5 feet and 10 feet).
5. Volume calculations include a 30 percent shrinkage factor applied to cut volumes.

DEPARTMENT OF THE ARMY
MEMPHIS DISTRICT, CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

MISSISSIPPI RIVER AND TRIBUTARIES

Eastern Arkansas Region
Grand Prairie Area
Typical Canal Sections

| SIZE | CODE IDENT. NO. | SERIAL NO. / FILE NO. |
|---|---|---|
| SCALE: NONE | | SHEET OF |

PLATE III-C-8

## CANAL STRUCTURES

| CANAL NUMBER | STRUCTURE NAME | STRUCTURE TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| 1000 | ---------- | ---------- | 227.20 | 218.50 | Begin Canal |
| | T-1000.01 | TURNOUT STR | 227.20 | 218.29 | Gravity Feed To 1000.01 |
| | T-1100 | TURNOUT STR | 227.20 | 218.12 | To Natural Stream 1100 |
| | T-1200 | TURNOUT STR | 227.20 | 217.52 | To Natural Stream 1200 |
| | T-1300 | TURNOUT STR | 227.20 | 218.57 | To LAT/Natural Stream 1300 |
| | T-1400 | TURNOUT STR | 227.20 | 217.46 | To LAT/Natural Stream 1400 |
| | ---------- | SEE 1500 | 227.20 | 217.40 | To LATERAL 1500 |
| | | | | | |
| 2000 | P-2000.01 | TURNOUT STR | 227.20 | 217.01 | Pump To 2000.01 |
| | T-2100 | TURNOUT STR | 227.20 | 216.69 | To LAT/Natural Stream 2100 |
| | ---------- | SEE 2200 | 227.20 | 216.58 | To LATERAL 2200 |
| | P-2000.02 | TURNOUT STR | 227.20 | 216.43 | Pump To 2000.02 |
| | T-2300 | TURNOUT STR | 227.20 | 216.24 | To Natural Stream 2300 |
| | ---------- | SEE 2400 | 227.20 | 215.88 | To LATERAL 2400 |
| | P-2000.03 | TURNOUT STR | 227.20 | 215.64 | Pump To 2000.03 |
| | P-2000.04 | TURNOUT STR | 227.20 | 215.46 | Pump To 2000.04 |
| | T-2500 | TURNOUT STR | 227.20 | 215.33 | To Natural Stream 2500 |
| | | | | | |
| 3000 | ---------- | SEE 3100 | 227.20 | 215.20 | To LATERAL 3100 |
| | P-3000.01 | TURNOUT STR | 227.20 | 215.07 | Pump To 3000.01 |
| | ---------- | SEE 3200 | 227.20 | 214.94 | To LATERAL 3200 |
| | ---------- | SEE 3300 | 224.50 | 214.68 | To LATERAL 3300 |
| | C-3000.01 | CHECK STR | 227.20 | 214.69 | |
| | ---------- | SEE 3400 | 224.50 | 214.41 | To LATERAL 3400 |
| | P-3000.02 | TURNOUT STR | 224.50 | 213.82 | Pump To 3000.02 |
| | P-3000.03 | TURNOUT STR | 224.50 | 213.09 | Pump To 3000.03 |
| | P-3000.04 | TURNOUT STR | 224.50 | 213.02 | Pump To 3000.04 |
| | P-3000.05 | TURNOUT STR | 224.50 | 212.76 | Pump To 3000.05 |
| | P-3000.06 | TURNOUT STR | 224.50 | 212.50 | Pump To 3000.06 |
| | P-3000.07 | TURNOUT STR | 224.50 | 212.50 | Pump To 3000.07 |
| | ---------- | SEE 3500A | 224.50 | 212.21 | To LATERAL 3500A |
| | | | | | |
| 4000 | C-4000.01 | CHECK STR | 224.50 | 212.00 | |
| | P-4000.01 | TURNOUT STR | 221.00 | 211.94 | Pump To 4000.01 |
| | P-4000.02 | TURNOUT STR | 221.00 | 210.87 | Pump To 4000.02 |
| | P-4000.03 | TURNOUT STR | 221.00 | 210.60 | Pump To 4000.03 |
| | ---------- | SEE 4100 | 221.00 | 210.04 | To LATERAL 4100 |
| | ---------- | SEE 3500B | 221.00 | 210.04 | To LATERAL 3500B |

| CANAL NUMBER | STRUCTURE NAME | STRUCTURE TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| | P-4000.04 | TURNOUT STR | 221.00 | 209.93 | Pump To 4000.04 |
| | ---------- | SEE 4200 | 221.00 | 209.82 | To LATERAL 4200 |
| . | P-4000.05 | TURNOUT STR | 221.00 | 209.79 | Pump To 4000.05 |
| | P-4000.06 | TURNOUT STR | 221.00 | 209.60 | Pump To 4000.06 |
| | T-4300 | TURNOUT STR | 221.00 | 209.53 | Gravity Feed To 4300 (Pipe) |
| | ---------- | SEE 4400 | 221.00 | 209.20 | To LATERAL 4400 |
| | ---------- | SEE 4500 | 221.00 | 209.20 | To LATERAL 4500 |
| | | | | | |
| 5000 | C-5000.01 | CHECK STR | 221.00 | 209.10 | |
| | T-5100 | TURNOUT STR | 218.90 | 208.56 | To Natural Stream 5100 |
| | ---------- | SEE 5200 | 218.90 | 208.30 | To LATERAL 5200 |
| | P-5000.01 | TURNOUT STR | 218.90 | 208.02 | Pump To 5000.01 |
| | ---------- | SEE 5300 | 218.90 | 207.80 | To LATERAL 5300 |
| | ---------- | SEE 5400 | 218.90 | 207.80 | To LATERAL 5400 |
| | P-5000.02 | TURNOUT STR | 218.90 | 207.50 | Pump To 5000.02 |
| | ---------- | SEE 5500 | 218.90 | 207.36 | To LATERAL 5500 |
| | | | | | |
| 6000 | C-6000.01 | CHECK STR | 218.90 | 207.36 | |
| | T-6100 | TURNOUT STR | 214.30 | 206.41 | To Natural Stream 6100 |
| | ---------- | SEE 6200 | 214.30 | 205.23 | To LATERAL 6200 |
| | T-6300 | TURNOUT STR | 214.30 | 204.72 | To Natural Stream 6300 |
| | P-6000.01 | TURNOUT STR | 214.30 | 204.70 | Pump To 6000.01 |
| | T-6400 | TURNOUT STR | 214.30 | 204.17 | To LATERAL 6400 |
| | C-6000.02 | CHECK STR | 214.30 | ➤➤➤ | 204.17/202.43 (1.74' DROP) |
| | T-6500 | TURNOUT STR | 204.30 | 202.19 | To Natural Stream 6500 |
| | P-6000.02 | TURNOUT STR | 204.30 | 200.40 | Pump To 6000.02 |
| | P-6000.03 | TURNOUT STR | 204.30 | 198.26 | Pump To 6000.03 |
| | ---------- | SEE 6600 | 204.30 | 198.26 | To LATERAL 6600 |
| | C-6000.03 | CHECK STR | 204.30 | ➤➤➤ | 195.37/190.43 (4.94' DROP) |
| | P-6000.04 | TURNOUT STR | 196.50 | 190.43 | Pump To 6000.04 |
| | P-6000.05 | TURNOUT STR | 196.50 | 187.17 | Pump To 6000.05 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 1500 | T-1500 | TURNOUT STR | 227.20 | 218.00 | 229+73 on Main Canal |
| | T-1510 | TURNOUT STR | 222.00 | 217.74 | To LATERAL 1510 |

| CANAL NUMBER | STRUCTURE NAME | STRUCTURE TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| | P-1500.01 | TURNOUT STR | 222.00 | 217.61 | Pump To 1500.01 |
| | P-1500.02 | TURNOUT STR | 222.00 | 217.61 | Pump To 1500.02 |
| | P-1500.03 | TURNOUT STR | 222.00 | 216.77 | Pump To 1500.03 |
| | C-1500.01 | CHECK STR | 222.00 | ➤➤➤ | 216.77/216.00 (0.77' DROP) |
| | P-1500.04 | TURNOUT STR | 219.00 | 215.82 | Pump To 1500.04 |
| | ---------- | SEE 1520 | 219.00 | 215.71 | To LATERAL 1520 |
| | T-1500X | TURNOUT STR | 219.00 | 215.64 | End Canal, Begin Nat Strm |
| | | | | | |
| 1520 | T-1520 | TURNOUT STR | 219.00 | 212.50 | 307+19 on 1500 |
| | P-1520.01 | TURNOUT STR | 214.50 | 212.31 | Pump To 1520.01 |
| | P-1520.02 | TURNOUT STR | 214.50 | 212.27 | Pump To 1520.02 |
| | T-1520X | TURNOUT STR | 214.50 | 212.24 | To Natural Stream 1520 |
| | | | | | |
| 2200 | T-2200 | TURNOUT STR | 227.20 | 216.00 | 407+73 on Main Canal |
| | P-2200.01 | TURNOUT STR | 221.26 | 215.37 | Pump To 2200.01 |
| | P-2200.02 | TURNOUT STR | 221.26 | 215.10 | Pump To 2200.02 |
| | T-2210 | TURNOUT STR | 221.26 | 214.97 | To Natural Stream 2210 |
| | P-2200.03 | TURNOUT STR | 221.26 | 214.83 | Pump To 2200.03 |
| | P-2200.04 | TURNOUT STR | 221.26 | 214.56 | Pump To 2200.04 |
| | C-2200.01 | CHECK STR | 221.26 | 214.26 | |
| | T-2220 | TURNOUT STR | 218.64 | 213.45 | To Natural Stream 2220 |
| | ---------- | SEE 2230 | 218.64 | 213.04 | To LATERAL 2230 |
| | ---------- | SEE 2240 | 218.64 | 212.78 | To LATERAL 2240 |
| | T-2250 | TURNOUT STR | 218.64 | 212.70 | To Natural Stream 2250 |
| | T-2260 | TURNOUT STR | 218.64 | 212.67 | To Natural Stream 2260 |
| | P-2200.05 | TURNOUT STR | 218.64 | 212.64 | Pump To 2200.05 |
| | T-2200X | TURNOUT STR | 218.64 | 212.64 | End Canal, Begin Nat Strm |
| | | | | | |
| 2230 | ---------- | EXTEND 2200 | 218.64 | 215.00 | 591+90 on 2200 |
| | T-2230 | TURNOUT STR | 218.64 | 214.91 | To Pipe 2230 |
| | P-2230.01 | PIPE JUNCTION | 2-48" RCP | 210.41 | Pump To 2230.01 |
| | T-2230X | TURNOUT STR | 2-48" RCP | 203.80 | To Natural Stream 2230 |
| | | | | | |
| 2240 | T-2240 | TURNOUT STR | 218.64 | 206.52 | 644+89 on 2200 |
| | P-2240.01 | PIPE JUNCTION | 2-24" RCP | 206.25 | Pump To 2240.01 |
| | T-2240X | TURNOUT STR | 2-24" RCP | 206.20 | To Natural Stream 2240 |
| | | | | | |
| 2400 | T-2400 | TURNOUT STR | 227.20 | 219.00 | 549+38 on Main Canal |
| | T-2410 | TURNOUT STR | 223.00 | 218.89 | To Natural Stream 2410 |

| CANAL NUMBER | STRUCTURE NAME | TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| | P-2400.01 | TURNOUT STR | 223.00 | 218.70 | Pump To 2400.01 |
| | ---------- | NO STRUCTURE | 223.00 | 218.54 | End Canal |
| | | | | | |
| 3100 | T-3100 | TURNOUT STR | 227.20 | 220.00 | 674+06 on Main Canal |
| | P-3100.01 | TURNOUT STR | 224.00 | 219.47 | Pump To 3100.01 |
| | P-3100.02 | TURNOUT STR | 224.00 | 219.34 | Pump To 3100.02 |
| | T-3100X | TURNOUT STR | 224.00 | 218.88 | To Natural Stream 3110 |
| | C-3100.01 | CHECK STR | 224.00 | ➤➤➤ | 218.88/214.00 (4.88' DROP) |
| | ---------- | NO STRUCTURE | 217.00 | 213.85 | End Canal |
| | | | | | |
| 3200 | ---------- | NO STRUCTURE | 227.20 | 221.00 | Extend Main Canal to 35+00 |
| | T-3210 | TURNOUT STR | 227.20 | 220.87 | To Natural Stream 3210 |
| | ---------- | PUMP STATION | 227.20 | ➤➤➤ | 220.83/231.83 (11.00' LIFT) |
| | ---------- | SEE 3220 | 235.99 | 231.74 | To LATERAL 3220 |
| | T-3230 | TURNOUT STR | 235.99 | 231.64 | To Natural Stream 3230 |
| | P-3200.01 | TURNOUT STR | 235.99 | 231.47 | Pump To 3200.01 |
| | T-3240 | TURNOUT STR | 235.99 | 231.27 | To LATERAL 3240 |
| | P-3250 | TURNOUT STR | 235.99 | 230.94 | Pump To 3250 |
| | T-3260 | TURNOUT STR | 235.99 | 230.74 | To LATERAL 3260 |
| | C-3200.01 | CHECK STR | 235.99 | 230.73 | |
| | P-3200.02 | TURNOUT STR | 233.14 | 230.68 | Pump To 3200.02 |
| | P-3200.03 | TURNOUT STR | 233.14 | 230.28 | Pump To 3200.03 |
| | P-3200.04 | TURNOUT STR | 233.14 | 230.14 | Pump To 3200.04 |
| | T-3200X | TURNOUT STR | 233.14 | 230.14 | To Natural Stream 3200 |
| | | | | | |
| 3220 | T-3220 | TURNOUT STR | 235.99 | 230.85 | 53+80 on 3200 |
| | T-3221 | TURNOUT STR | 233.12 | 230.33 | To LATERAL 3221 |
| | C-3220.01 | CHECK STR | 233.12 | ➤➤➤ | 230.19/224.19 (6.00' DROP) |
| | T-3222 | TURNOUT STR | 225.15 | 223.85 | To Natural Stream 3222 |
| | T-3220X | TURNOUT STR | 225.15 | 223.59 | To Natural Stream 3220 |
| | | | | | |
| 3300 | T-3300 | TURNOUT STR | 224.50 | 219.50 | 781+30 on Main Canal |
| | P-3300.01 | TURNOUT STR | 222.50 | 219.24 | Pump To 3300.01 |
| | T-3300X | TURNOUT STR | 222.50 | 218.97 | To Natural Stream 3300 |
| | | | | | |
| 3400 | T-3400 | TURNOUT STR | 224.50 | 214.41 | 835+07 on Main Canal |
| | T-3400X | TURNOUT STR | 1-30" RCP | 209.68 | To Natural Stream 3400 |
| 3500A | T-3500A | TURNOUT STR | 224.50 | 211.50 | 1273+29 on Main Canal |
| | P-3500.01 | TURNOUT STR | 214.80 | 210.76 | Pump To 3500.01 |

| CANAL NUMBER | STRUCTURE NAME | STRUCTURE TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| | T-3510 | TURNOUT STR | 214.80 | 209.68 | To Natural Stream 3510 |
| | | | | | |
| 3500B | T-3500B | TURNOUT STR | 221.00 | 210.04 | 1704+22 on Main Canal |
| | P-3500.02 | PIPE JUNCTION | 1-30" RCP | 209.49 | Pump To 3500.02 |
| | P-3500.03 | PIPE JUNCTION | 1-30" RCP | 209.49 | Pump To 3500.03 |
| | | | | | |
| 4100 | T-4100 | TURNOUT STR | 221.00 | 216.00 | 1704+22 on Main Canal |
| | P-4100.01 | TURNOUT STR | 219.00 | 215.81 | Pump To 4100.01 |
| . | ---------- | PIPE INLET | 219.00 | | 215.72 / 204.72 |
| | P-4100.02 | PIPE JUNCTION | 2-48" RCP | 204.67 | Pump To 4100.02 |
| | P-4100.03 | PIPE JUNCTION | 2-48" RCP | 204.26 | Pump To 4100.03 |
| | T-4100X | TURNOUT STR | 2-48" RCP | 204.00 | To Natural Stream 4100 |
| | | | | | |
| 4200 | T-4200 | TURNOUT STR | 221.00 | 216.75 | 1756+24 on Main Canal |
| | P-4200.01 | TURNOUT STR | 219.75 | 216.58 | Pump To 4200.01 |
| | P-4200.02 | TURNOUT STR | 219.75 | 216.17 | Pump To 4200.02 |
| | ---------- | PIPE INLET | 219.75 | ➤➤➤ | 216.05/202.75 (13.3' DROP) |
| | T-4200X | TURNOUT STR | 1-30" RCP | 194.78 | To Natural Stream 4200 |
| | | | | | |
| 4400 | T-4400 | TURNOUT STR | 221.00 | 217.50 | 1863+83 on Main Canal |
| | ---------- | PIPE INLET | 220.50 | ➤➤➤ | 217.24/213.24 (4.00' DROP) |
| | ---------- | PIPE OUTLET | 2-24" RCP | 208.00 | |
| | ---------- | PIPE INLET | 211.00 | ➤➤➤ | 207.91/203.94 (7.00' DROP) |
| | ---------- | PIPE JUNCTION | 2-24" RCP | | Gravity Feed To 4400.013 |
| | ---------- | NO STRUCTURE | ---- | ---- | End Pipe |
| | | | | | |
| 4500 | T-4500 | TURNOUT STR | 221.00 | 216.15 | 1863+83 on Main Canal |
| | ---------- | SEE 4510 | 220.50 | 216.23 | To LATERAL 4510 (Pipe) |
| | ---------- | SEE 4520 | 220.50 | 215.97 | To LATERAL 4520 |
| | ---------- | PIPE INLET | 220.50 | ➤➤➤ | 215.85/212.85 (3.00' DROP) |
| | ---------- | ---------- | 2-30" RCP | 190.35 | GRADE CHANGE |
| | P-4500.01 | PIPE JUNCTION | 2-30" RCP | 189.94 | Pump To 4500.01 |
| | ---------- | PIPE OUTLET | 2-30" RCP | ➤➤➤ | 189.93 / 194.00 (4.07' RISE) |
| | P-4500.02 | TURNOUT STR | 197.00 | 193.60 | Pump To 4500.02 |
| | T-4500.03 | TURNOUT STR | 197.00 | 193.60 | Gravity Feed To 4500.03 |
| | | | | | |
| | | | | | |
| 4510 | T-4510 | TURNOUT STR | 220.50 | 216.24 | 52+65 on 4500 |
| | ---------- | ---------- | | | 6 GRADE CHANGES |

| CANAL NUMBER | STRUCTURE NAME | TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| | ---------- | END PIPE | 1-48" RCP | 189.25 | End Pipe |
| | | | | | |
| 4520 | T-4520 | TURNOUT STR | 220.50 | 216.92 | 106+05 on 4500 |
| | ---------- | PIPE INLET | 220.00 | ➤➤➤ | 216.56/214.00 (2.56' DROP) |
| | ---------- | END PIPE | 1-24" RCP | 208.23 | End Pipe |
| | | | | | |
| 5200 | T-5200 | TURNOUT STR | 218.90 | 211.30 | 2057+42 on Main Canal |
| | C-5200.01 | CHECK STR | 218.90 | ➤➤➤ | 211.17/208.50 (2.67' DROP) |
| | ---------- | PIPE INLET | 211.50 | ➤➤➤ | 207.86/194.86 (13.0' DROP) |
| | ---------- | PIPE OUTLET | 2-42" RCP | ➤➤➤ | 194.31/207.00 (12.7' DROP) |
| | ---------- | END CANAL | 210.00 | 206.37 | End Canal |
| | | | | | |
| 5300 | T-5300 | TURNOUT STR | 218.90 | 211.23 | 2164+36 on Main Canal |
| | ---------- | SEE 5310 | 218.40 | 210.83 | To LATERAL 5310 |
| | ---------- | PIPE INLET | 218.40 | | 210.69 / |
| | P-5300.02 | PIPE JUNCTION | 2-54" RCP | | To 5300.02 (DIA CHANGE) |
| | ---------- | PIPE OUTLET | 2-48" RCP | | / 196.00 |
| | P-5300.03 | TURNOUT STR | 199.62 | 196.62 | Pump To 5300.03 |
| | T-5300X | TURNOUT STR | 199.62 | 195.48 | To Natural Stream 5300 |
| | | | | | |
| 5310 | T-5310 | TURNOUT STR | 218.40 | 214.00 | 80+20 on 5300 |
| | ---------- | PIPE INLET | 218.00 | 213.90 | 213.89/198.61 (15.3' DROP) |
| | T-5311 | TURNOUT STR | 2-36" RCP | ➤➤➤ | To Natural Stream 5311 |
| | T-5310X | TURNOUT STR | 2-36" RCP | 197.99 | To Natural Stream 5310 |
| | | | | | |
| 5400 | T-5400 | TURNOUT STR | 218.90 | 214.97 | 2164+36 on Main Canal |
| | C-5400.01 | CHECK STR | 218.40 | ➤➤➤ | 214.70/209.10 (5.60' DROP) |
| | P-5400.01 | TURNOUT STR | 214.10 | 208.57 | Pump To 5400.01 |
| | P-5400.02 | TURNOUT STR | 214.10 | 208.57 | Pump To 5400.02 |
| | | | | | |
| 5500 | T-5500 | TURNOUT STR | 218.90 | 207.50 | 2243+63 on Main Canal |
| | T-5510 | TURNOUT STR | 211.50 | 207.23 | To Natural Stream 5510 |
| | P-5500.02 | TURNOUT STR | 211.50 | 206.68 | Pump To 5500.02 |
| | P-5500.03 | TURNOUT STR | 211.50 | 206.41 | Pump To 5500.03 |
| | P-5500.04 | TURNOUT STR | 211.50 | 206.15 | Pump To 5500.04 |
| | T-5520 | TURNOUT STR | 211.50 | 205.72 | To Natural Stream 5520 |
| | C-5500.01 | CHECK STR | 211.50 | ➤➤➤ | 205.50 / 206.50 (1.00' RISE) |
| | T-5530 | TURNOUT STR | 209.50 | 205.38 | To Natural Stream 5530 |
| | P-5500.05 | TURNOUT STR | 209.50 | 205.36 | Pump To 5500.05 |

| CANAL NUMBER | STRUCTURE NAME | STRUCTURE TYPE | MIN U.S. POOL EL. | BOTTOM ELEV | REMARKS |
|---|---|---|---|---|---|
| | P-5500.06 | TURNOUT STR | 209.50 | 204.84 | Pump To 5500.06 |
| | T-5505 | TURNOUT STR | 209.50 | 204.84 | To LATERAL 5505 |
| | | | | | |
| 6200 | T-6200 | TURNOUT STR | 214.30 | 202.10 | 2540+70 on Main Canal |
| | C-6200.01 | CHECK STR | 209.10 | ➤➤➤ | 201.10/199.20 (1.90' DROP) |
| | T-6210 | TURNOUT STR | 205.20 | 198.83 | To Natural Stream 6210 |
| | P-6200.02 | TURNOUT STR | 205.20 | 197.49 | Pump To 6200.02 |
| | T-6215 | TURNOUT STR | 205.20 | 197.49 | To LATERAL 6215 |
| | P-6200.03 | TURNOUT STR | 205.20 | 196.69 | Pump To 6200.03 |
| | P-6200.04 | TURNOUT STR | 205.20 | 196.43 | Pump To 6200.04 |
| | T-6216 | TURNOUT STR | 205.20 | 196.43 | To LATERAL 6216 |
| | C-6200.02 | CHECK STR | 205.20 | ➤➤➤ | 196.20/193.20 (3.00' DROP) |
| | T-6220 | TURNOUT STR | 197.87 | 192.57 | To Natural Stream 6220 |
| | C-6200.03 | CHECK STR | 197.87 | ➤➤➤ | 190.87/190.30 (0.57' DROP) |
| | | | | | |
| 6200/ | T-6230 | TURNOUT STR | 194.63 | 189.95 | To Natural Stream 6230 |
| 6230 | P-6200.06 | TURNOUT STR | 194.63 | 192.37 | Pump To 6200.06 |
| | T-6230X | TURNOUT STR | 194.63 | 192.30 | To Natural Stream 6100 |
| | | | | | |
| 6600 | T-6600 | TURNOUT STR | 204.30 | 195.25 | 2941+80 on Main Canal |
| | T-6300X | TURNOUT STR | 198.58 | 194.47 | To Natural Stream 6300 |
| | T-6610 | TURNOUT STR | 198.58 | 194.11 | To Natural Stream 6610 |
| | C-6600.01 | CHECK STR | 198.58 | 193.58 | |
| | P-6600.01 | TURNOUT STR | 197.02 | 193.15 | Pump To 6600.01 |
| | ---------- | NO STRUCTURE | 197.02 | 193.02 | End Canal |
| | | | | | |
| | | | | | |
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| X-SECTION STATION FEET | X-SECTION STATION MILE | MAXIMUM W.S. ELEVATION | MINIMUM LEVEE GRADE ELEVATION | MINIMUM REQ'D OPERATION RANGE FEET |
|---|---|---|---|---|
| | | **MAIN CANAL** | | |
| 1650 | 0 | 232.787 | 236.79 | 4 |
| 40814.4 | 7.73 | 230.33 | 234.33 | 4 |
| 40814.4 | 7.73 | 230.318 | 234.22 | 3.9 |
| 65456.16 | 12.397 | 228.569 | 232.47 | 3.9 |
| 67425.6 | 12.77 | 228.481 | 232.33 | 3.85 |
| 70910.4 | 13.43 | 228.315 | 232.17 | 3.85 |
| 72864 | 13.8 | 228.23 | 232.03 | 3.8 |
| 112886.4 | 21.38 | 225.935 | 229.74 | 3.8 |
| 116424 | 22.05 | 225.788 | 229.54 | 3.75 |
| 130838.4 | 24.78 | 224.721 | 228.47 | 3.75 |
| 132797.28 | 25.151 | 224.635 | 228.34 | 3.7 |
| 186325.92 | 35.289 | 221.271 | 224.97 | 3.7 |
| 186384 | 35.3 | 221.273 | 224.92 | 3.65 |
| 203913.6 | 38.62 | 220.265 | 223.92 | 3.65 |
| 205751.04 | 38.968 | 220.188 | 223.79 | 3.6 |
| 214368 | 40.6 | 219.383 | 222.98 | 3.6 |
| 217905.6 | 41.27 | 219.247 | 222.75 | 3.5 |
| 221390.4 | 41.93 | 219.127 | 222.63 | 3.5 |
| 224093.76 | 42.442 | 219.047 | 222.45 | 3.4 |
| 239062.56 | 45.277 | 216.552 | 219.95 | 3.4 |
| 239236.8 | 45.31 | 216.546 | 219.85 | 3.3 |
| 251064 | 47.55 | 214.993 | 218.29 | 3.3 |
| 251074.56 | 47.552 | 215.041 | 217.64 | 2.6 |
| 261676.8 | 49.56 | 209.34 | 211.94 | 2.6 |
| 261729.6 | 49.57 | 209.023 | 211.52 | 2.5 |
| 287020.8 | 54.36 | 205.348 | 207.85 | 2.5 |
| 288235.2 | 54.59 | 205.279 | 207.58 | 2.3 |
| 318859.2 | 60.39 | 196.5 | 198.8 | 2.3 |
| | | | | |
| | | **CANAL 1500** | | |
| 0 | 0 | 223.25 | 224.85 | 1.6 |
| 24710 | 4.68 | 220.64 | 222.24 | 1.6 |
| 24974 | 4.73 | 219.1 | 220.3 | 1.2 |
| 32683 | 6.19 | 219 | 220.2 | 1.2 |
| | | | | |
| | | **CANAL 1520** | | |
| 0 | 0 | 214.6 | 215.8 | 1.2 |
| 5016 | 0.95 | 214.5 | 215.7 | 1.2 |
| | | | | |
| | | **CANAL 2200** | | |
| 0 | 0 | 223.12 | 225.32 | 2.2 |
| 34795 | 6.59 | 221.3 | 223.5 | 2.2 |
| 34848 | 6.6 | 220.52 | 222.52 | 2 |
| 67109 | 12.71 | 218.6 | 220.6 | 2 |
| | | | | |
| | | **CANAL 2230** | | |

| X-SECTION STATION FEET | X-SECTION STATION MILE | MAXIMUM W.S. ELEVATION | MINIMUM LEVEE GRADE ELEVATION | MINIMUM REQ'D OPERATION RANGE FEET |
|---|---|---|---|---|
| 0 | 0 | 219.7 | 222.01 | 2.31 |
| 1742 | 0.33 | 218.6 | 220.91 | 2.31 |
| | | | | |
| | | **CANAL 2400** | | |
| 0 | 0 | 223.55 | 225.05 | 1.5 |
| 9134 | 1.73 | 223 | 224.5 | 1.5 |
| | | | | |
| | | **CANAL 3100** | | |
| 0 | 0 | 224.81 | 226.01 | 1.2 |
| 14203 | 2.69 | 217 | 218.2 | 1.2 |
| | | | | |
| | | **CANAL 3200** | | |
| 0 | 0 | 228.23 | 232.03 | 3.8 |
| 3500 | 0.66 | 228.23 | 232.03 | 3.8 |
| | | | | PUMP STATION @ ~35+00 |
| 3500 * | 0.66 | 238.15 | 241.15 | 3 |
| 25397 | 4.81 | 236 | 239 | 3 |
| 37382 | 7.08 | 233.1 | 235.6 | 2.5 |
| | | | | |
| | | **CANAL 3220** | | |
| 0 | 0 | 234 | 235.5 | 1.5 |
| 19272 | 3.65 | 225.2 | 226.7 | 1.5 |
| | | | | |
| | | **CANAL 3240** | | |
| 0 | 0 | 234.37 | 235.57 | 1.2 |
| 3854 | 0.73 | 234.3 | 235.5 | 1.2 |
| | | | | |
| | | **CANAL 3250** | | |
| 0 | 0 | 235.59 | 236.79 | 1.2 |
| 7075 | 1.34 | 235.5 | 236.7 | 1.2 |
| | | | | |
| | | **CANAL 3300** | | |
| 0 | 0 | 222.73 | 223.93 | 1.2 |
| 10507 | 1.99 | 222.5 | 223.7 | 1.2 |
| | | | | |
| | | **CANAL 3500** | | |
| 0 | 0 | 216.45 | 218.05 | 1.6 |
| 36485 | 6.91 | 214.8 | 216.4 | 1.6 |
| | | | | |
| | | **CANAL 4100** | | |
| 0 | 0 | 219.3 | 220.6 | 1.3 |
| 5491 | 1.04 | 219 | 220.3 | 1.3 |
| | | | | |
| | | **CANAL 4200** | | |
| 0 | 0 | 220.46 | 221.76 | 1.3 |
| 13992 | 2.65 | 219.8 | 221.1 | 1.3 |

| X-SECTION STATION FEET | X-SECTION STATION MILE | MAXIMUM W.S. ELEVATION | MINIMUM LEVEE GRADE ELEVATION | MINIMUM REQ'D OPERATION RANGE FEET |
|---|---|---|---|---|
| | | | | |
| | | CANAL 4400 | | |
| 0 | 0 | 220.69 | 221.99 | 1.3 |
| 5,227 | 0.99 | 220.5 | 221.8 | 1.3 |
| 5250 | 0.994 | Pipeline | | |
| 6750 | 1.278 | Pipeline | | |
| 6,758 | 1.28 | 211.15 | 212.35 | 1.2 |
| 8,550 | 1.62 | 211 | 212.2 | 1.2 |
| 8550 | 1.62 | Pipeline | | |
| 10697 | 2.025 | Pipeline | | |
| | | | | |
| | | CANAL 4500 | | |
| 0 | 0 | 221.01 | 222.61 | 1.6 |
| 12883 | 2.44 | 220.5 | 222.1 | 1.6 |
| 12936 | 2.45 | | | PIPELINE FROM 129+00 |
| 18586 | 3.52 | | | END PIPELINE 186+00 |
| 19177 | 3.632 | 197.16 | 198.36 | 1.2 |
| 26558 | 5.03 | 197 | 198.2 | 1.2 |
| | | | | |
| | | CANAL 4520 | | |
| 0 | 0 | 220.43 | 221.73 | 1.3 |
| 7181 | 1.36 | 220 | 221.3 | 1.3 |
| | | | | |
| | | CANAL 5200 | | |
| 0 | 0 | 214.44 | 223.79 | 3.6 |
| 2693 | 0.51 | 212.44 | 223.79 | 3.6 |
| 2746 | 0.52 | 212.44 | 213.94 | 1.5 |
| 15470 | 2.93 | 211.5 | 213 | 1.5 |
| 15523 | 2.94 | | | PIPELINE FROM 154+85 |
| 20365 | 3.857 | | | END PIPELINE @ 210+00 |
| 21014 | 3.98 | 210.91 | 212.41 | 1.5 |
| 33686 | 6.38 | 210 | 211.5 | 1.5 |
| | | | | |
| | | CANAL 5300 | | |
| 0 | 0 | 219.263 | 221.46 | 2.2 |
| 10877 | 2.06 | 218.4 | 220.6 | 2.2 |
| 30782 | 5.83 | 200.8 | 202.5 | 1.7 |
| 41078 | 7.78 | 199.6 | 201.3 | 1.7 |
| | | | | |
| | | CANAL 5310 | | |
| 0 | 0 | 218.3 | 220 | 1.7 |
| 2218 | 0.42 | 218 | 219.7 | 1.7 |
| | | | | |
| | | CANAL 5400 | | |

| X-SECTION STATION FEET | X-SECTION STATION MILE | MAXIMUM W.S. ELEVATION | MINIMUM LEVEE GRADE ELEVATION | MINIMUM REQ'D OPERATION RANGE FEET |
|---|---|---|---|---|
| 0 | 0 | 218.66 | 220.16 | 1.5 |
| 15787 | 2.99 | 214.1 | 215.6 | 1.5 |
| | | | | |
| | | **CANAL 5500** | | |
| 0 | 0 | 213.15 | 215.15 | 2 |
| 39257 | 7.435 | 211.71 | 213.71 | 2 |
| 40022 | 7.58 | 211.71 | 213.21 | 1.5 |
| 73128 | 13.85 | 209.5 | 211 | 1.5 |
| | | | | |
| | | **CANAL 6200** | | |
| 0 | 0 | 210.81 | 213.81 | 3 |
| 79992 | 15.15 | 205.2 | 208.2 | 3 |
| 80045 | 15.16 | 200.89 | 203.39 | 2.5 |
| 174398 | 33.03 | 190.9 | 193.4 | 2.5 |
| | | | | |
| | | **CANAL 6230** | | |
| 6125 | 1.16 | 194.49 | 195.75 | 1.26 |
| 845 | 0.16 | 194.4 | 195.66 | 1.26 |
| | | | | |
| | | **CANAL 6260** | | |
| 0 | 0 | 194.86 | 196.16 | 1.3 |
| 8870 | 1.68 | 194.3 | 195.6 | 1.3 |
| | | | | |
| | | **CANAL 6280** | | |
| 0 | 0 | 190.51 | 191.71 | 1.2 |
| 1637 | 0.31 | 190.5 | 191.7 | 1.2 |
| | | | | |
| | | **CANAL 6290** | | |
| 0 | 0 | 190.67 | 191.87 | 1.2 |
| 3221 | 0.61 | 190.4 | 191.6 | 1.2 |
| | | | | |
| | | **CANAL 6400** | | |
| 0 | 0 | 205.86 | 207.26 | 1.4 |
| 19378 | 3.67 | 204.7 | 206.1 | 1.4 |
| | | | | |
| | | **CANAL 6600** | | |
| 0 | 0 | 200.7 | 202.695 | 2 |
| 33158 | 6.28 | 198.76 | 200.756 | 2 |
| 33422 | 6.33 | 198.6 | 200.1 | 1.5 |
| 44563 | 8.44 | 197 | 198.5 | 1.5 |
| | | | | |
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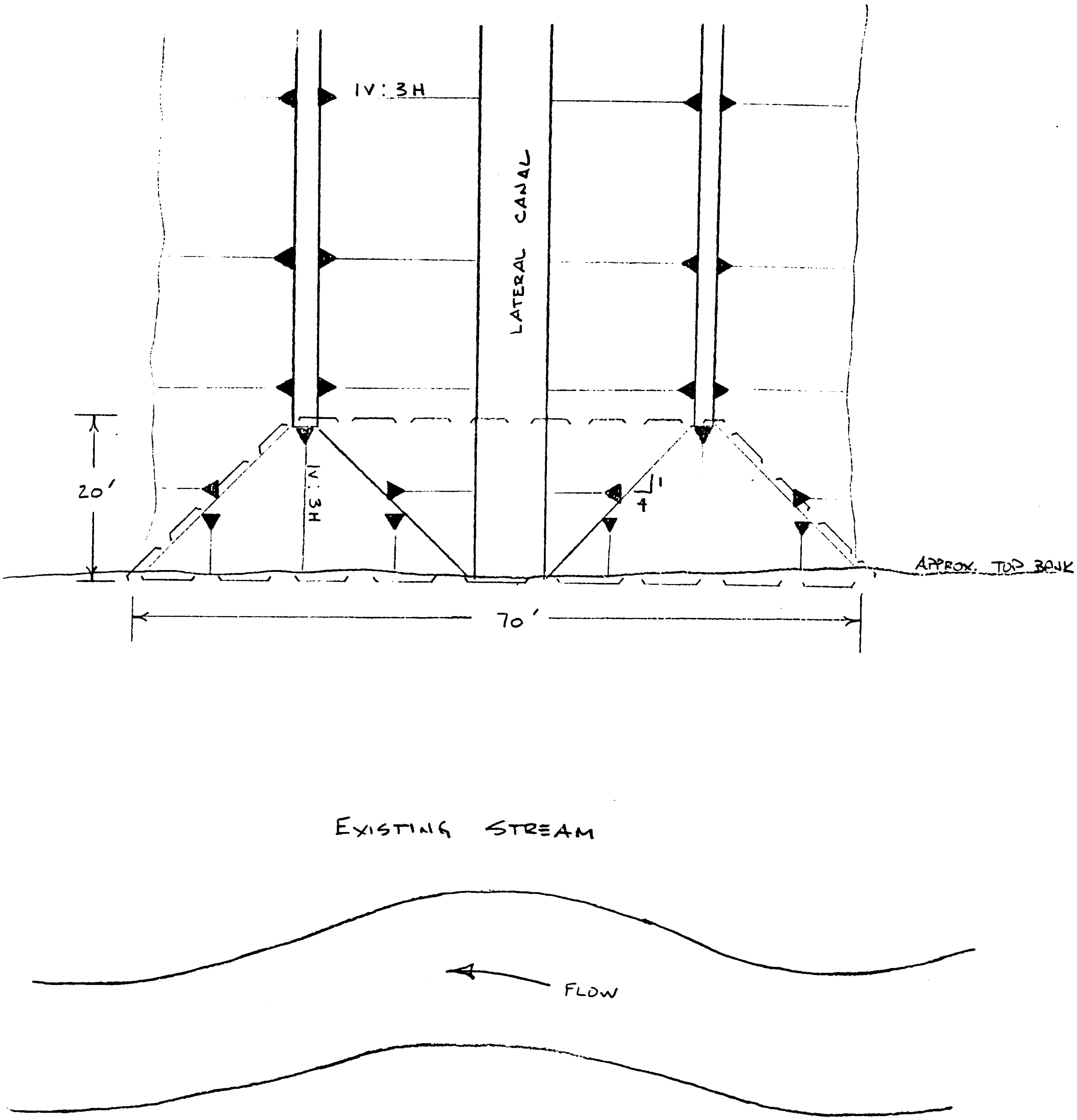


TYPICAL LAYOUT OF TRANSITION FROM LATERALS 6215 AND 6216 INTO LITTLE LAGRUE BAYOU

## COMPUTATION SHEET

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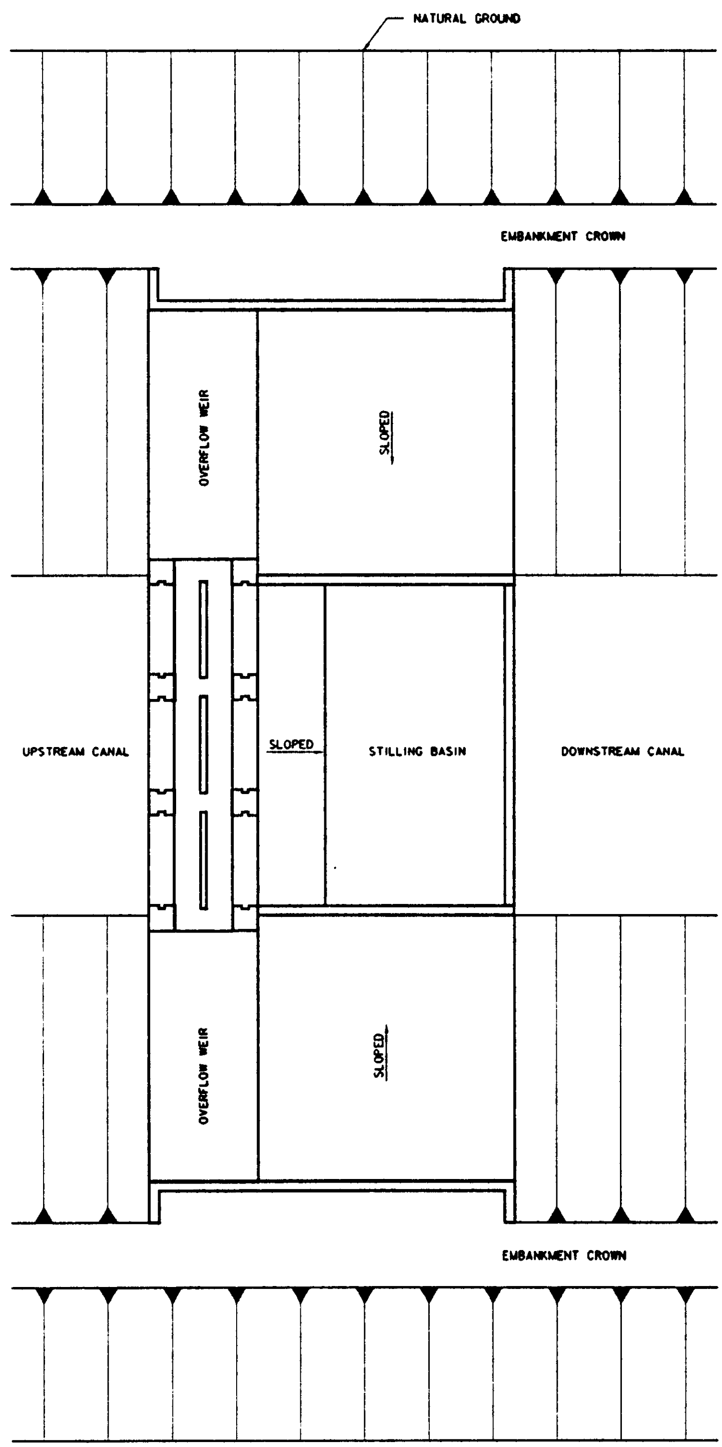
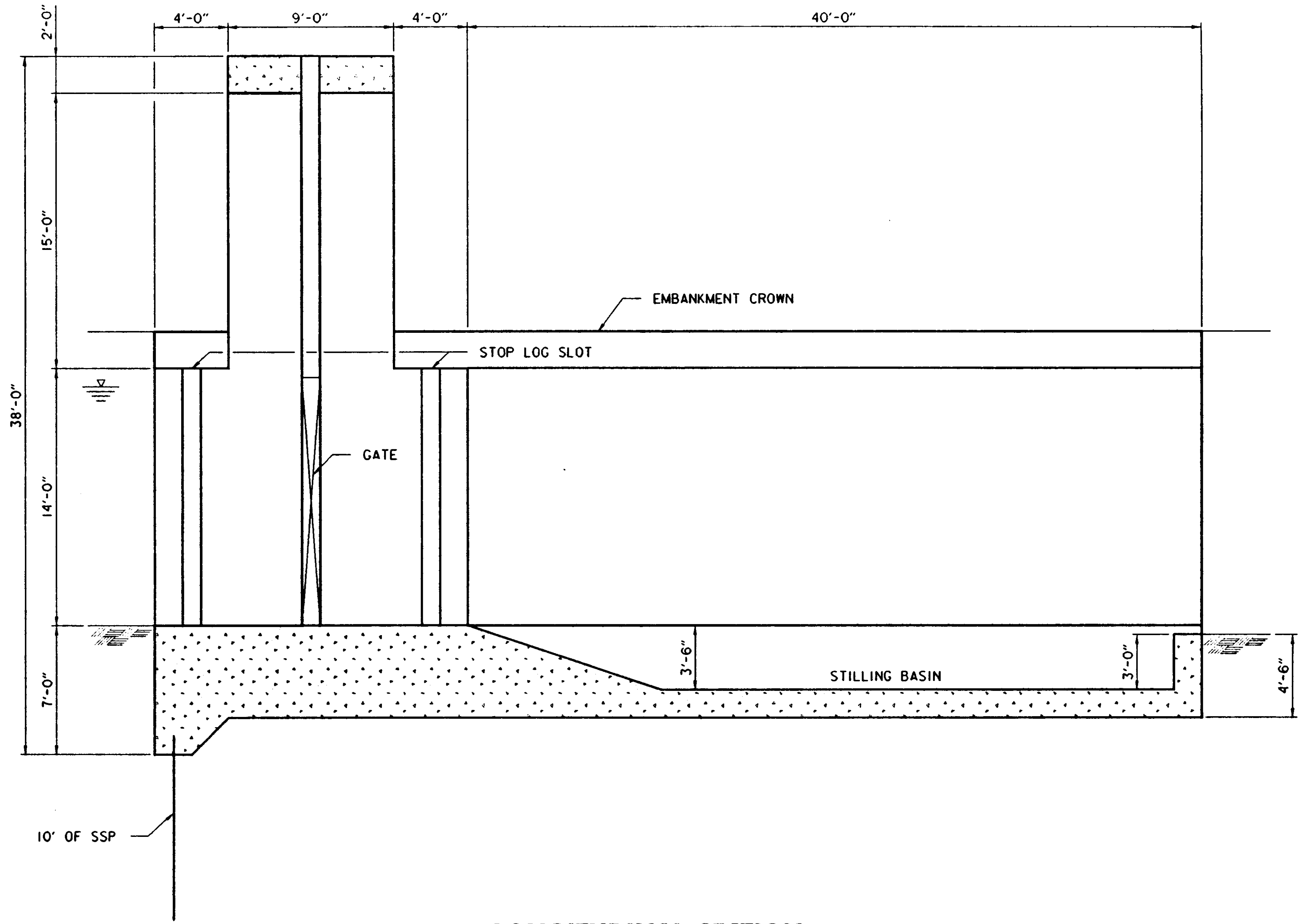
| SUBJECT **Gated Check Structure Design** | | CHECKED BY | DATE |




**TYPICAL SITE LAYOUT**
N.T.S.




## LONGITUDINAL SECTION

SCALE 1/8" = 1'-0"

COMPUTATION SHEET

| | |
|---|---|
| PROJECT | Grand Prairie Demonstration Project Eastern Arkansas |
| SUBJECT | Gated Check Structure Design |
| PAGE | OF |
| COMPUTED BY | MSW |
| DATE | 92096 |
| CHECKED BY | |
| DATE | |

# COMPUTATION SHEET

PROJECT Grand Prairie Demonstration Project Eastern Arkansas

SUBJECT Gated Check Structure Design

PAGE OF

COMPUTED BY MSW

DATE 92096

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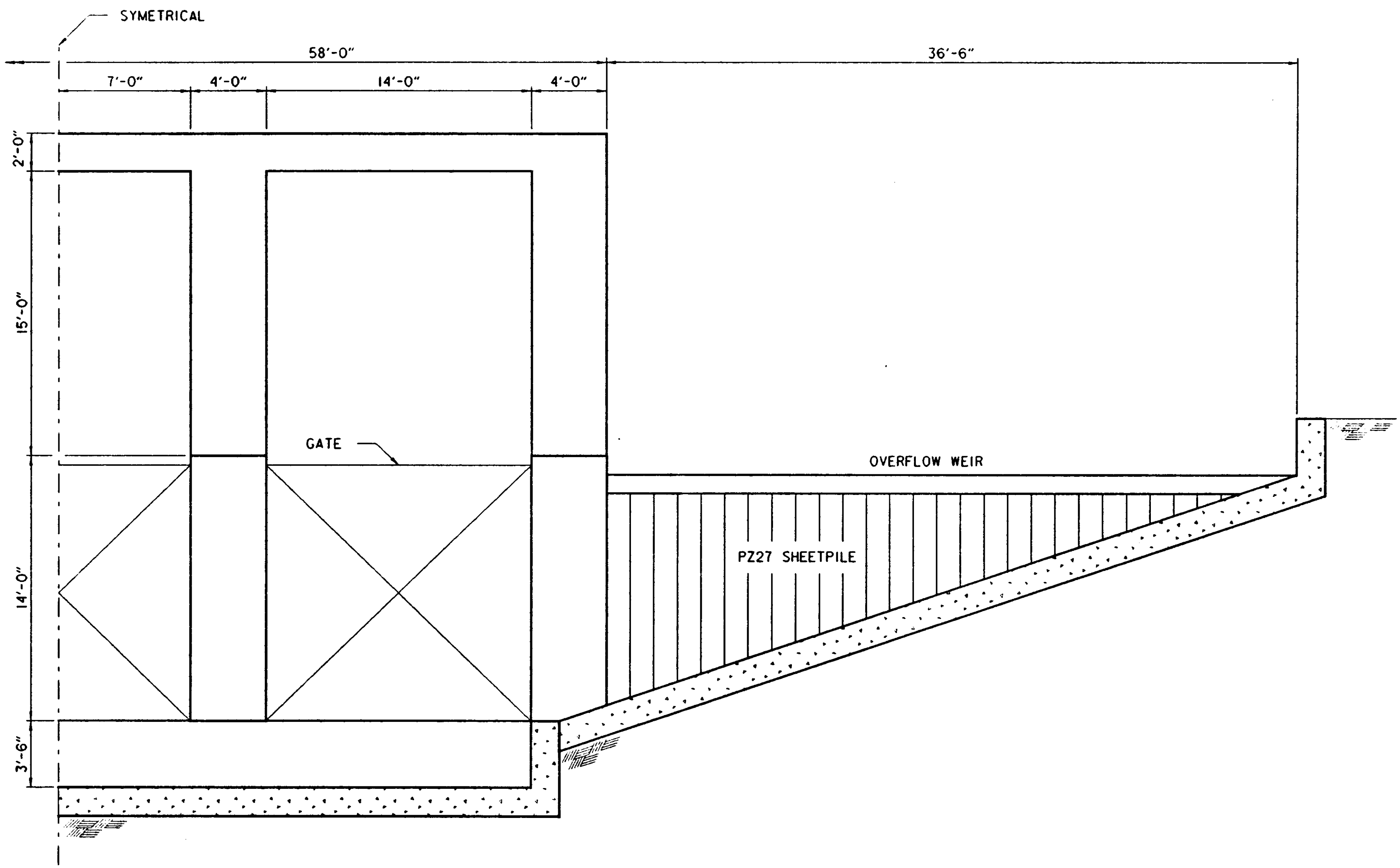
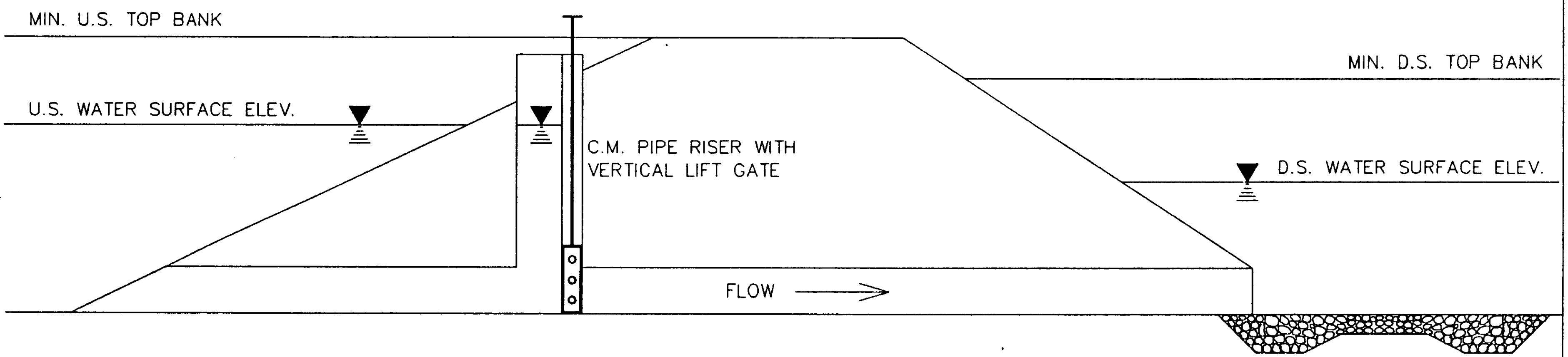
DATE




**TRANSVERSE SECTION**

SCALE 1/8" = 1'-0"




U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY
TYPICAL
CONDUIT CHECK STRUCTURE

H: \COMMON\EARK\CANALS\CYBERNET\CHECKSTR.DWG

| GATED CHECK STRUCTURES | | | | | | |
|---|---|---|---|---|---|---|
| Canal Number | Name | Number of Gates | Gate Width (ft.) | Gate Height (ft.) | Stilling Basin Length (ft) | End Sill Height (ft) |
| 3000 | C-3000.01 | 3 | 14.0 | 13.5 | 40 | 3.0 |
| 4000 | C-4000.01 | 3 | 14.0 | 13.5 | 38 | 3.0 |
| 5000 | C-5000.01 | 3 | 12.5 | 13.0 | 37 | 3.0 |
| 6000 | C-6000.01 | 1 | 13.0 | 13.0 | 45 | 3.0 |
| | | | | | | |

| GATED CONDUIT CHECK STRUCTURES | | | | | | |
|---|---|---|---|---|---|---|
| Canal Number | Name | Check Conduit(s) | | Check Riser(s) | | Gate Size(s) (ft.) |
| | | Diameter | Length (ft.) | Diameter | Height (ft.) | |
| 6000 | C-6000.02 | 3-3.5 | 50 | 5.5 | 13.5 | 3.5 |
| 6000 | C-6000.03 | 2-2.5 | 50 | 4.0 | 12.0 | 2.5 |
| | | | | | | |
| | | | | | | |
| 1500 | C-1500.01 | 2-1.5 | 50 | 4.0 | 7.0 | 1.5 |
| | | | | | | |
| 2200 | C-2200.01 | 2-4.0 | 50 | 6.0 | 9.5 | 4.0 |
| | | | | | | |
| 3100 | C-3100.01 | 2-1.5 | 50 | 4.0 | 6.5 | 1.5 |
| | | | | | | |
| 3200 | C-3200.01 | 2-2.0 | 50 | 4.0 | 9.5 | 2.0 |
| | | | | | | |
| 3220 | C-3220.01 | 2-1.5 | 50 | 4.0 | 4.5 | 1.5 |
| | | | | | | |
| 5200 | C-5200.01 | 2-2.0 | 50 | 4.0 | 13.0 | 2.0 |
| | | | | | | |
| 5400 | C-5400.01 | 2-1.5 | 50 | 4.0 | 5.5 | 1.5 |
| | | | | | | |
| 5500 | C-5500.01 | 2-4.0 | 50 | 6.0 | 7.5 | 4.0 |
| | | | | | | |
| 6200 | C-6200.01 | 2-5.0 | 50 | 7.5 | 11.5 | 5.0 |
| 6200 | C-6200.02 | 2-2.0 | 50 | 3.0 | 12.0 | 2.0 |
| 6200 | C-6200.03 | 2-4.5 | 50 | 7.0 | 9.5 | 4.5 |
| | | | | | | |
| | | | | | | |
| 6600 | C-6600.01 | 2-2.5 | 50 | 4.0 | 7.0 | 2.5 |
| | | | | | | |

# Barnes Creek Summary Profile Plot

## Existing Conditions

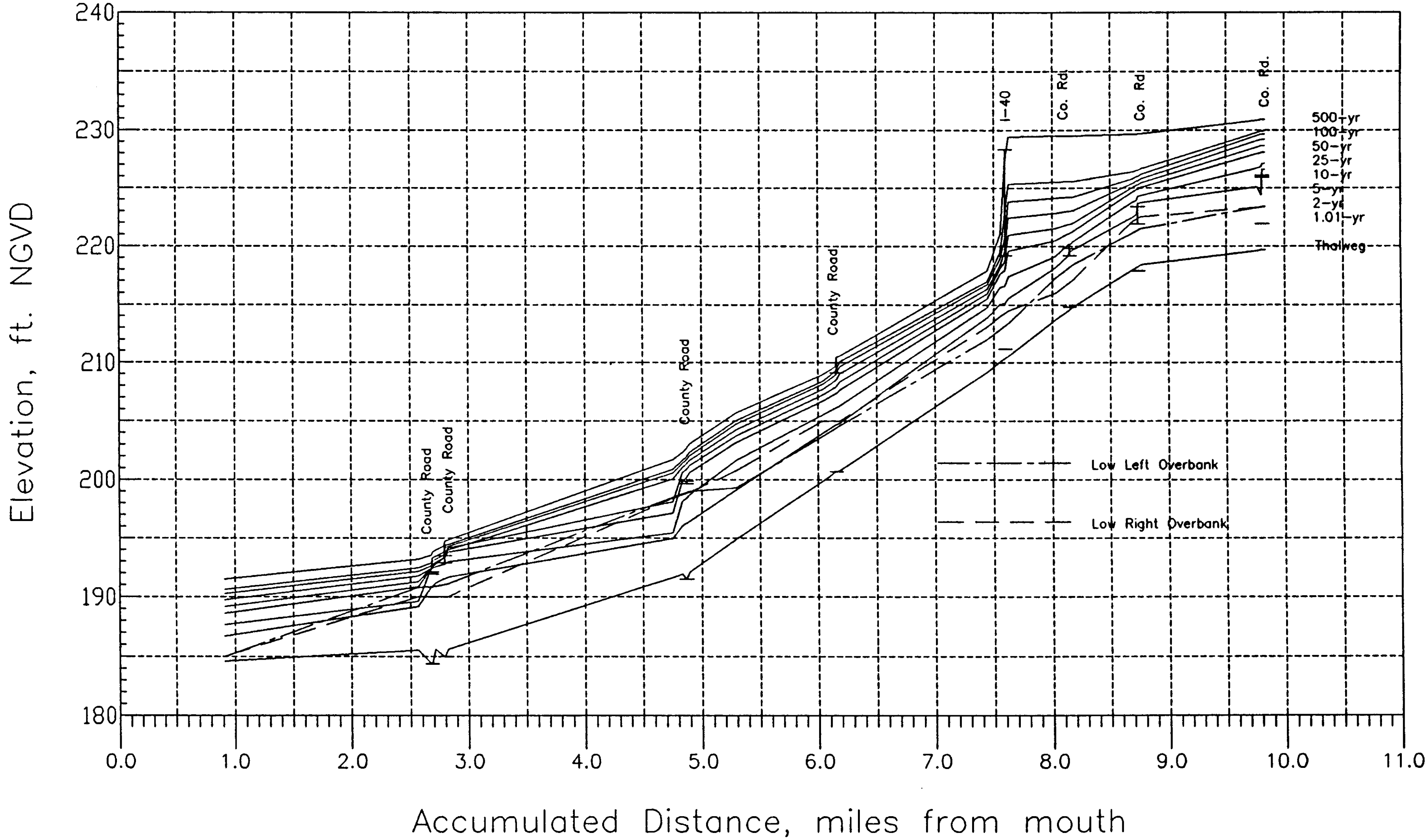
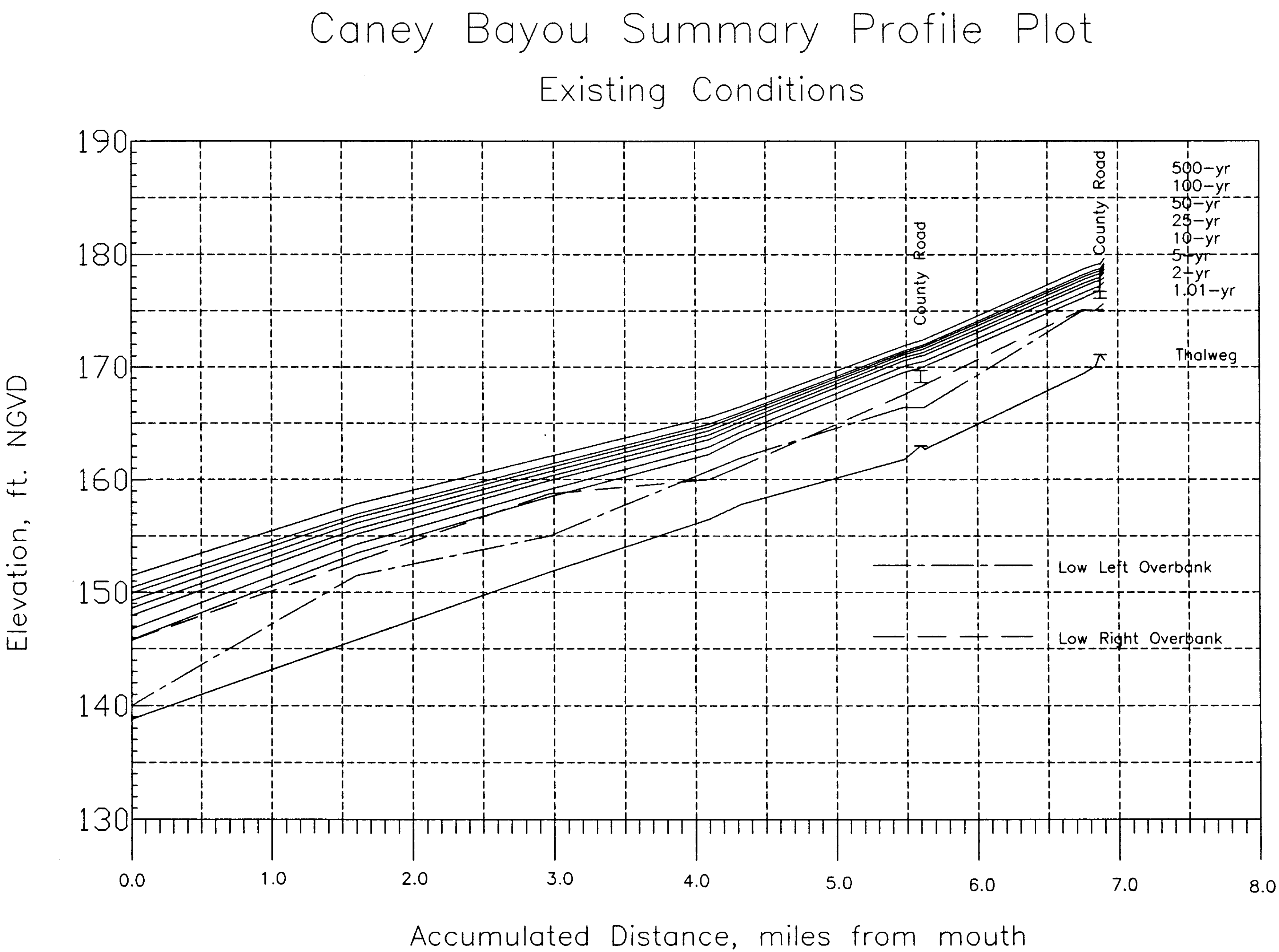



PLATE III-C-18 (1)

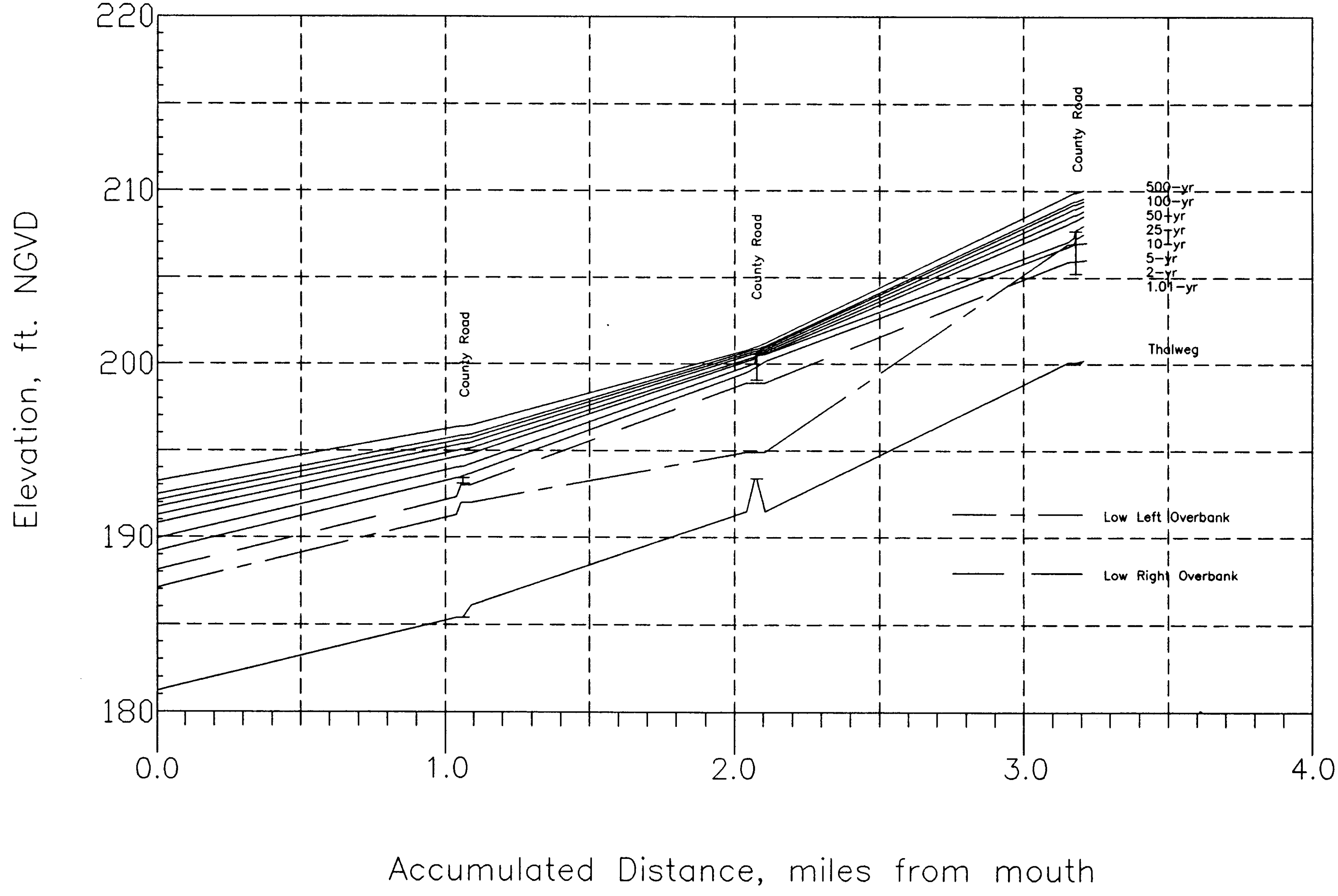


Caney Bayou Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
Accumulated Distance, miles from mouth
190
180
170
160
150
140
130
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
County Road
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank


(2)

# East Stuttgart King Bayou Summary Profile Plot

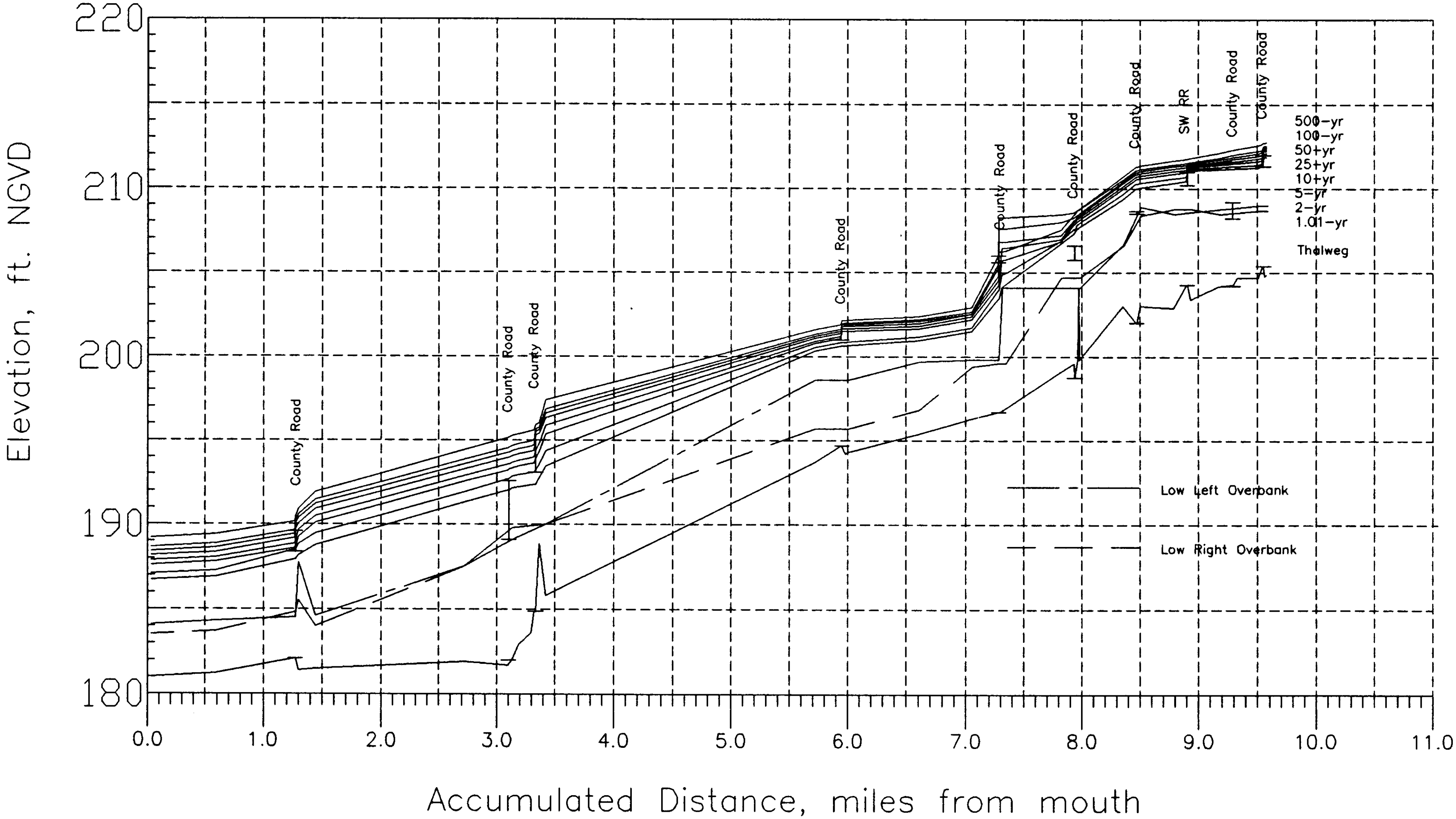
## Existing Conditions




(3)

# Elm Prong Mill Bayou Summary Profile Plot

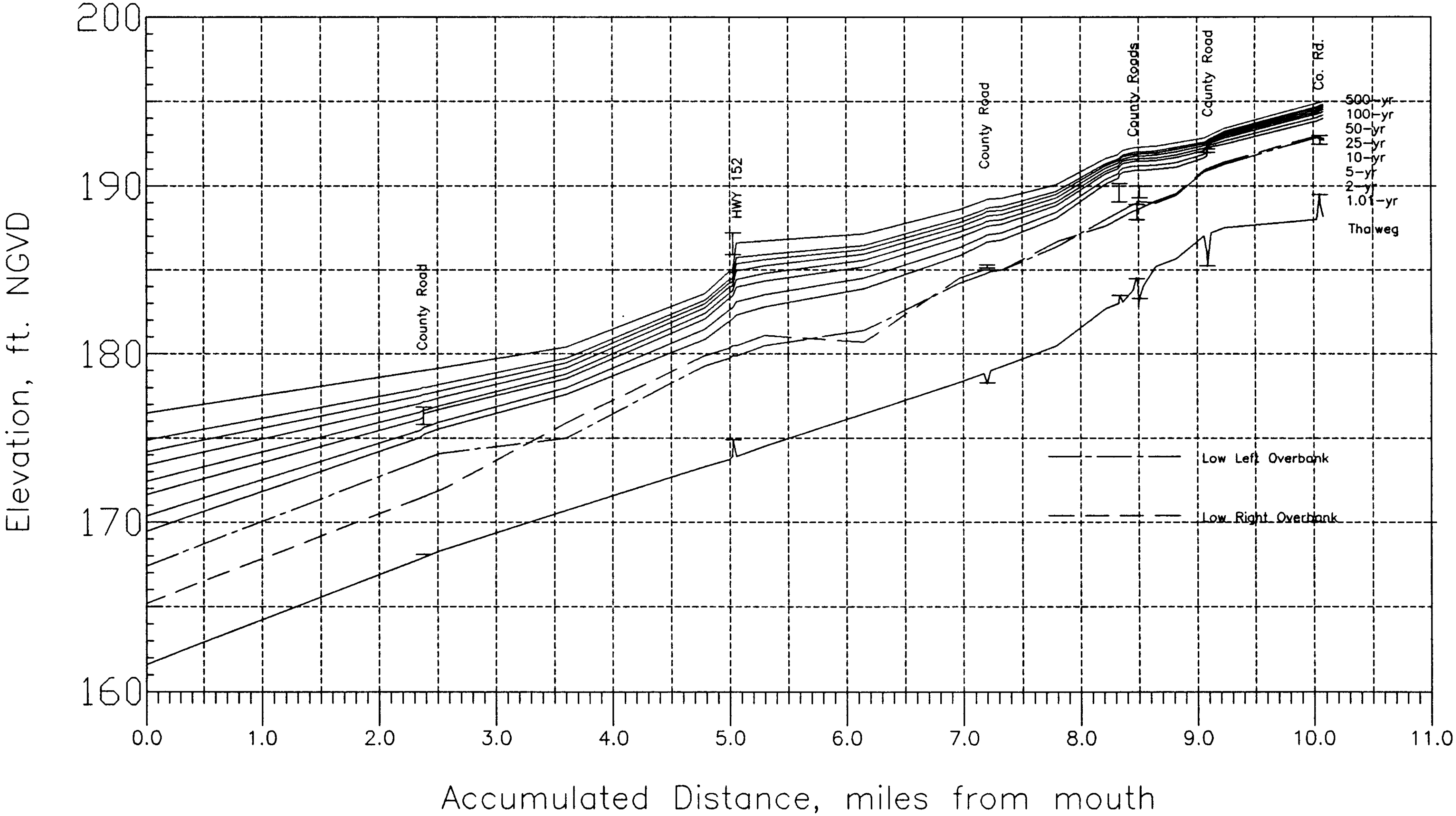
## Existing Conditions




(4)

# Hurricane Bayou Summary Profile Plot

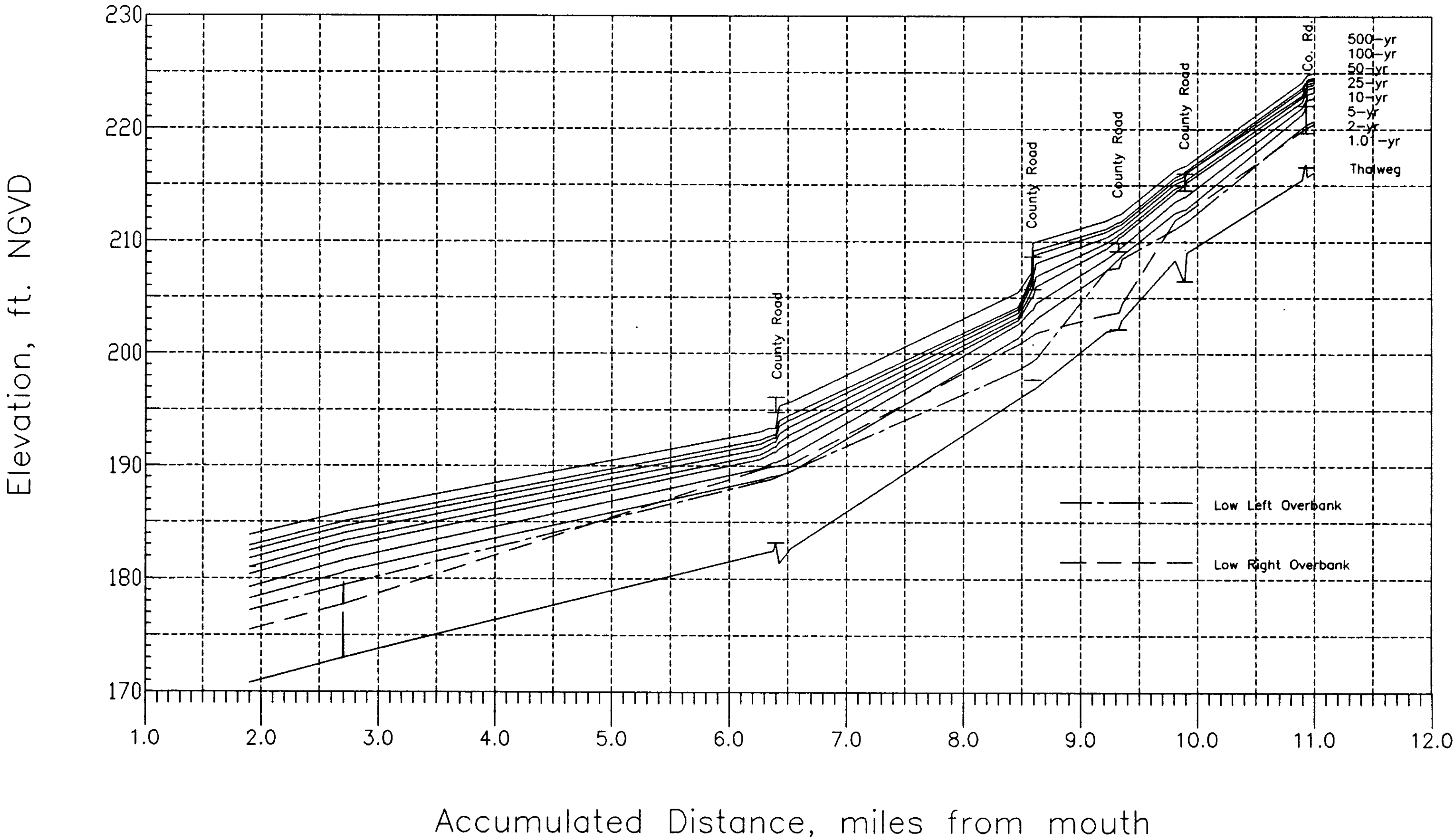
## Existing Conditions

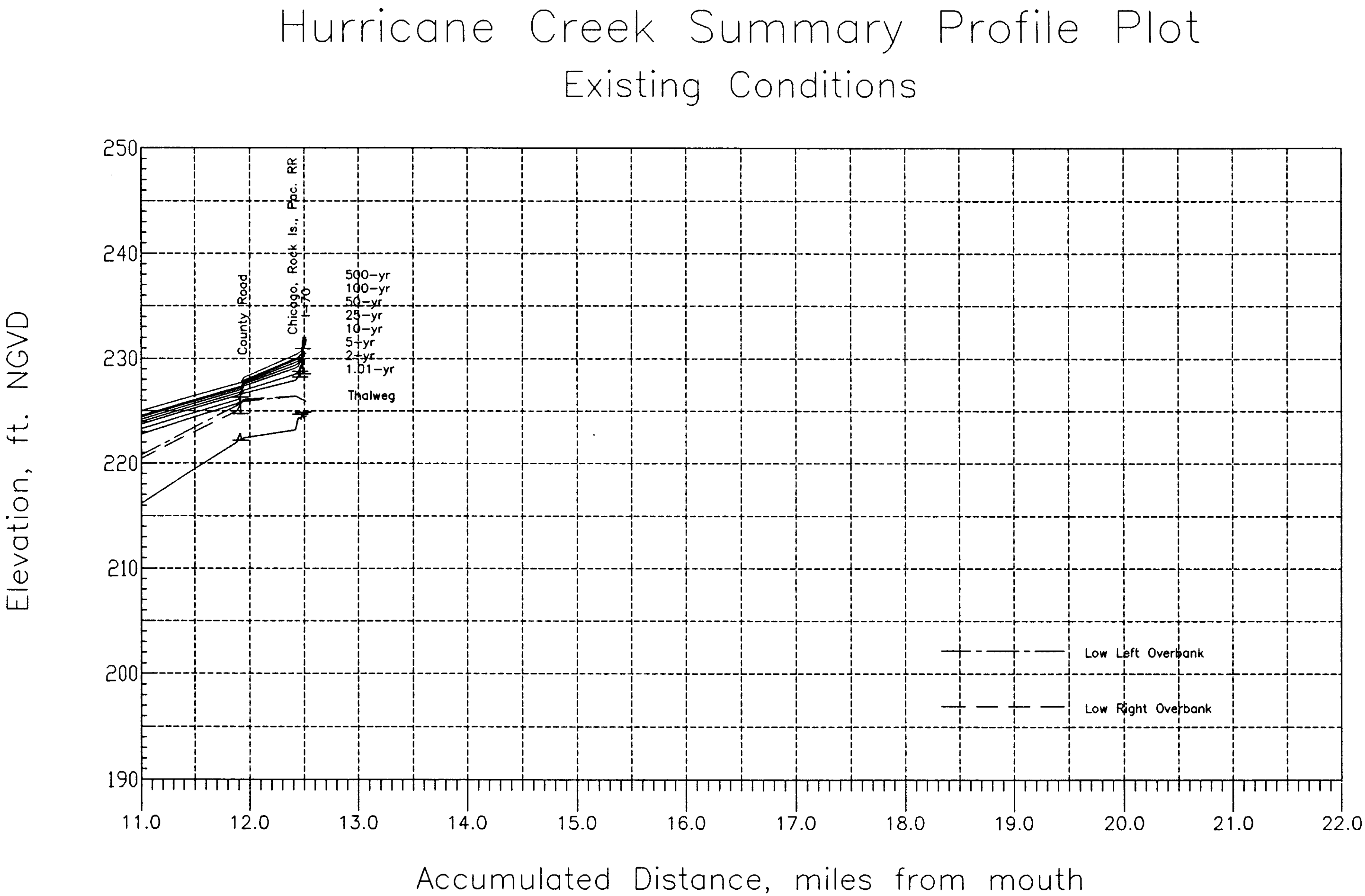



(5)

# Hurricane Creek Summary Profile Plot

## Existing Conditions

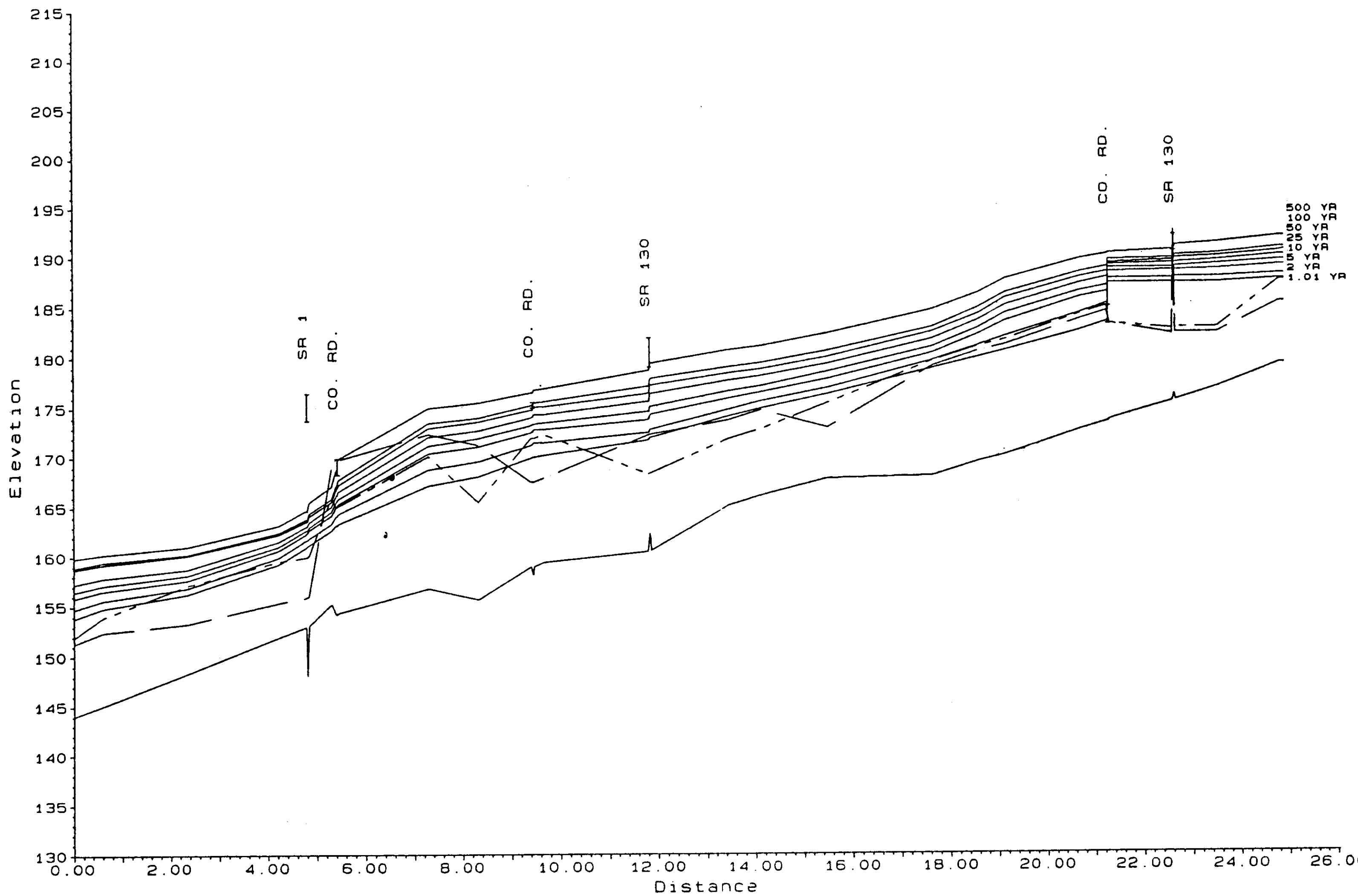




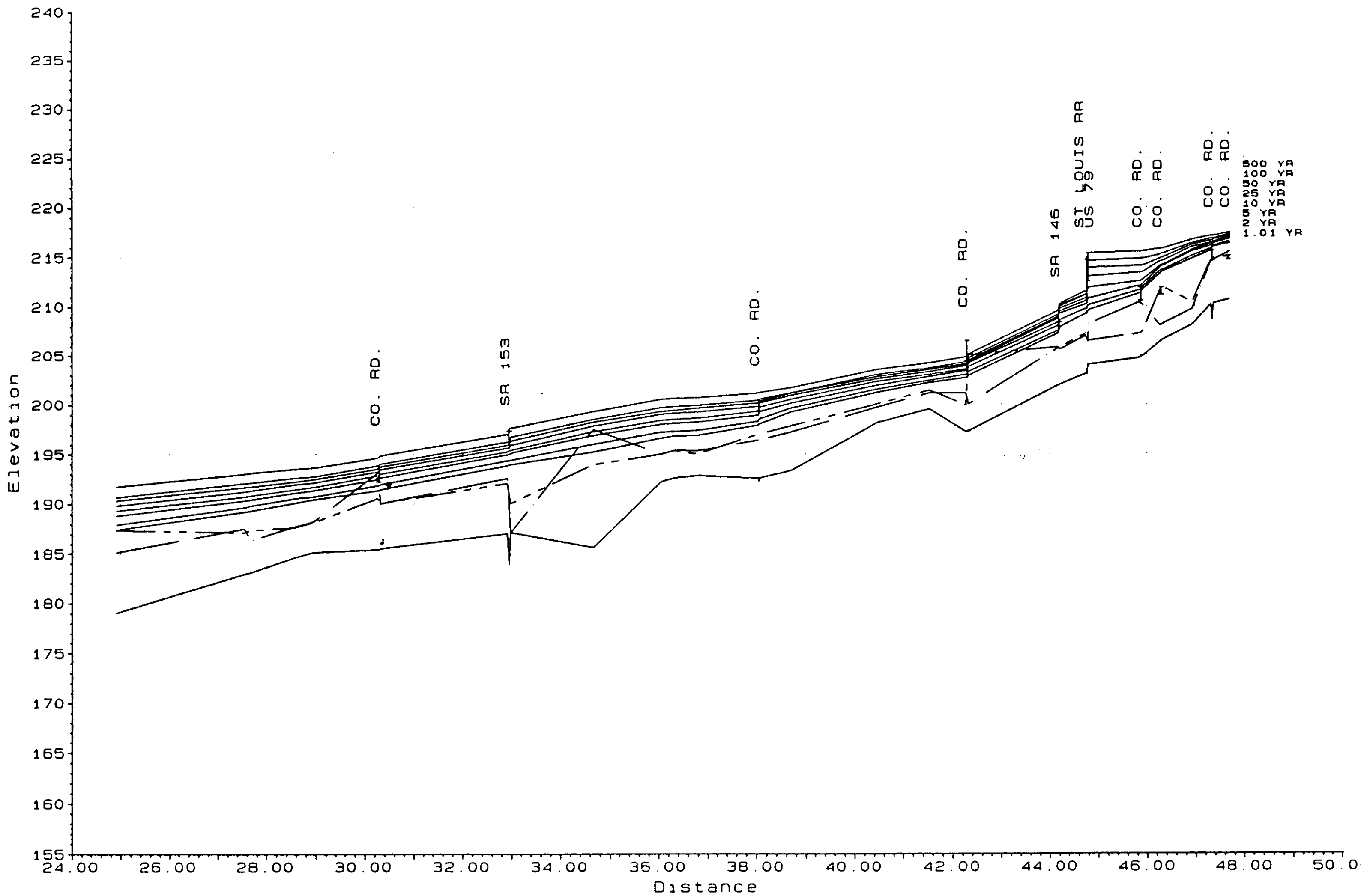
Hurricane Creek Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
250
240
230
220
210
200
190
County Road
Chicago, Rock Is., Pac. RR
I-70
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
Accumulated Distance, miles from mouth

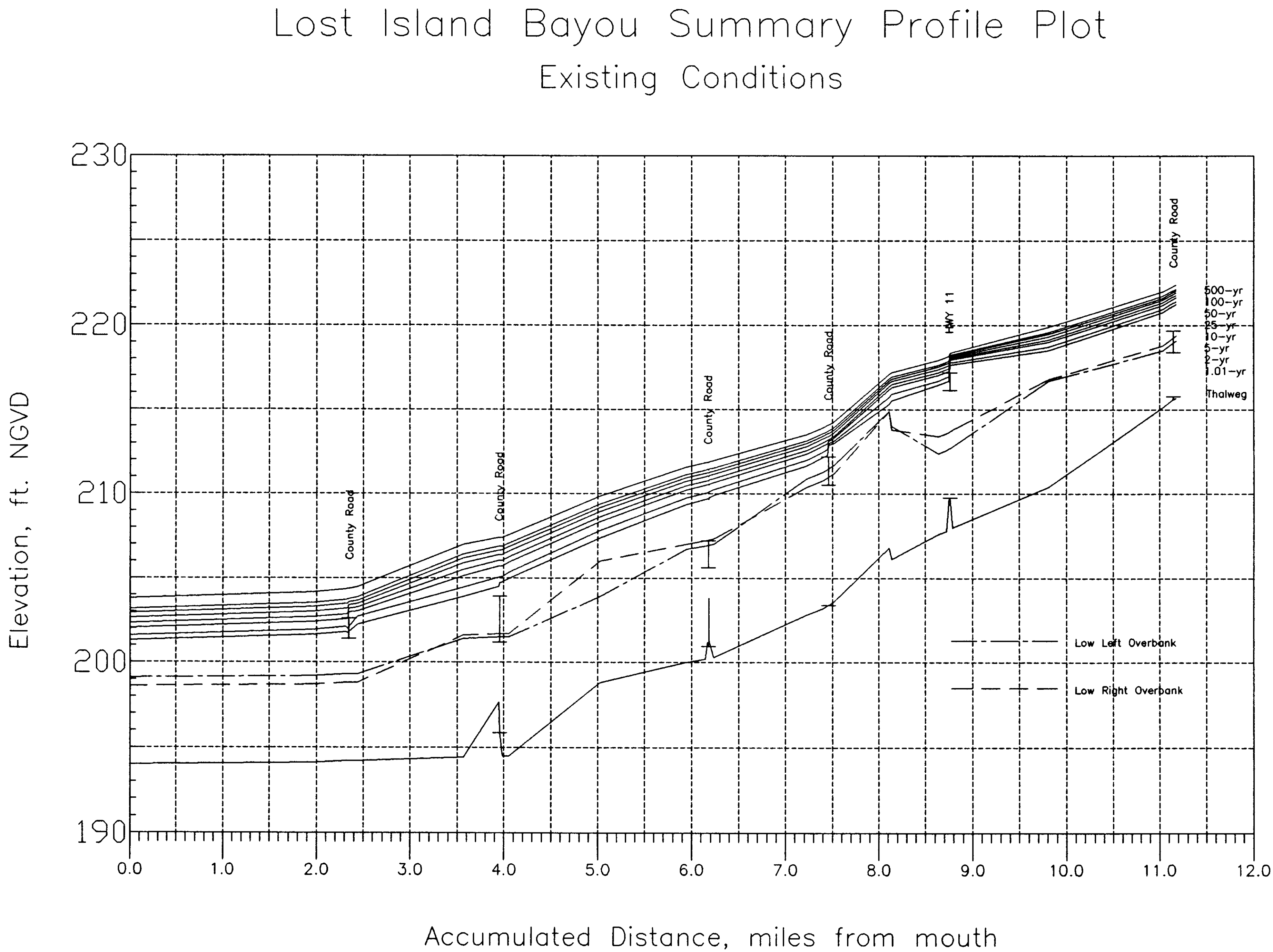

(7)

Little LaGrue Bayou
(Mile 0.00 - 24.91)



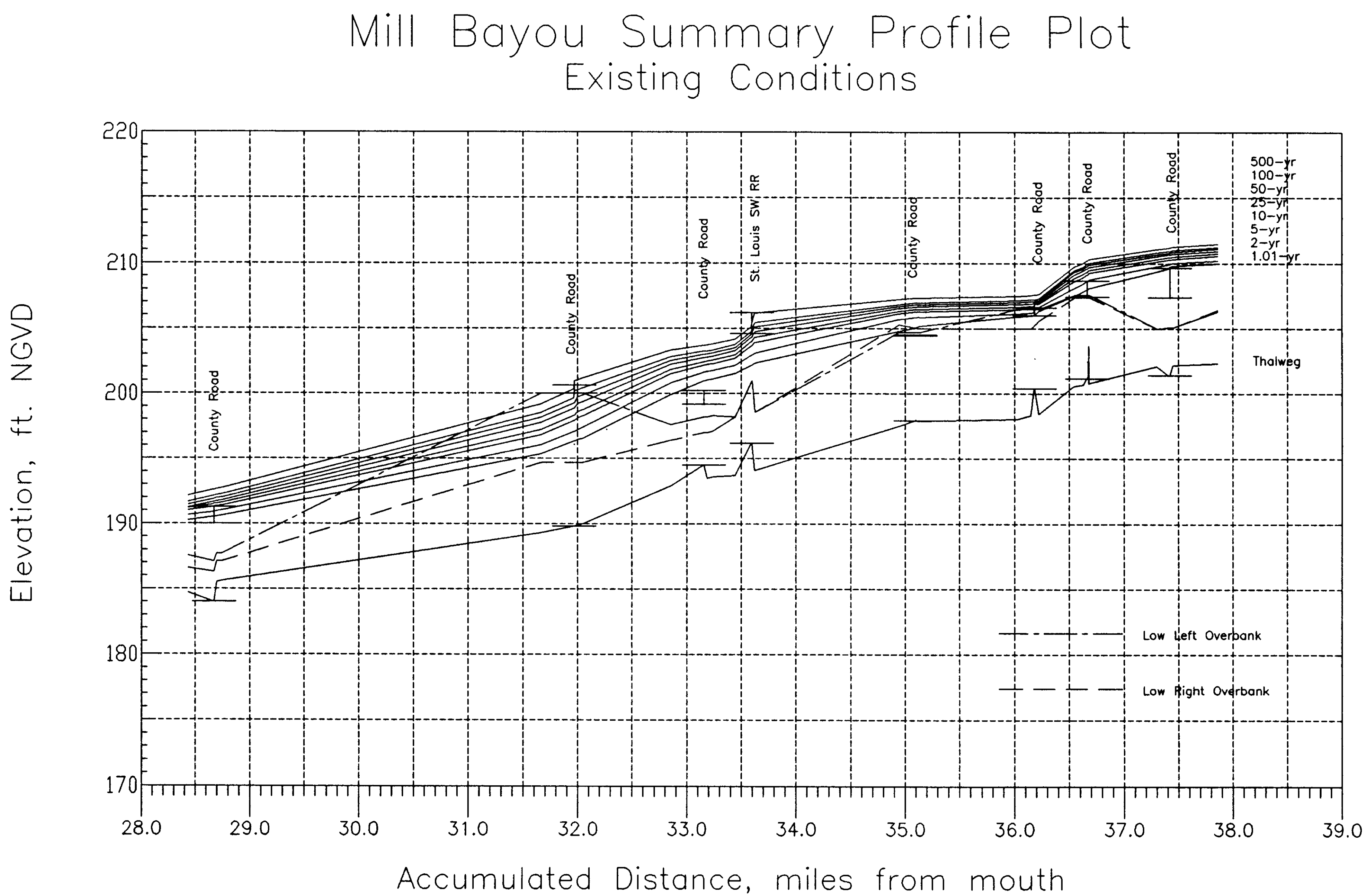
Little LaGrue Bayou
(Mile 24.91 - 47.73)





Lost Island Bayou Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
Accumulated Distance, miles from mouth
230
220
210
200
190
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
County Road
County Road
County Road
County Road
HWY 11
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank


(10)

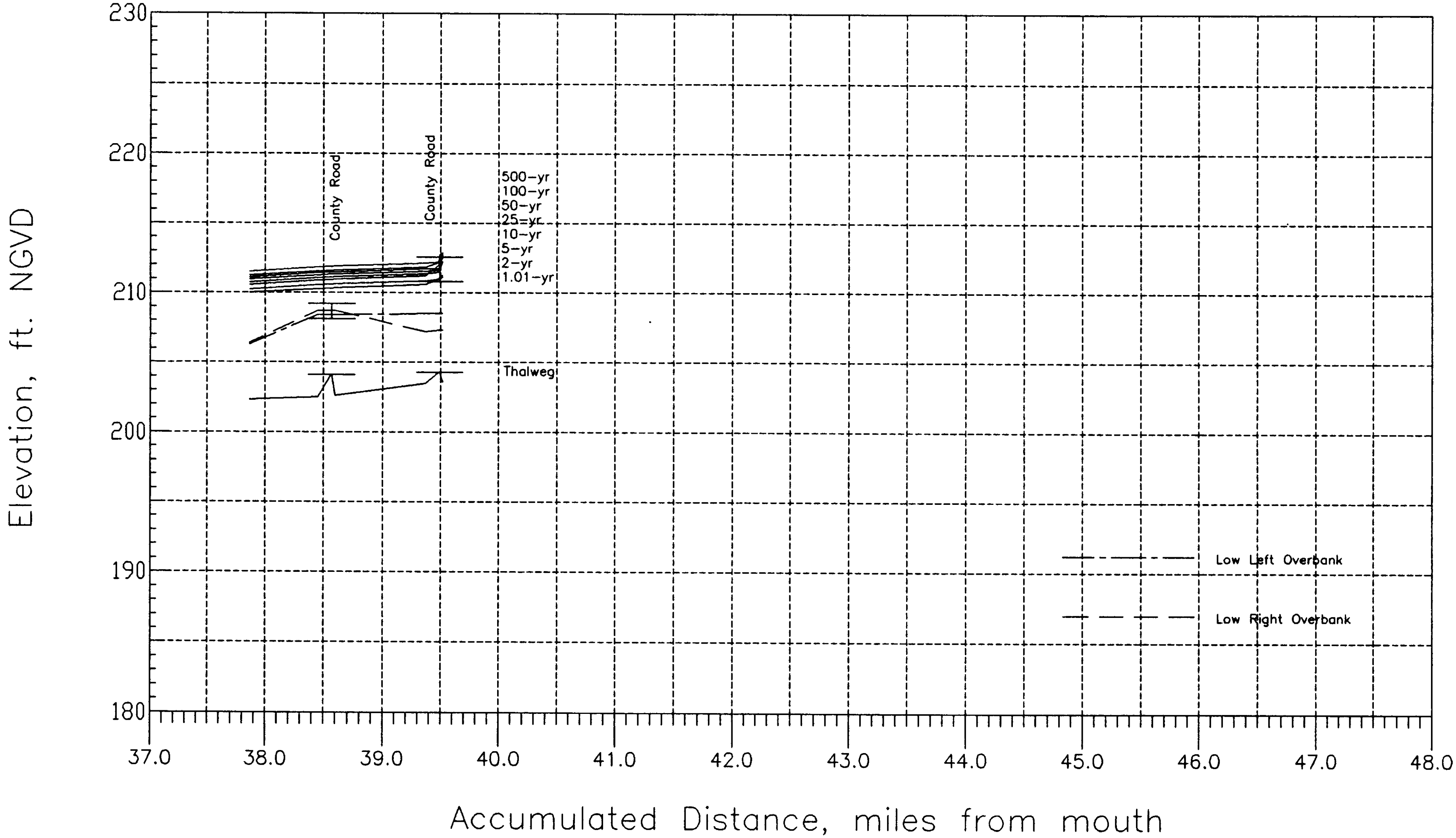


Mill Bayou Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
Accumulated Distance, miles from mouth
220
210
200
190
180
170
28.0
29.0
30.0
31.0
32.0
33.0
34.0
35.0
36.0
37.0
38.0
39.0
County Road
County Road
County Road
St. Louis SW RR
County Road
County Road
County Road
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank


(11)

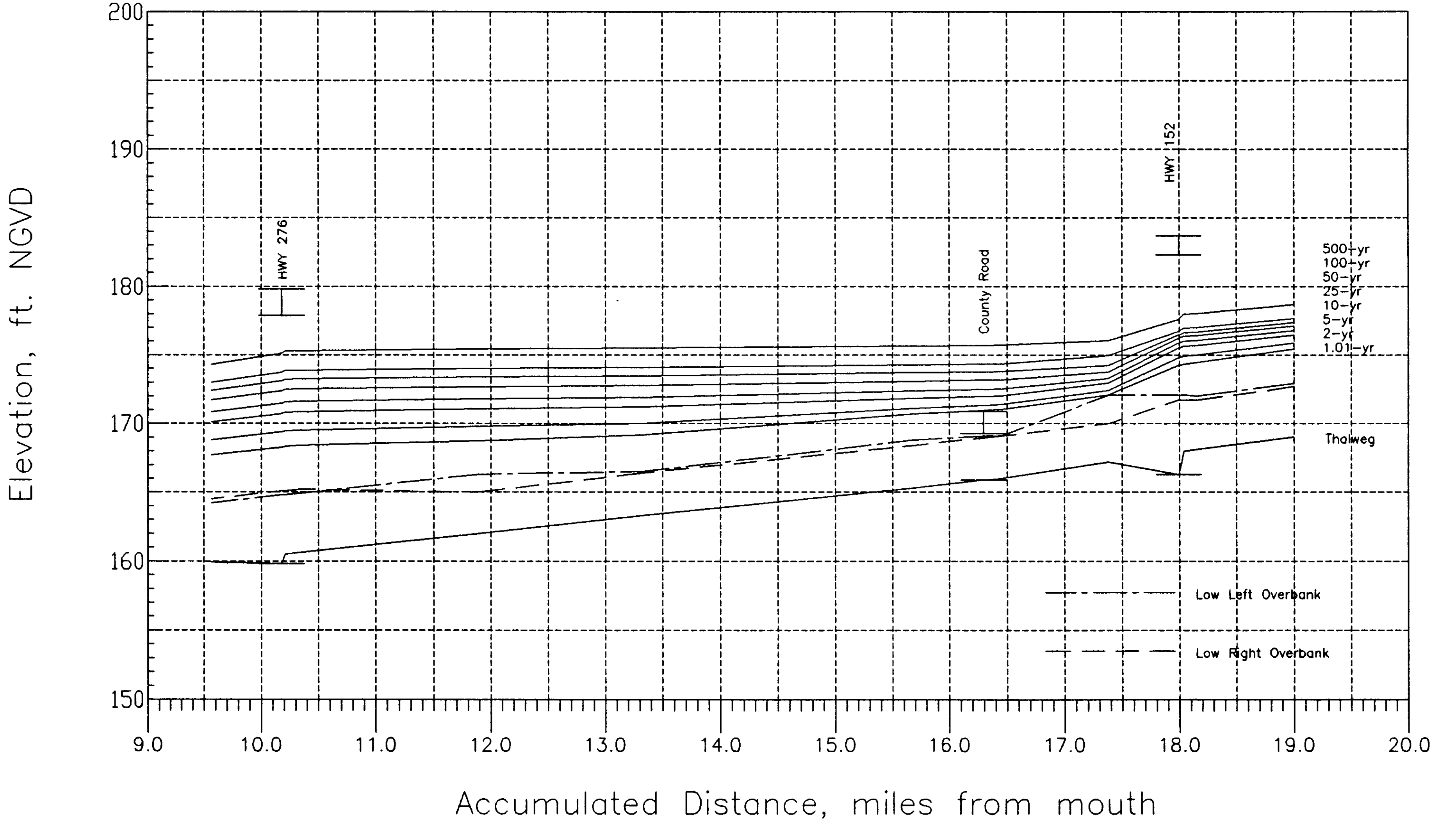
# Mill Bayou Summary Profile Plot

## Existing Conditions

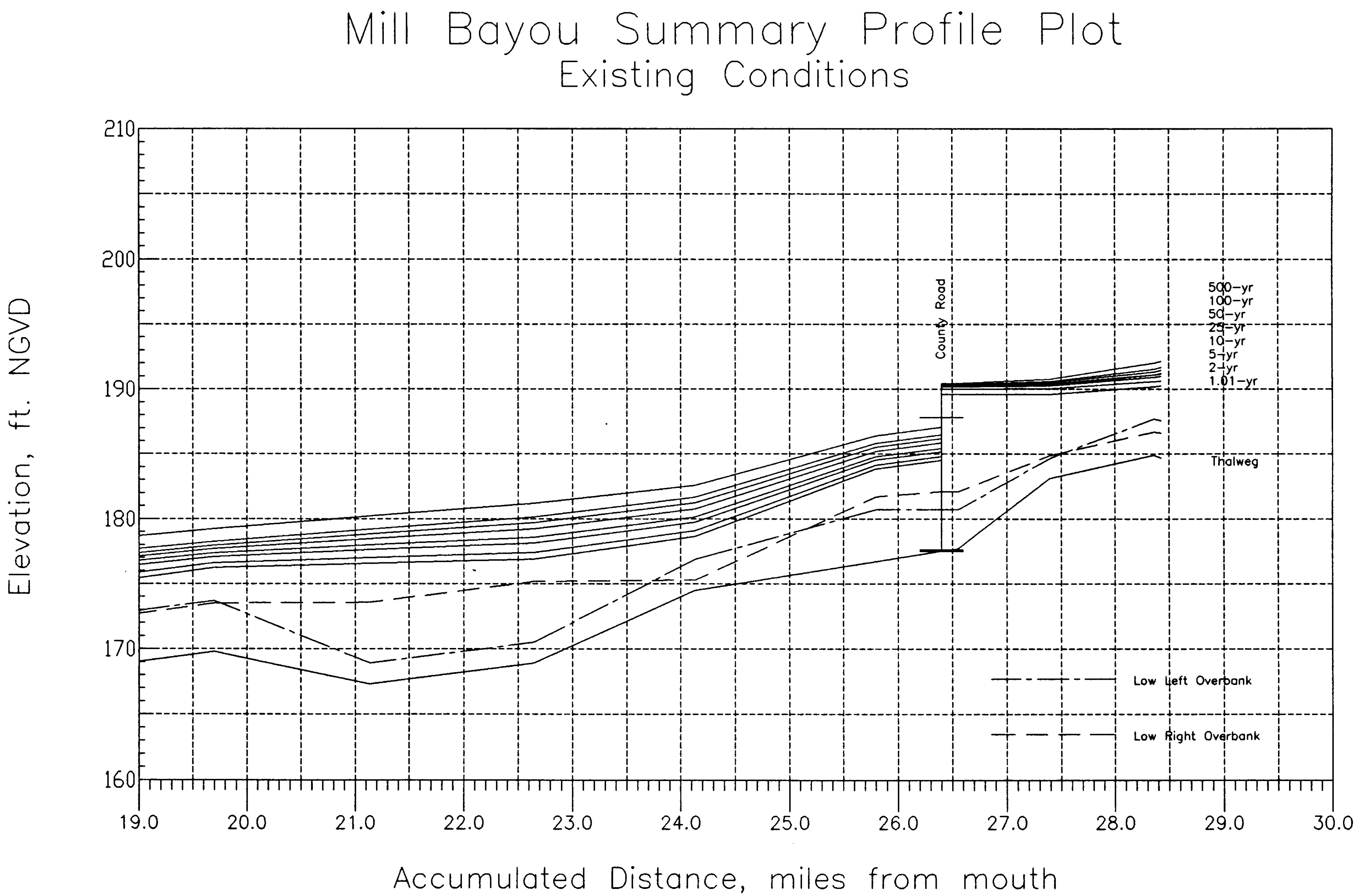



(12)

# Mill Bayou Summary Profile Plot
## Existing Conditions




(13)

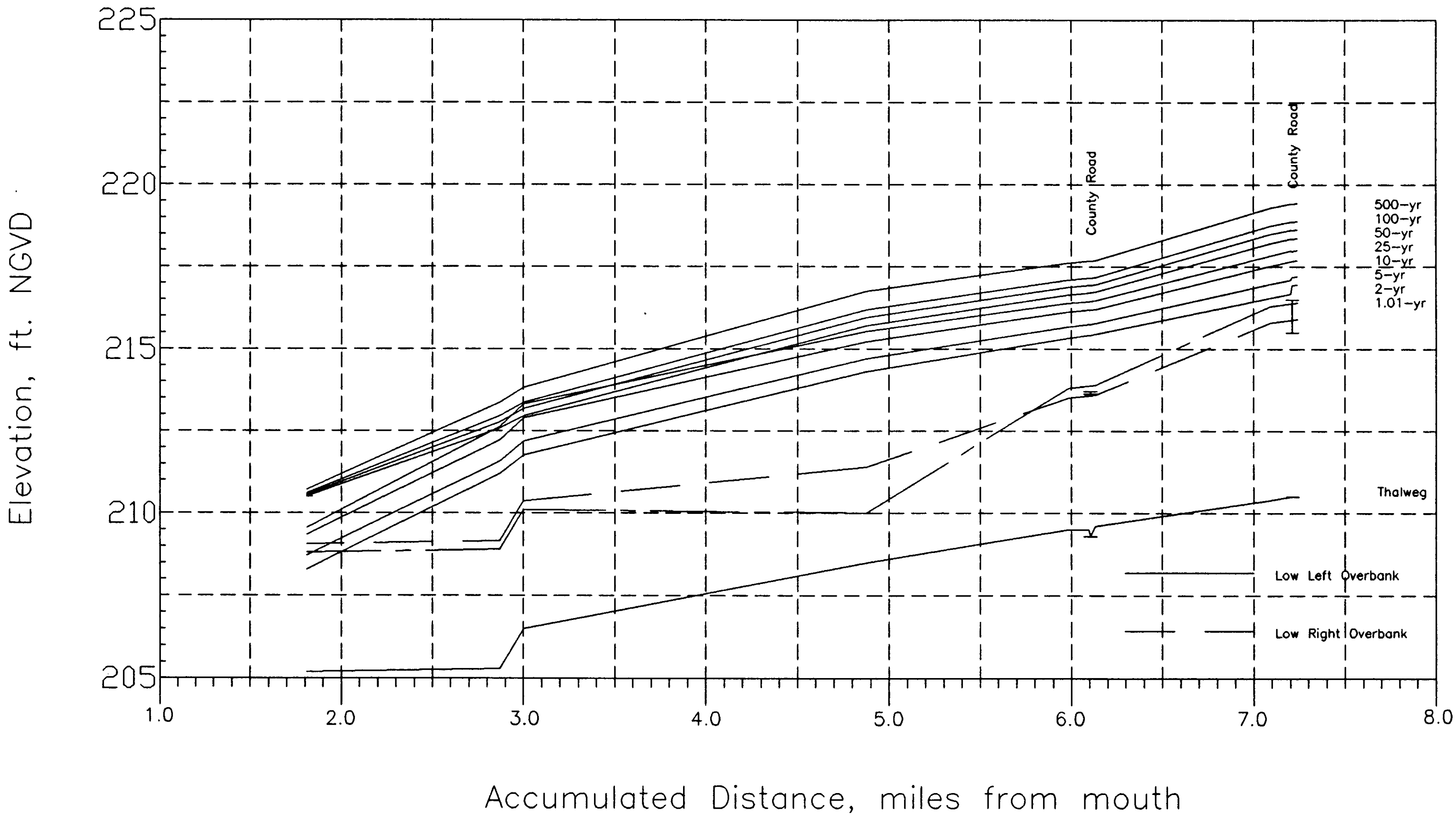


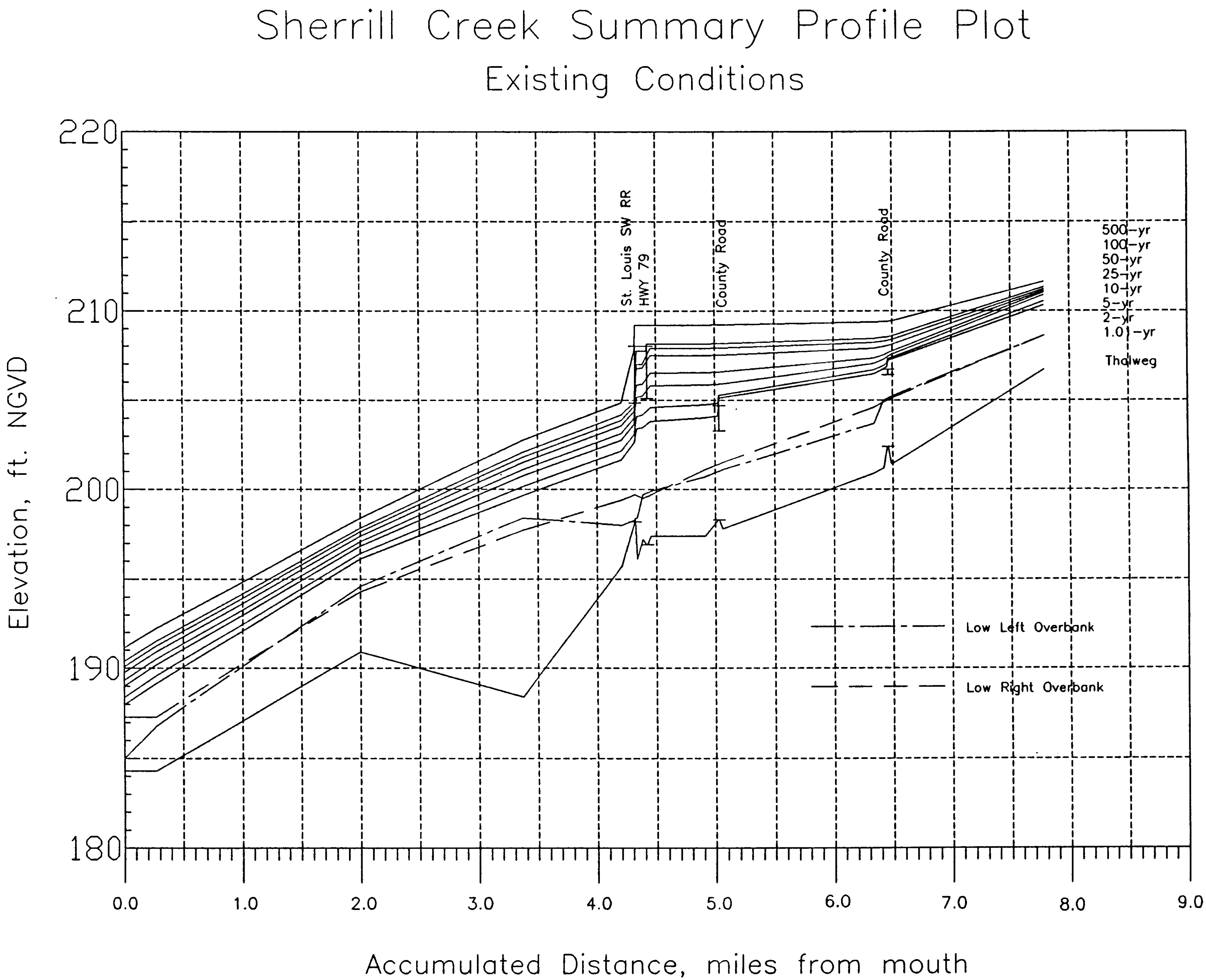
Mill Bayou Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
210
200
190
180
170
160
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0
Accumulated Distance, miles from mouth
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank


(14)

# Peckerwood Lateral Summary Profile Plot

## Existing Conditions

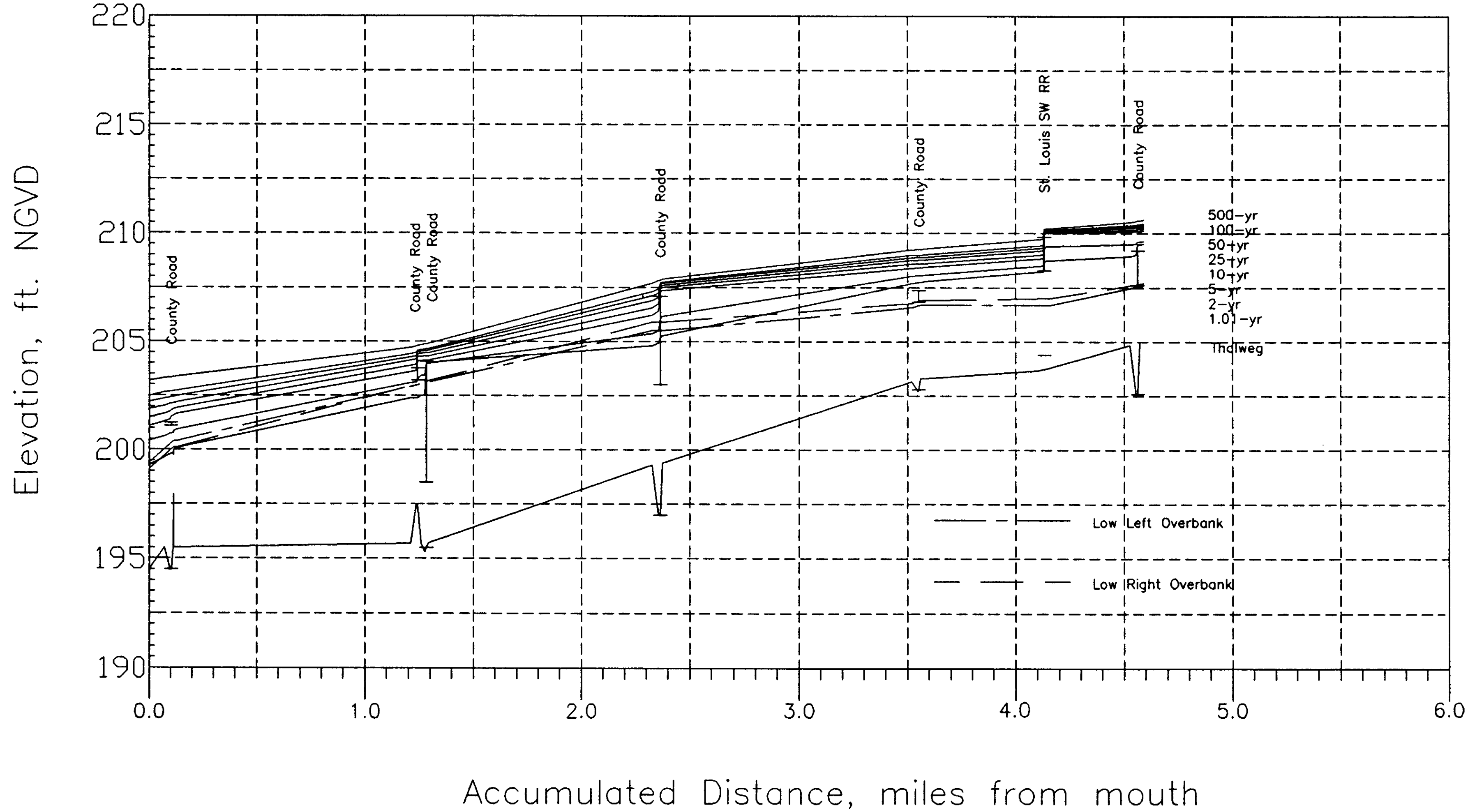




Sherrill Creek Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
220
210
200
190
180
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Accumulated Distance, miles from mouth
St. Louis SW RR
HWY 79
County Road
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank

# South Mill Bayou Summary Profile Plot

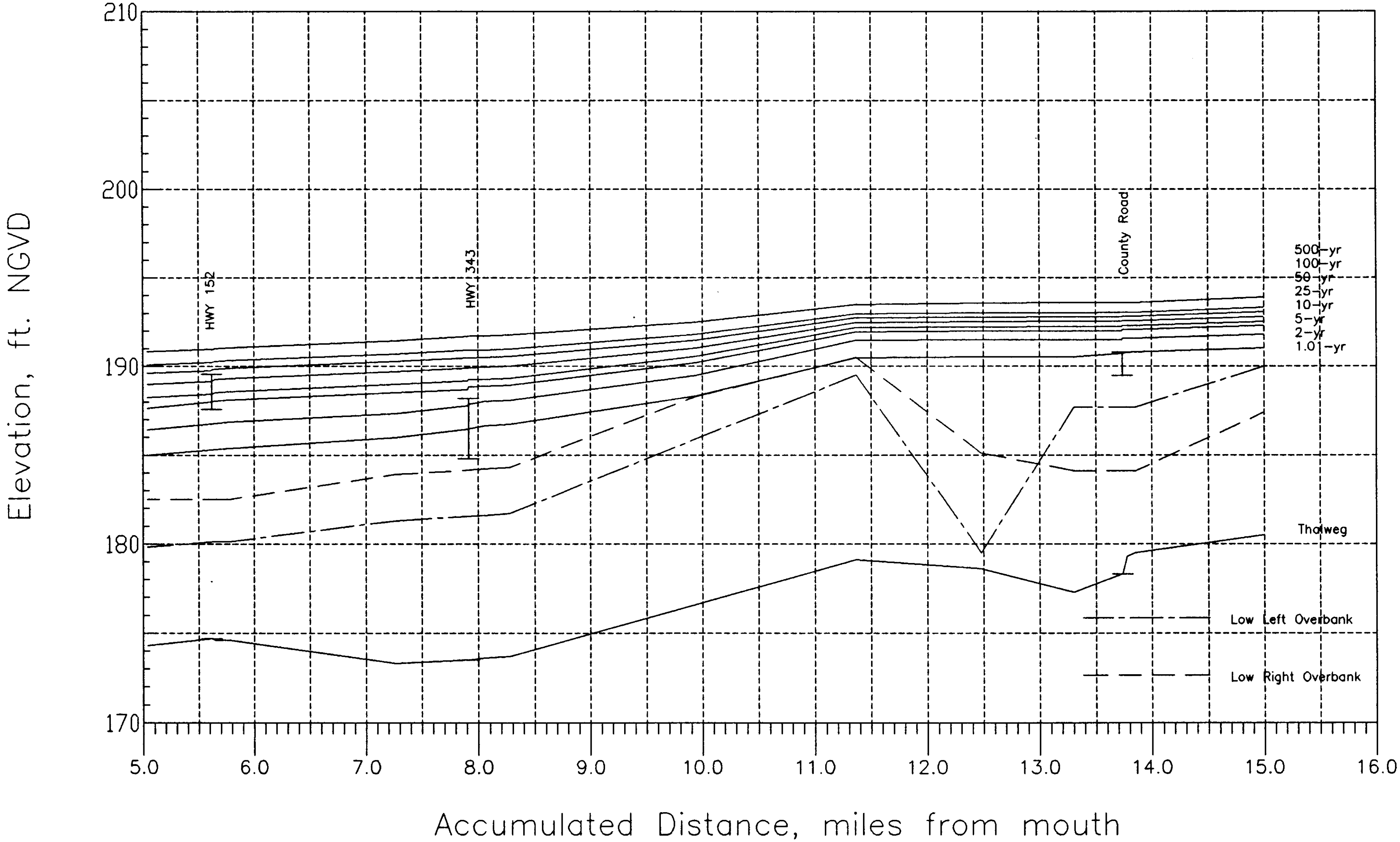
## Existing Conditions



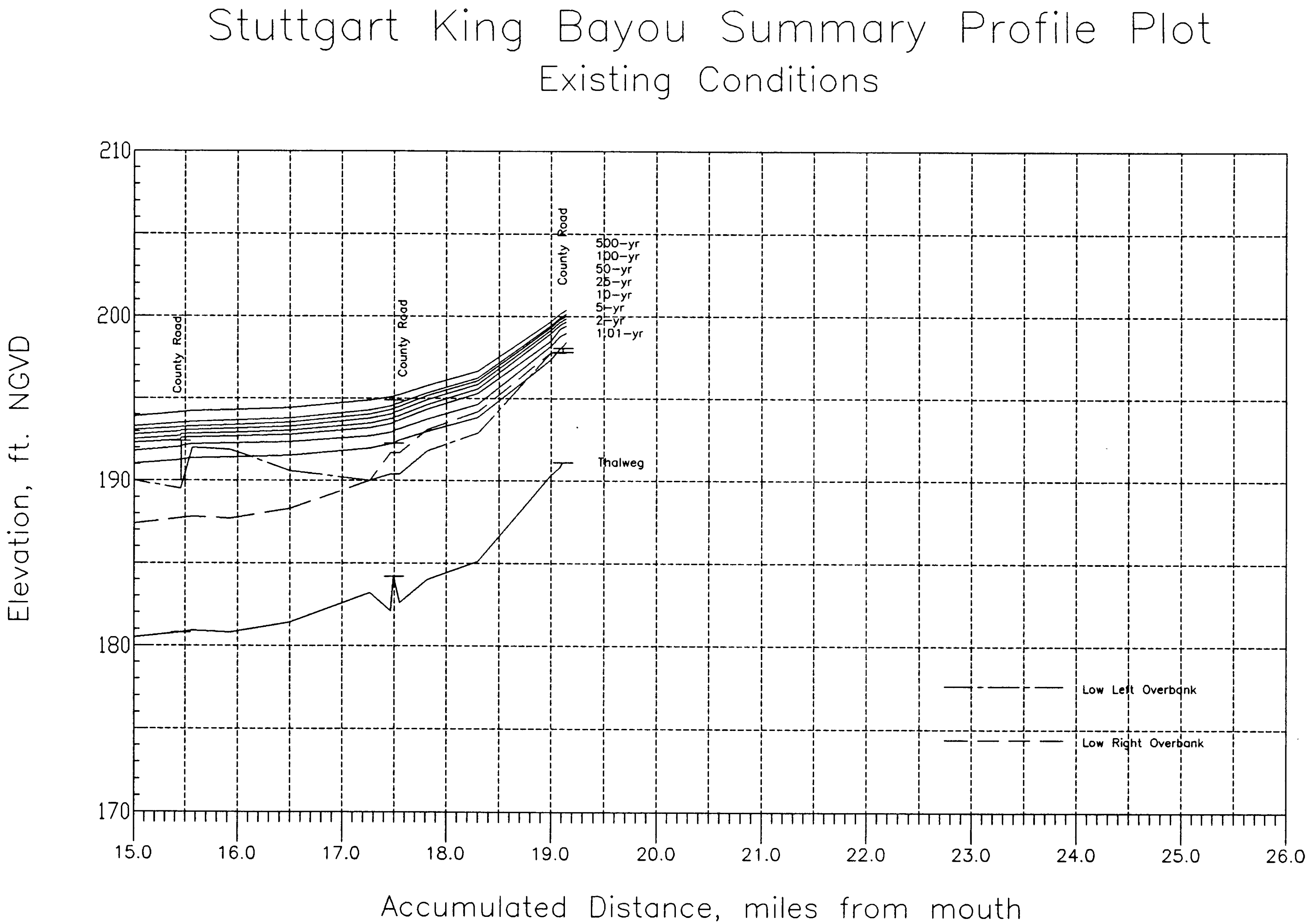

(17)

# Stuttgart King Bayou Summary Profile Plot

## Existing Conditions



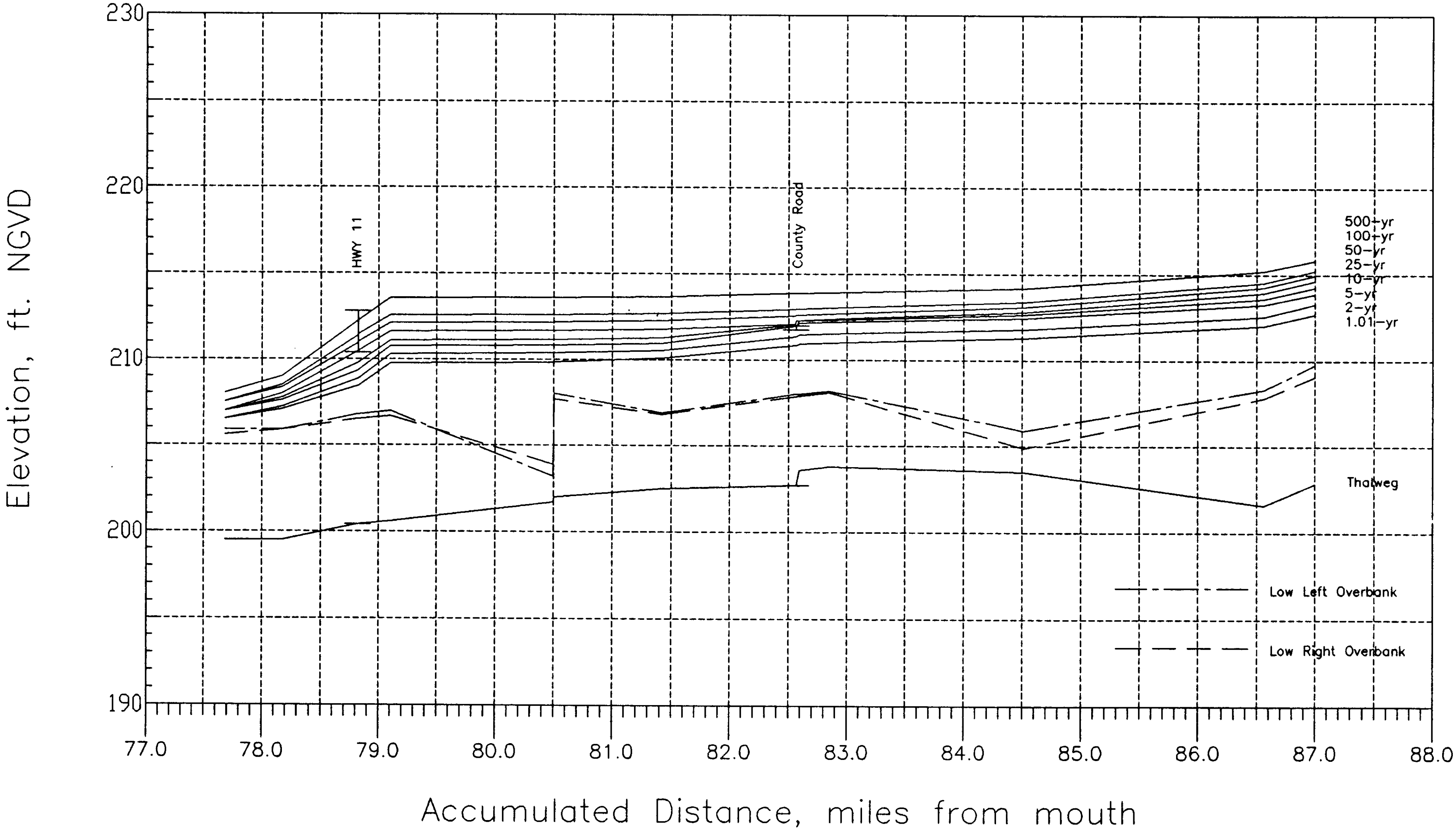

(18)


Stuttgart King Bayou Summary Profile Plot
Existing Conditions
Elevation, ft. NGVD
Accumulated Distance, miles from mouth
County Road
County Road
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank
210
200
190
180
170
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0

(19)

# Upper La Grue Bayou Summary Profile Plot

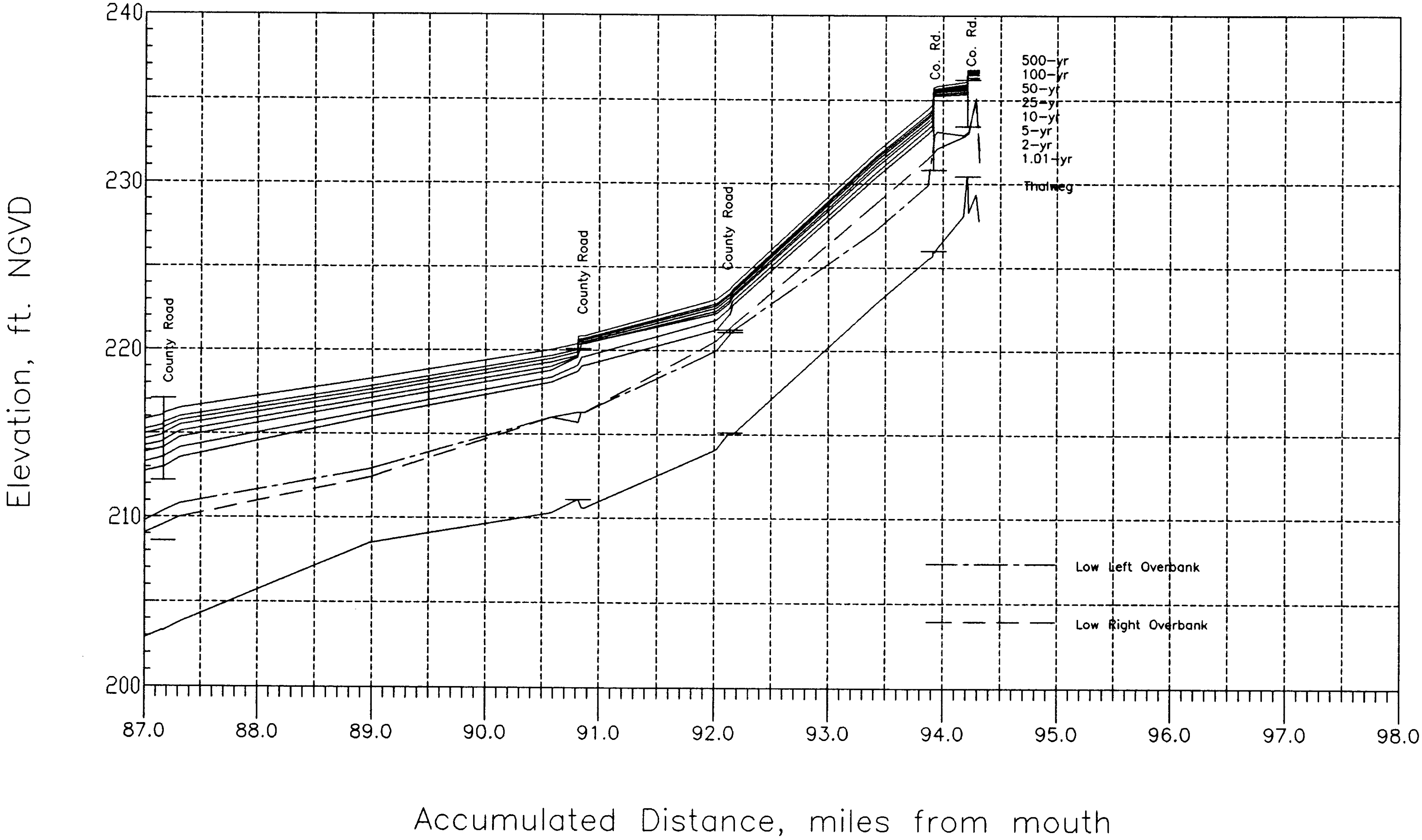
## Existing Conditions



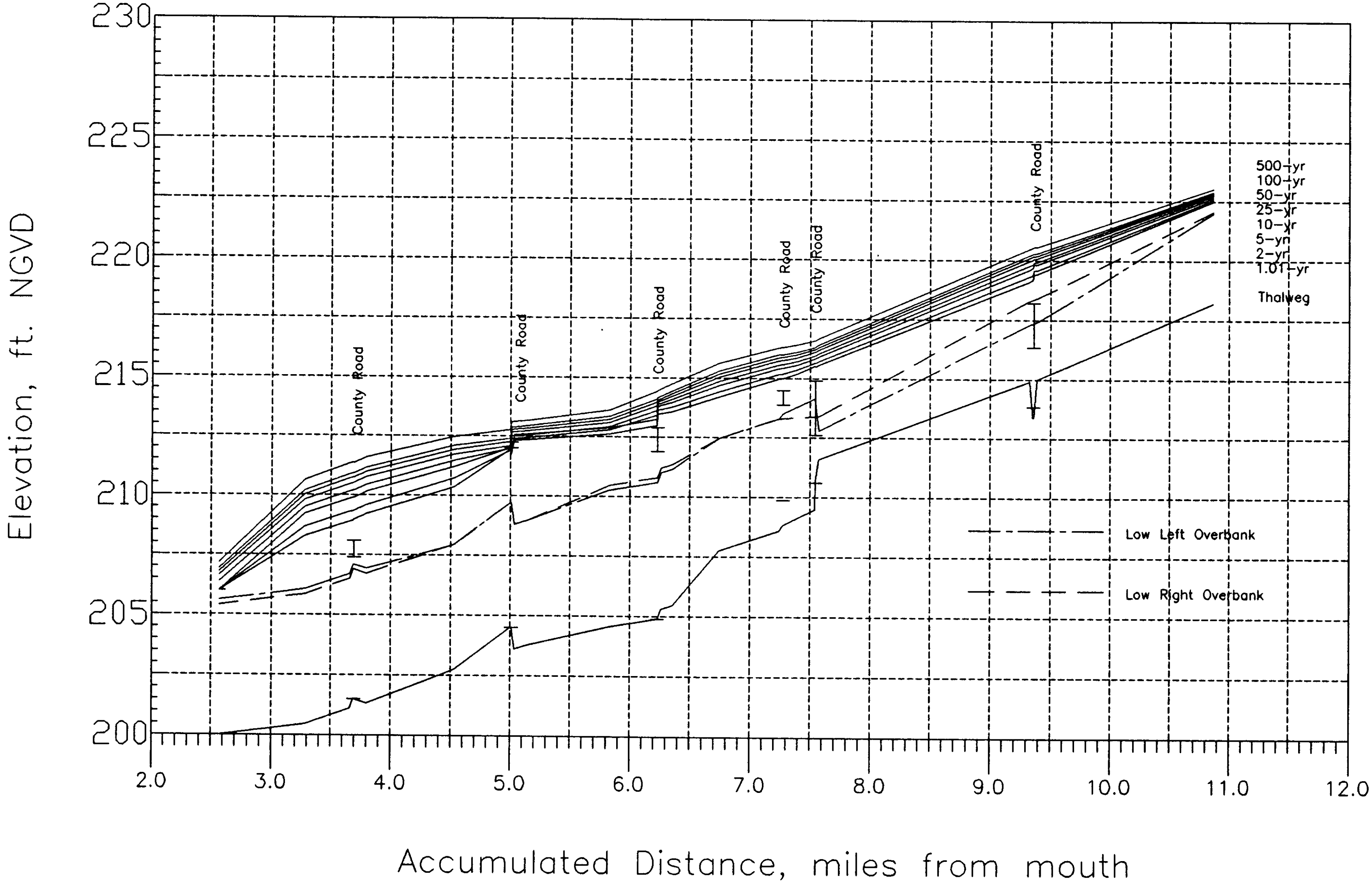

(20)

# Upper La Grue Bayou Summary Profile Plot

## Existing Conditions



Wolf Island Slash Summary Profile Plot
Existing Conditions



# Barnes Creek Summary Profile Plot

## With Project Conditions

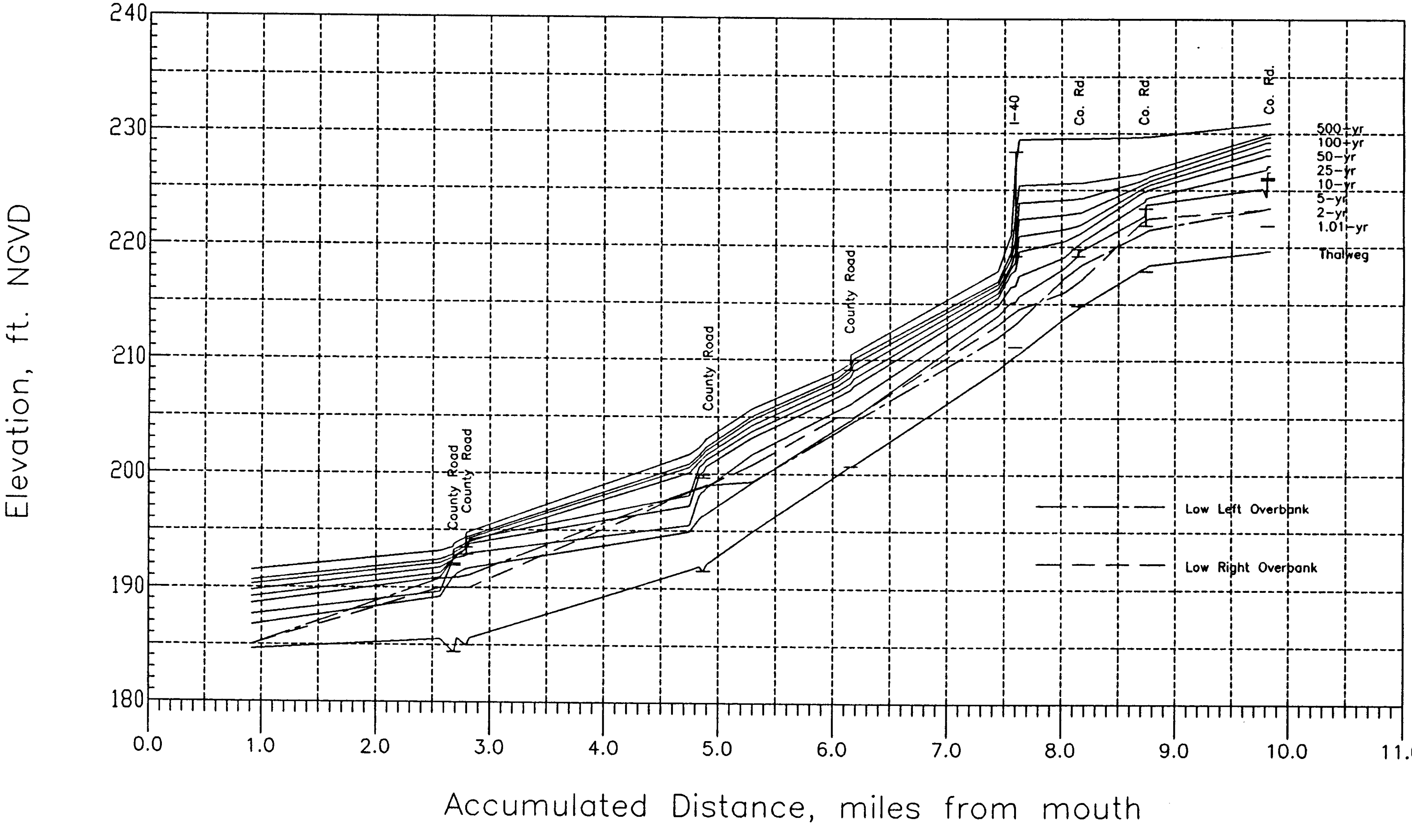
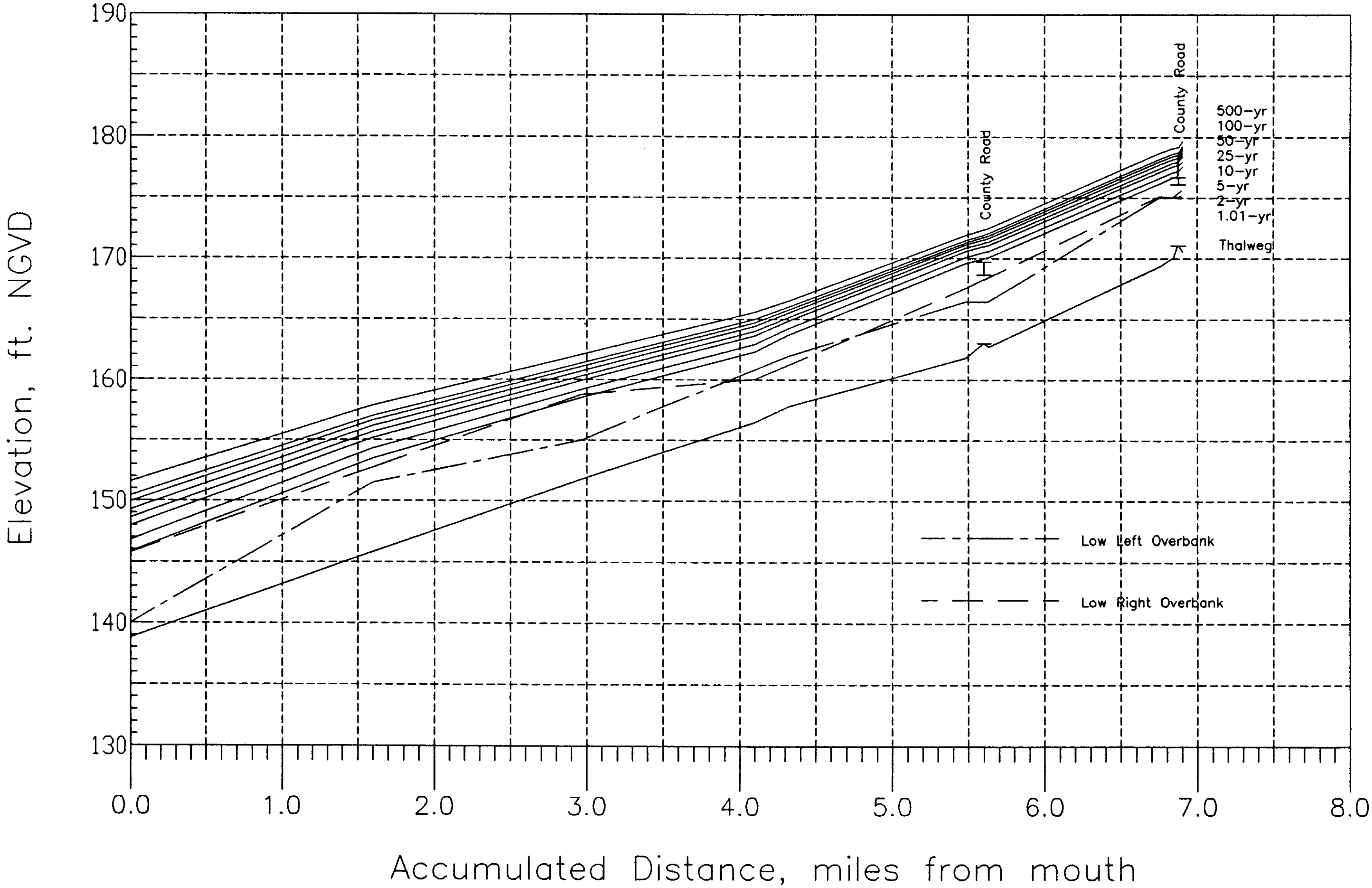
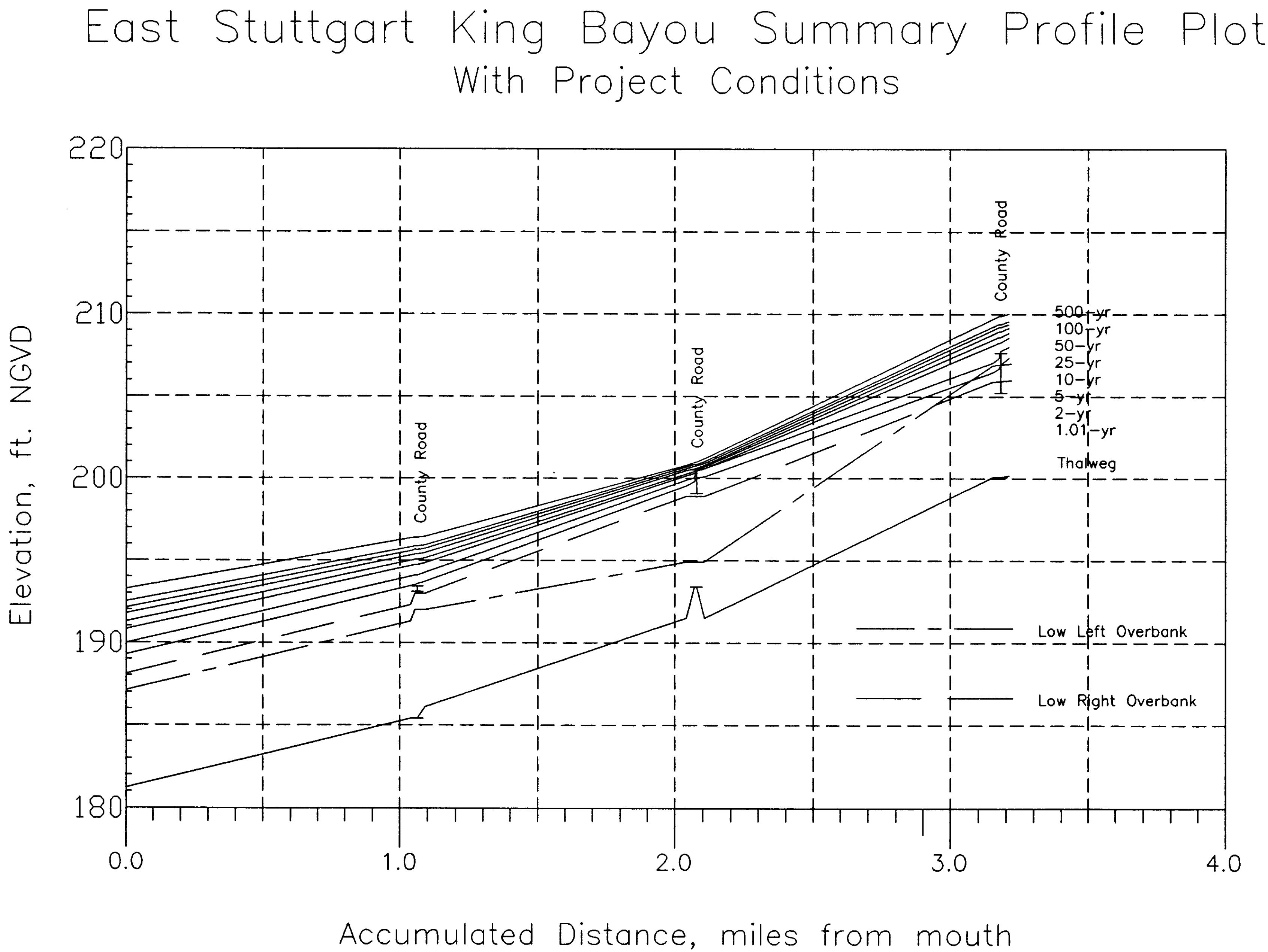



PLATE III-C-19 (1)

# Caney Bayou Summary Profile Plot
## With Project Conditions



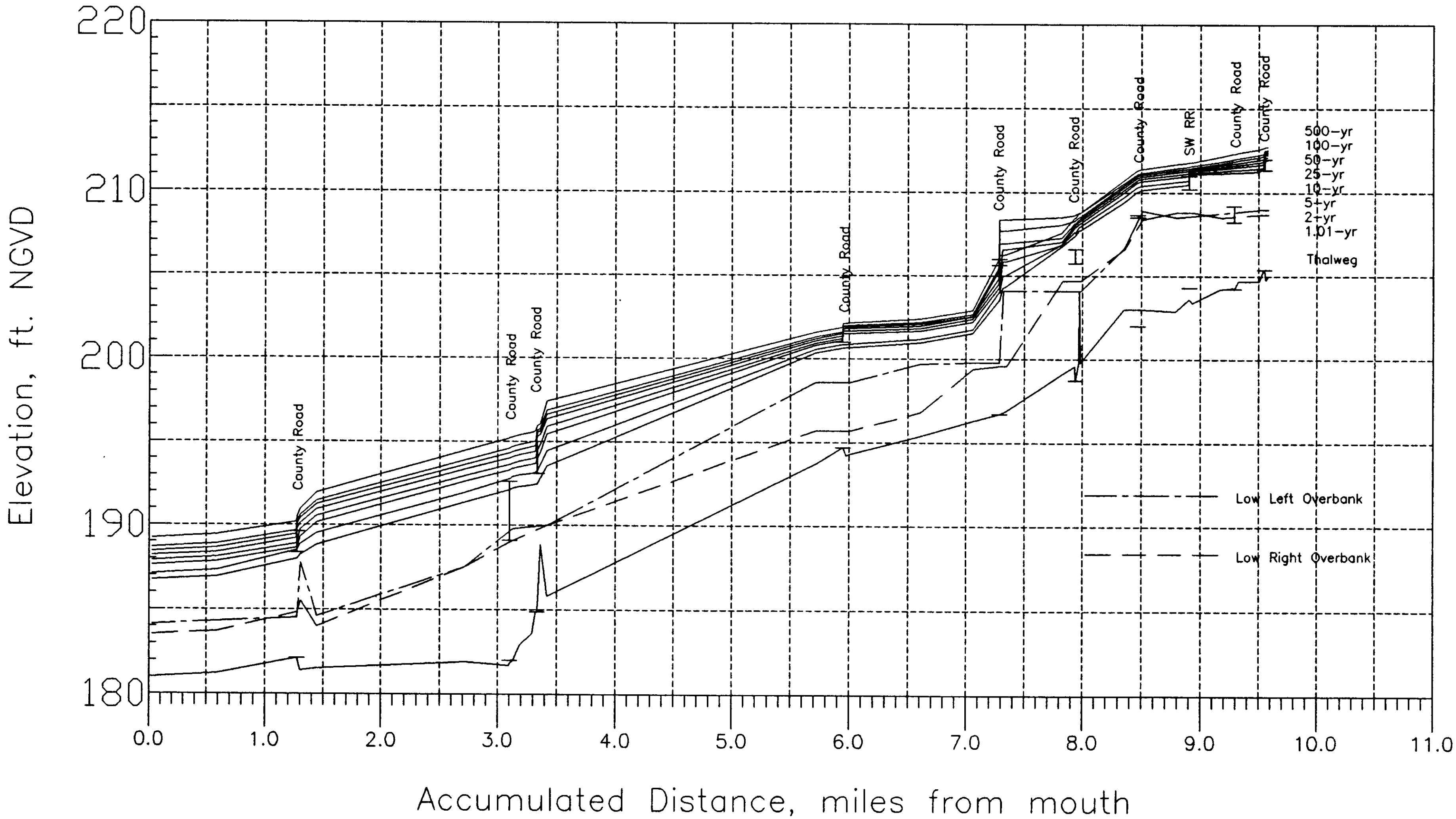

(2)


East Stuttgart King Bayou Summary Profile Plot
With Project Conditions
Elevation, ft. NGVD
220
210
200
190
180
0.0
1.0
2.0
3.0
4.0
Accumulated Distance, miles from mouth
County Road
County Road
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank

(3)

# Elm Prong Mill Bayou Summary Profile Plot

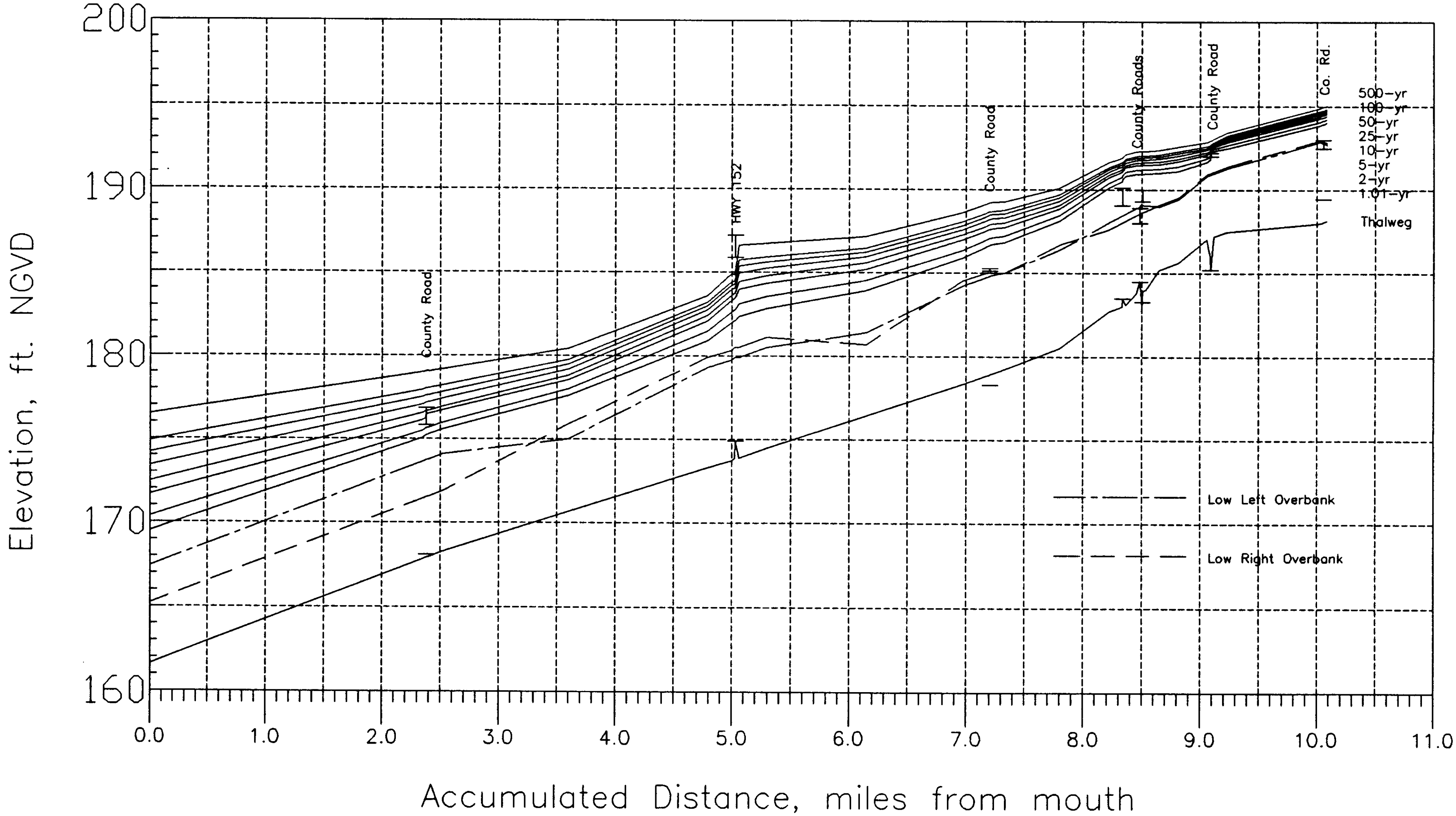
## With Project Conditions




(4)

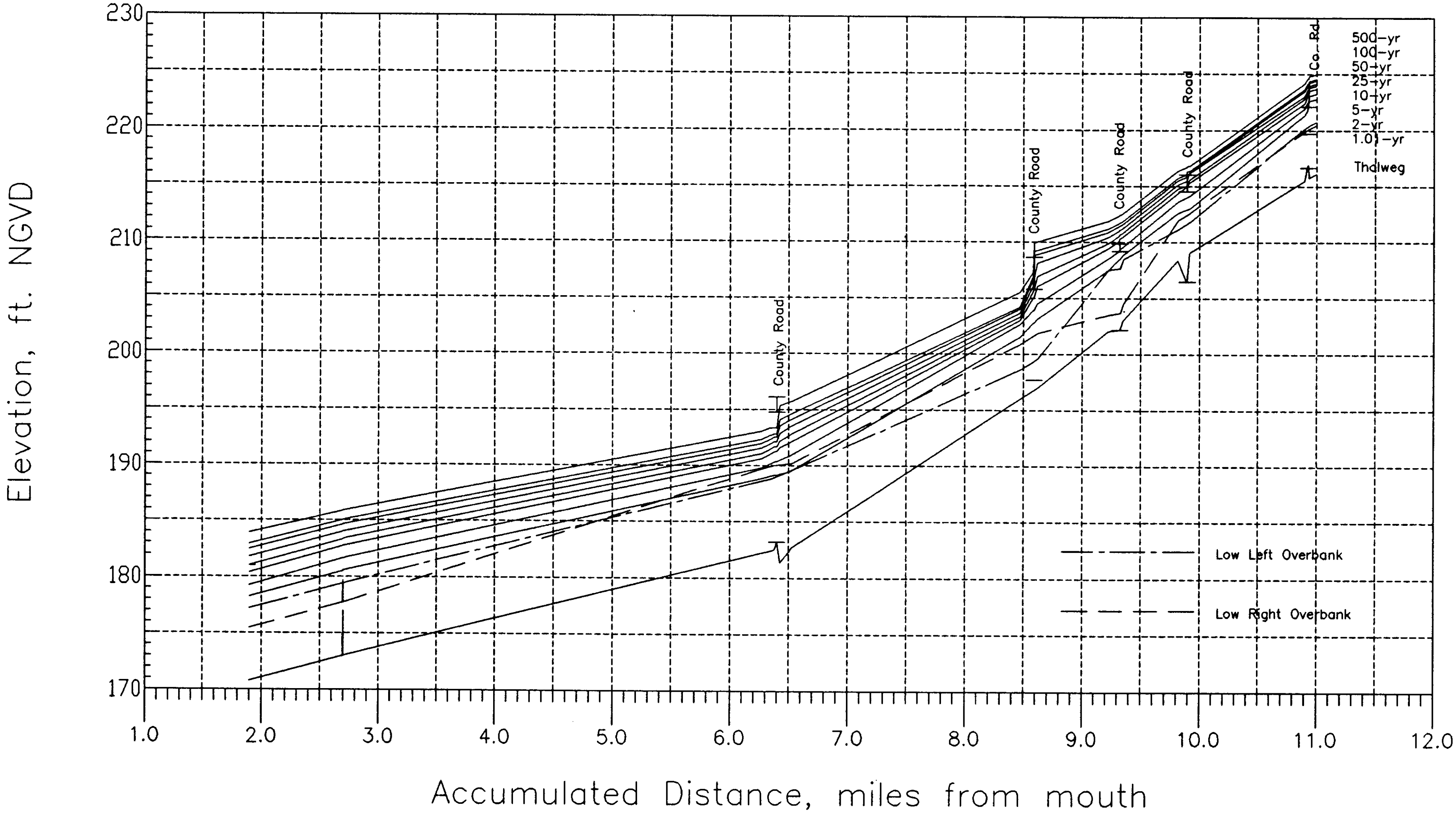
# Hurricane Bayou Summary Profile Plot

## With Project Conditions

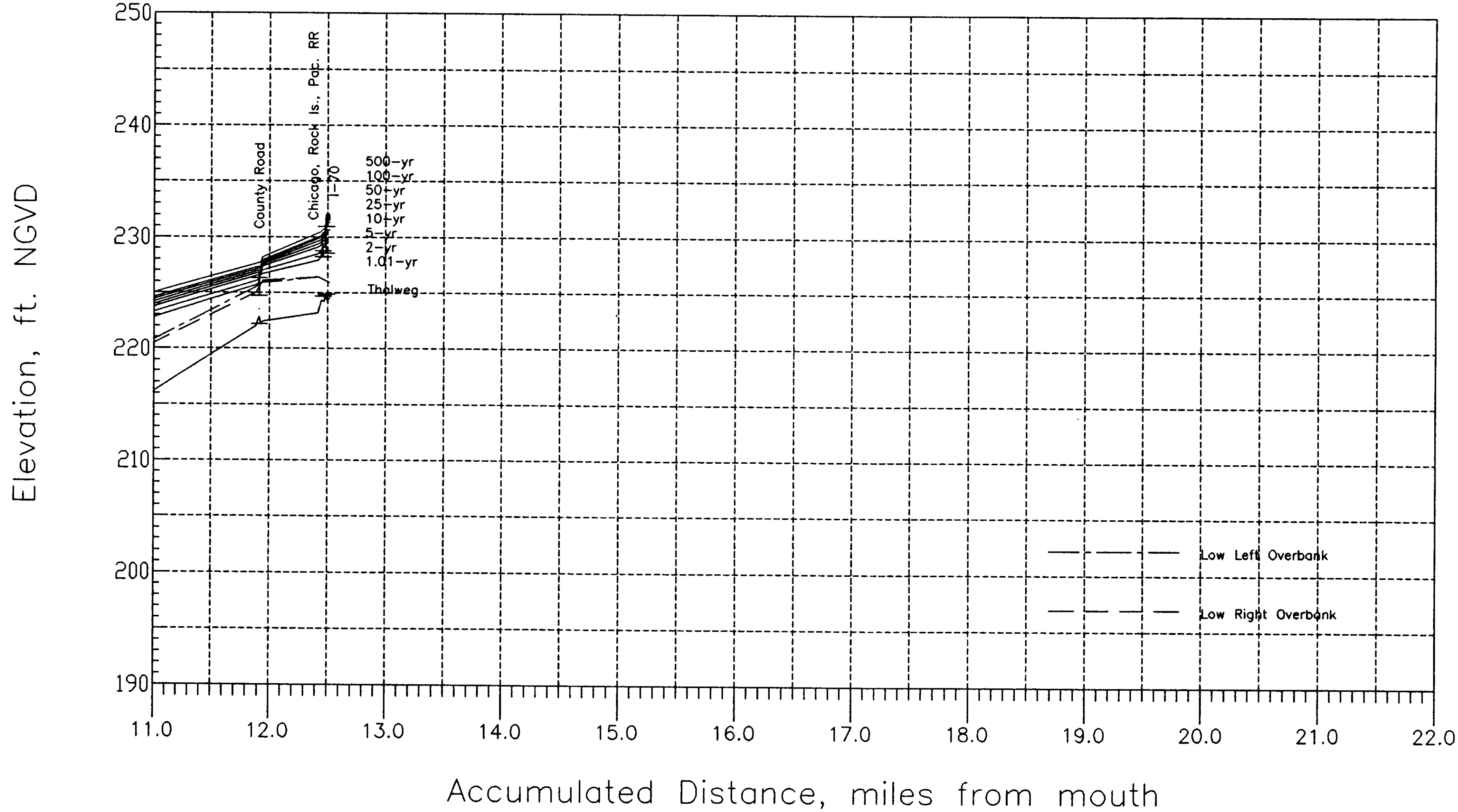



(5)

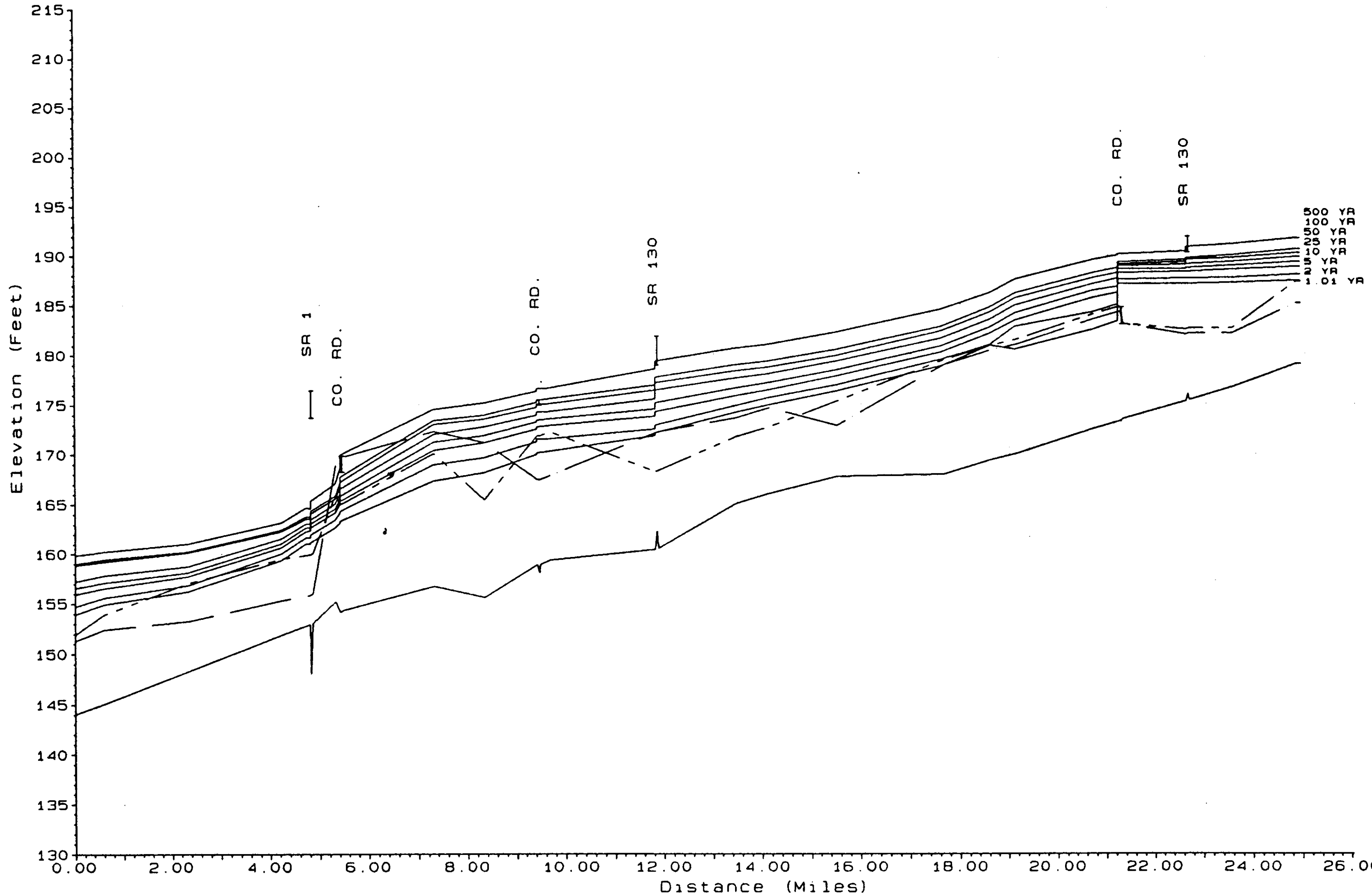
# Hurricane Creek Summary Profile Plot
## With Project Conditions



# Hurricane Creek Summary Profile Plot
## With Project Conditions

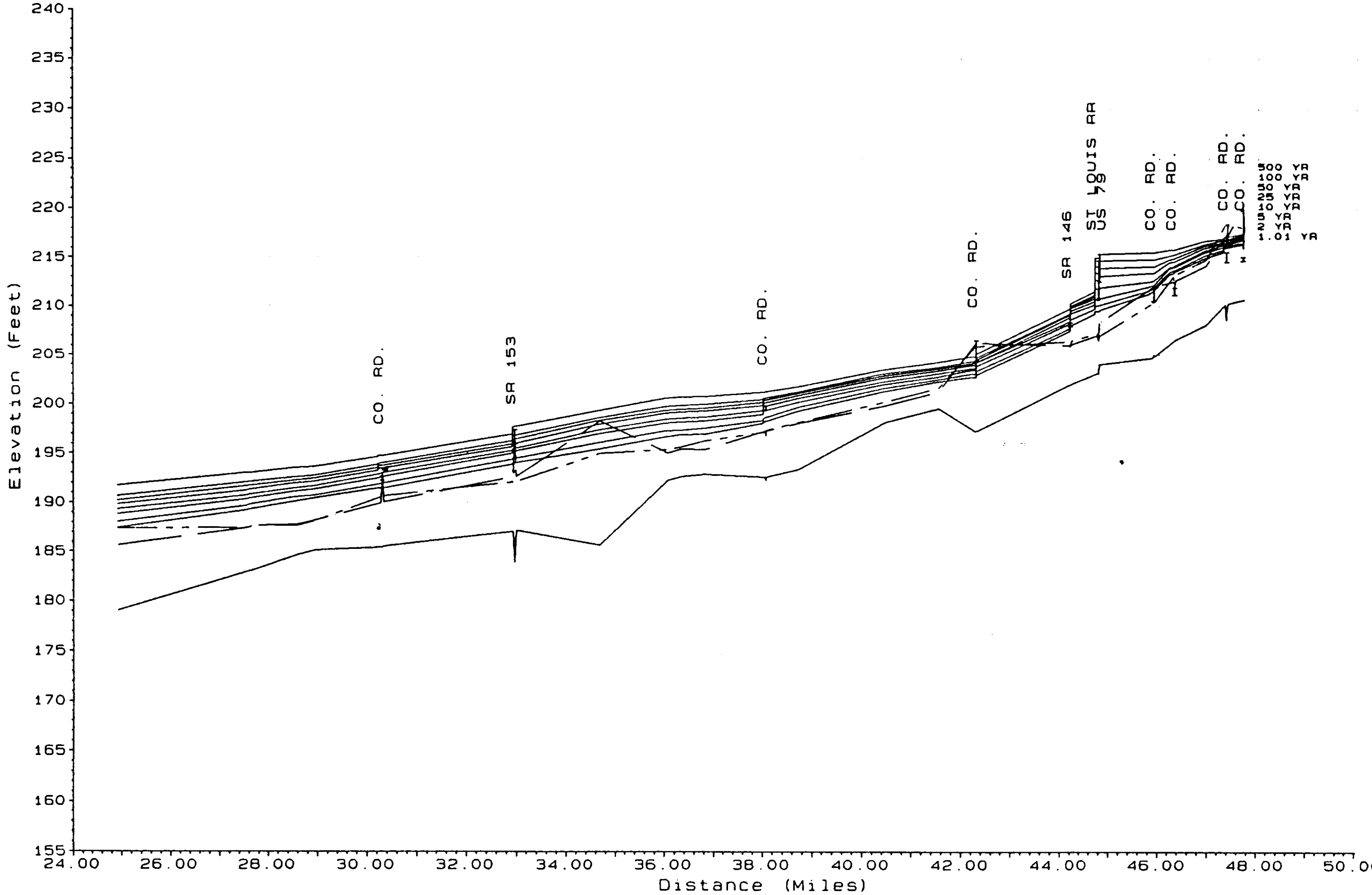


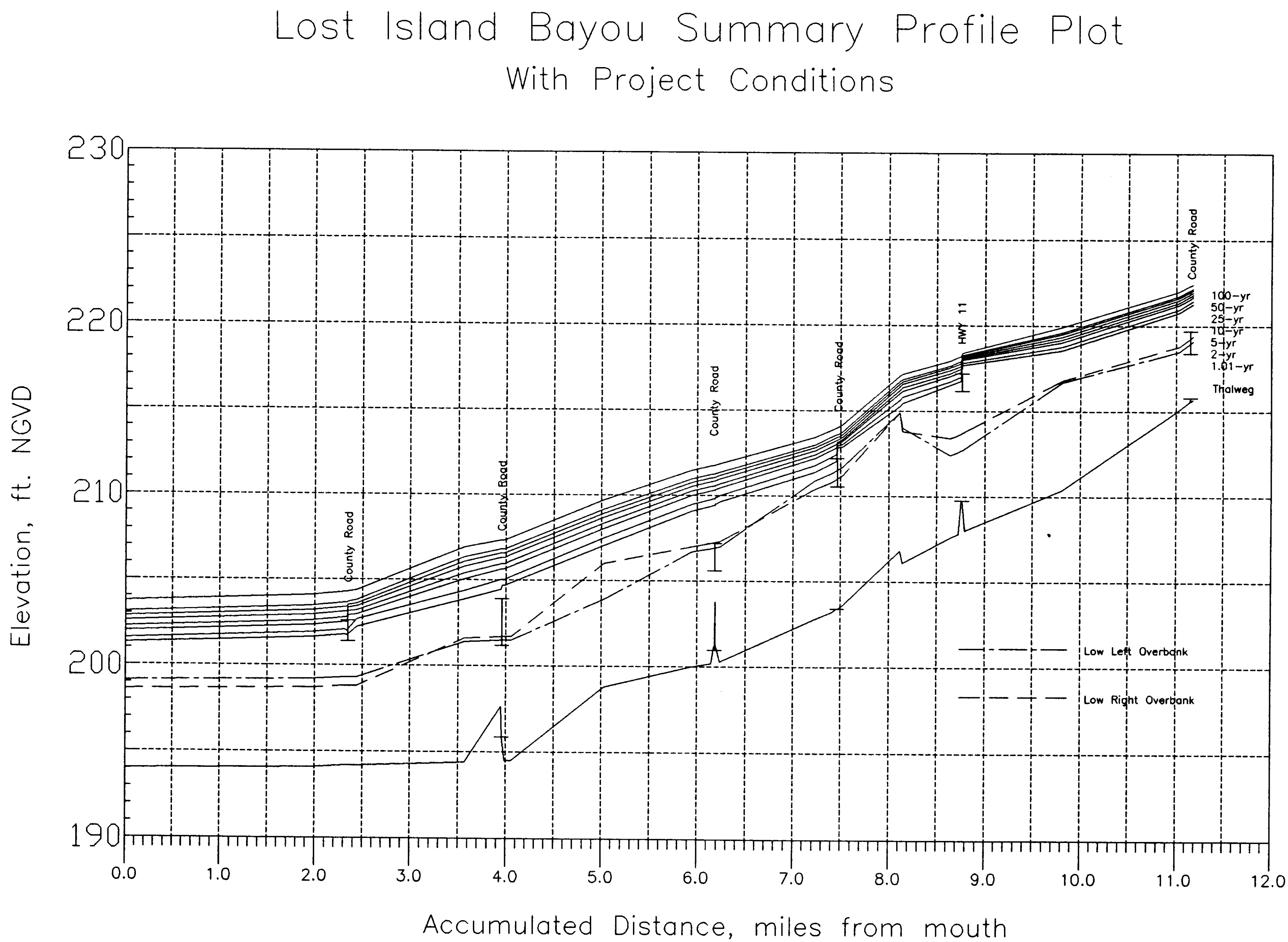
Little LaGrue Bayou
(Existing + Irrigation)




(8)

Little LaGrue Bayou
(Existing + Irrigation)

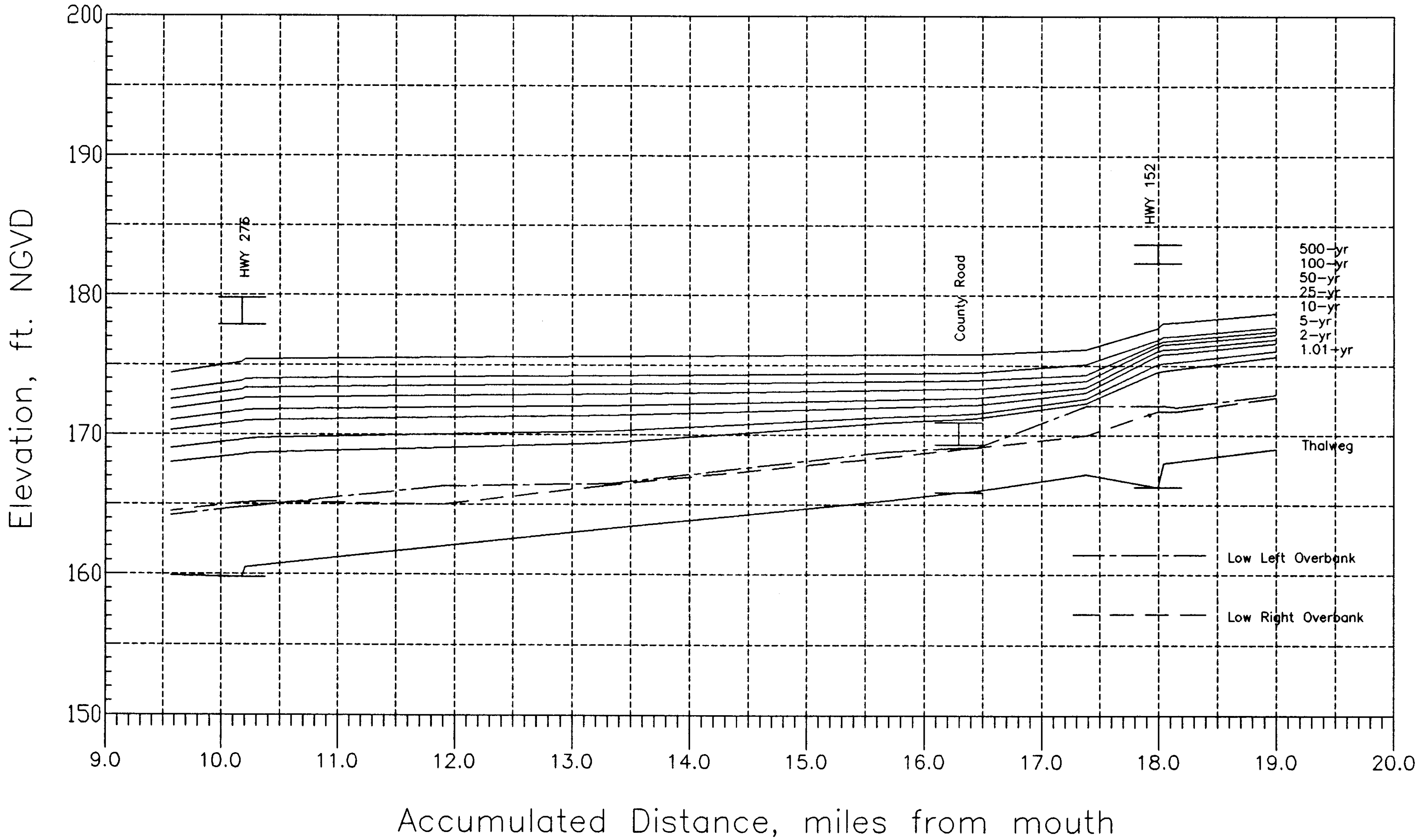




Lost Island Bayou Summary Profile Plot
With Project Conditions
Elevation, ft. NGVD
Accumulated Distance, miles from mouth
230
220
210
200
190
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
County Road
County Road
County Road
County Road
HWY 11
County Road
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank

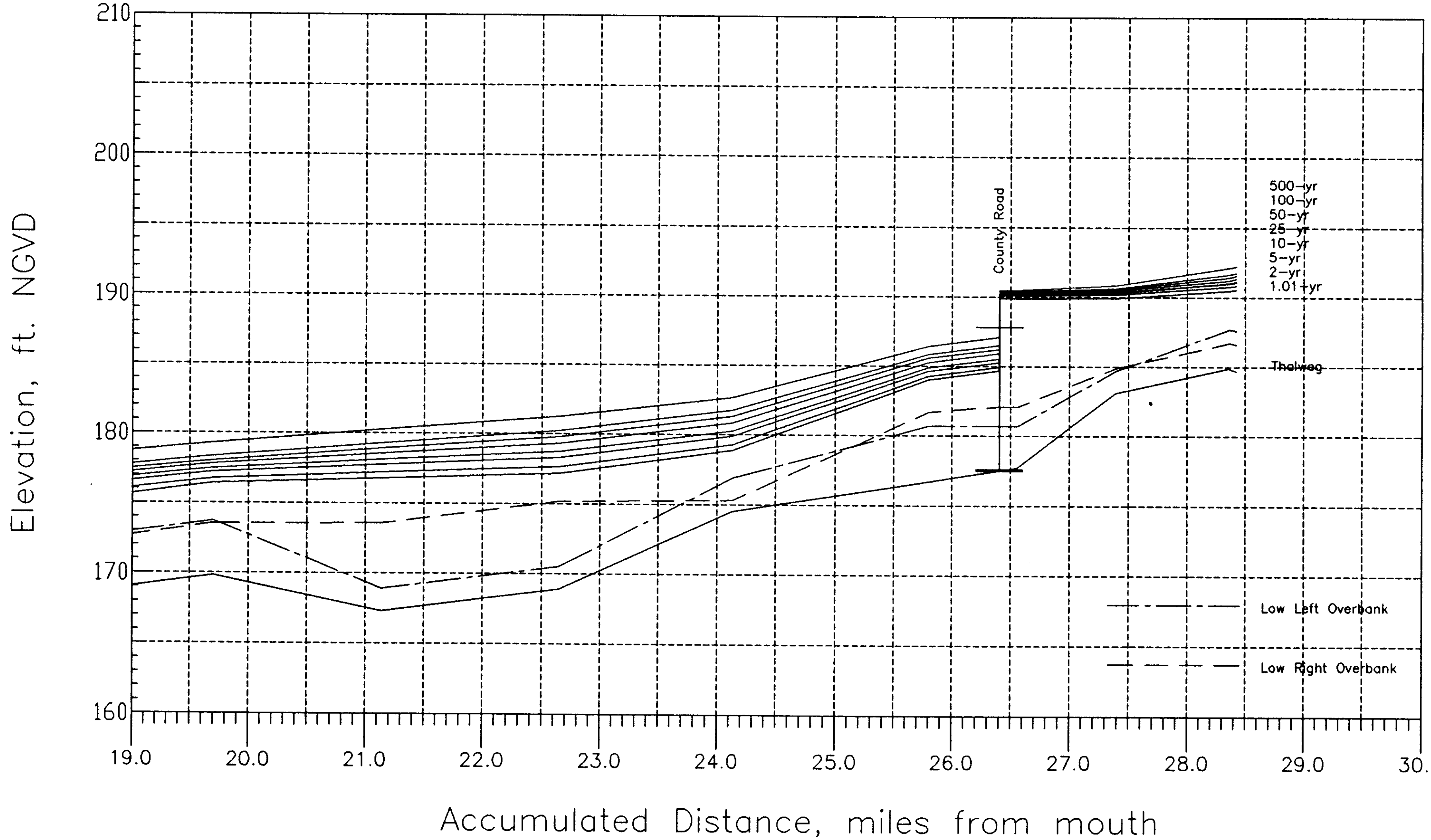

(10)

# Mill Bayou Summary Profile Plot
## With Project Conditions



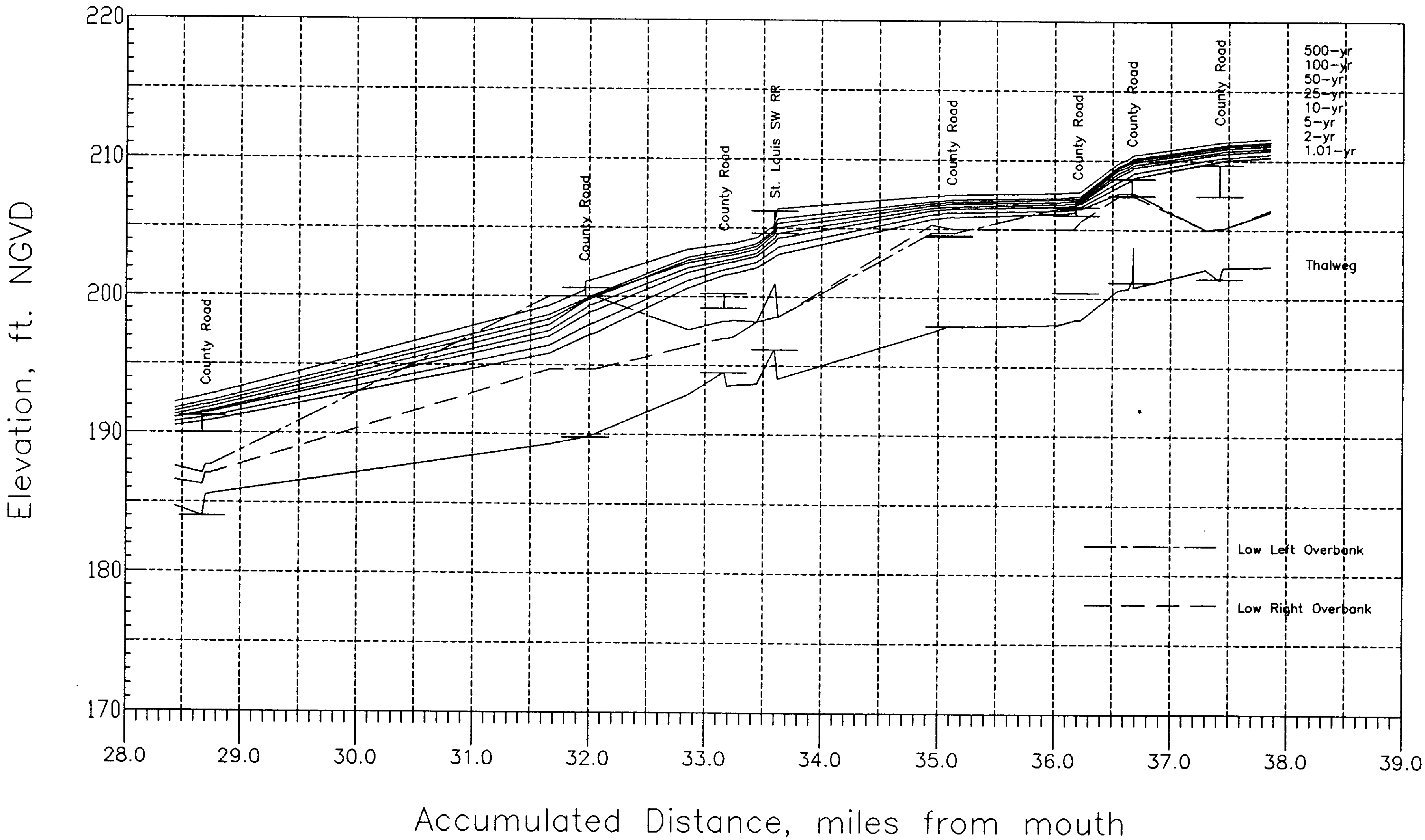

(11)

# Mill Bayou Summary Profile Plot
## With Project Conditions




(12)

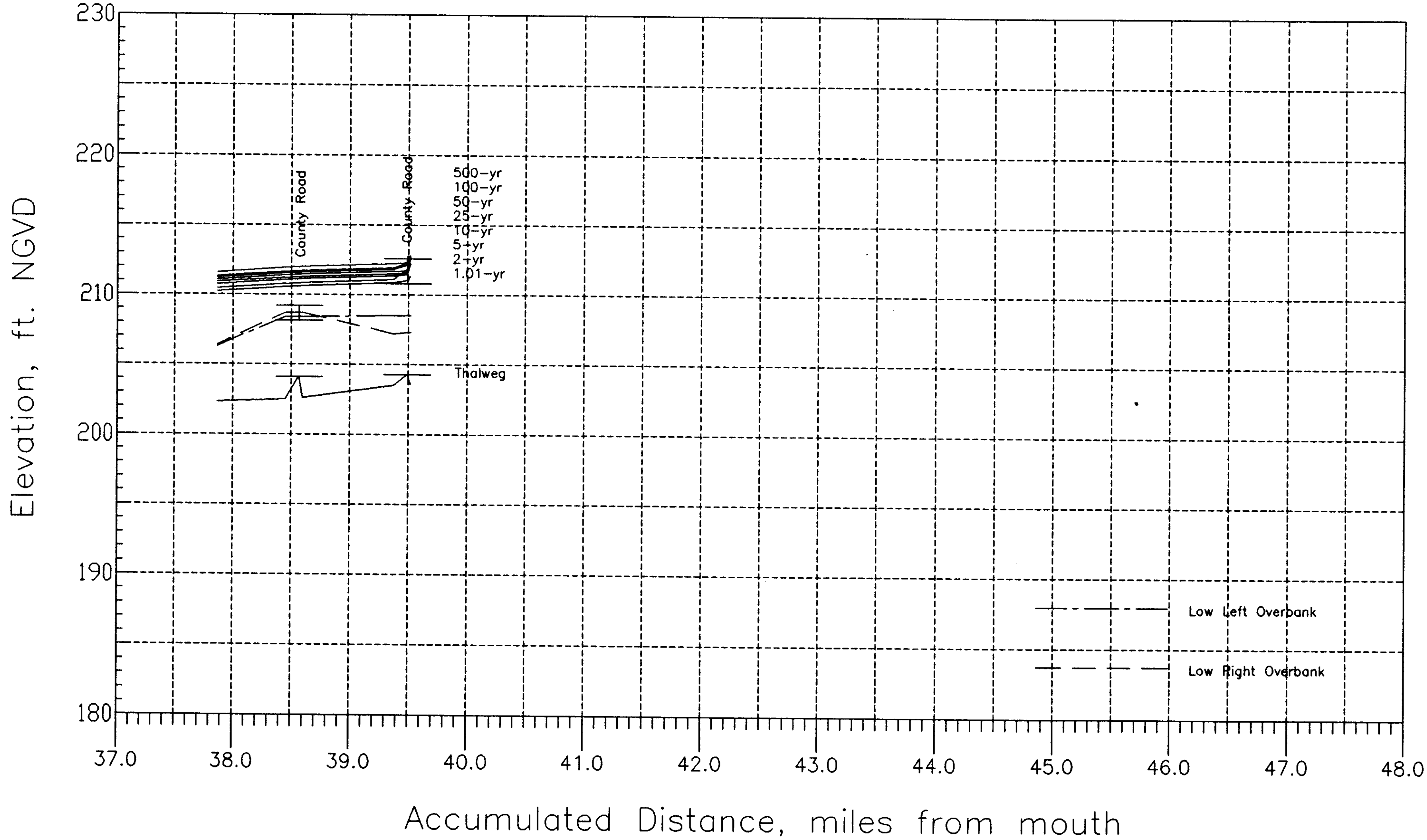
# Mill Bayou Summary Profile Plot
## With Project Conditions



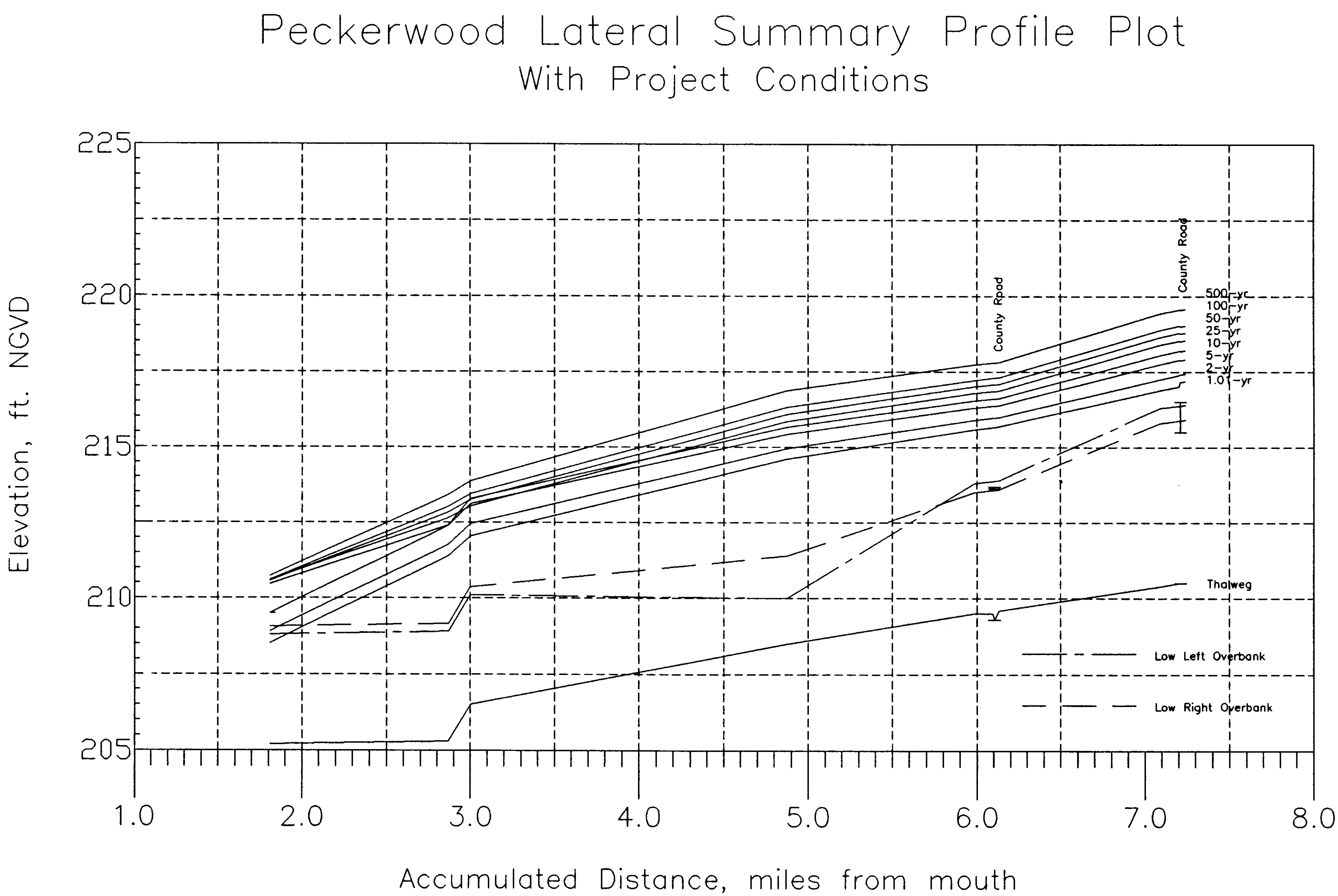

(13)

Mill Bayou Summary Profile Plot

With Project Conditions



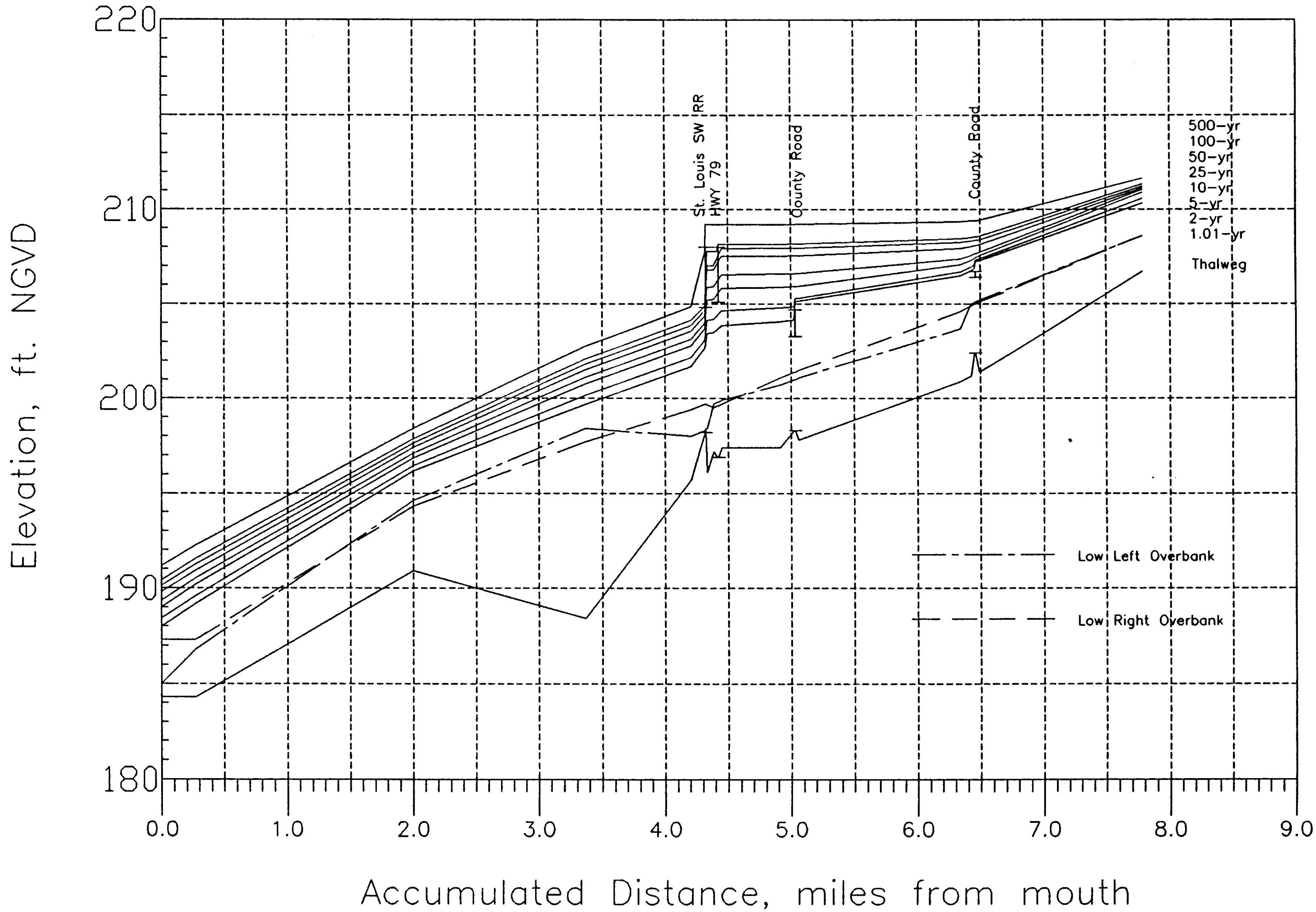

(141)



Peckerwood Lateral Summary Profile Plot
With Project Conditions
Elevation, ft. NGVD
225
220
215
210
205
County Road
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Accumulated Distance, miles from mouth

# Sherrill Creek Summary Profile Plot

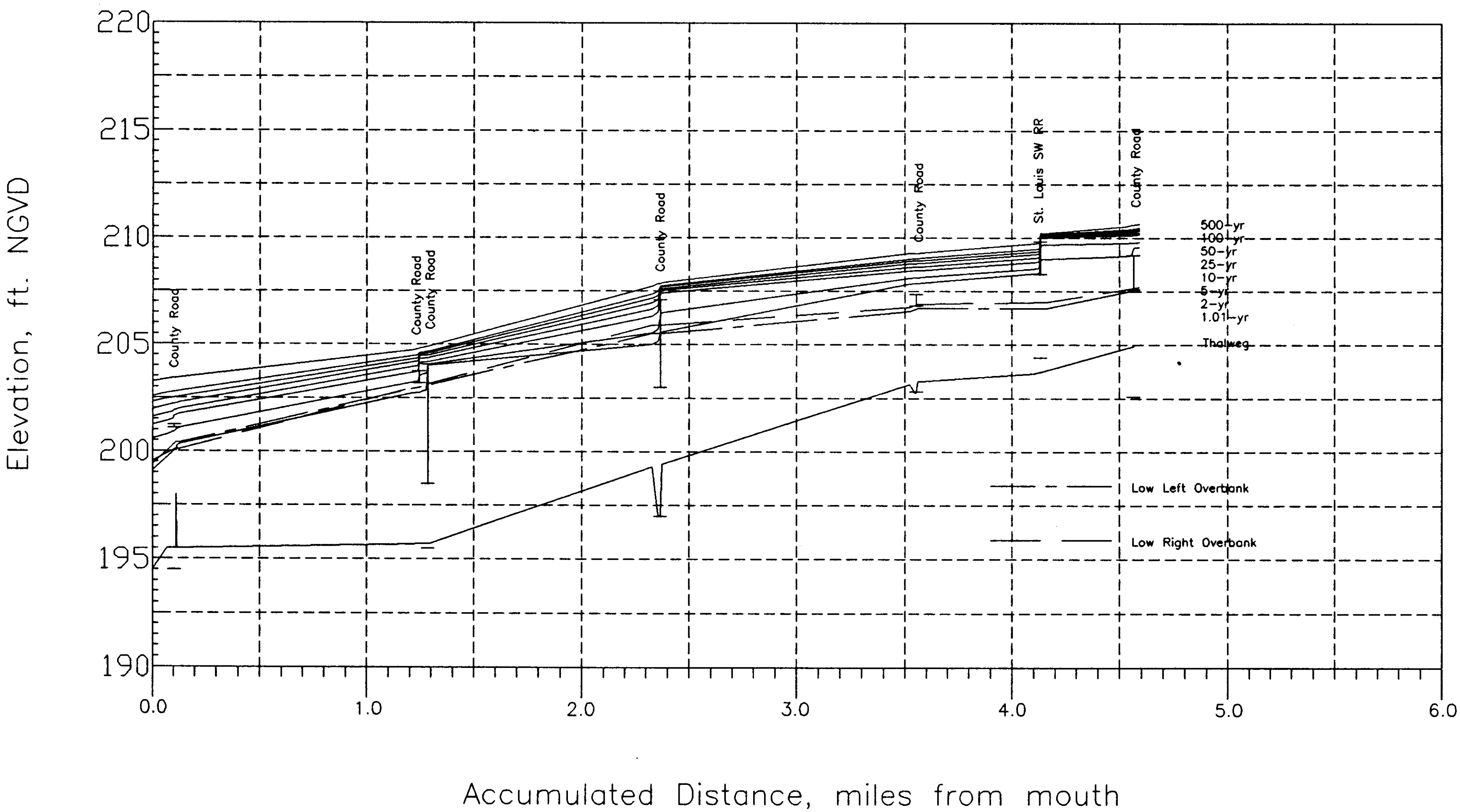
## With Project Conditions




(16)

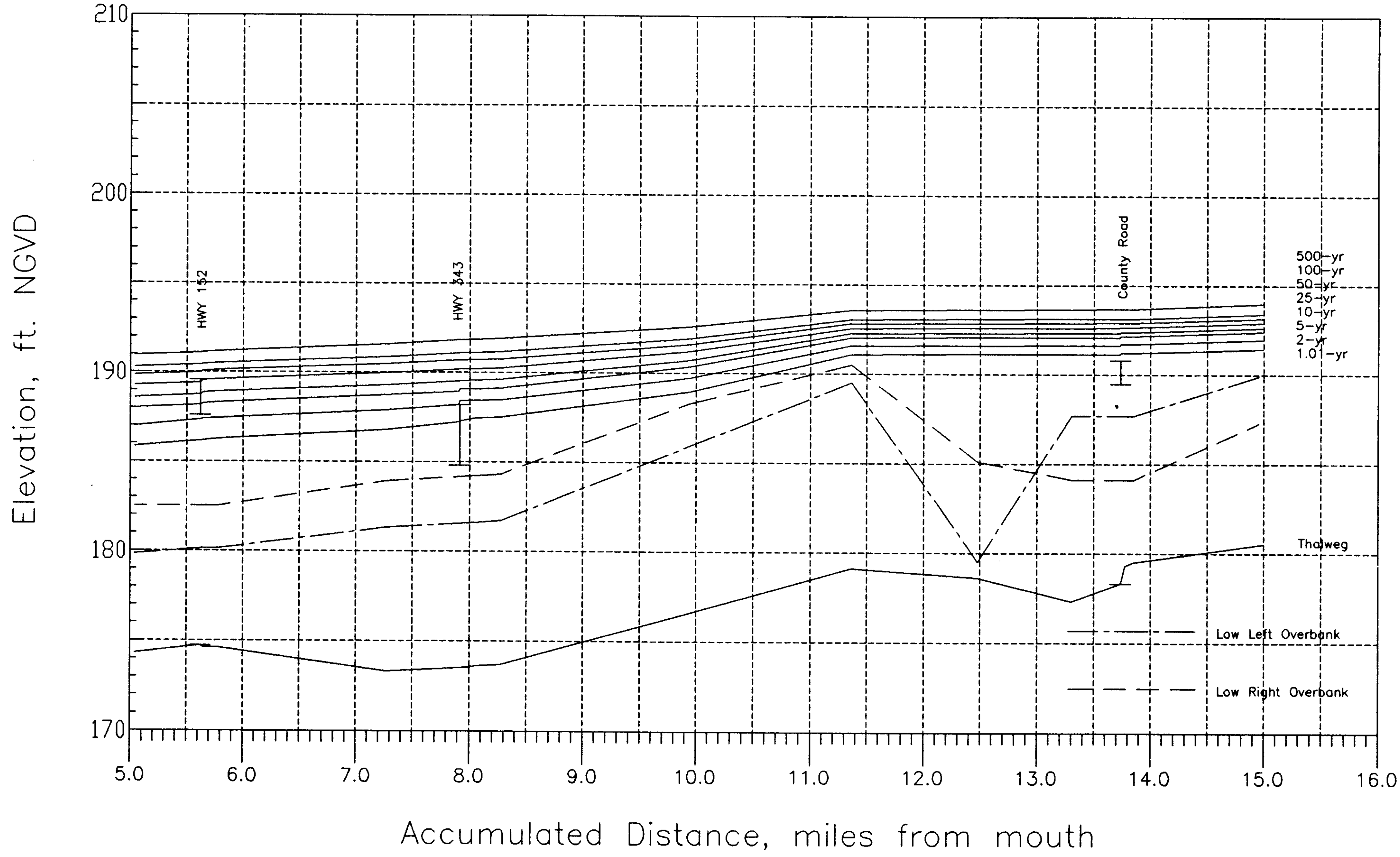
# South Mill Bayou Summary Profile Plot

## With Project Conditions



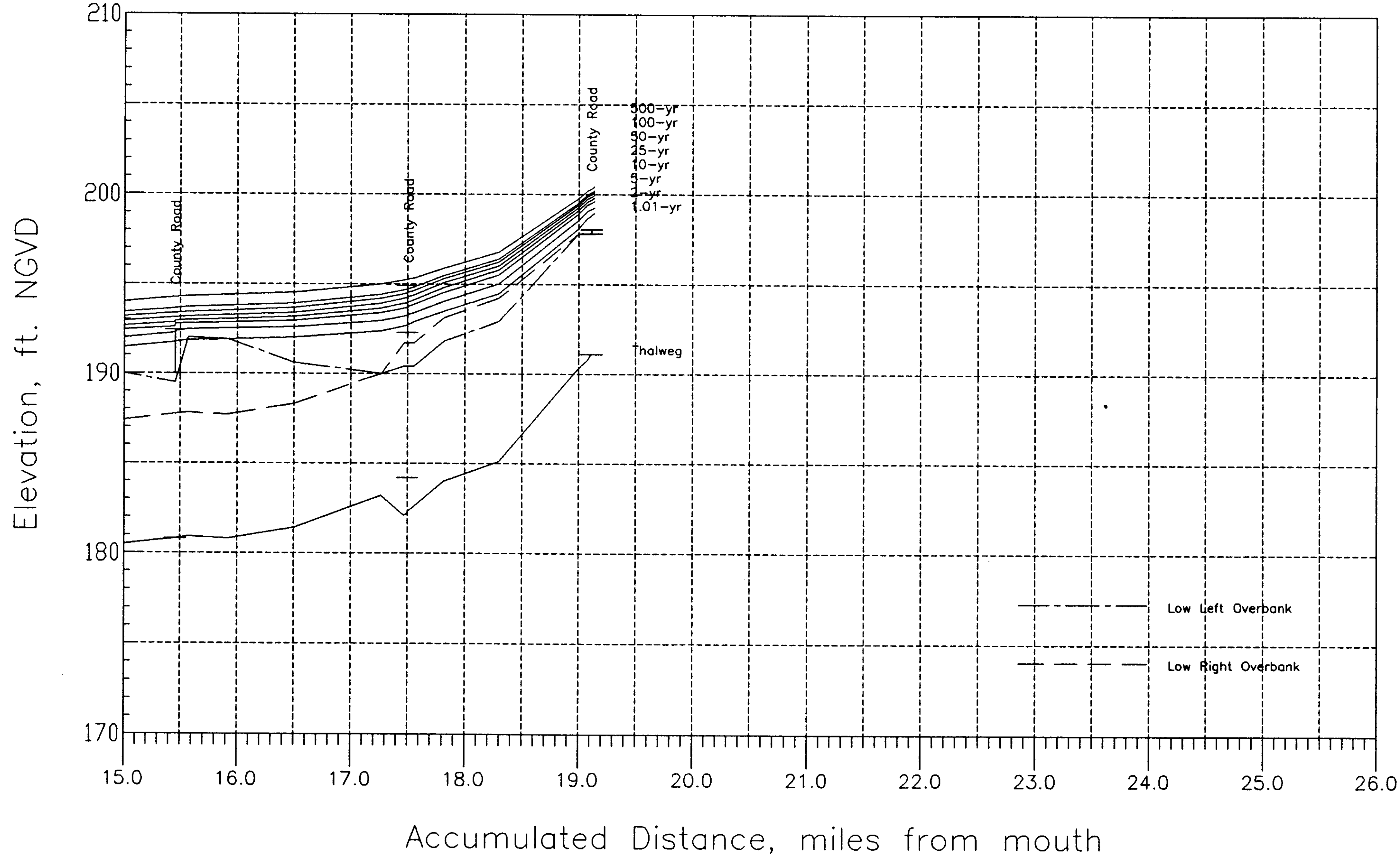

(17)

# Stuttgart King Bayou Summary Profile Plot
## With Project Conditions

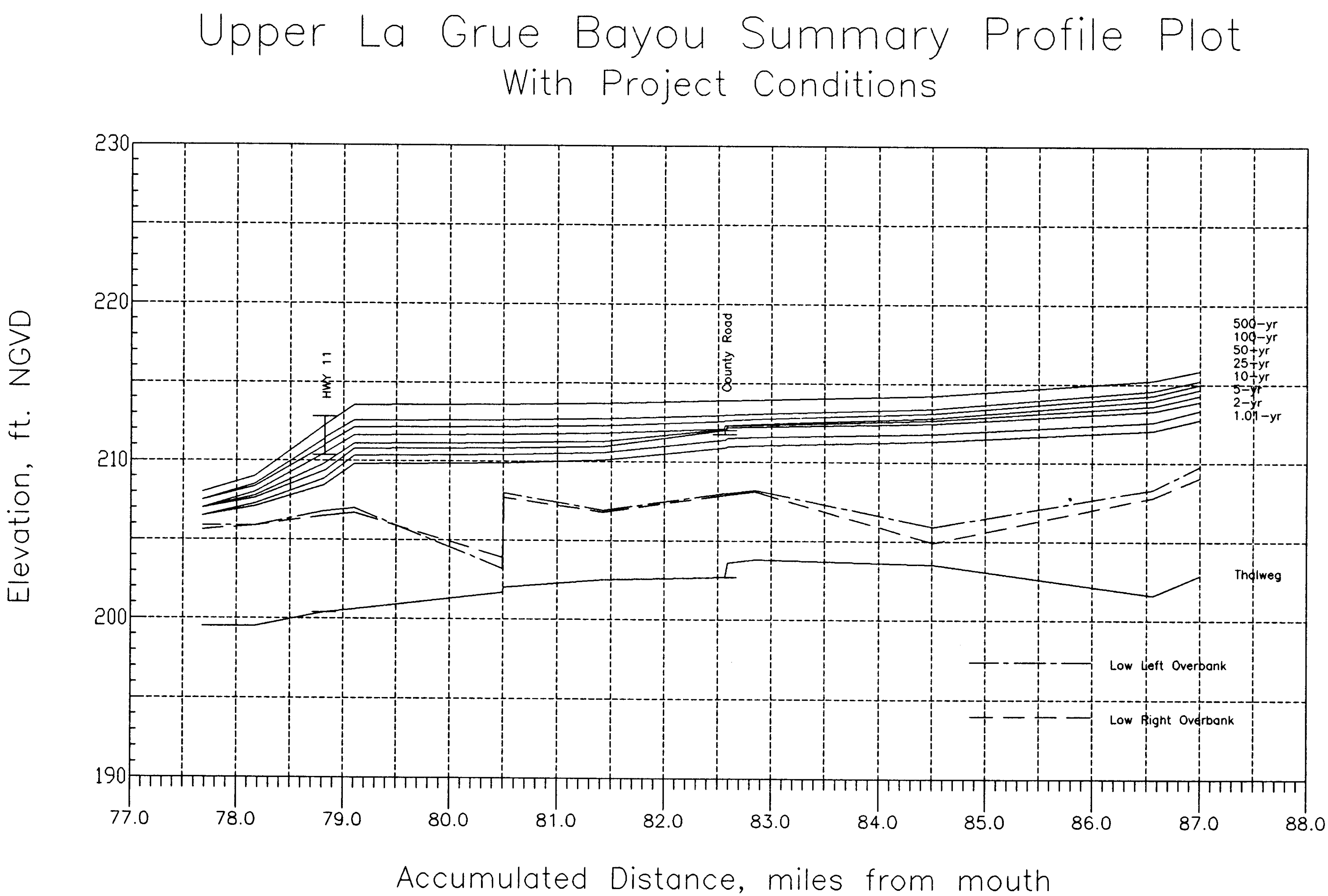


# Stuttgart King Bayou Summary Profile Plot

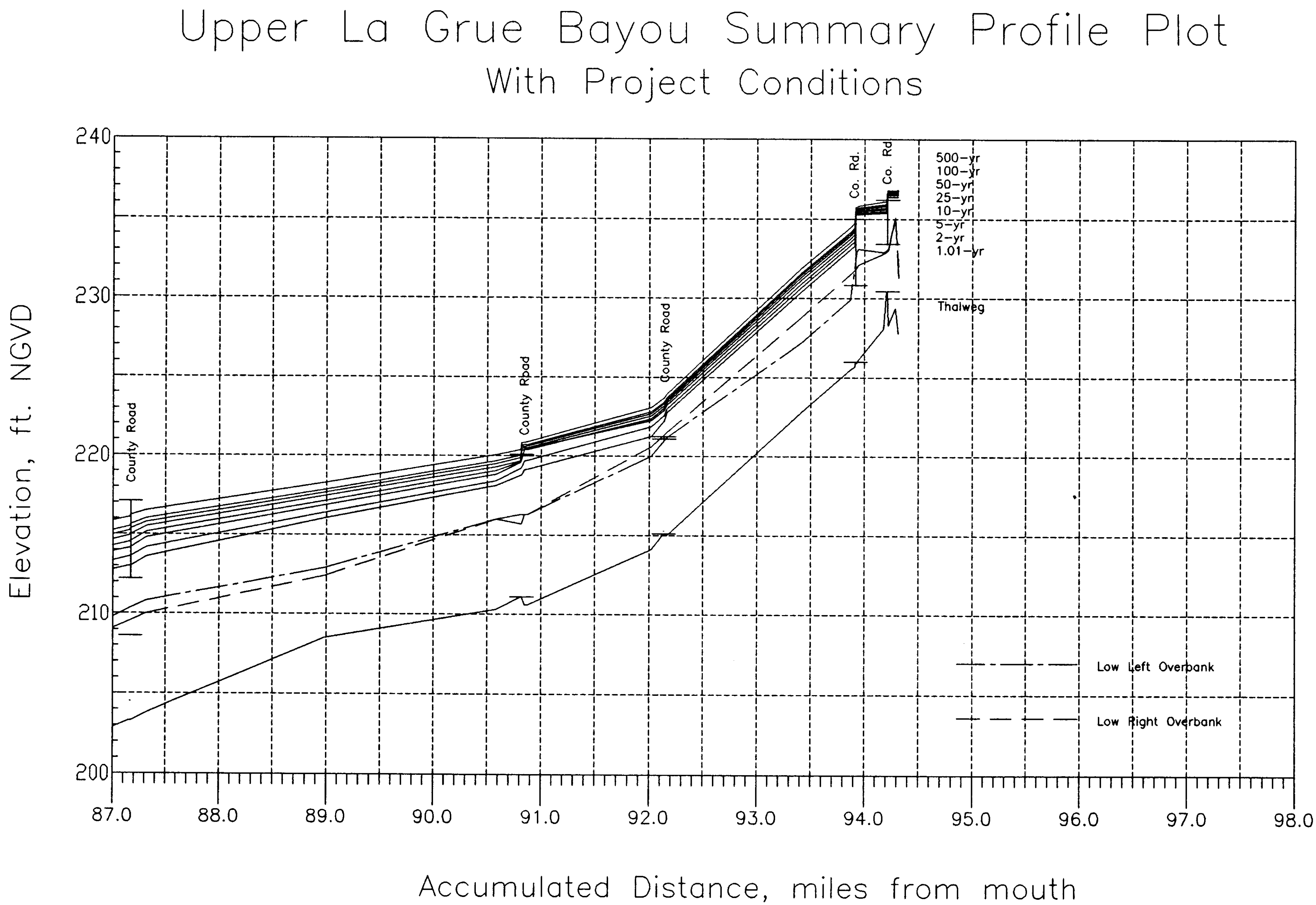
## With Project Conditions




(19)


Upper La Grue Bayou Summary Profile Plot
With Project Conditions
Elevation, ft. NGVD
230
220
210
200
190
77.0
78.0
79.0
80.0
81.0
82.0
83.0
84.0
85.0
86.0
87.0
88.0
Accumulated Distance, miles from mouth
HWY 11
County Road
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank

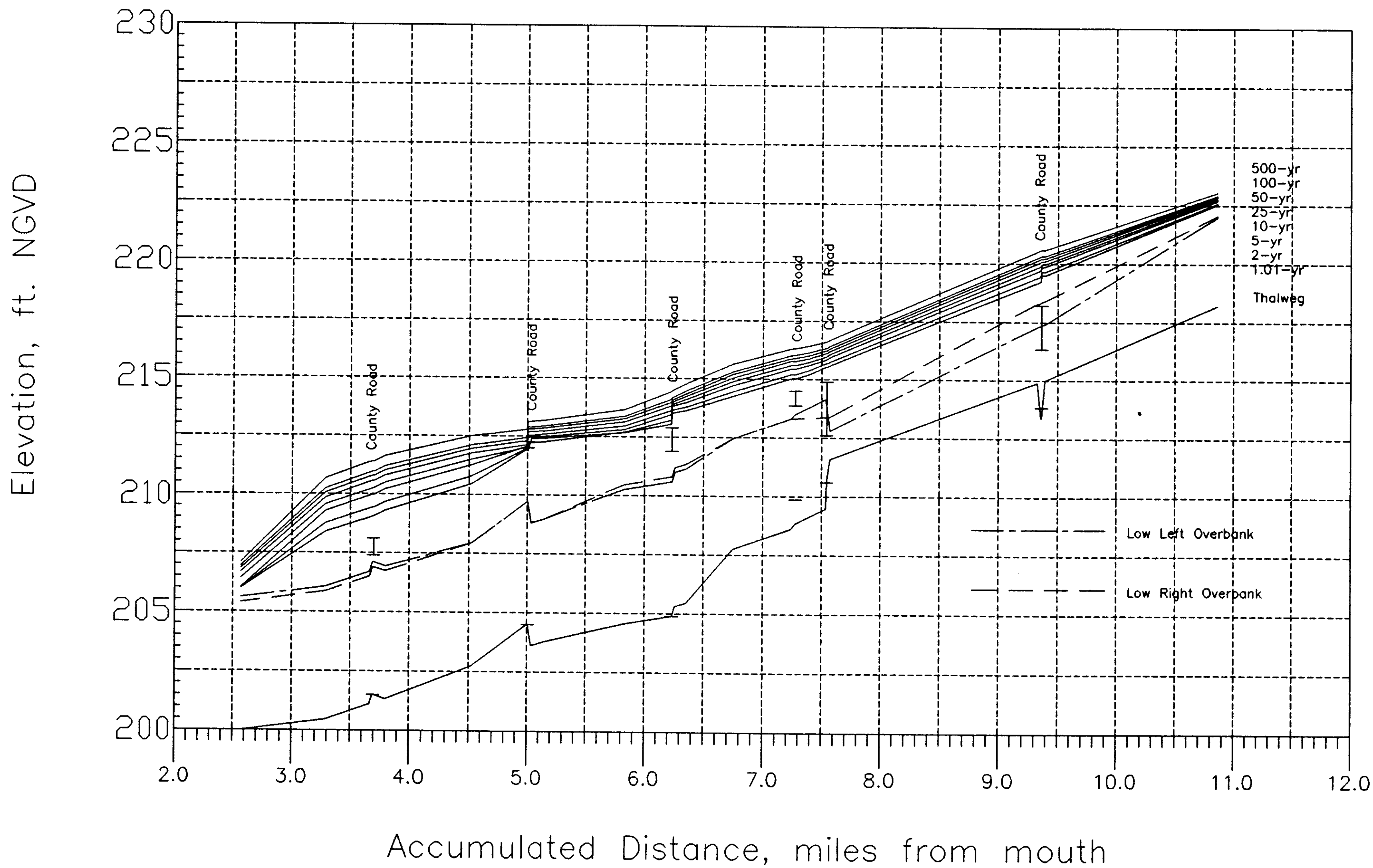
(20)


Upper La Grue Bayou Summary Profile Plot
With Project Conditions
Elevation, ft. NGVD
Accumulated Distance, miles from mouth
240
230
220
210
200
87.0
88.0
89.0
90.0
91.0
92.0
93.0
94.0
95.0
96.0
97.0
98.0
County Road
County Road
County Road
Co. Rd.
Co. Rd
500-yr
100-yr
50-yr
25-yr
10-yr
5-yr
2-yr
1.01-yr
Thalweg
Low Left Overbank
Low Right Overbank

(21)

# Wolf Island Slash Summary Profile Plot

## With Project Conditions



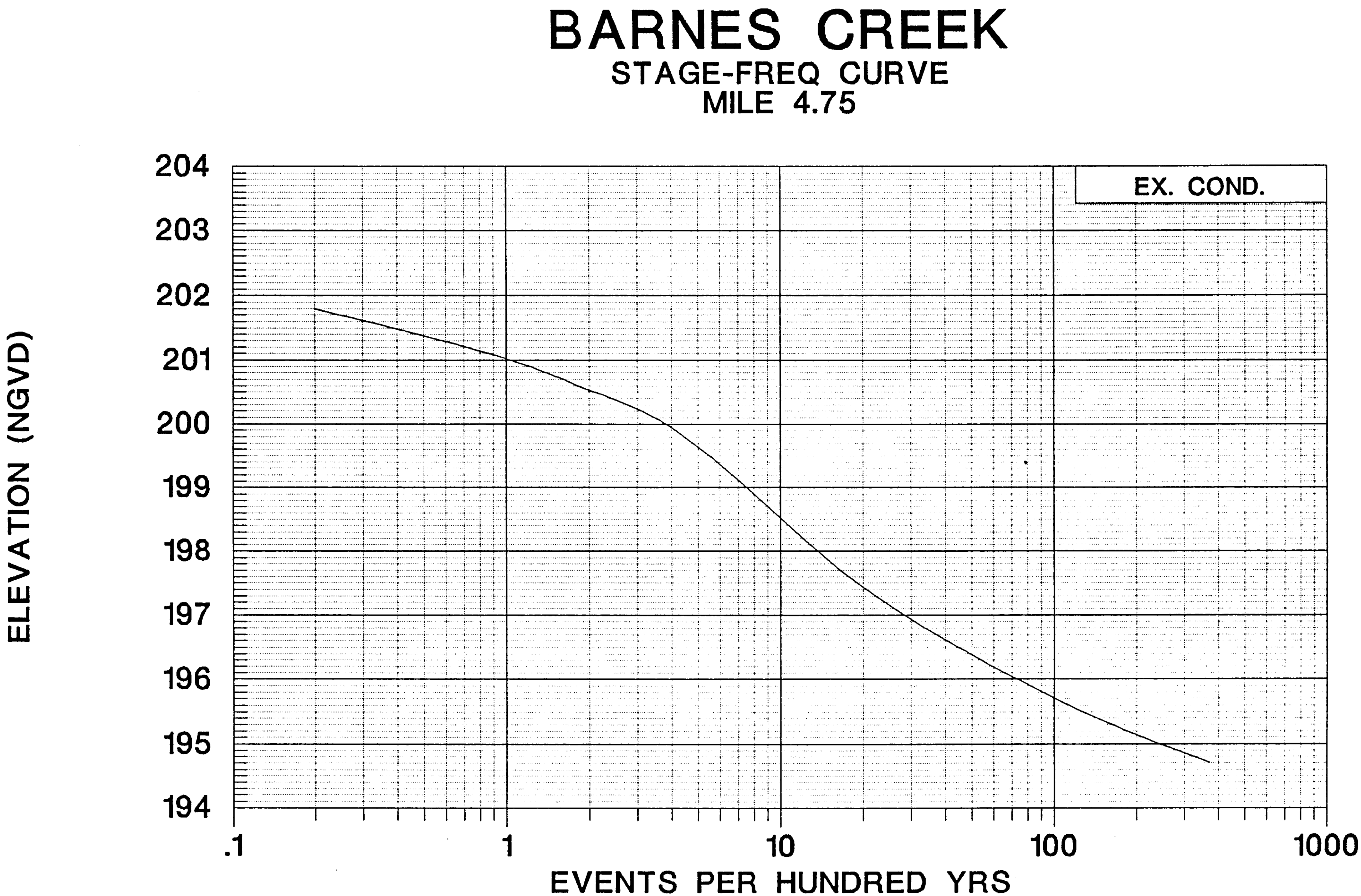
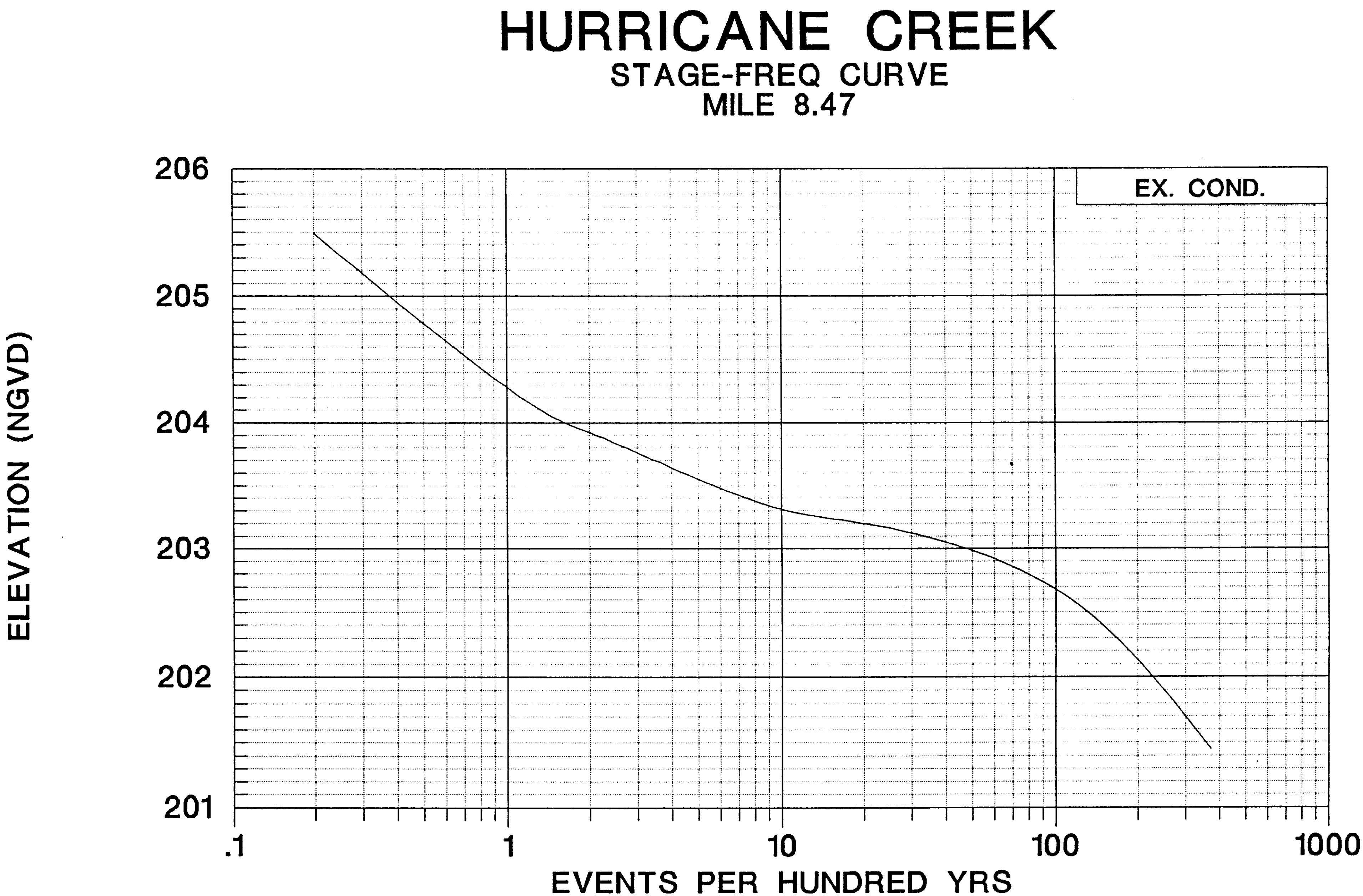
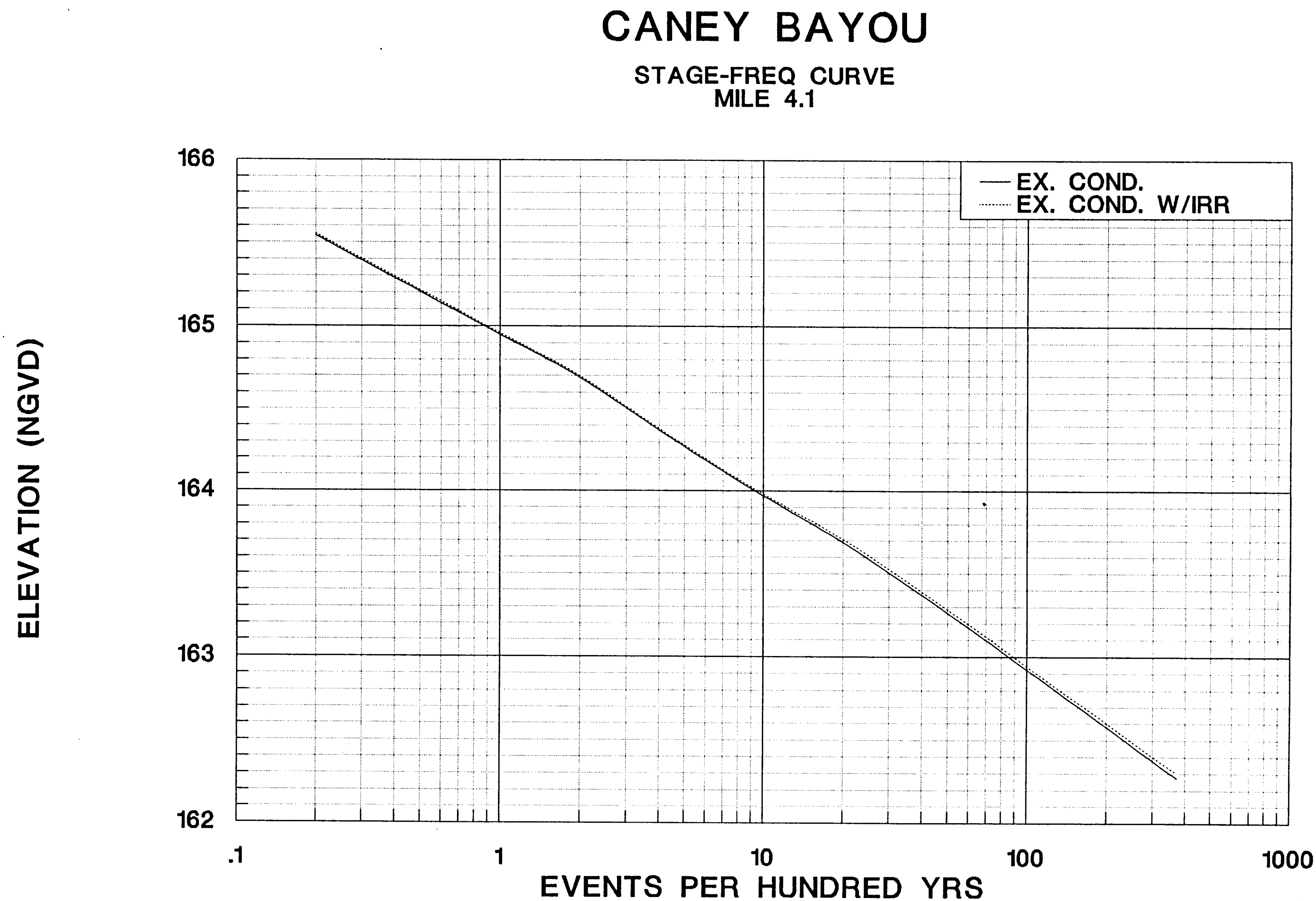



PLATE III-C-20 (1)


HURRICANE CREEK
STAGE-FREQ CURVE
MILE 8.47
EX. COND.
ELEVATION (NGVD)
206
205
204
203
202
201
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

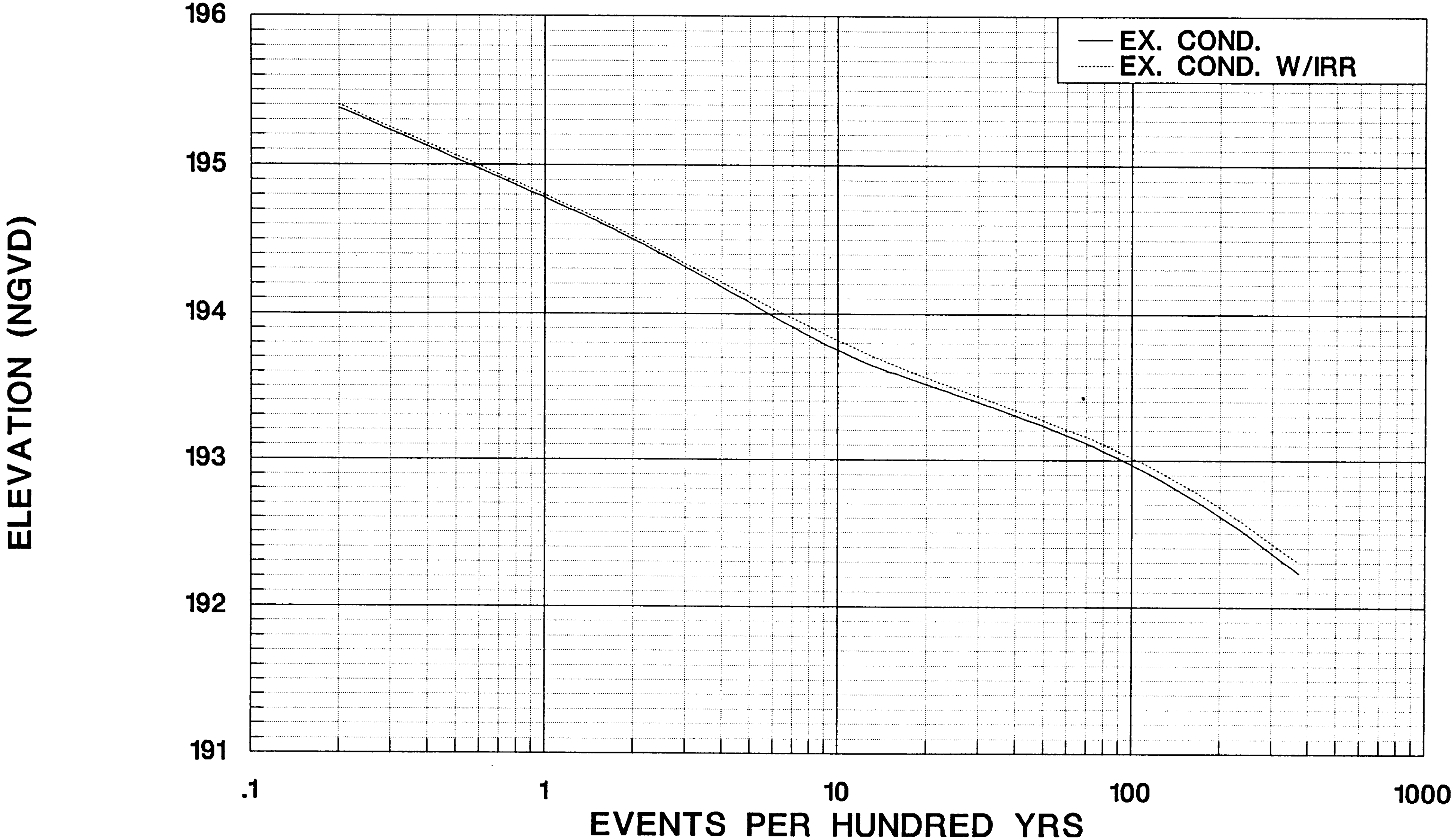
(2)

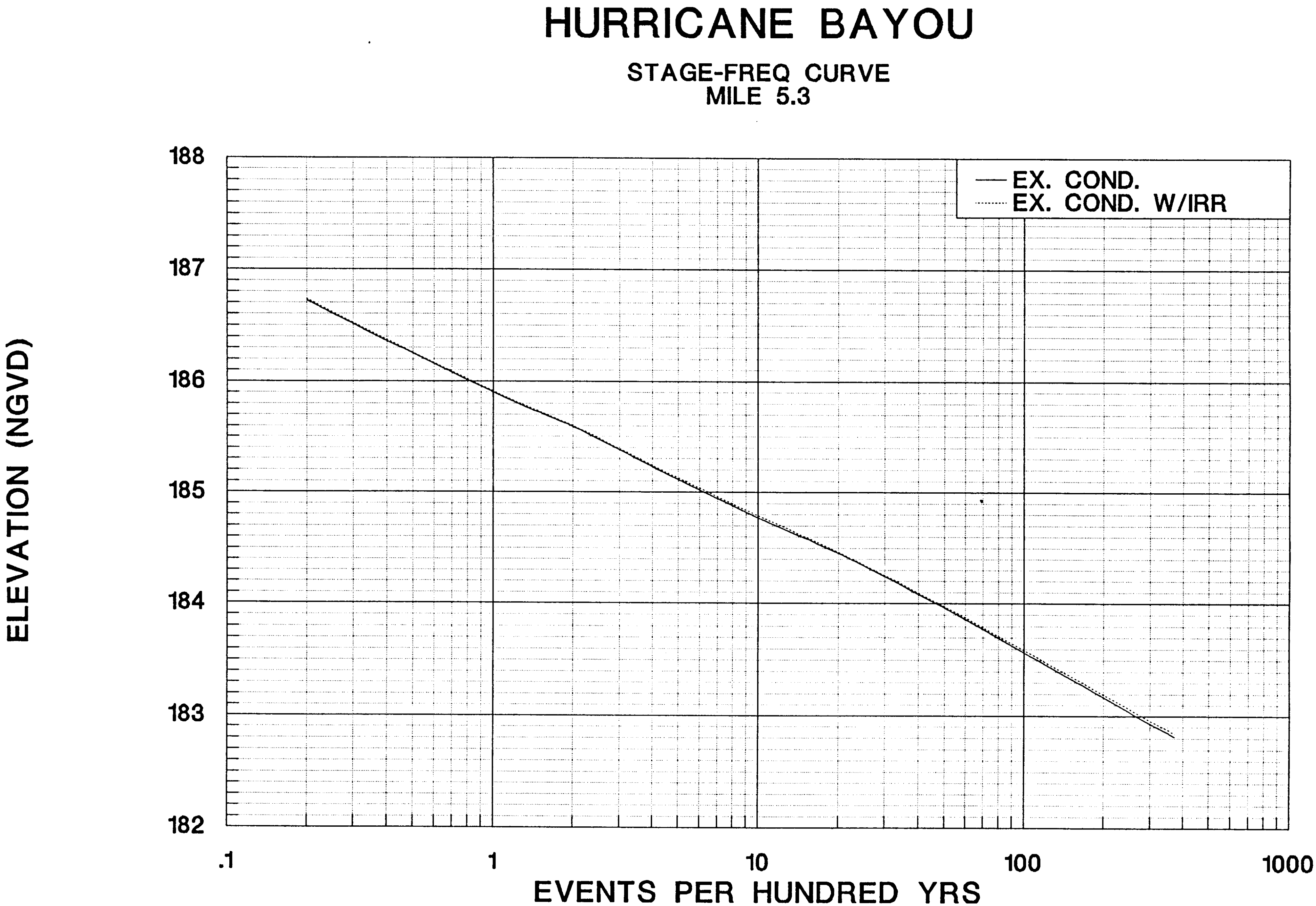

CANEY BAYOU
STAGE-FREQ CURVE
MILE 4.1
EX. COND.
EX. COND. W/IRR
ELEVATION (NGVD)
166
165
164
163
162
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

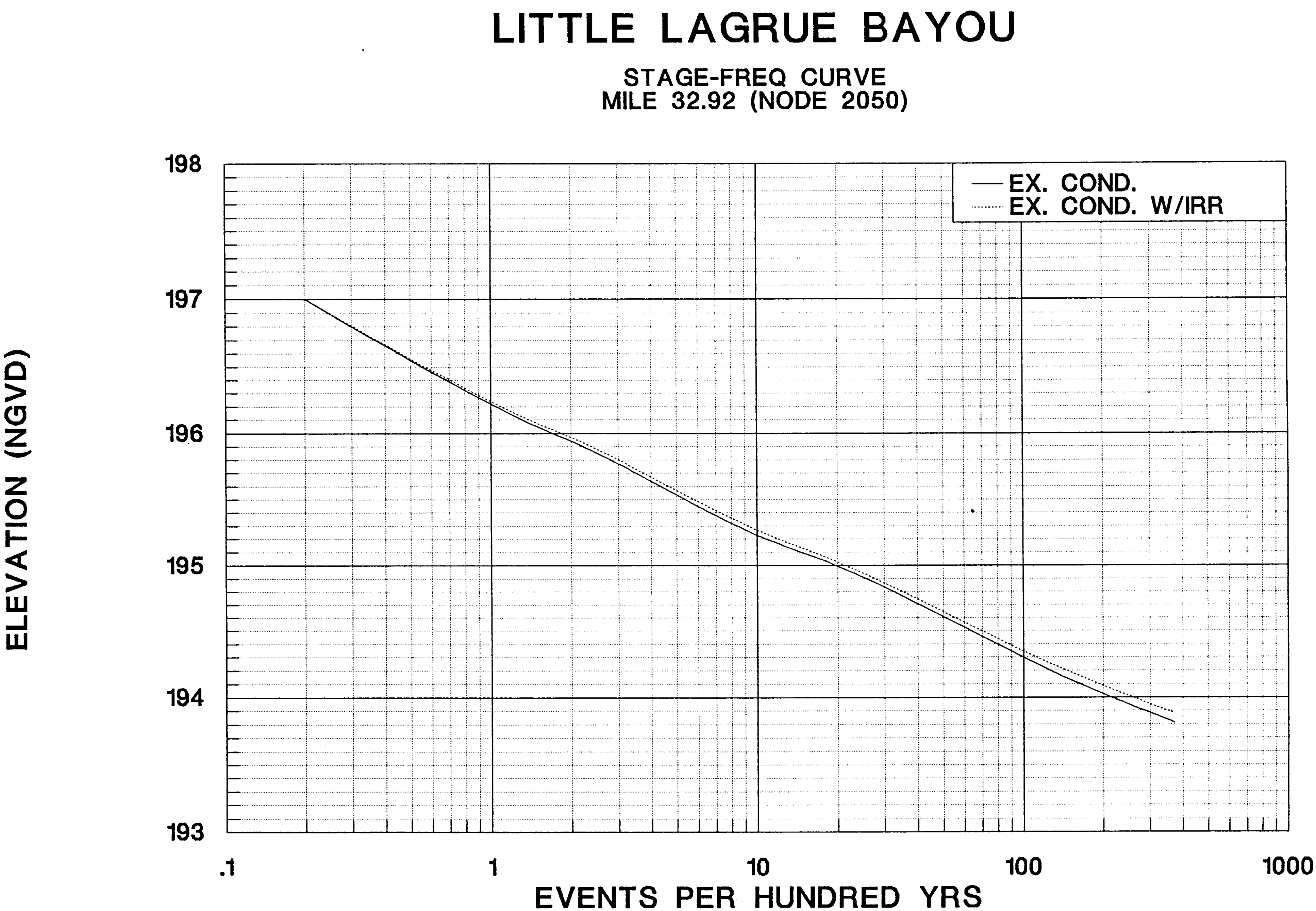
(3)

# ELM PRONG MILL BAYOU

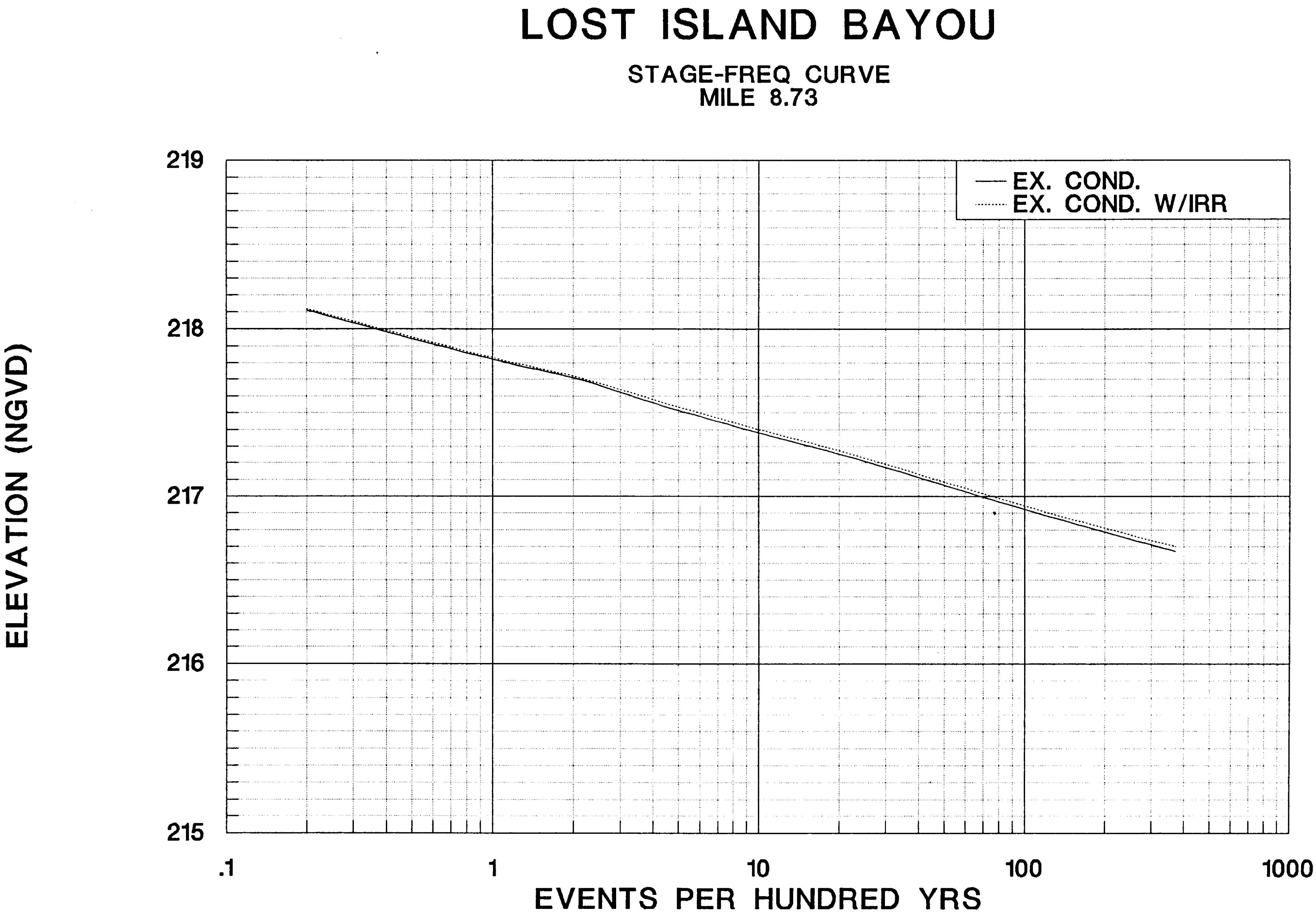
STAGE-FREQ CURVE
MILE 3.18



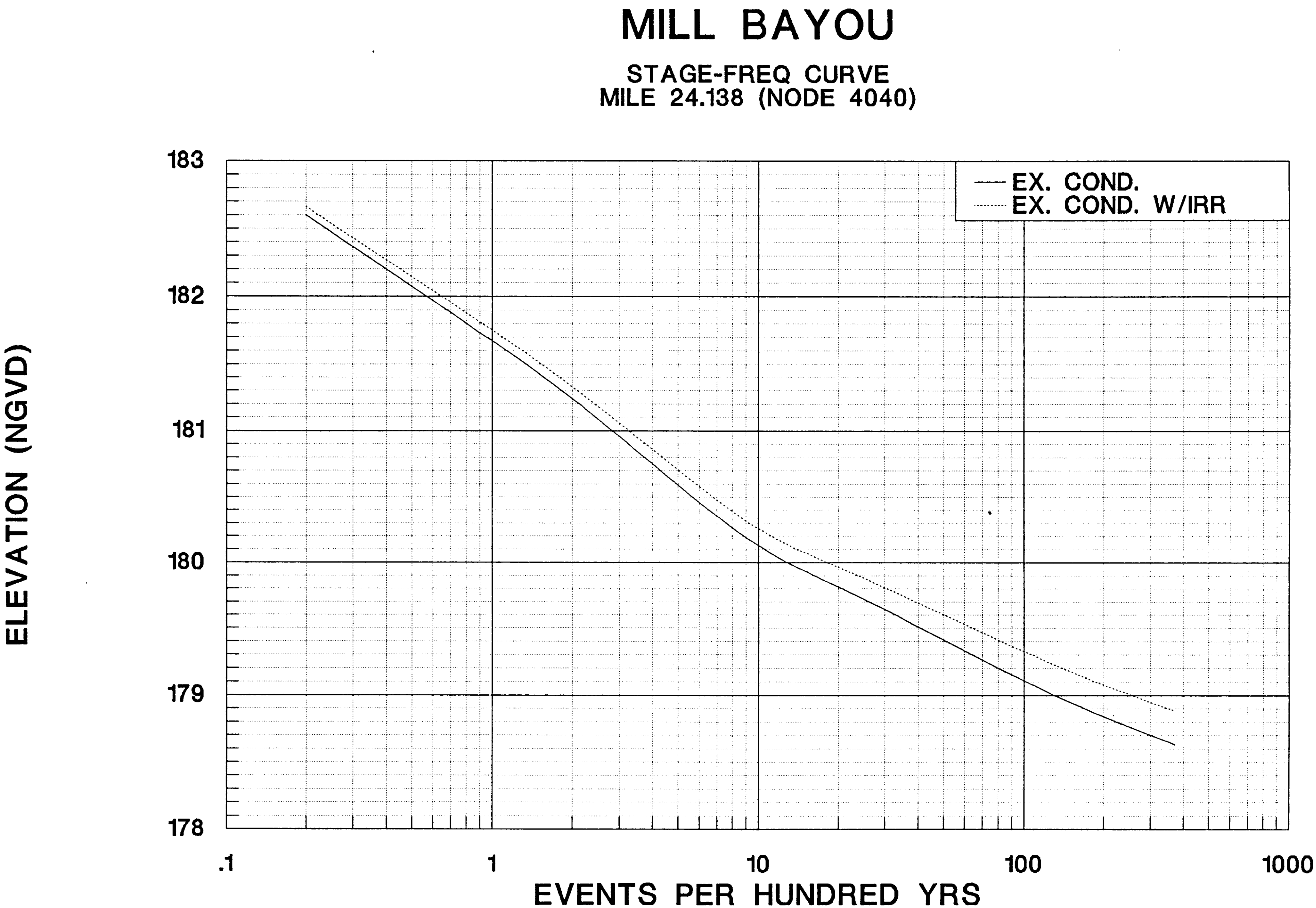

HURRICANE BAYOU
STAGE-FREQ CURVE
MILE 5.3
EX. COND.
EX. COND. W/IRR
ELEVATION (NGVD)
188
187
186
185
184
183
182
.1
1
10
100
1000
EVENTS PER HUNDRED YRS
(5)


LITTLE LAGRUE BAYOU
STAGE-FREQ CURVE
MILE 32.92 (NODE 2050)
EX. COND.
EX. COND. W/IRR
198
197
196
195
194
193
ELEVATION (NGVD)
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

(9)


LOST ISLAND BAYOU
STAGE-FREQ CURVE
MILE 8.73
EX. COND.
EX. COND. W/IRR
ELEVATION (NGVD)
219
218
217
216
215
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

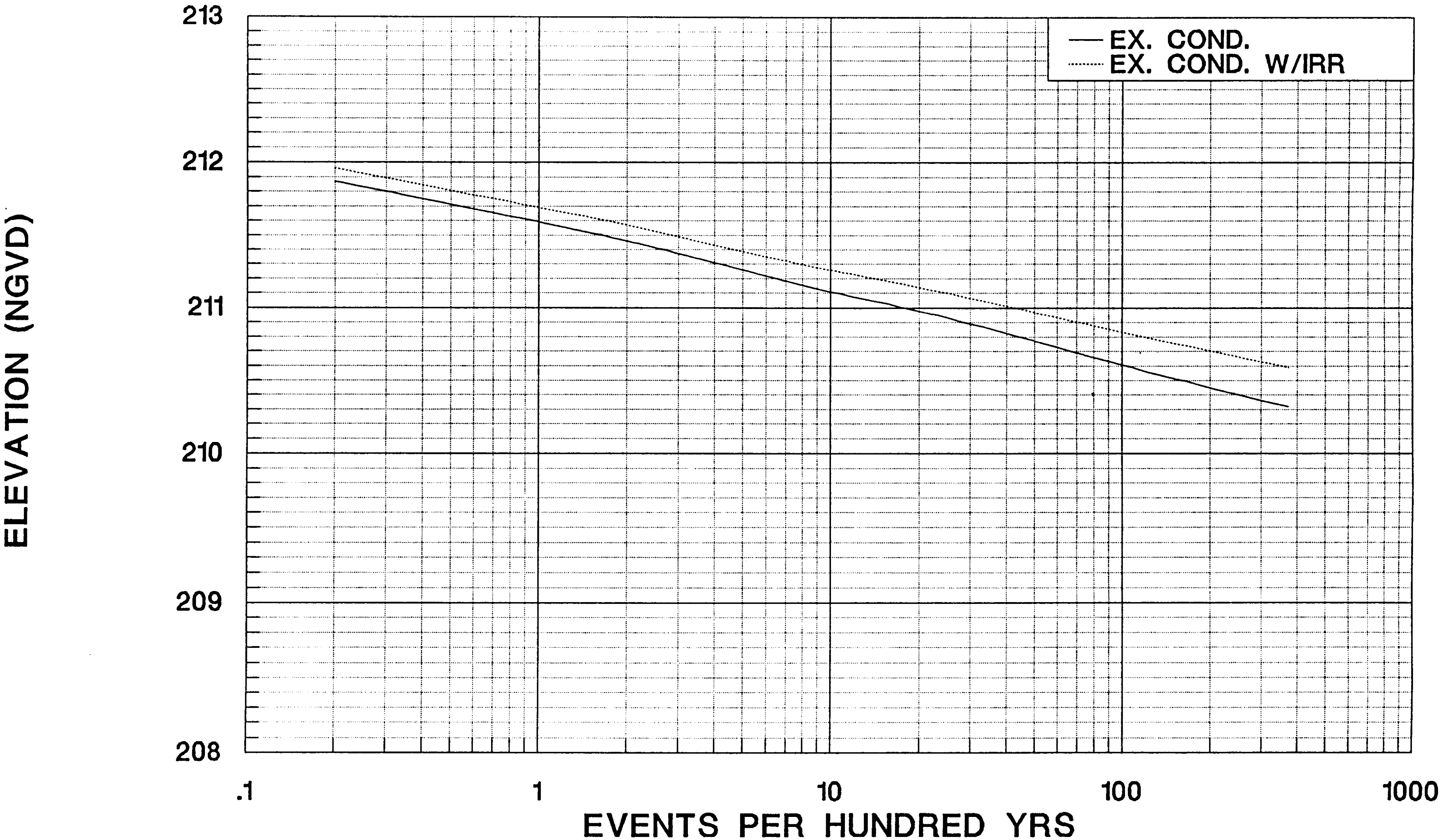
(7)



MILL BAYOU
STAGE-FREQ CURVE
MILE 24.138 (NODE 4040)
EX. COND.
EX. COND. W/IRR
ELEVATION (NGVD)
183
182
181
180
179
178
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

# MILL BAYOU

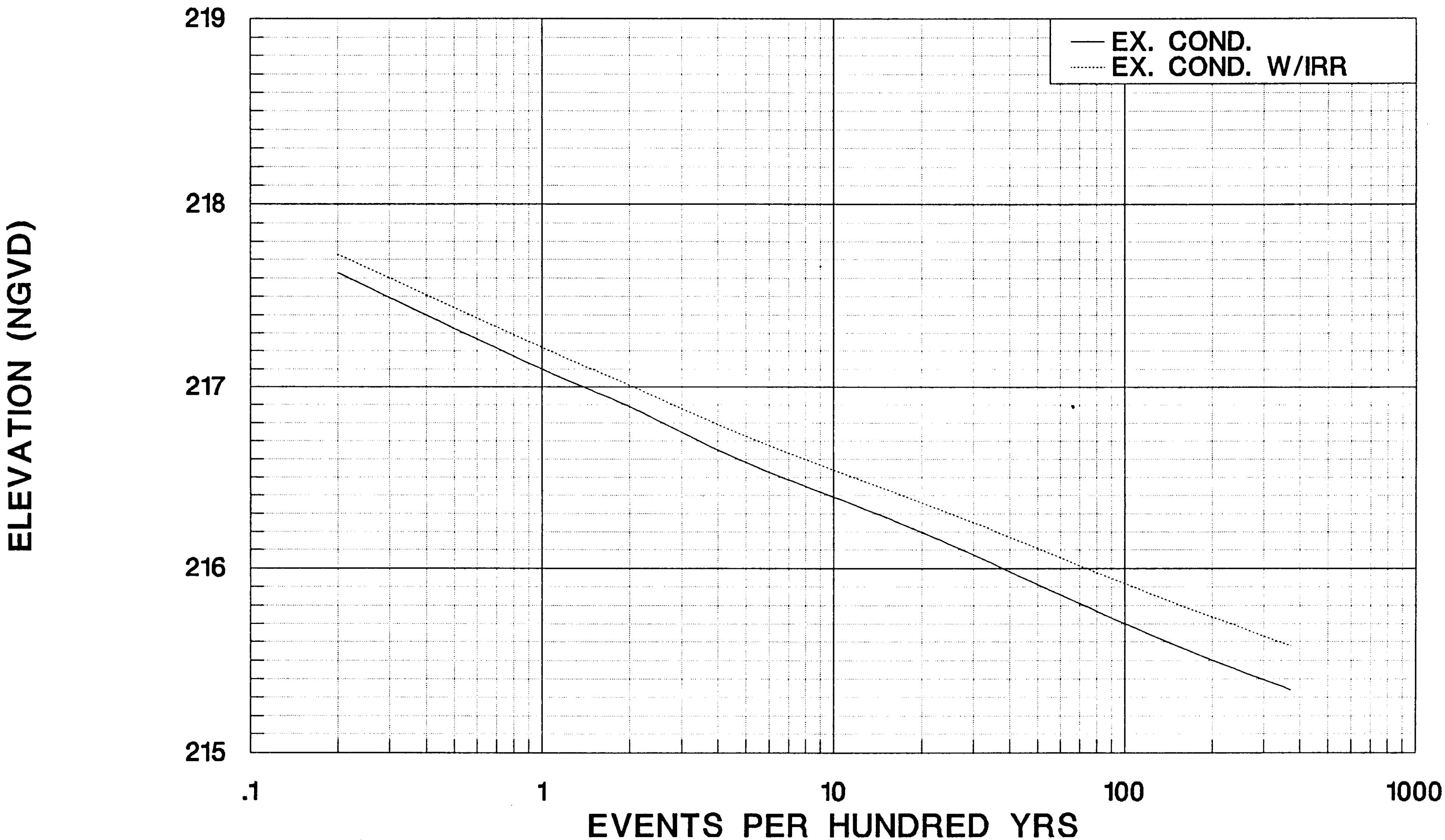
STAGE-FREQ CURVE
MILE 38.57 (NODE 4010)




(6)

# PECKERWOOD LATERAL

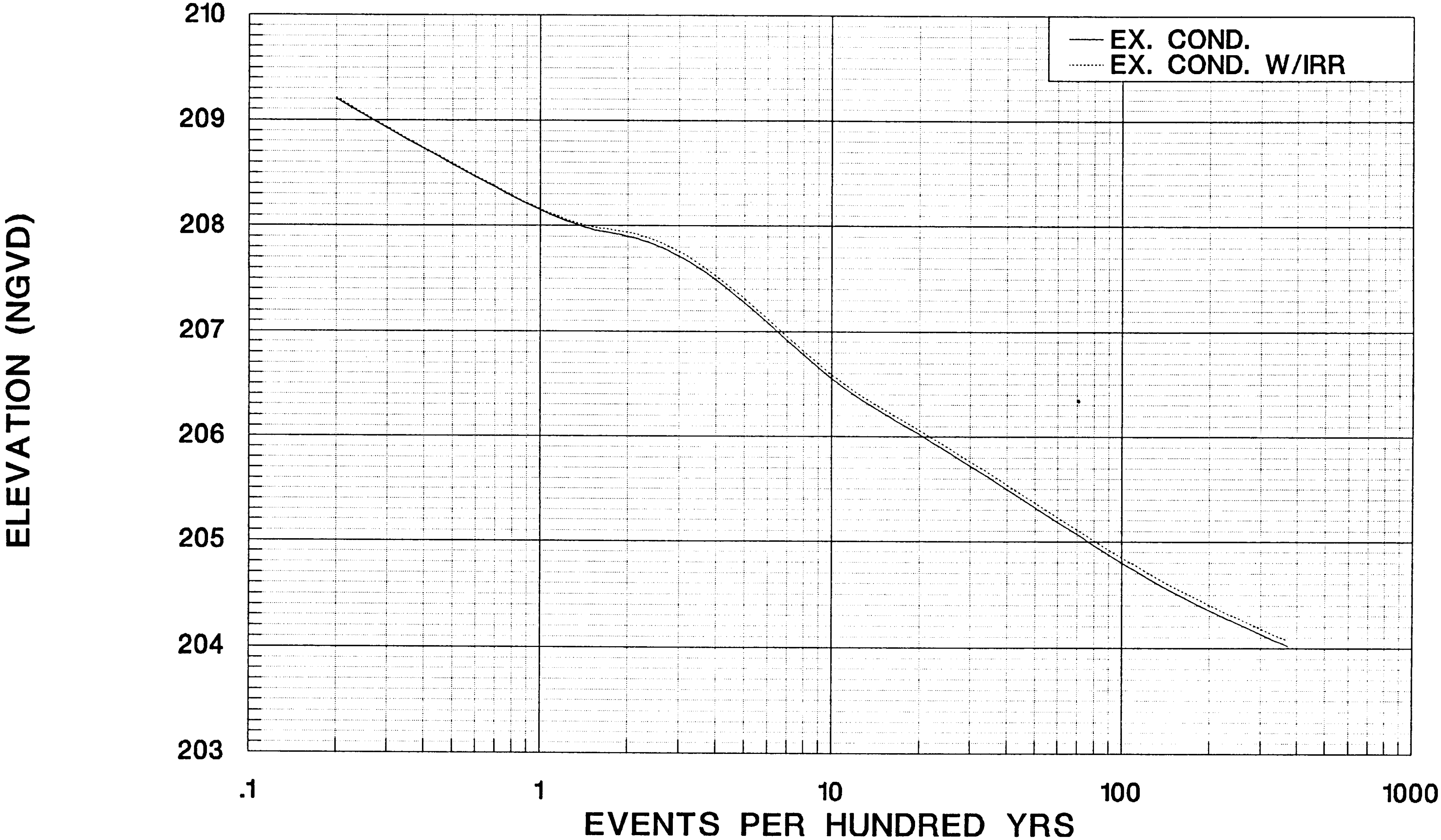
STAGE-FREQ CURVE
MILE 5.99

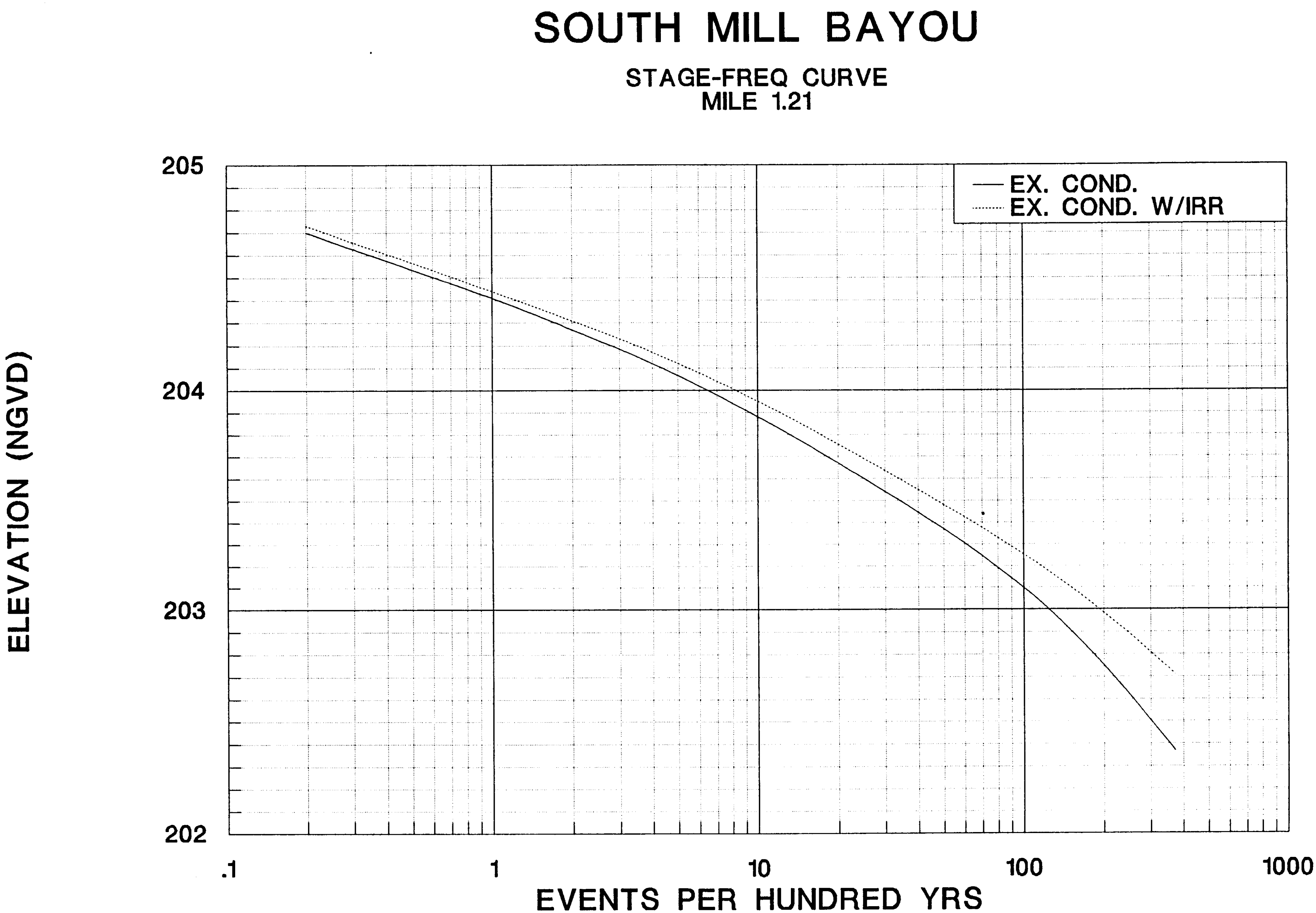



(01)

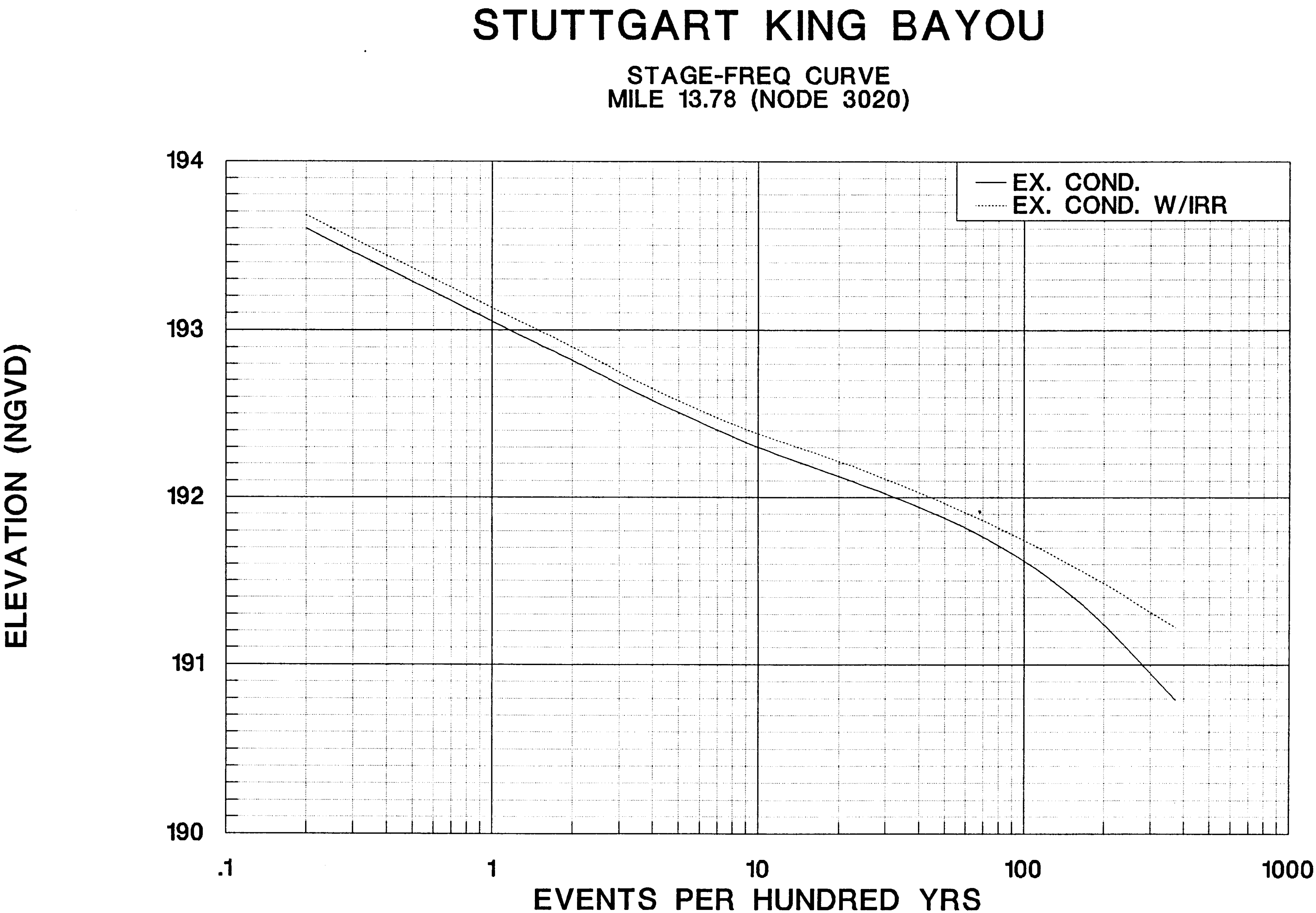
# SHERRILL CREEK

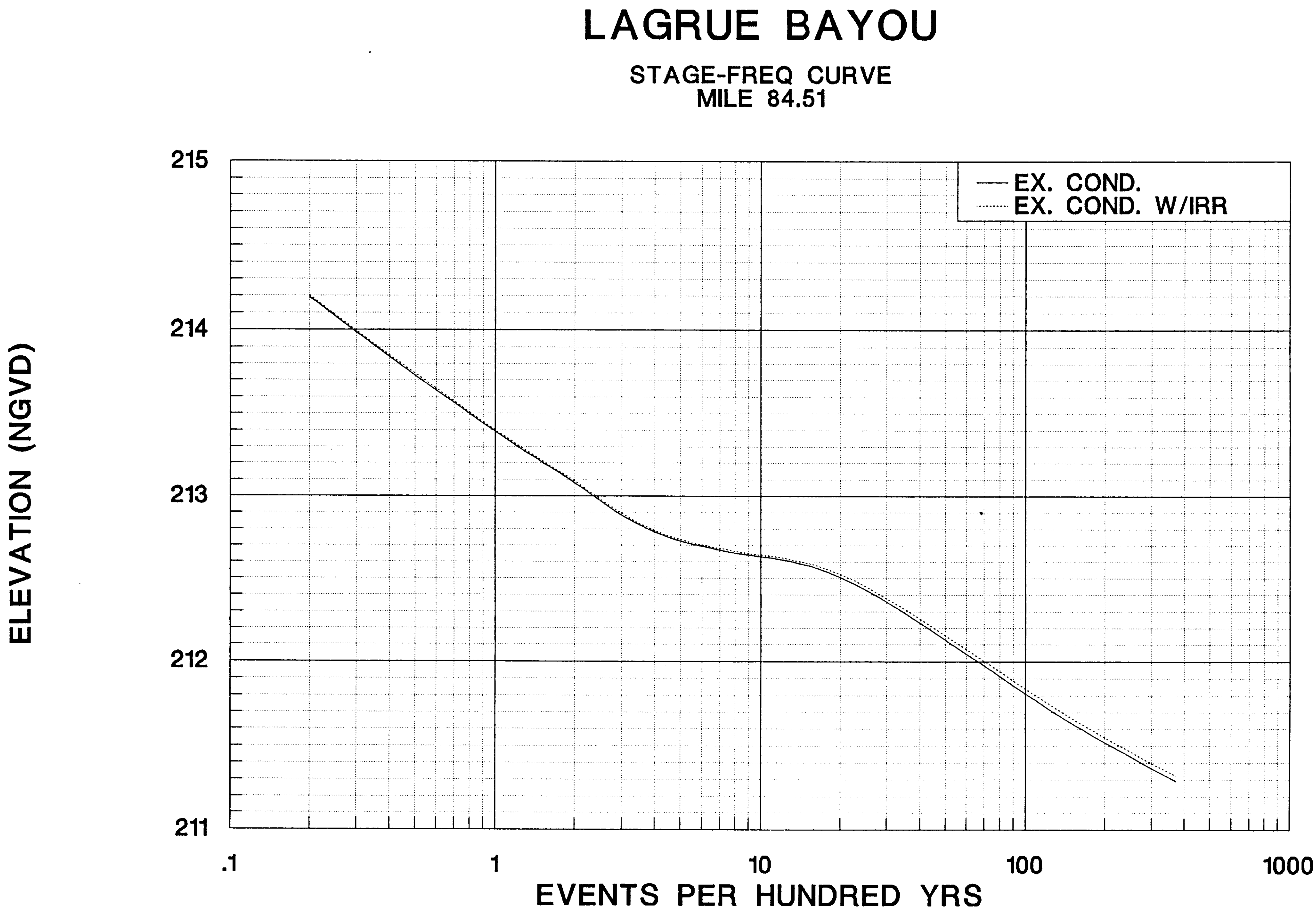
## STAGE-FREQ CURVE
## MILE 4.91




SOUTH MILL BAYOU
STAGE-FREQ CURVE
MILE 1.21
ELEVATION (NGVD)
205
204
203
202
EX. COND.
EX. COND. W/IRR
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

(12)

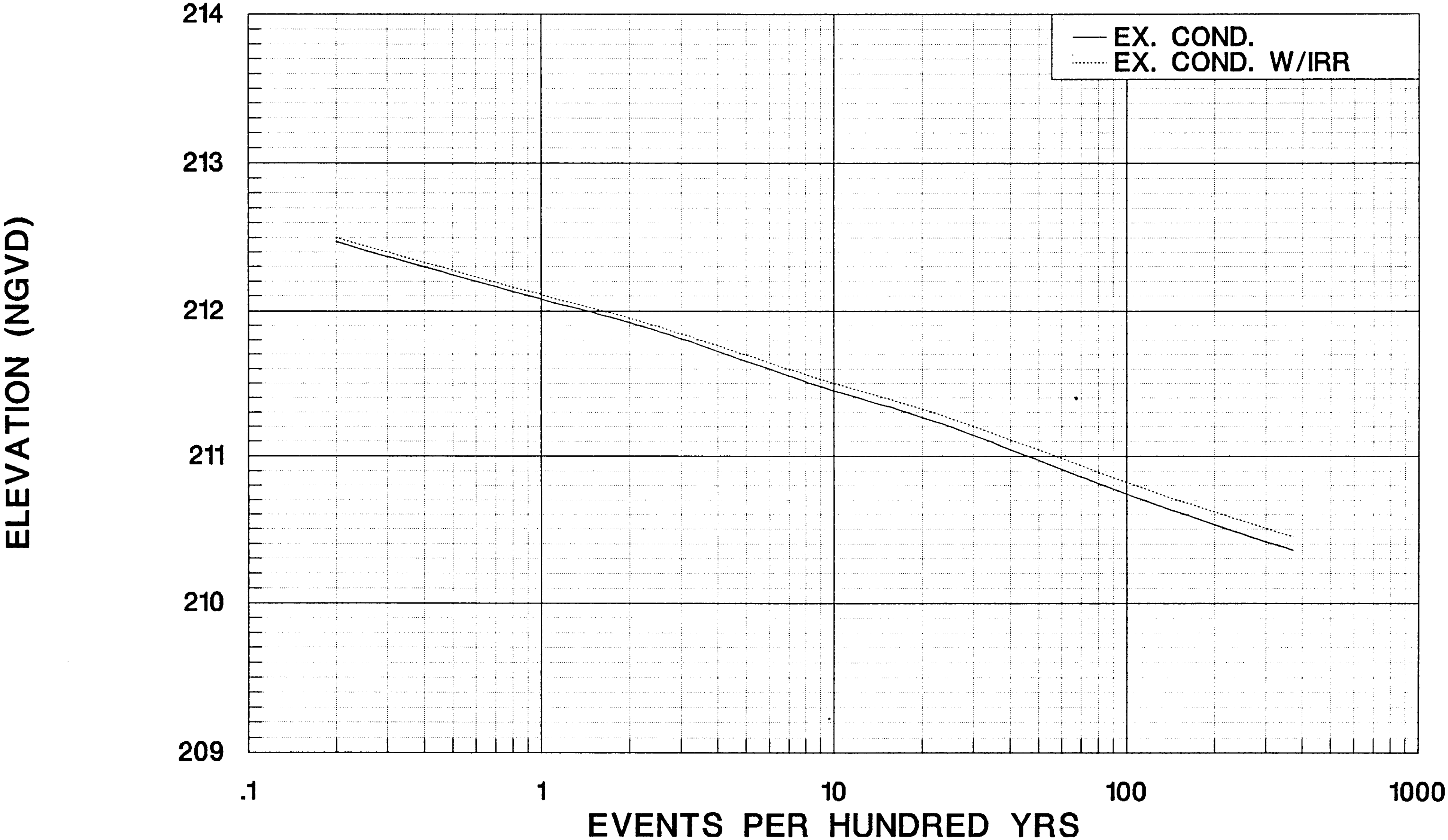

STUTTGART KING BAYOU
STAGE-FREQ CURVE
MILE 13.78 (NODE 3020)
ELEVATION (NGVD)
194
193
192
191
190
.1
1
10
100
1000
EVENTS PER HUNDRED YRS
EX. COND.
EX. COND. W/IRR

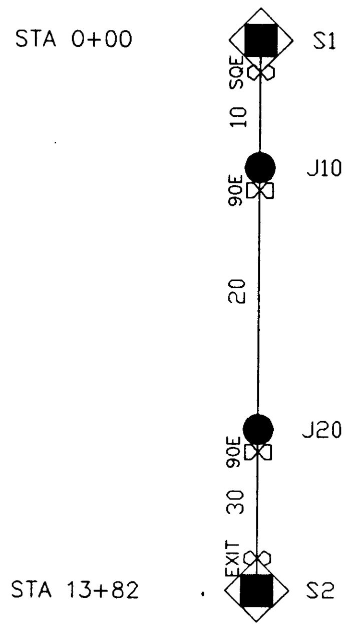

LAGRUE BAYOU
STAGE-FREQ CURVE
MILE 84.51
EX. COND.
EX. COND. W/IRR
ELEVATION (NGVD)
215
214
213
212
211
.1
1
10
100
1000
EVENTS PER HUNDRED YRS

(14)

# WOLF ISLAND SLASH

STAGE-FREQ CURVE
MILE 4.526






| | | | |
|---|---|---|---|
| Pipe - Description | 10 | 20 | 30 |
| Pipe - Length ft | 5.00 ft | 1372.00 ft | 5.00 ft |
| Pipe - Diameter in | 10.00 in | 10.00 in | 10.00 in |
| Pipe - Roughness | 117.00 | 117.00 | 117.00 |
| Pipe - Minor Loss | 0.18 | 0.09 | 0.27 |
| Pipe - Flowrate cfs | 1.76 cfs | 1.76 cfs | 1.76 cfs |
| Pipe - Headloss ft | 0.02 ft | 6.62 ft | 0.02 ft |
| Pipe - Pump Head ft | 0.00 ft | 0.00 ft | 0.00 ft |
| Pipe - Velocity ft/s | 3.22 ft/s | 3.22 ft/s | 3.22 ft/s |
| Pipe - Headloss/1000 | 4.83 | 4.83 | 4.83 |
| Pipe - Travel Time Hours | 0.00 Hour | 0.12 Hour | 0.00 Hour |
| Node - Description | J10 | J20 | |
| Node - Elevation ft | 213.20 ft | 210.00 ft | |
| Node - Pressure | 5.98 psig | 4.46 psig | |
| BND - Description | S1 | S2 | |
| BND - HGL ft | 227.20 ft | 220.00 ft | |
| BND - Net Flow cfs | 1.76 cfs | -1.76 cfs | |

FILE 1000-01.DWG

REQUIRED Q = 0.12 cfs
USE: 1 - 10" PVC

U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY

PIPE 1000.01

# INPUT FOR 1000-01

**************************************************
SUMMARY OF ORIGINAL DATA
**************************************************

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 10" PVC w/NO PUMP
Drawing: 1000-01

PIPELINE DATA

| STATUS CODE: | XX -CLOSED PIPE | BN -BOUNDARY NODE | PU -PUMP LINE |
|---|---|---|---|
| | CV -CHECK VALVE | RV -REGULATING VALVE | |

| PIPE NUMBER | NODE NOS. #1 | #2 | LENGTH (ft) | DIAMETER (in) | ROUGHNESS COEFF. | MINOR LOSS COEFF. | BND-HGL (ft) |
|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 5.0 | 10.0 | 117.00 | 1.10 | 227.20 |
| 20 | 10 | 20 | 1372.0 | 10.0 | 117.00 | 0.55 | |
| 30-BN | 20 | 0 | 5.0 | 10.0 | 117.00 | 1.65 | 220.00 |

JUNCTION NODE DATA

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | JUNCTION ELEVATION (ft) | CONNECTING PIPES | |
|---|---|---|---|---|---|
| 10-1 | | 0.00 | 213.20 | 10 | 20 |
| 20-1 | | 0.00 | 210.00 | 20 | 30 |

# OUTPUT FOR 1000-01

| MAXIMUM DIMENSIONS | |
|---|---|
| Number of pipes | 250 |
| Number of pumps | 62 |
| Number junction nodes | 250 |
| Flow meters | 62 |
| Boundary nodes | 25 |
| Variable storage tanks | 62 |
| Pressure switches | 62 |
| Regulating Valves | 62 |
| Items for limited output | 250 |
| limit for non-consecutive numbering | 2510 |

Cybernet version 2.16. SN: 1132161165-250

Extended Description:

UNITS SPECIFIED

FLOWRATE ............................................ = cubic feet/second
HEAD (HGL) ............................................ = feet
PRESSURE ............................................ = psig

OUTPUT OPTION DATA

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

SYSTEM CONFIGURATION

NUMBER OF PIPES ...................................... (p) = 3
NUMBER OF JUNCTION NODES .......................... (j) = 2
NUMBER OF PRIMARY LOOPS ............................ (l) = 0
NUMBER OF BOUNDARY NODES .......................... (f) = 2
NUMBER OF SUPPLY ZONES ............................. (z) = 1

**************************************
SIMULATION RESULTS
**************************************

The results are obtained after 3 trials with an accuracy = 0.00018

SIMULATION DESCRIPTION

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 10" PVC w/NO PUMP
Drawing: 1000-01

PIPELINE RESULTS

| STATUS CODE: | XX -CLOSED PIPE | BN -BOUNDARY NODE | PU -PUMP LINE |
|---|---|---|---|
| | CV -CHECK VALVE | RV -REGULATING VALVE | TK -STORAGE TANK |

| PIPE NUMBER | NODE NOS. #1 | #2 | FLOWRATE (cfs) | HEAD LOSS (ft) | PUMP HEAD (ft) | MINOR LOSS (ft) | LINE VEL (ft/s) | HL/ 1000 (ft/ft) |
|---|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 1.76 | 0.02 | 0.00 | 0.18 | 3.22 | 4.83 |
| 20 | 10 | 20 | 1.76 | 6.62 | 0.00 | 0.09 | 3.22 | 4.83 |
| 30-BN | 20 | 0 | 1.76 | 0.02 | 0.00 | 0.27 | 3.22 | 4.83 |

JUNCTION NODE RESULTS

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | HYDRAULIC GRADE (ft) | JUNCTION ELEVATION (ft) | PRESSURE HEAD (ft) | JUNCTION PRESSURE (psi) |
|---|---|---|---|---|---|---|
| 10-1 | | 0.00 | 227.00 | 213.20 | 13.80 | 5.98 |
| 20-1 | | 0.00 | 220.29 | 210.00 | 10.29 | 4.46 |

SUMMARY OF INFLOWS AND OUTFLOWS

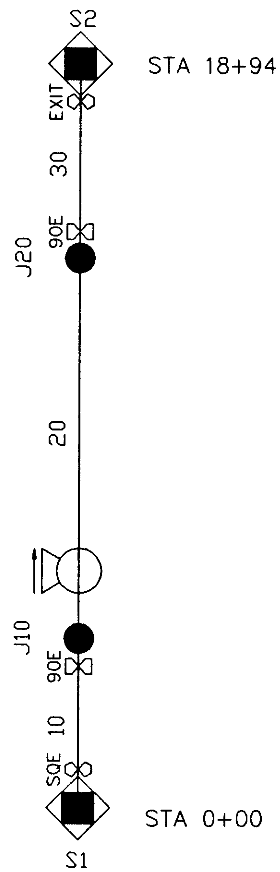
(+) INFLOWS INTO THE SYSTEM FROM BOUNDARY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO BOUNDARY NODES

| PIPE NUMBER | FLOWRATE (cfs) |
|---|---|
| 10 | 1.76 |
| 30 | -1.76 |

NET SYSTEM INFLOW = 1.76
NET SYSTEM OUTFLOW = -1.76
NET SYSTEM DEMAND = 0.00

**** CYBERNET SIMULATION COMPLETED ****

DATE: 9/12/1996
TIME: 13:06:18




| | | | |
|---|---|---|---|
| Pipe - Description | 10 | 20 | 30 |
| Pipe - Length ft | 5.00 ft | 1884.00 ft | 5.00 ft |
| Pipe - Diameter in | 6.00 in | 6.00 in | 6.00 in |
| Pipe - Roughness | 117.00 | 117.00 | 117.00 |
| Pipe - Minor Loss | 0.52 | 0.00 | 0.52 |
| Pipe - Flowrate cfs | 0.88 cfs | 0.88 cfs | 0.88 cfs |
| Pipe - Headloss ft | 0.08 ft | 30.45 ft | 0.08 ft |
| Pipe - Pump Head ft | 0.00 ft | 50.64 ft | 0.00 ft |
| Pipe - Velocity ft/s | 4.49 ft/s | 4.49 ft/s | 4.49 ft/s |
| Pipe - Headloss/1000 | 16.16 | 16.16 | 16.16 |
| Pipe - Travel Time Hours | 0.00 Hour | 0.12 Hour | 0.00 Hour |
| Node - Description | J10 | J20 | |
| Node - Elevation ft | 199.00 ft | 215.00 ft | |
| Node - Pressure | 2.77 psig | 4.59 psig | |
| BND - Description | S1 | S2 | |
| BND - HGL ft | 206.00 ft | 225.00 ft | |
| BND - Net Flow cfs | 0.88 cfs | -0.88 cfs | |

FILE: 1400-01.DWG

REQUIRED Q = 0.79 cfs

USE: 1 – 6" PVC

7.5 hp PUMP (5.06)

U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY

PIPE 1400.01

# INPUT FOR 1400-01

**************************************************
S U M M A R Y   O F   O R I G I N A L   D A T A
**************************************************

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 6 PVC w/7.5 hp PUMP
Drawing: 1400-01

P I P E L I N E   D A T A

STATUS CODE: XX -CLOSED PIPE   BN -BOUNDARY NODE   PU -PUMP LINE
CV -CHECK VALVE   RV -REGULATING VALVE

| PIPE NUMBER | NODE NOS. #1 | #2 | LENGTH (ft) | DIAMETER (in) | ROUGHNESS COEFF. | MINOR LOSS COEFF. | BND-HGL (ft) |
|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 5.0 | 6.0 | 117.00 | 1.65 | 206.00 |
| 20-PU | 10 | 20 | 1884.0 | 6.0 | 117.00 | 0.00 | |
| 30-BN | 20 | 0 | 5.0 | 6.0 | 117.00 | 1.65 | 225.00 |

P U M P   D A T A

THERE IS A PUMP IN LINE 20 - USEFUL POWER = 5.06

J U N C T I O N   N O D E   D A T A

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | JUNCTION ELEVATION (ft) | CONNECTING PIPES | |
|---|---|---|---|---|---|
| 10-1 | | 0.00 | 199.00 | 10 | 20 |
| 20-1 | | 0.00 | 215.00 | 20 | 30 |

# OUTPUT FOR 1400-01

| MAXIMUM DIMENSIONS | |
|---|---|
| Number of pipes | 250 |
| Number of pumps | 62 |
| Number junction nodes | 250 |
| Flow meters | 62 |
| Boundary nodes | 25 |
| Variable storage tanks | 62 |
| Pressure switches | 62 |
| Regulating Valves | 62 |
| Items for limited output | 250 |
| limit for non-consecutive numbering | 2510 |

Cybernet version 2.16. SN: 1132161165-250

Extended Description:

## UNITS SPECIFIED

FLOWRATE ............................................ = cubic feet/second
HEAD (HGL) ............................................ = feet
PRESSURE ............................................ = psig

## OUTPUT OPTION DATA

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

## SYSTEM CONFIGURATION

| | | | |
|---|---|---|---|
| NUMBER OF PIPES | (p) | = | 3 |
| NUMBER OF JUNCTION NODES | (j) | = | 2 |
| NUMBER OF PRIMARY LOOPS | (l) | = | 0 |
| NUMBER OF BOUNDARY NODES | (f) | = | 2 |
| NUMBER OF SUPPLY ZONES | (z) | = | 1 |

**************************************
SIMULATION RESULTS
**************************************

The results are obtained after 2 trials with an accuracy = 0.00386

## SIMULATION DESCRIPTION

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 6 PVC w/7.5 hp PUMP
Drawing: 1400-01

## PIPELINE RESULTS

| STATUS CODE: | XX -CLOSED PIPE | BN -BOUNDARY NODE | PU -PUMP LINE |
|---|---|---|---|
| | CV -CHECK VALVE | RV -REGULATING VALVE | TK -STORAGE TANK |

| PIPE NUMBER | NODE NOS. #1 | #2 | FLOWRATE (cfs) | HEAD LOSS (ft) | PUMP HEAD (ft) | MINOR LOSS (ft) | LINE VEL (ft/s) | HL/ 1000 (ft/ft) |
|---|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 0.88 | 0.08 | 0.00 | 0.52 | 4.49 | 16.16 |
| 20-PU | 10 | 20 | 0.88 | 30.45 | 50.64 | 0.00 | 4.49 | 16.16 |
| 30-BN | 20 | 0 | 0.88 | 0.08 | 0.00 | 0.52 | 4.49 | 16.16 |

JUNCTION NODE RESULTS

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | HYDRAULIC GRADE (ft) | JUNCTION ELEVATION (ft) | PRESSURE HEAD (ft) | JUNCTION PRESSURE (psi) |
|---|---|---|---|---|---|---|
| 10-1 | | 0.00 | 205.40 | 199.00 | 6.40 | 2.77 |
| 20-1 | | 0.00 | 225.60 | 215.00 | 10.60 | 4.59 |

SUMMARY OF INFLOWS AND OUTFLOWS

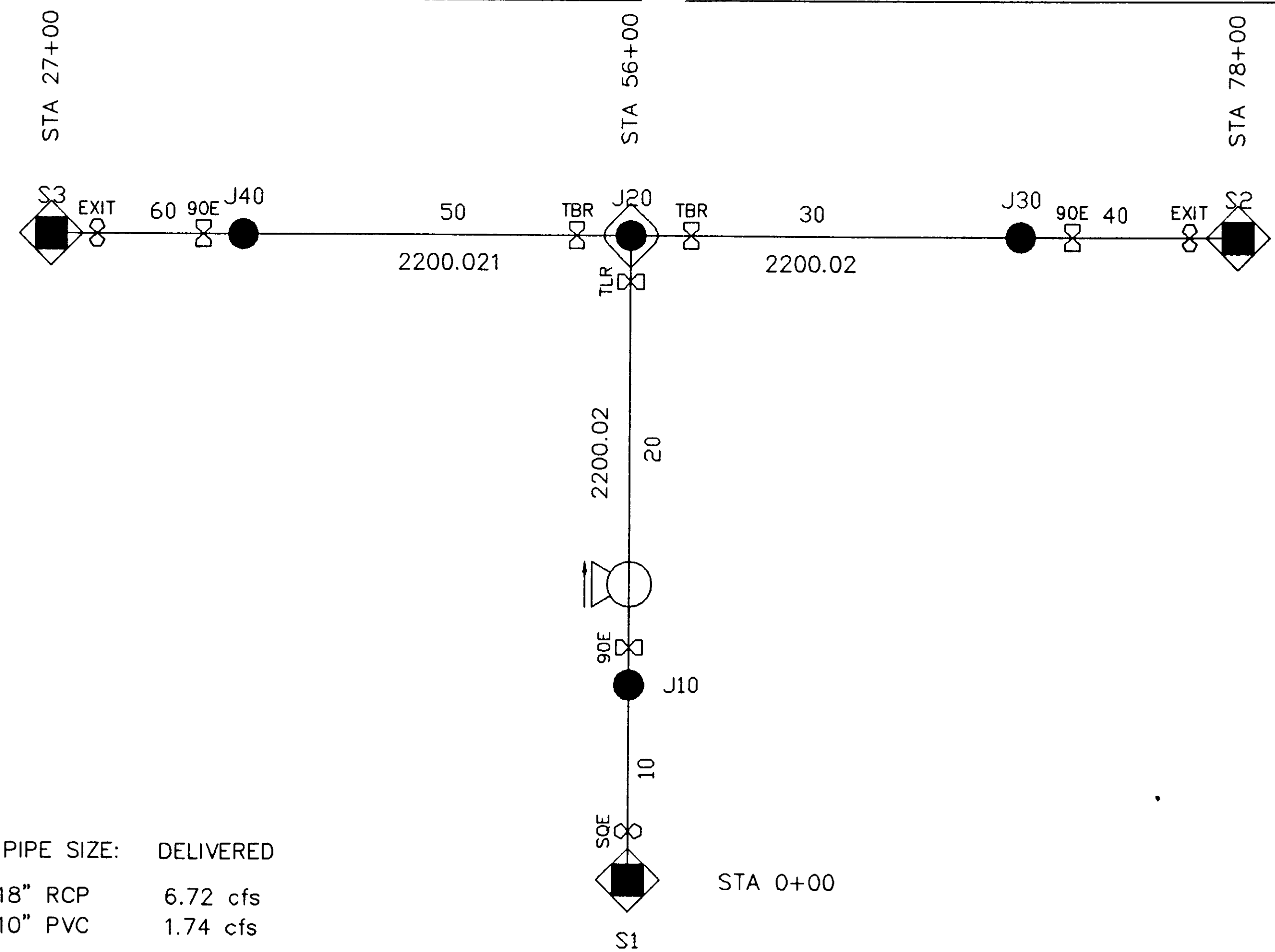
(+) INFLOWS INTO THE SYSTEM FROM BOUNDARY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO BOUNDARY NODES

| PIPE NUMBER | FLOWRATE (cfs) |
|---|---|
| 10 | 0.88 |
| 30 | -0.88 |

NET SYSTEM INFLOW = 0.88
NET SYSTEM OUTFLOW = -0.88
NET SYSTEM DEMAND = 0.00

**** CYBERNET SIMULATION COMPLETED ****

DATE: 9/12/1996
TIME: 13:18:16




| SEGMENT: | REQ'D Q: | PIPE SIZE: | DELIVERED |
|---|---|---|---|
| 10 – 40 | 6.72 cfs | 18" RCP | 6.72 cfs |
| 50 – 60 | 1.31 cfs | 10" PVC | 1.74 cfs |

95 hp PUMP (64.13)

| | | | | | | |
|---|---|---|---|---|---|---|
| Pipe - Description | 10 | 20 | 30 | 40 | 50 | 60 |
| Pipe - Length ft | 5.00 ft | 5595.00 ft | 2195.00 ft | 5.00 ft | 2695.00 ft | 5.00 ft |
| Pipe - Diameter in | 18.00 in | 18.00 in | 18.00 in | 18.00 in | 10.00 in | 10.00 in |
| Pipe - Roughness | 90.00 | 90.00 | 90.00 | 90.00 | 117.00 | 117.00 |
| Pipe - Minor Loss | 0.39 | 0.31 | 0.00 | 0.37 | 0.31 | 0.26 |
| Pipe - Flowrate cfs | 8.46 cfs | 8.46 cfs | 6.72 cfs | 6.72 cfs | 1.74 cfs | 1.74 cfs |
| Pipe - Headloss ft | 0.04 ft | 46.03 ft | 0.00 ft | 0.03 ft | 12.73 ft | 0.02 ft |
| Pipe - Pump Head ft | 0.00 ft | 66.84 ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft |
| Pipe - Velocity ft/s | 4.79 ft/s | 4.79 ft/s | 3.80 ft/s | 3.80 ft/s | 3.18 ft/s | 3.18 ft/s |
| Pipe - Headloss/1000 | 8.23 | 8.23 | 0.00 | 5.37 | 4.72 | 4.72 |
| Pipe - Travel Time Hours | 0.00 Hour | 0.32 Hour | 0.16 Hour | 0.00 Hour | 0.24 Hour | 0.00 Hour |
| Node - Description | J10 | J20 | J30 | J40 | | |
| Node - Elevation ft | 210.10 ft | 211.00 ft | 217.00 ft | 218.00 ft | | |
| Node - Pressure | 4.65 psig | 13.14 psig | 4.51 psig | 4.46 psig | | |
| BND - Description | S1 | S2 | S3 | | | |
| BND - HGL ft | 221.26 ft | 227.00 ft | 228.00 ft | | | |
| BND - Net Flow cfs | 8.46 cfs | -6.72 cfs | -1.74 cfs | | | |

U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY

PIPE 2200.02 & 2200.021

FILE: 2200-02.DWG

# INPUT FOR 2200-02

************************************************

SUMMARY OF ORIGINAL DATA

************************************************

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 18" RCP MAIN w/95 hp PUMP 10" PVC BRANCH
Drawing: 2200-02

REGULATING VALVE DATA

| VALVE TYPE | POSITION JUNCTION | CONTROLLED PIPE | VALVE SETTING (ft or cfs) |
|---|---|---|---|
| FCV-2 | 20 | 30 | 6.72 |

PIPELINE DATA

STATUS CODE: XX -CLOSED PIPE BN -BOUNDARY NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE

| PIPE NUMBER | NODE NOS. #1 | #2 | LENGTH (ft) | DIAMETER (in) | ROUGHNESS COEFF. | MINOR LOSS COEFF. | BND-HGL (ft) |
|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 5.0 | 18.0 | 90.00 | 1.10 | 221.26 |
| 20-PU | 10 | 20 | 5595.0 | 18.0 | 90.00 | 0.88 | |
| 30-RV | 20 | | 2195.0 | 18.0 | 90.00 | 1.98 | |
| 40-BN | 30 | 0 | 5.0 | 18.0 | 90.00 | 1.65 | 227.00 |
| 50 | 20 | 40 | 2695.0 | 10.0 | 117.00 | 1.98 | |
| 60-BN | 40 | 0 | 5.0 | 10.0 | 117.00 | 1.65 | 228.00 |

PUMP DATA

THERE IS A PUMP IN LINE 20 - USEFUL POWER = 64.13

JUNCTION NODE DATA

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | JUNCTION ELEVATION (ft) | CONNECTING PIPES | | |
|---|---|---|---|---|---|---|
| 10-1 | | 0.00 | 210.10 | 10 | 20 | |
| 20-1 | | 0.00 | 211.00 | 20 | 30 | 50 |
| 30-1 | | 0.00 | 217.00 | 30 | 40 | |
| 40-1 | | 0.00 | 218.00 | 50 | 60 | |

# OUTPUT FOR 2200-02

| MAXIMUM DIMENSIONS | |
|---|---|
| Number of pipes | 250 |
| Number of pumps | 62 |
| Number junction nodes | 250 |
| Flow meters | 62 |
| Boundary nodes | 25 |
| Variable storage tanks | 62 |
| Pressure switches | 62 |
| Regulating Valves | 62 |
| Items for limited output | 250 |
| limit for non-consecutive numbering | 2510 |

Cybernet version 2.16. SN: 1132161165-250

Extended Description:

## UNITS SPECIFIED

| | |
|---|---|
| FLOWRATE | = cubic feet/second |
| HEAD (HGL) | = feet |
| PRESSURE | = psig |

## OUTPUT OPTION DATA

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

## SYSTEM CONFIGURATION

| | | | |
|---|---|---|---|
| NUMBER OF PIPES | (p) | = | 6 |
| NUMBER OF JUNCTION NODES | (j) | = | 4 |
| NUMBER OF PRIMARY LOOPS | (l) | = | 0 |
| NUMBER OF BOUNDARY NODES | (f) | = | 3 |
| NUMBER OF SUPPLY ZONES | (z) | = | 1 |

*************************************

## SIMULATION RESULTS

*************************************

The results are obtained after 2 trials with an accuracy = 0.00353

## SIMULATION DESCRIPTION

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description:18" RCP MAIN w/95hp PUMP 10" PVC BRANCH
Drawing: 2200-02

## PIPELINE RESULTS

| STATUS CODE: | | | |
|---|---|---|---|
| | XX -CLOSED PIPE | BN -BOUNDARY NODE | PU -PUMP LINE |
| | CV -CHECK VALVE | RV -REGULATING VALVE | TK -STORAGE TANK |

| PIPE NUMBER | NODE NOS. #1 | NODE NOS. #2 | FLOWRATE (cfs) | HEAD LOSS (ft) | PUMP HEAD (ft) | MINOR LOSS (ft) | LINE VEL (ft/s) | HL/ 1000 (ft/ft) |
|---|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 8.46 | 0.04 | 0.00 | 0.39 | 4.79 | 8.23 |
| 20-PU | 10 | 20 | 8.46 | 46.03 | 66.84 | 0.31 | 4.79 | 8.23 |
| 30-RV | 20 | 30 | 6.72 | | | | 3.80 | |
| 40-BN | 30 | 0 | 6.72 | 0.03 | 0.00 | 0.37 | 3.80 | 5.37 |
| 50 | 20 | 40 | 1.74 | 12.73 | 0.00 | 0.31 | 3.18 | 4.72 |
| 60-BN | 40 | 0 | 1.74 | 0.02 | 0.00 | 0.26 | 3.18 | 4.72 |

## JUNCTION NODE RESULTS

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | HYDRAULIC GRADE (ft) | JUNCTION ELEVATION (ft) | PRESSURE HEAD (ft) | JUNCTION PRESSURE (psi) |
|---|---|---|---|---|---|---|
| 10-1 | | 0.00 | 220.83 | 210.10 | 10.73 | 4.65 |
| 20-1 | | 0.00 | 241.32 | 211.00 | 30.32 | 13.14 |
| 30-1 | | 0.00 | 227.40 | 217.00 | 10.40 | 4.51 |
| 40-1 | | 0.00 | 228.28 | 218.00 | 10.28 | 4.46 |

## REGULATING VALVE REPORT

| VALVE TYPE | POSITION NODE | CONTROLLED PIPE | VALVE SETTING (ft or cfs) | VALVE STATUS | UPSTREAM GRADE (ft) | DOWNSTREAM GRADE (ft) | THROUGH FLOW (cfs) |
|---|---|---|---|---|---|---|---|
| FCV-2 | 20 | 30 | 6.72 | THROTTLED | 241.32 | 227.40 | 6.72 |

## SUMMARY OF INFLOWS AND OUTFLOWS

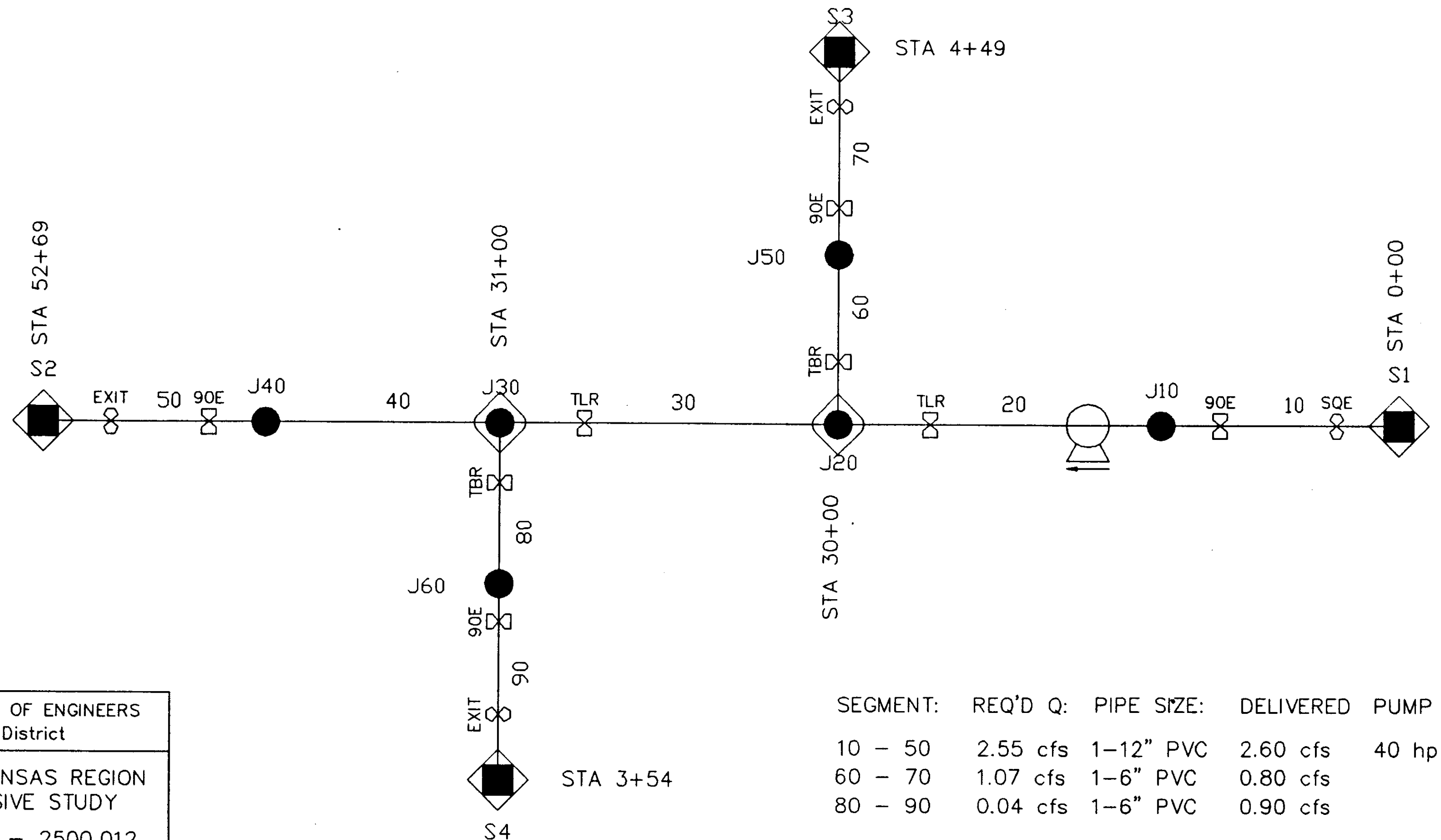
(+) INFLOWS INTO THE SYSTEM FROM BOUNDARY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO BOUNDARY NODES

| PIPE NUMBER | FLOWRATE (cfs) |
|---|---|
| 10 | 8.46 |
| 40 | -6.72 |
| 60 | -1.74 |

NET SYSTEM INFLOW = 8.46
NET SYSTEM OUTFLOW = -8.46
NET SYSTEM DEMAND = 0.00

**** CYBERNET SIMULATION COMPLETED ****

DATE: 9/12/1996
TIME: 13:31:36




U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY

PIPE 2500.010 – 2500.012

| SEGMENT: | REQ'D Q: | PIPE SIZE: | DELIVERED | PUMP |
|---|---|---|---|---|
| 10 – 50 | 2.55 cfs | 1–12" PVC | 2.60 cfs | 40 hp (27.00) |
| 60 – 70 | 1.07 cfs | 1–6" PVC | 0.80 cfs | |
| 80 – 90 | 0.04 cfs | 1–6" PVC | 0.90 cfs | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pipe - Description | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| Pipe - Length ft | 5.00 ft | 2995.00 ft | 100.00 ft | 2164.00 ft | 5.00 ft | 444.00 ft | 5.00 ft | 349.00 ft | 5.00 ft |
| Pipe - Diameter in | 12.00 in | 12.00 in | 12.00 in | 12.00 in | 12.00 in | 6.00 in | 6.00 in | 6.00 in | 6.00 in |
| Pipe - Roughness | 117.00 | 117.00 | 117.00 | 117.00 | 117.00 | 117.00 | 117.00 | 117.00 | 117.00 |
| Pipe - Minor Loss | 0.77 | 0.15 | 0.10 | 0.00 | 0.28 | 0.51 | 0.43 | 0.65 | 0.54 |
| Pipe - Flowrate cfs | 4.31 cfs | 4.31 cfs | 3.51 cfs | 2.60 cfs | 2.60 cfs | 0.80 cfs | 0.80 cfs | 0.90 cfs | 0.90 cfs |
| Pipe - Headloss ft | 0.05 ft | 31.28 ft | 0.71 ft | 8.89 ft | 0.02 ft | 6.01 ft | 0.07 ft | 5.92 ft | 0.08 ft |
| Pipe - Pump Head ft | 0.00 ft | 55.27 ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft |
| Pipe - Velocity ft/s | 5.48 ft/s | 5.48 ft/s | 4.46 ft/s | 3.31 ft/s | 3.31 ft/s | 4.07 ft/s | 4.07 ft/s | 4.60 ft/s | 4.60 ft/s |
| Pipe - Headloss/1000 | 10.44 | 10.44 | 7.14 | 4.11 | 4.11 | 13.53 | 13.53 | 16.95 | 16.95 |
| Pipe - Travel Time Hours | 0.00 Hour | 0.15 Hour | 0.01 Hour | 0.18 Hour | 0.00 Hour | 0.03 Hour | 0.00 Hour | 0.02 Hour | 0.00 Hour |
| Node - Description | J10 | J20 | J30 | J40 | J50 | J60 | | | |
| Node - Elevation ft | 213.00 ft | 226.00 ft | 226.00 ft | 203.00 ft | 226.00 ft | 225.00 ft | | | |
| Node - Pressure | 2.68 psig | 7.37 psig | 7.02 psig | 13.13 psig | 4.55 psig | 4.61 psig | | | |
| BND - Description | S1 | S2 | S3 | S4 | | | | | |
| BND - HGL ft | 220.00 ft | 233.00 ft | 236.00 ft | 235.00 ft | | | | | |
| BND - Net Flow cfs | 4.31 cfs | -2.60 cfs | -0.80 cfs | -0.90 cfs | | | | | |

FILE: 2500-01.DWG

# INPUT FOR 2200-02

****************************************************

SUMMARY OF ORIGINAL DATA

****************************************************

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: MAIN - 12" PVC w/40 hp PUMP LAT - 6" PVC
Drawing: 2500-01

## PIPELINE DATA

STATUS CODE: XX -CLOSED PIPE BN -BOUNDARY NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE

| PIPE NUMBER | NODE NOS. #1 | #2 | LENGTH (ft) | DIAMETER (in) | ROUGHNESS COEFF. | MINOR LOSS COEFF. | BND-HGL (ft) |
|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 5.0 | 12.0 | 117.00 | 1.65 | 220.00 |
| 20-PU | 10 | 20 | 2995.0 | 12.0 | 117.00 | 0.33 | |
| 30 | 20 | 30 | 100.0 | 12.0 | 117.00 | 0.33 | |
| 40 | 30 | 40 | 2164.0 | 12.0 | 117.00 | 0.00 | |
| 50-BN | 40 | 0 | 5.0 | 12.0 | 117.00 | 1.65 | 233.00 |
| 60 | 20 | 50 | 444.0 | 6.0 | 117.00 | 1.98 | |
| 70-BN | 50 | 0 | 5.0 | 6.0 | 117.00 | 1.65 | 236.00 |
| 80 | 30 | 60 | 349.0 | 6.0 | 117.00 | 1.98 | |
| 90-BN | 60 | 0 | 5.0 | 6.0 | 117.00 | 1.65 | 235.00 |

## PUMP DATA

THERE IS A PUMP IN LINE 20 - USEFUL POWER = 27.00

## JUNCTION NODE DATA

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | JUNCTION ELEVATION (ft) | CONNECTING PIPES | |
|---|---|---|---|---|---|
| 10-1 | 0.00 | 213.00 | 10 | 20 | |
| 20-1 | 0.00 | 226.00 | 20 | 30 | 60 |
| 30-1 | 0.00 | 226.00 | 30 | 40 | 80 |
| 40-1 | 0.00 | 203.00 | 40 | 50 | |
| 50-1 | 0.00 | 226.00 | 60 | 70 | |
| 60-1 | 0.00 | 225.00 | 80 | 90 | |

## OUTPUT FOR 2200-02

| MAXIMUM DIMENSIONS | |
|---|---|
| Number of pipes | 250 |
| Number of pumps | 62 |
| Number junction nodes | 250 |
| Flow meters | 62 |
| Boundary nodes | 25 |
| Variable storage tanks | 62 |
| Pressure switches | 62 |
| Regulating Valves | 62 |
| Items for limited output | 250 |
| limit for non-consecutive numbering | 2510 |

Cybernet version 2.16. SN: 1132161165-250

Extended Description:

### UNITS SPECIFIED

| | |
|---|---|
| FLOWRATE | = cubic feet/second |
| HEAD (HGL) | = feet |
| PRESSURE | = psig |

### OUTPUT OPTION DATA

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

### SYSTEM CONFIGURATION

| | | | |
|---|---|---|---|
| NUMBER OF PIPES | (p) | = | 9 |
| NUMBER OF JUNCTION NODES | (j) | = | 6 |
| NUMBER OF PRIMARY LOOPS | (l) | = | 0 |
| NUMBER OF BOUNDARY NODES | (f) | = | 4 |
| NUMBER OF SUPPLY ZONES | (z) | = | 1 |

*************************************
SIMULATION RESULTS
*************************************

The results are obtained after 3 trials with an accuracy = 0.00034

### SIMULATION DESCRIPTION

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: MAIN - 12" PVC w/40 hp PUMP LAT - 6" PVC
Drawing: 2500-01

### PIPELINE RESULTS

| STATUS CODE: | | | |
|---|---|---|---|
| | XX -CLOSED PIPE | BN -BOUNDARY NODE | PU -PUMP LINE |
| | CV -CHECK VALVE | RV -REGULATING VALVE | TK -STORAGE TANK |

| PIPE NUMBER | NODE NOS. #1 | NODE NOS. #2 | FLOWRATE (cfs) | HEAD LOSS (ft) | PUMP HEAD (ft) | MINOR LOSS (ft) | LINE VEL (ft/s) | HL/ 1000 (ft/ft) |
|---|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 4.31 | 0.05 | 0.00 | 0.77 | 5.48 | 10.44 |
| 20-PU | 10 | 20 | 4.31 | 31.28 | 55.27 | 0.15 | 5.48 | 10.44 |
| 30 | 20 | 30 | 3.51 | 0.71 | 0.00 | 0.10 | 4.46 | 7.14 |
| 40 | 30 | 40 | 2.60 | 8.89 | 0.00 | 0.00 | 3.31 | 4.11 |
| 50-BN | 40 | 0 | 2.60 | 0.02 | 0.00 | 0.28 | 3.31 | 4.11 |
| 60 | 20 | 50 | 0.80 | 6.01 | 0.00 | 0.51 | 4.07 | 13.53 |
| 70-BN | 50 | 0 | 0.80 | 0.07 | 0.00 | 0.43 | 4.07 | 13.53 |
| 80 | 30 | 60 | 0.90 | 5.92 | 0.00 | 0.65 | 4.60 | 16.95 |
| 90-BN | 60 | 0 | 0.90 | 0.08 | 0.00 | 0.54 | 4.60 | 16.95 |

JUNCTION NODE RESULTS

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | HYDRAULIC GRADE (ft) | JUNCTION ELEVATION (ft) | PRESSURE HEAD (ft) | JUNCTION PRESSURE (psi) |
|---|---|---|---|---|---|---|
| 10-1 | | 0.00 | 219.18 | 213.00 | 6.18 | 2.68 |
| 20-1 | | 0.00 | 243.01 | 226.00 | 17.01 | 7.37 |
| 30-1 | | 0.00 | 242.19 | 226.00 | 16.19 | 7.02 |
| 40-1 | | 0.00 | 233.30 | 203.00 | 30.30 | 13.13 |
| 50-1 | | 0.00 | 236.49 | 226.00 | 10.49 | 4.55 |
| 60-1 | | 0.00 | 235.63 | 225.00 | 10.63 | 4.61 |

SUMMARY OF INFLOWS AND OUTFLOWS

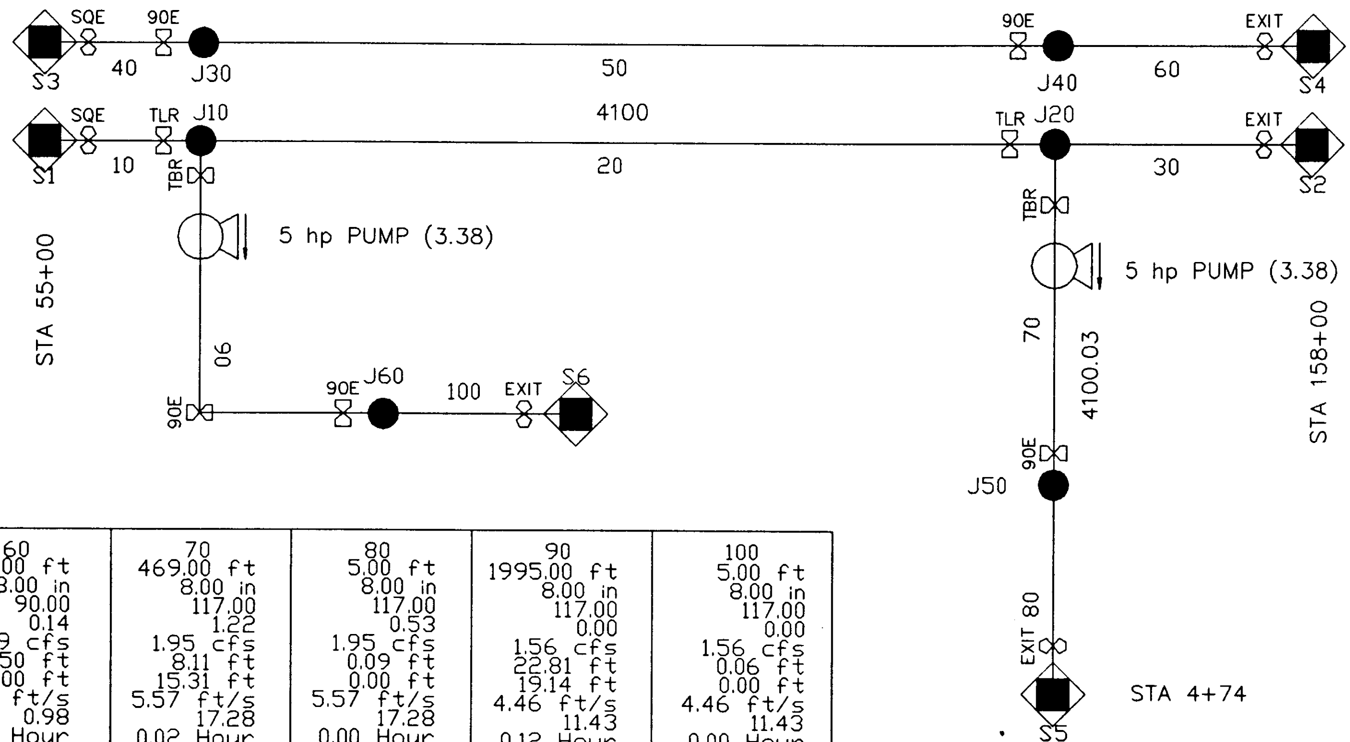
(+) INFLOWS INTO THE SYSTEM FROM BOUNDARY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO BOUNDARY NODES

| PIPE NUMBER | FLOWRATE (cfs) |
|---|---|
| 10 | 4.31 |
| 50 | -2.60 |
| 70 | -0.80 |
| 90 | -0.90 |

NET SYSTEM INFLOW = 4.31
NET SYSTEM OUTFLOW = -4.31
NET SYSTEM DEMAND = 0.00

**** CYBERNET SIMULATION COMPLETED ****

DATE: 9/12/1996
TIME: 13:42:49




| | | | | | |
|---|---|---|---|---|---|
| Pipe – Description | 60 | 70 | 80 | 90 | 100 |
| Pipe – Length ft | 5600.00 ft | 469.00 ft | 5.00 ft | 1995.00 ft | 5.00 ft |
| Pipe – Diameter in | 48.00 in | 8.00 in | 8.00 in | 8.00 in | 8.00 in |
| Pipe – Roughness | 90.00 | 117.00 | 117.00 | 117.00 | 117.00 |
| Pipe – Minor Loss | 0.14 | 1.22 | 0.53 | 0.00 | 0.00 |
| Pipe – Flowrate cfs | 35.39 cfs | 1.95 cfs | 1.95 cfs | 1.56 cfs | 1.56 cfs |
| Pipe – Headloss ft | 5.50 ft | 8.11 ft | 0.09 ft | 22.81 ft | 0.06 ft |
| Pipe – Pump Head ft | 0.00 ft | 15.31 ft | 0.00 ft | 19.14 ft | 0.00 ft |
| Pipe – Velocity ft/s | 2.82 ft/s | 5.57 ft/s | 5.57 ft/s | 4.46 ft/s | 4.46 ft/s |
| Pipe – Headloss/1000 | 0.98 | 17.28 | 17.28 | 11.43 | 11.43 |
| Pipe – Travel Time Hours | 0.55 Hour | 0.02 Hour | 0.00 Hour | 0.12 Hour | 0.00 Hour |
| Node – Description | J60 | | | | |
| Node – Elevation ft | 205.00 ft | | | | |
| Node – Pressure | 4.36 psig | | | | |
| BND – Description | S6 | | | | |
| BND – HGL ft | 215.00 ft | | | | |
| BND – Net Flow cfs | -1.56 cfs | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Pipe – Description | 10 | 20 | 30 | 40 | 50 |
| Pipe – Length ft | 5.00 ft | 4695.00 ft | 5600.00 ft | 5.00 ft | 4695.00 ft |
| Pipe – Diameter in | 48.00 in | 48.00 in | 48.00 in | 48.00 in | 48.00 in |
| Pipe – Roughness | 90.00 | 90.00 | 90.00 | 90.00 | 90.00 |
| Pipe – Minor Loss | 0.27 | 0.15 | 0.32 | 0.15 | 0.12 |
| Pipe – Flowrate cfs | 37.22 cfs | 35.67 cfs | 35.67 cfs | 37.33 cfs | 37.33 cfs |
| Pipe – Headloss ft | 0.01 ft | 4.68 ft | 5.58 ft | 0.01 ft | 5.09 ft |
| Pipe – Pump Head ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft | 0.00 ft |
| Pipe – Velocity ft/s | 2.96 ft/s | 2.84 ft/s | 2.84 ft/s | 2.97 ft/s | 2.97 ft/s |
| Pipe – Headloss/1000 | 1.08 | 1.00 | 1.00 | 1.08 | 1.08 |
| Pipe – Travel Time Hours | 0.00 Hour | 0.46 Hour | 0.55 Hour | 0.00 Hour | 0.44 Hour |
| Node – Description | J10 | J20 | J30 | J40 | J50 |
| Node – Elevation ft | 204.73 ft | 204.26 ft | 204.73 ft | 204.26 ft | 209.00 ft |
| Node – Pressure | 6.06 psig | 4.18 psig | 6.12 psig | 4.06 psig | 4.60 psig |
| BND – Description | S1 | S2 | S3 | S4 | S5 |
| BND – HGL ft | 219.00 ft | 208.00 ft | 219.00 ft | 208.00 ft | 219.00 ft |
| BND – Net Flow cfs | 37.22 cfs | -35.67 cfs | 37.33 cfs | -35.39 cfs | -1.95 cfs |

| SEGMENT: | REQ'D Q: | PIPE SIZE: | DELIVERED |
|---|---|---|---|
| 10 – 30 | 12 cfs | 1–48" RCP | 35.67 cfs |
| 40 – 60 | | 1–48" RCP | 35.39 cfs |
| 70 – 80 | 0.45 cfs | 1–8" PVC | 1.95 cfs |
| 90–100 | 0.45 cfs | 1–8" PVC | 1.56 cfs |

U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY

CANAL 4100

FILE: 4100.DWG & 4100–03.DWG

# INPUT FOR 4100

****************************************************
SUMMARY OF ORIGINAL DATA
****************************************************

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 48" RCP MAIN, 8" PVC BRANCH w/5 hp PUMP
Drawing: 4100

## PIPELINE DATA

STATUS CODE: XX -CLOSED PIPE BN -BOUNDARY NODE PU -PUMP LINE
CV -CHECK VALVE RV -REGULATING VALVE

| PIPE NUMBER | NODE NOS. #1 | #2 | LENGTH (ft) | DIAMETER (in) | ROUGHNESS COEFF. | MINOR LOSS COEFF. | BND-HGL (ft) |
|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 5.0 | 48.0 | 90.00 | 1.98 | 219.00 |
| 20 | 10 | 20 | 4695.0 | 48.0 | 90.00 | 1.21 | |
| 30-BN | 20 | 0 | 5600.0 | 48.0 | 90.00 | 2.53 | 208.00 |
| 40-BN | 0 | 30 | 5.0 | 48.0 | 90.00 | 1.10 | 219.00 |
| 50 | 30 | 40 | 4695.0 | 48.0 | 90.00 | 0.88 | |
| 60-BN | 40 | 0 | 5600.0 | 48.0 | 90.00 | 1.10 | 208.00 |
| 70-PU | 40 | 50 | 469.0 | 8.0 | 117.00 | 2.53 | |
| 80-BN | 50 | 0 | 5.0 | 8.0 | 117.00 | 1.10 | 219.00 |
| 90-PU | 10 | 60 | 1995.0 | 8.0 | 117.00 | 0.00 | |
| 100-BN | 60 | 0 | 5.0 | 8.0 | 117.00 | 0.00 | 215.00 |

## PUMP DATA

THERE IS A PUMP IN LINE 70 - USEFUL POWER = 3.38
THERE IS A PUMP IN LINE 90 - USEFUL POWER = 3.38

## JUNCTION NODE DATA

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | JUNCTION ELEVATION (ft) | CONNECTING PIPES | |
|---|---|---|---|---|---|
| 10-1 | 0.00 | 204.73 | 10 | 20 | 90 |
| 20-1 | 0.00 | 204.26 | 20 | 30 | |
| 30-1 | 0.00 | 204.73 | 40 | 50 | |
| 40-1 | 0.00 | 204.26 | 50 | 60 | 70 |
| 50-1 | 0.00 | 209.00 | 70 | 80 | |
| 60-1 | 0.00 | 205.00 | 90 | 100 | |

# INPUT FOR 4100

| MAXIMUM DIMENSIONS | |
|---|---|
| Number of pipes | 250 |
| Number of pumps | 62 |
| Number junction nodes | 250 |
| Flow meters | 62 |
| Boundary nodes | 25 |
| Variable storage tanks | 62 |
| Pressure switches | 62 |
| Regulating Valves | 62 |
| Items for limited output | 250 |
| limit for non-consecutive numbering | 2510 |

Cybernet version 2.16. SN: 1132161165-250

Extended Description:

UNITS SPECIFIED

| | |
|---|---|
| FLOWRATE | = cubic feet/second |
| HEAD (HGL) | = feet |
| PRESSURE | = psig |

OUTPUT OPTION DATA

OUTPUT SELECTION: ALL RESULTS ARE INCLUDED IN THE TABULATED OUTPUT

SUPPLY ZONE DATA

THIS SYSTEM HAS MULTIPLE SUPPLY ZONES

ZONE NO. 1 IS SUPPLIED THROUGH THE FOLLOWING PIPES: 1 30 100

ZONE NO. 2 IS SUPPLIED THROUGH THE FOLLOWING PIPES: 40 60 80

SYSTEM CONFIGURATION

| | | | |
|---|---|---|---|
| NUMBER OF PIPES | (p) | = | 10 |
| NUMBER OF JUNCTION NODES | (j) | = | 6 |
| NUMBER OF PRIMARY LOOPS | (l) | = | 0 |
| NUMBER OF BOUNDARY NODES | (f) | = | 6 |
| NUMBER OF SUPPLY ZONES | (z) | = | 2 |

**************************************
SIMULATION RESULTS
**************************************

The results are obtained after 3 trials with an accuracy = 0.00095

SIMULATION DESCRIPTION

CyberNet Version 2.16 . Copyright 1991,92 Haestad Methods Inc.
Run Description: 48" RCP MAIN, 8" RCP w/5 hp PUMP
Drawing: 4100

## PIPELINE RESULTS

STATUS CODE: XX -CLOSED PIPE; CV -CHECK VALVE; BN -BOUNDARY NODE; RV -REGULATING VALVE; PU -PUMP LINE; TK -STORAGE TANK

| PIPE NUMBER | NODE NOS. #1 | #2 | FLOWRATE (cfs) | HEAD LOSS (ft) | PUMP HEAD (ft) | MINOR LOSS (ft) | LINE VEL (ft/s) | HL/ 1000 (ft/ft) |
|---|---|---|---|---|---|---|---|---|
| 10-BN | 0 | 10 | 37.22 | 0.01 | 0.00 | 0.27 | 2.96 | 1.08 |
| 20 | 10 | 20 | 35.67 | 4.68 | 0.00 | 0.15 | 2.84 | 1.00 |
| 30-BN | 20 | 0 | 35.67 | 5.58 | 0.00 | 0.32 | 2.84 | 1.00 |
| 40-BN | 0 | 30 | 37.33 | 0.01 | 0.00 | 0.15 | 2.97 | 1.08 |
| 50 | 30 | 40 | 37.33 | 5.09 | 0.00 | 0.12 | 2.97 | 1.08 |
| 60-BN | 40 | 0 | 35.39 | 5.50 | 0.00 | 0.14 | 2.82 | 0.98 |
| 70-PU | 40 | 50 | 1.95 | 8.11 | 15.31 | 1.22 | 5.57 | 17.28 |
| 80-BN | 50 | 0 | 1.95 | 0.09 | 0.00 | 0.53 | 5.57 | 17.28 |
| 90-PU | 10 | 60 | 1.56 | 22.81 | 19.14 | 0.00 | 4.46 | 11.43 |
| 100-BN | 60 | 0 | 1.56 | 0.06 | 0.00 | 0.00 | 4.46 | 11.43 |

## JUNCTION NODE RESULTS

| JUNCTION NUMBER | JUNCTION TITLE | EXTERNAL DEMAND (cfs) | HYDRAULIC GRADE (ft) | JUNCTION ELEVATION (ft) | PRESSURE HEAD (ft) | JUNCTION PRESSURE (psi) |
|---|---|---|---|---|---|---|
| 10-1 | | 0.00 | 218.72 | 204.73 | 13.99 | 6.06 |
| 20-1 | | 0.00 | 213.90 | 204.26 | 9.64 | 4.18 |
| 30-1 | | 0.00 | 218.84 | 204.73 | 14.11 | 6.12 |
| 40-1 | | 0.00 | 213.63 | 204.26 | 9.37 | 4.06 |
| 50-1 | | 0.00 | 219.62 | 209.00 | 10.62 | 4.60 |
| 60-1 | | 0.00 | 215.06 | 205.00 | 10.06 | 4.36 |

## SUMMARY OF INFLOWS AND OUTFLOWS

(+) INFLOWS INTO THE SYSTEM FROM BOUNDARY NODES
(-) OUTFLOWS FROM THE SYSTEM INTO BOUNDARY NODES

| PIPE NUMBER | FLOWRATE (cfs) |
|---|---|
| 10 | 37.22 |
| 30 | -35.67 |
| 40 | 37.33 |
| 60 | -35.39 |
| 80 | -1.95 |
| 100 | -1.56 |

NET SYSTEM INFLOW = 74.56
NET SYSTEM OUTFLOW = -74.56
NET SYSTEM DEMAND = 0.00

**** CYBERNET SIMULATION COMPLETED ****

DATE: 9/12/1996
TIME: 14:09:25

# PIPELINES AND PUMPS

| RCH | DESC | LEN (ft) | REQD FLOW (cfs) | PVC USED 6" (ft) | PVC USED 8" (ft) | PVC USED 10" (ft) | PVC USED 12" (ft) | PVC USED 14" (ft) | RCP USED 18" (ft) | RCP USED 24" (ft) | RCP USED 30" (ft) | RCP USED 36" (ft) | PUMP USED (hp) | DELIVERED FLOW (cfs) | DELIVERED VEL (fps) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R3 | 1000.01 | 1382 | 0.12 | | | 1382 | | | | | | | Grav. | 1.76 | 3.22 |
| R3 | 1300 | | | | | | | | | | | | | | |
| R3 | 1300.01 | 200 | 0.17 | 200 | | | | | | | | | 5.0 | 1.47 | 7.50 |
| R3 | 1400 | | | | | | | | | | | | | | |
| R3 | 1400.01 | 1894 | 0.79 | 1894 | | | | | | | | | 7.5 | 0.88 | 4.49 |
| R3 | 1400.02 | 1575 | 0.04 | 1575 | | | | | | | | | 5.0 | 0.76 | 3.87 |
| R4 | 1500.01 | 8605 | 0.05 | 8605 | | | | | | | | | 6.0 | 0.59 | 3.02 |
| R4 | 1500.02 | 1882 | 0.88 | 1882 | | | | | | | | | 5.0 | 0.87 | 4.46 |
| R4 | 1500.03 | 2133 | 4.32 | | | | | | 2133 | | | | 10.0 | 5.38 | 3.04 |
| R4 | 1500.04 | 740 | 0.77 | 740 | | | | | | | | | 5.0 | 1.12 | 5.73 |
| R4 | 1500.05 | 1721 | 0.13 | 1721 | | | | | | | | | 5.0 | 0.71 | 3.60 |
| R4 | 1500.06 | 7300 | 1.51 | | | 5950 | 1350 | | | | | | 35.0 | 1.92 | 3.52 |
| R4 | 1500.061 | 1617 | 1.04 | 1617 | | | | | | | | | Brnch | 0.99 | 5.07 |
| R4 | 1500.07 | 593 | 0.03 | 593 | | | | | | | | | 5.0 | 0.75 | 3.81 |
| R4 | 1520.01 | 1476 | 0.03 | 1476 | | | | | | | | | 5.0 | 1.03 | 5.25 |
| R4 | 1520.02 | 3582 | 0.31 | 3582 | | | | | | | | | 5.0 | 0.85 | 3.84 |
| R4 | 1520.03 | 421 | 0.01 | 421 | | | | | | | | | 5.0 | 1.20 | 6.09 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| R3 | 2000.01 | 2661 | 0.17 | 2661 | | | | | | | | | 5.0 | 0.80 | 4.06 |
| R3 | 2000.02 | 2249 | 0.70 | 2249 | | | | | | | | | 5.0 | 0.84 | 4.30 |
| R3 | 2000.03 | 8230 | 0.69 | | 8230 | | | | | | | | 10.0 | 1.07 | 3.07 |
| R3 | 2000.04 | 1255 | 0.05 | 1255 | | | | | | | | | 5.0 | 1.43 | 4.09 |
| R4 | 2100.01 | 1192 | 0.21 | 1192 | | | | | | | | | 5.0 | 0.80 | 4.09 |
| R4 | 2100.02 | 999 | 0.73 | 999 | | | | | | | | | 5.0 | 0.80 | 4.07 |
| R4 | 2200.01 | 13670 | 7.22 | | | | | | | 13670 | | | 60.0 | 9.86 | 3.14 |
| R4 | 2200.02 | 7800 | 6.72 | | | | | | 7800 | | | | 95.0 | 6.72 | 3.80 |
| R4 | 2200.021 | 2700 | 1.31 | | | 2700 | | | | | | | FCV | 1.74 | 4.72 |
| R4 | 2200.03 | 5476 | 0.58 | 5476 | | | | | | | | | 5.0 | 0.64 | 3.26 |
| R4 | 2200.04 | 7660 | 1.53 | | | 7660 | | | | | | | 10.0 | 1.88 | 3.45 |
| R4 | 2200.05 | 5412 | 0.20 | 5412 | | | | | | | | | 5.0 | 0.62 | 3.17 |
| R4 | 2200.06 | 2800 | 0.31 | 2800 | | | | | | | | | 5.0 | 0.59 | 2.99 |
| R5 | 2210.03 | 1301 | | 1301 | | | | | | | | | 7.5 | 0.99 | 5.02 |
| R5 | 2210.04 | 10695 | 1.05 | | 10695 | | | | | | | | 20.0 | 1.17 | 3.35 |
| R5 | 2210.05 | 774 | | | 774 | | | | | | | | 5.0 | 1.78 | 5.11 |
| R5 | 2210.06 | 467 | 0.04 | 467 | | | | | | | | | 5.0 | 1.00 | 5.08 |
| R5 | 2210.07 | 9216 | 0.70 | | 5866 | 3350 | | | | | | | 30.0 | 1.06 | 3.05 |
| R5 | 2210.071 | 1418 | 0.27 | 1418 | | | | | | | | | FCV | 1.03 | 5.26 |
| R5 | 2210.08 | 1266 | 0.08 | 1266 | | | | | | | | | 5.0 | 0.92 | 4.69 |
| R4 | 2220.01 | 1000 | 0.00 | | 1000 | | | | | | | | 5.0 | 1.27 | 3.63 |
| R4 | 2230.01 | 2641 | 1.66 | | | 2641 | | | | | | | 8.0 | 1.91 | 3.50 |
| R4 | 2230.02 | 2540 | 1.14 | | 2540 | | | | | | | | 5.0 | 1.18 | 3.39 |
| R4 | 2230.03 | 17700 | 3.25 | | | | | 17700 | | | | | 70.0 | 3.25 | 3.04 |
| R4 | 2230.031 | 1456 | 0.08 | 1456 | | | | | | | | | Brnch | 1.11 | 5.64 |
| R4 | 2240.01 | 3400 | 0.04 | 3400 | | | | | | | | | 5.0 | 0.67 | 3.42 |
| R4 | 2240.02 | 1300 | 0.87 | 1300 | | | | | | | | | 8.0 | 0.92 | 4.68 |
| R4 | 2240.03 | 2200 | 0.36 | 2200 | | | | | | | | | 8.0 | 0.75 | 3.83 |
| R4 | 2240.04 | 7700 | 0.32 | 7700 | | | | | | | | | 10.0 | 0.61 | 3.09 |
| R3 | 2300.01 | 1002 | 0.18 | 1002 | | | | | | | | | 5.0 | 0.81 | 4.12 |
| R3 | 2300.02 | 1743 | 0.05 | 1743 | | | | | | | | | 5.0 | 0.67 | 3.41 |
| R3 | 2300.03 | 794 | 0.05 | 794 | | | | | | | | | 5.0 | 0.79 | 4.05 |
| R5 | 2400.01 | 2334 | 1.18 | | 2334 | | | | | | | | 5.0 | 1.22 | 3.48 |
| R5 | 2410.01 | 794 | 0.56 | 794 | | | | | | | | | 5.0 | 1.02 | 5.19 |
| R5 | 2410.02 | 1608 | 2.31 | | | 1608 | | | | | | | 15.0 | 2.77 | 5.07 |
| R5 | 2410.03 | 1092 | 0.14 | 1092 | | | | | | | | | 5.0 | 0.86 | 4.37 |
| R5 | 2410.04 | 579 | 0.27 | 579 | | | | | | | | | 5.0 | 1.17 | 5.94 |
| R5 | 2410.05 | 1671 | 0.68 | 1671 | | | | | | | | | 5.0 | 0.82 | 4.17 |
| R3 | 2500.01 | 5269 | 2.55 | | 5269 | | | | | | | | 40.0 | 2.60 | 3.31 |

| RCH | DESC | LEN (ft) | REQD FLOW (cfs) | PVC USED 6" (ft) | 8" (ft) | 10" (ft) | 12" (ft) | 14" (ft) | RCP USED 18" (ft) | 24" (ft) | 30" (ft) | 36" (ft) | PUMP USED (hp) | DELIVERED FLOW (cfs) | VEL (fps) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R3 | 2500.011 | 449 | 1.07 | 449 | | | | | | | | | Brnch | 0.80 | 4.07 |
| R3 | 2500.012 | 354 | 0.04 | 354 | | | | | | | | | Brnch | 0.90 | 4.60 |
| R3 | 2500.02 | 645 | 0.90 | | 645 | | | | | | | | 5.0 | 1.26 | 3.61 |
| R3 | 2500.03 | 1328 | 0.13 | 1328 | | | | | | | | | 5.0 | 0.70 | 3.56 |
| R3 | 2500.04 | 3043 | 0.29 | 3043 | | | | | | | | | 5.0 | 0.60 | 3.06 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| R3 | 3000.01 | 3510 | 0.30 | 3510 | | | | | | | | | 5.0 | 0.68 | 3.44 |
| R3 | 3000.02 | 2629 | 3.00 | | | | 2629 | | | | | | 20.0 | 3.34 | 4.26 |
| R3 | 3000.03 | 1572 | 2.12 | | | 1572 | | | | | | | 5.0 | 2.36 | 4.33 |
| R3 | 3000.04 | 5966 | 2.90 | | | | | 5966 | | | | | 15.0 | 3.69 | 3.45 |
| R3 | 3000.05 | 2538 | 2.26 | | | 2538 | | | | | | | 10.0 | 2.27 | 4.17 |
| R3 | 3000.06 | 4154 | 5.39 | | | | | | 4154 | | | | 20.0 | 5.42 | 3.07 |
| R3 | 3000.07 | 6586 | 1.94 | | | | | 6586 | | | | | 10.0 | 3.36 | 3.14 |
| R3 | 3000.071 | 1527 | 1.13 | | | 1527 | | | | | | | Brnch | 2.34 | 4.29 |
| R5 | 3100.01 | 2530 | 2.30 | | | | 2530 | | | | | | 7.5 | 2.76 | 3.51 |
| R5 | 3100.02 | 4949 | 1.96 | | | | 4949 | | | | | | 7.5 | 2.56 | 3.26 |
| R5 | 3110.01 | 884 | 0.27 | | 884 | | | | | | | | 5.0 | 1.64 | 4.69 |
| R2 | 3200.01 | 3806 | 0.97 | | 3806 | | | | | | | | 5.0 | 1.11 | 3.18 |
| R2 | 3200.02 | 1738 | 0.23 | 1738 | | | | | | | | | 5.0 | 0.86 | 4.38 |
| R2 | 3200.03 | 2477 | 1.18 | | 2477 | | | | | | | | 7.5 | 1.33 | 3.80 |
| R2 | 3200.04 | 1297 | 3.41 | | | | 1297 | | | | | | 15.0 | 4.03 | 5.13 |
| R2 | 3200.05 | 1045 | 0.05 | 1045 | | | | | | | | | 5.0 | 0.96 | 4.89 |
| R2 | 3200.06 | 1624 | 0.23 | 1624 | | | | | | | | | 5.0 | 0.66 | 3.37 |
| R2 | 3210.01 | 3343 | 1.07 | | 3343 | | | | | | | | 7.5 | 1.23 | 3.52 |
| R2 | 3210.02 | 332 | 0.04 | | 332 | | | | | | | | Grav. | 1.75 | 5.01 |
| R2 | 3221.01 | 500 | 1.00 | | 500 | | | | | | | | 5.0 | 1.09 | 3.11 |
| R2 | 3221.02 | 8000 | 0.70 | | 2700 | | | | | | 5300 | | 50.0 | 1.06 | 3.05 |
| R2 | 3221.021 | 1500 | 0.61 | | 1500 | | | | | | | | Brnch | 1.22 | 3.49 |
| R2 | 3221.022 | 1400 | 1.53 | | | | 1400 | | | | | | Brnch | 3.68 | 4.69 |
| R2 | 3221.03 | 600 | 1.00 | | 600 | | | | | | | | 5.0 | 1.16 | 3.34 |
| R2 | 3230.01 | 450 | 0.05 | 450 | | | | | | | | | 5.0 | 1.09 | 5.55 |
| R2 | 3230.02 | 1734 | 0.70 | 1734 | | | | | | | | | 5.0 | 0.76 | 3.88 |
| R2 | 3230.03 | 1037 | 0.74 | | 1037 | | | | | | | | 7.5 | 1.12 | 3.20 |
| R2 | 3240.01 | 1073 | 0.35 | 1073 | | | | | | | | | 5.0 | 0.91 | 4.65 |
| R2 | 3240.02 | 677 | 0.39 | 677 | | | | | | | | | 5.0 | 1.03 | 5.24 |
| R2 | 3240.03 | 7400 | 4.00 | | | | | 7400 | | | | | 40.0 | 4.30 | 4.03 |
| R2 | 3250.01 | 594 | 0.22 | 594 | | | | | | | | | 5.0 | 1.16 | 5.90 |
| R2 | 3261.05 | 3700 | 0.34 | 3700 | | | | | | | | | 7.5 | 0.70 | 3.56 |
| R2 | 3261.06 | 600 | 1.03 | 600 | | | | | | | | | 5.0 | 1.02 | 5.20 |
| R2 | 3261.07 | 300 | 0.13 | 300 | | | | | | | | | 5.0 | 1.26 | 6.43 |
| R5 | 3300.01 | 2929 | 2.50 | | | | 2929 | | | | | | 10.0 | 2.65 | 3.37 |
| R5 | 3300.02 | 483 | 1.11 | 483 | | | | | | | | | 5.0 | 1.25 | 6.35 |
| R5 | 3500.01 | 1500 | 0.31 | 1500 | | | | | | | | | 5.0 | 0.87 | 4.47 |
| R5 | 3500.02 | 9660 | 2.82 | | | | | 9660 | | | | | 25.0 | 3.71 | 3.47 |
| R5 | 3500.03 | 5857 | 3.02 | | | | | 5857 | | | | | 30.0 | 3.86 | 3.61 |
| R6 | 3510.01 | 2710 | 1.14 | | 2710 | | | | | | | | 7.5 | 1.27 | 3.65 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| R5 | 4000.01 | 4004 | 0.05 | 4004 | | | | | | | | | 5.0 | 0.70 | 3.57 |
| R5 | 4000.02 | 4280 | 2.90 | | | | | 4280 | | | | | 7.5 | 3.23 | 3.03 |
| R5 | 4000.03 | 9502 | 6.11 | | | | 1784 | 2766 | 4952 | | | | 80.0 | 7.52 | 4.25 |
| R5 | 4000.031 | 1858 | 0.29 | 1858 | | | | | | | | | Brnch | 0.91 | 4.61 |
| R5 | 4000.032 | 2634 | 1.27 | | | | 2634 | | | | | | Brnch | 3.10 | 3.94 |
| R5 | 4000.033 | 1445 | 0.23 | 1445 | | | | | | | | | Brnch | 1.03 | 5.26 |
| R6 | 4000.04 | 2127 | 0.53 | 2127 | | | | | | | | | 5.0 | 0.83 | 4.24 |
| R6 | 4000.05 | 13139 | 6.98 | | | | | | | 13139 | | | 40.0 | 10.00 | 3.18 |
| R6 | 4000.06 | 1924 | 0.00 | | | 1924 | | | | | | | 5.0 | 1.81 | 3.33 |
| R6 | 4100.01 | 1205 | 0.06 | 1205 | | | | | | | | | 5.0 | 1.01 | 5.15 |
| R6 | 4100.02 | 2000 | 0.45 | | | 2000 | | | | | | | 5.0 | 1.95 | 5.57 |

| RCH | DESC | LEN (ft) | REQD FLOW (cfs) | PVC USED | | | | | RCP USED | | | | PUMP USED (hp) | DELIVERED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 6" (ft) | 8" (ft) | 10" (ft) | 12" (ft) | 14" (ft) | 18" (ft) | 24" (ft) | 30" (ft) | 36" (ft) | | FLOW (cfs) | VEL (fps) |
| R6 | 4100.03 | 474 | 0.45 | | | 474 | | | | | | | 5.0 | 1.56 | 4.46 |
| R6 | 4200.01 | 1341 | 0.04 | | 1341 | | | | | | | | 5.0 | 0.96 | 4.90 |
| R6 | 4200.02 | 3000 | 2.22 | | | | | 3000 | | | | | 7.5 | 2.48 | 3.15 |
| R6 | 4300.01 | 834 | 0.39 | | | | | | | 834 | | | Grav. | 10.23 | 3.26 |
| R6 | 4500.01 | 2753 | 2.30 | | | | | 2753 | | | | | 10.0 | 2.98 | 3.80 |
| R6 | 4500.02 | 2860 | 0.88 | 2860 | | | | | | | | | 7.5 | 0.83 | 4.24 |
| R6 | 4500.03 | 2860 | 0.18 | 2860 | | | | | | | | | Grav. | 0.69 | 3.52 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| R7 | 5000.01 | 2886 | 2.40 | | | | | 2886 | | | | | 5.0 | 2.37 | 3.02 |
| R7 | 5000.02 | 2784 | 1.00 | 2784 | | | | | | | | | 7.5 | 0.88 | 4.50 |
| R7 | 5100.01 | 459 | 2.33 | | | | 459 | | | | | | 10.0 | 2.96 | 3.77 |
| R7 | 5100.02 | 8015 | 4.85 | | | | | | 8015 | | | | 80.0 | 5.39 | 1.93 |
| R7 | 5100.021 | 2597 | 0.61 | | | 2597 | | | | | | | Brnch | 1.67 | 3.06 |
| R7 | 5100.03 | 2661 | 1.29 | | | 2661 | | | | | | | 7.5 | 1.86 | 3.24 |
| R7 | 5300.02 | 5127 | 2.00 | | | 5127 | | | | | | | 15.0 | 2.05 | 3.76 |
| R7 | 5300.03 | 2762 | 0.77 | | 2762 | | | | | | | | 5.0 | 1.13 | 3.23 |
| R7 | 5300.031 | 1281 | 0.21 | | 1281 | | | | | | | | Brnch | 1.13 | 3.23 |
| R10 | 5300.04 | 565 | 0.20 | 565 | | | | | | | | | 5.0 | 1.08 | 5.50 |
| R10 | 5300.05 | 700 | 6.51 | | | | | | 700 | | | | 30.0 | 8.21 | 4.64 |
| R10 | 5300.06 | 2645 | 0.58 | 2645 | | | | | | | | | 5.0 | 0.70 | 3.56 |
| R10 | 5300.07 | 3483 | 1.12 | | 3483 | | | | | | | | 7.5 | 1.14 | 3.27 |
| R10 | 5300.08 | 1623 | 0.12 | 1623 | | | | | | | | | 5.0 | 0.78 | 3.99 |
| R7 | 5310.01 | 500 | 2.09 | | 500 | | | | | | | | 5.0 | 1.43 | 4.11 |
| R7 | 5310.02 | 3000 | 4.65 | | | | | | 3000 | | | | 30.0 | 6.34 | 3.59 |
| R7 | 5311.01 | 3400 | 4.55 | | | | | | 3400 | | | | 20.0 | 5.93 | 3.36 |
| R7 | 5311.02 | 2400 | 2.24 | | | | 2400 | | | | | | 10.0 | 2.57 | 3.27 |
| R7 | 5400.01 | 2863 | 0.49 | 2863 | | | | | | | | | 5.0 | 0.74 | 3.78 |
| R7 | 5400.02 | 4258 | 0.43 | 4258 | | | | | | | | | 5.0 | 0.64 | 3.27 |
| R8 | 5500.02 | 11033 | 5.78 | | | | | | 11033 | | | | 80.0 | 5.89 | 3.34 |
| R8 | 5500.021 | 3125 | 0.20 | 3125 | | | | | | | | | Brnch | 0.70 | 3.56 |
| R8 | 5500.022 | 1959 | 0.77 | | 1959 | | | | | | | | Brnch | 1.17 | 3.36 |
| R8 | 5500.03 | 3200 | 1.73 | | 3200 | | | | | | | | 10.0 | 1.50 | 4.30 |
| R8 | 5500.04 | 5510 | 0.90 | | 5510 | | | | | | | | 7.5 | 1.14 | 3.26 |
| R8 | 5500.05 | 3051 | 1.42 | | | 3051 | | | | | | | 7.5 | 1.98 | 3.63 |
| R8 | 5500.06 | 8073 | 0.42 | 8073 | | | | | | | | | 7.5 | 0.63 | 3.20 |
| R8 | 5510.01 | 965 | 0.86 | | 965 | | | | | | | | 5.0 | 1.50 | 4.31 |
| R8 | 5510.02 | 748 | 0.05 | | 748 | | | | | | | | 5.0 | 1.51 | 4.31 |
| R8 | 5510.03 | 1183 | 1.26 | | 1183 | | | | | | | | 5.0 | 1.33 | 3.81 |
| R8 | 5510.04 | 1031 | 0.12 | | 1031 | | | | | | | | 5.0 | 1.38 | 3.94 |
| R8 | 5510.05 | 3856 | 1.70 | | | 3856 | | | | | | | 10.0 | 1.72 | 3.16 |
| R8 | 5520.01 | 4461 | 1.77 | | | 4461 | | | | | | | 10.0 | 1.80 | 3.30 |
| R8 | 5520.02 | 1241 | 1.00 | | 1241 | | | | | | | | 5.0 | 1.36 | 3.90 |
| R8 | 5530.01 | 800 | 1.35 | | 800 | | | | | | | | 5.0 | 1.32 | 3.79 |
| R8 | 5530.02 | 1388 | 0.05 | | 1388 | | | | | | | | 5.0 | 1.06 | 3.03 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| R8 | 6000.01 | 6293 | 0.66 | 6293 | | | | | | | | | 7.5 | 0.66 | 3.35 |
| R10 | 6000.02 | 8014 | 5.71 | | | | | | 2734 | 5280 | | | 75.0 | 5.81 | 3.29 |
| R10 | 6000.021 | 2678 | 2.00 | | | | 2678 | | | | | | Brnch | 2.94 | 3.74 |
| R10 | 6000.022 | 4000 | 1.72 | | | | 4000 | | | | | | Brnch | 2.64 | 3.37 |
| R10 | 6000.03 | 2713 | 1.88 | | | 2713 | | | | | | | 5.0 | 2.08 | 3.81 |
| R10 | 6000.04 | 2886 | 25.93 | | | | | | | | | 2886 | 50.0 | 26.79 | 3.79 |
| R10 | 6000.05 | 1503 | 0.32 | 1503 | | | | | | | | | 5.0 | 0.70 | 3.54 |
| R8 | 6100.01 | 750 | 2.12 | | | | 750 | | | | | | 7.5 | 3.01 | 3.84 |
| R8 | 6100.02 | 10741 | 11.05 | | | | | | | | 10741 | | 85.0 | 15.05 | 3.07 |
| R8 | 6100.03 | 1301 | 3.56 | | | | | 1301 | | | | | 7.5 | 3.67 | 3.44 |
| R8 | 6100.04 | 2799 | 1.12 | | 2799 | | | | | | | | 5.0 | 1.13 | 3.25 |
| R8 | 6100.05 | 4440 | 4.30 | | | | | 4440 | | | | | 30.0 | 4.49 | 4.20 |
| R8 | 6100.06 | 6772 | 1.72 | | | 6772 | | | | | | | 15.0 | 1.73 | 3.18 |

| RCH | DESC | LEN (ft) | REQD FLOW (cfs) | PVC USED | | | | | RCP USED | | | | PUMP USED (hp) | DELIVERED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 6" (ft) | 8" (ft) | 10" (ft) | 12" (ft) | 14" (ft) | 18" (ft) | 24" (ft) | 30" (ft) | 36" (ft) | | FLOW (cfs) | VEL (fps) |
| R8 | 6100.07 | 1015 | 0.43 | | 1015 | | | | | | | | 5.0 | 1.30 | 3.71 |
| R8 | 6100.08 | 1662 | 2.20 | | | | 1662 | | | | | | 10.0 | 2.67 | 3.39 |
| R8 | 6100.09 | 5429 | 2.70 | | | | 5429 | | | | | | 30.0 | 2.75 | 3.51 |
| R8 | 6100.091 | 1364 | 0.21 | 1364 | | | | | | | | | Brnch | 0.59 | 3.01 |
| R8 | 6100.10 | 17984 | 7.81 | | | | | | 2884 | 15100 | | | 50.0 | 10.73 | 3.42 |
| R8 | 6100.101 | 1000 | 0.77 | 1000 | | | | | | | | | Brnch | 0.77 | 3.92 |
| R8 | 6100.102 | 1426 | 0.41 | 1426 | | | | | | | | | Brnch | 0.75 | 3.82 |
| R8 | 6100.11 | 13485 | 2.87 | | | | | 13485 | | | | | 35.0 | 3.32 | 3.11 |
| R8 | 6100.12 | 2454 | 1.95 | | | | 2454 | | | | | | 15.0 | 2.94 | 3.74 |
| R8 | 6100.13 | 934 | 1.65 | | | 934 | | | | | | | 5.0 | 1.81 | 3.32 |
| R8 | 6100.14 | 15518 | 1.18 | | | | 15518 | | | | | | 30.0 | 1.70 | 2.17 |
| R8 | 6100.141 | 1249 | 0.00 | 1249 | | | | | | | | | Brnch | 0.93 | 4.73 |
| R8 | 6100.15 | 22000 | 7.57 | | | | | | 2700 | 19300 | | | 150.0 | 8.33 | 4.71 |
| R8 | 6100.151 | 1594 | 0.00 | 1594 | | | | | | | | | 5.0 | 1.19 | 6.07 |
| R8 | 6100.16 | 1752 | 3.43 | | | | | 1752 | | | | | 20.0 | 3.91 | 3.66 |
| R8 | 6100.17 | 23700 | 14.92 | | | | | | | | 23700 | | 225.0 | 15.25 | 3.11 |
| R8 | 6100.171 | 1078 | 0.21 | | 1078 | | | | | | | | Brnch | 1.25 | 3.58 |
| R8 | 6100.172 | 719 | 1.14 | | 719 | | | | | | | | Brnch | 1.25 | 3.58 |
| R8 | 6100.18 | 25377 | 16.13 | | | | | | | | 25377 | | 200.0 | 15.43 | 3.14 |
| R8 | 6100.181 | 1380 | 0.27 | 1380 | | | | | | | | | Brnch | 0.62 | 3.15 |
| R8 | 6100.19 | 5167 | 5.84 | | | | | | 5167 | | | | 50.0 | 6.03 | 3.41 |
| R8 | 6100.20 | 827 | 0.27 | | 827 | | | | | | | | 5.0 | 1.21 | 3.47 |
| R9 | 6100.21 | 2000 | 0.81 | 2000 | | | | | | | | | 10.0 | 0.88 | 4.49 |
| R9 | 6100.22 | 8300 | 3.69 | | | | | 3900 | 4400 | | | | 75.0 | 3.35 | 3.14 |
| R9 | 6100.221 | 673 | 0.40 | 673 | | | | | | | | | Brnch | 1.31 | 6.69 |
| R9 | 6100.222 | 1374 | 0.05 | 1374 | | | | | | | | | Brnch | 0.92 | 4.68 |
| R9 | 6100.223 | 2588 | 0.81 | 2588 | | | | | | | | | Brnch | 0.81 | 4.13 |
| R9 | 6100.23 | 10280 | 1.49 | | | 7380 | 2900 | | | | | | 30.0 | 1.63 | 2.98 |
| R9 | 6100.231 | 1373 | 0.03 | 1373 | | | | | | | | | Brnch | 1.03 | 5.24 |
| R9 | 6100.24 | 1200 | 0.39 | | 1200 | | | | | | | | 5.0 | 1.20 | 3.45 |
| R9 | 6100.25 | 7300 | 1.64 | | | | 7300 | | | | | | 50.0 | 2.74 | 3.49 |
| R9 | 6100.251 | 1340 | 0.08 | 1340 | | | | | | | | | Brnch | 0.64 | 3.24 |
| R9 | 6100.26 | 7309 | 0.52 | 3509 | 3800 | | | | | | | | 40.0 | 0.66 | 3.34 |
| R9 | 6100.261 | 1799 | 0.20 | 1799 | | | | | | | | | Brnch | 1.13 | 5.78 |
| R9 | 6100.27 | 2384 | 0.60 | 2384 | | | | | | | | | 7.5 | 0.67 | 3.42 |
| R9 | 6100.28 | 1302 | 0.09 | 1302 | | | | | | | | | 5.0 | 0.73 | 3.73 |
| R9 | 6200.02 | 2703 | 1.20 | | 2703 | | | | | | | | 5.0 | 1.31 | 3.74 |
| R9 | 6200.03 | 2740 | 0.53 | | 2740 | | | | | | | | 5.0 | 1.30 | 3.72 |
| R9 | 6200.04 | 2800 | 2.98 | | | | 2800 | | | | | | 15.0 | 3.87 | 4.93 |
| R9 | 6200.06 | 4700 | 5.00 | | | | | | | 4700 | | | Grav. | 5.00 | 3.00 |
| R9 | 6230.01 | 465 | 0.64 | | 465 | | | | | | | | 5.0 | 1.70 | 4.88 |
| R9 | 6230.02 | 805 | 0.27 | | 805 | | | | | | | | 5.0 | 0.82 | 4.18 |
| R9 | 6230.03 | 511 | 0.86 | 511 | | | | | | | | | 5.0 | 0.89 | 4.53 |
| R10 | 6300.01 | 2515 | 2.16 | | | | 2515 | | | | | | 10.0 | 2.59 | 3.29 |
| R10 | 6300.02 | 450 | 0.96 | | 450 | | | | | | | | 5.0 | 1.68 | 4.81 |
| R10 | 6300.03 | 820 | 1.48 | | | 820 | | | | | | | 5.0 | 1.79 | 3.28 |
| R10 | 6300.04 | 3978 | 2.07 | | | 3978 | | | | | | | 15.0 | 2.15 | 3.94 |
| R10 | 6300.05 | 654 | 1.14 | | 654 | | | | | | | | 5.0 | 1.36 | 3.90 |
| R10 | 6300.06 | 3254 | 3.22 | | | | | 3254 | | | | | 20.0 | 3.73 | 3.49 |
| R10 | 6300.07 | 3615 | 0.42 | 3615 | | | | | | | | | 5.0 | 0.63 | 3.22 |
| R10 | 6300.08 | 1575 | 0.18 | | 1575 | | | | | | | | 5.0 | 1.25 | 3.59 |
| R10 | 6300.09 | 1395 | 6.55 | | | | | | | 1395 | | | 40.0 | 10.46 | 3.33 |
| R10 | 6310.01 | 500 | 1.33 | | | 500 | | | | | | | 5.0 | 2.33 | 4.27 |
| R10 | 6310.02 | 688 | 0.90 | | 688 | | | | | | | | 5.0 | 1.55 | 4.44 |
| R10 | 6310.03 | 700 | 1.77 | | | 700 | | | | | | | 5.0 | 1.80 | 3.31 |
| R10 | 6400.01 | 2581 | 1.00 | | 2581 | | | | | | | | 5.0 | 1.15 | 3.31 |
| R10 | 6410.01 | 2757 | 3.61 | | | | | 2757 | | | | | 15.0 | 3.72 | 3.48 |
| R10 | 6500.01 | 1690 | 4.52 | | | | | 1690 | | | | | 20.0 | 4.86 | 4.55 |
| R10 | 6500.02 | 600 | 2.54 | | | | 600 | | | | | | 10.0 | 3.66 | 4.66 |
| R10 | 6500.03 | 2600 | 0.97 | | 2600 | | | | | | | | 7.5 | 1.25 | 3.59 |
| R10 | 6600.01 | 3300 | 2.07 | | | | 3300 | | | | | | 7.5 | 2.54 | 3.24 |

| RCH | DESC | LEN (ft) | REQD FLOW (cfs) | PVC USED | | | | | RCP USED | | | | PUMP USED (hp) | DELIVERED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 6" (ft) | 8" (ft) | 10" (ft) | 12" (ft) | 14" (ft) | 18" (ft) | 24" (ft) | 30" (ft) | 36" (ft) | | FLOW (cfs) | VEL (fps) |
| | | | | | | | | | | | | | | | |
| TOTAL: | | 753710 | | 179307 | 111333 | 80876 | 76267 | 101433 | 63072 | 73418 | 65118 | 2886 | = | 753710 | |

IN - LINE DUAL LINE PIPE

| STATION | DESC | LENGTH (ft) | FLOW (cfs) | RCP | | | | | | PUMP USED (hp) | DELIVERED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 24" (ft) | 30" (ft) | 36" (ft) | 42" (ft) | 48" (ft) | 54" (ft) | | FLOW (cfs) | VEL (fps) |
| 17+50 - 106+00 | 2230 | 8850 | 18.00 | | | | | 17700 | | Grav. | 79.47 | 3.16 |
| 0+00 - 32+00 | 2240 | 3200 | 9.00 | 6400 | | | | | | Grav. | 20.77 | 3.61 |
| 55+00 - 128+00 | 4100 | 7308 | 12.00 | | | | | 14616 | | Grav. | 71.06 | 2.82 |
| 52+50 - 67+50 | 4400 -A | 1500 | 22.00 | 3000 | | | | | | Grav. | 29.26 | 4.66 |
| 85+50 - 106+97 | 4400 -B | 2147 | 12.36 | | | | | | 4294 | Grav. | 99.84 | 3.14 |
| 0+00 - 31+00 | 4400 | 3100 | 12.36 | | | | | | 6200 | Grav. | 99.84 | 3.14 |
| 129+00 - 186+00 | 4500 | 5700 | 19.00 | | 11400 | | | | | Grav. | 37.45 | 3.56 |
| 154+85 - 210+00 | 5200 | 5515 | 19.00 | | | | 11030 | | | Grav. | 24.18 | 1.26 |
| 109+00 - 307+50 | 5300 | 19850 | 66.00 | | | | | 13380 | 26320 | Grav. | 81.31 | 3.29 |
| 22+00 - 84+00 | 5310 | 6200 | 53.00 | | | 12400 | | | | Grav. | 51.52 | 3.64 |
| | | | | | | | | | | | | |
| SUB-TOTAL | | 63370 | | 9400 | 11400 | 12400 | 11030 | 45696 | 36814 | = | 126740 | |
| | | X2 | | | | | | | | | | |
| | | 126740 | | | | | | | | | | |
| | | | | | | | | | | | | |

IN - LINE SINGLE PIPE

| STATION | DESC | LENGTH (ft) | FLOW (cfs) | PVC | RCP | | | | | PUMP USED (hp) | DELIVERED | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 12" (ft) | 24" (ft) | 30" (ft) | 48" (ft) | | | | FLOW (cfs) | VEL (fps) |
| 0+00 - 71+41 | 3250 | 7141 | 2.00 | 7141 | | | | | | 10 | 2.40 | 3.06 |
| 0+00 - 117+45 | 3400 | 11745 | 13.00 | | | 11745 | | | | 50 | 15.15 | 3.09 |
| 429+95 - 377+00 | 3500B | 5475 | 9.00 | | | 5475 | | | | ---- | 16.57 | 3.38 |
| 140+00 - 194+78 | 4200 | 5478 | 7.00 | | | 5478 | | | | Grav. | 15.32 | 3.12 |
| 0+00 - 105+37 | 4300 | 10537 | 8.00 | | 10537 | | | | | 15 | 10.23 | 3.26 |
| 0+00 - 105+50 | 4510 | 10550 | 6.00 | | | | 10550 | | | Grav. | 37.94 | 3.02 |
| 72+00 - 86+43 | 4520 | 1443 | 11.00 | | 1443 | | | | | 10 | 12.28 | 3.91 |
| | | | | | | | | | | | | |
| SUB-TOTAL | | 52369 | | 7141 | 11980 | 22698 | 10550 | | | = | 52369 | |
| | | | | | | | | | | | | |

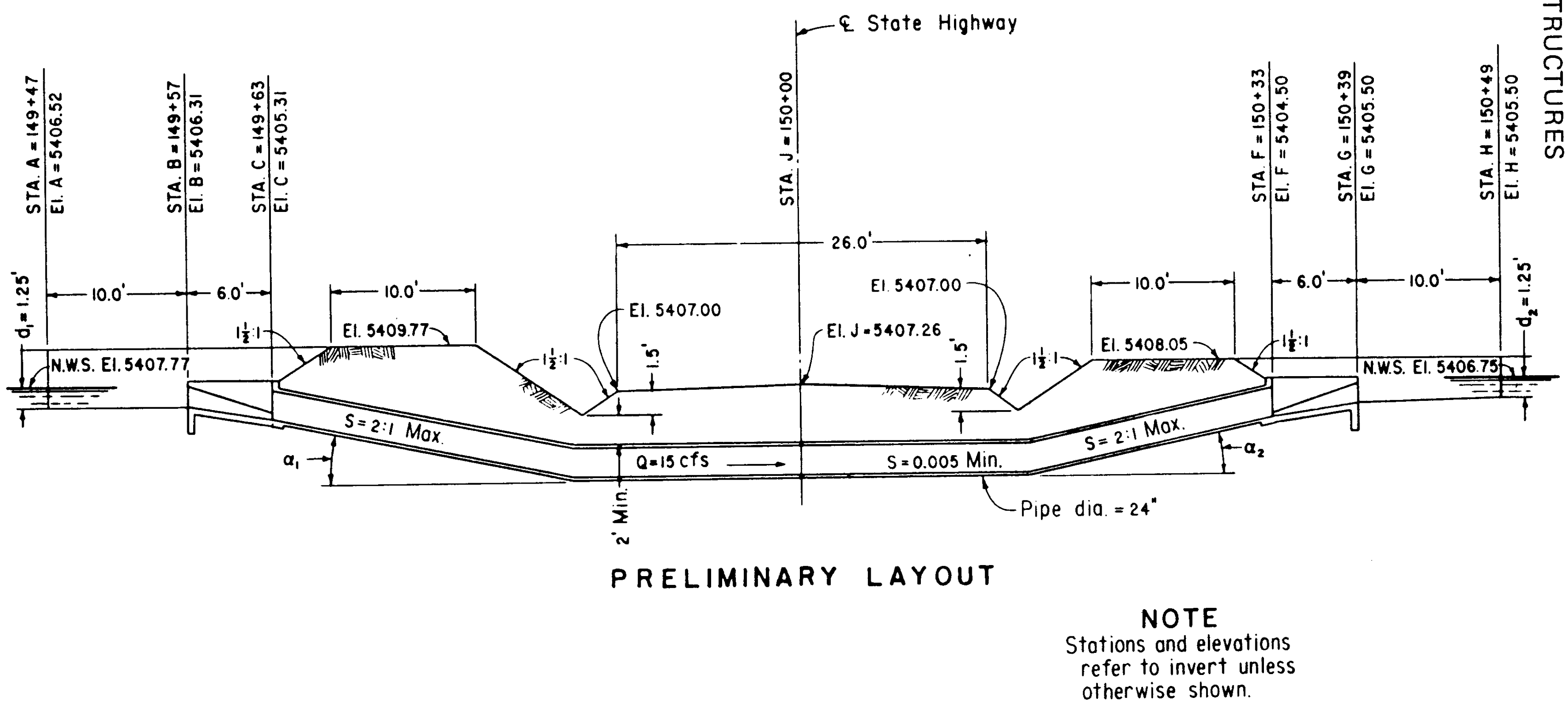



*Figure 2-8.* Preliminary layout of inverted siphon. 103-D-1256

## Eastern Arkansas Water Supply Study
## Inverted Siphon Design for Natural Drainage

| Inverted Siphon Name | Drainage Basin Area (sq mi) | Calculated Q100 (cfs) | | Selected Q100 (cfs) | Head (ft.) | Tailwater Depth (ft.) | Energy Loss (ft.) | | | | Selected Siphon Diameter (in.) | Number of Siphons |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rational Method | Previous Study | | | | Entrance K = 0.8 | Exit K = 1.0 | Bend K = 0.16 | Friction C = 60 | | |
| S1000-01 | 0.082 | 44 | | 44 | 0.0 | | 0.259 | 0.323 | 0.207 | 1.490 | 42 | 1 |
| S1000-02 | 0.094 | 50 | | 50 | 0.0 | | 0.199 | 0.249 | 0.159 | 1.001 | 48 | 1 |
| S1000-03 | 0.101 | 54 | | 54 | 0.0 | | 0.230 | 0.288 | 0.184 | 1.144 | 48 | 1 |
| S1000-04 | 0.112 | 60 | | 60 | 0.0 | | 0.283 | 0.354 | 0.226 | 1.385 | 48 | 1 |
| S1500-02 | 0.204 | 109 | | 109 | 0.3 | | 0.384 | 0.481 | 0.308 | 1.417 | 60 | 1 |
| S1520-01 | 0.067 | 36 | | 36 | 0.0 | | 0.173 | 0.216 | 0.138 | 1.025 | 42 | 1 |
| S2000-01 | 0.221 | 118 | | 118 | 0.0 | | 0.308 | 0.385 | 0.247 | 1.034 | 66 | 1 |
| S2000-02 | 0.36 | 193 | | 193 | 0.1 | | 0.419 | 0.524 | 0.335 | 1.131 | 78 | 1 |
| S2000-03 | 0.261 | 140 | | 140 | 0.0 | | 0.303 | 0.379 | 0.243 | 0.921 | 72 | 1 |
| S2000-04 | 0.323 | 173 | | 173 | 0.0 | | 0.337 | 0.422 | 0.270 | 0.925 | 78 | 1 |
| S2000-05 | 0.136 | 73 | | 73 | 0.0 | | 0.260 | 0.326 | 0.208 | 1.118 | 54 | 1 |
| S2000-06 | 0.073 | 39 | | 39 | 0.0 | | 0.205 | 0.256 | 0.164 | 1.202 | 42 | 1 |
| S2200-02 | 0.188 | 101 | | 101 | 0.0 | | 0.327 | 0.408 | 0.261 | 1.219 | 60 | 1 |
| S2200-03 | 0.236 | 126 | | 126 | 0.0 | | 0.351 | 0.439 | 0.281 | 1.167 | 66 | 1 |
| S2200-04 | 0.236 | 126 | | 126 | 0.0 | | 0.351 | 0.439 | 0.281 | 1.167 | 66 | 1 |
| S2200-05 | 0.068 | 36 | | 36 | 0.0 | | 0.178 | 0.222 | 0.142 | 1.054 | 42 | 1 |
| S2200-06 | 0.171 | 92 | | 92 | 0.0 | | 0.270 | 0.338 | 0.216 | 1.023 | 60 | 1 |
| S2200-07 | 0.093 | 50 | | 50 | 0.0 | | 0.195 | 0.244 | 0.156 | 0.982 | 48 | 1 |
| S2200-08 | 0.258 | 138 | | 138 | 0.3 | | 0.420 | 0.525 | 0.336 | 1.376 | 66 | 1 |
| S3000-01 | 0.5 | 268 | | 268 | 0.1 | | 0.456 | 0.570 | 0.365 | 1.035 | 90 | 1 |
| S3000-03 | 0.077 | 41 | | 41 | 0.0 | | 0.228 | 0.285 | 0.182 | 1.326 | 42 | 1 |
| S3000-06 | 0.888 | 475 | | 475 | 0.3 | | 0.474 | 0.593 | 0.379 | 1.162 | 84 | 2 |
| S3000-07 | 0.734 | 393 | 360 | 360 | 0.0 | 3.3 | 0.366 | 0.457 | 0.292 | 0.996 | 78 | 2 |
| S3000-08 | 0.108 | 58 | | 58 | 0.0 | | 0.263 | 0.329 | 0.210 | 1.295 | 48 | 1 |
| S3000-09 | 0.024 | 13 | | 13 | 0.0 | | 0.085 | 0.106 | 0.068 | 0.789 | 30 | 1 |
| S3200-01 | 0.223 | 119 | | 119 | 0.0 | | 0.314 | 0.392 | 0.251 | 1.051 | 66 | 1 |
| S3200-02 | 0.145 | 78 | | 78 | 0.0 | | 0.296 | 0.370 | 0.237 | 1.259 | 54 | 1 |
| S3200-03 | 0.5 | 268 | | 268 | 0.1 | | 0.456 | 0.570 | 0.365 | 1.035 | 90 | 1 |
| S3220-01 | 0.052 | 28 | | 28 | 0.0 | | 0.193 | 0.241 | 0.154 | 1.358 | 36 | 1 |
| S3220-02 | 0.111 | 59 | | 59 | 0.0 | | 0.278 | 0.347 | 0.222 | 1.362 | 48 | 1 |
| S3300-01 | 0.662 | 354 | | 354 | 0.0 | | 0.354 | 0.443 | 0.284 | 0.968 | 78 | 2 |
| S3500-01 | 0.192 | 103 | | 103 | 0.0 | | 0.341 | 0.426 | 0.272 | 1.267 | 60 | 1 |
| S3500-02 | 0.455 | 244 | | 244 | 0.0 | | 0.378 | 0.472 | 0.302 | 0.869 | 90 | 1 |
| S3500-03 | 0.497 | 266 | | 266 | 0.1 | | 0.451 | 0.563 | 0.361 | 1.023 | 90 | 1 |
| S3500-05 | 0.439 | 235 | | 235 | 0.2 | | 0.463 | 0.579 | 0.371 | 1.138 | 84 | 1 |
| S4000-01 | 0.298 | 160 | | 160 | 0.0 | | 0.396 | 0.495 | 0.317 | 1.177 | 72 | 1 |
| S4000-02 | 0.076 | 41 | | 41 | 0.0 | | 0.222 | 0.278 | 0.178 | 1.295 | 42 | 1 |
| S4000-03 | 0.797 | 427 | | 427 | 0.0 | | 0.382 | 0.477 | 0.306 | 0.951 | 84 | 2 |
| S4000-05 | 0.113 | 61 | | 61 | 0.0 | | 0.288 | 0.360 | 0.230 | 1.408 | 48 | 1 |
| S4000-07 | 0.139 | 74 | | 74 | 0.0 | | 0.272 | 0.340 | 0.218 | 1.164 | 54 | 1 |
| S4200-01 | 0.883 | 473 | | 473 | 0.2 | | 0.469 | 0.586 | 0.375 | 1.150 | 84 | 2 |
| S4200-02 | 0.476 | 255 | | 255 | 0.0 | | 0.413 | 0.517 | 0.331 | 0.945 | 90 | 1 |
| S4500-01 | 0.533 | 285 | | 285 | 0.0 | | 0.400 | 0.501 | 0.320 | 0.851 | 96 | 1 |
| S4500-02 | 0.328 | 176 | | 176 | 0.0 | | 0.348 | 0.435 | 0.278 | 0.952 | 78 | 1 |
| S5000-01 | 0.068 | 36 | | 86 | 0.0 | | 0.178 | 0.222 | 0.142 | 1.054 | 42 | 1 |

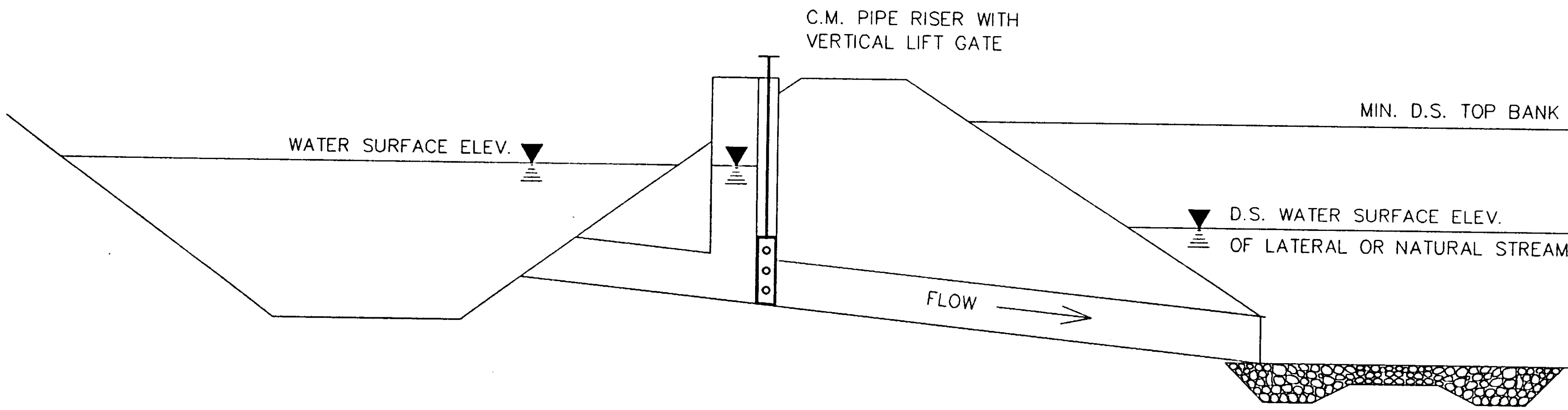
## Eastern Arkansas Water Supply Study
## Inverted Siphon Design for Natural Drainage

| Inverted Siphon Name | Drainage Basin Area (sq mi) | Calculated Q100 (cfs) | | Selected Q100 (cfs) | Head (ft.) | Tailwater Depth (ft.) | Energy Loss (ft.) | | | | Selected Siphon Diameter (in.) | Number of Siphons |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rational Method | Previous Study | | | | Entrance K = 0.8 | Exit K = 1.0 | Bend K = 0.16 | Friction C = 60 | | |
| S5000-02 | 0.921 | 493 | | 493 | 0.0 | | 0.387 | 0.484 | 0.310 | 0.888 | 90 | 2 |
| S5000-03 | 0.504 | 270 | | 270 | 0.1 | | 0.464 | 0.579 | 0.371 | 1.050 | 90 | 1 |
| S5000-04 | 0.643 | 344 | | 344 | 0.0 | | 0.334 | 0.418 | 0.267 | 0.917 | 78 | 2 |
| S5000-05 | 0.09 | 48 | | 48 | 0.0 | | 0.183 | 0.228 | 0.146 | 0.924 | 48 | 1 |
| S5200-06 | 0.5 | 268 | | 268 | 0.1 | | 0.456 | 0.570 | 0.365 | 1.035 | 90 | 1 |
| S5200-07 | 0.102 | 55 | | 55 | 0.0 | | 0.235 | 0.293 | 0.188 | 1.165 | 48 | 1 |
| S5400-01 | 0.538 | 288 | | 288 | 0.0 | | 0.408 | 0.510 | 0.326 | 0.865 | 96 | 1 |
| S5500-02 | 1.33 | 712 | | 712 | 0.3 | | 0.473 | 0.591 | 0.378 | 1.159 | 84 | 3 |
| S5500-04 | 0.164 | 88 | | 88 | 0.0 | | 0.248 | 0.311 | 0.199 | 0.947 | 60 | 1 |
| S5500-05 | 0.129 | 69 | | 69 | 0.0 | | 0.234 | 0.293 | 0.187 | 1.014 | 54 | 1 |
| S5500-06 | 0.168 | 90 | | 90 | 0.0 | | 0.261 | 0.326 | 0.209 | 0.990 | 60 | 1 |
| S5500-07 | 0.156 | 84 | | 84 | 0.1 | | 0.343 | 0.428 | 0.274 | 1.441 | 54 | 1 |
| S5500-08 | 0.529 | 283 | | 283 | 0.0 | | 0.394 | 0.493 | 0.316 | 0.839 | 96 | 1 |
| S5500-09 | 0.873 | 467 | | 467 | 0.2 | | 0.458 | 0.573 | 0.367 | 1.126 | 84 | 2 |
| S5500-10 | 0.225 | 120 | | 120 | 0.0 | | 0.319 | 0.399 | 0.256 | 1.068 | 66 | 1 |
| S5500-12 | 0.129 | 69 | | 69 | 0.0 | | 0.234 | 0.293 | 0.187 | 1.014 | 54 | 1 |
| S5500-13 | 0.213 | 114 | | 114 | 0.0 | | 0.286 | 0.358 | 0.229 | 0.965 | 66 | 1 |
| S5500-14 | 0.133 | 71 | | 71 | 0.0 | | 0.249 | 0.311 | 0.199 | 1.073 | 54 | 1 |
| S6000-01 | 1.234 | 661 | | 661 | 0.0 | | 0.407 | 0.509 | 0.325 | 1.009 | 84 | 3 |
| S6000-02 | 0.529 | 283 | | 283 | 0.0 | | 0.394 | 0.493 | 0.316 | 0.839 | 96 | 1 |
| S6000-03 | 0.599 | 321 | | 321 | 0.3 | | 0.506 | 0.632 | 0.405 | 1.056 | 96 | 1 |
| S6000-04 | 0.262 | 140 | | 140 | 0.0 | | 0.306 | 0.382 | 0.245 | 0.927 | 72 | 1 |
| S6000-08 | 0.525 | 281 | | 281 | 0.3 | | 0.503 | 0.629 | 0.402 | 1.132 | 90 | 1 |
| S6000-09 | 0.23 | 123 | | 123 | 0.0 | | 0.334 | 0.417 | 0.267 | 1.113 | 66 | 1 |
| S6000-10 | 0.021 | 11 | | 11 | 0.0 | | 0.159 | 0.199 | 0.127 | 1.826 | 24 | 1 |
| S6000-11 | 0.209 | 112 | | 112 | 0.0 | | 0.276 | 0.345 | 0.220 | 0.932 | 66 | 1 |
| S6000-12 | 0.705 | 377 | | 377 | 0.0 | | 0.402 | 0.502 | 0.322 | 1.087 | 78 | 2 |
| S6000-13 | 0.493 | 264 | | 264 | 0.0 | | 0.444 | 0.554 | 0.355 | 1.008 | 90 | 1 |
| S6200-01 | 0.113 | 61 | | 61 | 0.0 | | 0.288 | 0.360 | 0.230 | 1.408 | 48 | 1 |
| S6200-04 | 0.603 | 323 | | 323 | 0.3 | | 0.513 | 0.641 | 0.410 | 1.069 | 96 | 1 |
| S6200-05 | 0.727 | 389 | | 389 | 0.1 | | 0.427 | 0.534 | 0.342 | 1.151 | 78 | 2 |
| S6200-06 | 0.214 | 115 | | 115 | 0.0 | | 0.289 | 0.361 | 0.231 | 0.974 | 66 | 1 |
| S6200-07 | 0.103 | 55 | | 55 | 0.0 | | 0.239 | 0.299 | 0.191 | 1.186 | 48 | 1 |
| S6200-08 | 0.355 | 190 | | 190 | 0.0 | | 0.408 | 0.510 | 0.326 | 1.102 | 78 | 1 |
| S6200-11 | 0.32 | 171 | | 171 | 0.0 | | 0.331 | 0.414 | 0.265 | 0.909 | 78 | 1 |
| S6200-12 | 1.702 | 911 | 743 | 743 | 0.0 | 7.1 | 0.390 | 0.488 | 0.312 | 0.896 | 90 | 3 |
| S6200-13 | 2.262 | 1211 | | 1211 | 0.0 | | 0.451 | 0.563 | 0.361 | 0.949 | 96 | 4 |
| S6200-14 | 2.737 | 1466 | | 1466 | 0.0 | | 0.422 | 0.528 | 0.338 | 0.894 | 96 | 5 |
| S6200-15 | 0.115 | 62 | | 62 | 0.0 | | 0.298 | 0.373 | 0.239 | 1.454 | 48 | 1 |
| S6200-16 | 0.281 | 150 | | 150 | 0.0 | | 0.352 | 0.440 | 0.281 | 1.055 | 72 | 1 |
| S6260-01 | 0.136 | 73 | | 73 | 0.0 | | 0.260 | 0.326 | 0.208 | 1.118 | 54 | 1 |
| S6400-02 | 0.262 | 140 | | 140 | 0.0 | | 0.306 | 0.382 | 0.245 | 0.927 | 72 | 1 |
| S6600-01 | 0.629 | 337 | | 337 | 0.3 | | 0.441 | 0.551 | 0.353 | 1.300 | 72 | 2 |
| S6600-02 | 0.174 | 93 | | 93 | 0.0 | | 0.280 | 0.350 | 0.224 | 1.056 | 60 | 1 |
| S6600-03 | 0.236 | 126 | | 126 | 0.0 | | 0.351 | 0.439 | 0.281 | 1.167 | 66 | 1 |

## Eastern Arkansas Water Supply Study
## Inverted Siphon Design for Canal System
## Under Natural Drainage

| Inverted Siphon Name | Demand Flows (from SCS) (cfs) | Head (ft.) | Tailwater Elevation (ft.) | Energy Loss (ft.) | | | | Selected Sip Diameter (in.) | Number of Siphons |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Entrance K = 0.8 | Exit K = 1.0 | Bend K = 0.16 | Friction C = 60 | | |
| S1500-01 | 49 | 0.0 | 222.0 | 0.189 | 0.236 | 0.151 | 0.953 | 48 | 1 |
| S2200-01 | 134 | 0.3 | 221.3 | 0.203 | 0.253 | 0.162 | 0.577 | 78 | 1 |
| S2400-01 | 31 | 0.0 | 223.0 | 0.129 | 0.161 | 0.103 | 0.783 | 42 | 1 |
| S3100-01 | 32 | 0.0 | 224.0 | 0.137 | 0.172 | 0.110 | 0.830 | 42 | 1 |
| S3100-02 | 32 | 0.0 | 224.0 | 0.137 | 0.172 | 0.110 | 0.830 | 42 | 1 |
| S4000-08 | 1080 | 0.1 | 221.4 | 0.229 | 0.287 | 0.184 | 0.508 | 96 | 5 |
| S5200-02 | 20 | 0.0 | 218.9 | 0.099 | 0.124 | 0.080 | 0.737 | 36 | 1 |
| S5200-04 | 20 | 0.0 | 218.9 | 0.099 | 0.124 | 0.080 | 0.737 | 36 | 1 |
| S6200-02 | 257 | 0.2 | 209.1 | 0.325 | 0.406 | 0.260 | 0.701 | 96 | 1 |
| S6200-03 | 257 | 0.2 | 209.1 | 0.325 | 0.406 | 0.260 | 0.701 | 96 | 1 |
| S6200-09 | 114 | 0.3 | 209.0 | 0.286 | 0.358 | 0.229 | 0.965 | 66 | 1 |
| S6600-04 | 58 | 0.0 | 205.1 | 0.108 | 0.135 | 0.087 | 0.439 | 60 | 1 |
| S6600-05 | 58 | 0.0 | 205.1 | 0.108 | 0.135 | 0.087 | 0.439 | 60 | 1 |

# TYPE 1 TURNOUT STRUCTURE
## Side (Gravity) Flow to Lateral Or Natural Stream

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EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY
TYPICAL TURNOUT
STRUCTURE (TYPE 1)

PLATE III-C-28

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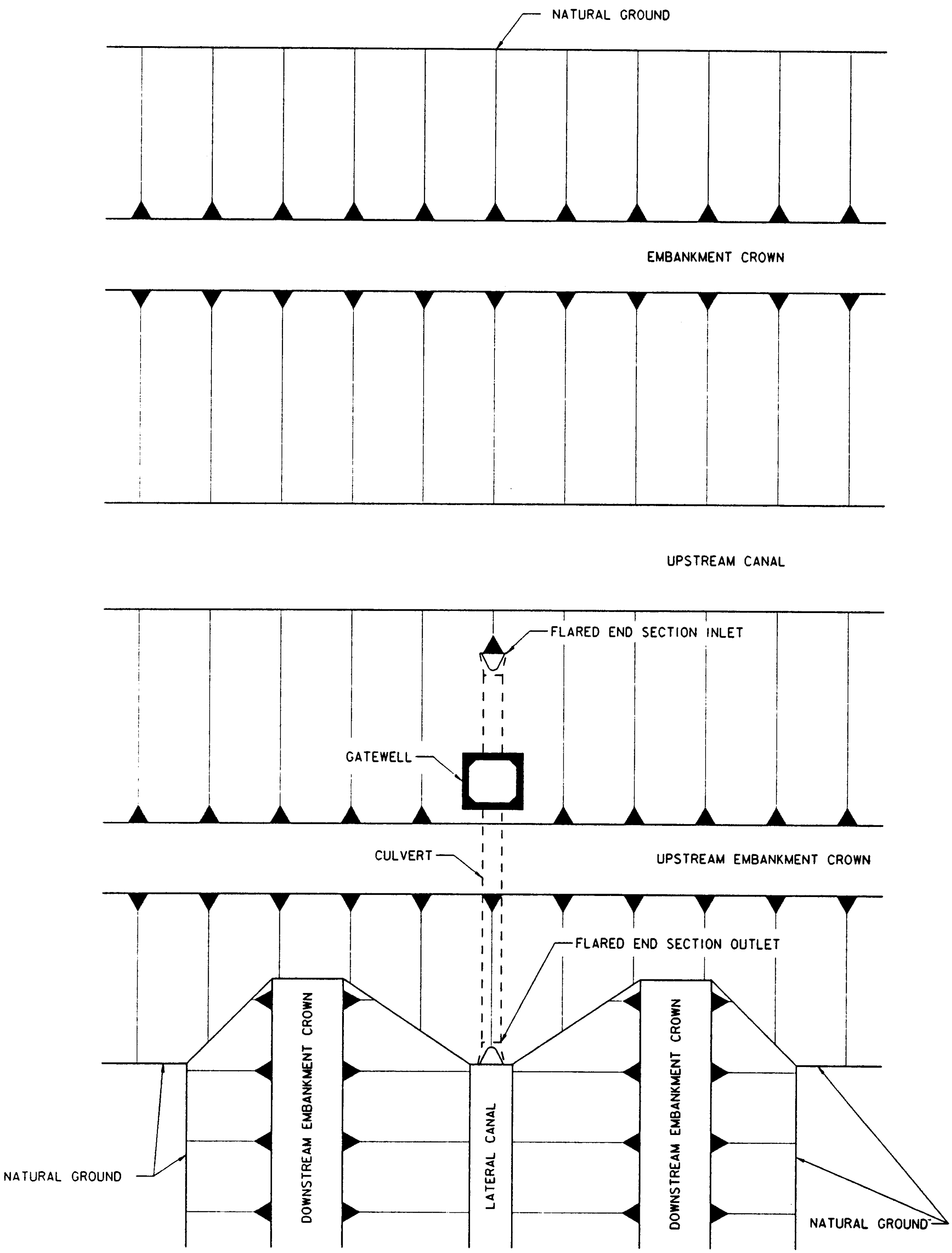
## COMPUTATION SHEET

| | | | |
|---|---|---|---|
| PROJECT **Grand Prairie Demostration Project Eastern Arkansas** | PAGE OF | COMPUTED BY **MSW** | DATE **9/20/96** |
| SUBJECT **Turnouts, Wasteways and Conduit Check Structure Designs** | | CHECKED BY | DATE |

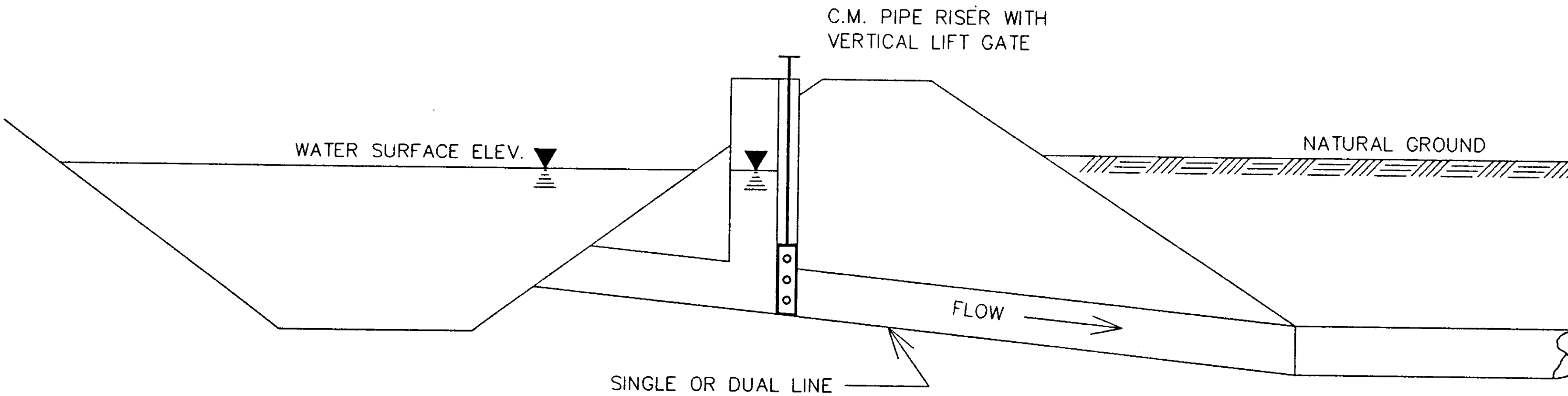



**TYPICAL SITE LAYOUT**

N.T.S.

# TYPE 2 TURNOUT STRUCTURE
## Side (Gravity) Flow to Pipeline

2a – Single Line
2b – Dual Line

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COMPREHENSIVE STUDY
TYPICAL TURNOUT
STRUCTURE (TYPE 2)

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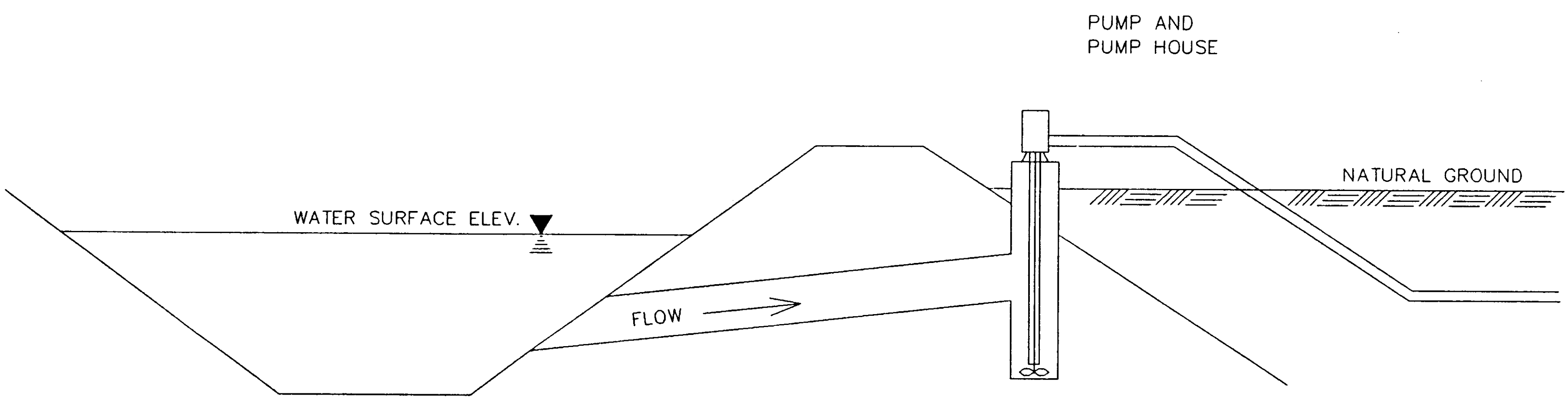
# TYPE 3 TURNOUT STRUCTURE
## Side (Pump) to Pipeline

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TYPICAL TURNOUT
STRUCTURE (TYPE 3)

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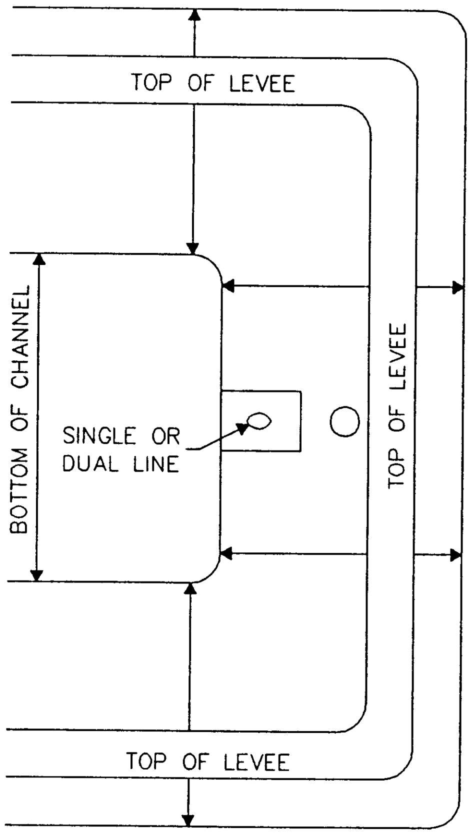
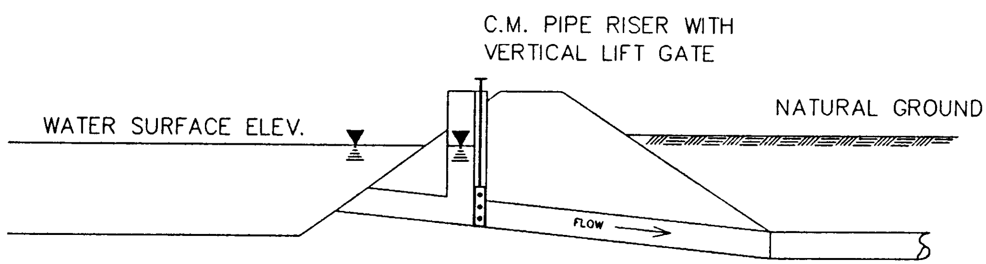
# TYPE 4 TURNOUT STRUCTURE

## End (Gravity Flow to Lateral, Natural Stream or Pipeline

4a – Single Line
4b – Dual Line

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TYPICAL TURNOUT
STRUCTURE (TYPE 4)

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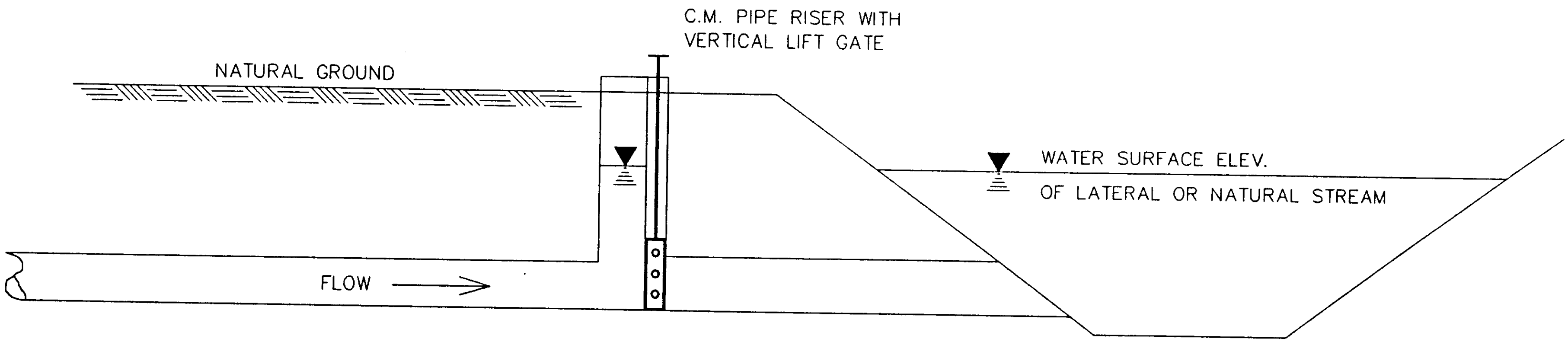
# TYPE 5 TURNOUT STRUCTURE

## Gravity Flow From Pipe to Lateral or Natural Stream

5a – Single Line
5b – Dual Line

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COMPREHENSIVE STUDY
TYPICAL TURNOUT
STRUCTURE (TYPE 5)

H:\COMMON\EARK\CANALS\CYBERNET\TURNOUT.DWG

| MAIN CANAL TURNOUTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Canal Number | Structure Name | Turnout Conduit | | Turnout Riser | | Gate Size | Typical Type |
| | | Diameter | Length (Ft.) | Diameter | Heigh (Ft.) | | |
| **1000** | | | | | | | |
| to 1000.01 | T-1000.01 | 1-18" | 50 | 48" | 12 | 18" | 2A |
| to 1100 | T-1100 | 1-18" | 50 | 48" | 12 | 18" | 1 |
| to 1200 | T-1200 | 1-18" | 50 | 48" | 12 | 18" | 1 |
| to 1300 | T-1300 | 1-18" | 50 | 48" | 11 | 18" | 1 |
| to 1400 | T-1400 | 1-18" | 50 | 48" | 11 | 18" | 1 |
| to 1500 | T-1500 | 1-48" | 50 | 72" | 13.5 | 48" | 1 |
| | | | | | | | |
| **2000** | | | | | | | |
| to 2000.01 | P-2000.01 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 2100 | T-2100 | 1-24" | 50 | 48" | 10.5 | 24" | 1 |
| to 2200 | T-2200 | 1-42" | 50 | 66" | 11.5 | 42" | 1 |
| to 2000.02 | P-2000.02 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 2300 | T-2300 | 1-18" | 50 | 48" | 9 | 18" | 1 |
| to 2400 | T-2400 | 1-36" | 50 | 54" | 10.5 | 36" | 1 |
| to 2000.03 | P-2000.03 | Pump-10hp | 50 | ------ | ------ | ------ | 3 |
| to 2000.04 | P-2000.04 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 2500 | T-2500 | 1-48" | 50 | 72" | 11 | 48" | 1 |
| | | | | | | | |
| **3000** | | | | | | | |
| to 3100 | T-3100 | 1-42" | 50 | 66" | 10 | 42" | 1 |
| to 3000.01 | P-3000.01 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 3200 | EXT 3000 | ------- | ------ | ------ | ------ | ------ | 1 |
| to 3300 | T-3300 | 1-30" | 50 | 48" | 11 | 30" | 1 |
| to 3400 | T-3400 | 1-30" | 50 | 48" | 10.5 | 30" | 2A |
| to 3000.02 | P-3000.02 | Pump-20hp | 50 | ------ | ------ | ------ | 3 |
| to 3000.03 | P-3000.03 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 3000.04 | P-3000.04 | Pump-15hp | 50 | ------ | ------ | ------ | 3 |
| to 3000.05 | P-3000.05 | Pump-10hp | 50 | ------ | ------ | ------ | 3 |
| to 3000.06 | P-3000.06 | Pump-20hp | 50 | ------ | ------ | ------ | 3 |
| to 3000.07 | P-3000.07 | Pump-10hp | 50 | ------ | ------ | ------ | 3 |
| to 3500A | T-3500A | 1-48" | 50 | 72" | 9.5 | 48" | 1 |
| to 3500B | T-3500B | 1-30" | 50 | 48" | 8.5 | 30" | 2A |
| | | | | | | | |

| MAIN CANAL TURNOUTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Canal Number | Structure Name | Turnout Conduit | | Turnout Riser | | Gate Size | Typical Type |
| | | Diameter | Length (Ft.) | Diameter | Heigh (Ft.) | | |
| **4000** | | | | | | | |
| to 4000.01 | P-4000.01 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 4000.02 | P-4000.02 | Pump-7.5hp | 50 | ------ | ------ | ------ | 3 |
| to 4000.03 | P-4000.03 | Pump-80hp | 50 | ------ | ------ | ------ | 3 |
| to 4100 | T-4100 | 1-30" | 50 | 48" | 8.5 | 30" | 1 |
| to 4000.04 | P-4000.04 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 4200 | T-4200 | 1-30" | 50 | 48" | 8.5 | 30" | 1 |
| to 4000.05 | P-4000.05 | Pump-40hp | 50 | ------ | ------ | ------ | 3 |
| to 4000.06 | P-4000.06 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 4300 | T-4300 | 1-24" | 50 | 48" | 7.5 | 24" | 2A |
| to 4400 | T-4400 | 1-30" | 50 | 48" | 7.5 | 30" | 1 |
| to 4500 | T-4500 | 1-42" | 50 | 66" | 9 | 42" | 1 |
| | | | | | | | |
| **5000** | | | | | | | |
| to 5100 | T-5100 | 1-36" | 50 | 54" | 9.5 | 36" | 1 |
| to 5200 | T-5200 | 1-30" | 50 | 48" | 8 | 30" | 1 |
| to 5000.01 | P-5000.01 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 5300 | T-5300 | 4-36" | 50 | 54" | 8.5 | 36" | 1 |
| to 5400 | T-5400 | 1-30" | 50 | 48" | 7.5 | 30" | 1 |
| to 5000.02 | P-5000.02 | Pump-7.5hp | 50 | ------ | ------ | ------ | 3 |
| to 5500 | T-5500 | 2-42" | 50 | 66" | 8.5 | 42" | 1 |
| | | | | | | | |
| **6000** | | | | | | | |
| to 6100 | T-6100 | 2-48" | 50 | 72" | 10 | 48" | 1 |
| to 6200 | T-6200 | 4-36" | 50 | 54" | 9.5 | 36" | 1 |
| to 6300 | T-6300 | 2-48" | 50 | 72" | 10 | 48" | 1 |
| to 6000.01 | P-6000.01 | Pump-7.5hp | 50 | ------ | ------ | ------ | 3 |
| to 6400 | T-6400 | 1-36" | 50 | 54" | 12 | 36" | 2A |
| to 6500 | T-6500 | 1-36" | 50 | 54" | 11 | 36" | 1 |
| to 6000.02 | P-6000.02 | Pump-75hp | 50 | ------ | ------ | ------ | 3 |
| to 6000.03 | P-6000.03 | Pump-5hp | 50 | ------ | ------ | ------ | 3 |
| to 6600 | T-6600 | 1-48" | 50 | 72" | 8.5 | 48" | 1 |
| to 6000.04 | P-6000.04 | Pump-50hp | 50 | ------ | ------ | ------ | 4A |
| to 6000.05 | P-6000.05 | Pump-5hp | 50 | ------ | ------ | ------ | 4A |

| LATERAL TURNOUTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Canal Number | Structure Name | Turnout Conduit | | Turnout Riser | | Gate Size | Typical Type |
| | | Diameter | Length (Ft.) | Diameter | Height (Ft.) | | |
| **1500** | | | | | | | |
| to 1510 | T-1510 | 1-18" | 40 | 48" | 5 | 18" | 1 |
| to 1500.01 | P-1500.01 | Pump-6hp | 40 | ------ | ------ | ------ | 3 |
| to 1500.02 | P-1500.02 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 1500.03 | P-1500.03 | Pump-10hp | 40 | ------ | ------ | ------ | 3 |
| to 1500.04 | P-1500.04 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 1520 | T-1520 | 1-18" | 40 | 48" | 3.5 | 18" | 1 |
| to 1500 | T-1500X | 1-18" | 40 | 48" | 3.5 | 18" | 1 |
| | | | | | | | |
| **1520** | | | | | | | |
| to 1520.01 | P-1520.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 1520.02 | P-1520.02 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 1520 | T-1520X | 1-18" | 40 | 48" | 3.5 | 18" | 1 |
| | | | | | | | |
| **2200** | | | | | | | |
| to 2200.01 | P-2200.01 | Pump-60hp | 40 | ------ | ------ | ------ | 3 |
| to 2200.02 | P-2200.02 | Pump-95hp | 40 | ------ | ------ | ------ | 3 |
| to 2210 | T-2210 | 1-48" | 40 | 72" | 8.5 | 48" | 1 |
| to 2200.03 | P-2200.03 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 2200.04 | P-2200.04 | Pump-10hp | 40 | ------ | ------ | ------ | 3 |
| to 2220 | T-2220 | 1-18" | 40 | 48" | 5.5 | 18" | 1 |
| to 2230 | T-2230 | 1-30" | 40 | 48" | 6 | 30" | 4B |
| to 2240 | T-2240 | 2-24" | 40 | 48" | 4.5 | 24" | 2B |
| to 2250 | T-2250 | 1-18" | 40 | 48" | 4.5 | 18" | 1 |
| to 2260 | T-2260 | 1-18" | 40 | 48" | 4.5 | 18" | 1 |
| to 2200.05 | P-2200.05 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 2200 | T-2200X | 1-48" | 40 | 72" | 7.5 | 48" | 1 |
| | | | | | | | |
| **2230** | | | | | | | |
| to 2230.01 | P-2230.01 | Pump-8hp | 40 | 48" | 10 | 18" | 3 |
| to 2230 | T-2230X | 2-48" | 20 | 72" | 10 | 48" | 5B |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| LATERAL TURNOUTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Canal Number | Structure Name | Turnout Conduit | | Turnout Riser | | Gate Size | Typical Type |
| | | Diameter | Length (Ft.) | Diameter | Height (Ft.) | | |
| **2240** | | | | | | | |
| to 2240 | T-2240X | 2-24" | 40 | 48" | 10 | 24" | 5B |
| | | | | | | | |
| **2400** | | | | | | | |
| to 2410 | T-2410 | 1-30" | 40 | 48" | 5.5 | 30" | 1 |
| to 2400.01 | P-2400.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| | | | | | | | |
| **3100** | | | | | | | |
| to 3100.01 | P-3100.01 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 3100.02 | P-3100.02 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 3100 | T-3100X | 1-24" | 40 | 48" | 4.5 | 24" | 1 |
| | | | | | | | |
| **3200** | | | | | | | |
| to 3210 | T-3210 | 1-18" | 40 | 48" | 7.5 | 18" | 1 |
| to 3220 | T-3220 | 1-30" | 40 | 48" | 9 | 30" | 1 |
| to 3230 | T-3230 | 1-18" | 40 | 48" | 7.5 | 18" | 1 |
| to 3200.01 | P-3200.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 3240 | T-3240 | 1-18" | 40 | 48" | 6.5 | 18" | 1 |
| to 3250 | P-3250 | Pump-10hp | 40 | 48" | 6 | 18" | 3 |
| to 3260 | T-3260 | 1-30" | 40 | 54" | 7.5 | 30" | 1 |
| to 3200.02 | P-3200.02 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 3200.03 | P-3200.03 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 3200.04 | P-3200.04 | Pump-15hp | 40 | ------ | ------ | ------ | 3 |
| to 3200 | T-3200X | 1-24" | 40 | 48" | 5.5 | 24 | 1 |
| | | | | | | | |
| **3220** | | | | | | | |
| to 3221 | T-3221 | 1-24" | 40 | 48" | 3.5 | 24" | 1 |
| to 3222 | T-3222 | 1-18" | 40 | 48" | 4 | 18" | 1 |
| to 3220 | T-3220X | 1-30" | 40 | 54" | 5 | 30" | 1 |
| | | | | | | | |
| **3300** | | | | | | | |
| to 3300.01 | P-3300.01 | Pump-10hp | 40 | ------ | ------ | ------ | 3 |
| to 3300 | T-3300X | 1-24" | 40 | 48" | 4.5 | 24" | 1 |
| | | | | | | | |

| LATERAL TURNOUTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Canal Number | Structure Name | Turnout Conduit | | Turnout Riser | | Gate Size | Typical Type |
| | | Diameter | Length (Ft.) | Diameter | Height (Ft.) | | |
| **3400** | | | | | | | |
| to 3400 | T-3400X | 1-30" | 20 | 54 | 10 | 30" | 5A |
| | | | | | | | |
| **3500A** | | | | | | | |
| to 3500.01 | P-3500.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 3510 | T-3510 | 1-24" | 40 | 48" | 5 | 24" | 1 |
| | | | | | | | |
| **4100** | | | | | | | |
| to 4100.01 | P-4100.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 4100 | T-4100X | 2-48" | 40 | 72" | 10 | 48" | 5B |
| | | | | | | | |
| **4200** | | | | | | | |
| to 4200.01 | P-4200.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 4200.02 | P-4200.02 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 4200 | T-4200X | 1-30" | 40 | 48" | 10 | 30" | 5A |
| | | | | | | | |
| **4500** | | | | | | | |
| to 4510 | T-4510 | 1-24" | 50 | 48" | 7.5 | 24" | 2 |
| to 4520 | T-4520 | 1-24" | 40 | 48" | 4.5 | 24" | 1 |
| to 4500.01 | P-4500.01 | Pump-10hp | 40 | ------ | ------ | ------ | 3 |
| to 4500.02 | P-4500.02 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 4500.03 | T-4500.03 | 1-18" | 40 | 48" | 6 | 18" | 2A |
| | | | | | | | |
| **5300** | | | | | | | |
| to 5310 | T-5310 | 1-42" | 40 | 66" | 7.5 | 42" | 1 |
| to 5300.03 | P-5300.03 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 5300 | T-5300X | 2-42" | 40 | 66" | 7.5 | 42" | 1 |
| | | | | | | | |
| **5310** | | | | | | | |
| to 5311 | T-5311 | 2-36" | 40 | 54" | 7.5 | 36" | 5 |
| to 5310 | T-5310X | 2-36" | 40 | 54" | 7.5 | 36" | 5 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

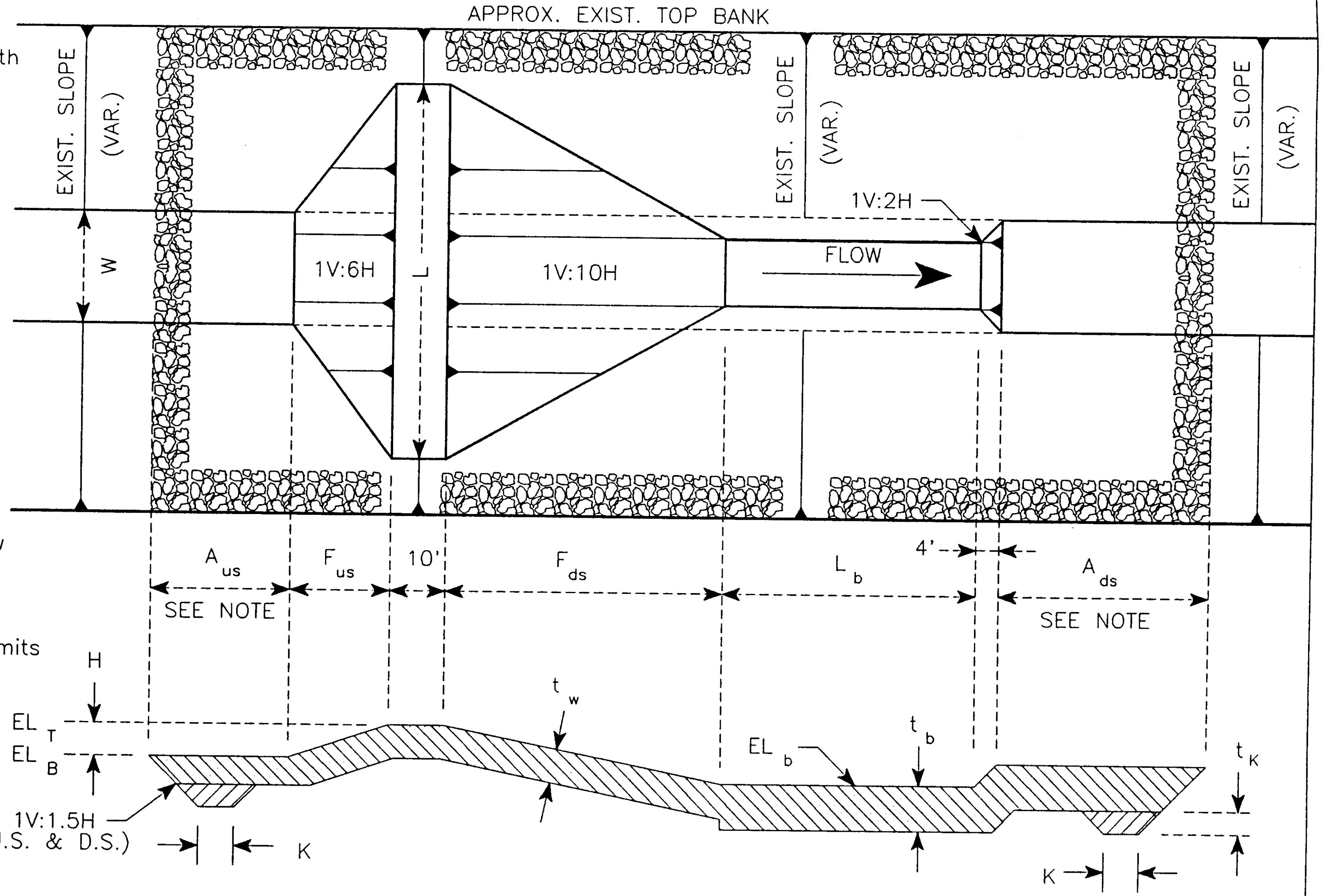
| LATERAL TURNOUTS | | | | | | | |
|---|---|---|---|---|---|---|---|
| Canal Number | Structure Name | Turnout Conduit | | Turnout Riser | | Gate Size | Typical Type |
| | | Diameter | Length (Ft.) | Diameter | Height (Ft.) | | |
| **5400** | | | | | | | |
| to 5400.01 | P-5400.01 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 5400.02 | P-5400.02 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| | | | | | | | |
| **5500** | | | | | | | |
| to 5510 | T-5510 | 1-24" | 40 | 48" | 7 | 24" | 1 |
| to 5500.02 | P-5500.02 | Pump-80hp | 40 | ------ | ------ | ------ | 3 |
| to 5500.03 | P-5500.03 | Pump-10hp | 40 | ------ | ------ | ------ | 3 |
| to 5500.04 | P-5500.04 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 5520 | T-5520 | 1-24" | 40 | 48" | 5.5 | 24" | 1 |
| to 5530 | T-5530 | 1-18" | 40 | 48" | 6 | 18" | 1 |
| to 5500.05 | P-5500.05 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 5500.06 | P-5500.06 | Pump-7.5hp | 40 | ------ | ------ | ------ | 3 |
| to 5505 | T-5505 | 1-42" | 40 | 66" | 7.5 | 42" | 1 |
| | | | | | | | |
| **6200** | | | | | | | |
| to 6210 | T-6210 | 1-24" | 40 | 48" | 7 | 24" | 1 |
| to 6200.02 | P-6200.02 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 6215 | T-6215 | 1-42" | 40 | 66" | 8 | 42" | 1 |
| to 6200.03 | P-6200.03 | Pump-5hp | 40 | ------ | ------ | ------ | 3 |
| to 6200.04 | P-6200.04 | Pump-15hp | 40 | ------ | ------ | ------ | 3 |
| to 6216 | T-6216 | 2-42" | 40 | 66" | 7.5 | 42" | 1 |
| to 6220 | T-6220 | 1-24" | 40 | 48" | 7 | 24" | 1 |
| to 6230 | T-6230 | 1-18" | 40 | 48" | 7 | 18" | 1 |
| to 6200.06 | P-6200.06 | 1-24" | 40 | 48" | 4 | 24" | 2A |
| to 6100 | T-6230X | 1-24" | 40 | 48" | 4 | 24" | 1 |
| | | | | | | | |
| **6600** | | | | | | | |
| to 6300 | T-6300X | 1-24" | 40 | 48" | 4 | 18" | 1 |
| to 6610 | T-6310 | 1-24" | 40 | 48" | 4 | 18" | 1 |
| to 6600.01 | P-6600.01 | Pump-7.5 | 40 | ------ | ------ | ------ | 3 |
| | | | | | | | |
| | | | | | | | |

ABBREVIATIONS:
W = Channel Width
L = Weir Length
F = Weir Face
K = Key Width
A = Apron
t = Thickness

SUBSCRIPTS:
T = Top
B = Bottom
w = Weir
b = Stilling Basin
us = Upstream
ds = Downstream

NOTE:
Increase Rip–Rap thickness (except $t_K$ & K) by 50% when placed below water surface.

= Rip–Rap Limits




EQUATIONS:

$F_{us} = H \times 6$

$F_{ds} = (H + 2) \times 10$

$t_b = t_w + 12''$

$t_K = t_w$ (NO 50% INCREASE)

$K = 2t_w$ (NO 50% INCREASE)

$A_{us} = [(t_K \times 1.5) \times 2 + (t_w \times 1.5) + 2t_w] / 12$

$A_{ds} = [(t_K \times 1.5) \times 2 + (t_b \times 1.5) + 2t_w] / 12$

NOTE:

$A_{us}$ AS COMPUTED FOR KEY
15' MINIMUM

$A_{ds}$ AS COMPUTED FOR KEY
15' MINIMUM FOR H ≤ 3'
20' MINIMUM FOR H > 3'

U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY
WEIR DIMENSIONS

H:\COMMON\EARK\CANALS\CYBERNET\WEIR.DWG

# TABLE 1 - WEIR LOCATIONS

| WEIR # | MILE | CHANNEL BANKFULL EL | CHANNEL BOTTOM EL | TOP OF WEIR EL | WEIR HEIGHT (H) | WEIR LENGTH (L) | MIN Q ESTIMATE D | MIN Q ACTUAL |
|---|---|---|---|---|---|---|---|---|
| **STUTTGART KING BAYOU** (SKB 5300) $H_{AVG}$ = 4.0 $L_{AVG}$ = 40 - Representative of 5310 & 5311 | | | | | | | | |
| W5300-01 | 8.227 | 185.00 | 173.70 | 179.00 | 5.30 | 40 | 500 | 450 |
| W5300-02 | 11.366 | 191.00 | 179.10 | 183.00 | 3.90 | 45 | 990 | 990 |
| **MILL BAYOU** (MB 6300) | | | | | | | | |
| ~~1~~ | ~~11.900~~ | ~~167.00~~ | ~~162.00~~ | ~~166.00~~ | ~~4.00~~ | ~~160~~ | ~~365~~ | ~~365~~ |
| ~~2~~ | ~~16.451~~ | ~~169.00~~ | ~~166.00~~ | ~~168.00~~ | ~~2.00~~ | ~~40~~ | ~~250~~ | ~~40~~ |
| W6300-03 | 18.047 | 172.00 | 168.00 | 170.00 | 2.00 | 50 | 265 | 150 |
| W6300-04 | 22.650 | 175.00 | 168.90 | 173.00 | 4.10 | 65 | 365 | 200 |
| W6300-05 | 24.138 | 179.00 | 174.50 | 177.00 | 2.50 | 20 | 640 | 640 |
| W6300-06 | 25.803 | 182.00 | 176.70 | 181.00 | 4.30 | 35 | 315 | 182 |
| W6300-07 | 27.400 | 186.00 | 183.10 | 185.50 | 2.40 | 50 | 126 | 65 |
| W6300-08 | 28.747 | 188.50 | 185.60 | 187.00 | 1.40 | 25 | 150 | 50 |
| W6300-09 | 30.100 | 191.00 | 187.00 | 190.00 | 3.00 | 175 | 250 | 150 |
| W6300-10 | 32.047 | 197.00 | 190.00 | 194.00 | 4.00 | 35 | 400 | 350 |
| W6300-11 | 34.945 | 205.00 | 197.50 | 200.00 | 2.50 | 30 | 300 | 275 |
| W6300-12 | 37.308 | 208.00 | 202.10 | 205.00 | 2.90 | 20 | 170 | 130 |
| **SHERRIL CREEK** (SC 5510) | | | | | | | | |
| W5510-01 | 0.270 | 187.50 | 184.30 | 186.50 | 2.20 | 60 | 370 | 200 |
| W5510-02 | 1.000 | 189.50 | 187.00 | 189.00 | 2.00 | 50 | 1050 | 100 |
| W5510-03 | 1.700 | 194.00 | 190.00 | 192.00 | 2.00 | 30 | 2935 | 250 |
| ~~W5510-04~~ | ~~4.000~~ | ~~—~~ | ~~—~~ | ~~—~~ | ~~—~~ | ~~—~~ | ~~—~~ | ~~—~~ |
| W5510-05 | 4.914 | 201.00 | 197.40 | 200.50 | 3.10 | 20 | 135 | 50 |
| W5510-06 | 6.344 | 205.00 | 200.90 | 204.00 | 3.10 | 25 | 245 | 100 |
| **ELM PRONG MILL BAYOU** (EPMB 6500) | | | | | | | | |
| W6500-01 | 0.028 | 186.00 | 181.00 | 185.00 | 4.00 | 55 | 500 | 300 |
| W6500-02 | 2.720 | 189.00 | 181.90 | 187.00 | 6.10 | 35 | 250 | 225 |
| W6500-03 | 4.000 | 192.00 | 187.80 | 190.50 | 3.20 | 35 | 250 | 175 |
| W6500-04 | 5.719 | 198.50 | 193.70 | 197.00 | 3.30 | 30 | 330 | 200 |
| **SOUTH MILL BAYOU** (SMB 6310) | | | | | | | | |
| W6310-01 | 0.130 | 200.00 | 195.50 | 198.00 | 2.50 | 25 | 175 | 125 |
| W6310-02 | 1.292 | 203.00 | 195.71 | 200.00 | 4.29 | 55 | 150 | 60 |
| W6310-03 | 2.374 | 205.75 | 199.41 | 203.00 | 3.59 | 25 | 180 | 200 |
| W6310-04 | 3.580 | 207.00 | 203.30 | 206.00 | 2.70 | 30 | 130 | 100 |
| **EAST STUTTGART KING BAYOU** (ESKB 6410) | | | | | | | | |
| W6410-01 | 0.000 | 188.00 | 181.20 | 184.00 | 2.80 | 20 | 260 | 260 |
| W6410-02 | 0.600 | 191.00 | 183.60 | 186.00 | 2.40 | 20 | 180 | 275 |
| W6410-03 | 1.090 | 193.00 | 186.10 | 189.00 | 2.90 | 20 | 275 | 275 |
| W6410-04 | 1.700 | 197.50 | 189.60 | 192.00 | 2.40 | 10 | 360 | 325 |
| W6410-05 | 2.104 | 199.00 | 191.50 | 195.00 | 3.50 | 15 | 240 | 200 |
| **WOLF ISLAND SLASH** (WIS 3510) | | | | | | | | |
| W3510-01 | 2.568 | 205.50 | 200.00 | 204.50 | 4.50 | 30 | 445 | 445 |
| W3510-02 | 5.829 | 210.50 | 204.57 | 208.50 | 3.93 | 15 | 300 | 100 |
| **LOST ISLAND BAYOU** (LIB 5100) $H_{AVG}$ = 3.0 $L_{AVG}$ = 25 - Representative of 2230, 2410, 3110, & 5530 | | | | | | | | |
| W5100-01 | 1.000 | 197.00 | 194.00 | 196.00 | 2.00 | 20 | 50 | 10 |
| W5100-02 | 4.060 | 202.00 | 194.50 | 200.00 | 5.50 | 30 | 1350 | 125 |
| EXISTING | 6.190 | — | — | — | — | — | — | — |
| **WILDCAT DITCH** (WD 6210) $H_{AVG}$ = 3.4 $L_{AVG}$ = 30 - Representative of 5520 | | | | | | | | |
| W6210-01 | 1.780 | 190.00 | 185.60 | 189.00 | 3.40 | 30 | 100 | 100 |
| **HURRICANE BAYOU** (HB 6610) | | | | | | | | |
| W6610-01 | 5.060 | 181.00 | 173.90 | 178.00 | 4.10 | 35 | 370 | 370 |
| W6610-02 | 7.330 | 185.00 | 179.25 | 183.00 | 3.75 | 15 | 175 | 100 |
| **LAGRUE BAYOU (LOWER) MILE 12.48 - MILE 72.16** (LBEX 2210) | | | | | | | | |
| ~~1~~ | ~~53.420~~ | ~~184.00~~ | ~~175.60~~ | ~~181.00~~ | ~~5.40~~ | ~~125~~ | ~~1325~~ | ~~1325~~ |
| W2210-02 | 56.050 | 190.00 | 184.10 | 188.00 | 3.90 | 135 | 900 | 750 |
| **LAGRUE BAYOU (UPPER) MILE 72.160 - MILE 94.308** (LB 3110) | | | | | | | | |
| W3110-01 | 79.100 | 210.00 | 200.60 | 206.00 | 5.40 | 60 | 810 | 810 |
| W3300-01 | 87.314 | 212.50 | 203.80 | 211.00 | 7.20 | 55 | 670 | 100 |
| | | | | | | | | |

| WEIR # | MILE | CHANNEL BANKFULL EL | CHANNEL BOTTOM EL | TOP OF WEIR EL | WEIR HEIGHT (H) | WEIR LENGTH (L) | MIN Q ESTIMATE D | MIN Q ACTUAL |
|---|---|---|---|---|---|---|---|---|
| **PECKERWOOD LATERAL** (P 2110) | | | | | | | | |
| NO WEIRS | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| **BARNES CREEK** (BC 3230) | | | | | | | | |
| W3230-01 | 4.900 | 199.00 | 192.10 | 196.10 | 4.00 | 25 | 600 | 600 |
| W3230-02 | 6.041 | 204.00 | 199.90 | 203.00 | 3.10 | 65 | 180 | 180 |
| W3230-03 | 6.700 | 208.00 | 204.20 | 207.00 | 2.80 | 65 | 150 | 150 |
| W3230-04 | 7.150 | 211.00 | 207.20 | 210.00 | 2.80 | 65 | 180 | 180 |
| W3230-05 | 7.628 | 214.00 | 210.60 | 213.00 | 2.40 | 10 | 130 | 50 |
| W3230-06 | 8.026 | 217.50 | 213.70 | 216.50 | 2.80 | 20 | 170 | 100 |
| W3230-07 | 8.766 | 222.00 | 218.40 | 221.00 | 2.60 | 20 | 130 | 60 |
| **HURRICANE CREEK** (HUC 3210) $H_{AVG}$ = 3.5 $L_{AVG}$ = 20 - Representative of 1300, 1400, 2300, 2500, 3200, 3221, | | | | | | | | |
| W3210-01 | 8.622 | 202.00 | 197.00 | 201.00 | 4.00 | 20 | 200 | 125 |
| W3210-02 | 9.225 | 207.50 | 202.03 | 205.50 | 3.47 | 20 | 260 | 260 |
| W3210-03 | 9.832 | 211.50 | 208.38 | 211.50 | 3.12 | 35 | 190 | 100 |
| W3210-04 | 10.960 | 220.50 | 215.78 | 219.50 | 3.72 | 10 | 150 | 50 |
| **HONEY CREEK** (2100) $H_{AVG}$ = 4.2 $L_{AVG}$ = 40 - Representative of 1500, 1510, 1520, 2200, 2240, 2250, & 2260 | | | | | | | | |
| W2100-01 | 2.980 | 173.00 | 166.40 | 172.00 | 5.60 | 45 | 350 | 250 |
| W2100-02 | 5.540 | 181.00 | 174.30 | 179.50 | 5.20 | 40 | 500 | 300 |
| W2100-03 | 8.000 | 188.00 | 182.30 | 187.00 | 4.70 | 40 | 400 | 200 |
| W2100-04 | 10.180 | 198.00 | 193.30 | 197.00 | 3.70 | 45 | 400 | 300 |
| W2100-05 | 11.760 | 202.00 | 197.10 | 201.00 | 3.90 | 25 | 150 | 50 |
| W2100-06 | 13.500 | 211.00 | 207.70 | 210.00 | 2.30 | 15 | 150 | 25 |
| **LITTLE LAGRUE BAYOU** (LLB 6100) | | | | | | | | |
| ~~1~~ | ~~1.900~~ | ~~153.00~~ | ~~148.00~~ | ~~152.00~~ | ~~4.00~~ | ~~65~~ | ~~40~~ | ~~100~~ |
| W6100-02 | 4.230 | 155.00 | 151.90 | 154.00 | 2.10 | 45 | 50 | 50 |
| W6100-03 | 5.460 | 165.00 | 154.26 | 160.00 | 5.74 | 105 | 2500 | 2500 |
| W6100-04 | 13.000 | 170.50 | 163.70 | 168.50 | 4.80 | 80 | 400 | 400 |
| W6100-05 | 15.510 | 173.00 | 167.70 | 171.00 | 3.30 | 40 | 350 | 200 |
| W6100-06 | 19.150 | 181.00 | 170.00 | 177.00 | 7.00 | 75 | 750 | 850 |
| W6100-07 | 23.530 | 184.00 | 176.70 | 182.00 | 5.30 | 85 | 500 | 500 |
| W6100-08 | 27.550 | 186.50 | 182.90 | 185.50 | 2.60 | 25 | 250 | 50 |
| W6100-09 | 28.940 | 188.00 | 185.06 | 187.00 | 1.94 | 50 | 200 | 50 |
| W6100-10 | 36.050 | 195.00 | 192.20 | 194.00 | 1.80 | 115 | 300 | 200 |
| W6100-11 | 44.169 | 205.50 | 201.90 | 204.00 | 2.10 | 30 | 180 | 200 |
| (1300) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W1300-01 | 1.500 | estimated | estimated | estimated | 4.00 | 20 | estimated | estimated |
| (1400) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W1400-01 | 3.500 | estimated | estimated | estimated | 4.00 | 20 | estimated | estimated |
| **PATE BRANCH** (1500) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W1500-01 | 2.300 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W1500-02 | 3.600 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| (1510) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W1510-01 | 0.000 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| (1520) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W1520-01 | 0.100 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W1520-02 | 0.800 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W1520-03 | 1.400 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| (2200) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2200-01 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| **WASHINGTON CREEK** (2220) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2220-01 | 0.400 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W2220-02 | 1.900 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| (2230) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W2230-01 | 0.400 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| W2230-02 | 1.600 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| (2240) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2240-01 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W2240-02 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W2240-03 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
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| WEIR # | MILE | CHANNEL BANKFULL EL | CHANNEL BOTTOM EL | TOP OF WEIR EL | WEIR HEIGHT (H) | WEIR LENGTH (L) | MIN Q ESTIMATE D | MIN Q ACTUAL |
|---|---|---|---|---|---|---|---|---|
| (2250) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2250-01 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W2250-02 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| (2260) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2260-01 | | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| **SOUTH FORK OF HURRICANE CREEK** (2300) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W2300-01 | 1.200 | estimated | estimated | estimated | 4.20 | 40 | estimated | estimated |
| W2300-02 | 1.800 | estimated | estimated | estimated | 3.50 | 40 | estimated | estimated |
| W2300-03 | 2.500 | estimated | estimated | estimated | 3.50 | 40 | estimated | estimated |
| **OAK CREEK** (2410) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W2410-01 | 0.000 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| W2410-02 | 0.900 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| W2410-03 | 1.650 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| W2410-04 | 2.800 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| W2410-05 | 3.500 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| W2410-06 | 4.200 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| **LITTLE HURRICANE CREEK** (2500) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W2500-01 | 1.200 | estimated | estimated | estimated | 3.50 | 25 | estimated | estimated |
| W2500-02 | 1.800 | estimated | estimated | estimated | 3.50 | 25 | estimated | estimated |
| W2500-03 | 3.300 | estimated | estimated | estimated | 3.50 | 25 | estimated | estimated |
| (3110) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W3100-01 | 0.750 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| (3200) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W3200-01 | 0.300 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| W3200-02 | 2.200 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| **PAYNE CREEK** (3221) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W3221-01 | 1.900 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| W3221-02 | 2.800 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| W3221-03 | 3.800 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| **JOHNSON BRANCH** (3261) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W3261-01 | 0.000 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| W3261-02 | 0.500 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| W3261-03 | 1.200 | estimated | estimated | estimated | 3.50 | 20 | estimated | estimated |
| (5310) Dimensions estimated using 5300 as a basis. | | | | | | | | |
| W5310-01 | 0.000 | estimated | estimated | estimated | 4.00 | 40 | estimated | estimated |
| W5310-02 | 1.700 | estimated | estimated | estimated | 4.00 | 40 | estimated | estimated |
| **CLEARPOINT CREEK** (5311) Dimensions estimated using 5300 as a basis. | | | | | | | | |
| W5311-01 | 0.000 | estimated | estimated | estimated | 4.00 | 40 | estimated | estimated |
| W5311-02 | 4.230 | estimated | estimated | estimated | 4.00 | 40 | estimated | estimated |
| W5311-03 | 6.450 | estimated | estimated | estimated | 4.00 | 40 | estimated | estimated |
| **LITTLE LAGRUE LATERAL** (5520) Dimensions estimated using 6210 as a basis. | | | | | | | | |
| W5520-01 | 0.000 | estimated | estimated | estimated | 3.40 | 30 | estimated | estimated |
| W5520-02 | 1.500 | estimated | estimated | estimated | 3.40 | 30 | estimated | estimated |
| (5530) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W5530-01 | 0.500 | estimated | estimated | estimated | 3.00 | 25 | estimated | estimated |
| (6220) Dimensions estimated using 6270 as a basis. | | | | | | | | |
| W6220-01 | 0.500 | estimated | estimated | estimated | 3.00 | 30 | estimated | estimated |
| W6220-02 | 1.900 | estimated | estimated | estimated | 3.00 | 30 | estimated | estimated |
| **HOLT BRANCH** (6230)) Dimensions estimated using 6270 as a basis. | | | | | | | | |
| W6230-01 | 0.500 | estimated | estimated | estimated | 3.00 | 30 | estimated | estimated |
| W6230-02 | 1.500 | estimated | estimated | estimated | 3.00 | 30 | estimated | estimated |
| W6230-03 | 2.000 | estimated | estimated | estimated | 3.00 | 30 | estimated | estimated |
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# TABLE 2 - STILLING BASIN LENGTHS

| FROM TABLE 1 | | | | FROM HEC-2 | FROM CALCULATIONS (SEE TABLE 2 FOOTNOTES) | | | |
|---|---|---|---|---|---|---|---|---|
| WEIR # | MILE | TOP OF WEIR EL | WEIR HEIGHT (H) | 10 YR CRIWS | $Y_C$ | $X_b$ | $L_b$ | $L_b$ ROUNDED |
| **STUTTGART KING BAYOU** (SKB 5300) $L_{b\ (AVG)}$ = 70 - Representative of 5310 & 5311 | | | | | | | | |
| W5300-01 | 8.227 | 179.00 | 5.30 | 182.37 | 3.37 | 34.51 | 69.02 | 70 |
| W5300-02 | 11.366 | 183.00 | 3.90 | 187.42 | 4.42 | 32.26 | 64.52 | 65 |
| **MILL BAYOU** (MB 6300) | | | | | | | | |
| ~~1~~ | ~~11.900~~ | ~~166.00~~ | ~~4.00~~ | — | — | — | — | — |
| ~~2~~ | ~~16.451~~ | ~~168.00~~ | ~~2.00~~ | — | — | — | — | — |
| W6300-03 | 18.047 | 170.00 | 2.00 | 172.95 | 2.95 | 18.96 | 37.93 | 40 |
| W6300-04 | 22.650 | 173.00 | 4.10 | 175.79 | 2.79 | 27.34 | 54.69 | 55 |
| W6300-05 | 24.138 | 177.00 | 2.50 | 177.76 | 0.76 | 13.34 | 26.68 | 30 |
| W6300-06 | 25.803 | 181.00 | 4.30 | 183.42 | 2.42 | 26.88 | 53.77 | 55 |
| W6300-07 | 27.400 | 185.50 | 2.40 | 186.59 | 1.09 | 14.08 | 28.17 | 30 |
| W6300-08 | 28.747 | 187.00 | 1.40 | 189.49 | 2.49 | 14.78 | 29.56 | 30 |
| W6300-09 | 30.100 | 190.00 | 3.00 | 191.01 | 1.01 | 16.36 | 32.71 | 35 |
| W6300-10 | 32.047 | 194.00 | 4.00 | 196.75 | 2.75 | 26.78 | 53.55 | 55 |
| W6300-11 | 34.945 | 200.00 | 2.50 | 202.66 | 2.66 | 20.07 | 40.13 | 45 |
| W6300-12 | 37.308 | 205.00 | 2.90 | 209.03 | 4.03 | 26.62 | 53.24 | 55 |
| **SHERRIL CREEK** (SC 5510) | | | | | | | | |
| W5510-01 | 0.270 | 186.50 | 2.20 | 188.86 | 2.36 | 17.73 | 35.45 | 40 |
| W5510-02 | 1.000 | 189.00 | 2.00 | 190.66 | 1.66 | 14.40 | 28.79 | 30 |
| W5510-03 | 1.700 | 192.00 | 2.00 | 195.02 | 3.02 | 19.21 | 38.42 | 40 |
| ~~W5510-04~~ | ~~4.000~~ | — | — | — | — | — | — | — |
| W5510-05 | 4.914 | 200.50 | 3.10 | 202.20 | 1.70 | 19.22 | 38.45 | 40 |
| W5510-06 | 6.344 | 204.00 | 3.10 | 205.79 | 1.79 | 19.54 | 39.09 | 40 |
| **ELM PRONG MILL BAYOU** (EPMB 6500) | | | | | | | | |
| W6500-01 | 0.028 | 185.00 | 4.00 | 185.34 | 0.34 | 18.24 | 36.49 | 40 |
| W6500-02 | 2.720 | 187.00 | 6.10 | 190.79 | 3.79 | 39.40 | 78.81 | 80 |
| W6500-03 | 4.000 | 190.50 | 3.20 | 193.80 | 3.30 | 25.31 | 50.63 | 55 |
| W6500-04 | 5.719 | 197.00 | 3.30 | 200.29 | 3.29 | 25.70 | 51.41 | 55 |
| **SOUTH MILL BAYOU** (SMB 6310) | | | | | | | | |
| W6310-01 | 0.130 | 198.00 | 2.50 | 200.71 | 2.71 | 20.24 | 40.49 | 45 |
| W6310-02 | 1.292 | 200.00 | 4.29 | 201.37 | 1.37 | 23.13 | 46.25 | 50 |
| W6310-03 | 2.374 | 203.00 | 3.59 | 205.33 | 2.33 | 23.54 | 47.08 | 50 |
| W6310-04 | 3.580 | 206.00 | 2.70 | 207.47 | 1.47 | 16.71 | 33.41 | 35 |
| **EAST STUTTGART KING BAYOU** (ESKB 6410) | | | | | | | | |
| W6410-01 | 0.000 | 184.00 | 2.80 | 188.91 | 4.91 | 29.31 | 58.62 | 60 |
| W6410-02 | 0.600 | 186.00 | 2.40 | 190.47 | 4.47 | 26.05 | 52.10 | 55 |
| W6410-03 | 1.090 | 189.00 | 2.90 | 193.84 | 4.84 | 29.49 | 58.98 | 60 |
| W6410-04 | 1.700 | 192.00 | 2.40 | 198.23 | 6.23 | 32.28 | 64.56 | 65 |
| W6410-05 | 2.104 | 195.00 | 3.50 | 198.75 | 3.75 | 28.19 | 56.37 | 60 |
| **WOLF ISLAND SLASH** (WIS 3510) | | | | | | | | |
| W3510-01 | 2.568 | 204.50 | 4.50 | 206.75 | 2.25 | 27.14 | 54.27 | 55 |
| W3510-02 | 5.829 | 208.50 | 3.93 | 211.52 | 3.02 | 27.43 | 54.87 | 55 |
| **LOST ISLAND BAYOU** (LIB 5100) $L_{b\ (AVG)}$ = 60 - Representative of 2230, 2410, 3110, & 5530 | | | | | | | | |
| W5100-01 | 1.000 | 196.00 | 2.00 | 198.32 | 2.32 | 16.73 | 33.47 | 35 |
| W5100-02 | 4.060 | 200.00 | 5.50 | 204.77 | 4.77 | 40.32 | 80.63 | 85 |
| EXISTING | 6.190 | 209.81 | 6.00 | | | | | |
| **WILDCAT DITCH** (WD 6210) $L_{b\ (AVG)}$ = 45 - Representative of 5520 | | | | | | | | |
| W6210-01 | 1.780 | 189.00 | 3.40 | 191.03 | 2.03 | 21.67 | 43.34 | 45 |
| **HURRICANE BAYOU** (HB 6610) | | | | | | | | |
| W6610-01 | 5.060 | 178.00 | 4.10 | 182.35 | 4.35 | 32.87 | 65.73 | 70 |
| W6610-02 | 7.330 | 183.00 | 3.75 | 186.04 | 3.04 | 26.74 | 53.47 | 55 |
| **LAGRUE BAYOU (LOWER) MILE 12.48 - MILE 72.16** (LBEX 2210) | | | | | | | | |
| ~~1~~ | ~~53.420~~ | ~~181.00~~ | ~~5.40~~ | ~~183.62~~ | ~~2.62~~ | ~~32.28~~ | ~~64.56~~ | ~~65~~ |
| W2210-02 | 56.050 | 188.00 | 3.90 | 190.48 | 2.48 | 25.39 | 50.79 | 55 |
| | | | | | | | | |
| | | | | | | | | |

| FROM TABLE 1 | | | | FROM HEC-2 | FROM CALCULATIONS (SEE TABLE 2 FOOTNOTES) | | | |
|---|---|---|---|---|---|---|---|---|
| WEIR # | MILE | TOP OF WEIR EL | WEIR HEIGHT (H) | 10 YR CRIWS | $Y_c$ | $X_b$ | $L_b$ | $L_b$ ROUNDED |
| **LAGRUE BAYOU (UPPER) MILE 72.160 - MILE 94.308** (LB 3110) | | | | | | | | |
| W3110-01 | 79.100 | 206.00 | 5.40 | 208.42 | 2.42 | 31.57 | 63.14 | 65 |
| W3300-01 | 87.314 | 211.00 | 7.20 | 213.71 | 2.71 | 40.27 | 80.53 | 85 |
| **PECKERWOOD LATERAL** (P 2110) | | | | | | | | |
| NO WEIRS | — | — | — | — | — | — | — | |
| **BARNES CREEK** (BC 3230) | | | | | | | | |
| W3230-01 | 4.900 | 196.10 | 4.00 | 197.61 | 1.51 | 22.39 | 44.77 | 45 |
| W3230-02 | 6.041 | 203.00 | 3.10 | 204.37 | 1.37 | 18.06 | 36.11 | 40 |
| W3230-03 | 6.700 | 207.00 | 2.80 | 208.79 | 1.79 | 18.26 | 36.53 | 40 |
| W3230-04 | 7.150 | 210.00 | 2.80 | 211.71 | 1.71 | 17.98 | 35.96 | 40 |
| W3230-05 | 7.628 | 213.00 | 2.40 | 215.93 | 2.93 | 20.60 | 41.19 | 45 |
| W3230-06 | 8.026 | 216.50 | 2.80 | 219.22 | 2.72 | 21.56 | 43.11 | 45 |
| W3230-07 | 8.766 | 221.00 | 2.60 | 223.74 | 2.74 | 20.78 | 41.55 | 45 |
| **HURRICANE CREEK** (HUC 3210) $L_{b\,(AVG)}$ = 50 - Representative of 1300, 1400, 2300, 2500, 3200, 3221, & 3261 | | | | | | | | |
| W3210-01 | 8.622 | 201.00 | 4.00 | 203.09 | 2.09 | 24.44 | 48.88 | 50 |
| W3210-02 | 9.225 | 205.50 | 3.47 | 208.06 | 2.56 | 23.84 | 47.69 | 50 |
| W3210-03 | 9.832 | 211.50 | 3.12 | 213.21 | 1.71 | 19.34 | 38.69 | 40 |
| W3210-04 | 10.960 | 219.50 | 3.72 | 221.93 | 2.43 | 24.45 | 48.90 | 50 |
| **HONEY CREEK** (2100)) $L_{b\,(AVG)}$ = 60 - Representative of 1500, 1510, 1520, 2200, 2240, 2250, & 2260 | | | | | | | | |
| W2100-01 | 2.980 | 172.00 | 5.60 | 175.36 | 3.36 | 35.75 | 71.50 | 75 |
| W2100-02 | 5.540 | 179.50 | 5.20 | 182.88 | 3.38 | 34.12 | 68.23 | 70 |
| W2100-03 | 8.000 | 187.00 | 4.70 | 189.83 | 2.83 | 30.04 | 60.08 | 60 |
| W2100-04 | 10.180 | 197.00 | 3.70 | 199.56 | 2.56 | 24.82 | 49.65 | 50 |
| W2100-05 | 11.760 | 201.00 | 3.90 | 204.21 | 3.21 | 27.98 | 55.95 | 55 |
| W2100-06 | 13.500 | 210.00 | 2.30 | 213.24 | 3.24 | 21.27 | 42.54 | 45 |
| **LITTLE LAGRUE BAYOU** (LLB 6100) | | | | | | | | |
| ~~1~~ | ~~1.900~~ | ~~152.00~~ | ~~4.00~~ | ~~153.82~~ | ~~1.82~~ | ~~23.48~~ | ~~46.97~~ | ~~50~~ |
| W6100-02 | 4.230 | 154.00 | 2.10 | 158.14 | 4.14 | 23.60 | 47.20 | 50 |
| W6100-03 | 5.460 | 160.00 | 5.74 | 163.06 | 3.06 | 35.28 | 70.57 | 70 |
| W6100-04 | 13.000 | 168.50 | 4.80 | 171.51 | 3.01 | 31.10 | 62.21 | 65 |
| W6100-05 | 15.510 | 171.00 | 3.30 | 174.62 | 3.62 | 26.87 | 53.75 | 55 |
| W6100-06 | 19.150 | 177.00 | 7.00 | 180.23 | 3.23 | 41.25 | 82.51 | 85 |
| W6100-07 | 23.530 | 182.00 | 5.30 | 185.14 | 3.14 | 33.69 | 67.39 | 70 |
| W6100-08 | 27.550 | 185.50 | 2.60 | 188.16 | 2.66 | 20.49 | 40.98 | 40 |
| W6100-09 | 28.940 | 187.00 | 1.94 | 189.64 | 2.64 | 17.61 | 35.22 | 35 |
| W6100-10 | 36.050 | 194.00 | 1.80 | 195.57 | 1.57 | 13.23 | 26.45 | 30 |
| W6100-11 | 44.169 | 204.00 | 2.10 | 207.17 | 3.17 | 20.17 | 40.34 | 40 |
| (1300) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W1300-01 | 1.500 | 0.00 | 3.50 | 2.20 | 2.20 | 22.70 | 45.40 | 45 |
| (1400) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W1400-01 | 3.500 | 0.00 | 3.50 | 2.20 | 2.20 | 22.70 | 45.40 | 45 |
| **PATE BRANCH** (1500) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W1500-01 | 2.300 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| W1500-02 | 3.600 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| (1510) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W1510-01 | 0.000 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| (1520) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W1520-01 | 0.100 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| W1520-02 | 0.800 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| W1520-03 | 1.400 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| (2200) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2200-01 | | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| **WASHINGTON CREEK** (2220) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2220-01 | 0.400 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| W2220-02 | 1.900 | 0.00 | 4.20 | 3.10 | 3.10 | 28.87 | 57.73 | 60 |
| (2230) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W2230-01 | 0.400 | 0.00 | 3.00 | 3.50 | 3.50 | 25.17 | 50.34 | 50 |
| W2230-02 | 1.600 | 0.00 | 3.00 | 3.50 | 3.50 | 25.17 | 50.34 | 50 |

| FROM TABLE 1 | | | | FROM HEC-2 | FROM CALCULATIONS (SEE TABLE 2 FOOTNOTES) | | | |
|---|---|---|---|---|---|---|---|---|
| WEIR # | MILE | TOP OF WEIR EL | WEIR HEIGHT (H) | 10 YR CRIWS | $Y_c$ | $X_b$ | $L_b$ | $L_b$ ROUNDED |
| (2240) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2240-01 | | 0.00 | 4.20 | 3.10 | 3.1 | 28.87 | 57.73 | 60 |
| W2240-02 | | 0.00 | 4.20 | 3.10 | 3.1 | 28.87 | 57.73 | 60 |
| W2240-03 | | 0.00 | 4.20 | 3.10 | 3.1 | 28.87 | 57.73 | 60 |
| (2250) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2250-01 | | 0.00 | 4.20 | 3.10 | 3.1 | 28.87 | 57.73 | 60 |
| W2250-02 | | 0.00 | 4.20 | 3.10 | 3.1 | 28.87 | 57.73 | 60 |
| (2260) Dimensions estimated using 2100 as a basis. | | | | | | | | |
| W2260-01 | | 0.00 | 4.20 | 3.10 | 3.1 | 28.87 | 57.73 | 60 |
| **SOUTH FORK OF HURRICANE CREEK** (2300) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W2300-01 | 1.200 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W2300-02 | 1.800 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W2300-03 | 2.500 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| **OAK CREEK** (2410) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W2410-01 | 0.000 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| W2410-02 | 0.900 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| W2410-03 | 1.650 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| W2410-04 | 2.800 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| W2410-05 | 3.500 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| W2410-06 | 4.200 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| **LITTLE HURRICANE CREEK** (2500) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W2500-01 | 1.200 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W2500-02 | 1.800 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W2500-03 | 3.300 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| (3110) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W3110-01 | 0.750 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| (3200) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W3200-01 | 0.300 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W3200-02 | 2.200 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| **PAYNE CREEK** (3221) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W3221-01 | 1.900 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W3221-02 | 2.800 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W3221-03 | 3.800 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| **JOHNSON BRANCH** (3261) Dimensions estimated using 3210 as a basis. | | | | | | | | |
| W3261-01 | 0.000 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W3261-02 | 0.500 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| W3261-03 | 1.200 | 0.00 | 3.50 | 2.20 | 2.2 | 22.70 | 45.40 | 45 |
| (5310) Dimensions estimated using 5300 as a basis. | | | | | | | | |
| W5310-01 | 0.000 | 0.00 | 4.00 | 3.60 | 3.6 | 29.78 | 59.57 | 60 |
| W5310-02 | 1.700 | 0.00 | 4.00 | 3.60 | 3.6 | 29.78 | 59.57 | 60 |
| **CLEARPOINT CREEK** (5311) Dimensions estimated using 5300 as a basis. | | | | | | | | |
| W5311-01 | 0.000 | 0.00 | 4.00 | 3.60 | 3.6 | 29.78 | 59.57 | 60 |
| W5311-02 | 4.230 | 0.00 | 4.00 | 3.60 | 3.6 | 29.78 | 59.57 | 60 |
| W5311-03 | 6.450 | 0.00 | 4.00 | 3.60 | 3.6 | 29.78 | 59.57 | 60 |
| **LITTLE LAGRUE LATERAL** (5520) Dimensions estimated using 6210 as a basis. | | | | | | | | |
| W5520-01 | 0.000 | 0.00 | 3.40 | 2.03 | 2.03 | 21.67 | 43.34 | 45 |
| W5520-02 | 1.500 | 0.00 | 3.40 | 2.03 | 2.03 | 21.67 | 43.34 | 45 |
| (5530) Dimensions estimated using 5100 as a basis. | | | | | | | | |
| W5530-01 | 0.500 | 0.00 | 3.00 | 3.50 | 3.5 | 25.17 | 50.34 | 50 |
| (6220) Dimensions estimated using 6270 as a basis. | | | | | | | | |
| W6220-01 | 0.500 | 0.00 | 3.00 | 2.50 | 2.5 | 21.63 | 43.26 | 45 |
| W6220-02 | 1.900 | 0.00 | 3.00 | 2.50 | 2.5 | 21.63 | 43.26 | 45 |
| **HOLT BRANCH** (6230) Dimensions estimated using 6270 as a basis. | | | | | | | | |
| W6230-01 | 0.500 | 0.00 | 3.00 | 2.50 | 2.5 | 21.63 | 43.26 | 45 |
| W6230-02 | 1.500 | 0.00 | 3.00 | 2.50 | 2.5 | 21.63 | 43.26 | 45 |
| W6230-03 | 2.000 | 0.00 | 3.00 | 2.50 | 2.5 | 21.63 | 43.26 | 45 |
| | | | | | | | | |
| | | | | | | | | |

**TABLE 2 FOOTNOTES:**

$Y_c$ = CRIWS - TOP OF WEIR EL

$X_b = [\ 3.54 + 4.26 \times (H/Y_c)\ ] \times Y_c$

$L_b = 2 \times (X_b)$

# TABLE 3 - WEIR DIMENSIONS

| FROM TABLE 1 | | | | TBL 2 | CHT | FROM EQUATIONS (SEE END OF TABLE) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WEIR # | MILE | H (FT) | L (FT) | $L_b$ (FT) | $t_w$ (IN) | $F_{us}$ (FT) | $F_{ds}$ (FT) | $t_b$ (IN) | $t_K$ (IN) | K (IN) | $A_{us}$ (FT) | $A_{ds}$ (FT) | TOT LEN |
| **STUTTGART KING BAYOU** (SKB 5300) | | | | | | | | | | | | | |
| W5300-01 | 8.227 | 5.30 | 40 | 70 | 18 | 32 | 73 | 30 | 18 | 36 | 15 | 20 | 224 |
| W5300-02 | 11.366 | 3.90 | 45 | 65 | 18 | 23 | 59 | 30 | 18 | 36 | 15 | 20 | 196 |
| **MILL BAYOU** (MB 6300) | | | | | | | | | | | | | |
| ~~1~~ | ~~11.900~~ | ~~4.00~~ | ~~160~~ | — | — | — | — | — | — | — | — | — | — |
| ~~2~~ | ~~16.451~~ | ~~2.00~~ | ~~40~~ | — | — | — | — | — | — | — | — | — | — |
| W6300-03 | 18.047 | 2.00 | 50 | 40 | 18 | 12 | 40 | 30 | 18 | 36 | 15 | 15 | 136 |
| W6300-04 | 22.650 | 4.10 | 65 | 55 | 18 | 25 | 61 | 30 | 18 | 36 | 15 | 20 | 190 |
| W6300-05 | 24.138 | 2.50 | 20 | 30 | 18 | 15 | 45 | 30 | 18 | 36 | 15 | 15 | 134 |
| W6300-06 | 25.803 | 4.30 | 35 | 55 | 18 | 26 | 63 | 30 | 18 | 36 | 15 | 20 | 193 |
| W6300-07 | 27.400 | 2.40 | 50 | 30 | 18 | 14 | 44 | 30 | 18 | 36 | 15 | 15 | 132 |
| W6300-08 | 28.747 | 1.40 | 25 | 30 | 18 | 8 | 34 | 30 | 18 | 36 | 15 | 15 | 116 |
| W6300-09 | 30.100 | 3.00 | 175 | 35 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 147 |
| W6300-10 | 32.047 | 4.00 | 35 | 55 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 188 |
| W6300-11 | 34.945 | 2.50 | 30 | 45 | 18 | 15 | 45 | 30 | 18 | 36 | 15 | 15 | 149 |
| W6300-12 | 37.308 | 2.90 | 20 | 55 | 18 | 17 | 49 | 30 | 18 | 36 | 15 | 15 | 165 |
| **SHERRIL CREEK** (SC 5510) | | | | | | | | | | | | | |
| W5510-01 | 0.270 | 2.20 | 60 | 40 | 18 | 13 | 42 | 30 | 18 | 36 | 15 | 15 | 139 |
| W5510-02 | 1.000 | 2.00 | 50 | 30 | 18 | 12 | 40 | 30 | 18 | 36 | 15 | 15 | 126 |
| W5510-03 | 1.700 | 2.00 | 30 | 40 | 18 | 12 | 40 | 30 | 18 | 36 | 15 | 15 | 136 |
| ~~W5510-04~~ | ~~4.000~~ | — | — | — | — | — | — | — | — | — | — | — | — |
| W5510-05 | 4.914 | 3.10 | 20 | 40 | 18 | 19 | 51 | 30 | 18 | 36 | 15 | 20 | 159 |
| W5510-06 | 6.344 | 3.10 | 25 | 40 | 18 | 19 | 51 | 30 | 18 | 36 | 15 | 20 | 159 |
| **ELM PRONG MILL BAYOU** (EPMB 6500) | | | | | | | | | | | | | |
| W6500-01 | 0.028 | 4.00 | 55 | 40 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 173 |
| W6500-02 | 2.720 | 6.10 | 35 | 80 | 18 | 37 | 81 | 30 | 18 | 36 | 15 | 20 | 247 |
| W6500-03 | 4.000 | 3.20 | 35 | 55 | 18 | 19 | 52 | 30 | 18 | 36 | 15 | 20 | 175 |
| W6500-04 | 5.719 | 3.30 | 30 | 55 | 18 | 20 | 53 | 30 | 18 | 36 | 15 | 20 | 177 |
| **SOUTH MILL BAYOU** (SMB 6310) | | | | | | | | | | | | | |
| W6310-01 | 0.130 | 2.50 | 25 | 45 | 18 | 15 | 45 | 30 | 18 | 36 | 15 | 15 | 149 |
| W6310-02 | 1.292 | 4.29 | 55 | 50 | 18 | 26 | 63 | 30 | 18 | 36 | 15 | 20 | 188 |
| W6310-03 | 2.374 | 3.59 | 25 | 50 | 18 | 22 | 56 | 30 | 18 | 36 | 15 | 20 | 176 |
| W6310-04 | 3.580 | 2.70 | 30 | 35 | 18 | 16 | 47 | 30 | 18 | 36 | 15 | 15 | 142 |
| **EAST STUTTGART KING BAYOU** (ESKB 6410) | | | | | | | | | | | | | |
| W6410-01 | 0.000 | 2.80 | 20 | 60 | 18 | 17 | 48 | 30 | 18 | 36 | 15 | 15 | 169 |
| W6410-02 | 0.600 | 2.40 | 20 | 55 | 18 | 14 | 44 | 30 | 18 | 36 | 15 | 15 | 157 |
| W6410-03 | 1.090 | 2.90 | 20 | 60 | 18 | 17 | 49 | 30 | 18 | 36 | 15 | 15 | 170 |
| W6410-04 | 1.700 | 2.40 | 10 | 65 | 18 | 14 | 44 | 30 | 18 | 36 | 15 | 15 | 167 |
| W6410-05 | 2.104 | 3.50 | 15 | 60 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 185 |
| **WOLF ISLAND SLASH** (WIS 3510) | | | | | | | | | | | | | |
| W3510-01 | 2.568 | 4.50 | 30 | 55 | 18 | 27 | 65 | 30 | 18 | 36 | 15 | 20 | 196 |
| W3510-02 | 5.829 | 3.93 | 15 | 55 | 18 | 24 | 59 | 30 | 18 | 36 | 15 | 20 | 187 |
| **LOST ISLAND BAYOU** (LIB 5100) | | | | | | | | | | | | | |
| W5100-01 | 1.000 | 2.00 | 20 | 35 | 18 | 12 | 40 | 30 | 18 | 36 | 15 | 15 | 131 |
| W5100-02 | 4.060 | 5.50 | 30 | 85 | 18 | 33 | 75 | 30 | 18 | 36 | 15 | 20 | 242 |
| EXISTING | 6.190 | — | — | — | — | — | — | — | — | — | — | — | — |
| **WILDCAT DITCH** (WD 6210) | | | | | | | | | | | | | |
| W6210-01 | 1.780 | 3.40 | 30 | 45 | 18 | 20 | 54 | 30 | 18 | 36 | 15 | 20 | 168 |
| **HURRICANE BAYOU** (HB 6610) | | | | | | | | | | | | | |
| W6610-01 | 5.060 | 4.10 | 35 | 70 | 18 | 25 | 61 | 30 | 18 | 36 | 15 | 20 | 205 |
| W6610-02 | 7.330 | 3.75 | 15 | 55 | 18 | 23 | 58 | 30 | 18 | 36 | 15 | 20 | 184 |
| **LAGRUE BAYOU (LOWER) MILE 12.48 - MILE 72.16** (LBEX 2210) | | | | | | | | | | | | | |
| ~~1~~ | ~~53.420~~ | ~~5.40~~ | ~~125~~ | ~~65~~ | ~~18~~ | ~~32~~ | ~~74~~ | ~~30~~ | ~~18~~ | ~~36~~ | ~~15~~ | ~~20~~ | ~~220~~ |
| W2210-02 | 56.050 | 3.90 | 135 | 55 | 18 | 23 | 59 | 30 | 18 | 36 | 15 | 20 | 186 |
| **LAGRUE BAYOU (UPPER) MILE 72.160 - MILE 94.308** (LB 3110) | | | | | | | | | | | | | |
| W3110-01 | 79.100 | 5.40 | 60 | 65 | 18 | 32 | 74 | 30 | 18 | 36 | 15 | 20 | 220 |
| W3300-01 | 87.314 | 7.20 | 55 | 85 | 18 | 43 | 92 | 30 | 18 | 36 | 15 | 20 | 269 |

| FROM TABLE 1 | | | | TBL 2 | CHT | FROM EQUATIONS (SEE END OF TABLE) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WEIR # | MILE | H (FT) | L (FT) | $L_b$ (FT) | $t_w$ (IN) | $F_{us}$ (FT) | $F_{ds}$ (FT) | $t_b$ (IN) | $t_K$ (IN) | K (IN) | $A_{us}$ (FT) | $A_{ds}$ (FT) | TOT LEN |
| **PECKERWOOD LATERAL** (P 2110) | | | | | | | | | | | | | |
| NO WEIRS | — | — | — | — | — | — | — | — | — | — | — | — | — |
| **BARNES CREEK** (BC 3230) | | | | | | | | | | | | | |
| W3230-01 | 4.900 | 4.00 | 25 | 45 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 178 |
| W3230-02 | 6.041 | 3.10 | 65 | 40 | 18 | 19 | 51 | 30 | 18 | 36 | 15 | 20 | 159 |
| W3230-03 | 6.700 | 2.80 | 65 | 40 | 18 | 17 | 48 | 30 | 18 | 36 | 15 | 15 | 149 |
| W3230-04 | 7.150 | 2.80 | 65 | 40 | 18 | 17 | 48 | 30 | 18 | 36 | 15 | 15 | 149 |
| W3230-05 | 7.628 | 2.40 | 10 | 45 | 18 | 14 | 44 | 30 | 18 | 36 | 15 | 15 | 147 |
| W3230-06 | 8.026 | 2.80 | 20 | 45 | 18 | 17 | 48 | 30 | 18 | 36 | 15 | 15 | 154 |
| W3230-07 | 8.766 | 2.60 | 20 | 45 | 18 | 16 | 46 | 30 | 18 | 36 | 15 | 15 | 151 |
| **HURRICANE CREEK** (HUC 3210) | | | | | | | | | | | | | |
| W3210-01 | 8.622 | 4.00 | 20 | 50 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 183 |
| W3210-02 | 9.225 | 3.47 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W3210-03 | 9.832 | 3.12 | 35 | 40 | 18 | 19 | 51 | 30 | 18 | 36 | 15 | 20 | 159 |
| W3210-04 | 10.960 | 3.72 | 10 | 50 | 18 | 22 | 57 | 30 | 18 | 36 | 15 | 20 | 179 |
| **HONEY CREEK** (2100) | | | | | | | | | | | | | |
| W2100-01 | 2.980 | 5.60 | 45 | 75 | 18 | 34 | 76 | 30 | 18 | 36 | 15 | 20 | 234 |
| W2100-02 | 5.540 | 5.20 | 40 | 70 | 18 | 31 | 72 | 30 | 18 | 36 | 15 | 20 | 222 |
| W2100-03 | 8.000 | 4.70 | 40 | 60 | 18 | 28 | 67 | 30 | 18 | 36 | 15 | 20 | 204 |
| W2100-04 | 10.180 | 3.70 | 45 | 50 | 18 | 22 | 57 | 30 | 18 | 36 | 15 | 20 | 178 |
| W2100-05 | 11.760 | 3.90 | 25 | 55 | 18 | 23 | 59 | 30 | 18 | 36 | 15 | 20 | 186 |
| W2100-06 | 13.500 | 2.30 | 15 | 45 | 18 | 14 | 43 | 30 | 18 | 36 | 15 | 15 | 146 |
| **LITTLE LAGRUE BAYOU** (LLB 6100) | | | | | | | | | | | | | |
| ~~1~~ | ~~1.900~~ | ~~4.00~~ | ~~65~~ | ~~50~~ | ~~18~~ | ~~24~~ | ~~60~~ | ~~30~~ | ~~18~~ | ~~36~~ | ~~15~~ | ~~20~~ | ~~183~~ |
| W6100-02 | 4.230 | 2.10 | 45 | 50 | 18 | 13 | 41 | 30 | 18 | 36 | 15 | 15 | 148 |
| W6100-03 | 5.460 | 5.74 | 105 | 70 | 18 | 34 | 77 | 30 | 18 | 36 | 15 | 20 | 231 |
| W6100-04 | 13.000 | 4.80 | 80 | 65 | 18 | 29 | 68 | 30 | 18 | 36 | 15 | 20 | 211 |
| W6100-05 | 15.510 | 3.30 | 40 | 55 | 18 | 20 | 53 | 30 | 18 | 36 | 15 | 20 | 177 |
| W6100-06 | 19.150 | 7.00 | 75 | 85 | 18 | 42 | 90 | 30 | 18 | 36 | 15 | 20 | 266 |
| W6100-07 | 23.530 | 5.30 | 85 | 70 | 18 | 32 | 73 | 30 | 18 | 36 | 15 | 20 | 224 |
| W6100-08 | 27.550 | 2.60 | 25 | 40 | 18 | 16 | 46 | 30 | 18 | 36 | 15 | 15 | 146 |
| W6100-09 | 28.940 | 1.94 | 50 | 35 | 18 | 12 | 39 | 30 | 18 | 36 | 15 | 15 | 130 |
| W6100-10 | 36.050 | 1.80 | 115 | 30 | 18 | 11 | 38 | 30 | 18 | 36 | 15 | 15 | 123 |
| W6100-11 | 44.169 | 2.10 | 30 | 40 | 18 | 13 | 41 | 30 | 18 | 36 | 15 | 15 | 138 |
| (1300) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W1300-01 | 1.500 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| (1400) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W1400-01 | 3.500 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| **PATE BRANCH** (1500) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W1500-01 | 2.300 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W1500-02 | 3.600 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| (1510) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W1510-01 | 0.000 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| (1520) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W1520-01 | 0.100 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W1520-02 | 0.800 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W1520-03 | 1.400 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| (2200) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W-2200- | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| **WASHINGTON CREEK** (2220) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W2220-01 | 0.400 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W2220-02 | 1.900 | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| (2230) Dimensions estimated using 5100 as a basis. | | | | | | | | | | | | | |
| W2230-01 | 0.400 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| W2230-02 | 1.600 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| (2240) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W2240-01 | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W2240-02 | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W2240-03 | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |

| FROM TABLE 1 | | | | TBL 2 | CHT | FROM EQUATIONS (SEE END OF TABLE) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WEIR # | MILE | H (FT) | L (FT) | $L_b$ (FT) | $t_w$ (IN) | $F_{us}$ (FT) | $F_{ds}$ (FT) | $t_b$ (IN) | $t_K$ (IN) | K (IN) | $A_{us}$ (FT) | $A_{ds}$ (FT) | TOT LEN |
| (2250) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W2250-01 | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| W2250-02 | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| (2260) Dimensions estimated using 2100 as a basis. | | | | | | | | | | | | | |
| W2260-01 | | 4.20 | 40 | 60 | 18 | 25 | 62 | 30 | 18 | 36 | 15 | 20 | 196 |
| **SOUTH FORK OF HURRICANE CREEK** (2300) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W2300-01 | 1.200 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W2300-02 | 1.800 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W2300-03 | 2.500 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| **OAK CREEK** (2410) Dimensions estimated using 5100 as a basis. | | | | | | | | | | | | | |
| W2410-01 | 0.000 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| W2410-02 | 0.900 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| W2410-03 | 1.650 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| W2410-04 | 2.800 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| W2410-05 | 3.500 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| W2410-06 | 4.200 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| **LITTLE HURRICANE CREEK** (2500) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W2500-01 | 1.200 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W2500-02 | 1.800 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W2500-03 | 3.300 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| (3110) Dimensions estimated using 5100 as a basis. | | | | | | | | | | | | | |
| W3110-01 | 0.750 | 3.00 | 25 | 50 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 162 |
| (3200) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W3200-01 | 0.300 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W3200-02 | 2.200 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| **PAYNE CREEK** (3221) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W3221-01 | 1.900 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W3221-02 | 2.800 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W3221-03 | 3.800 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| **JOHNSON BRANCH** (3261) Dimensions estimated using 3210 as a basis. | | | | | | | | | | | | | |
| W3261-01 | 0.000 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W3261-02 | 0.500 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| W3261-03 | 1.200 | 3.50 | 20 | 50 | 18 | 21 | 55 | 30 | 18 | 36 | 15 | 20 | 175 |
| (5310) Dimensions estimated using 5300 as a basis. | | | | | | | | | | | | | |
| W5310-01 | 0.000 | 4.00 | 40 | 70 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 203 |
| W5310-02 | 1.700 | 4.00 | 40 | 70 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 203 |
| **CLEARPOINT CREEK** (5311) Dimensions estimated using 5300 as a basis. | | | | | | | | | | | | | |
| W5311-01 | 0.000 | 4.00 | 40 | 70 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 203 |
| W5311-02 | 4.230 | 4.00 | 40 | 70 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 203 |
| W5311-03 | 6.450 | 4.00 | 40 | 70 | 18 | 24 | 60 | 30 | 18 | 36 | 15 | 20 | 203 |
| **LITTLE LAGRUE LATERAL** (5520) Dimensions estimated using 6210 as a basis. | | | | | | | | | | | | | |
| W5520-01 | 0.000 | 3.40 | 30 | 45 | 18 | 20 | 54 | 30 | 18 | 36 | 15 | 20 | 168 |
| W5520-02 | 1.500 | 3.40 | 30 | 45 | 18 | 20 | 54 | 30 | 18 | 36 | 15 | 20 | 168 |
| (5530) Dimensions estimated using 5100 as a basis. | | | | | | | | | | | | | |
| W5530-01 | 0.500 | 3.00 | 25 | 60 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 172 |
| (6220) Dimensions estimated using 6270 as a basis. | | | | | | | | | | | | | |
| W6220-01 | 0.500 | 3.00 | 30 | 55 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 167 |
| W6220-02 | 1.900 | 3.00 | 30 | 55 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 167 |
| **HOLT BRANCH** (6230)) Dimensions estimated using 6270 as a basis. | | | | | | | | | | | | | |
| W6230-01 | 0.500 | 3.00 | 30 | 55 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 167 |
| W6230-02 | 1.500 | 3.00 | 30 | 55 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 167 |
| W6230-03 | 2.000 | 3.00 | 30 | 55 | 18 | 18 | 50 | 30 | 18 | 36 | 15 | 15 | 167 |

**EQUATIONS**

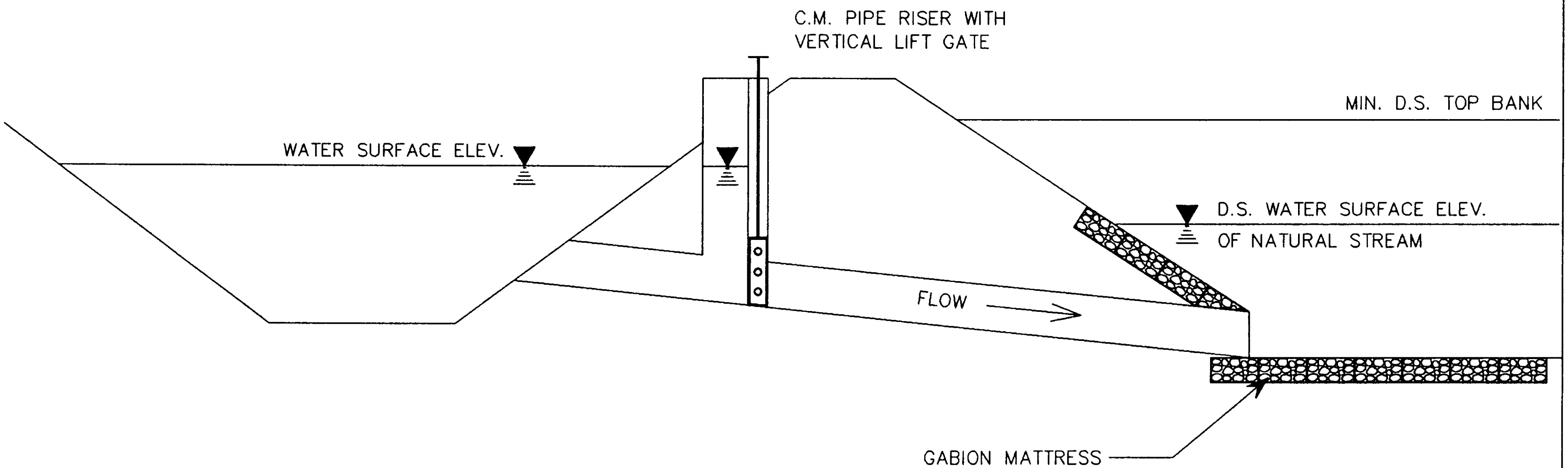
$F_{us} = H \times 6$ $\qquad$ $F_{ds} = (H \times 2) \times 10$

$t_b = t_w + 12"$ $\qquad$ $t_K = t_w$ $\qquad$ $K = 2 \times t_w$

$A_{us} = \{(t_K \times 1.5) \times 2 + (t_w \times 1.5) + (2 \times t_w)\} \div 12$

$A_{ds} = \{(t_K \times 1.5) \times 2 + (t_b \times 1.5) + (2 \times t_w)\} \div 12$

# WASTEWAY
## Side (Gravity) Flow to Natural Stream




U.S. ARMY CORPS OF ENGINEERS
Memphis District

EASTERN ARKANSAS REGION
COMPREHENSIVE STUDY
TYPICAL WASTEWAY

H: \COMMON\EARK\CANALS\CYBERNET\TURNOUT.DWG

# COMPUTATION SHEET

PROJECT Grand Prairie Demostration Project
Eastern Arkansas

PAGE OF

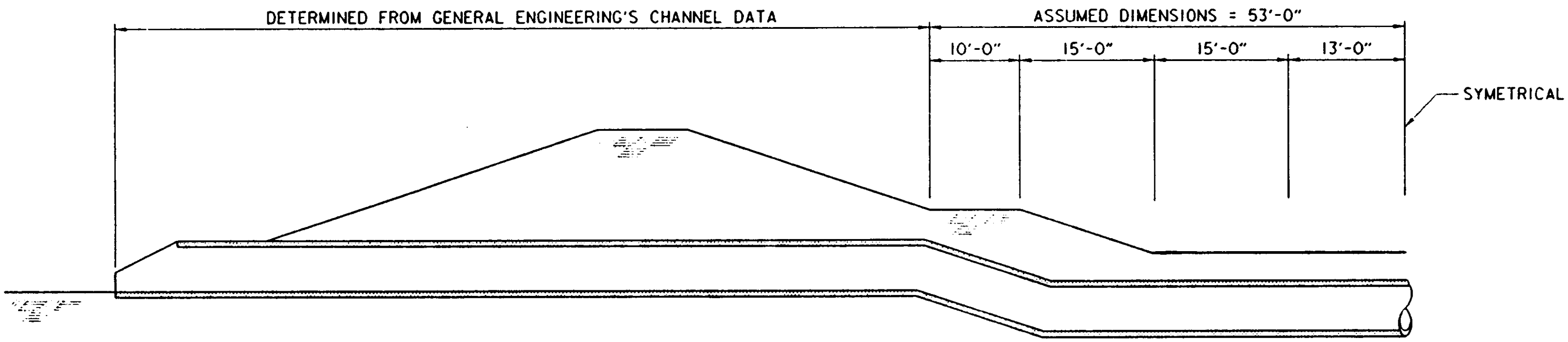
COMPUTED BY MSW

DATE 9/20/96

SUBJECT Inverted Pipe Siphons Design

CHECKED BY

DATE




**TYPICAL CROSS SECTION**
N.T.S.

# COMPUTATION SHEET

PROJECT Grand Prairie Demonstration Project Eastern Arkansas

SUBJECT Inverted Box Culvert Design

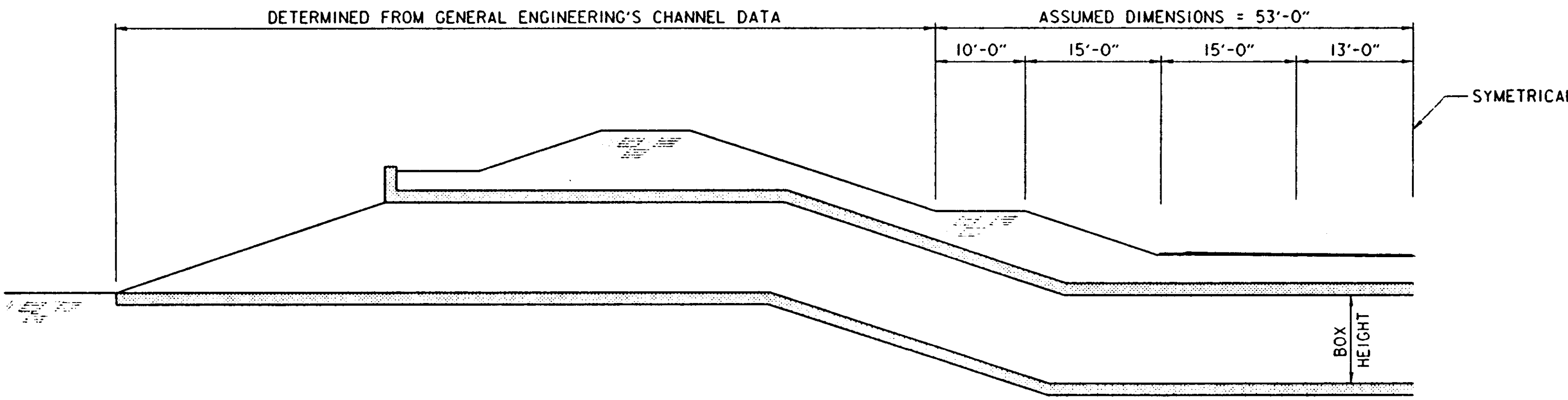
PAGE OF

COMPUTED BY MSW

DATE 9/20/96

CHECKED BY

DATE




## TYPICAL CROSS SECTION

N.T.S.

# COMPUTATION SHEET

PROJECT Grand Prairie Demonstration Project
Eastern Arkansas

SUBJECT Bridge Design

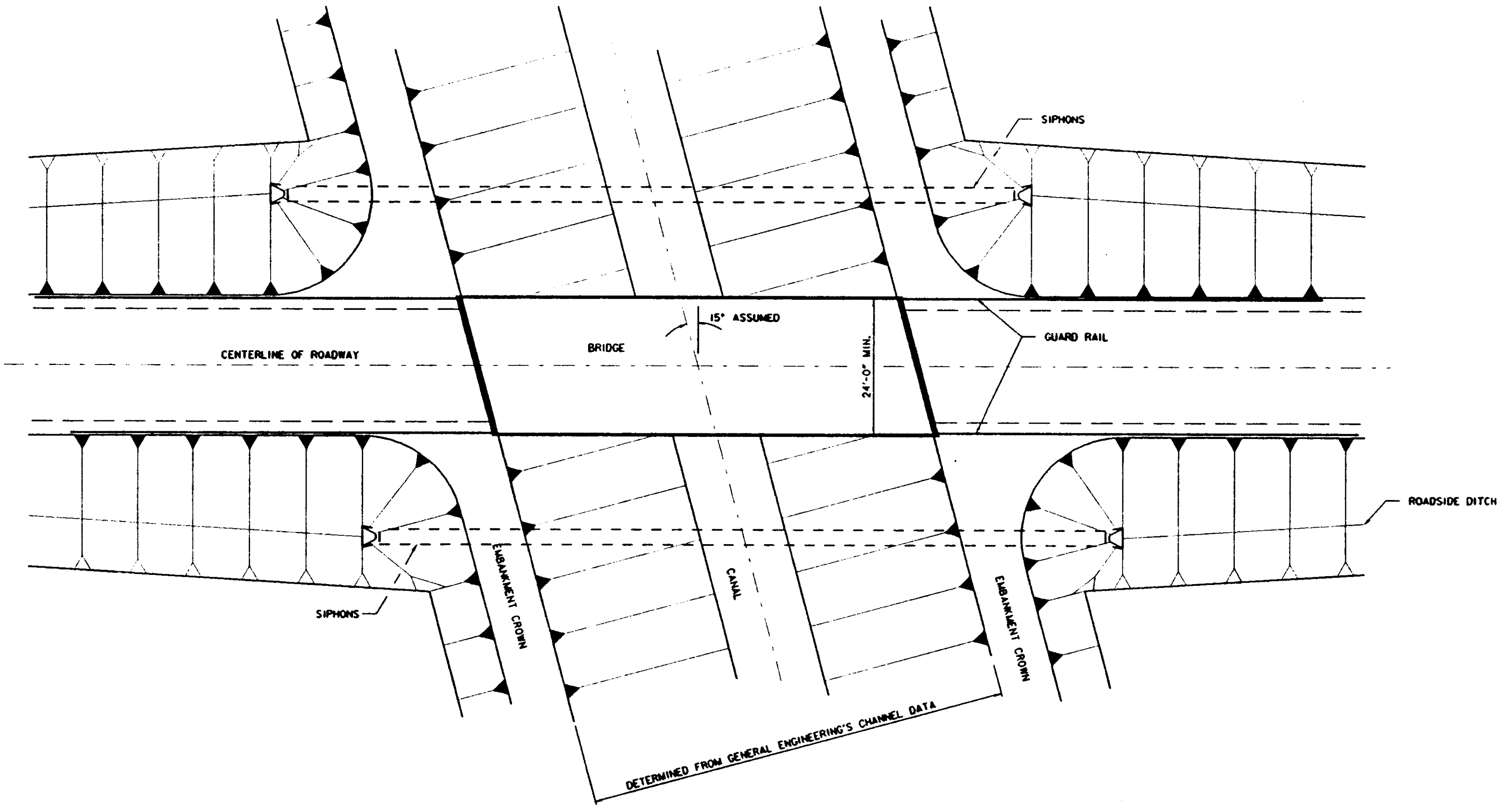
PAGE OF

COMPUTED BY MSW

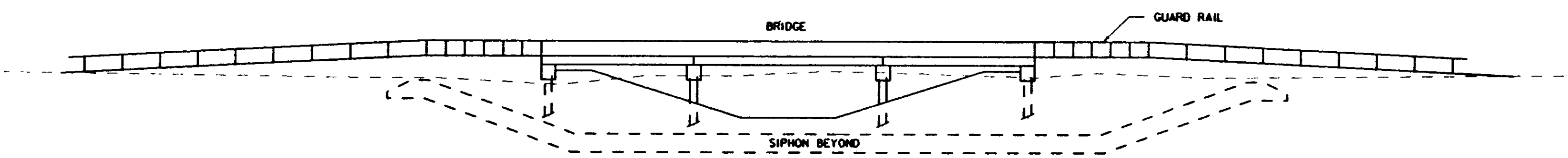
DATE 92096

CHECKED BY

DATE




**TYPICAL SITE LAYOUT**
N.T.S.




**CENTERLINE PROFILE**
N.T.S.

**ROAD CROSSINGS**

| CANAL NUMBER | GENERAL DESCRIPTION | CULVERTS REQUIRED | | | | | BRIDGE REQ'D | | SPECIAL NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | QUAN. | LEN. | PIPE DIA | BOX | | | | |
| | | | | | HEIGHT | WIDTH | Y/N | LOW CHD | |
| CV1000-1 | CO.RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV1000-3 | CO. RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV1000-5 | US 70 | 7 | 250 | | 8 | 10 | | | CULVERT |
| | | | | | | | | | |
| CV2000-1 | CO. RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-1A | CO. RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-2 | CO. RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-2B | CO. RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-3 | CO. RD. | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-4 | SR 11 | 7 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-5 | CO. RD. | 6 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-6 | SR 249 | 6 | 250 | | 8 | 10 | | | CULVERT |
| CV2000-7 | SR 249 | 6 | 250 | | 8 | 10 | | | CULVERT |
| | | | | | | | | | |
| BR3000-1 | CO. RD. | | | | | | YES | 229.50 | BRIDGE |
| BR3000-2 | Airfield Rd. | | | | | | YES | 229.10 | BRIDGE |
| BR3000-4 | CO. RD. | | | | | | YES | 229.65 | BRIDGE |
| CV3000-5 | SR 86 | 5 | 250 | | 8 | 10 | | | CULVERT |
| BR3000-6 | CO. RD. | | | | | | YES | 228.10 | BRIDGE |
| CV3000-7 | FIELD RD. | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| CV3000-10 | CO. RD. | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| CV3000-11 | CO. RD. | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| | | | | | | | | | |
| CV4000-2 | CO. RD. | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| CV4000-3 | SR 86 | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| CV4000-4 | CO. RD. | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| BR4000-6 | CO. RD. | | | | | | YES | 223.60 | BRIDGE |
| BR4000-7 | CO. RD. | | | | | | YES | 223.40 | BRIDGE |
| BR4000-8 | CO. RD. | | | | | | YES | 223.40 | BRIDGE |
| BR4000-10 | CO. RD. | | | | | | YES | 223.90 | BRIDGE |
| BR4000-11 | CO. RD. | | | | | | YES | 222.70 | BRIDGE |
| BR4000-12 | CO. RD. | | | | | | YES | 222.20 | BRIDGE |
| | | | | | | | | | |
| CV5000-1A | CO. RD. | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| CV5000-1 | SR. 11 | 5 | 250 | | 7.5 | 10 | | | CULVERT |
| CV5000-3 | CO. RD. | 4 | 250 | | 7.5 | 10 | | | CULVERT |
| CV5000-5 | CO. RD. | 4 | 250 | | 7.5 | 10 | | | CULVERT |
| CV5000-6 | CO. RD. | 4 | 250 | | 7.5 | 10 | | | CULVERT |
| CV5000-6A | CO. RD. | 4 | 250 | | 7.5 | 10 | | | CULVERT |
| | | | | | | | | | |
| CV6000-1 | CO. RD. | 4 | 250 | | 7.5 | 10 | YES | 217.90 | CULVERT & BR |
| CV6000-2 | CO. RD. | 4 | 250 | | 7.5 | 10 | | | CULVERT |
| CV6000-3/4 | US 79 & R/R | 4 | 250 | | 7.5 | 10 | | | CULVERT |
| CV6000-5 | SR 146 | 4 | 1000 | | 7.5 | 10 | | | CULVERT |
| CV6000-5A | CO. RD. | 4 | 1000 | | 7.5 | 10 | | | CULVERT |
| CV6000-5B | DRIVE | 4 | 1000 | | 7.5 | 10 | | | CULVERT |
| CV6000-6 | CO. RD. | 3 | 250 | | 7.5 | 10 | | | CULVERT |
| CV6000-8 | CO. RD. | 3 | 250 | | 7.5 | 10 | | | CULVERT |
| CV6000-9 | SR 11/130 | 3 | 250 | 8 | | | | | CULVERT |
| CV6000-9A | FIELD RD. | | | | | | | | |
| CV6000-10 | abandoned R/R | 3 | 250 | 8 | | | | | |

| CANAL NUMBER | GENERAL DESCRIPTION | CULVERTS REQUIRED | | | | | BRIDGE REQ'D | | SPECIAL NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | QUAN. | LEN. | PIPE DIA | BOX | | | | |
| | | | | | HEIGHT | WIDTH | Y/N | LOW CHD | |
| CV6000-11 | CO. RD. | 3 | 250 | 8 | | | | | CULVERT |
| BR6000-12 | CO. RD. | | | | | | YES | 208.90 | BRIDGE |
| BR6000-14 | CO. RD. | | | | | | YES | 207.70 | BRIDGE |
| CV6000-15 | FIELD RD. | 3 | 250 | 8 | | | | | CULVERT |
| CV6000-16 | FIELD RD. | 3 | 250 | 8 | | | | | CULVERT |
| CV6000-17 | CO. RD. | 3 | 250 | 8 | | | | | CULVERT |
| CV6000-18 | CO. RD. | 3 | 250 | 8 | | | | | CULVERT |
| CV6000-18B | CO. RD. | 3 | 250 | 8 | | | | | CULVERT |
| CV6000-19 | CO. RD. | 3 | 250 | 6 | | | | | CULVERT |
| CV6000-19B | CO. RD. | 3 | 250 | 6 | | | | | CULVERT |
| CV6000-20 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV6000-23 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV6000-25 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| | | | | | | | | | |
| CV1500-1 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV1500-3 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV1500-4 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| CV1500-6 | SR 33 | 2 | 250 | 2 | | | | | CULVERT |
| | | | | | | | | | |
| CV1520-1 | CO. RD. | 1 | 250 | 2 | | | | | CULVERT |
| | | | | | | | | | |
| CV2200-1 | CO. RD. | 2 | 250 | 8 | | | | | CULVERT |
| CV2200-4 | CO. RD. | 2 | 250 | 8 | | | | | CULVERT |
| CV2200-5 | CO. RD. | 2 | 250 | 8 | | | | | CULVERT |
| CV2200-6 | CO. RD. | 2 | 250 | 8 | | | | | CULVERT |
| CV2200-8 | CO. RD. | 2 | 250 | 8 | | | | | CULVERT |
| CV2200-10 | CO. RD. | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-11 | DRIVE | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-12 | SR 86 | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-14 | DR. | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-15 | FIELD RD. | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-16 | SR 86 (arbitrary) | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-18 | FIELD RD. | 2 | 250 | 7 | | | | | CULVERT |
| CV2200-19 | DR. | 2 | 250 | 7 | | | | | CULVERT |
| | | | | | | | | | |
| PL2230-2 | | | | | | | | | PIPELINE |
| PL2230-3 | | | | | | | | | PIPELINE |
| PL2230-4 | | | | | | | | | PIPELINE |
| | | | | | | | | | |
| PL2240-1 | | | | | | | | | PIPELINE |
| PL2240-2 | | | | | | | | | PIPELINE |
| | | | | | | | | | |
| CV2400-1 | CO. RD. | 2 | 250 | 4.5 | | | | | CULVERT |
| CV2400-4 | CO. RD. | 1 | 250 | 3 | | | | | CULVERT |
| | | | | | | | | | |
| CV2500-1 | CO. RD. | 2 | 250 | 2 | | | | | CULVERT |
| | | | | | | | | | |
| CV3100-1 | CO. RD. | 1 | 250 | 3.5 | | | | | CULVERT |
| CV3100-2 | CO. RD. | 1 | 250 | 3 | | | | | CULVERT |
| | | | | | | | | | |
| CV3200-1 | US 70 | 2 | 250 | 8 | | | | | CULVERT |
| CV3200-4 | CO. RD. | 1 | 250 | 8 | | | | | CULVERT |

| CANAL NUMBER | GENERAL DESCRIPTION | CULVERTS REQUIRED | | | | | BRIDGE REQ'D | | SPECIAL NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | QUAN. | LEN. | PIPE DIA | BOX | | | | |
| | | | | | HEIGHT | WIDTH | Y/N | LOW CHD | |
| CV3200-5 | CO. RD. | 1 | 250 | 7 | | | | | CULVERT |
| CV3200-6 | CO. RD. | 1 | 250 | 6.5 | | | | | CULVERT |
| CV3200-7 | CO. RD. | 1 | 250 | 6.5 | | | | | CULVERT |
| CV3200-8 | FIELD RD. | 1 | 250 | 6 | | | | | CULVERT |
| CV3200-9 | CO. RD. | 1 | 250 | 5 | | | | | CULVERT |
| CV3200-10 | CO. RD. | 1 | 250 | 5 | | | | | CULVERT |
| CV3200-11 | FIELD RD. | 1 | 250 | 4 | | | | | CULVERT |
| | | | | | | | | | |
| CV3220-1A | CO. RD. | 1 | 250 | 4 | | | | | CULVERT |
| CV3220-1B | US 70 | 1 | 250 | 4 | | | | | CULVERT |
| CV3220-1 | US 70 | 1 | 250 | 4 | | | | | CULVERT |
| CV3220-2 | CO RD/HWY 249 | 1 | 250 | 4 | | | | | CULVERT |
| CV3220-3 | CO RD/HWY 249 | 1 | 250 | 4 | | | | | CULVERT |
| | | | | | | | | | |
| PL3250-1 | CO. RD. | | | | | | | | PIPELINE |
| PL3250-1A | ---- | | | | | | | | PIPELINE |
| | | | | | | | | | |
| CV3300-1 | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV3300-2 | CO. RD. | 2 | 250 | 2.5 & 2.0 | | | | | CULVERT |
| CV3300-3 | CO. RD. | 2 | 250 | 1.5 | | | | | CULVERT |
| | | | | | | | | | |
| PL3400-1 | CO. RD. | | | | | | | | PIPELINE |
| PL3400-2 | FIELD RD. | | | | | | | | PIPELINE |
| PL3400-3 | CO. RD. | | | | | | | | PIPELINE |
| | | | | | | | | | |
| CV3500-1A | SR 86 | 2 | 250 | 5 | | | | | CULVERT |
| CV3500-1 | FIELD RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV3500-3 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV3500-4 | DRIVE | 2 | 250 | 5 | | | | | CULVERT |
| CV3500-5 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| CV3500-6 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| PL3500-1A | SR 86 | | | | | | | | PIPELINE |
| | | | | | | | | | |
| CV4100-1A | SR 86 | 2 | 250 | 3 | | | | | CULVERT |
| CV4100-1 | LEVEE | 2 | 250 | 3 | | | | | CULVERT |
| PL4100-2 | CO. RD. | 2 | 250 | 3 | | | | | PIPELINE |
| PL4100-3 | SR 11 | 2 | 250 | 3 | | | | | PIPELINE |
| CV4200-1A | SR 46 | 2 | 250 | 4 | | | | | CULVERT |
| CV4200-1 | DR. | 2 | 250 | 4 | | | | | CULVERT |
| CV4200-2 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| CV4200-3 | LEVEE | 2 | 250 | 3.5 | | | | | CULVERT |
| CV4200-4 | FIELD RD. | 2 | 250 | 3.5 | | | | | CULVERT |
| CV4200-5 | SR 11 | 2 | 250 | 3.5 | | | | | CULVERT |
| CV4200-6 | abandoned R/R | 2 | 250 | 3 | | | | | CULVERT |
| PL4200-7 | CO. RD. | | | | | | | | PIPELINE |
| PL4200-8 | DR. | | | | | | | | PIPELINE |
| | | | | | | | | | |
| PL4300-1 | SR 343 | | | | | | | | PIPELINE |
| PL4300-2 | DR. | | | | | | | | PIPELINE |
| | | | | | | | | | |
| CV4400-1 | SR 343 | 2 | 250 | 2.5 | | | | | CULVERT |
| CV4500-1 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |

| CANAL NUMBER | GENERAL DESCRIPTION | CULVERTS REQUIRED | | | | | BRIDGE REQ'D | | SPECIAL NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | QUAN. | LEN. | PIPE DIA | BOX | | | | |
| | | | | | HEIGHT | WIDTH | Y/N | LOW CHD | |
| CV4500-3 | SR 343 | 2 | 250 | 4 | | | | | CULVERT |
| | | | | | | | | | |
| PL4510-1 | DR. | | | | | | | | PIPELINE |
| PL4510-2 | LEVEE | | | | | | | | PIPELINE |
| PL4510-3 | SR 343 | | | | | | | | PIPELINE |
| PL4510-4 | FIELD | | | | | | | | PIPELINE |
| | | | | | | | | | |
| CV4520-1 | CO. RD. | 1 | 250 | 3 | | | | | CULVERT |
| | | | | | | | | | |
| CV5200-1 | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV5200-1A | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV5200-3 | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV5200-3A | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| PL5200-4 | CO. RD. | 2 | 250 | 3 | | | | | PIPELINE |
| CV5200-5 | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV5200-7 | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| | | | | | | | | | |
| CV5300-1 | FIELD RD. | 2 | 250 | 7 | | | | | CULVERT |
| CV5300-3 | SR 11 | 2 | 250 | 7 | | | | | CULVERT |
| CV5300-4 | FIELD RD. | 2 | 250 | 6.5 | | | | | CULVERT |
| CV5300-5 | CO. RD. | 2 | 250 | 6.5 | | | | | CULVERT |
| PL5300-6 | CO. RD. | | | | | | | | PIPELINE |
| PL5300-7 | FIELD RD. | | | | | | | | PIPELINE |
| PL5300-8 | SR 130 | | | | | | | | PIPELINE |
| PL5300-10 | CO. RD. | | | | | | | | PIPELINE |
| PL5300-11 | CO. RD. | | | | | | | | PIPELINE |
| PL5300-11B | --- | | | | | | | | PIPELINE |
| CV5300-12 | DR. | 2 | 250 | 6 | | | | | CULVERT |
| CV5300-13 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5300-14 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| | | | | | | | | | |
| PL5310-3 | CO. RD. | 2 | 250 | 5 | | | | | PIPELINE |
| | | | | | | | | | |
| CV5400-1 | CO. RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV5400-2 | FIELD RD. | 2 | 250 | 3 | | | | | CULVERT |
| CV5400-3 | CO. RD. | 2 | 250 | 2.5 | | | | | CULVERT |
| | | | | | | | | | |
| CV5500-1A | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-1B | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-1 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-2 | US 79 | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-2 | R/R | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-3 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-4A | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-5 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-6 | CO. RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-8 | DR. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-8A | FIELD RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV5500-9 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV5500-10 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV5500-11 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV5500-12 | CO. RD. | 1 | 250 | 5 | | | | | CULVERT |

| CANAL NUMBER | GENERAL DESCRIPTION | CULVERTS REQUIRED | | | | | BRIDGE REQ'D | | SPECIAL NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | QUAN. | LEN. | PIPE DIA | BOX | | | | |
| | | | | | HEIGHT | WIDTH | Y/N | LOW CHD | |
| CV5500-13 | DR. | 1 | 250 | 5 | | | | | CULVERT |
| CV5500-14 | CO. RD. | 1 | 250 | 5 | | | | | CULVERT |
| CV5500-15 | CO. RD. | 1 | 250 | 4 | | | | | CULVERT |
| CV5500-16 | CO. RD. | 1 | 250 | 4 | | | | | CULVERT |
| | | | | | | | | | |
| CV6200-1 | CO. RD. | 1 | 250 | | 9.5 | 9.5 | | | CULVERT |
| CV6200-3 | CO. RD. | 1 | 250 | | 9.5 | 9.5 | | | CULVERT |
| CV6200-4 | CO. RD. | 1 | 250 | | 9.5 | 9.5 | | | CULVERT |
| CV6200-6 | CO. RD. | 1 | 250 | | 9 | 9 | | | CULVERT |
| CV6200-7 | CO. RD. | 1 | 250 | | 9 | 9 | | | CULVERT |
| CV6200-9 | CO. RD. | 1 | 250 | | 8 | 8 | | | CULVERT |
| CV6200-12 | CO. RD. | 1 | 250 | | 8 | 8 | | | CULVERT |
| CV6200-13 | CO. RD. | 1 | 250 | | 8 | 8 | | | CULVERT |
| CV6200-14 | CO. RD. | 1 | 250 | | 8 | 8 | | | CULVERT |
| CV6200-17 | CO. RD. | 1 | 250 | | 8 | 8 | | | CULVERT |
| CV6200-18 | abandoned R/R | 1 | 250 | | 7.5 | 7.5 | | | CULVERT |
| CV6200-19 | CO. RD. | 1 | 250 | | 7.5 | 7.5 | | | CULVERT |
| CV6200-20 | CO. RD. | 1 | 250 | | 7.5 | 7.5 | | | CULVERT |
| CV6200-21 | CO. RD. | 1 | 250 | | 7.5 | 7.5 | | | CULVERT |
| CV6200-22 | CO. RD. | 1 | 250 | | 7.5 | 7.5 | | | CULVERT |
| CV6200-24 | CO. RD. | 1 | 250 | | 7 | 7 | | | CULVERT |
| CV6200-26 | FIELD RD. | 1 | 250 | | 7 | 7 | | | CULVERT |
| CV6200-27 | CO. RD. | 1 | 250 | 5 | | | | | CULVERT |
| CV6200-28 | DR. | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-29 | CO. RD. | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-30 | CO. RD. | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-31 | CO. RD./RR | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-32 | FIELD RD. | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-33 | CO. RD. | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-35 | CO. RD. | 1 | 250 | 4.5 | | | | | CULVERT |
| CV6200-36 | DR. | 1 | 250 | 4.5 | | | | | CULVERT |
| | | | | | | | | | |
| CV6400-1 | CO. RD. | 2 | 250 | 3.5 | | | | | CULVERT |
| CV6400-1B | FIELD RD. | 2 | 250 | 3.5 | | | | | CULVERT |
| CV6400-2 | SR165 | 2 | 250 | 3.5 | | | | | CULVERT |
| CV6400-3 | CO. RD. | 2 | 250 | 2.5 | | | | | CULVERT |
| CV6400-4 | CO. RD. | 2 | 250 | 2.5 | | | | | CULVERT |
| CV6400-5 | CO. RD. | 2 | 250 | 2.5 | | | | | CULVERT |
| | | | | | | | | | |
| CV6600-4 | FIELD RD. | 2 | 250 | 6 | | | | | CULVERT |
| CV6600-5 | DR. | 2 | 250 | 6 | | | | | CULVERT |
| CV6600-7 | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV6600-9 | FIELD RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV6600-9A | CO. RD. | 2 | 250 | 5 | | | | | CULVERT |
| CV6600-11 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| CV6600-13 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| CV6600-14 | CO. RD. | 2 | 250 | 4 | | | | | CULVERT |
| CV6600-17 | FIELD RD. | 2 | 250 | 4 | | | | | CULVERT |
| | | | | | | | | | |
| PL6215-1 | | | | | | | | | PIPELINE |
| PL6215-2 | | | | | | | | | PIPELINE |

# SECTION I

# PART D - (4)

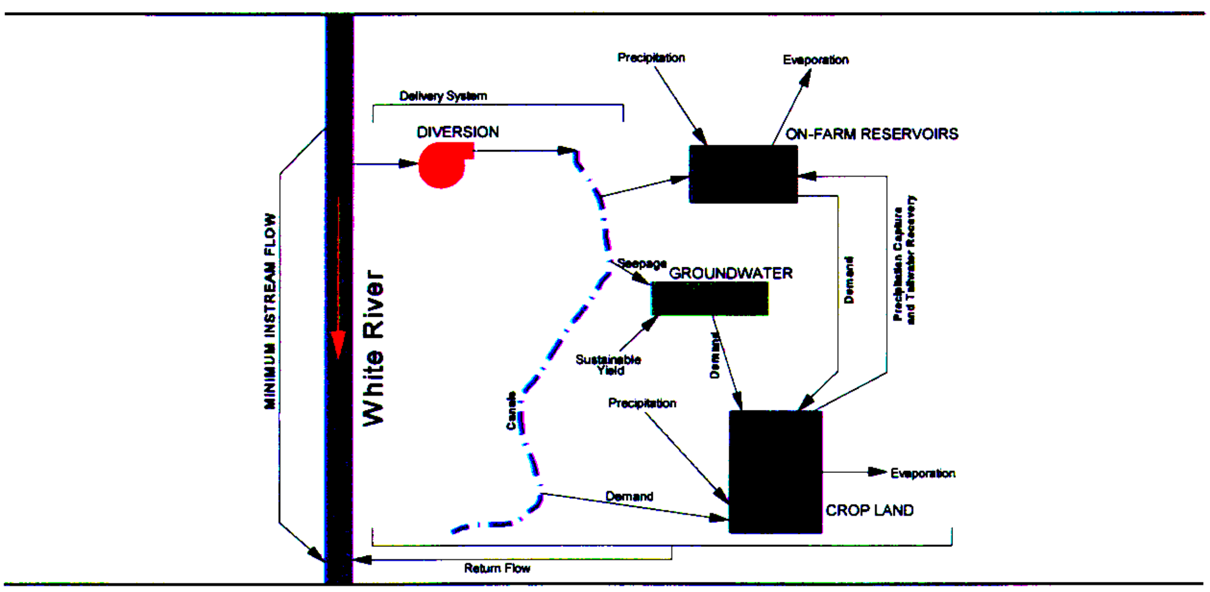
# WATER BALANCE

# PART D - (4) - WATER BALANCES

## TOPIC A - INTRODUCTION

A water balance is an accounting of all water inputs, outputs, and net change in storage for a defined hydrologic system. Often the defined hydrologic system is simply a specified area of landscape. Determination of the amount of water available from the White River and the delivery system's ability to supply the required water was key in evaluating project functionality and feasibility. Therefore, a water balance computation was conducted for the Grand Prairie Demonstration Project area, considering all sources and agricultural uses of water. Specifically, the water balance considered rainfall, evaporation, White River flow availability, safe sustainable ground water yield, on-farm storage, tailwater recovery, irrigation efficiencies, crop water budgets (i.e. crop water requirements varying throughout the growing season) , and delivery system seepage losses. General evaluations made during the Eastern Arkansas Region Comprehensive Study (EARCS) indicated that the White River has sufficient water available on a mean monthly basis for meeting water demands in the White River Basin. Specific evaluation of source reliability was not made until the water demands were determined (including delivery system losses). However, development of new on-farm reservoir storage as a component of the irrigation project included the seasonality of the White River discharges. Figure IV-A-01 illustrates the water balance components evaluated. The water balance was conducted for a 46-year period of recond using the Corps of Engineers computer program HEC-5 --Simulation of Flood Control and Conservation Systems.

**Figure IV-A-01 Water Balance Schematic**



## 4-A-01. FACTORS AFFECTING WATER BALANCE.

Factors affecting the water balance included White River discharges, rainfall amounts, evaporation, on-farm storage reservoirs, ground water, import system capacity, delivery system losses, water demands for crops and for waterfowl flooding. The water balance was also affected by minimum White River in-stream flows, state water resource allocation requirements, the Arkansas State Water Plan (ASWP) and navigation interests.

a. Source. The White River is the source of water for the proposed irrigation import system. Lakes on the upper White and Black Rivers regulate discharges in the lower White River. Low flow discharges, generally summer and late summer months, are augmented by lake releases while flood peak discharges are attenuated. The last of the White River basin lakes was constructed and filled in 1964. Lake regulation was to be according to set operation procedures (rule curves); however, numerous operational deviations were requested and granted over the years. These deviations from the authorized operation procedures produce a nonhomogeneous data set (i.e. no two years operations were necessarily the same). The ASWCC, the Little Rock District CE, Southwestern Power Association, and several local interests are presently attempting to establish operation procedures that are acceptable for the needs of hydropower, agriculture, and recreation, thereby eliminating deviations. The reservoir system was operated in 1994 and 1995 under an interim operation schedule. The interim schedule was slightly modified for the Black River in 1996. Overall, the interim schedule produces only slight changes in discharge hydrographs for low-flow periods when compared to the authorized operation schedules. Low-flow augmentation is generally higher with the interim schedules than the authorized release schedules.

Daily flow data for the Clarendon, Arkansas gaging station were used to compute statistics for the river. Statistics were computed using 1965 to 1986 historic data at Clarendon. Because of the nonhomogeneous historic data, water balance analyses utilized synthetic daily discharges produced from the CE White River "Super" Model, developed by the Tulsa District. The Super Model uses historic precipitation data and computed hydrologic parameters with a set of reservoir operation criteria (flood control and hydropower) to simulate downstream river conditions. The Super Model outputs were daily discharges for the period being analyzed with a constant set of lake operation criteria (i.e. producing a homogeneous data set). Synthetic discharges were utilized to represent consistent reservoir operations over an extended period of time. The synthetic data were for 1940 through 1986. Annual flow duration, monthly flow duration, annual volume duration, and monthly volume duration curves were developed for the synthetic data at Clarendon.

Water balance simulations were conducted for seven minimum flow conditions on the White River using the Super Model outputs for the authorized lake operation schedules. The minimum flows are shown in Table IV-A-01. Flow was considered available when White River discharges were greater than the minimum values. The 1986 State Water Plan is shown in Table

IV-A-02.

| Table IV-A-01 Minimum Flow Conditions on the White River | |
|---|---|
| 5,250 cfs | 7q10 Water Quality Flow Criteria |
| 7,125 cfs | 5.0 Gage Reading at Clarendon, AR and Navigation Maintenance Key Stage |
| 9,650 cfs | Minimum Navigation Requirement from the ASWP (1986) |
| 11,350 cfs | 12.0 Gage Reading at Clarendon, AR and Authorized Channel Key Stage |
| 12,850 cfs | 13.0 Gage Reading at Clarendon, AR and 9 foot channel depth with Authorized Channel Maintenance |
| 17,500 cfs | 16.0 Gage Reading at Clarendon, AR and No Depth Restrictions to Navigation |
| ASWP (1986) | Monthly Minimum based on the highest flow of three criteria: Water Quality, Navigation, and Fish and Wildlife as shown in Table 3-11 of the Arkansas State Water Plan |

**Table IV-A-02 Arkansas State Water Plan (1986) TABLE 3-11**

| Month | Estimated Mean Monthly Discharge (cfs) | Instream Flow Requirement | | | Current Available Stream Flow (cfs) |
|---|---|---|---|---|---|
| | | Water Quality (cfs) | Fish and Wildlife (cfs) | Navigation (cfs) | |
| January | 32,680 | 5,250-5,720 | 19,610 | 9,650 | 13,070 |
| February | 37,840 | 5,250-5,720 | 22,700 | 9,650 | 15,140 |
| March | 46,010 | 5,250-5,720 | 27,610 | 9,650 | 18,400 |
| April | 52,770 | 5,250-5,720 | 36,940 | 9,650 | 15,830 |
| May | 52,340 | 5,250-5,720 | 36,640 | 9,650 | 15,700 |
| June | 30,320 | 5,250-5,720 | 21,220 | 9,650 | 9,100 |
| July | 21,340 | 5,250-5,720 | 10,670 | 9,650 | 10,670 |

| Table IV-A-02 Arkansas State Water Plan (1986) TABLE 3-11 | | | | | |
|---|---|---|---|---|---|
| Month | Estimated Mean Monthly Discharge (cfs) | Instream Flow Requirement | | | Current Available Stream Flow (cfs) |
| | | Water Quality (cfs) | Fish and Wildlife (cfs) | Navigation (cfs) | |
| August | 18,180 | 5,250-5,720 | 9,060 | 9,650 | 8,530 |
| September | 15,040 | 5,250-5,720 | 7,520 | 9,650 | 5,390 |
| October | 13,840 | 5,250-5,720 | 6,920 | 9,650 | 4,190 |
| November | 18,420 | 5,250-5,720 | 11,050 | 9,650 | 7,370 |
| December | 29,310 | 5,250-5,720 | 17,590 | 9,650 | 11,720 |

b. Rainfall. Rainfall is generally abundant in the Grand Prairie with an annual average amount of 49.2 inches (1948 to 1986) at the National Weather Service gage in Stuttgart, Arkansas[1]. Average monthly rainfall for 1948 through 1986 is shown in Figure IV-A-02 and average annual rainfall is shown in Figure IV-A-03. Typically, the months of greatest rainfall do not coincide with the months of peak agricultural water demand. The uneven distribution results in excess water during the winter and early spring months and a deficit during the summer and early fall months. The deficit through the summer and early fall significantly affects crop yields. Surface reservoirs have been constructed to capture a portion of the excess runoff, especially during late winter and early spring. Tailwater recovery systems have been installed to further enhance capture of runoff and to re-capture water released from irrigated fields. Surface diversions from natural streams have increased dramatically in recent years. Evaporation for the Grand Prairie is high with an average annual value of 52.0 inches. Average annual pan evaporation was available at the Stuttgart experiment station for 1948 through 1986. Figure IV-A-04 shows average annual evaporation (potential) for 1948 to 1986.

The water balance used daily rainfall and daily evaporation in calculating available water. Available rainfall depths were adjusted for 1) falling on the ground surface or for 2) falling on the surface of an on-farm reservoir. Rain falling directly on the surface of a reservoir was considered fully available. Rain falling on the ground surface was adjusted to estimate seasonal infiltration and effective runoff. Effective runoff was further adjusted to reflect the amount that could be captured and stored. The stored amount of runoff was considered as available for water

[1] Average based on daily observed precipitation from 1948 through 1986 at NWS gage in Stuttgart, Arkansas.

balance calculations. Measured pan evaporation was converted to potential evaporation which was then subtracted from the available rainfall in the water balance model.

c. Groundwater. Several distinct aquifers exist in the Grand Prairie area, the alluvial aquifer and various confined aquifers. The alluvial aquifer is a relatively shallow unconfined aquifer most commonly used for irrigation. The confined aquifers are deeper and are used primarily for municipal and industrial purposes. Historical decline of the alluvial aquifer has resulted from pumpage in excess of recharge capacity. This has led to use of confined aquifers for irrigation. Ground water currently provides approximately 85 percent of irrigation water. Water quality within the alluvial aquifer is generally good. However, in some areas within the Grand Prairie, ground water quality has declined due to increased salinity concentrations caused by overdraft. Water quality within the confined aquifers is generally much superior to that of the alluvial aquifer. Groundwater studies conducted by the University of Arkansas[2], the USGS, and the University of Memphis[3] have modeled groundwater conditions in the area. The Peralta model used a sustained yield conjunctive use approach. The results from this model were used as the basis for estimating the safe sustained yield
for the alluvial aquifer. Simulations with the Peralta model were conducted utilizing present (early 1980s) and projected water needs. An estimate of the minimum saturated thickness of the alluvial aquifer was made during development of the Peralta model. A minimum saturated thickness of 20 feet was estimated as the minimum to sustain the aquifer characteristics. Based on a 20 foot saturated thickness as a minimum, long-term sustained yield from the alluvial aquifer was estimated to be 40,000 acre feet per year. The water balance used this value as water available from groundwater by prorating this annual value to a continuous flow rate.

d. Storage Reservoirs. On-farm storage reservoirs comprise a critical element of the irrigation system design. Existing reservoir capacity was estimated to provide 14 percent of present demands. The Grand Prairie Demonstration Project proposes to increase the amount of on-farm storage in order to provide approximately 25 percent of projected demands. Water balance simulations were conducted to evaluate several levels of on-farm storage.

e. Delivery System. Delivery system components evaluated in the water balance included maximum pumping station (and conveyance system) capacity and losses from the conveyance system. Maximum pumping station capacity was the upper limit for diversions from the White River when flow was available. Conveyance system seepage, estimated as a percentage of the canal flow, was considered to recharge to groundwater. Approximately one-

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[2] Work accomplished by Peralta, et al. at the University of Arkansas under contract to the Memphis District CE for the EARCS, 1984-1986.

[3] Work accomplished by Smith, et al. at the University of Memphis under contract to the Memphis District CE for the Grand Prairie Area Demonstration Project, 1994-1995.

**Figure IV-A-02 Average Monthly Rainfall at Stuttgart, Arkansas**

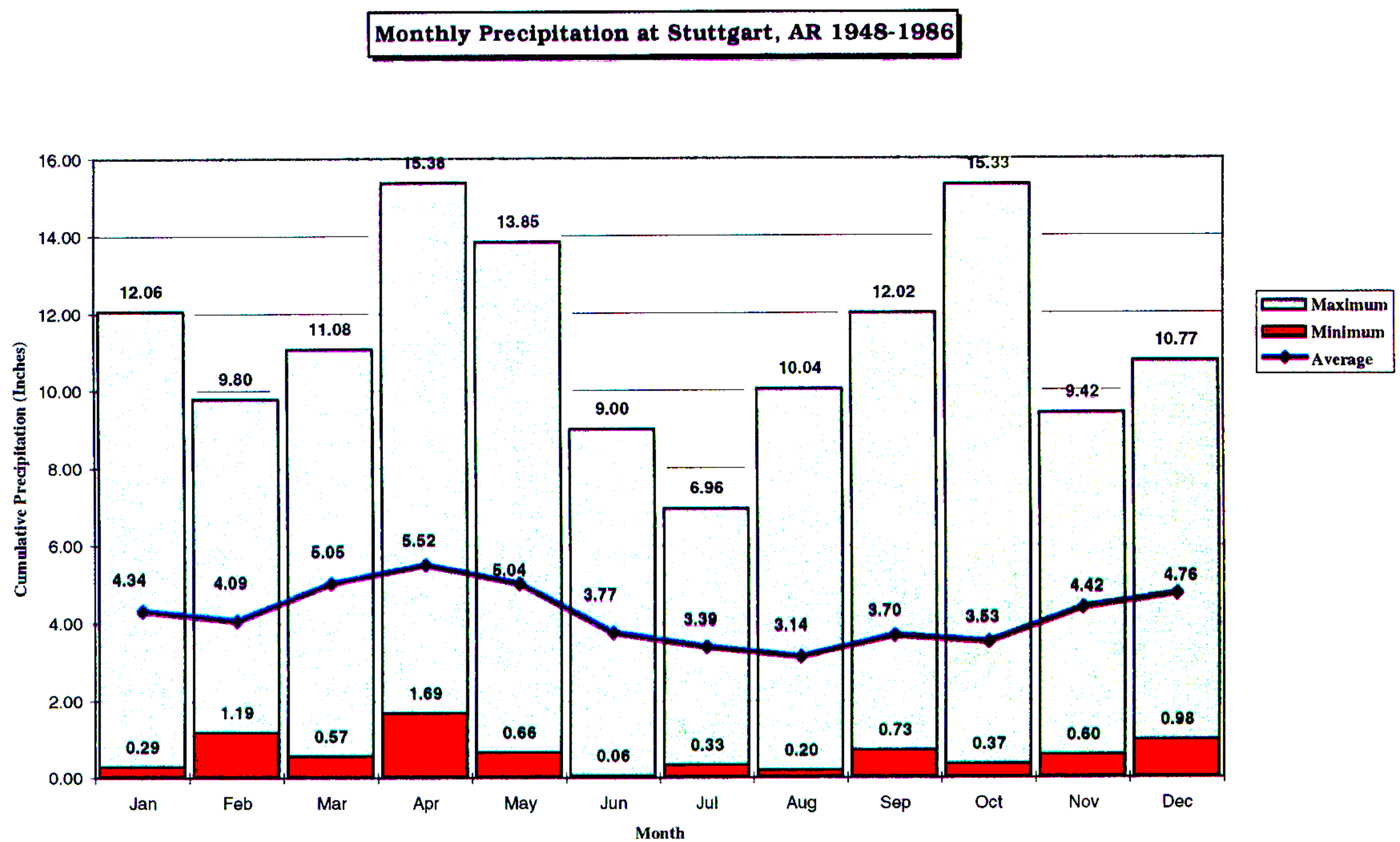


**Figure IV-A-03** Average Annual Rainfall at Stuttgart, Arkansas

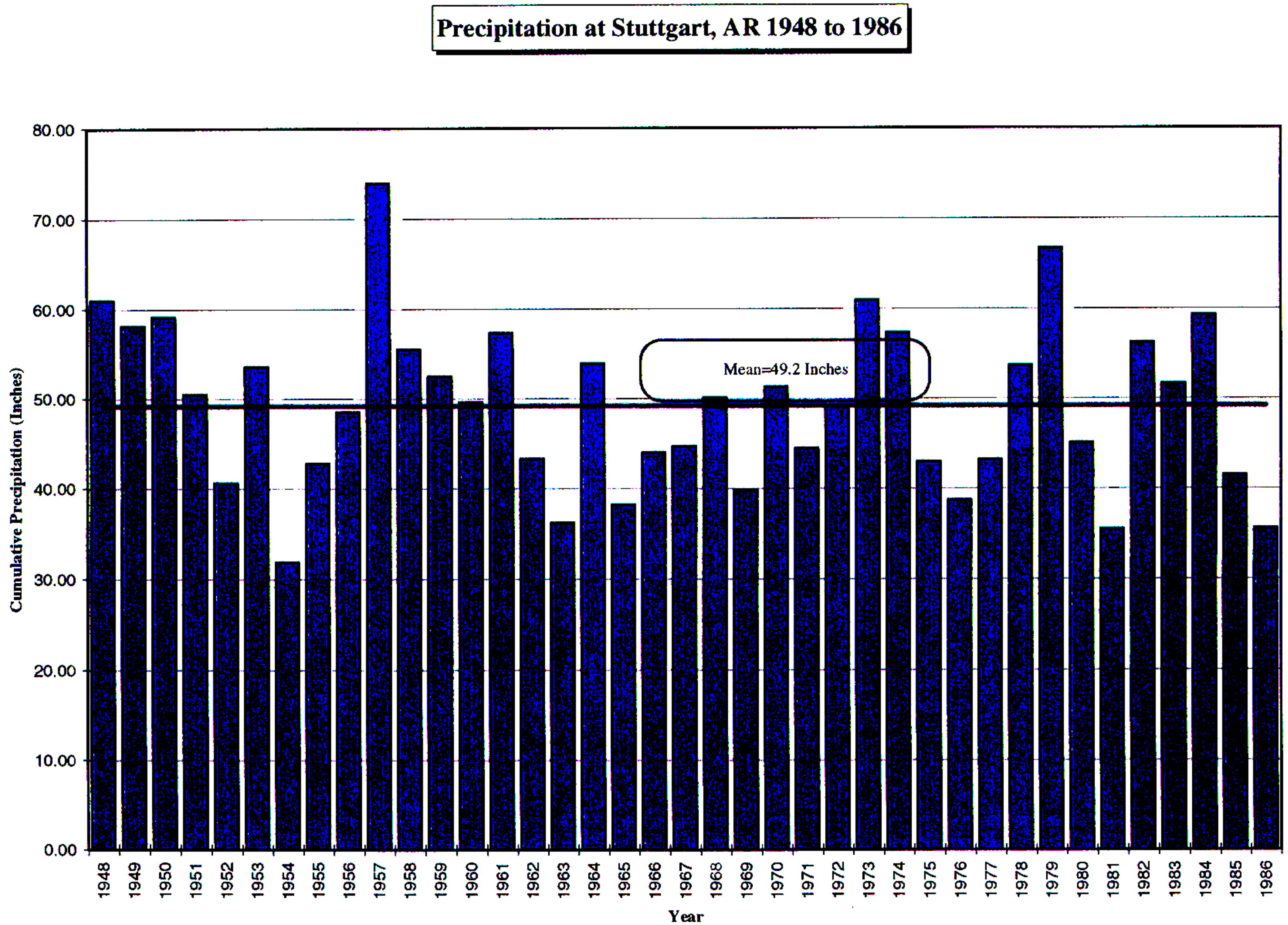
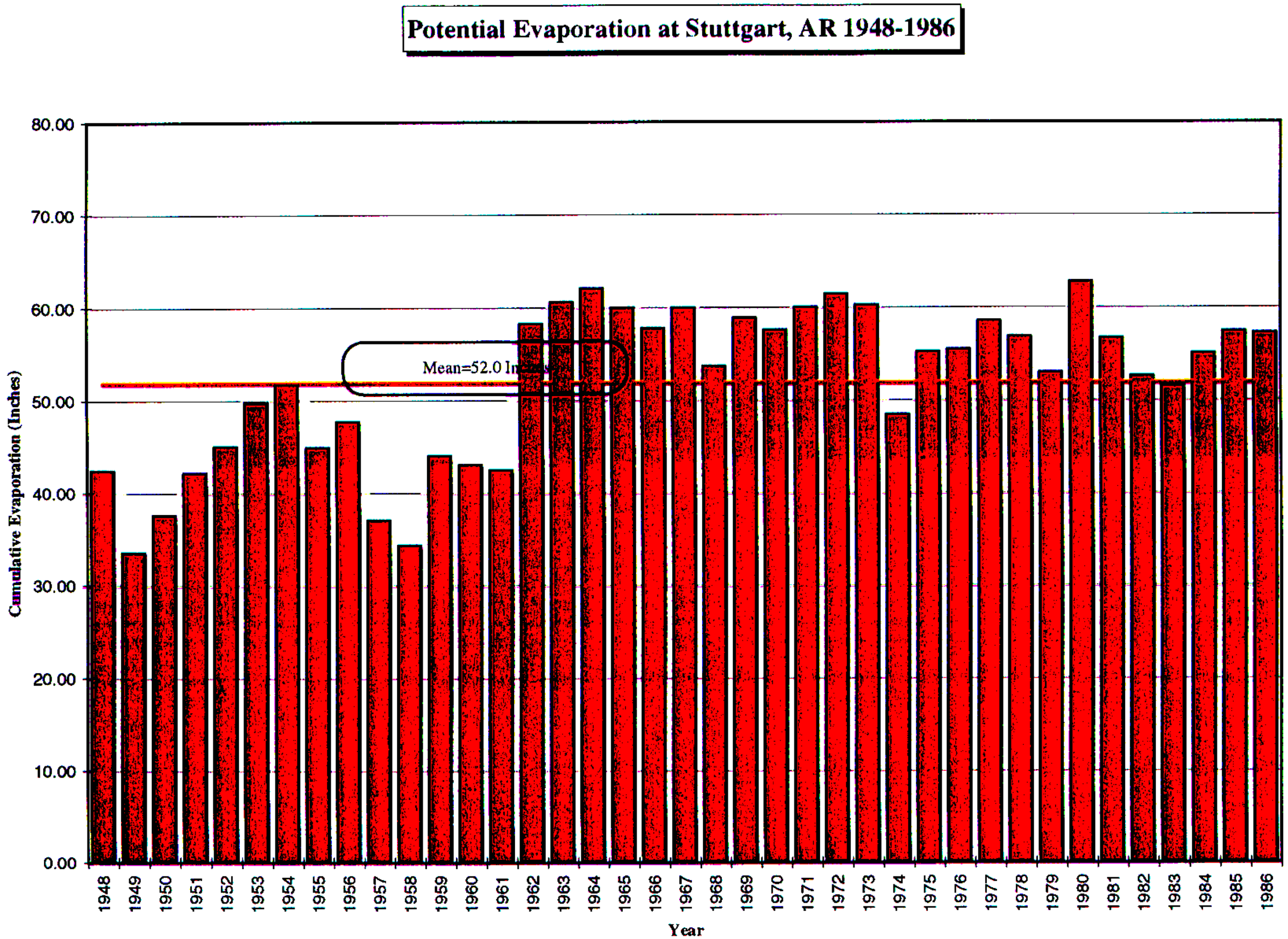


**Figure IV-A-04** Average Annual Evaporation at Stuttgart, Arkansas



half of the estimated seepage loss was made available to meet crop demands (one-half of the seepage from the delivery system was removed from consideration while the other one-half remained available to meet demands). The complete delivery system was not "modeled" in the water balance model. The water balance model incorporated the general components of the holistic system (demands, conveyance canals, pumping station, precipitation, on-farm reservoirs, etc.), but did not attempt to model discrete parts of any single component (individual structures, individual crops, etc.). Modeling efforts to simulate canal performance were accomplished prior to constructing the water balance model.

f. Agricultural Demand. Agricultural demands encompassed water needs for both crops and aquiculture. Crop water budgets were prepared by the NRCS for 10-day intervals. The 10-day interval was utilized because a ten day period is critical to crop production in terms of water availability. Aquiculture needs were also estimated by the NRCS. Agricultural water demands were initially calculated from historic climatic data for 1965 through 1981. These demands were extended for the 1940-1986 period by statistical methods that considered climatic data, crop distribution, and cropping patterns. Crop water demands for 1940 through 1986 were incorporated into the overall irrigation system water balance as a composite with all agriculture water needs reflected by a single value for each time period analyzed.

g. Waterfowl Demand. Water needed to flood areas for waterfowl use was estimated based on projections made in concert with the North American Waterfowl Agreement (NAWA). Approximately 45,000 acres have been identified by the NAWA as the target area to be flooded for waterfowl in the Grand Prairie. Required flooding depths were estimated by environmental specialists to be an average of three inches. The water necessary to establish and maintain this level from mid-October through the end of November was estimated as the water demand for the waterfowl season.

### 4-A-02. ANALYSIS TIME FRAME.

Overall water availability from the White River was evaluated during the EARCS. Excess water for diversion to the Grand Prairie was identified and summarized to be sufficient to provide an economic project. Detailed evaluations were deferred until further study. Comprehensive demand data were essential to a more in-depth evaluation of water availability. The monthly demand data were redeveloped for the Grand Prairie Area Demonstration Project by the NRCS to fully reflect current and projected crop rotations and acreages and other agricultural water needs for the study area. Additionally, 10-day demands were computed to more completely define peak water requirements. Because of the length and complexity of the proposed delivery system, demands had to be adjusted to account for delivery system hydraulic and seepage characteristics. An accurate detailed water balance could be evaluated only after completion of the detailed crop water budget calculations and the necessary delivery system design and analyses, both essential in fully defining water needs.

# TOPIC B - DATABASES

Data used in water balance calculations consisted of daily records of White River discharge and stage, precipitation, evaporation, rainfall runoff, tailwater capture, crop demands, waterfowl demands, sustainable groundwater yields, seepage, and minimum flow requirements for the White River.

## 4-B-01. CLIMATIC DATA.

The daily climatic data were compiled from National Climatic Data Center (NCDC) databases available on CD-ROM[4]. Climatic data were converted to HEC-DSS[5] for use by HEC-5. Conversion of pan evaporation to potential evaporation was accomplished by DSSMATH, the mathematical utility package available for HEC-DSS. Application of monthly factors used to estimate rainfall runoff and runoff capture were also accomplished by using DSSMATH. Missing data from the NCDC database was estimated for precipitation and evaporation by using additional gaging stations. Data were utilized for the NWS gaging station at Stuttgart, AR. This gage is the only gaging station covering the Grand Prairie area with both precipitation and pan evaporation data.

## 4-B-02. WATER DEMANDS.

Ten-day agricultural demands developed by the NRCS were converted to a daily HEC-DSS database.[6] The 10-day values were each repeated for ten consecutive days to fill between crop water-budget outputs, one value every 10th day. The time period used by the NRCS in calculating crop water-budgets, 1965 to 1981, was also extended to provide a longer time period for HEC-5 water balance simulations. Statistical methods were employed by the Economics Branch to extend the NRCS demand data. The resulting period-of-record spanned from 1940 through 1986.

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[4] Earthinfo, "Summary of the Day" CD-ROM database, 1994.

[5] US Army Corps of Engineers Hydrologic Engineering Center, <u>HEC-DSS User's Guide and Utility Manuals, User's Manuals</u>, Davis, CA 1995

[6] Crops do not require an absolutely uniform supply of moisture in order to grow satisfactorily, but it has been found that crops cannot be deprived of moisture for a period exceeding about ten days without suffering irrecoverable adverse effects. The ten-day demands determined by NRCS are then volumes of water required by the crop for successive ten-day periods throughout the year. These ten-day volumes were prorated uniformly across the ten-day periods to obtain the daily amounts used in the HEC-5 model.

## 4-B-03. GROUNDWATER AVAILABILITY.

Safe sustained aquifer yields estimated at 40,000 Acre-Feet per year were simulated in the water balance as a constant uniform rate of flow throughout the year. Seepage losses from the canal delivery system were also considered to contribute toward available groundwater (i.e. not all of the seepage was considered as removed from the system). Approximately one-half of the seepage losses were considered recoverable and were used to meet agricultural demands. Groundwater was loaded in the HEC-DSS database as a constant value for the period being analyzed. Daily values for recoverable seepage losses were evaluated in the water balance by using a percentage of the daily canal discharge[7].

## 4-B-04. DELIVERY SYSTEM AND SERVICE AREA.

Several alternatives have been evaluated through use of the HEC-5 water balance model. Initially, the service area extended from just north of US Interstate 40 to approximately 5 miles south of DeWitt, AR and from Carlisle, AR on the west to LaGrue Bayou on the East (Original Service Area). Subsequent to adjustments in the WRID boundaries, the southern boundary of the service area moved northward to DeWitt, AR (Adjusted Service Area). Cases evaluated included the following:

1. Existing Conditions I - 85,519 Acre-Feet of On-Farm Storage and No Import System for the original service area..
2. Alternative I - Increase in On-Farm Storage to 183,424 Acre-Feet with 1800 cfs diversion at White River for the original service area.
3. Alternative II - Increase in On-Farm Storage to 207,899 Acre-Feet with 1800 cfs diversion at White River for the original service area.
4. Existing Conditions II - 84,525 Acre-Feet of On-Farm Storage and No Import System for the adjusted service area.
5. Alternative III - Increase in On-Farm Storage to 173,108 Acre-Feet with 1640 cfs diversion at White River for the adjusted service area.
6. Alternative IV - Increase in On-Farm Storage to 173,108 Acre-Feet with 1800 cfs diversion at White River for the adjusted service area.

A summary of the service area is shown in Table IV-B-01 for the Original Service Area and in Table IV-B-02 for the Adjusted Service Area. Crop water-budgets by the NRCS included all

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[7] Losses from the delivery system were estimated to be thirty percent of the daily canal discharges. Seepage was approximated at one-half of the total losses (or Fifteen percent of the daily canal discharges). Recoverable seepage losses were estimated as one-half of the total seepage loss (or seven and one-half percent of the daily canal discharges).

irrigable cropland as being irrigated for both present and future conditions. New on-farm storage volumes were computed using 10.0 feet as an effective depth for new reservoir construction. Existing storage volumes were estimated using an average depth of 5.4 feet.

## 4-B-05. DIVERSION SOURCE.

Diversions to supply the proposed import system alternatives will be made from the White River at DeValls Bluff, AR. White River data compiled for the water balance analysis included daily observed stages at the DeValls Bluff and Clarendon gaging stations and computed daily discharges at Clarendon. The daily gage data were managed within the HEC-DSS

### Table IV-B-01 Original Service Area

| | Existing Conditions I (Acres) | Alternative I (Acres) | Alternative II (Acres) |
|---|---|---|---|
| Project Area | 394,475 | 394,475 | 394,475 |
| Tract Farmland | 381,585 | 381,585 | 381,585 |
| Tract Cropland | 281,980 | 272,190 | 269,742 |
| Fish Ponds | 3,101 | 3,101 | 3,101 |
| Fish & Wildlife Areas (Water) | 3,728 | 3,728 | 3,728 |
| On-Farm Storage Reservoirs | | | |
| Existing Reservoirs | 15,914 | 15,914 | 15,914 |
| Proposed Reservoirs | 0 | 9,790 | 12,238 |
| Sub-Total Reservoirs | 15,914 | 25,704 | 28,152 |

### Table IV-B-02 Adjusted Service Area

| | Existing Conditions II (Acres) | Alternative III (Acres) | Alternative IV (Acres) |
|---|---|---|---|
| Project Area | 362,662 | 362,662 | 362,662 |
| Tract Farmland | 340,834 | 340,834 | 340,834 |
| Tract Cropland | 254,406 | 254,406 | 254,406 |
| Fish Ponds | 3,070 | 3,070 | 3,070 |
| Fish & Wildlife Areas (Water) | 2,637 | 2,637 | 2,637 |
| On-Farm Storage Reservoirs | | | |

**Table IV-B-02 Adjusted Service Area**

| | | | |
|---|---|---|---|
| Existing Reservoirs | 15,566 | 15,566 | 15,566 |
| Proposed Reservoirs | 0 | 8,849 | 8,849 |
| Sub-Total Reservoirs | 15,566 | 24,415 | 24,415 |

database. Synthetic discharge data[8] for the Clarendon, AR gaging station were utilized in actual water balance calculations to remove any bias introduced by non-homogeneous observed data[9]. Super model results were used for the authorized operation schedules at each of the reservoirs.

## TOPIC C - SUPPLY / DELIVERY SIMULATIONS

Water supply and delivery was evaluated using a water balance approach. Detailed analyses of the delivery system (canals, turnouts, and pipelines) were conducted by steady and unsteady flow methodology. Detailed analyses were presented in a separate section. Composite project water supply and delivery[10] were evaluated to determine the reliability of the proposed alternatives, to provide the necessary data for computing economic benefits within the Grand Prairie Demonstration Project service area, and to provide the necessary data for evaluating potential impacts to the White River. A water balance was considered the appropriate method

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[8] Synthetic data, 1940 through 1986 daily discharges, were available from the White River "Super" Model developed by the Tulsa District Corps of Engineers as a tool in evaluating reservoir operations on the White River.

[9] Reservoir construction and fill ended in late 1964 after Greers Ferry Lake was filled. Lake operations beginning in 1965 have had numerous deviations from authorized operation schedules. Because no two years had consistent lake operations, observed data were considered non-homogeneous.

[10] As indicated in Figure IV-A-01, the water balance was performed on hypothetical system elements which are composites of numerous sub-elements existing in the field. For example, the single on-farm reservoir included in the water balance model is a composite of all reservoirs across the project area. Similarly, the crop land element is a composite of all crop land across the project area. Since the water requirements of the various irrigated crops vary, these requirements were determined for the project area on a crop by crop basis for each time step and then combined into a composite demand associated with the composite crop land element.

to conduct the analyses of various water sources (i.e. the White River, on-farm storage, rainfall, etc.), of various water demands, and of various system constraints. The water balance consisted of simple accounting of discrete time period values of water availability in the White River, climatic conditions, accumulative on-farm storage, groundwater, and delivery system losses. Since daily data were available for the source, the smallest time period evaluated was a daily interval. Climatic data were available for a 39 year period and simulated White River data were available for a 47 year period. Because of the complexity in managing multiple constraints, source and delivery system, for daily time periods, HEC-5 (HEC, 1989) was selected for water balance modeling. A sample HEC-5 input file is included as Exhibit IV-C-01, and a schematic of the water balance conditions evaluated is provided on Plate IV-1.

**4-C-01. WATER BALANCE MODEL.**

The maximum period of time for which any data existed was used to extend simulations over as long a period of time as possible. Since White River simulated data from the Super Model was available for 47 years, the water balance HEC-5 model was developed to simulate daily data for a 47 year period. All other data were adjusted to reflect a 47 year time period. Minimum in-stream flows for the White River, delivery system operation schedules, and water use priorities were incorporated into the model.

a. Model Inputs. Because a 47 year time period was selected for simulations, all input data had to be extended for the full 47 years. Simulated White River data were available for 1940 through 1986. Actual climatic data were available for 1948 through 1986. All other inputs such as rainfall capture and demands were directly related to the climatic data. Although the data "existed" for 1940 through 1986 for the White River, this data was considered as a projection of 47 years of data in time, not strictly limited to real times of 1940 through 1986, with climatic conditions the same as observed during 1948 through 1986[11]. The resulting 47 year long data set was, therefore, a hypothetical one and did not actually represent conditions[12] in 1940 for water balance simulations. Data output, however, was labeled with the 1940 through 1986 dates for simplicity. Available groundwater was considered constant throughout the 47 year simulation because the safe sustainable yield was used in water balance calculations. Project service area and on-farm storage reservoir surface area and volume were inputs to the model. Service area was used in determining evaporative losses, rainfall contribution, rainfall runoff and rainfall capture for the water balance. On-farm storage reservoir data were used to compute

[11] Historic climatic data were available for 1948 through 1986 at Stuttgart, AR, a 39 year period of time. To expand the input data set for a 47 year period, data for 1948 through 1955 were repeated (with dates adjusted appropriately) for 1940-1947.

[12] Actual conditions in 1940 were actually quite different from water balance model conditions primarily because of land use and farming practices.

volumes added directly by rainfall and volumes used from and/or added to the reservoirs depending on water demand and availability from the White River. Water demands were calculated by the NRCS with a crop water budget for crops grown in the service area and climatic data for 1965 through 1981. The NRCS water budget outputs were extended using statistics from the NRCS data and the 1940 through 1986 climatic data being used in the HEC-5 model.

b. Supply Constraints. Using the White River as a source for proposed diversions required the water balance model to provide a means to maintain minimum in-stream flows for the river. The minimum in-stream flows evaluated considered fish and wildlife requirements, water quality requirements, and navigation desires. Minimum in-stream flows ranged from level (constant) minimum flows to minimum flows that varied by month (such as the SWP). Flow in excess of the minimum in-stream flow being evaluated in any single HEC-5 simulation, was considered available for diversion subject to the maximum pumping station capacity for the simulation. When flow in excess of the minimum in-stream flow but less than the maximum pumping station capacity was computed, only the excess flow was available for diversion. Groundwater supply was limited to the safe sustainable yield established by the Peralta groundwater modeling conducted during the EARCS.

c. Delivery System Constraints. Limitations for the delivery system were the canal maximum flow capacities, maximum turnout/check flow capacities, the main pumping station capacity, and on-farm storage reservoir capacity. The delivery system also had operation restrictions imposed by practical and logistic conditions. Operation of on-farm storage reservoirs was the most difficult to simulate because establishing regulation schedules involved multiple independent controllers, i.e. individual farmers. Each individual was free to operate their on-farm storage reservoirs according to their desires. Evaluating multiple independent reservoir operations proved impossible and did not meet project objectives. Establishment of operation guidelines was essential for maximizing delivery system performance in meeting service area demands throughout the irrigation season. While a degree of flexibility exists in individual on-farm reservoir operations, all reservoir operations were required to fall within some specific guidelines. The specific guidelines were developed to best utilize available water in view of source reliability. Because the White River low flow periods generally occur in the summer through early fall (when demands are usually highest), a priority of water use was established. Water use patterns were also considered an integral part of operation schedules. General on-farm storage reservoir operation guidelines (as included in the HEC-5 model) are shown in Table IV-C-01. The guidelines' first priority for water use was rainfall. Imported water was the second priority for water use. On-farm storage (whether from rainfall, rainfall capture, tailwater recovery, or imported water) was considered as a third priority for water use. However, if storage was utilized early in the irrigation season for deliveries (with canals operating at less than full capacity and additional White River flow available for diversion), shortages in imports were likely to result particularly in late July through September. The lowest priority for water use was groundwater.

## 4-C-02. WATER BALANCE MODEL OUTPUTS.

The water balance model had many output options. Primary outputs for each time period in the simulation (each day) consisted of water available for diversion from the White River, flowrate diverted by the pumping station, residual flow remaining in the White River (flow downstream of the diversion), storage volume utilization, and water demand met.

**Table IV-C-01 General Operation Guidelines for Grand Prairie Demonstration Project**

| General Operation Scheduling for Delivery System | | | |
|---|---|---|---|
| Season Number | Management Concept | Month(s) of Operation | General Procedure |
| 1 | Fill Storage Prior to irrigation season if it has not already been filled by rainfall | Jan - Apr | Import water from White River as needed. Water is released to customers as needed. |
| 2 | Irrigation season begins. Use canal water first. Use stored water only If canal capacity does not meet crop demands. | May - Jun | Water released to customers upon demand for use directly on crops or to fill/refill storage. Import from White River continuously to meet demand (limited by White River minimum in-stream levels. Volume pumped may be determined by the demand or by other operation tools such as a "Water Budget." |
| 3 | Middle of irrigation season. Continue using canal water first then stored water. Water use is at maximum. If canal capacity and stored water do not meet full demand, ground water may be utilized. | Jul - Aug | Continue as in Season 2. The import system will be at full capacity during this period limited only by flow availability from White River. Actual diversions may be dictated by White River conditions. |

| General Operation Scheduling for Delivery System | | | |
|---|---|---|---|
| 4 | Late irrigation season. Rice irrigation has ended. Soybeans and other row crops continue to be irrigated. | Sep - mid Oct | Continue as in Season 3. |
| 5 | End of irrigation season. | Mid Oct - Nov | Import water according to needs and water availability for special purposes such as waterfowl, wildlife or other environmental needs. |
| 6 | General maintenance and inspection and major maintenance conducted. | Dec | No import system operations. |

a. Water Supplied. Water actually supplied was not a direct output from the HEC-5 model. Calculations with DSSMATH were made to convert HEC-5 outputs to the desired formats. Daily values over the 47 year simulation were also too numerous to obtain meaningful information by direct inspection. Daily values were accumulated into annual and monthly values to facilitate presentation. Actual statistical analyses and economic and environmental analyses were conducted with the full daily data set. Annual and monthly total demands and water supplied for a) no diversion with existing on-farm storage levels (as of 1992), b) 1640 cfs maximum diversion with adjusted service area and storage, c) 1800 cfs maximum diversion with adjusted service area and storage, d) 1480 cfs maximum diversion with adjusted service area and storage, and e) 1960 cfs maximum diversion with adjusted service area and storage are shown in Table IV-C-02. Monthly values for December were computed as zero (0.0) because no import system operation was allowed to provide a period for canal and canal structure maintenance. Values shown for supplied volumes in Table IV-C-02 were for all water sources.

b. Supply Reliability. Water supplied was sufficient to meet all demands approximately 85 percent of the time. All of the demands were met during some years.

## 4-C-03. RISK BASED ANALYSIS.

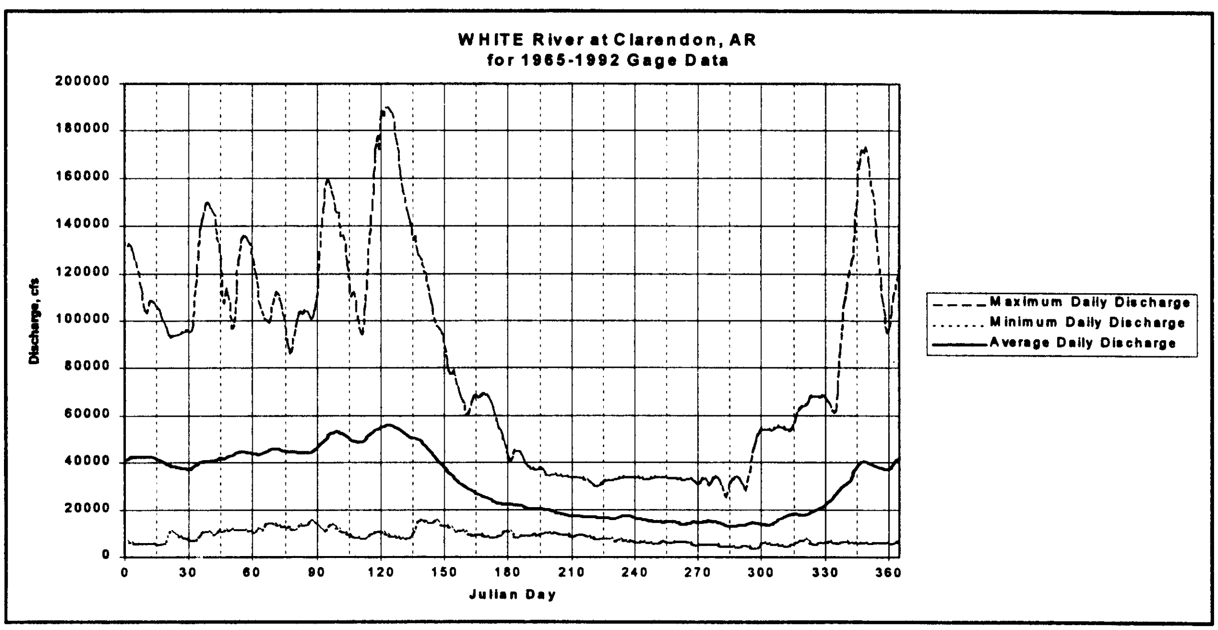
Risk based analysis with the @Risk addin for Microsoft Excel (Microsoft, 1995) was used with the daily annual and monthly data to evaluate Grand Prairie Demonstration Project performance for many combinations of climatic and White River conditions. The @Risk simulations produced essentially the same reliability as computed directly from the 47 years of data.

# TOPIC D - WHITE RIVER

The White River can be characterized into two distinct regions, the upper White and lower White Rivers. The upper White , upstream of the Black River confluence and Newport, AR, flows through the Ozark Mountains. Most of this region has relatively steep topography with some being quite rugged. River beds are founded in gravels, cobbles, and even bedrock. Commercial navigation in this region is limited with barge traffic only able to reach Batesville, AR. The lower White, downstream of the Black River confluence and Newport, AR, flows through relatively flat delta. Meanders, some tortuous, constitute the rivers planform, and sand bed with some gravel deposits predominate the river bed. Commercial navigation in this region is limited only by availability of stages sufficient to move loaded barges and tows. The lower reach , approximately 100 miles; is affected by Mississippi River backwater.

The White River discharges are highly variable throughout the year with extreme highs typically occurring during late winter and extreme lows typically occurring in late summer. Average daily, maximum daily, and minimum daily discharges at Clarendon, AR are shown in Figure IV-D-01. Prior to completion of several flood control and hydropower reservoirs in the

**Figure IV-D-01 Average Daily, Maximum Daily, and Minimum Daily Discharges for White River at Clarendon, AR 1965-1992**



upper reaches of the watershed, summer discharges were extremely low. Subsequent to reservoir construction, low summer flows have increased due to augmentation by lake releases. Augmentation results from storing flood peaks and releasing the water later in the year when agricultural damages can be prevented. The low-flow augmentation provides substantial benefits in providing a more reliable diversion source for any irrigation project. Because reservoir operations came about at full scale in 1964, observed data reflecting post reservoir construction conditions is limited. Authorized reservoir regulation schedules have been modified numerous times since 1964 because of requests by various local interests to alter operations. A method to simulate consistent reservoir operations in the White River basin was derived when the Super model was developed. The Super model is a hydrologic routing model that conducts routing using observed precipitation, calibrated reach routing parameters, and prescribed lake operation schedules (accounting for flood control and hydropower releases). The period-of-record available from the Super model for water balance calculations was 1940 through 1986. The use of homogeneous data, although synthetic, was considered essential in evaluating source and irrigation system reliability.

Present water users on the lower White River consist of commercial navigation interests, riparian agricultural diversions, recreation enthusiasts, and industrial diverters. The state of Arkansas regulates the amount of water available for diversion from the White River through the State Water Plan (SWP). Administration of this plan and all regulation and permitting activities are by the Arkansas Soil and Water Conservation Commission (ASWCC). The present SWP has been in effect since 1986 when approved by the state legislature. ASWCC is currently attempting to refine water allocation procedures through a new SWP. At the time of this writing (September 1996), the new SWP is only in draft form and has not yet undergone public notice procedures.

Channel maintenance for navigation on the White River was authorized by congress in 1892 to maintain a channel with a depth of 4.5 feet. Section 107 of the Rivers and Harbors Act of 1960 increased the authorized channel to 8 feet from the mouth to Augusta, AR for gage readings at Clarendon, AR of 12.0 feet or higher; a channel depth of 5 feet from the mouth to August, AR for gage readings at Clarendon, AR less than 12.0 feet, and a channel depth of 4.5 feet from Augusta, AR to Newport, AR. Present dredging practice maintains a channel with a depth of 8 feet up to Newport, AR when the Clarendon, AR gage is 12.0 or greater. Maintenance dredging currently begins during July and generally ends in October of each year.

**4-D-01. FLOW REQUIREMENTS OF THE WHITE RIVER.**

The amount of flow in the White River affects all river users. The ASWCC currently allocates water from the White River basin. Present allocation limitations are presented in the SWP (See Table IV-A-01); these allocations are based on mean monthly discharges and several categories of minimum instream-flow criteria. Instream-flow needs identified in the 1986 SWP are for 1) water quality (the 7Q10 discharge), 2) fish and wildlife, and 3) navigation. Six minimum instream-flow levels were analyzed in addition to the SWP (for the original service area and a maximum diversion of 1800 cfs) to evaluate the optimum diversion cut-off level based on resulting economic costs and benefits. Each minimum instream-flow, and resulting diversion cut-off level, produced different irrigation project reliabilities and, therefore, project benefits. Each diversion cut-off level also had varying degrees of impacts to fish and wildlife and navigation which were factored into the costs. The minimum instream-flow levels evaluated with the HEC-5 water balance model were (as related to the Clarendon, AR gaging station):

> 5,250 cfs - Water quality discharge (7Q10) - Interpreted from the SWP as the minimum acceptable flow for the White River above which diversions could take place.
>
> 7,125 cfs - Gage reading of 5.0 at Clarendon, AR - Evaluated in light of current navigation maintenance practices (under congressional authorization) for the White River. A 5.0 on the Clarendon, AR gage is a target stage at which a channel 5 feet in depth will be provided.
>
> 9,650 cfs - Gage reading of 10.5 at Clarendon, AR - Evaluated in light of SWP minimum navigation criteria.
>
> 11,350 cfs - Gage reading of 12.0 at Clarendon, AR - Evaluated in light of current navigation maintenance practices (under congressional authorization) for the White River. A 12.0 on the Clarendon, AR gage is a target stage at which a channel 8 feet in depth will be provided.
>
> 12,850 cfs - Gage reading of 13.0 at Clarendon, AR - Evaluated in light of current navigation maintenance practices (under congressional authorization) for the White River. A 13.0 on the Clarendon, AR gage is a stage at which a channel 9 feet in depth will be provided.
>
> 17,500 cfs - Gage reading of 16.0 at Clarendon, AR - Evaluated as zero impact to navigation level according to the local towing industry and primary shippers on the White River.
>
> SWP - Minimum levels vary by month ( January 19,610 cfs; February 22,700 cfs; March 27,610 cfs; April 36,940 cfs; May 21,220 cfs; June 21,220 cfs; July 10,670 cfs; August 9,650 cfs; September 9,650 cfs; October 9,650 cfs; November 11,050 cfs; and December 17,590 cfs) depending on highest criteria of 1) water quality, 2) fish and wildlife, and 3) navigation as described in the Arkansas State Water Plan.

Evaluation of any impacts to the White River resulting from proposed diversions was accomplished by the HEC-5 water balance model. Specifically, environmental and navigational impacts were analyzed. Although minimum criteria may be refined by future updates and revisions to the SWP, evaluations using the current SWP (1986) will identify any potential impacts and their relative magnitude. As previously stated, flow conditions on the White River are naturally quite variable. This translates into large fluctuations in water levels, or stages, with daily changes in stage of 4-5 feet or more being possible. The relative difference between pre- and post-diversion conditions should be viewed in light of this natural variability.

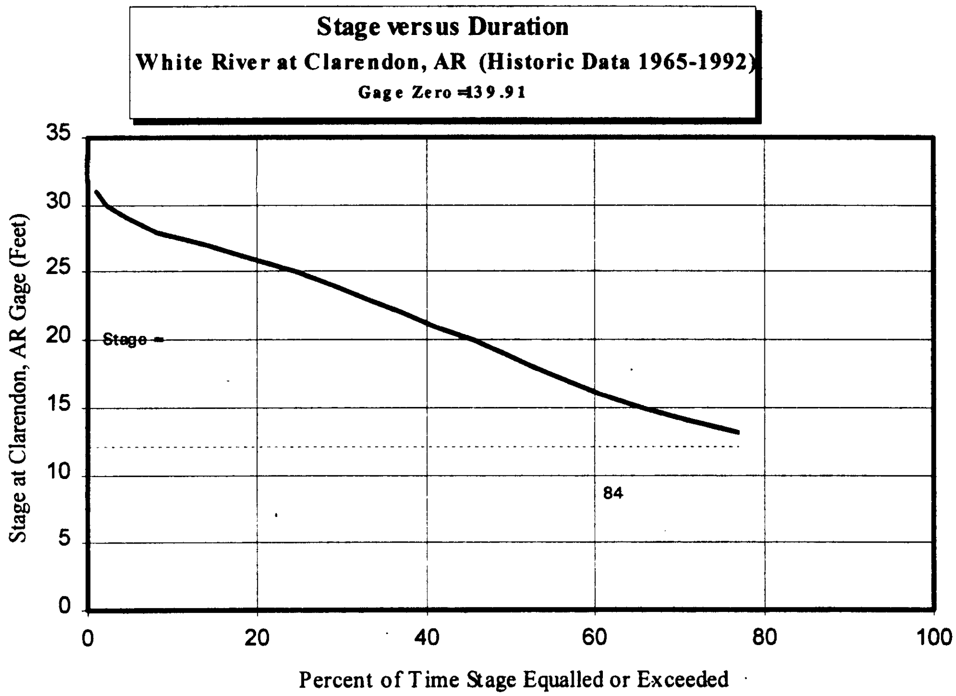
Water balance calculations were first based on the seven minimum in-stream flow conditions for the original project area and a maximum diversion of 1800 cfs. Use of the seven minimum in-stream flows provided data necessary to determine the optimum pump cut-off level (i.e. minimum in-stream flow). The minimum in-stream flows required by the SWP were determined to be the only in-stream flow criteria to be used for water balance calculations after the original project area had been evaluated. The SWP was the only in-stream flow requirement evaluated for additional analyses, because the SWP was the legal constraint and economic benefits for the Grand Prairie Demo Project were optimized.

**4-D-02. NAVIGATION.**

The lower White River supports commercial navigation on a seasonal basis with the amount of barge traffic depending on available stages. Maintenance dredging was authorized by the US Congress in 1892 with modifications to the original authorization in 1960. This authorization provided for a channel (up to Augusta) 8 feet in depth for stages at Clarendon, AR of 12.0 or greater and a channel 5 feet in depth for stages at Clarendon, AR of less than 12.0 feet. Present maintenance dredging consists of channel maintenance generally from July through October. At other times throughout the year, channel shoalling occurs at certain locations and reduces the channel's depth. Flow and/or stage duration analysis at several gaging stations on the White River indicate that a channel depth of 8 feet (12.0 at Clarendon, AR) is available approximately 84 percent of the time at Clarendon with present maintenance practices. A stage-duration curve at Clarendon, AR is shown in Figure IV-D-02.

a. Maximum Diversion of 1800 cfs and Original Project Area. Potential navigation impacts were first analyzed with HEC-5 for the original project area, a maximum diversion of 1800 cfs, minimum in-stream flows shown in Table IV-A-01, and synthetic White River discharges (for authorized operation schedules) at Clarendon. Clarendon was used as a key station in the HEC-5 analyses because of the consistent long-term data record at that gaging station used in developing the synthetic data, and because a consistent long-term rating curve exists for the gage. The Clarendon gage is also a key point in the authorized channel maintenance which provides an ideal point for making alternative comparisons.

**Figure IV-D-02** **Stage versus Duration at Clarendon, AR Gaging Station, White River Arkansas Using 1965-1992 Observed Stages.**




Effects on river stages that resulted from diversions from the White River were relatively small with changes ranging from 0.0 feet up to 1.2 feet depending on the time of year, river stage (in-bank versus out-of-bank stages), the minimum in-stream flow being analyzed, and the amount of water that could be diverted. Water diversions were limited by maximum pumping station capacity. Navigation impacts were evaluated for each of the seven minimum in-stream flows using pre- and post- maintenance dredging water depths. Water depths were estimated using historic dredging survey data. Mean depths were estimated for weekly (7 day) periods for the pre- and post-maintenance conditions. A seven day period was utilized in the analysis to reflect one-way trip durations required for tows to travel the navigable portion of the White River (Mouth to Newport, AR). Any stages falling below a target level (i.e. 12.0) at the Clarendon, AR gage, whether natural or affected by diversions, would prevent or limit travel by tows through the navigable channel. A stage of 16.0 at the Clarendon, AR gage was identified as the stage where no impedance to navigation occurs for fully loaded (9 feet of draft) barges[13]. The pre- and post-maintenance dredging mean weekly depths were estimated

[13] Correspondence and Personal Communication with Augusta Barge, Inc (principal towing company on the White River) and Bunge, Inc. (grain elevator

for minimum in-stream flows of 5,250 cfs; 7,125cfs; 9,650 cfs; 11,350 cfs; 12,850 cfs; 17500 cfs; and the SWP.

Changes in flow-duration were also computed for each of the minimum in-stream flows. Computed flow-durations are shown in Table IV-D-01 for existing stream-flows and for the minimum in-stream flows. Changes in flow-duration, percentage of time that a given flow (or corresponding stage) is available, indicated the potential for decreased water availability for tow operations. Higher minimum in-stream flow requirements resulted in less change in flow-duration (more reliable navigation) and less water available for irrigation diversions (less reliable irrigation source). These data were utilized for estimating irrigation project reliability and benefits and impacts, if any, to navigation.

**Table IV-D-01 Flow Durations for White River at Clarendon, AR Based on 1940-1986 Simulations**

| White River @ Clarendon, AR Flow-Durations for 1940-1986 Based on Simulations with Diversions (Maximum 1800 cfs Pumping Station) | | | | | | |
|---|---|---|---|---|---|---|
| White River Minimum Flow, cfs (Pump Cut-off Level) | Percentage of Time that Flow is Equaled or Exceeded | | | | | |
| | Discharge in cfs | | | | | |
| | 5,250 | 7,125 | 9,650 | 11,350 | 12,850 | 17,500 |
| | | | | | | |
| EXISTING | 99.3 | 94.0 | 83.8 | 76.8 | 70.8 | 56.7 |
| | | | | | | |
| 5,250 | 99.3 | 92.5 | 80.4 | 73.0 | 66.9 | 54.9 |
| 7,125 | 99.3 | 94.0 | 80.4 | 73.0 | 66.9 | 54.9 |
| 9,650 | 99.3 | 94.0 | 83.8 | 72.7 | 66.8 | 54.9 |
| 11,350 | 99.3 | 94.0 | 83.8 | 76.8 | 66.7 | 54.9 |
| 12,850 | 99.3 | 94.0 | 83.8 | 76.8 | 70.8 | 54.8 |
| 17,500 | 99.3 | 94.0 | 83.8 | 76.8 | 70.8 | 56.7 |
| SWP | 99.3 | 94.0 | 83.8 | 76.8 | 68.2 | 55.7 |

company and a principal shipper on the White River) identified stages at gaging stations on the White River where fully loaded 9 foot barges can be moved without depth restrictions.

b. Maximum Diversion of 1640 cfs and Adjusted Project Area. Potential navigation impacts were also analyzed for a maximum pumping station capacity of 1640 cfs using the same methodology used in evaluating the 1800 cfs maximum diversion. Changes in stages were similar to those computed for the 1800 cfs maximum diversion scenario, but were slightly less ranging from 0.1 feet (out-of-bank stages) to 1.1 feet (in-bank stages). Flow/stage durations were also reduced less than for the 1800 cfs maximum diversion. The reduced changes resulted from less demand from a smaller service area and a lower diversion capacity, both which left more water in the White River. Mean weekly depths were estimated for pre- and post- maintenance dredging conditions for use in computing impacts, if any, to navigation for the SWP minimum in-stream flow condition. Plates IV-2 through IV-48 show stage hydrographs for baseline and with 1640 cfs maximum diversion simulations (1940 through 1986) and the stage reduction resulting from the diversion.

**4-D-03. ENVIRONMENTAL.**

Environmental analyses evaluated the potential for both positive and negative impacts that may result from the Grand Prairie Demonstration Project for the White River and the service area.
Positive impacts would be primarily for increased water within the service area for aquatic species throughout the irrigation season, and for increased water availability for flooding fields after harvest for migratory waterfowl. Water balance modeling provided outputs for evaluating changed conditions for the White River and water availability to flood fields for waterfowl. Water balance HEC-5 models for environmental analyses were only developed for the adjusted project area and the following diversions: No diversion, a maximum diversion of 1480 cfs, a maximum diversion of 1640 cfs, a maximum diversion of 1800 cfs, and a maximum diversion of 1960 cfs. The no diversion case was evaluated to provide a baseline (to determine the amount of water available for waterfowl during the October 15 through November 30 time frame with no outside water sources). The four maximum diversion cases were evaluated to provide information necessary to optimize benefits and costs for pumping station capacity. As demonstrated by the fish and wildlife minimum in-stream flows set forth in the SWP, minimum flows varied monthly depending on several critical time windows pertaining to aquatic and terrestrial species life cycles.

a. White River. The lower White River and its floodplain provides diverse habitats for numerous aquatic and terrestrial species. These habitats varied from in-stream waters, to bottom land hardwoods, to both isolated and connected oxbow lakes. Possible changes in these habitats, resulting from any diversions, consisted of reduced inundation durations, less frequent connections between the floodplain and the river, and reduced inter-connectivity between the river and oxbow lakes. Evaluations were conducted using the HEC-5 water balance model to identify changes in discharges within the river and floodplain that might result from any proposed diversions. The changes in discharges were converted to stages using the Clarendon, AR rating curve. Tabular rating curve values are shown in Plate IV-49. Because minimum stream flows vary by month, durations were computed for annual and monthly data for each maximum diversion; 1480 cfs, 1640 cfs, 1800 cfs, and 1960 cfs. Annual and monthly flow durations are shown in Plates IV-50 through IV-54 and in Plates IV-55 through IV-59. From the tables, maximum changes in flows (and stages) occurred during summer months when agricultural demands are highest and river levels are lowest.

Although proposed diversions occurred at a single location (DeValls Bluff, Ar), potential environmental impacts, if any, were evaluated for the reaches downstream of the diversion point. Gage data for this reach of the White River were available at DeValls Bluff, Clarendon, and St. Charles, AR, and gage data for the Mississippi River were available at Rosedale, MS (near the mouth of the White River). These gaging stations were used in projecting potential changes to riverine conditions that might develop with diversions. As Figure IV-D-01 indicated, normal fluctuations at a particular gaging site were quite high (demonstrated by significant differences between the average daily, highest daily and lowest daily discharges in the figure). Further investigation demonstrates a high degree of variability in stage for a given discharge resulting from seasonal changes in the river bed, vegetation, and basin run-off characteristics. Normal variations in the reach below Clarendon, AR are also affected by Mississippi River backwater. Stage versus stage relationships were developed between the gages to attempt quantification of changes resulting from proposed diversions. Maximum changes in stage resulting from peak diversions were estimated (from the baseline simulations) for the 1480 cfs, 1640 cfs, 1800 cfs, and 1960 cfs pumping stations. A maximum change of 1.2 feet for the 1960 cfs maximum diversion seemed large initially, however, when compared to the natural fluctuations and high degree of variability in observed stage hydrographs, the 1.2 feet was relatively small. The smaller capacity pumping stations produced less change than the 1960 cfs pumping station. Seasonal stage variations at DeValls Bluff were as high as 3 to 4 feet for a given discharge. Because of the seasonal nature of any proposed diversions, seasonal, i.e. monthly, stage versus stage (or elevation versus elevation) curves were developed between adjacent gaging stations in order to evaluate potential stage reductions due to the diversions. Monthly elevation versus elevation relationships between DeValls Bluff (WR115) and Clarendon (WR116) were developed and are shown on Plates IV-60 through IV-71. Visual inspection of the plotted data for these two stations revealed a spread in the data of 2 to 3 feet. This was much higher than the projected 1.2 feet change for the 1960 cfs maximum diversion. Monthly elevation versus elevation relationships between Clarendon (WR116) and St. Charles (WR118) were developed and are shown on Plates IV-72 through IV-83. The plotted data for these two stations exhibited nearly the same trends as for the DeValls Bluff and Clarendon relationships. Finally, monthly elevation versus elevation data were plotted between St. Charles, AR (White River, WR118) and Rosedale, MS (Mississippi River, MS136) and are shown on Plates IV-84 through IV-95. The Rosedale, MS gaging station represented the closest gaging station to the mouth of the White River. The plotted data had such a high degree of variability (5 to 10 feet or more), no relationship could established for the most downstream reach being evaluated. The degree of variability was consistent for all months. The large variations between St. Charles and Rosedale were largely due to Mississippi River backwater dominating flow conditions much of the time. White River and Mississippi River mileage and gage datum for each gaging station used to evaluate potential changes in the White River downstream of any diversion are shown in Table IV-D-2.

Table IV-D-2

| Gage ID | Location | River Mile | Gage Zero El. NGVD |
|---|---|---|---|
| WR115 | White River at Devalls Bluff, AR | 121.8 | 152.96 |
| WR116 | White River at Clarendon, AR | 99.1 | 139.91 |
| WR118 | White River at St. Charles, AR | 57.0 | 129.95 |
| MS136 | Mississippi River at Rosedale, MS (near mouth of White River) | 592.1 | 108.73 |

b. <u>Flooding for Waterfowl</u>. The Grand Prairie was identified as part of the North American waterfowl migratory flyway. Each year significant numbers of waterfowl migrate to and through the area. Where available, flooded fields (especially rice fields) provide resting and feeding areas for the birds. The Grand Prairie was designated as part of the ***North American Waterfowl Agreement***[14] which established target areas (and acreages) for waterfowl resting and feeding during their annual migration. As such, part of the of the water supply project was targeted to increase the area flooded during the migration period. This involved reflooding fields after harvest to a nominal depth to provide the waterfowl their desired habitat for resting and feeding. The target established by the ***North American Waterfowl Agreement*** for the Grand Prairie was 45,000 acres.

[14] The ***North American Waterfowl Agreement*** was developed by a consortium of waterfowl and wildlife groups and state and federal agencies such as Ducks Unlimited, The Rice Foundation, The US Fish and Wildlife Service, Arkansas Game and Fish, etc. The agreement was established to foster and encourage measures to enhance waterfowl populations through increased habitat for migratory resting and feeding ***and for nesting areas***.

Water balance modeling to evaluate the ability to provide water for waterfowl was accomplished for the original project area and a maximum pumping station capacity of 1800 cfs. Water balance calculations included evaluation of water availability during the migratory period, October 15 through November 30. The HEC-5 water balance model operated to meet estimated water demands for providing and maintaining water over the 45,000 acres. An average water depth of three (3) inches was used in establishing waterfowl water demands. Sustaining the average three inch depth required continual balancing between rainfall, evaporation, and imported water. As expected, water availability from October 15 through November 30 was generally low owing to the fact that the White River is typically at its lowest during October and November. However, water needed for the waterfowl acreage was relatively small when compared to the total annual water demands for the Grand Prairie Demonstration project. All water needs for providing 45,000 acres of flooded fields were met 78[15] percent of the time. Further, 92 percent of the average water needs[16] were provided by the import system.

Although water balance modeling was based on the original project area and a maximum pumping station capacity of 1800 cfs, water provided for flooding the 45,000 acres using the adjusted project area and the 1480 cfs, the 1640 cfs, the 1800 cfs, or 1960 cfs maximum pumping station capacity would be similar to that presented. The water requirements for the October 15 through November 30 time period were of such a magnitude that reducing the diversion capacity slightly would not significantly alter the amount of water available for providing the 45,000 flooded acres. Reduced water demands for the adjusted project area also allowed more potential water carry-over in on-farm storage reservoirs.

---

[15] All water needed for October 15 through November 30 were provided 37 out of the 47 years simulated in the HEC-5 water balance model.

[16] The average water need for providing the flooded waterfowl habitat was calculated as the average of the water needs required to provide and maintain the 45,000 flooded acres at an average depth of 3 inches over the entire 47 year period analyzed.

Figure II-E.1 Schematic of Water Balance (HEC-5) Conditions Evaluated

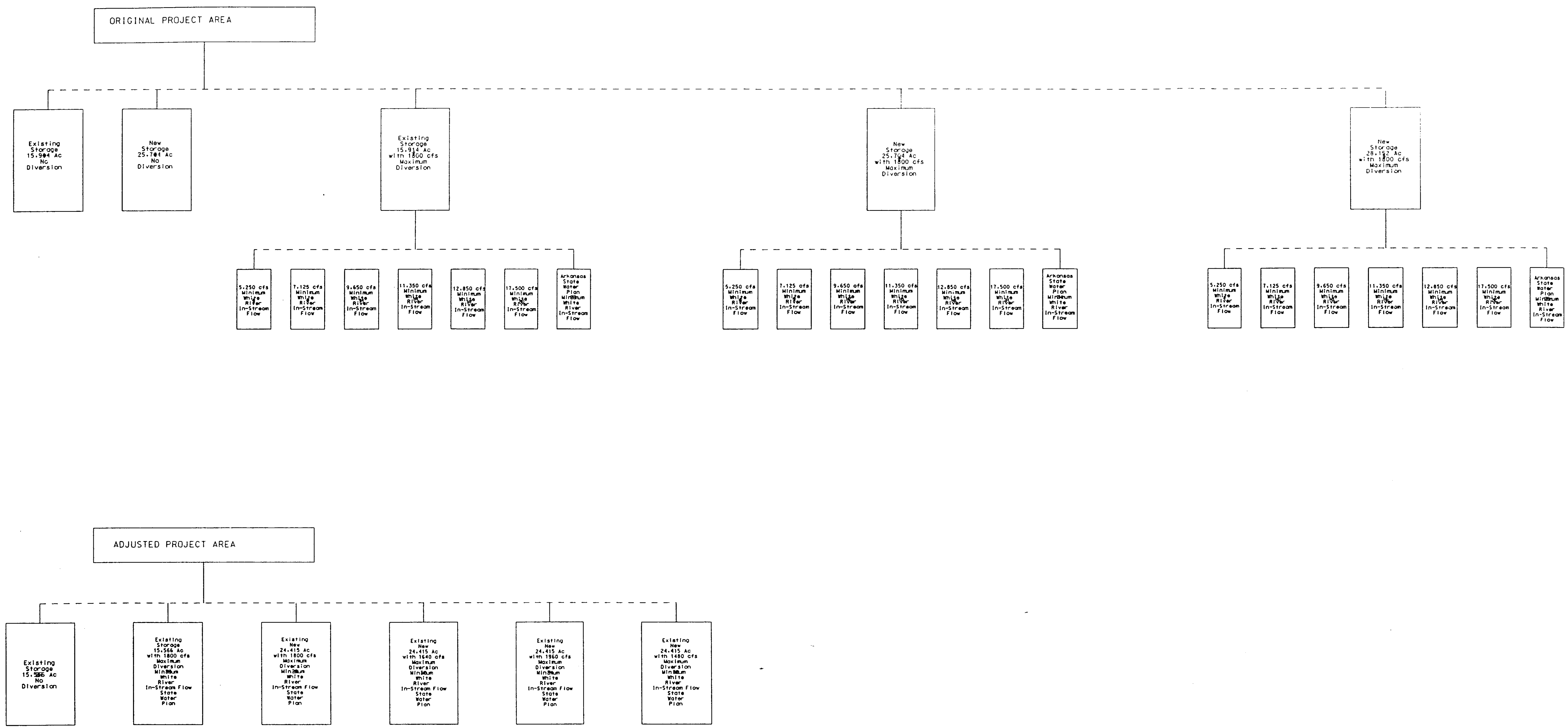


**Figure IV-B.2.1 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1940**

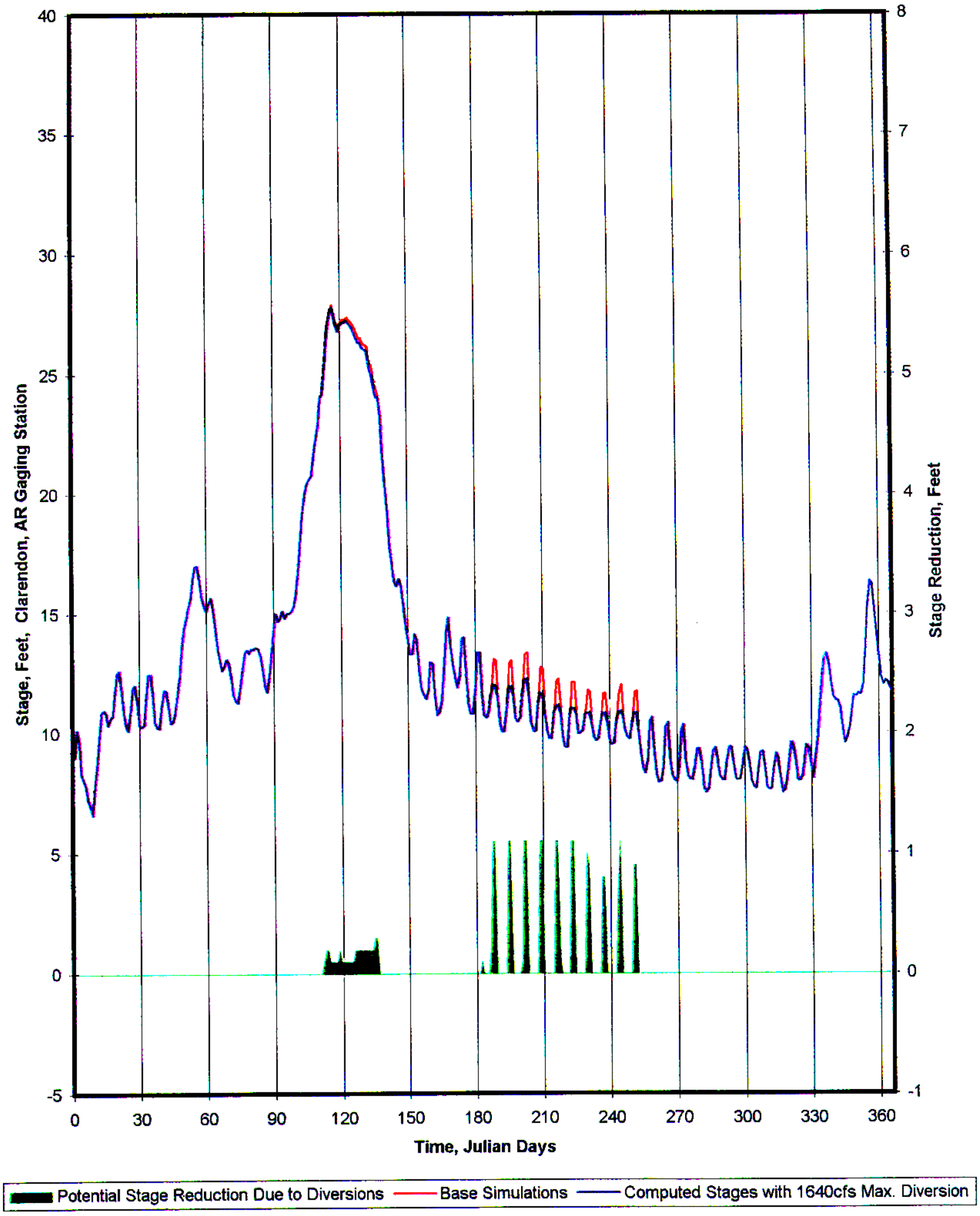



PLATE IV-2

**Figure IV-B.2.2 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1941**

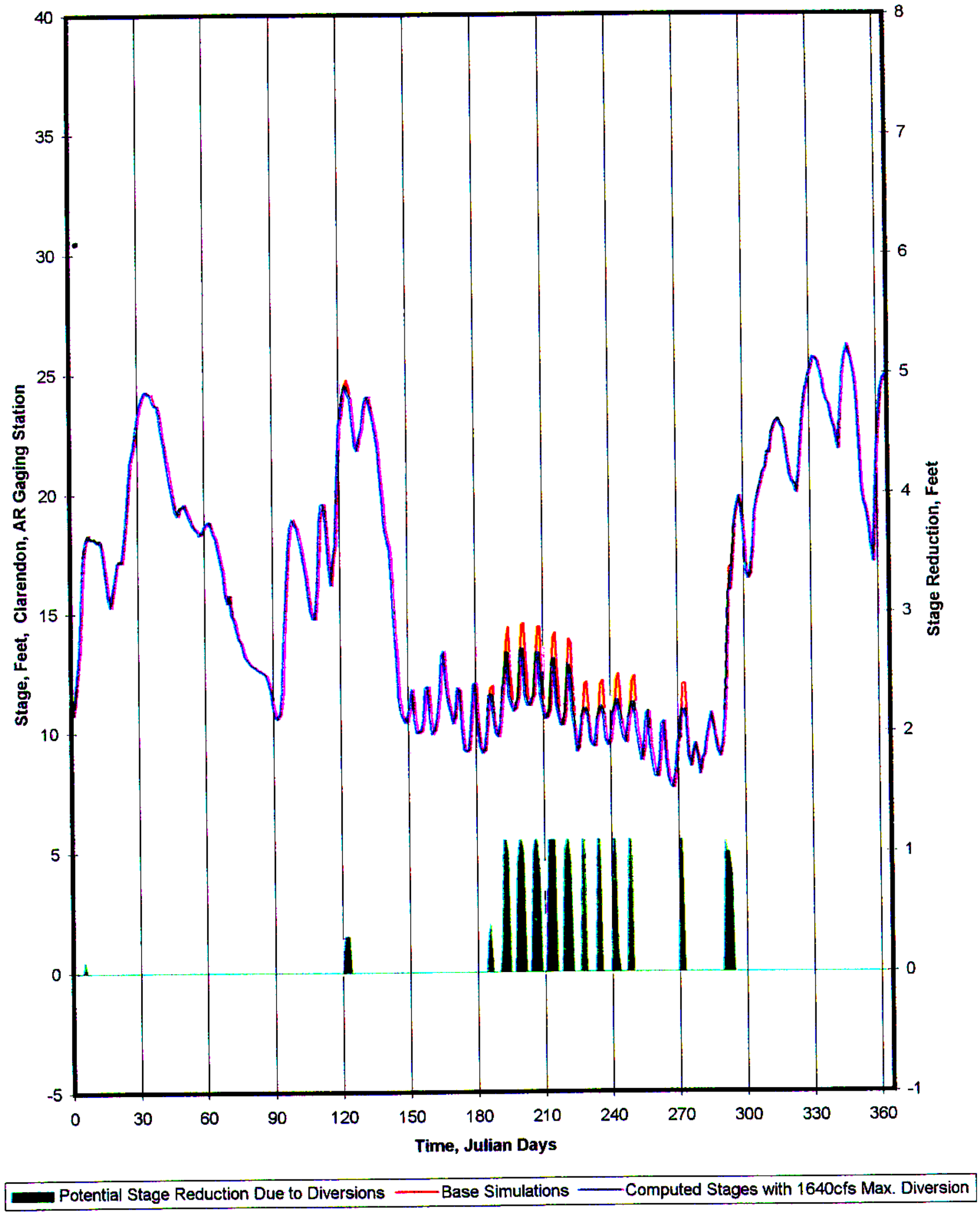



PLATE IV-3

**Figure IV-B.2.3 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1942**

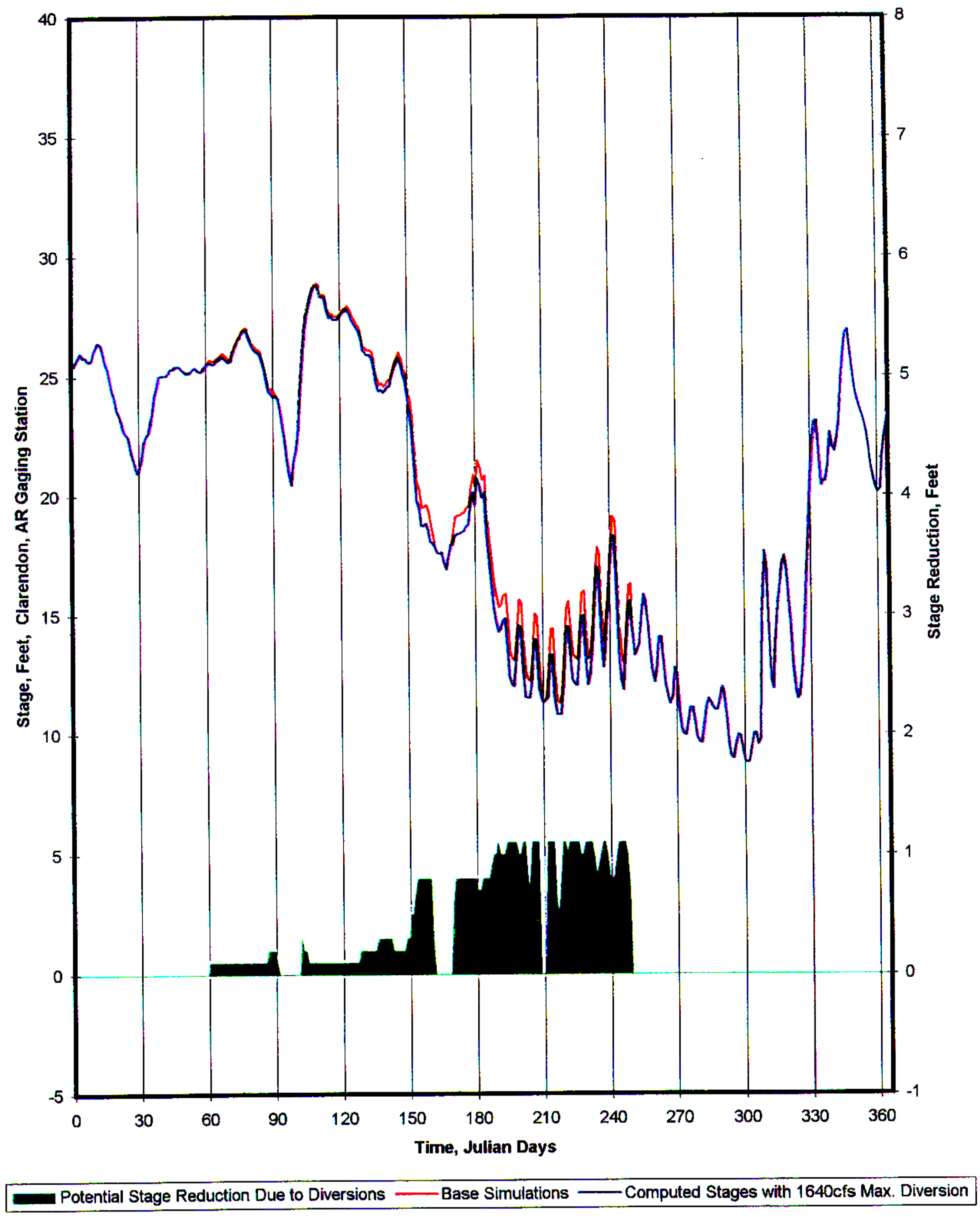



PLATE IV-4

**Figure IV-B.2.4 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1943**

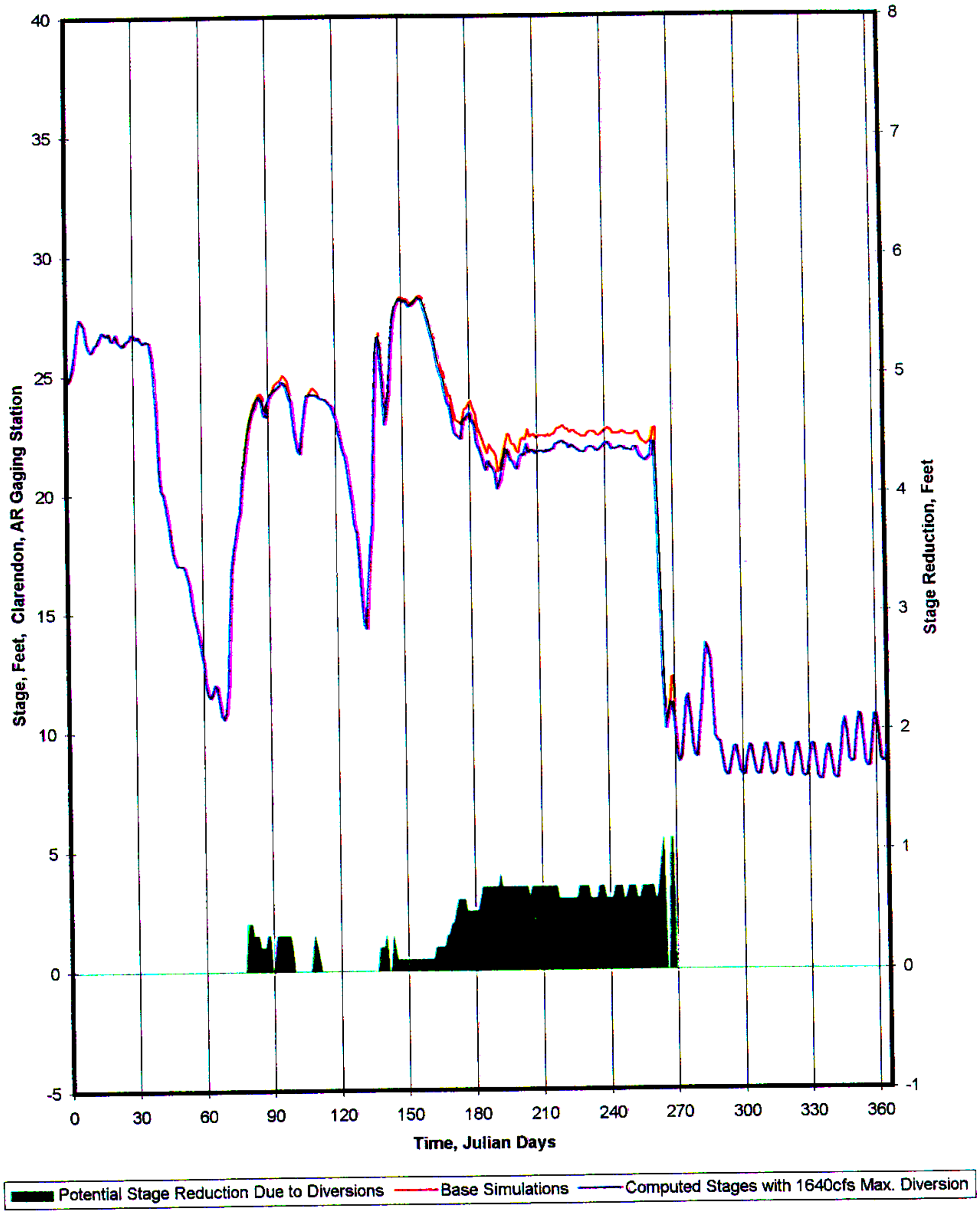



PLATE IV-5

**Figure IV-B.2.5 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1944**

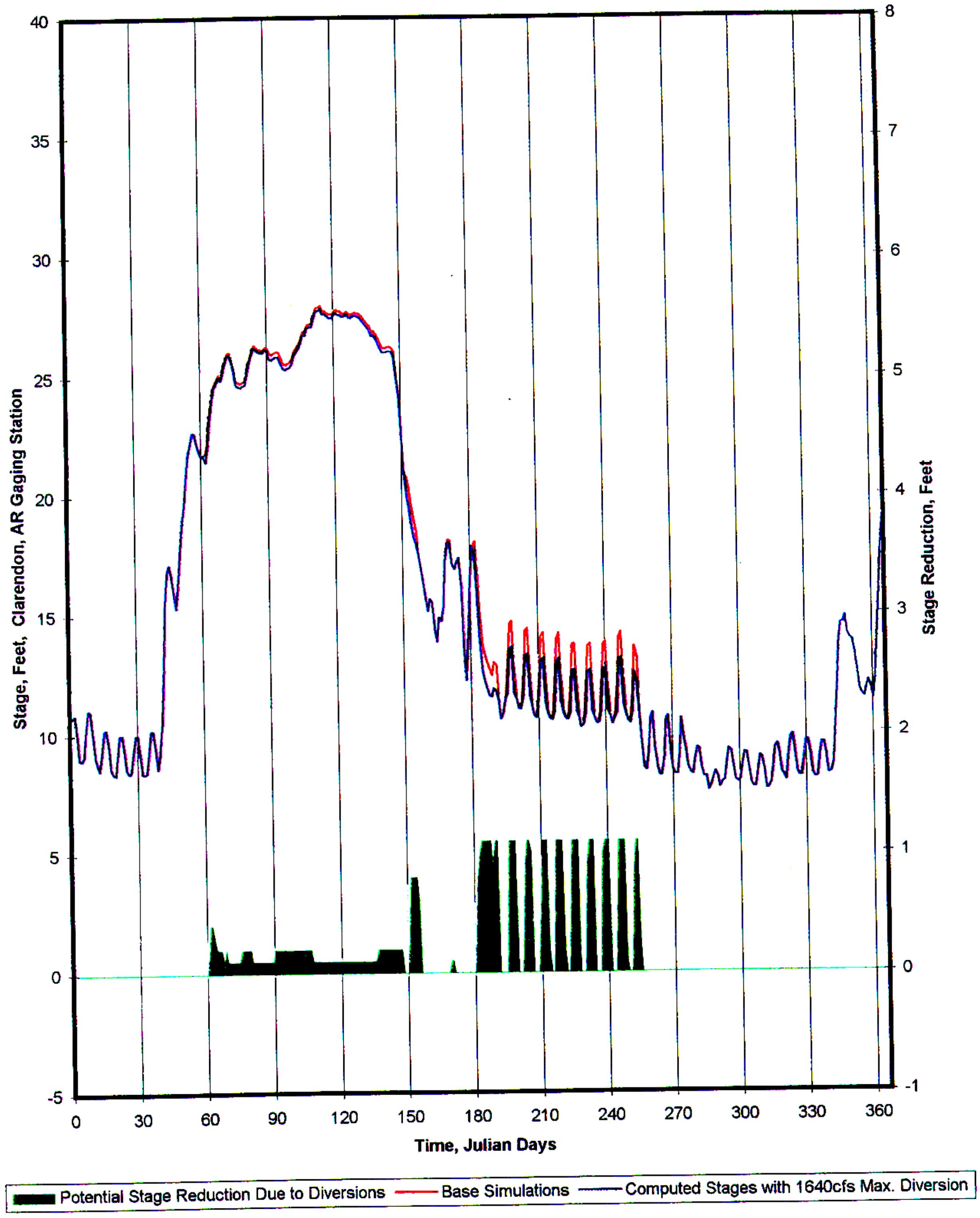



PLATE IV-6

**Figure IV-B.2.6 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1945**

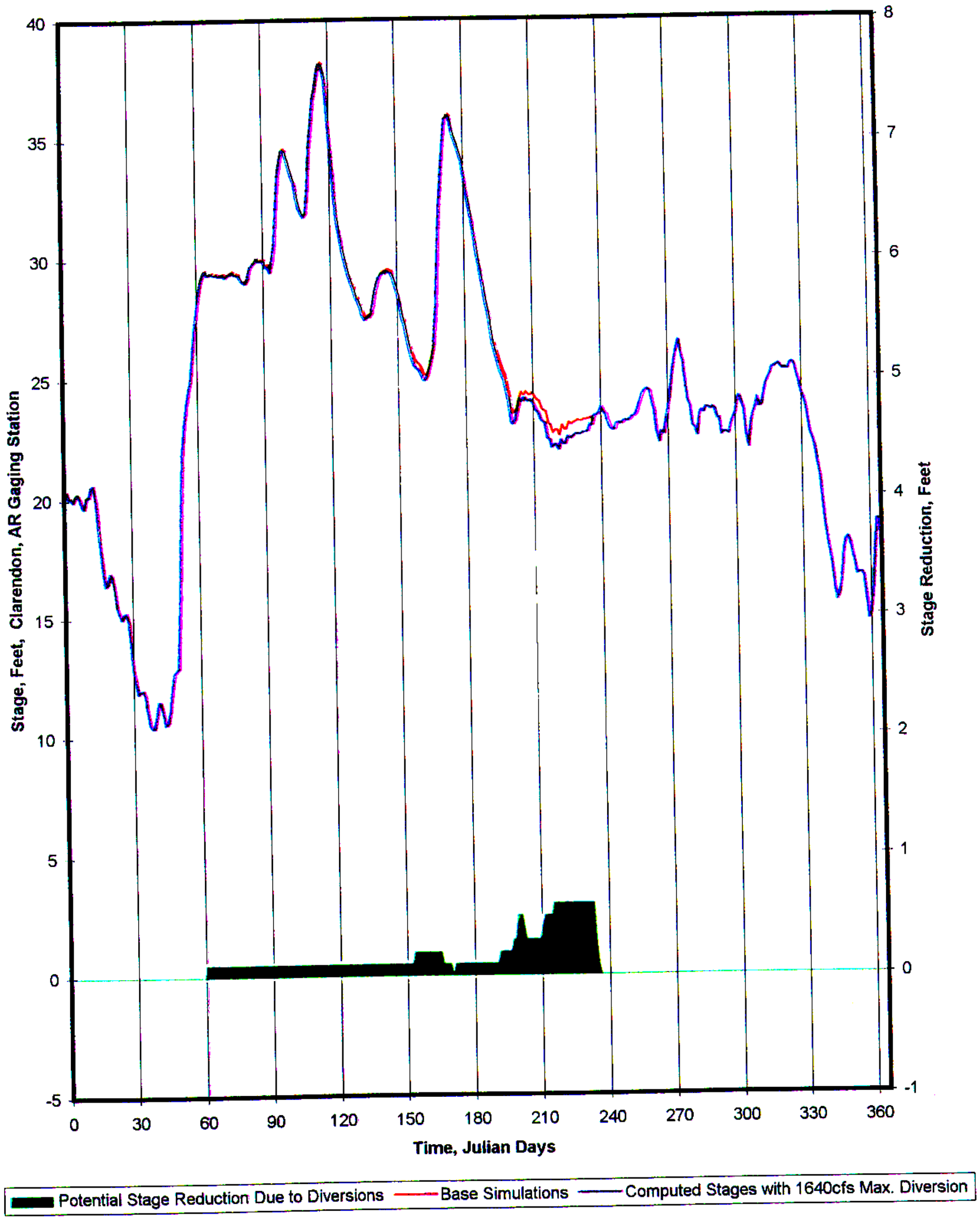



PLATE IV-7

**Figure IV-B.2.7 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1946**

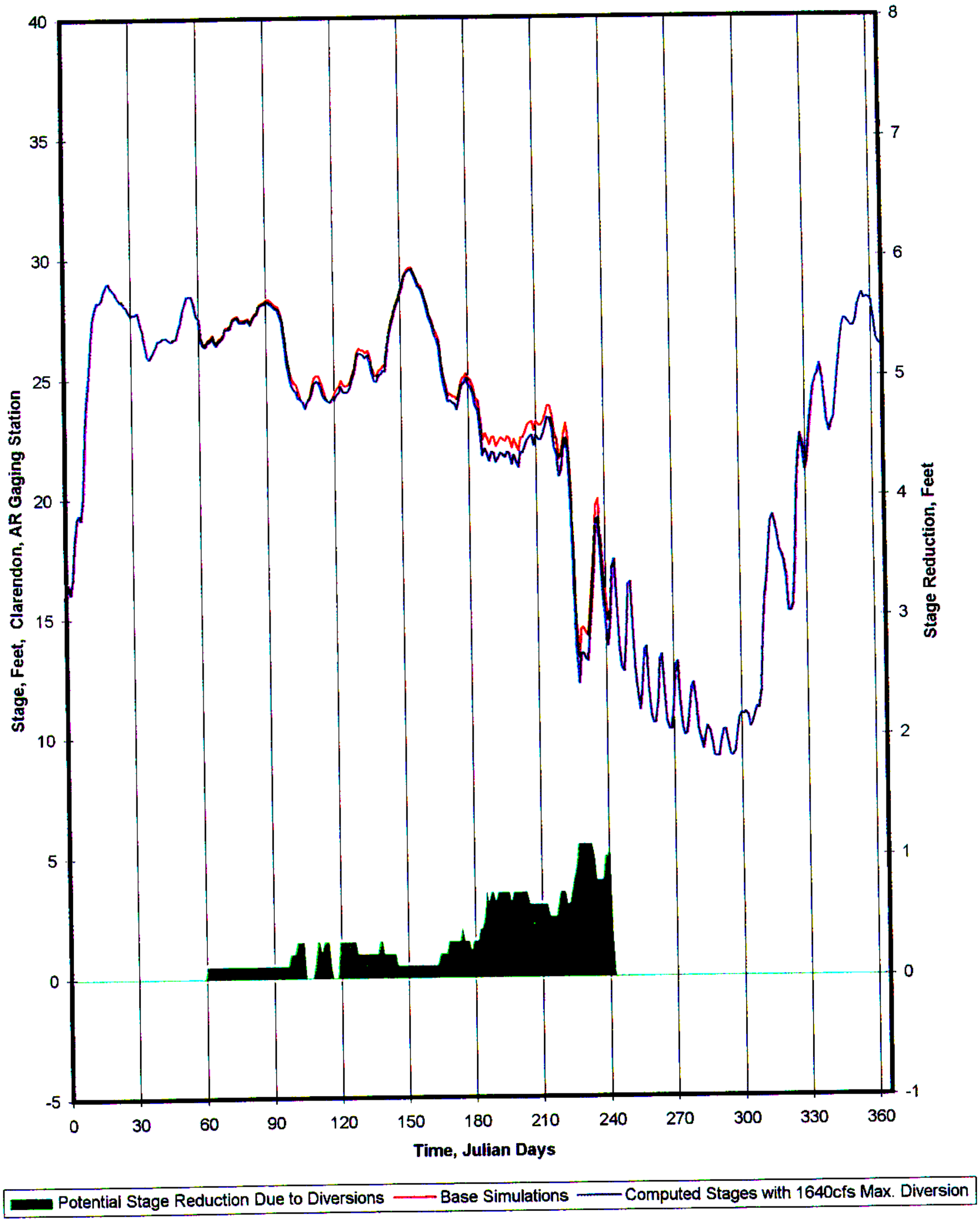
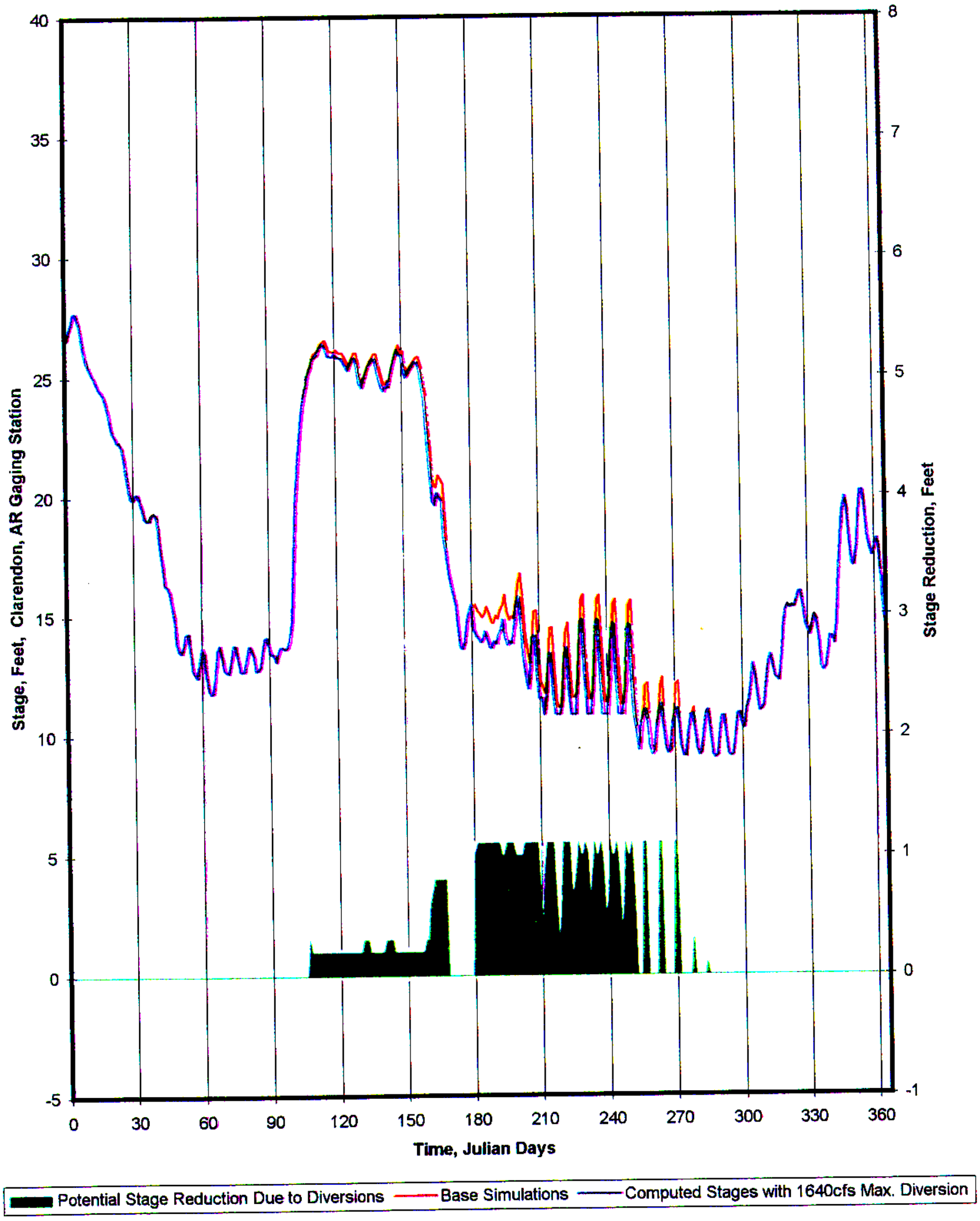



PLATE IV-8

**Figure IV-B.2.8 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1947**



## Figure IV-B.2.9 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1948

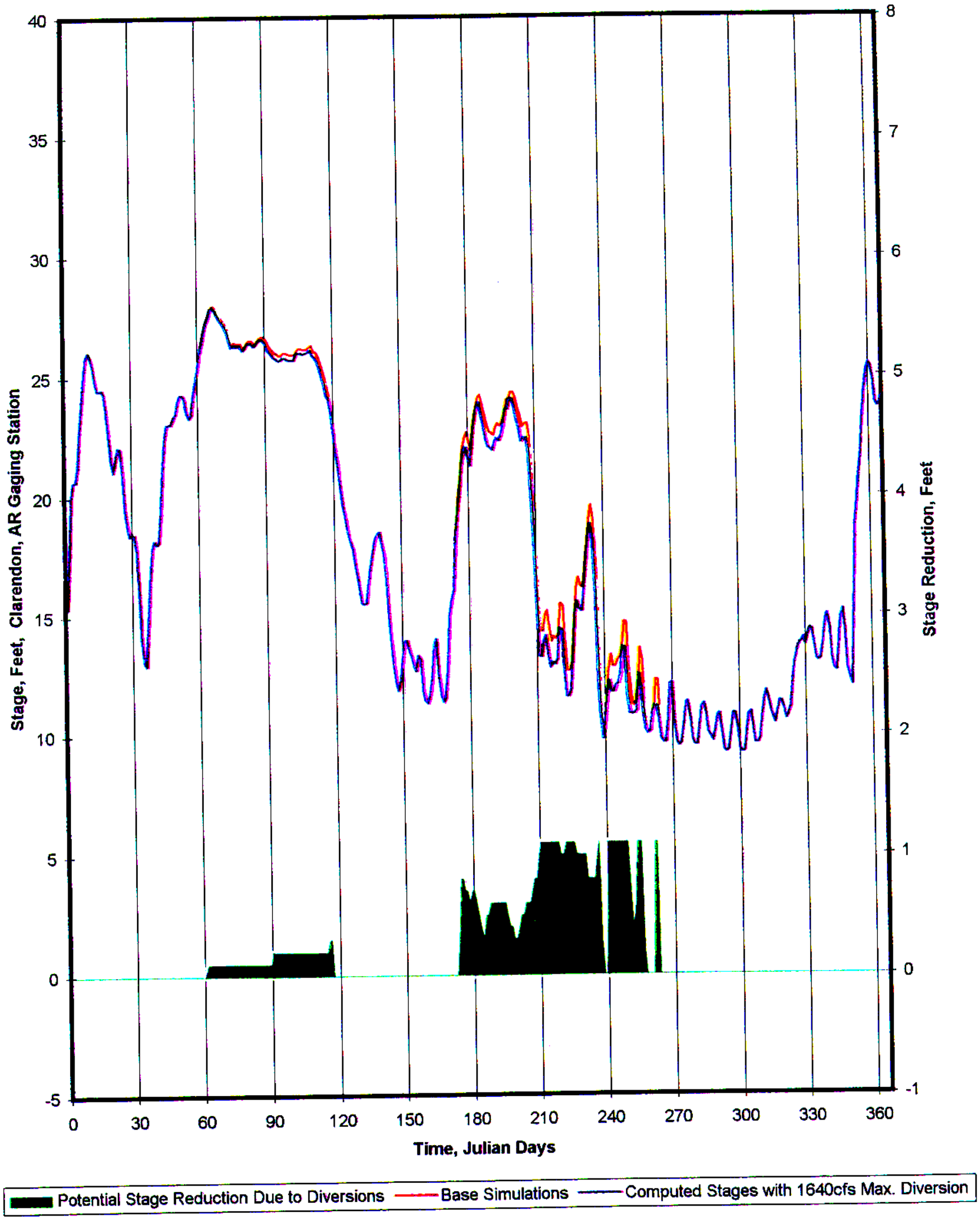



PLATE IV-10

## Figure IV-B.2.10 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1949

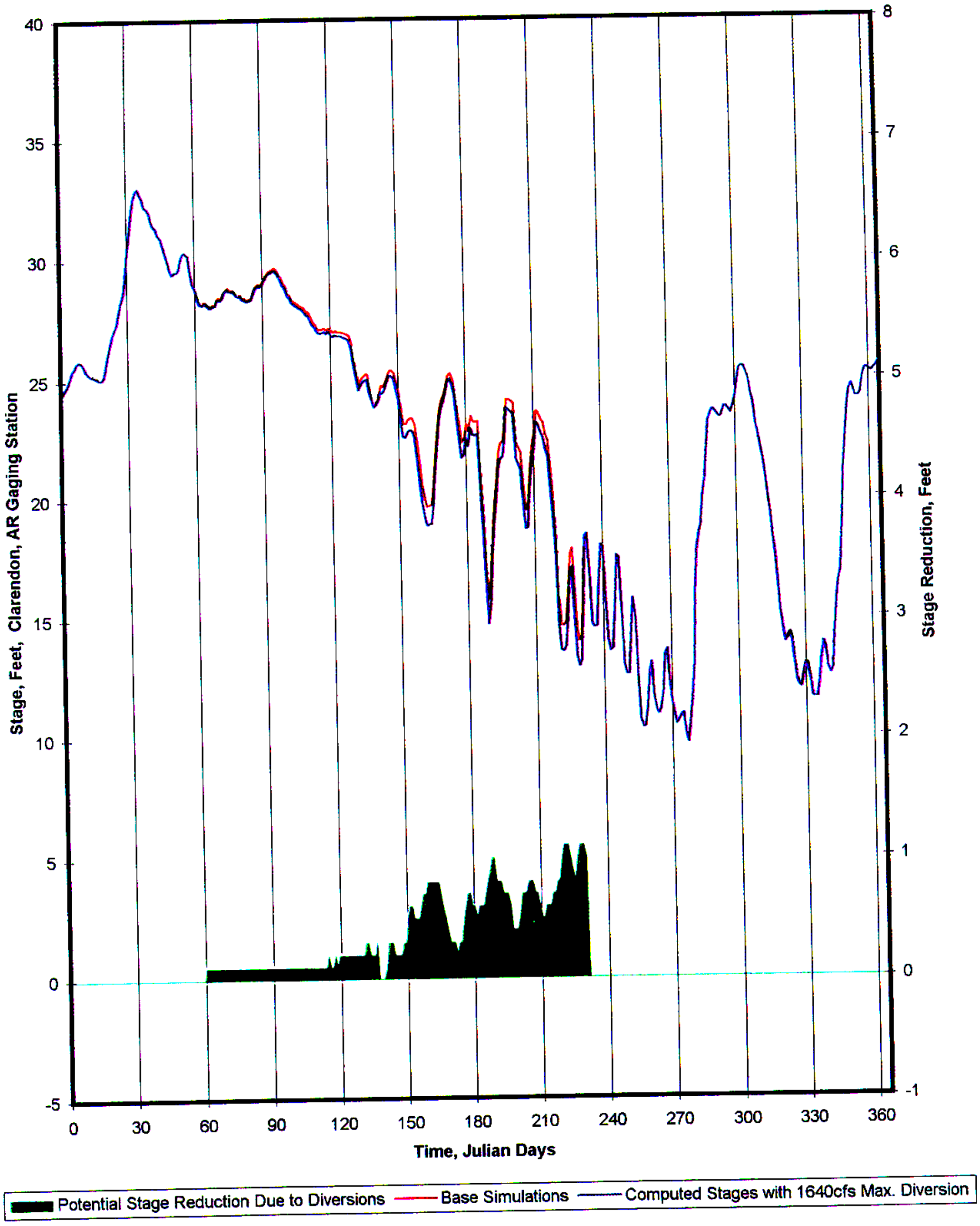


**Figure IV-B.2.11 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1950**

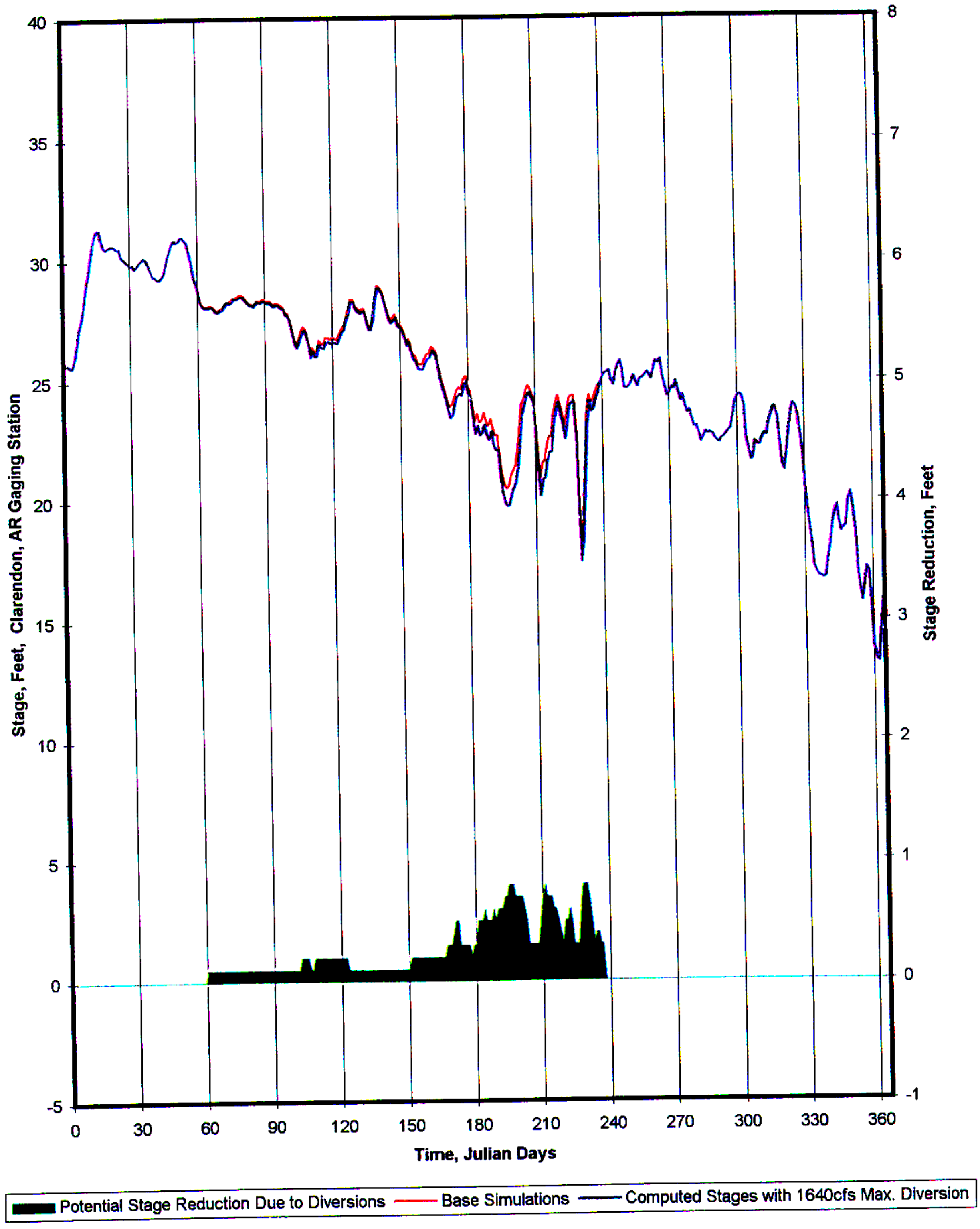


**Figure IV-B.2.12 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1951**

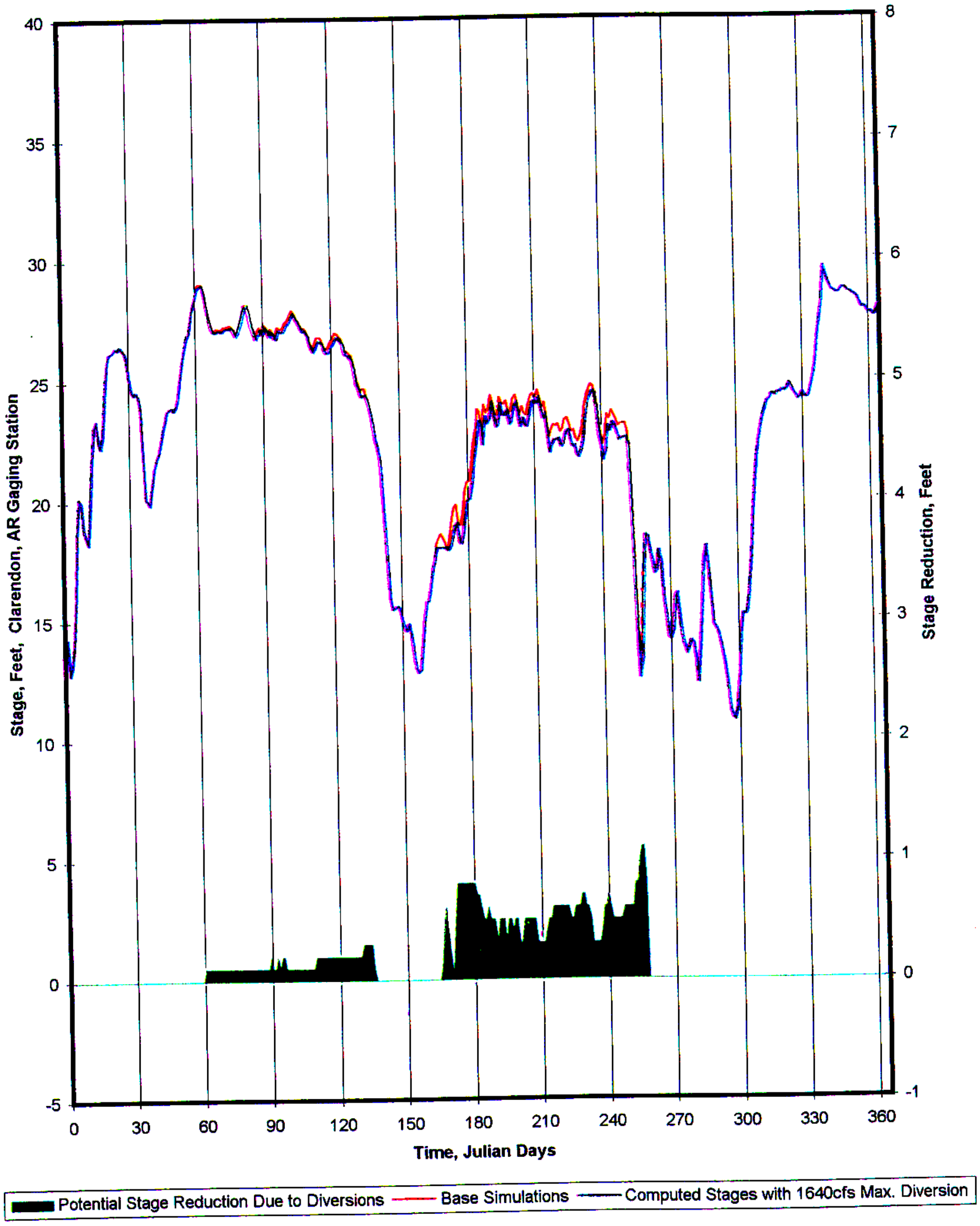



PLATE IV-13

**Figure IV-B.2.13 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1952**

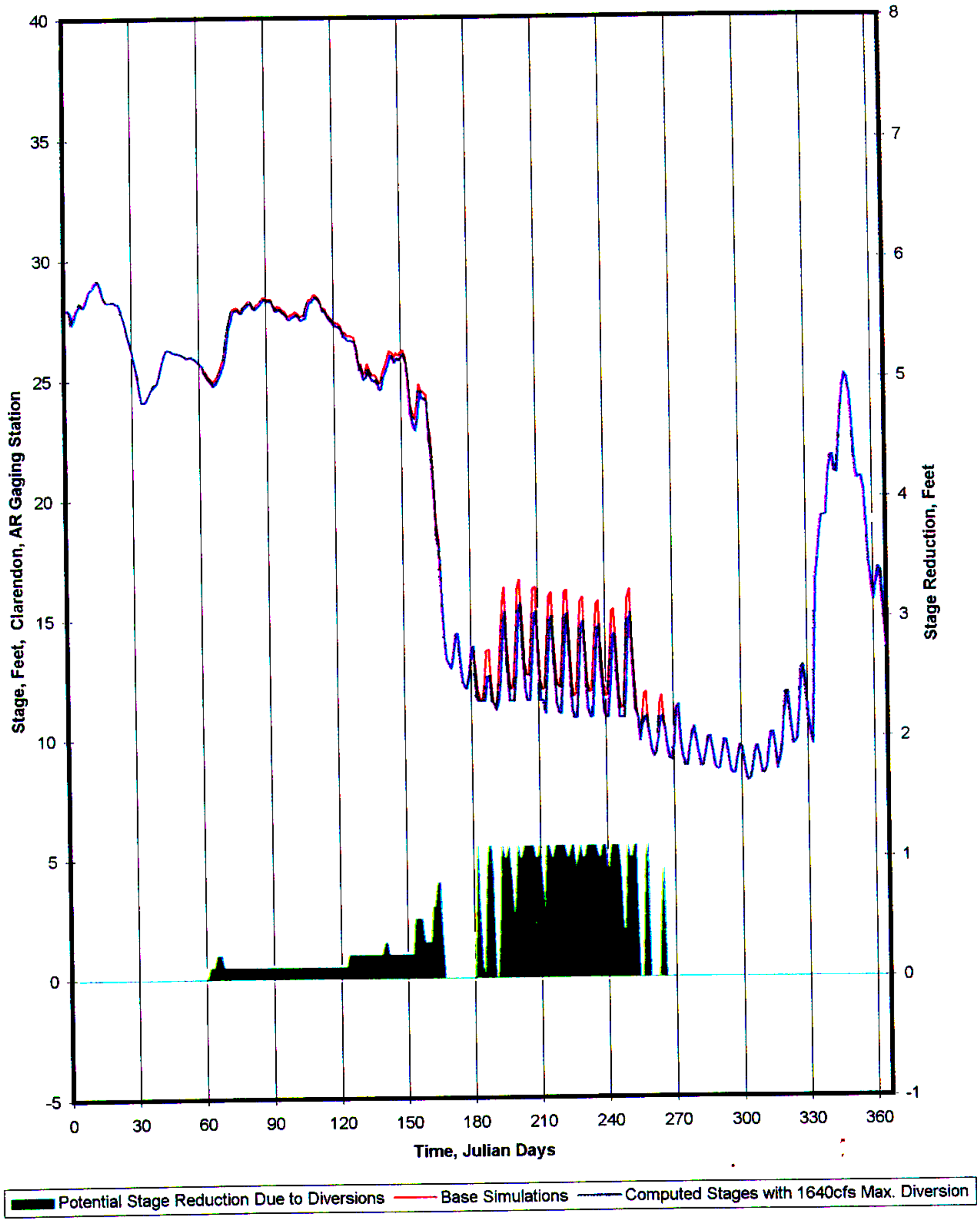


**Figure IV-B.2.14 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1953**

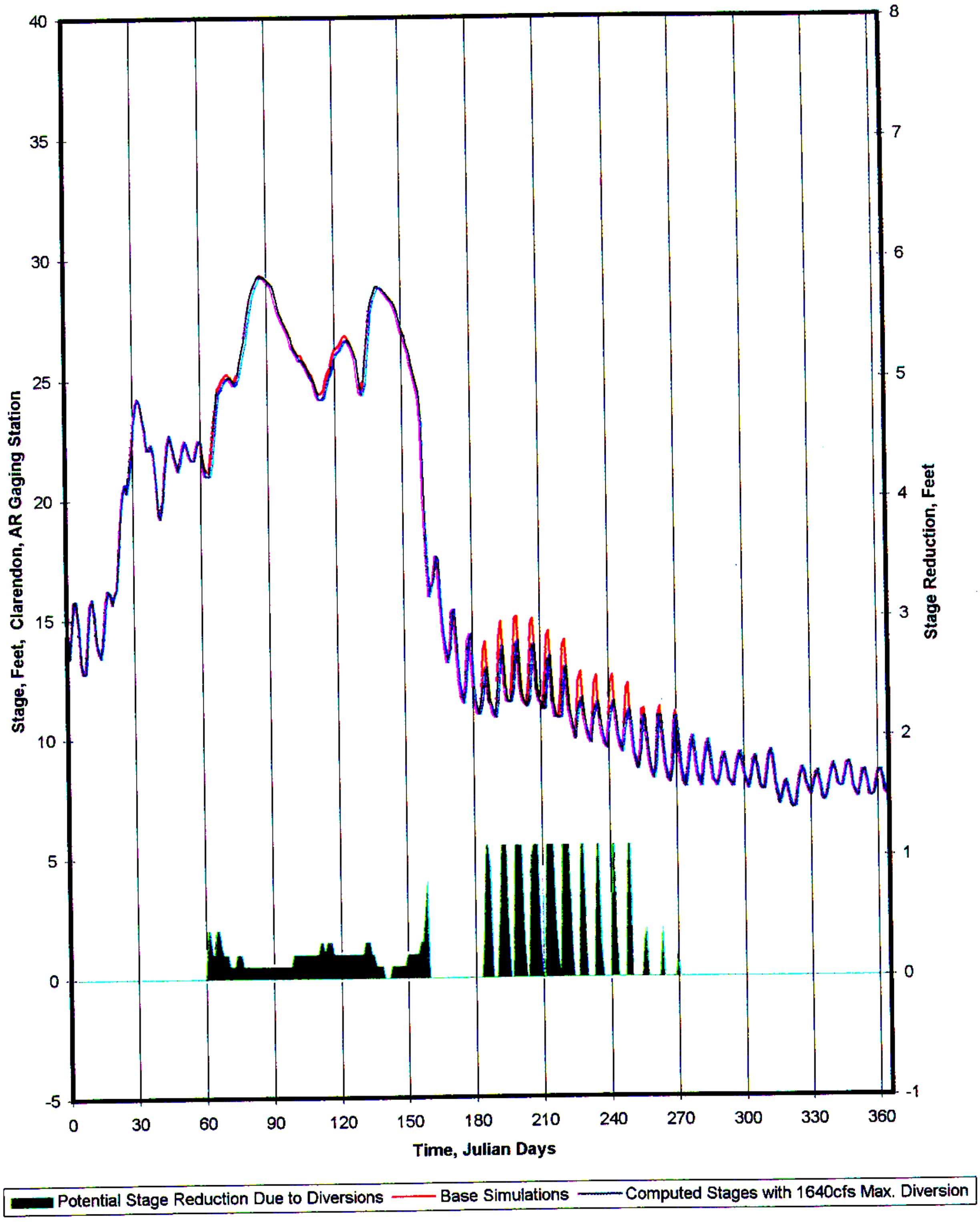


Figure IV-B.2.15 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1954

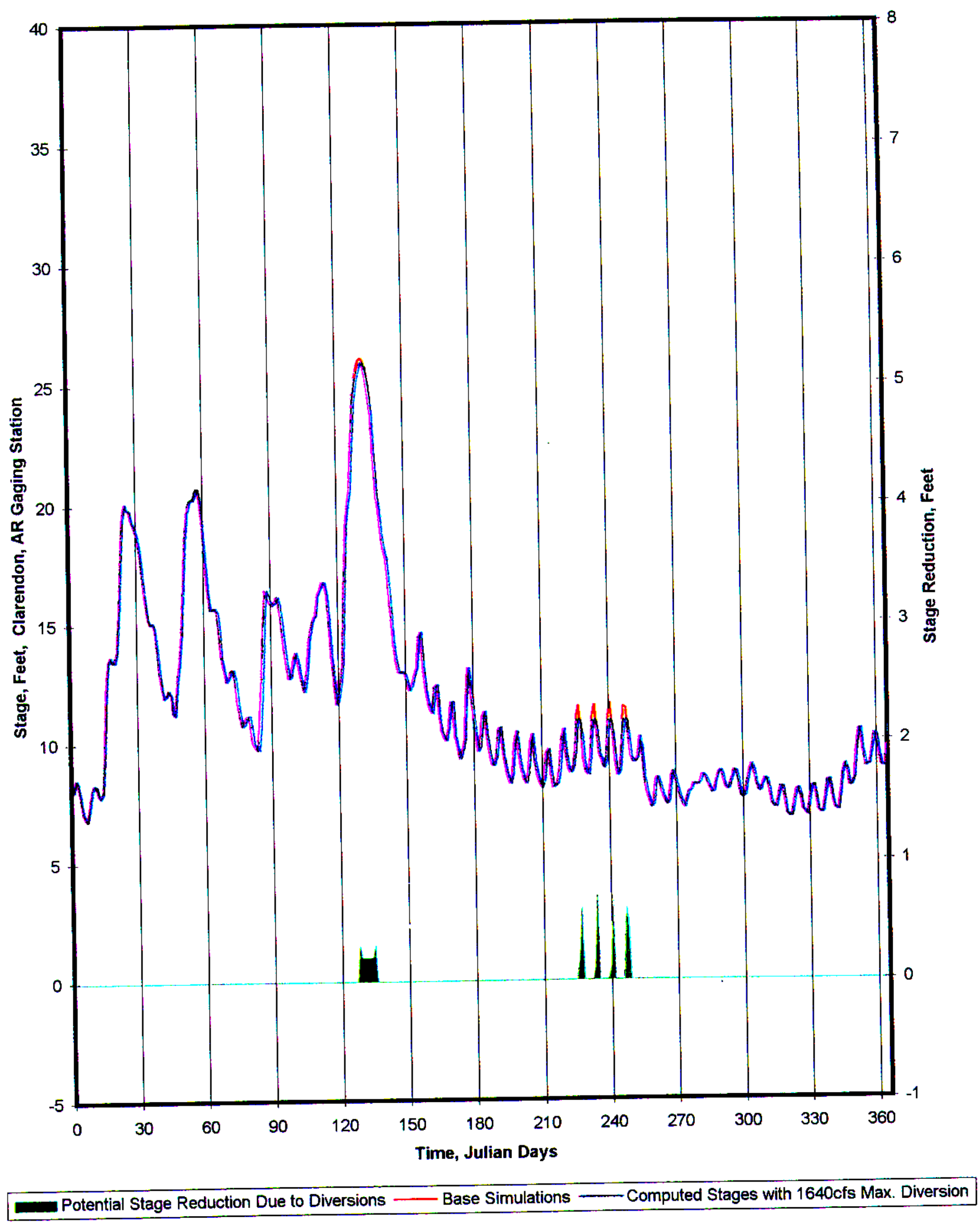
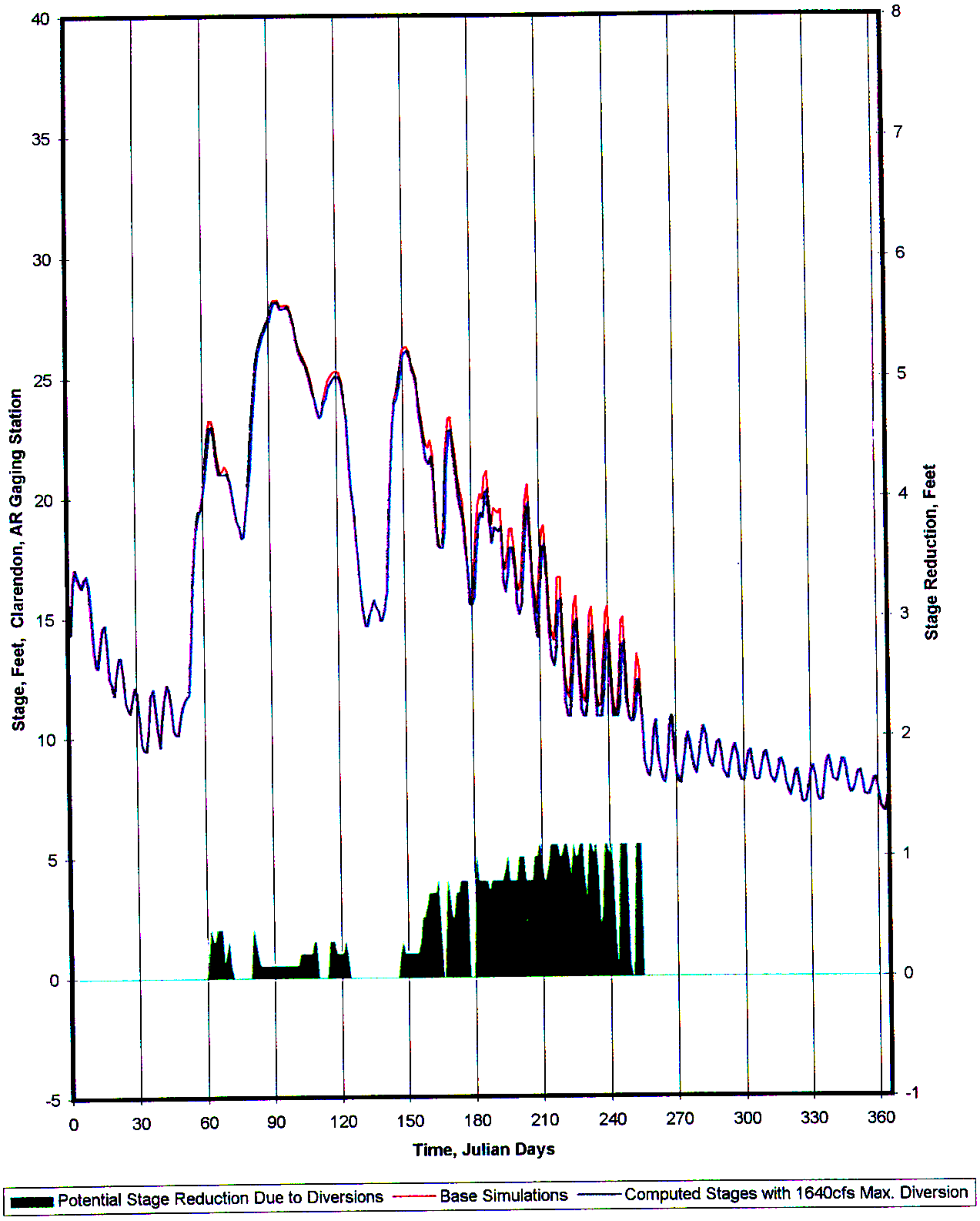
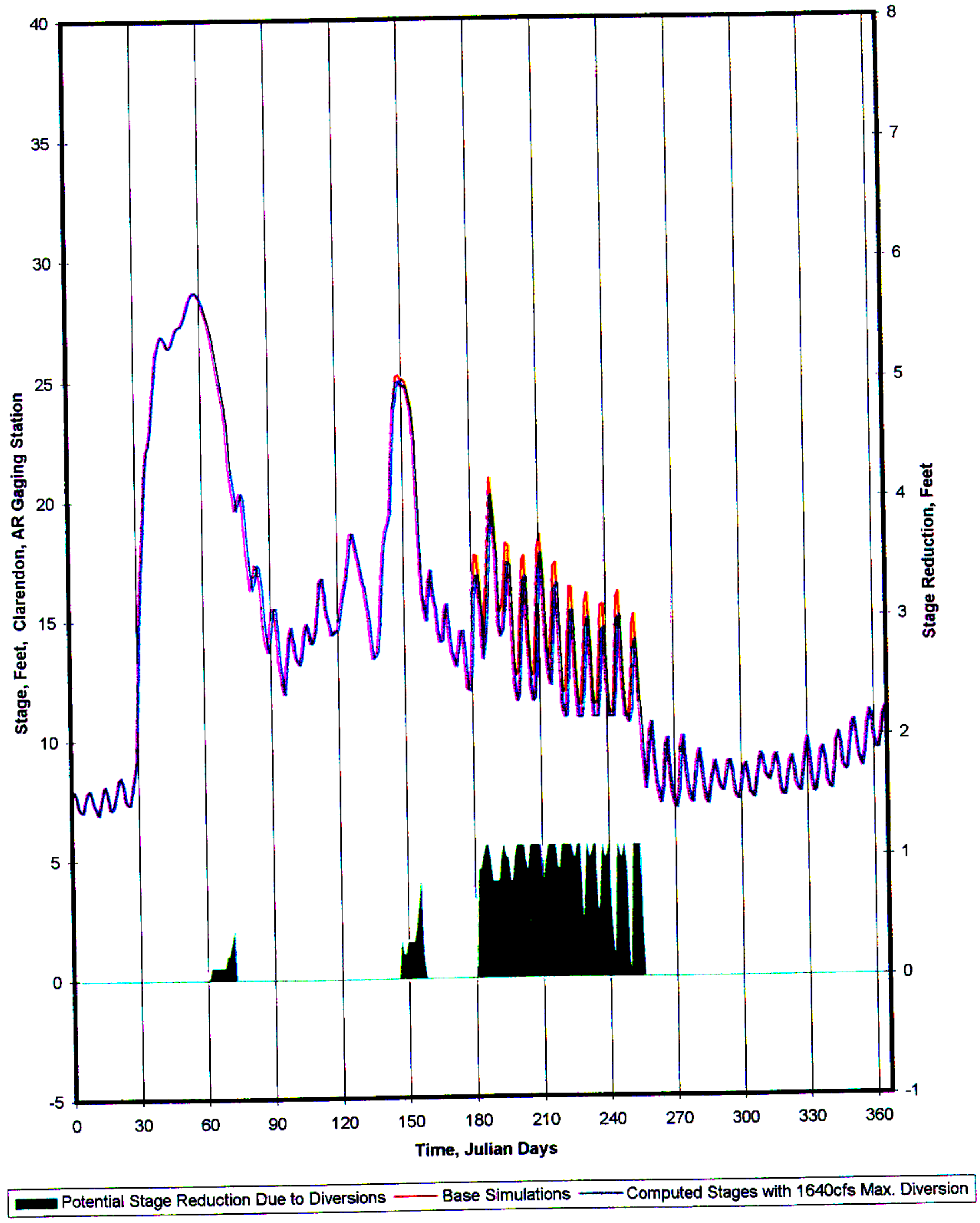



PLATE IV-16

**Figure IV-B.2.16 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1955**



## Figure IV-B.2.17 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1956



## Figure IV-B.2.18 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1957

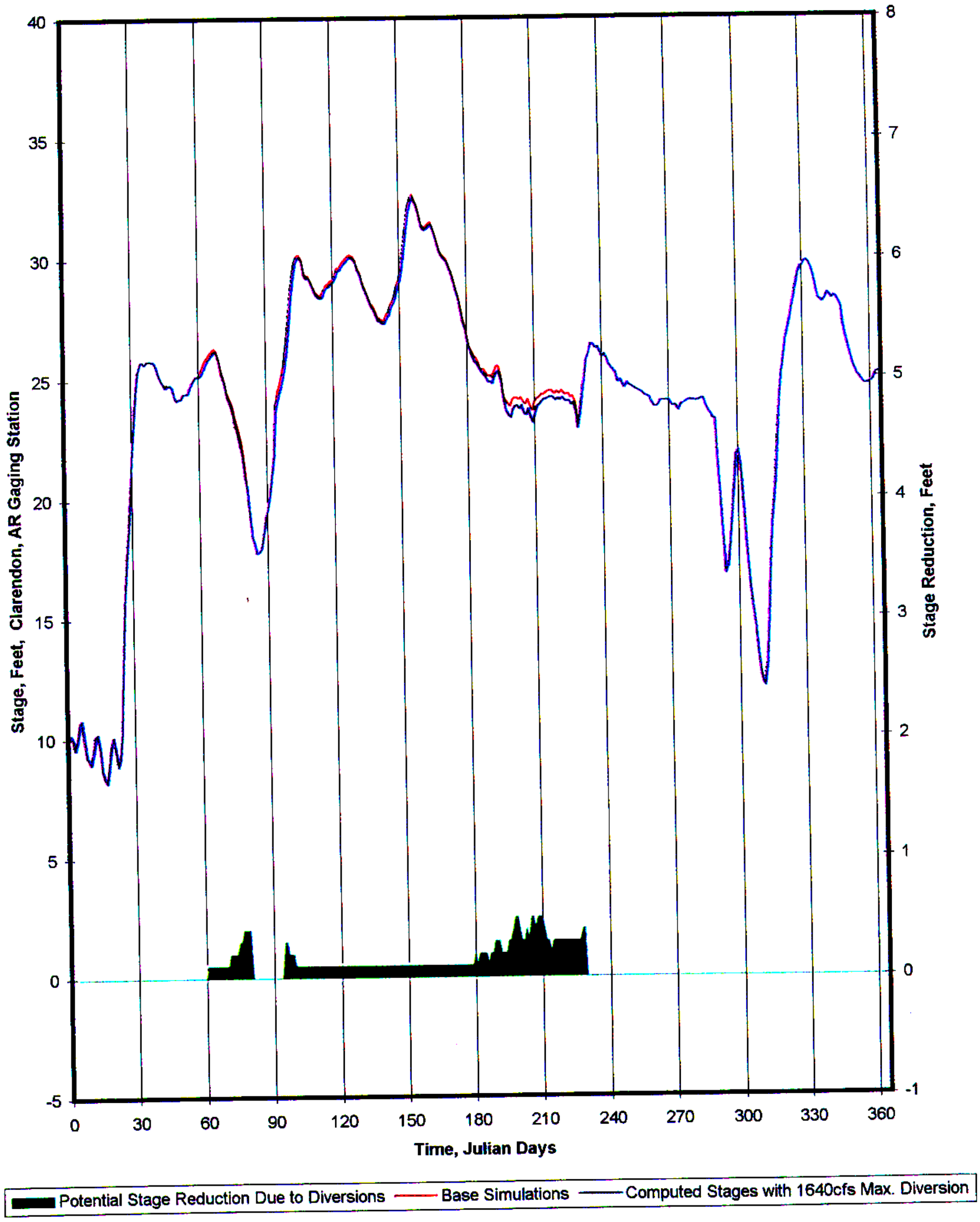



PLATE IV-19

**Figure IV-B.2.19 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1958**

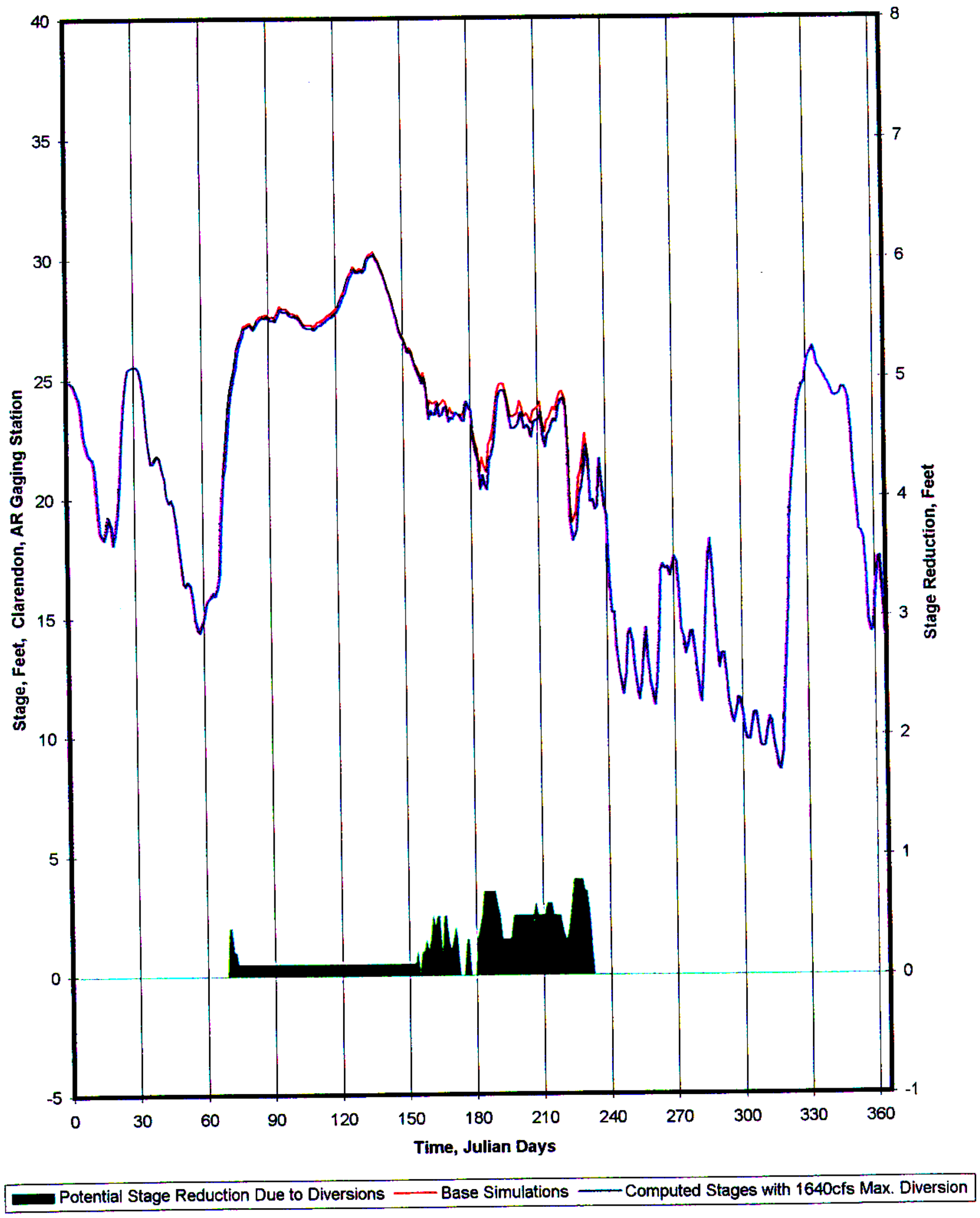



PLATE IV-20

**Figure IV-B.2.20 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1959**

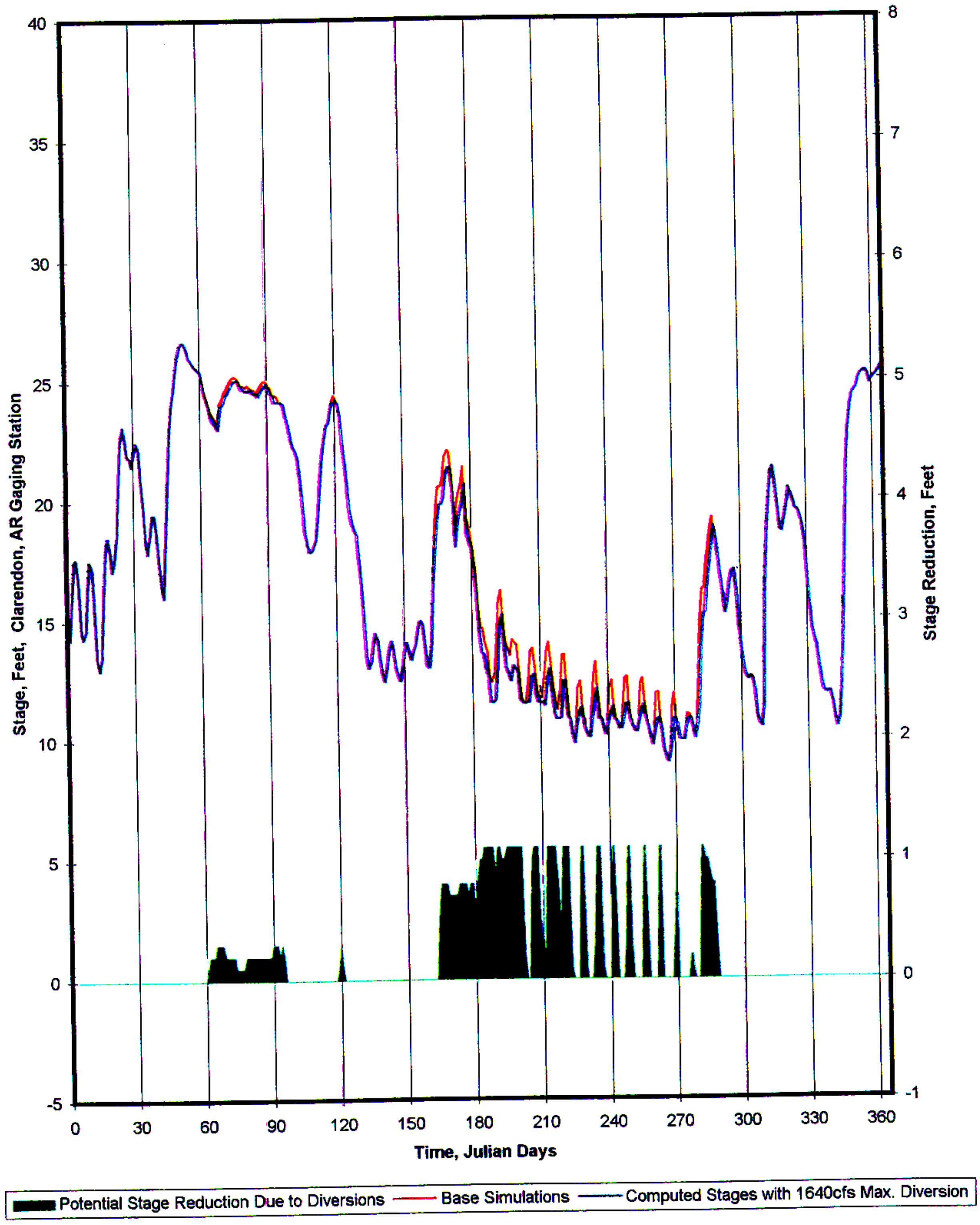


Figure IV-B.2.21 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1960

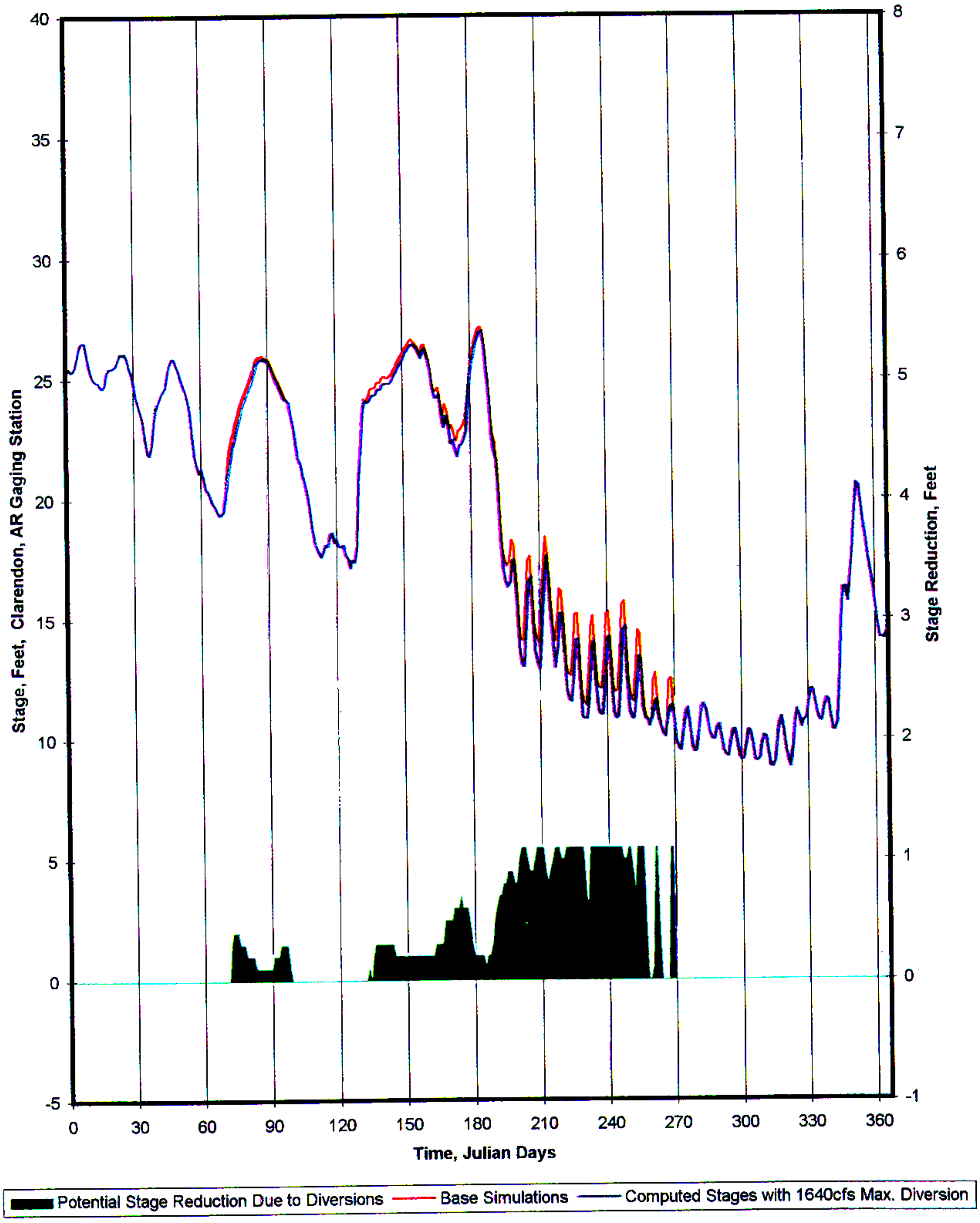


**Figure IV-B.2.22 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1961**

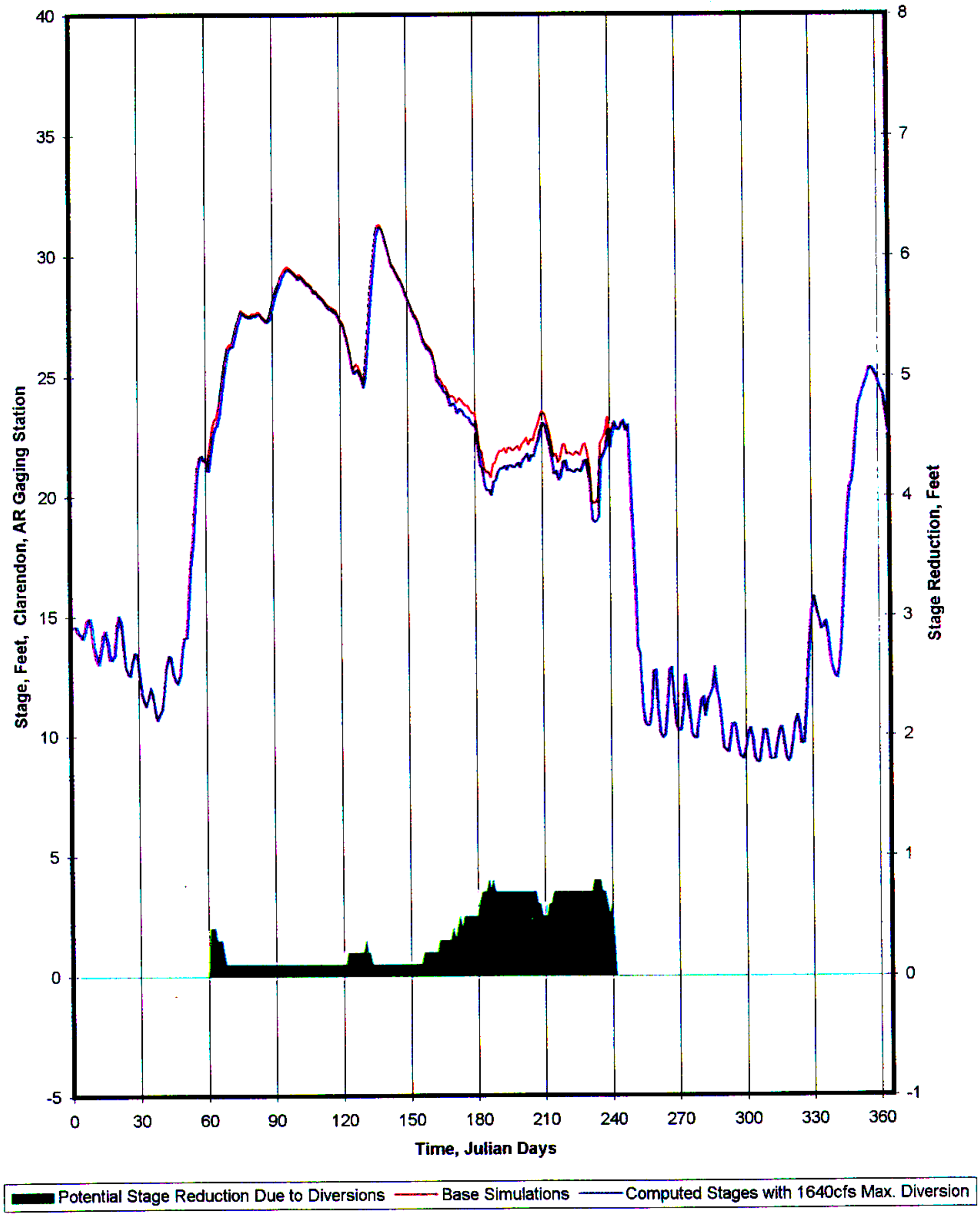


**Figure IV-B.2.23 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1962**

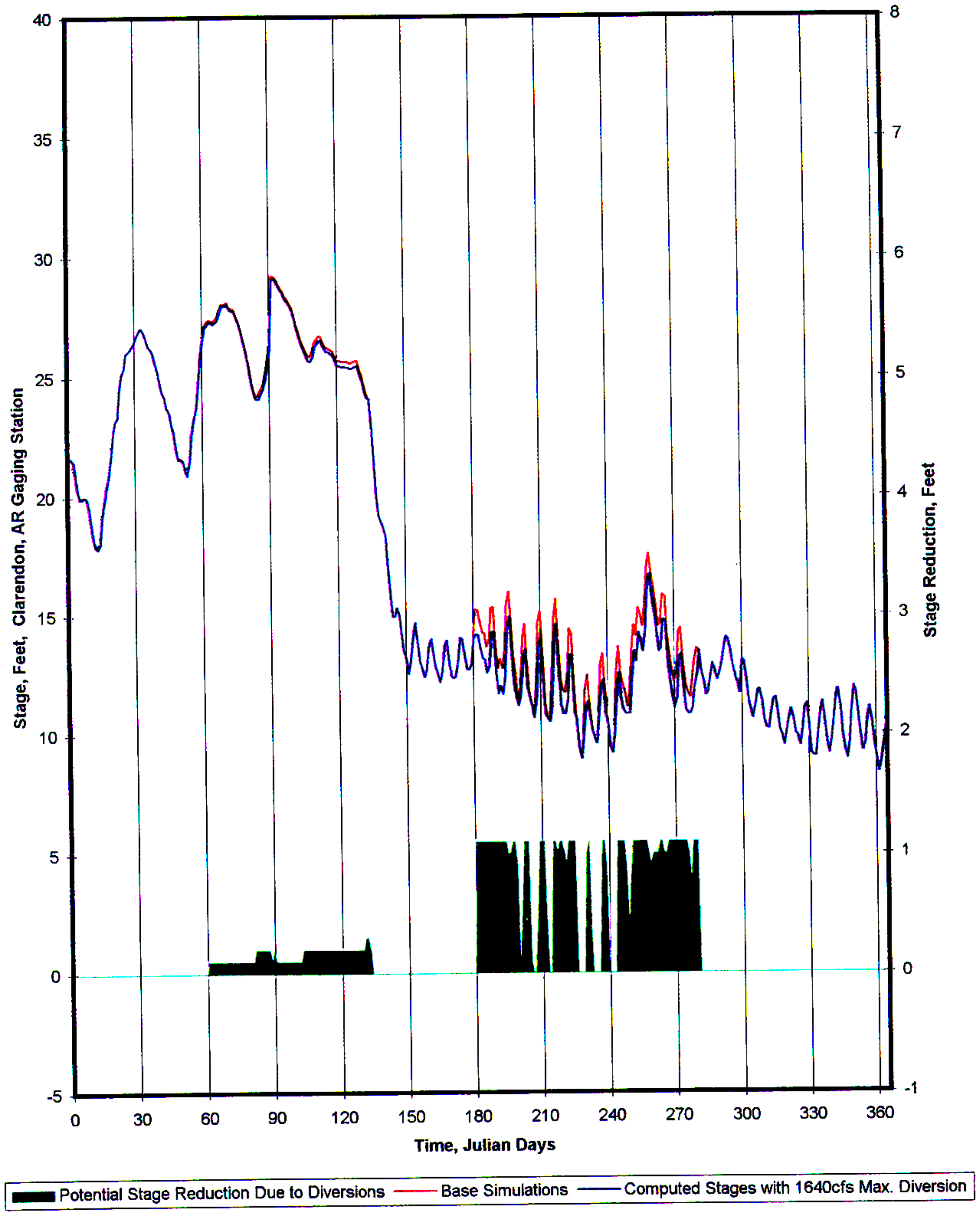


**Figure IV-B.2.24 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1963**

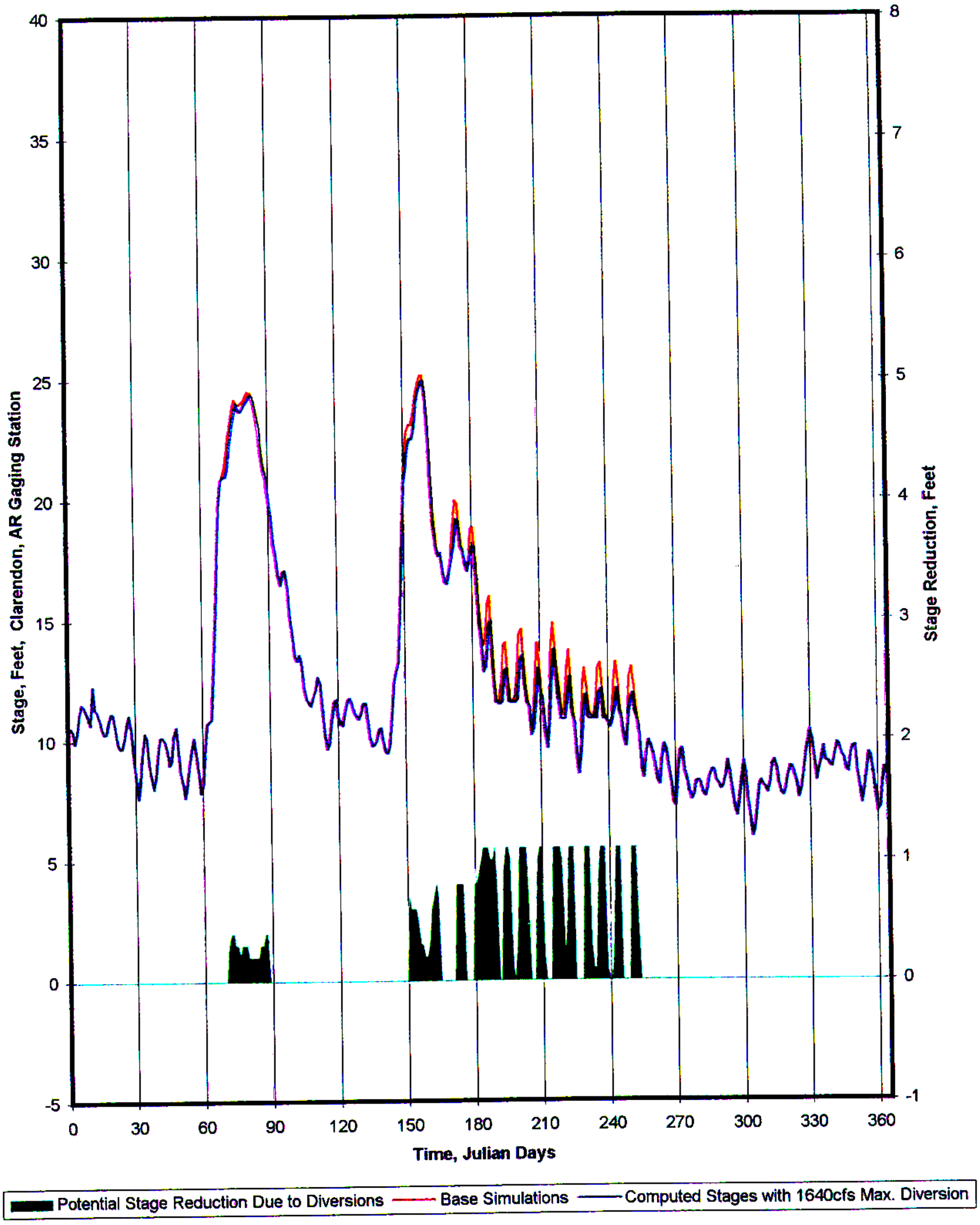


**Figure IV-B.2.25 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1964**

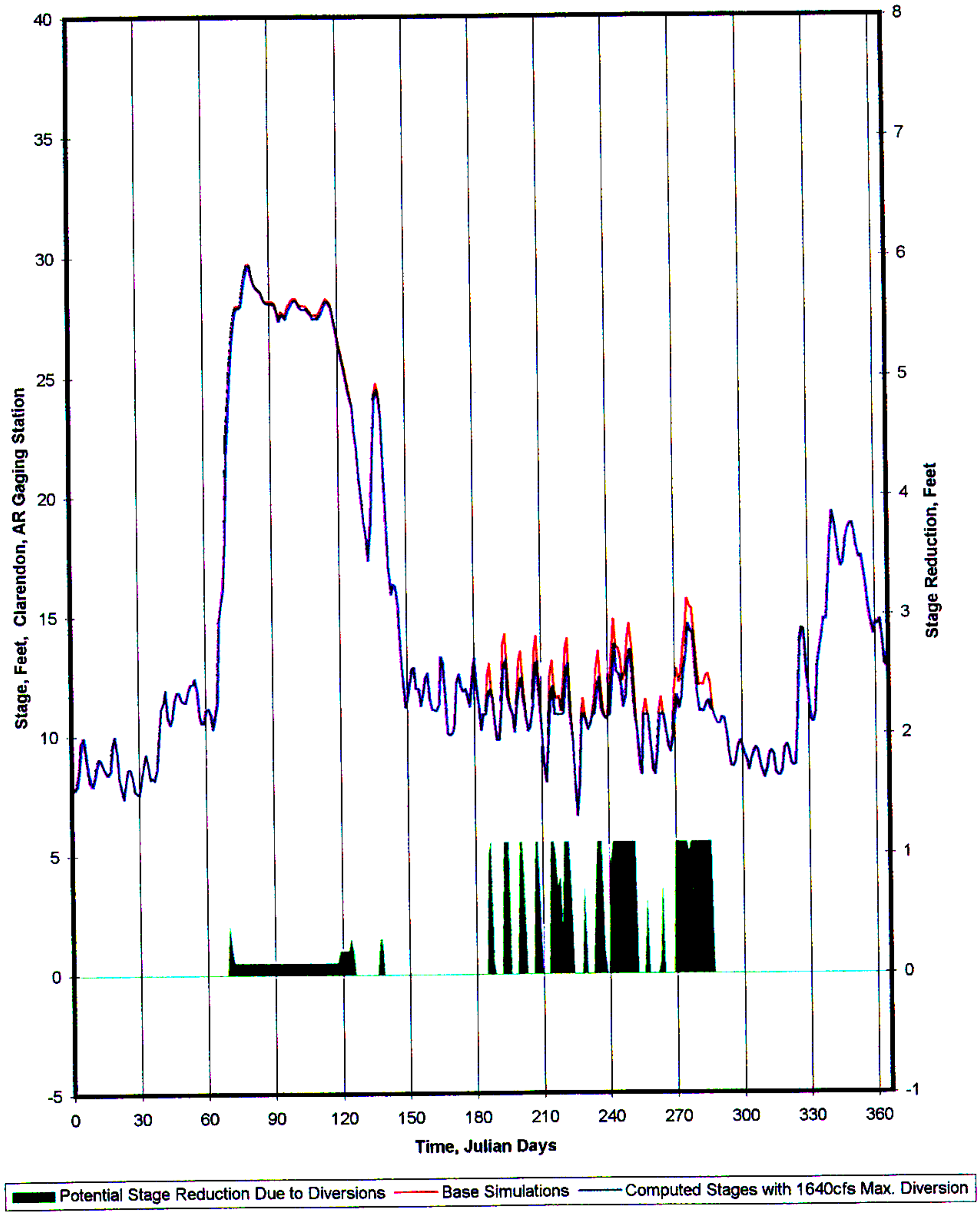


**Figure IV-B.2.26 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1965**

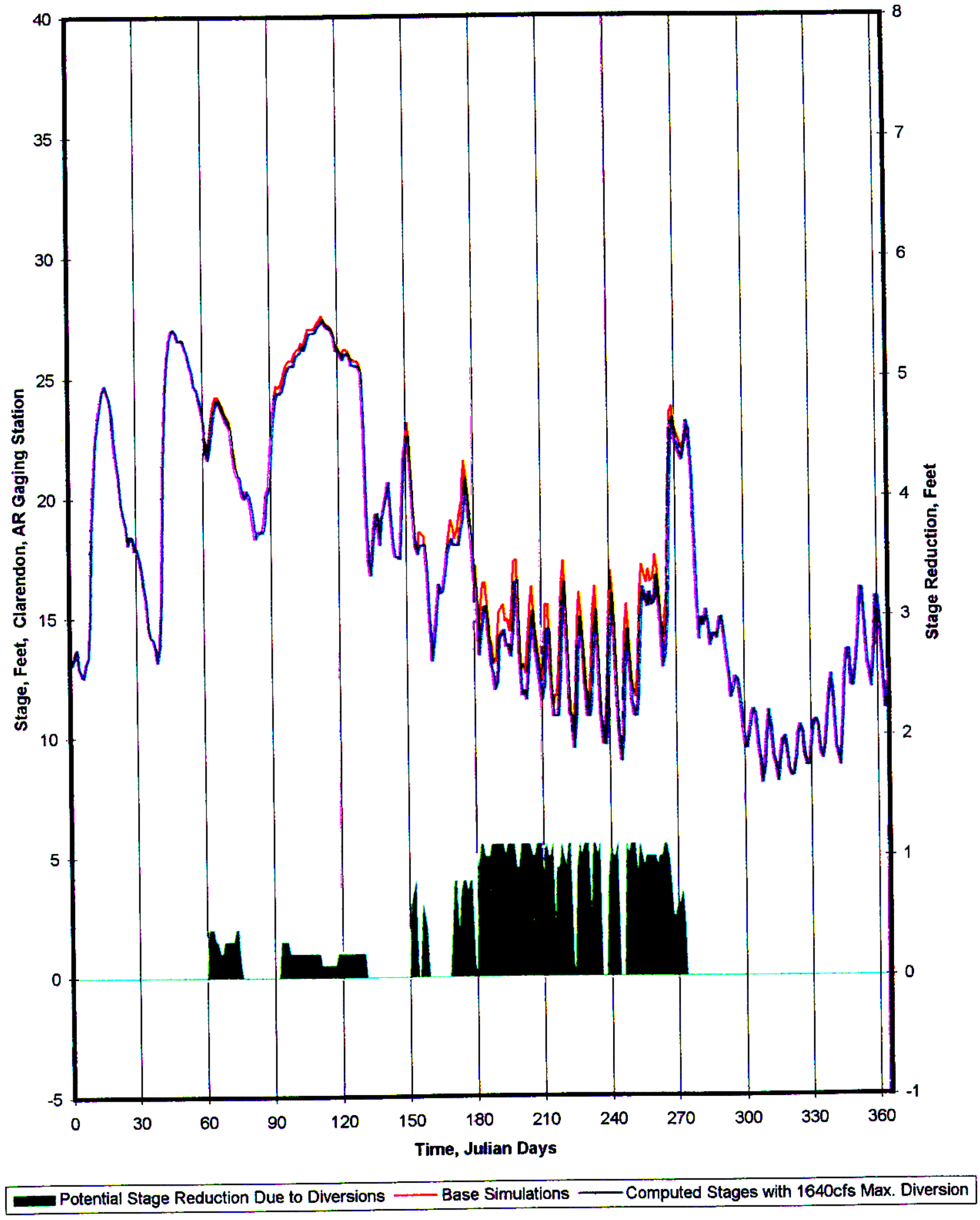


**Figure IV-B.2.27 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1966**

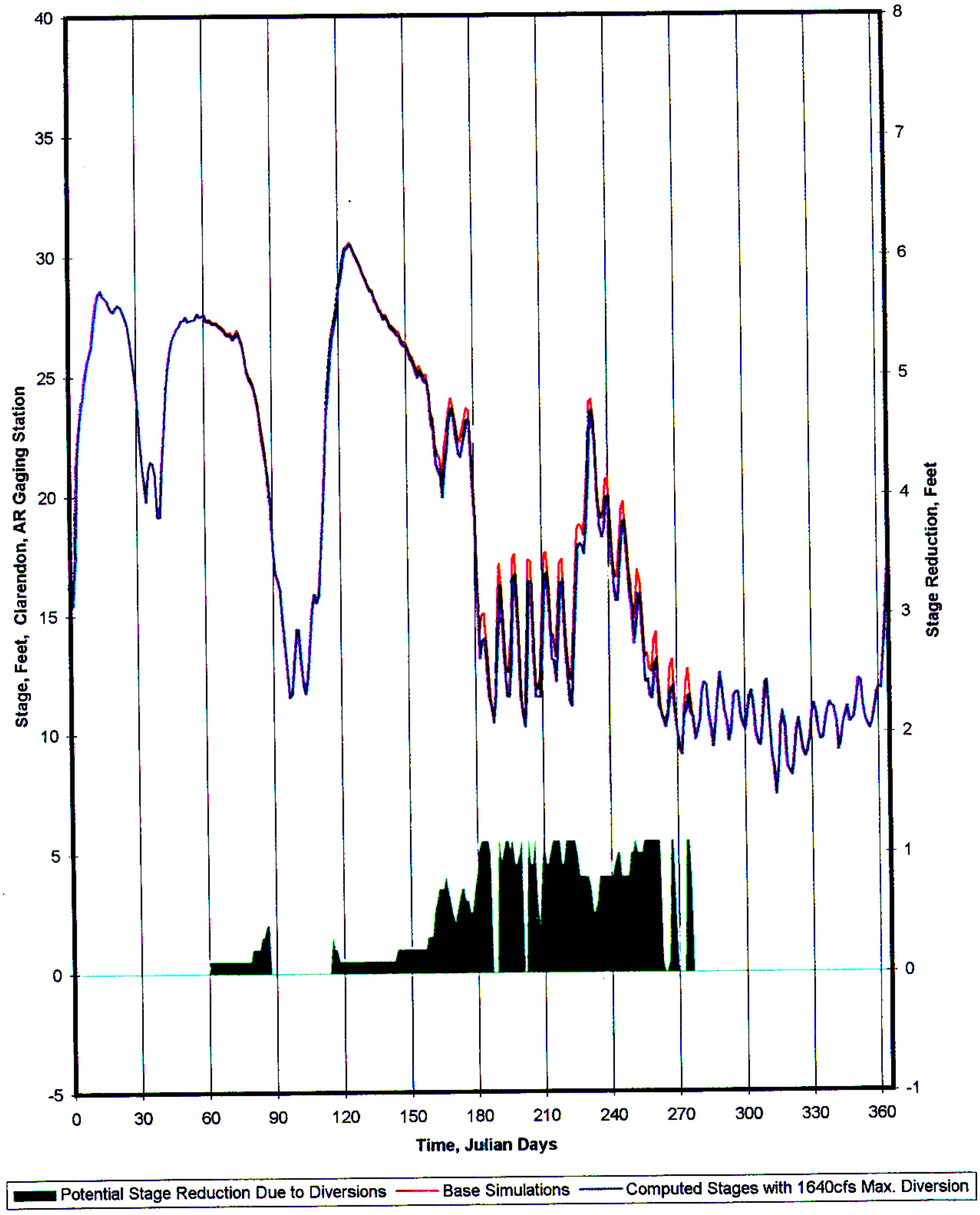


**Figure IV-B.2.28 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1967**

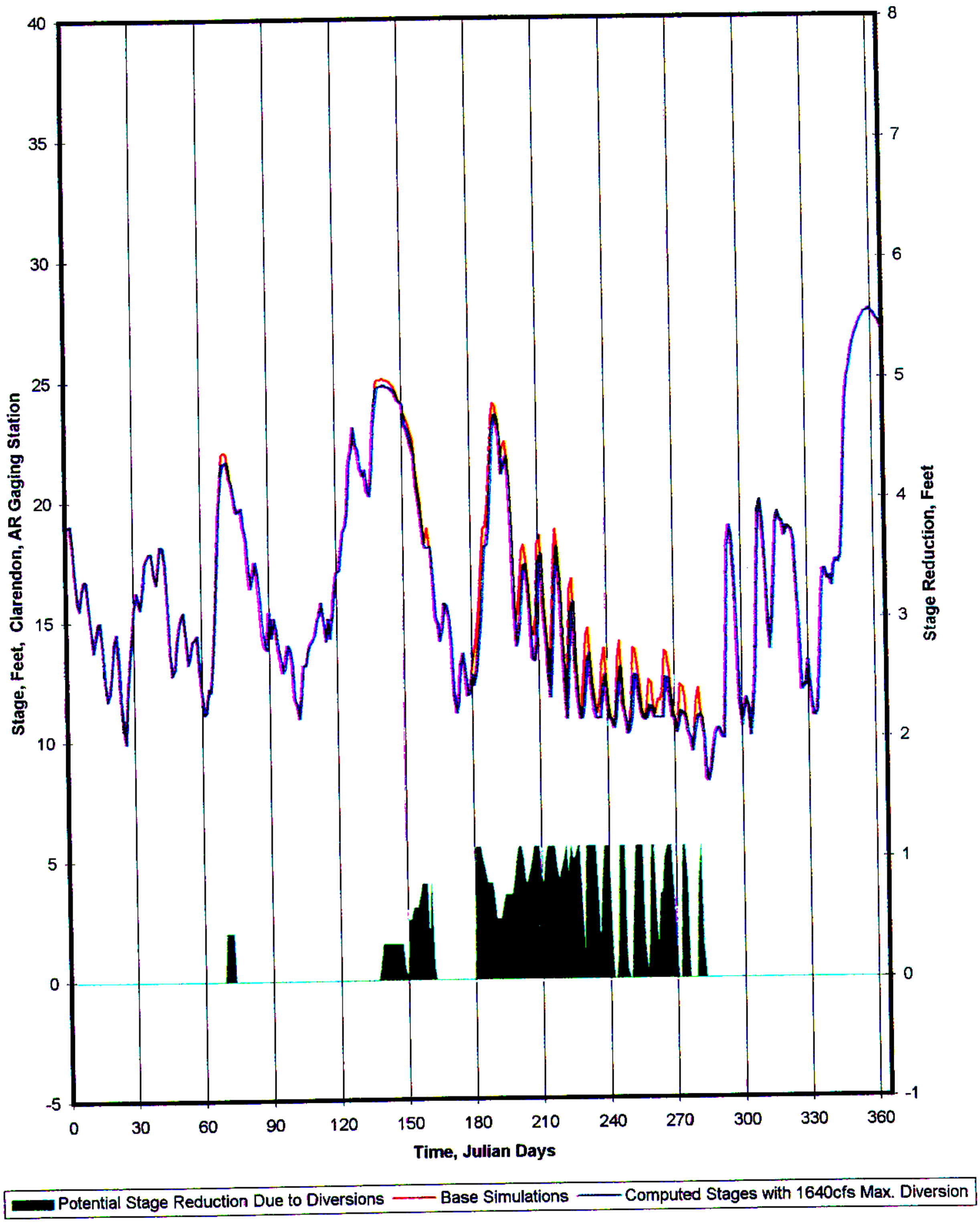


**Figure IV-B.2.29 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1968**

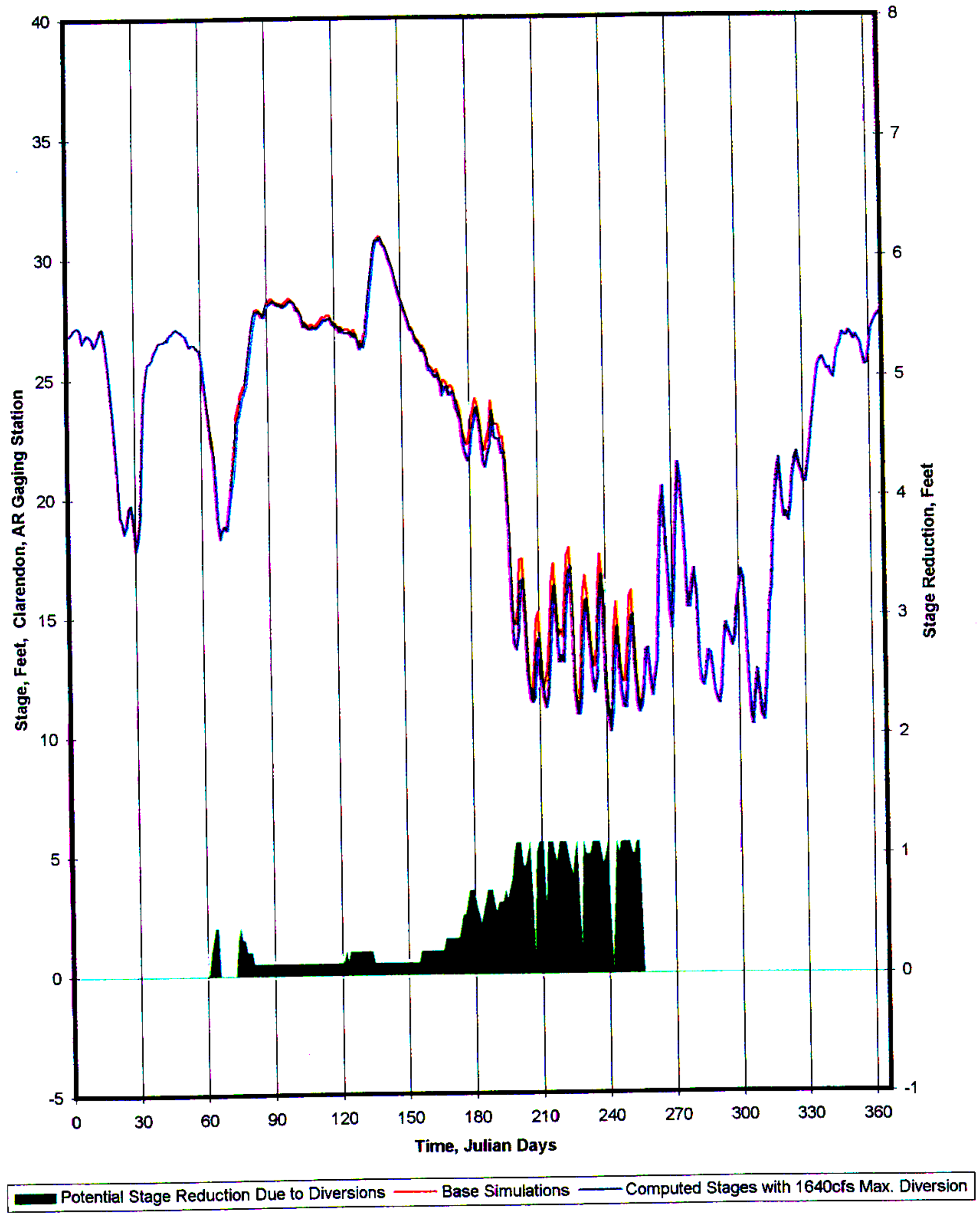


**Figure IV-B.2.30 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1969**

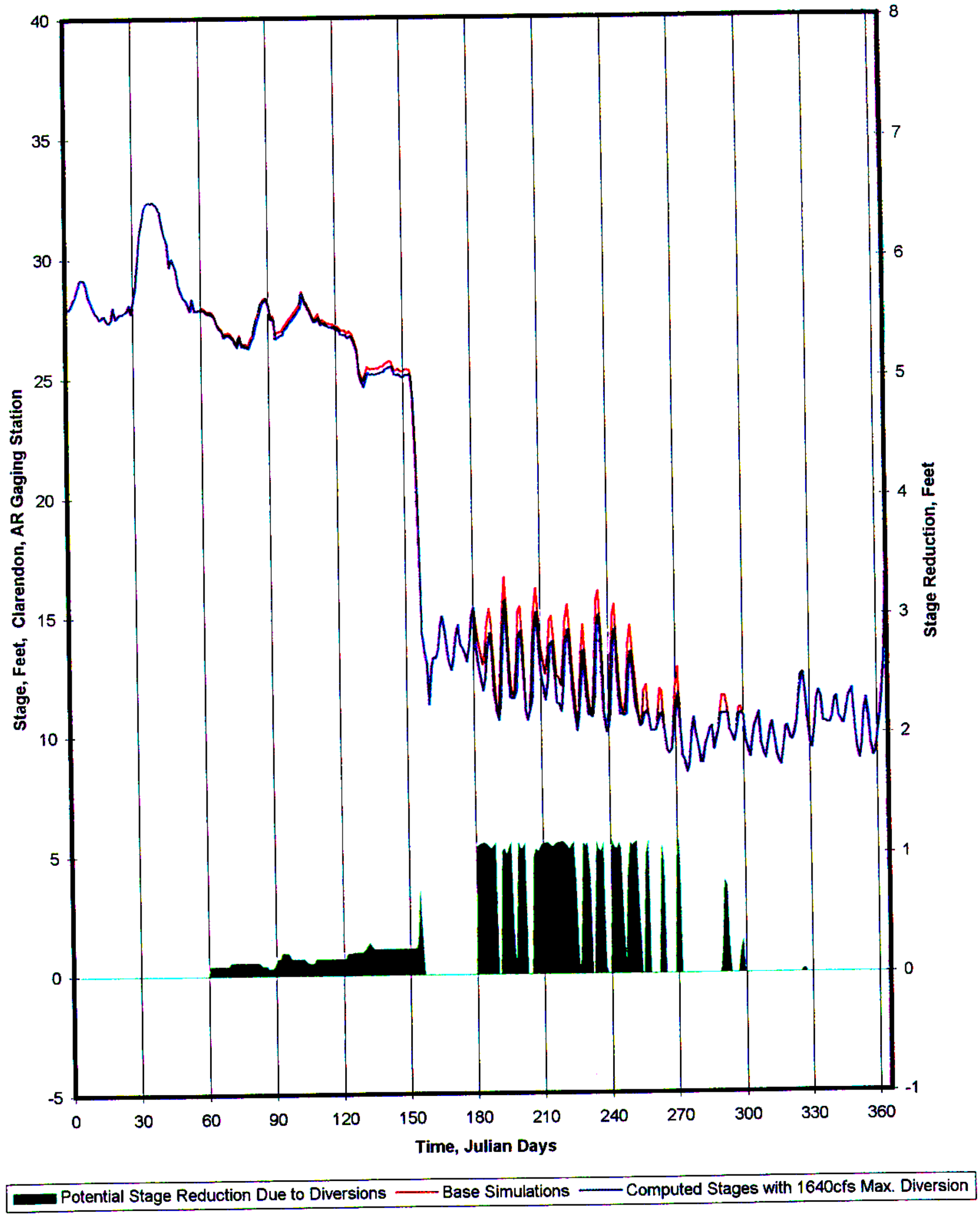


Figure IV-B.2.31 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1970

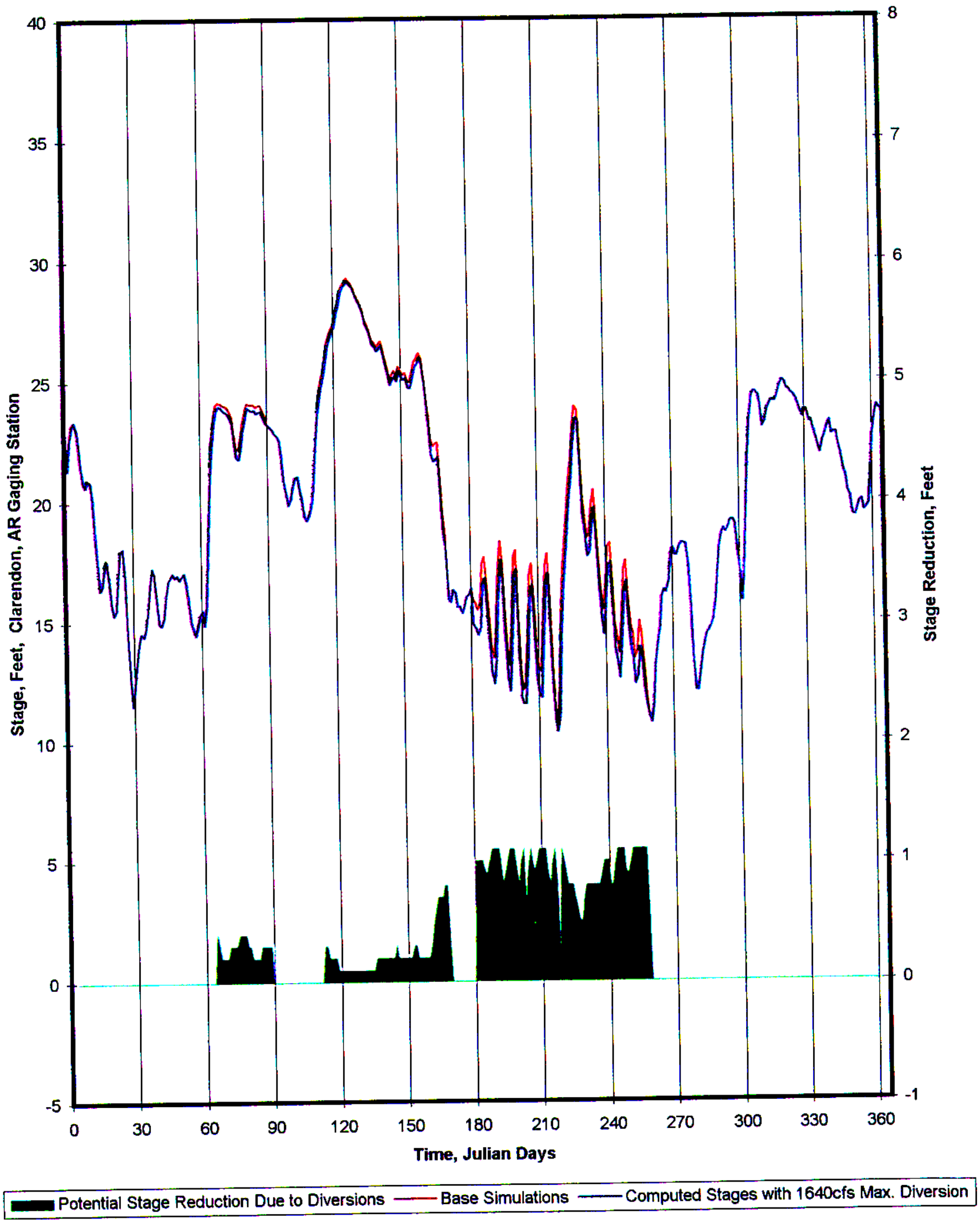


Figure IV-B.2.32 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1971

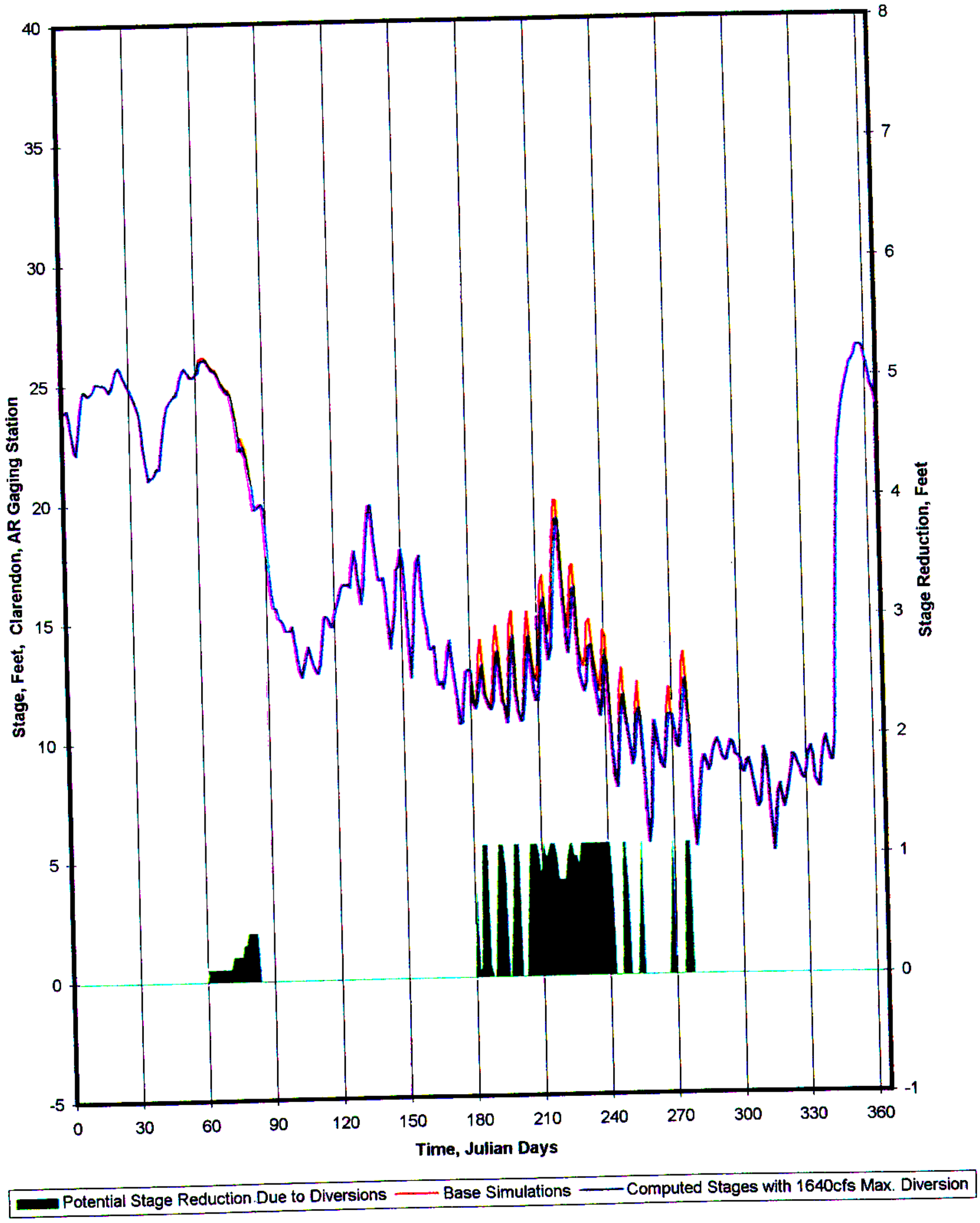


Figure IV-B.2.33 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1972

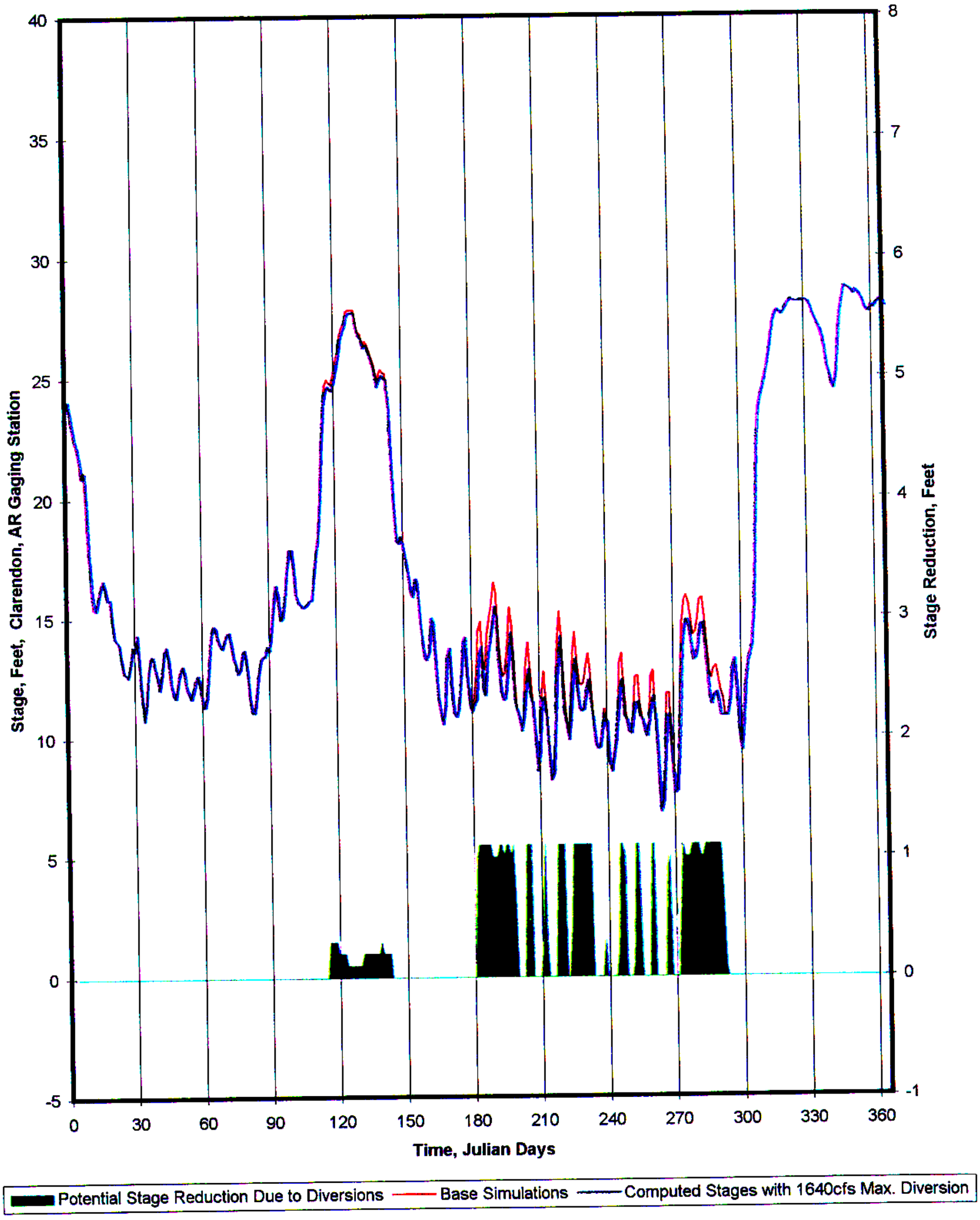


**Figure IV-B.2.34 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1973**

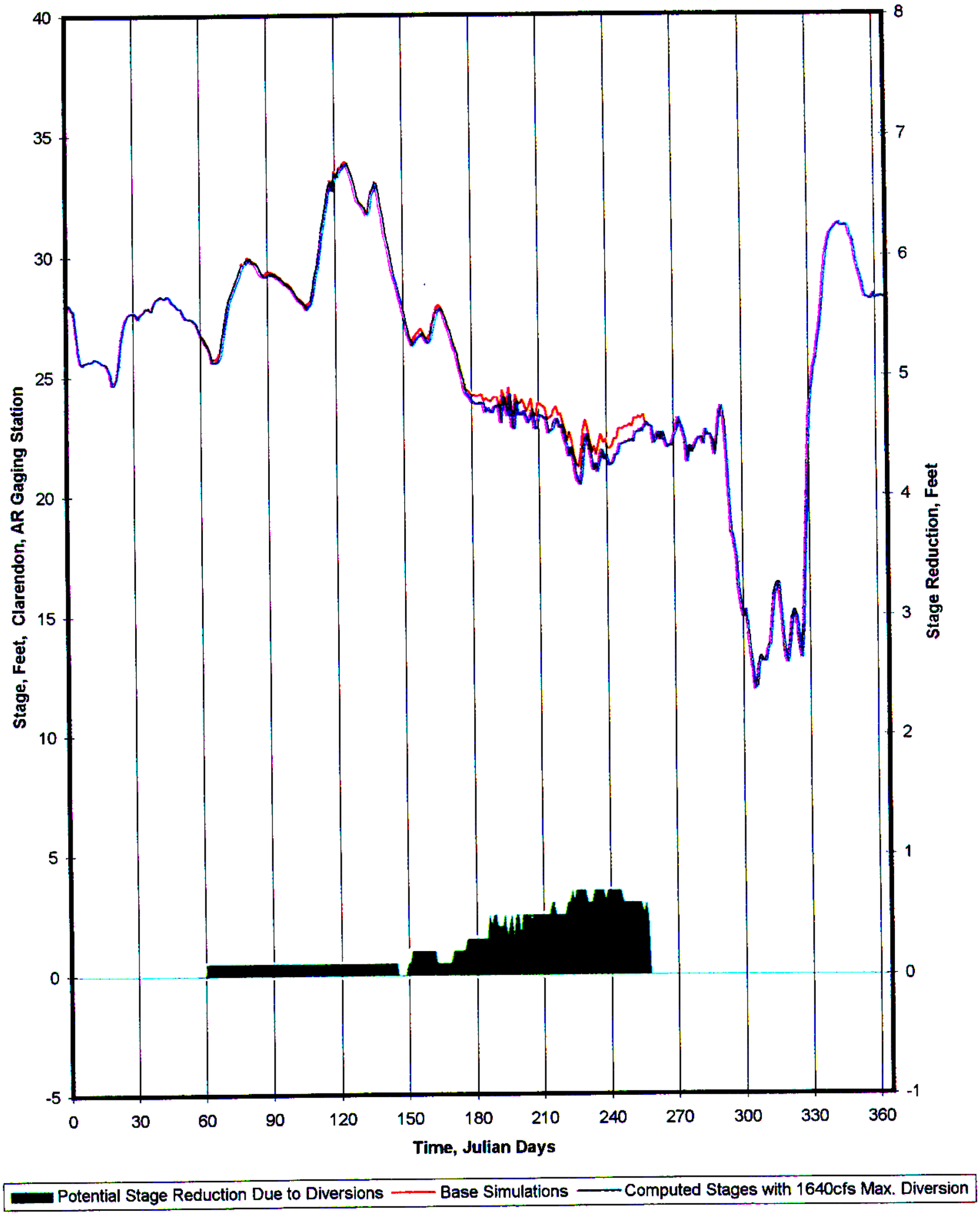


Figure IV-B.2.35 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1974

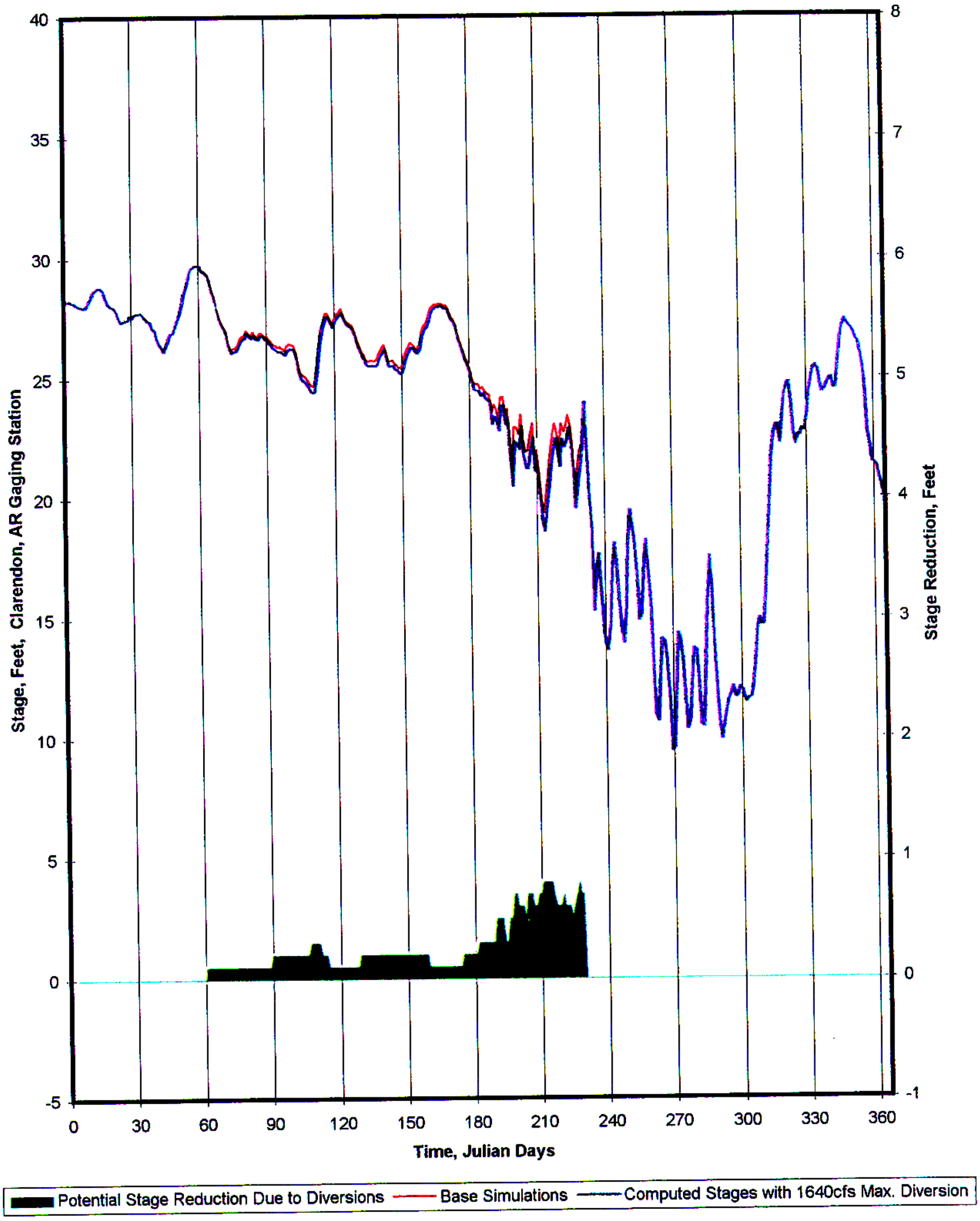


**Figure IV-B.2.36 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1975**

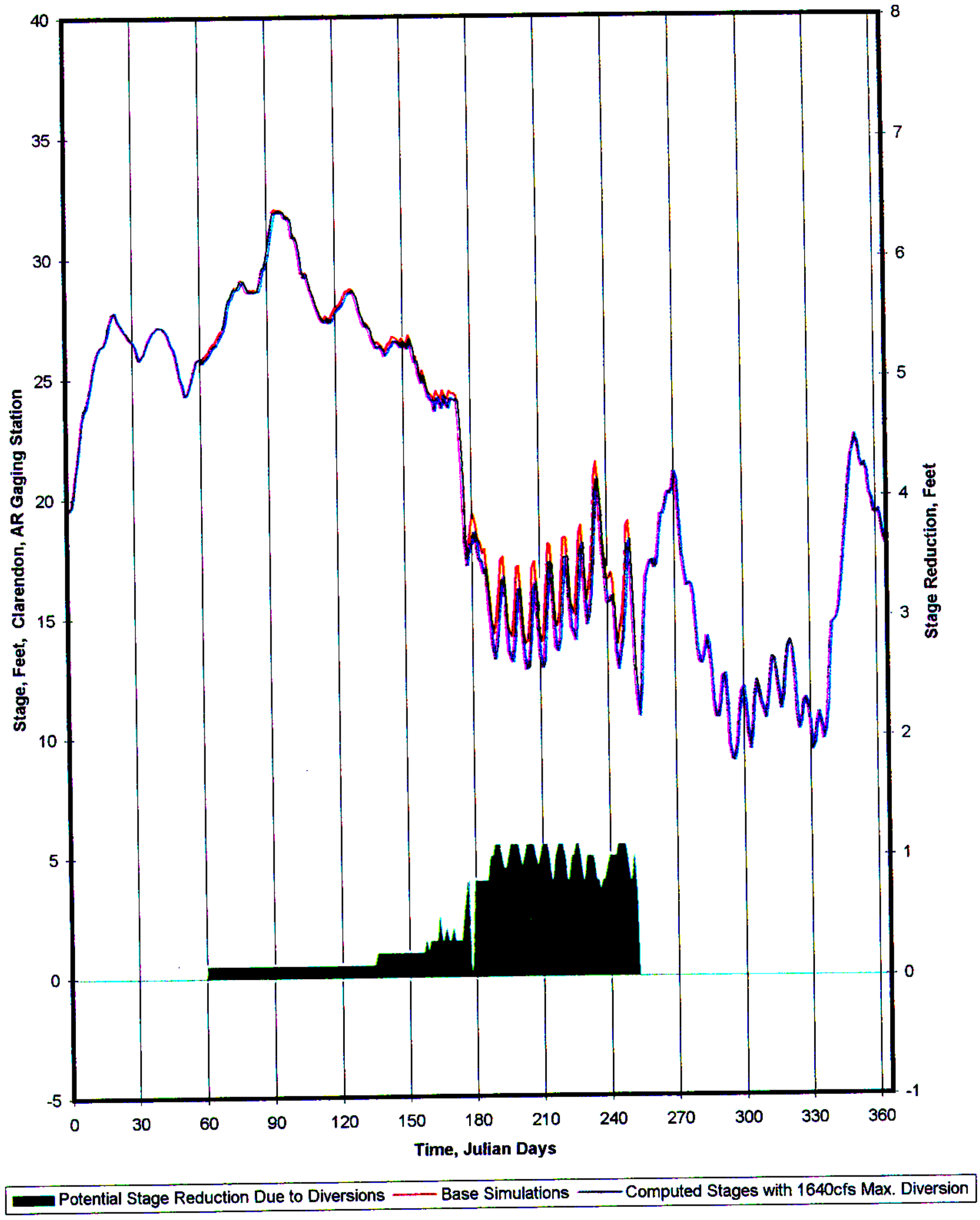


**Figure IV-B.2.37 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1976**

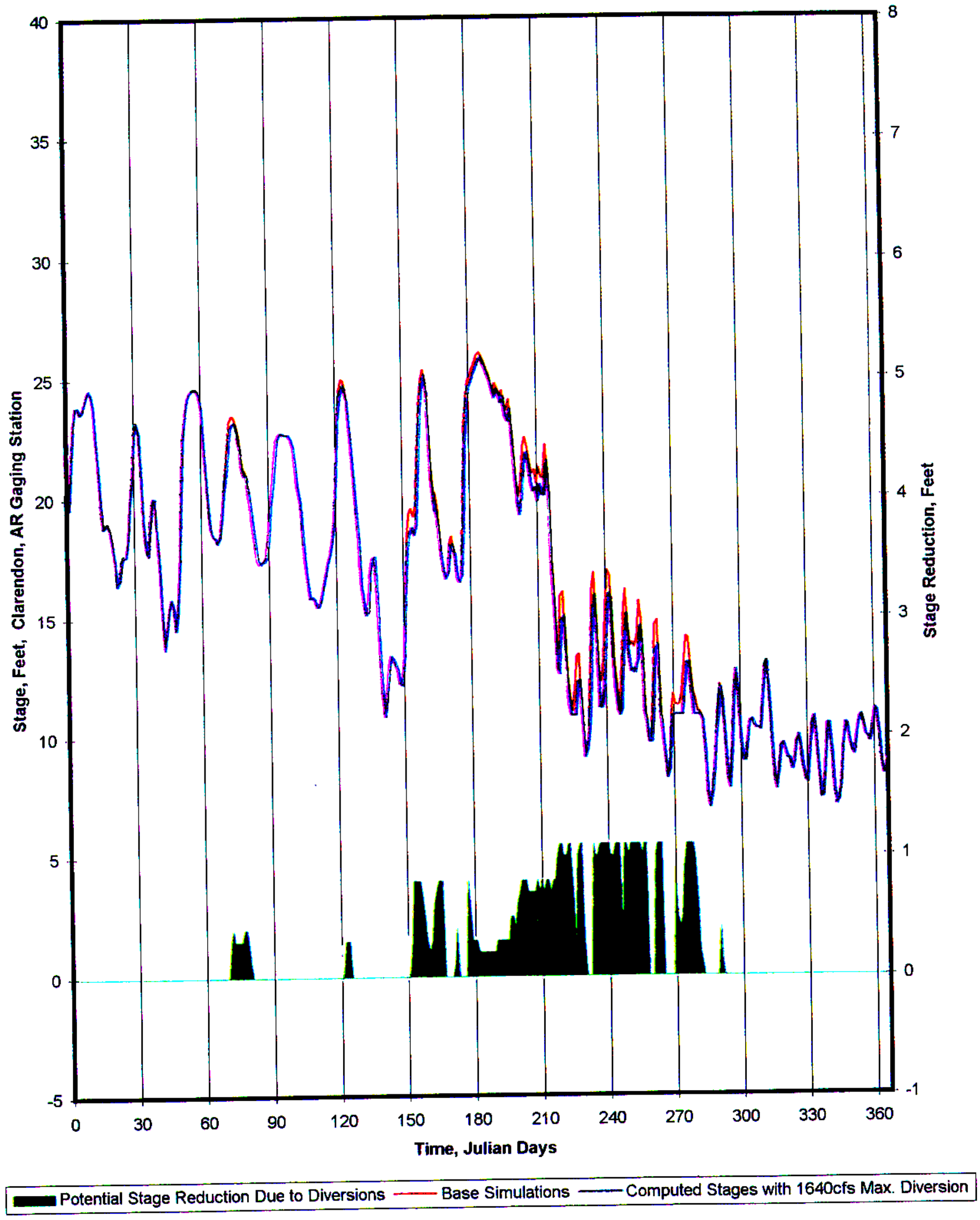


**Figure IV-B.2.38 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1977**

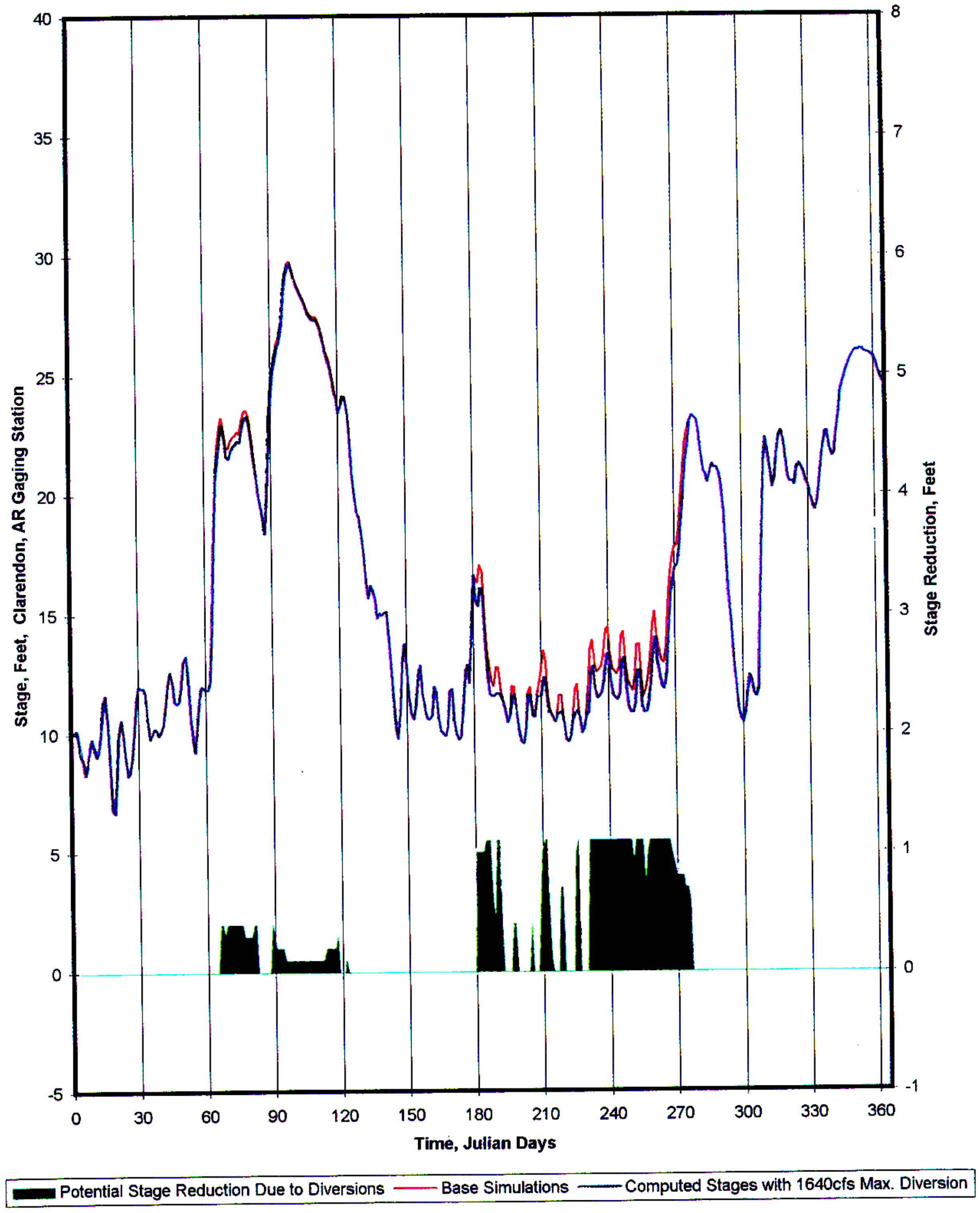


**Figure IV-B.2.39 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1978**

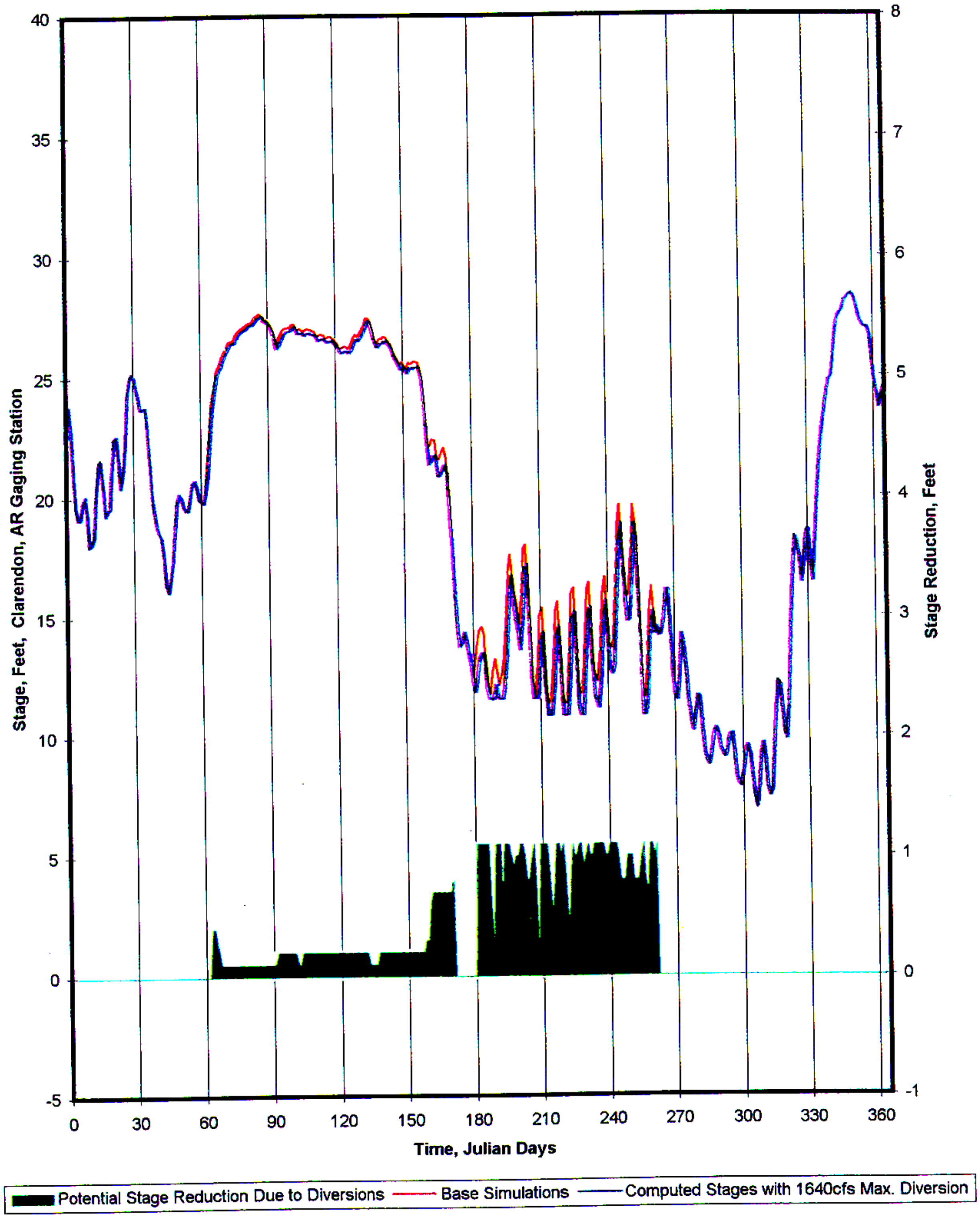


Figure IV-B.2.40 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1979

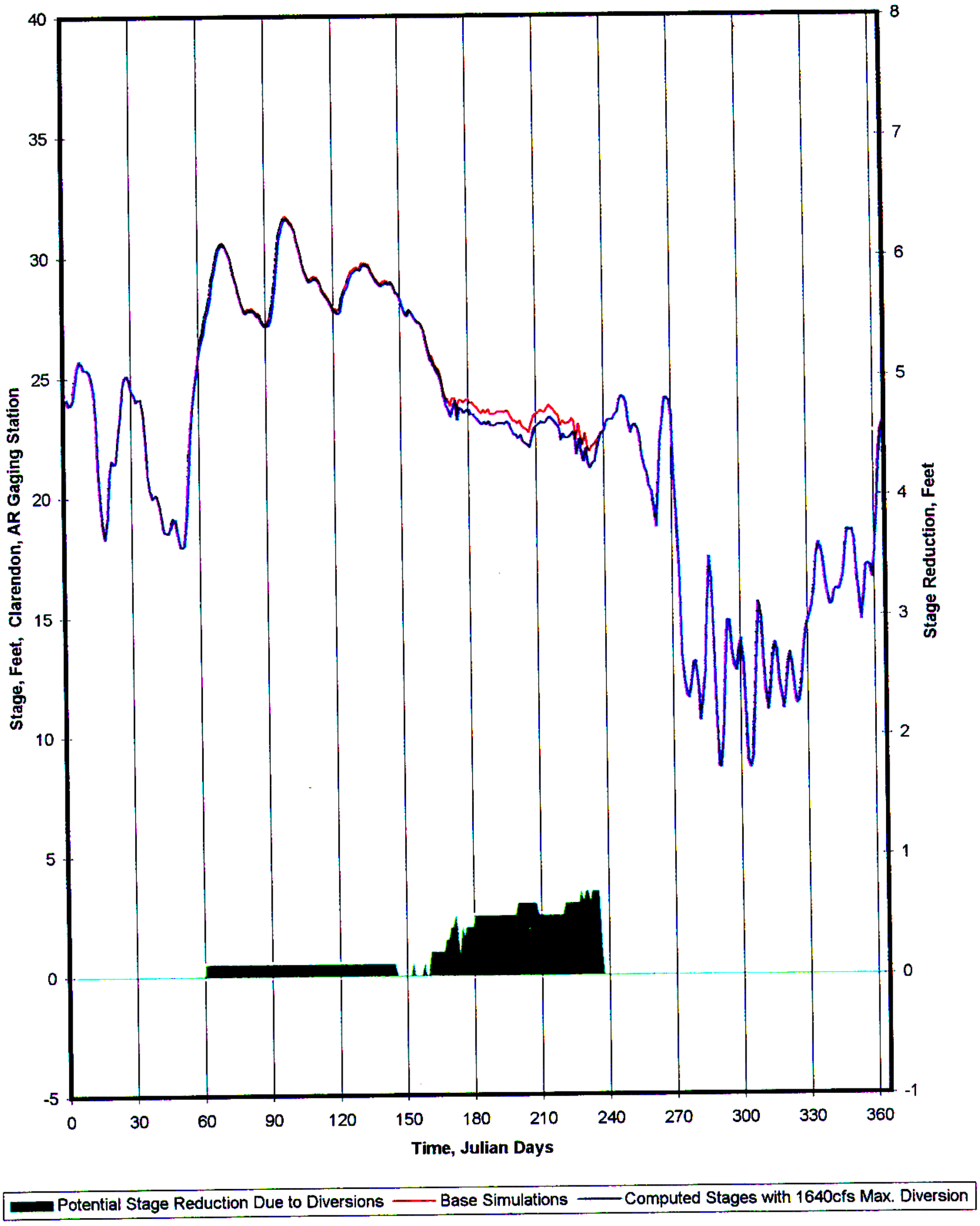


Figure IV-B.2.41 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1980

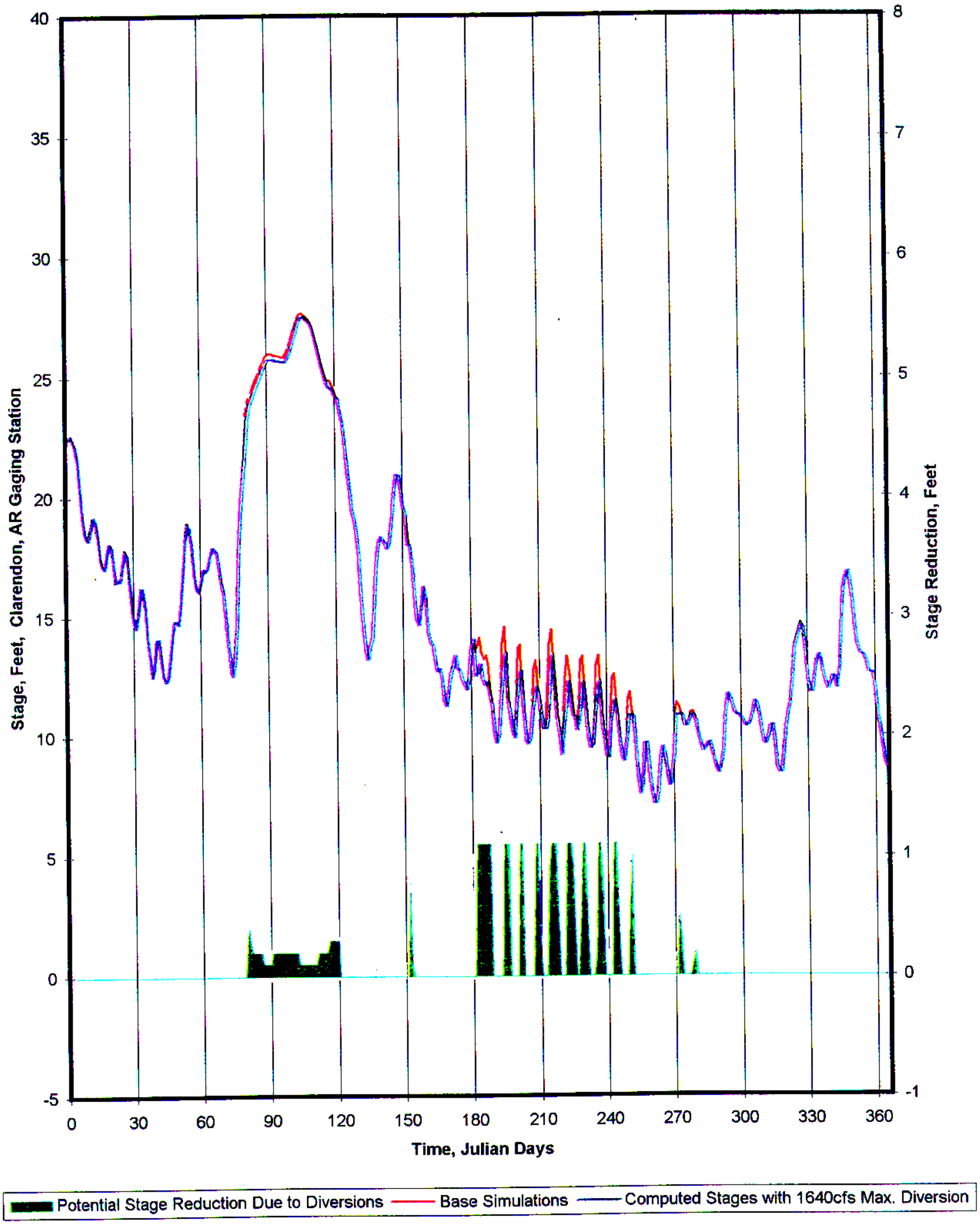
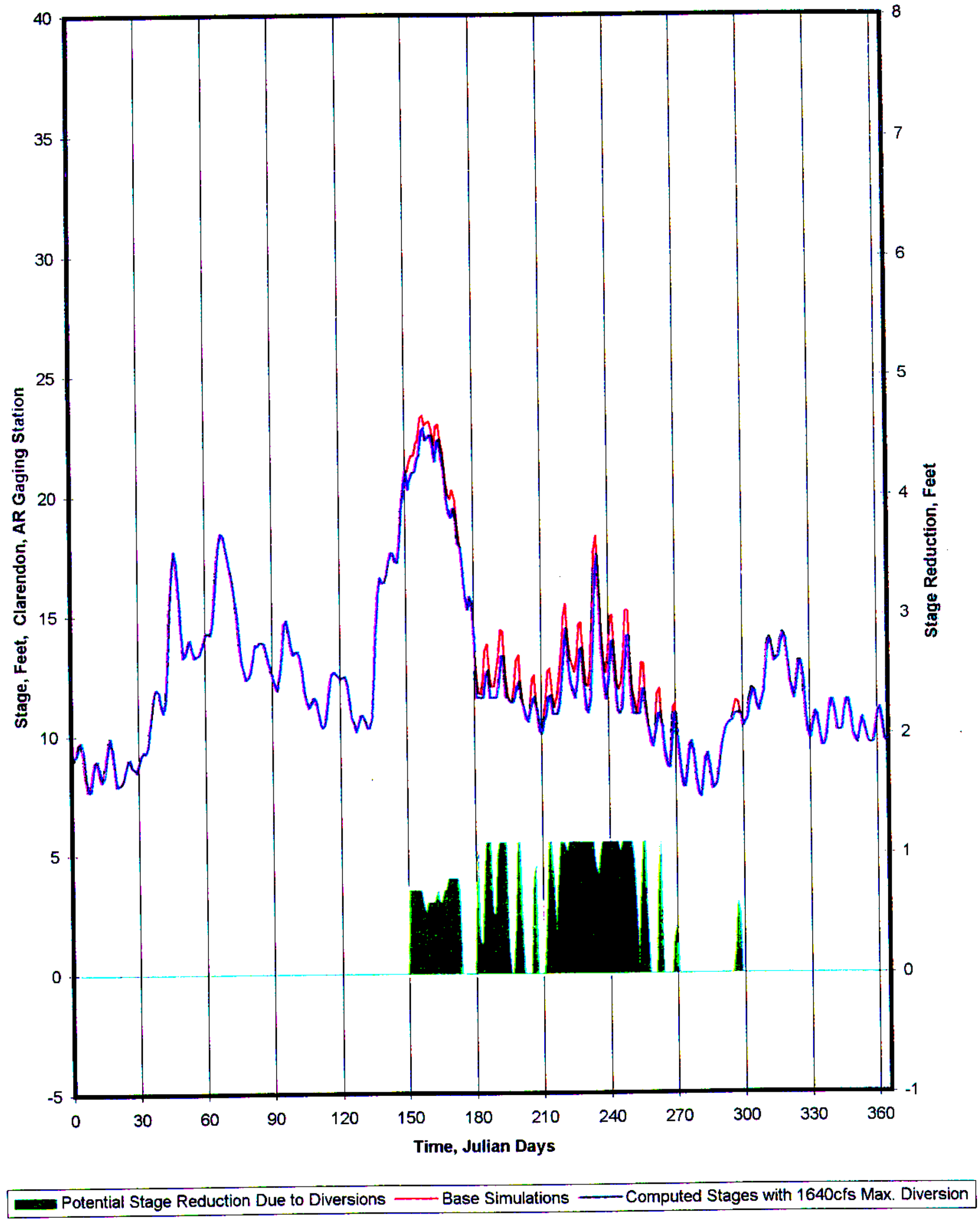


**Figure IV-B.2.42 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1981**



## Figure IV-B.2.43 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1982

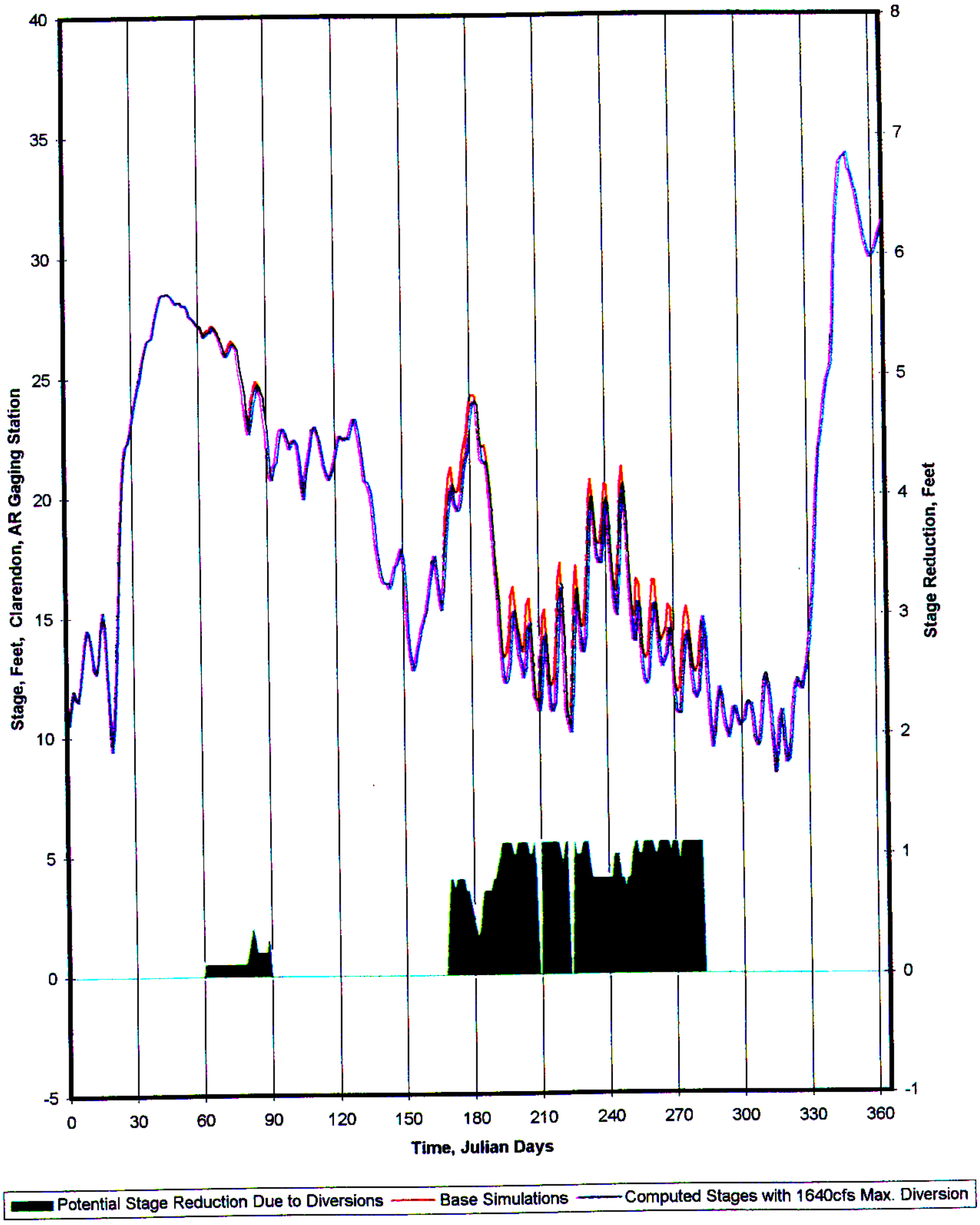


**Figure IV-B.2.44 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1983**

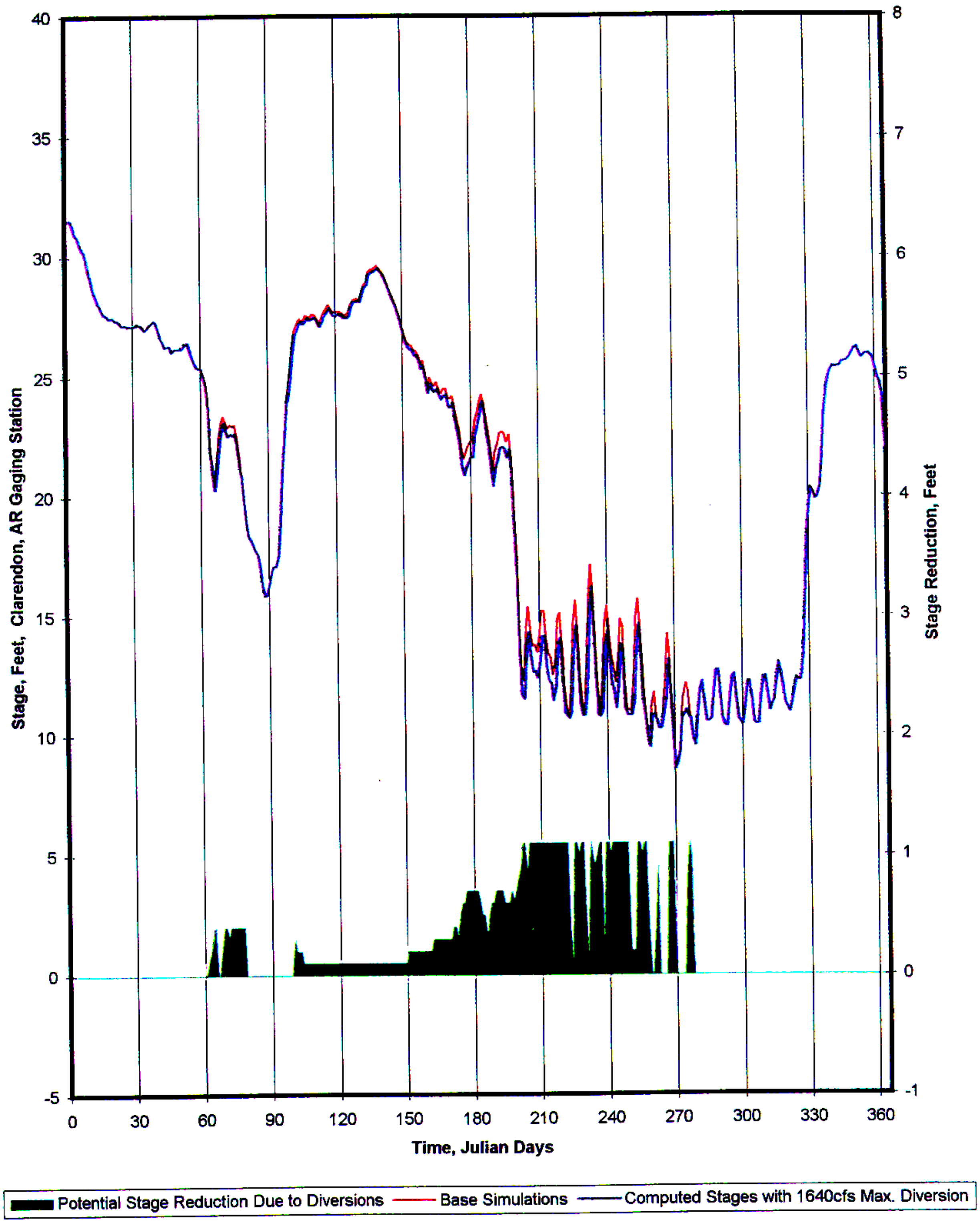
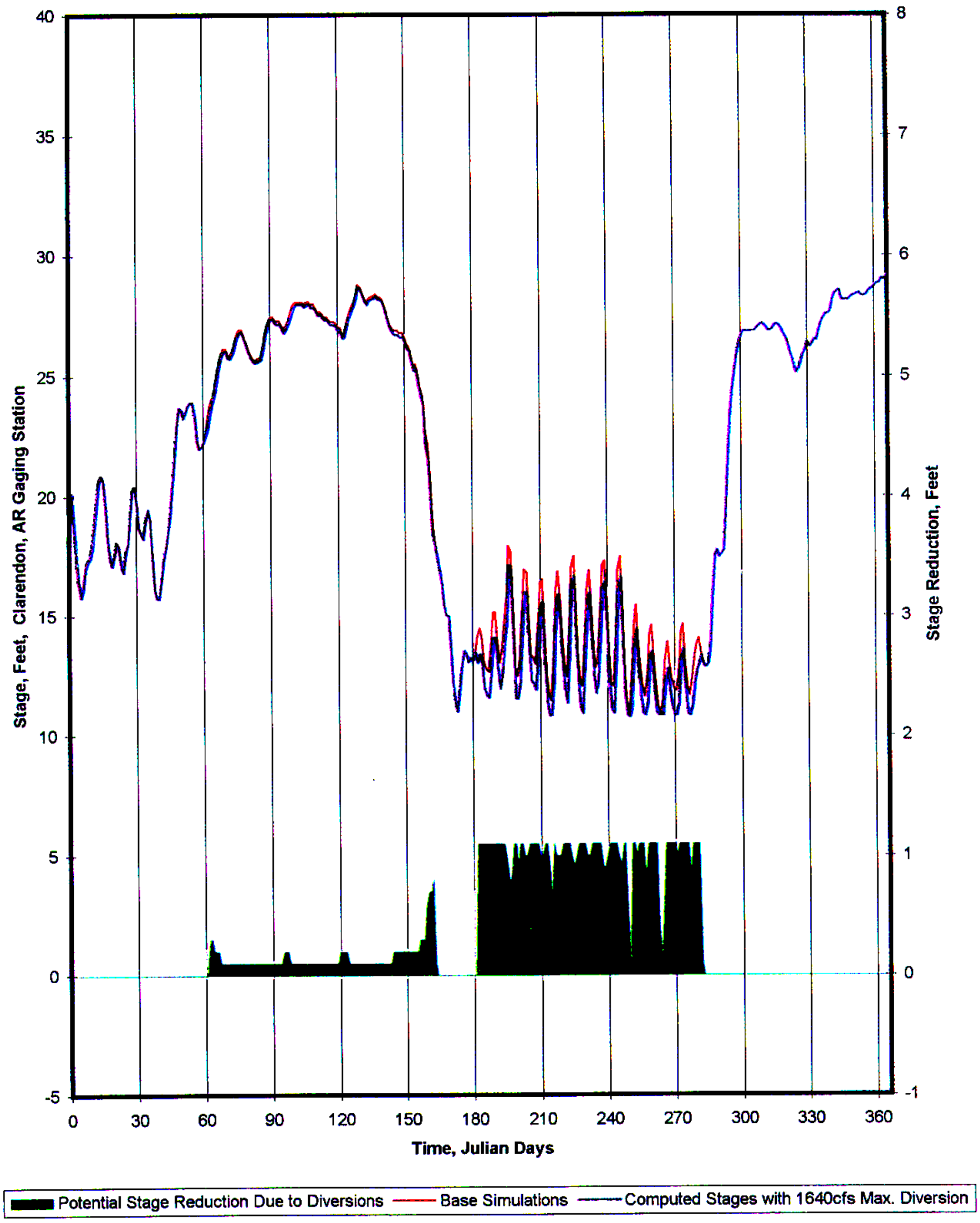


Figure IV-B.2.45 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1984



## Figure IV-B.2.46 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1985

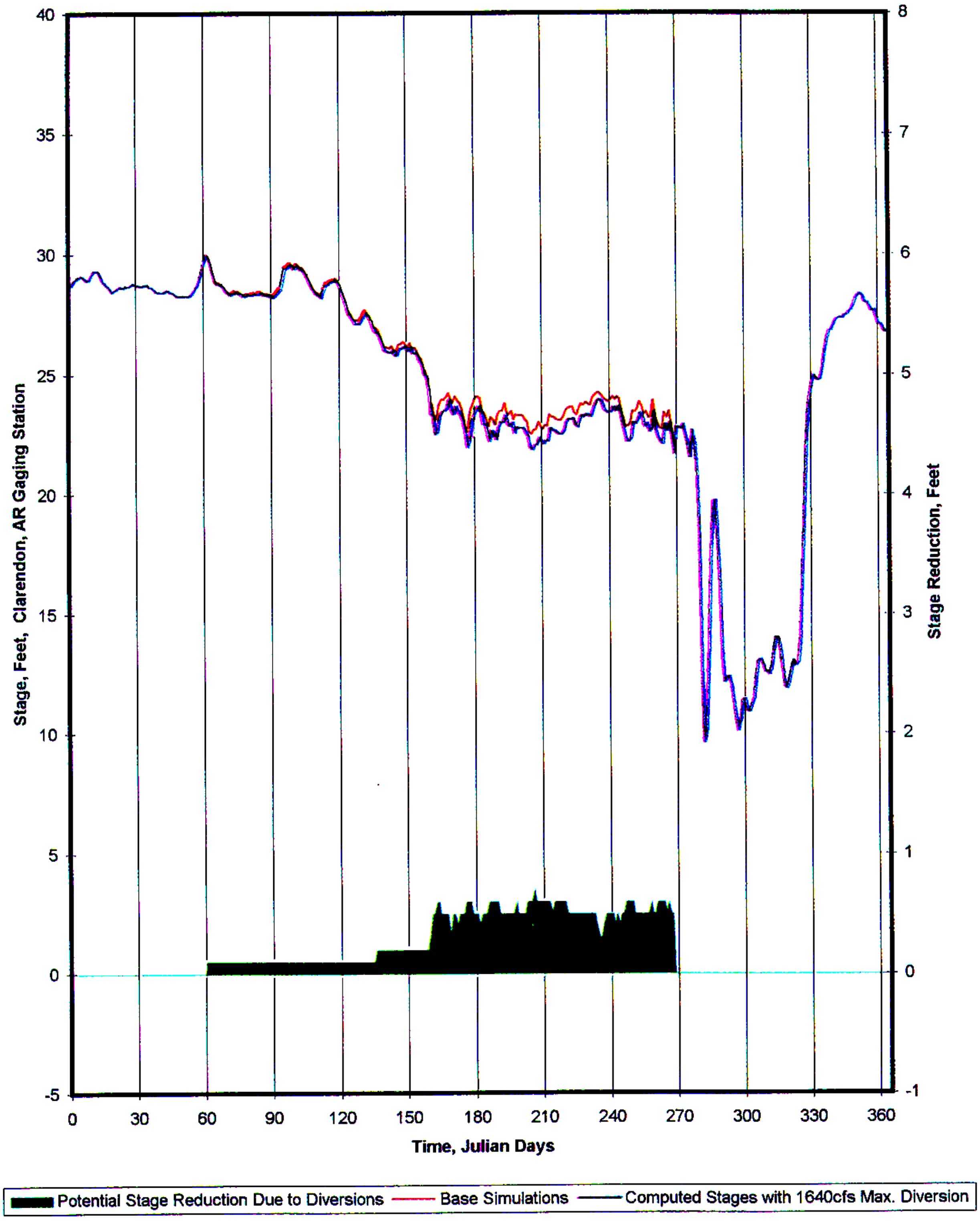
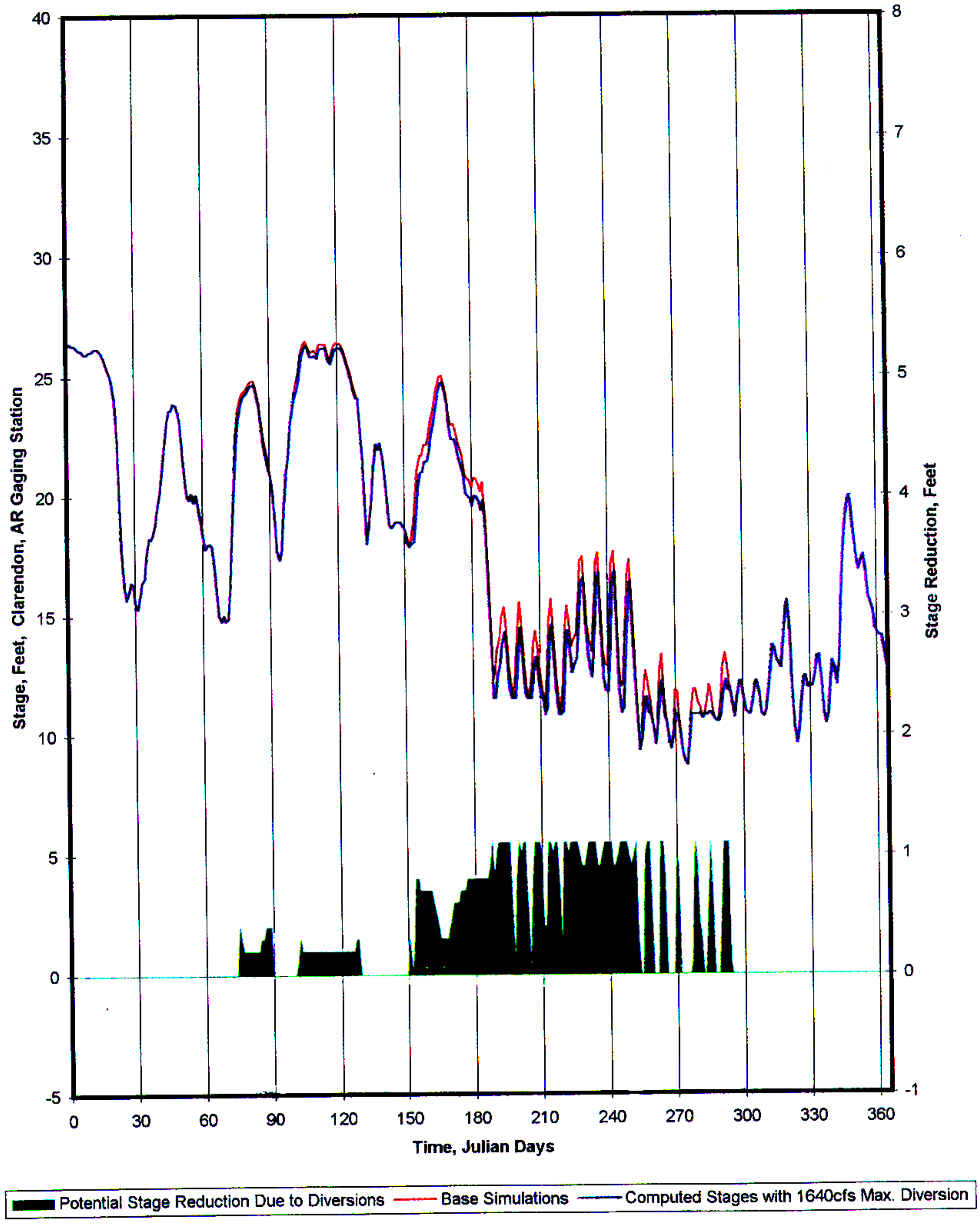


**Figure IV-B.2.47 Simulated Stage Hydrographs and Stage Reductions at Clarendon Gage for 1986**



## Table IV-D-02 Rating Table for White River at Clarendon, AR Gaging Station

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RATING TABLE | | | | PAGE | 1 OF 4 | |
| STREAM: | WHITE RIVER | | | | | | | | FILE NO.: | | WR116 |
| LOCATION | CLARENDON, ARK. | | | | | | | | PREPARED BY: | | BOB |
| FROM: | 1/1/95 | TO: 12/31/95 | | | GAGE DATUM: 139.91 | | | | DATE PREPARED: | | 3/10/96 |
| GAGE (FT) | DISCHARGE (CFS) | DIFF. (CFS) | GAGE (FT) | DISCHARGE (CFS) | DIFF. (CFS) | GAGE (FT) | DISCHARGE (CFS) | DIFF. (CFS) | GAGE (FT) | DISCHARGE (CFS) | DIFF. (CFS) |
| 4.0 | 1825 | | 6.5 | 4175 | | 9.0 | 7125 | | 11.5 | 10613 | |
| | | 90 | | | 105 | | | 134 | | | 147 |
| 4.1 | 1915 | | 6.6 | 4280 | | 9.1 | 7259 | | 11.6 | 10760 | |
| | | 90 | | | 105 | | | 133 | | | 148 |
| 4.2 | 2005 | | 6.7 | 4385 | | 9.2 | 7392 | | 11.7 | 10908 | |
| | | 90 | | | 105 | | | 134 | | | 147 |
| 4.3 | 2095 | | 6.8 | 4490 | | 9.3 | 7526 | | 11.8 | 11055 | |
| | | 90 | | | 105 | | | 133 | | | 148 |
| 4.4 | 2185 | | 6.9 | 4595 | | 9.4 | 7659 | | 11.9 | 11203 | |
| | | 90 | | | 105 | | | 134 | | | 147 |
| 4.5 | 2275 | | 7.0 | 4700 | | 9.5 | 7793 | | 12.0 | 11350 | |
| | | 90 | | | 115 | | | 133 | | | 150 |
| 4.6 | 2365 | | 7.1 | 4815 | | 9.6 | 7926 | | 12.1 | 11500 | |
| | | 90 | | | 115 | | | 134 | | | 150 |
| 4.7 | 2455 | | 7.2 | 4930 | | 9.7 | 8060 | | 12.2 | 11650 | |
| | | 90 | | | 115 | | | 133 | | | 150 |
| 4.8 | 2545 | | 7.3 | 5045 | | 9.8 | 8193 | | 12.3 | 11800 | |
| | | 90 | | | 115 | | | 134 | | | 150 |
| 4.9 | 2635 | | 7.4 | 5160 | | 9.9 | 8327 | | 12.4 | 11950 | |
| | | 90 | | | 115 | | | 133 | | | 150 |
| 5.0 | 2725 | | 7.5 | 5275 | | 10.0 | 8460 | | 12.5 | 12100 | |
| | | 93 | | | 115 | | | 142 | | | 150 |
| 5.1 | 2818 | | 7.6 | 5390 | | 10.1 | 8602 | | 12.6 | 12250 | |
| | | 92 | | | 115 | | | 141 | | | 150 |
| 5.2 | 2910 | | 7.7 | 5505 | | 10.2 | 8743 | | 12.7 | 12400 | |
| | | 93 | | | 115 | | | 142 | | | 150 |
| 5.3 | 3003 | | 7.8 | 5620 | | 10.3 | 8885 | | 12.8 | 12550 | |
| | | 92 | | | 115 | | | 141 | | | 150 |
| 5.4 | 3095 | | 7.9 | 5735 | | 10.4 | 9026 | | 12.9 | 12700 | |
| | | 93 | | | 115 | | | 142 | | | 150 |
| 5.5 | 3188 | | 8.0 | 5850 | | 10.5 | 9168 | | 13.0 | 12850 | |
| | | 92 | | | 128 | | | 141 | | | 150 |
| 5.6 | 3280 | | 8.1 | 5978 | | 10.6 | 9309 | | 13.1 | 13000 | |
| | | 93 | | | 127 | | | 142 | | | 150 |
| 5.7 | 3373 | | 8.2 | 6105 | | 10.7 | 9451 | | 13.2 | 13150 | |
| | | 92 | | | 128 | | | 141 | | | 150 |
| 5.8 | 3465 | | 8.3 | 6233 | | 10.8 | 9592 | | 13.3 | 13300 | |
| | | 93 | | | 127 | | | 142 | | | 150 |
| 5.9 | 3558 | | 8.4 | 6360 | | 10.9 | 9734 | | 13.4 | 13450 | |
| | | 92 | | | 128 | | | 141 | | | 150 |
| 6.0 | 3650 | | 8.5 | 6488 | | 11.0 | 9875 | | 13.5 | 13600 | |
| | | 105 | | | 127 | | | 148 | | | 150 |
| 6.1 | 3755 | | 8.6 | 6615 | | 11.1 | 10023 | | 13.6 | 13750 | |
| | | 105 | | | 128 | | | 147 | | | 150 |
| 6.2 | 3860 | | 8.7 | 6743 | | 11.2 | 10170 | | 13.7 | 13900 | |
| | | 105 | | | 127 | | | 148 | | | 150 |
| 6.3 | 3965 | | 8.8 | 6870 | | 11.3 | 10318 | | 13.8 | 14050 | |
| | | 105 | | | 128 | | | 147 | | | 150 |
| 6.4 | 4070 | | 8.9 | 6998 | | 11.4 | 10465 | | 13.9 | 14200 | |
| | | 105 | | | 127 | | | 148 | | | 150 |

## Table IV-D-02 Continued

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RATING TABLE | | | | PAGE | 2 OF 4 | |
| STREAM: | WHITE RIVER | | | | | | | | FILE NO.: | | WR116 |
| LOCATION | CLARENDON, ARK. | | | | | | | | PREPARED BY: | | BOB |
| FROM: | 1/1/95 | TO: 12/31/95 | | | GAGE DATUM: 139.91 | | | | DATE PREPARED: | | 3/10/96 |

| GAGE (FT) | ISCHARGE (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.0 | 14350 | | 16.5 | 18350 | | 19.0 | 23300 | | 21.5 | 28750 | |
| | | 155 | | | 170 | | | 210 | | | 230 |
| 14.1 | 14505 | | 16.6 | 18520 | | 19.1 | 23510 | | 21.6 | 28980 | |
| | | 155 | | | 170 | | | 210 | | | 230 |
| 14.2 | 14660 | | 16.7 | 18690 | | 19.2 | 23720 | | 21.7 | 29210 | |
| | | 155 | | | 170 | | | 210 | | | 230 |
| 14.3 | 14815 | | 16.8 | 18860 | | 19.3 | 23930 | | 21.8 | 29440 | |
| | | 155 | | | 170 | | | 210 | | | 230 |
| 14.4 | 14970 | | 16.9 | 19030 | | 19.4 | 24140 | | 21.9 | 29670 | |
| | | 155 | | | 170 | | | 210 | | | 230 |
| 14.5 | 15125 | | 17.0 | 19200 | | 19.5 | 24350 | | 22.0 | 29900 | |
| | | 155 | | | 200 | | | 210 | | | 260 |
| 14.6 | 15280 | | 17.1 | 19400 | | 19.6 | 24560 | | 22.1 | 30160 | |
| | | 155 | | | 200 | | | 210 | | | 260 |
| 14.7 | 15435 | | 17.2 | 19600 | | 19.7 | 24770 | | 22.2 | 30420 | |
| | | 155 | | | 200 | | | 210 | | | 260 |
| 14.8 | 15590 | | 17.3 | 19800 | | 19.8 | 24980 | | 22.3 | 30680 | |
| | | 155 | | | 200 | | | 210 | | | 260 |
| 14.9 | 15745 | | 17.4 | 20000 | | 19.9 | 25190 | | 22.4 | 30940 | |
| | | 155 | | | 200 | | | 210 | | | 260 |
| 15.0 | 15900 | | 17.5 | 20200 | | 20.0 | 25400 | | 22.5 | 31200 | |
| | | 160 | | | 200 | | | 220 | | | 260 |
| 15.1 | 16060 | | 17.6 | 20400 | | 20.1 | 25620 | | 22.6 | 31460 | |
| | | 160 | | | 200 | | | 220 | | | 260 |
| 15.2 | 16220 | | 17.7 | 20600 | | 20.2 | 25840 | | 22.7 | 31720 | |
| | | 160 | | | 200 | | | 220 | | | 260 |
| 15.3 | 16380 | | 17.8 | 20800 | | 20.3 | 26060 | | 22.8 | 31980 | |
| | | 160 | | | 200 | | | 220 | | | 260 |
| 15.4 | 16540 | | 17.9 | 21000 | | 20.4 | 26280 | | 22.9 | 32240 | |
| | | 160 | | | 200 | | | 220 | | | 260 |
| 15.5 | 16700 | | 18.0 | 21200 | | 20.5 | 26500 | | 23.0 | 32500 | |
| | | 160 | | | 210 | | | 220 | | | 340 |
| 15.6 | 16860 | | 18.1 | 21410 | | 20.6 | 26720 | | 23.1 | 32840 | |
| | | 160 | | | 210 | | | 220 | | | 340 |
| 15.7 | 17020 | | 18.2 | 21620 | | 20.7 | 26940 | | 23.2 | 33180 | |
| | | 160 | | | 210 | | | 220 | | | 340 |
| 15.8 | 17180 | | 18.3 | 21830 | | 20.8 | 27160 | | 23.3 | 33520 | |
| | | 160 | | | 210 | | | 220 | | | 340 |
| 15.9 | 17340 | | 18.4 | 22040 | | 20.9 | 27380 | | 23.4 | 33860 | |
| | | 160 | | | 210 | | | 220 | | | 340 |
| 16.0 | 17500 | | 18.5 | 22250 | | 21.0 | 27600 | | 23.5 | 34200 | |
| | | 170 | | | 210 | | | 230 | | | 340 |
| 16.1 | 17670 | | 18.6 | 22460 | | 21.1 | 27830 | | 23.6 | 34540 | |
| | | 170 | | | 210 | | | 230 | | | 340 |
| 16.2 | 17840 | | 18.7 | 22670 | | 21.2 | 28060 | | 23.7 | 34880 | |
| | | 170 | | | 210 | | | 230 | | | 340 |
| 16.3 | 18010 | | 18.8 | 22880 | | 21.3 | 28290 | | 23.8 | 35220 | |
| | | 170 | | | 210 | | | 230 | | | 340 |
| 16.4 | 18180 | | 18.9 | 23090 | | 21.4 | 28520 | | 23.9 | 35560 | |
| | | 170 | | | 210 | | | 230 | | | 340 |

## Table IV-D-02 Continued

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RATING TABLE | | | | PAGE | 3 OF 4 | |
| STREAM: | WHITE RIVER | | | | | | | | FILE NO.: | | WR116 |
| LOCATION | CLARENDON, ARK. | | | | | | | | PREPARED BY: | | BOB |
| FROM: | 1/1/95 | TO: 12/31/95 | | | GAGE DATUM: 139.91 | | | | DATE PREPARED: | | 3/10/96 |

| GAGE (FT) | ISCHARGE (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24.0 | 35900 | | 26.5 | 53600 | | 29.0 | 85500 | | 31.5 | 129500 | |
| | | 600 | | | 880 | | | 1650 | | | 1900 |
| 24.1 | 36500 | | 26.6 | 54480 | | 29.1 | 87150 | | 31.6 | 131400 | |
| | | 600 | | | 880 | | | 1650 | | | 1900 |
| 24.2 | 37100 | | 26.7 | 55360 | | 29.2 | 88800 | | 31.7 | 133300 | |
| | | 600 | | | 880 | | | 1650 | | | 1900 |
| 24.3 | 37700 | | 26.8 | 56240 | | 29.3 | 90450 | | 31.8 | 135200 | |
| | | 600 | | | 880 | | | 1650 | | | 1900 |
| 24.4 | 38300 | | 26.9 | 57120 | | 29.4 | 92100 | | 31.9 | 137100 | |
| | | 600 | | | 880 | | | 1650 | | | 1900 |
| 24.5 | 38900 | | 27.0 | 58000 | | 29.5 | 93750 | | 32.0 | 139000 | |
| | | 600 | | | 1180 | | | 1650 | | | 2000 |
| 24.6 | 39500 | | 27.1 | 59180 | | 29.6 | 95400 | | 32.1 | 141000 | |
| | | 600 | | | 1180 | | | 1650 | | | 2000 |
| 24.7 | 40100 | | 27.2 | 60360 | | 29.7 | 97050 | | 32.2 | 143000 | |
| | | 600 | | | 1180 | | | 1650 | | | 2000 |
| 24.8 | 40700 | | 27.3 | 61540 | | 29.8 | 98700 | | 32.3 | 145000 | |
| | | 600 | | | 1180 | | | 1650 | | | 2000 |
| 24.9 | 41300 | | 27.4 | 62720 | | 29.9 | 100350 | | 32.4 | 147000 | |
| | | 600 | | | 1180 | | | 1650 | | | 2000 |
| 25.0 | 41900 | | 27.5 | 63900 | | 30.0 | 102000 | | 32.5 | 149000 | |
| | | 730 | | | 1180 | | | 1800 | | | 2000 |
| 25.1 | 42630 | | 27.6 | 65080 | | 30.1 | 103800 | | 32.6 | 151000 | |
| | | 730 | | | 1180 | | | 1800 | | | 2000 |
| 25.2 | 43360 | | 27.7 | 66260 | | 30.2 | 105600 | | 32.7 | 153000 | |
| | | 730 | | | 1180 | | | 1800 | | | 2000 |
| 25.3 | 44090 | | 27.8 | 67440 | | 30.3 | 107400 | | 32.8 | 155000 | |
| | | 730 | | | 1180 | | | 1800 | | | 2000 |
| 25.4 | 44820 | | 27.9 | 68620 | | 30.4 | 109200 | | 32.9 | 157000 | |
| | | 730 | | | 1180 | | | 1800 | | | 2000 |
| 25.5 | 45550 | | 28.0 | 69800 | | 30.5 | 111000 | | 33.0 | 159000 | |
| | | 730 | | | 1570 | | | 1800 | | | 2030 |
| 25.6 | 46280 | | 28.1 | 71370 | | 30.6 | 112800 | | 33.1 | 161030 | |
| | | 730 | | | 1570 | | | 1800 | | | 2030 |
| 25.7 | 47010 | | 28.2 | 72940 | | 30.7 | 114600 | | 33.2 | 163060 | |
| | | 730 | | | 1570 | | | 1800 | | | 2030 |
| 25.8 | 47740 | | 28.3 | 74510 | | 30.8 | 116400 | | 33.3 | 165090 | |
| | | 730 | | | 1570 | | | 1800 | | | 2030 |
| 25.9 | 48470 | | 28.4 | 76080 | | 30.9 | 118200 | | 33.4 | 167120 | |
| | | 730 | | | 1570 | | | 1800 | | | 2030 |
| 26.0 | 49200 | | 28.5 | 77650 | | 31.0 | 120000 | | 33.5 | 169150 | |
| | | 880 | | | 1570 | | | 1900 | | | 2030 |
| 26.1 | 50080 | | 28.6 | 79220 | | 31.1 | 121900 | | 33.6 | 171180 | |
| | | 880 | | | 1570 | | | 1900 | | | 2030 |
| 26.2 | 50960 | | 28.7 | 80790 | | 31.2 | 123800 | | 33.7 | 173210 | |
| | | 880 | | | 1570 | | | 1900 | | | 2030 |
| 26.3 | 51840 | | 28.8 | 82360 | | 31.3 | 125700 | | 33.8 | 175240 | |
| | | 880 | | | 1570 | | | 1900 | | | 2030 |
| 26.4 | 52720 | | 28.9 | 83930 | | 31.4 | 127600 | | 33.9 | 177270 | |
| | | 880 | | | 1570 | | | 1900 | | | 2030 |

# Table IV-D-02 Continued

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | RATING TABLE | | | | PAGE | 4 OF 4 | |
| STREAM: | WHITE RIVER | | | | | | | | FILE NO.: | | WR116 |
| LOCATION | CLARENDON, ARK. | | | | | | | | PREPARED BY: | | BOB |
| FROM: | 1/1/95 | TO: 12/31/95 | | | GAGE DATUM: 139.91 | | | | DATE PREPARED: | | 3/10/96 |
| GAGE (FT) | ISCHARGE (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) | GAGE (FT) | ISCHARG (CFS) | DIFF. (CFS) |
| 34.0 | 179300 | | 35.1 | 203430 | | 36.2 | 228000 | | 37.3 | 252900 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.1 | 181490 | | 35.2 | 205660 | | 36.3 | 230250 | | 37.4 | 255200 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.2 | 183680 | | 35.3 | 207890 | | 36.4 | 232500 | | 37.5 | 257500 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.3 | 185870 | | 35.4 | 210120 | | 36.5 | 234750 | | 37.6 | 259800 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.4 | 188060 | | 35.5 | 212350 | | 36.6 | 237000 | | 37.7 | 262100 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.5 | 190250 | | 35.6 | 214580 | | 36.7 | 239250 | | 37.8 | 264400 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.6 | 192440 | | 35.7 | 216810 | | 36.8 | 241500 | | 37.9 | 266700 | |
| | | 2190 | | | 2230 | | | 2250 | | | 2300 |
| 34.7 | 194630 | | 35.8 | 219040 | | 36.9 | 243750 | | 38.0 | 269000 | |
| | | 2190 | | | 2230 | | | 2250 | | | |
| 34.8 | 196820 | | 35.9 | 221270 | | 37.0 | 246000 | | | | |
| | | 2190 | | | 2230 | | | 2300 | | | |
| 34.9 | 199010 | | 36.0 | 223500 | | 37.1 | 248300 | | | | |
| | | 2190 | | | 2250 | | | 2300 | | | |
| 35.0 | 201200 | | 36.1 | 225750 | | 37.2 | 250600 | | | | |
| | | 2230 | | | 2250 | | | 2300 | | | |

## Table IV-C.1.2 Annual and Monthly Flow-Duration Data for 1480 cfs Maximum Diversion and Simulated White River Data (1940-1986)

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1480 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 2827 | 100.00 | 4291 | | | | | | | | | | | | |
| 99.32 | 5250 | 98.49 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 |
| 98.37 | 5750 | 96.98 | 5750 | 99.85 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 |
| 96.82 | 6250 | 94.92 | 6250 | 99.32 | 6250 | 99.93 | 6250 | 100.00 | 6250 | 100.00 | 6250 | 100.00 | 6250 |
| 95.34 | 6750 | 92.72 | 6750 | 98.80 | 6750 | 99.93 | 6750 | 100.00 | 6750 | 100.00 | 6750 | 100.00 | 6750 |
| 93.64 | 7250 | 91.21 | 7250 | 98.42 | 7250 | 99.93 | 7250 | 100.00 | 7250 | 100.00 | 7250 | 100.00 | 7250 |
| 91.75 | 7750 | 89.70 | 7750 | 97.52 | 7750 | 99.93 | 7750 | 100.00 | 7750 | 99.93 | 7750 | 99.71 | 7750 |
| 89.74 | 8250 | 88.40 | 8250 | 96.69 | 8250 | 99.72 | 8250 | 99.93 | 8250 | 99.58 | 8250 | 99.50 | 8250 |
| 87.93 | 8750 | 86.41 | 8750 | 95.63 | 8750 | 99.65 | 8750 | 99.86 | 8750 | 99.31 | 8750 | 98.28 | 8750 |
| 85.76 | 9250 | 85.11 | 9250 | 93.98 | 9250 | 99.58 | 9250 | 99.57 | 9250 | 98.75 | 9250 | 97.35 | 9250 |
| 83.86 | 9650 | 84.15 | 9650 | 93.30 | 9650 | 98.89 | 9650 | 99.28 | 9650 | 98.06 | 9650 | 96.42 | 9650 |
| 80.34 | 10000 | 83.53 | 10000 | 92.62 | 10000 | 98.62 | 10000 | 99.07 | 10000 | 97.65 | 10000 | 95.49 | 10000 |
| 77.62 | 10670 | 82.43 | 10670 | 90.36 | 10670 | 97.72 | 10670 | 98.50 | 10670 | 96.96 | 10670 | 93.42 | 10670 |
| 75.49 | 11000 | 81.74 | 11000 | 89.53 | 11000 | 97.23 | 11000 | 97.78 | 11000 | 96.61 | 11000 | 91.99 | 11000 |
| 75.28 | 11050 | 81.74 | 11050 | 89.23 | 11050 | 97.09 | 11050 | 97.64 | 11050 | 96.54 | 11050 | 91.92 | 11050 |
| 74.07 | 11350 | 81.19 | 11350 | 87.73 | 11350 | 96.47 | 11350 | 97.28 | 11350 | 96.40 | 11350 | 90.13 | 11350 |
| 68.57 | 12850 | 78.45 | 12850 | 83.43 | 12850 | 93.01 | 12850 | 95.14 | 12850 | 94.39 | 12850 | 83.33 | 12850 |
| 64.35 | 14000 | 75.63 | 14000 | 80.72 | 14000 | 89.62 | 14000 | 92.20 | 14000 | 92.39 | 14000 | 77.40 | 14000 |
| 61.36 | 15000 | 73.71 | 15000 | 78.61 | 15000 | 87.61 | 15000 | 90.27 | 15000 | 91.21 | 15000 | 73.10 | 15000 |
| 58.82 | 16000 | 71.52 | 16000 | 76.43 | 16000 | 85.88 | 16000 | 87.63 | 16000 | 89.83 | 16000 | 70.17 | 16000 |
| 56.79 | 17000 | 69.66 | 17000 | 74.47 | 17000 | 84.98 | 17000 | 85.41 | 17000 | 87.82 | 17000 | 67.74 | 17000 |
| 55.76 | 17500 | 68.70 | 17500 | 73.34 | 17500 | 83.94 | 17500 | 84.19 | 17500 | 86.99 | 17500 | 66.17 | 17500 |
| 55.63 | 17590 | 68.57 | 17590 | 73.19 | 17590 | 83.94 | 17590 | 84.05 | 17590 | 86.78 | 17590 | 66.09 | 17590 |
| 52.11 | 19610 | 64.31 | 19610 | 68.45 | 19610 | 81.87 | 19610 | 81.40 | 19610 | 82.63 | 19610 | 61.95 | 19610 |
| 49.98 | 21220 | 61.08 | 21220 | 65.96 | 21220 | 79.65 | 21220 | 79.83 | 21220 | 79.10 | 21220 | 59.23 | 21220 |
| 47.76 | 22700 | 57.72 | 22700 | 63.45 | 22700 | 77.02 | 22700 | 78.40 | 22700 | 76.06 | 22700 | 53.93 | 22700 |
| 46.12 | 24000 | 55.11 | 24000 | 60.84 | 24000 | 75.64 | 24000 | 77.61 | 24000 | 73.70 | 24000 | 51.65 | 24000 |
| 42.07 | 27610 | 48.39 | 27610 | 54.52 | 27610 | 70.10 | 27610 | 74.39 | 27610 | 69.76 | 27610 | 46.92 | 27610 |

**Table IV-C.1.2 Annual and Monthly Flow-Duration Data for 1480 cfs Maximum Diversion and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1480 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

[redacted]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38.40 | 30000 | 45.16 | 30000 | 50.00 | 30000 | 65.74 | 30000 | 72.10 | 30000 | 67.61 | 30000 | 41.85 | 30000 |
| 34.08 | 32500 | 41.39 | 32500 | 46.31 | 32500 | 61.66 | 32500 | 69.17 | 32500 | 64.98 | 32500 | 36.91 | 32500 |
| 30.64 | 35000 | 38.98 | 35000 | 43.37 | 35000 | 57.58 | 35000 | 67.31 | 35000 | 63.25 | 35000 | 30.76 | 35000 |
| 28.64 | 36640 | 37.54 | 36640 | 40.81 | 36640 | 54.60 | 36640 | 65.74 | 36640 | 62.08 | 36640 | 27.47 | 36640 |
| 28.30 | 36940 | 37.34 | 36940 | 40.29 | 36940 | 54.39 | 36940 | 65.31 | 36940 | 60.83 | 36940 | 27.11 | 36940 |
| 27.68 | 37500 | 37.06 | 37500 | 39.23 | 37500 | 53.84 | 37500 | 63.16 | 37500 | 60.42 | 37500 | 25.97 | 37500 |
| 25.50 | 40000 | 34.93 | 40000 | 36.07 | 40000 | 50.80 | 40000 | 60.52 | 40000 | 56.54 | 40000 | 23.03 | 40000 |
| 23.85 | 42000 | 32.60 | 42000 | 34.49 | 42000 | 47.89 | 42000 | 58.94 | 42000 | 53.43 | 42000 | 20.10 | 42000 |
| 22.40 | 44000 | 30.40 | 44000 | 32.53 | 44000 | 46.23 | 44000 | 57.65 | 44000 | 49.90 | 44000 | 17.95 | 44000 |
| 20.87 | 46000 | 28.21 | 46000 | 30.42 | 46000 | 44.50 | 46000 | 56.15 | 46000 | 46.09 | 46000 | 15.67 | 46000 |
| 19.41 | 48000 | 25.26 | 48000 | 28.31 | 48000 | 41.45 | 48000 | 53.58 | 48000 | 43.60 | 48000 | 14.09 | 48000 |
| 17.93 | 50000 | 23.54 | 50000 | 26.20 | 50000 | 39.10 | 50000 | 50.36 | 50000 | 39.58 | 50000 | 12.37 | 50000 |
| 14.79 | 55000 | 18.87 | 55000 | 20.56 | 55000 | 32.39 | 55000 | 43.99 | 55000 | 32.53 | 55000 | 8.58 | 55000 |
| 12.06 | 60000 | 16.33 | 60000 | 16.34 | 60000 | 26.02 | 60000 | 36.34 | 60000 | 26.37 | 60000 | 6.94 | 60000 |
| 9.62 | 65000 | 13.52 | 65000 | 13.63 | 65000 | 20.14 | 65000 | 26.90 | 65000 | 21.87 | 65000 | 5.51 | 65000 |
| 7.41 | 70000 | 10.16 | 70000 | 11.37 | 70000 | 15.78 | 70000 | 19.10 | 70000 | 17.51 | 70000 | 3.93 | 70000 |
| 5.63 | 75000 | 7.28 | 75000 | 9.49 | 75000 | 11.49 | 75000 | 14.52 | 75000 | 14.39 | 75000 | 3.43 | 75000 |
| 3.45 | 85000 | 3.71 | 85000 | 6.10 | 85000 | 5.74 | 85000 | 9.59 | 85000 | 9.48 | 85000 | 3.08 | 85000 |
| 2.10 | 95000 | 2.13 | 95000 | 4.74 | 95000 | 2.15 | 95000 | 5.22 | 95000 | 5.47 | 95000 | 2.50 | 95000 |
| 1.41 | 105000 | 1.65 | 105000 | 3.31 | 105000 | 0.35 | 105000 | 4.08 | 105000 | 3.18 | 105000 | 2.22 | 105000 |
| 1.06 | 115000 | 0.69 | 115000 | 2.48 | 115000 | | | 3.65 | 115000 | 2.21 | 115000 | 1.93 | 115000 |
| 0.80 | 125000 | 0.34 | 125000 | 1.66 | 125000 | | | 3.22 | 125000 | 1.66 | 125000 | 1.72 | 125000 |
| 0.38 | 150000 | | | 0.38 | 150000 | | | 1.72 | 150000 | 1.04 | 150000 | 0.93 | 150000 |
| 0.18 | 175000 | | | | | | | 1.07 | 175000 | 0.21 | 175000 | 0.64 | 175000 |
| 0.08 | 200000 | | | | | | | 0.64 | 200000 | | | 0.36 | 200000 |
| 0.04 | 225000 | | | | | | | 0.50 | 225000 | | | | |
| 0.02 | 250000 | | | | | | | 0.29 | 250000 | | | | |

Table IV-C.1.2 Annual and Monthly Flow-Duration Data for 1480 cfs Maximum Diversion and Simulated White River Data (1940-1986)

[redacted]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100.00 | 4258 | 100.00 | 3205 | 100.00 | 3019 | 100.00 | 2827 | 100.00 | 4525 |
| 100.00 | 5250 | 99.93 | 5250 | 98.78 | 5250 | 98.75 | 5250 | 97.42 | 5250 | 98.41 | 5250 |
| 100.00 | 5750 | 99.86 | 5750 | 97.28 | 5750 | 96.06 | 5750 | 94.13 | 5750 | 96.40 | 5750 |
| 99.65 | 6250 | 99.52 | 6250 | 94.85 | 6250 | 90.87 | 6250 | 88.27 | 6250 | 94.60 | 6250 |
| 99.17 | 6750 | 99.03 | 6750 | 92.20 | 6750 | 86.44 | 6750 | 83.98 | 6750 | 91.97 | 6750 |
| 98.82 | 7250 | 98.55 | 7250 | 89.27 | 7250 | 80.14 | 7250 | 78.61 | 7250 | 89.00 | 7250 |
| 98.27 | 7750 | 96.96 | 7750 | 85.55 | 7750 | 72.73 | 7750 | 73.89 | 7750 | 87.13 | 7750 |
| 97.44 | 8250 | 94.53 | 8250 | 81.55 | 8250 | 67.54 | 8250 | 68.96 | 8250 | 83.60 | 8250 |
| 95.99 | 8750 | 92.66 | 8750 | 77.90 | 8750 | 61.94 | 8750 | 66.31 | 8750 | 81.80 | 8750 |
| 94.46 | 9250 | 89.97 | 9250 | 72.75 | 9250 | 56.26 | 9250 | 62.66 | 9250 | 79.17 | 9250 |
| 92.60 | 9650 | 86.99 | 9650 | 69.10 | 9650 | 51.88 | 9650 | 59.87 | 9650 | 76.89 | 9650 |
| 90.80 | 10000 | 73.63 | 10000 | 56.37 | 10000 | 45.19 | 10000 | 56.72 | 10000 | 75.78 | 10000 |
| 87.00 | 10670 | 68.65 | 10670 | 50.57 | 10670 | 39.86 | 10670 | 53.51 | 10670 | 73.84 | 10670 |
| 75.85 | 11000 | 66.51 | 11000 | 48.21 | 11000 | 37.16 | 11000 | 52.00 | 11000 | 72.73 | 11000 |
| 75.29 | 11050 | 66.23 | 11050 | 47.85 | 11050 | 36.96 | 11050 | 51.88 | 11050 | 72.66 | 11050 |
| 73.77 | 11350 | 64.29 | 11350 | 46.78 | 11350 | 35.22 | 11350 | 49.36 | 11350 | 71.63 | 11350 |
| 64.50 | 12850 | 54.26 | 12850 | 38.63 | 12850 | 28.86 | 12850 | 42.70 | 12850 | 67.68 | 12850 |
| 56.89 | 14000 | 47.40 | 14000 | 32.90 | 14000 | 24.91 | 14000 | 38.77 | 14000 | 65.33 | 14000 |
| 50.73 | 15000 | 42.84 | 15000 | 29.40 | 15000 | 22.01 | 15000 | 36.05 | 15000 | 62.77 | 15000 |
| 46.92 | 16000 | 38.41 | 16000 | 26.75 | 16000 | 20.07 | 16000 | 33.69 | 16000 | 60.62 | 16000 |
| 44.50 | 17000 | 34.88 | 17000 | 24.25 | 17000 | 18.82 | 17000 | 31.76 | 17000 | 59.17 | 17000 |
| 43.53 | 17500 | 33.36 | 17500 | 23.10 | 17500 | 18.27 | 17500 | 31.26 | 17500 | 58.20 | 17500 |
| 43.39 | 17590 | 33.15 | 17590 | 23.03 | 17590 | 18.06 | 17590 | 31.26 | 17590 | 57.98 | 17590 |
| 39.52 | 19610 | 29.41 | 19610 | 19.67 | 19610 | 15.64 | 19610 | 29.11 | 19610 | 53.15 | 19610 |
| 37.92 | 21220 | 27.34 | 21220 | 18.45 | 21220 | 14.39 | 21220 | 28.11 | 21220 | 50.52 | 21220 |
| 37.02 | 22700 | 25.88 | 22700 | 17.53 | 22700 | 12.73 | 22700 | 26.75 | 22700 | 48.44 | 22700 |
| 35.99 | 24000 | 24.57 | 24000 | 16.60 | 24000 | 12.11 | 24000 | 25.04 | 24000 | 46.30 | 24000 |
| 32.11 | 27610 | 22.08 | 27610 | 15.16 | 27610 | 10.45 | 27610 | 20.67 | 27610 | 41.87 | 27610 |

Table IV-C.1.2 Annual and Monthly Flow-Duration Data for 1480 cfs Maximum Diversion and Simulated White River Data (1940-1986)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24.43 | 30000 | 16.06 | 30000 | 13.02 | 30000 | 9.00 | 30000 | 18.03 | 30000 | 39.24 | 30000 |
| 16.61 | 32500 | 7.96 | 32500 | 8.01 | 32500 | 6.02 | 32500 | 14.88 | 32500 | 36.33 | 32500 |
| 8.44 | 35000 | 3.88 | 35000 | 5.51 | 35000 | 3.25 | 35000 | 12.30 | 35000 | 34.26 | 35000 |
| 4.78 | 36640 | 2.08 | 36640 | 4.01 | 36640 | 1.80 | 36640 | 11.02 | 36640 | 32.87 | 36640 |
| 4.50 | 36940 | 1.94 | 36940 | 3.93 | 36940 | 1.66 | 36940 | 10.80 | 36940 | 32.66 | 36940 |
| 4.15 | 37500 | 1.45 | 37500 | 3.72 | 37500 | 1.59 | 37500 | 10.30 | 37500 | 32.18 | 37500 |
| 2.91 | 40000 | 1.11 | 40000 | 2.15 | 40000 | 1.18 | 40000 | 7.94 | 40000 | 29.55 | 40000 |
| 2.49 | 42000 | 0.97 | 42000 | 1.43 | 42000 | 1.04 | 42000 | 6.72 | 42000 | 26.78 | 42000 |
| 2.01 | 44000 | 0.76 | 44000 | 0.79 | 44000 | 0.97 | 44000 | 6.08 | 44000 | 24.15 | 44000 |
| 1.59 | 46000 | 0.69 | 46000 | 0.43 | 46000 | 0.69 | 46000 | 4.94 | 46000 | 21.66 | 46000 |
| 1.25 | 48000 | 0.55 | 48000 | | | 0.69 | 48000 | 4.51 | 48000 | 20.28 | 48000 |
| 1.04 | 50000 | 0.28 | 50000 | | | 0.55 | 50000 | 4.15 | 50000 | 18.69 | 50000 |
| 0.90 | 55000 | | | | | 0.35 | 55000 | 3.29 | 55000 | 16.61 | 55000 |
| 0.69 | 60000 | | | | | | | 2.22 | 60000 | 13.91 | 60000 |
| 0.62 | 65000 | | | | | | | 1.86 | 65000 | 11.97 | 65000 |
| 0.55 | 70000 | | | | | | | 1.36 | 70000 | 9.69 | 70000 |
| 0.48 | 75000 | | | | | | | 0.64 | 75000 | 6.44 | 75000 |
| 0.42 | 85000 | | | | | | | 0.50 | 85000 | 3.25 | 85000 |
| 0.35 | 95000 | | | | | | | 0.36 | 95000 | 2.63 | 95000 |
| 0.28 | 105000 | | | | | | | | | 2.15 | 105000 |
| 0.21 | 115000 | | | | | | | | | 1.80 | 115000 |
| 0.14 | 125000 | | | | | | | | | 1.11 | 125000 |
| | | | | | | | | | | 0.55 | 150000 |
| | | | | | | | | | | 0.28 | 175000 |

**Table IV-C.1.3 Annual and Monthly Flow-Duration Data for 1640 cfs Maximum Diversion and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1640 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 2827 | 100.00 | 4291 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 |
| 99.32 | 5250 | 98.49 | 5250 | 99.85 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 |
| 98.37 | 5750 | 96.98 | 5750 | 99.32 | 6250 | 99.93 | 6250 | 100.00 | 6250 | 100.00 | 6250 | 100.00 | 6250 |
| 96.82 | 6250 | 94.92 | 6250 | 98.78 | 6750 | 99.93 | 6750 | 100.00 | 6750 | 100.00 | 6750 | 100.00 | 6750 |
| 95.34 | 6750 | 92.72 | 6750 | 98.40 | 7250 | 99.93 | 7250 | 100.00 | 7250 | 100.00 | 7250 | 100.00 | 7250 |
| 93.64 | 7250 | 91.21 | 7250 | 97.49 | 7750 | 99.93 | 7750 | 100.00 | 7750 | 99.93 | 7750 | 99.71 | 7750 |
| 91.75 | 7750 | 89.70 | 7750 | 96.66 | 8250 | 99.72 | 8250 | 99.93 | 8250 | 99.58 | 8250 | 99.50 | 8250 |
| 89.74 | 8250 | 88.40 | 8250 | 95.59 | 8750 | 99.65 | 8750 | 99.86 | 8750 | 99.31 | 8750 | 98.28 | 8750 |
| 87.93 | 8750 | 86.41 | 8750 | 93.92 | 9250 | 99.58 | 9250 | 99.57 | 9250 | 98.75 | 9250 | 97.35 | 9250 |
| 85.76 | 9250 | 85.11 | 9250 | 93.24 | 9650 | 98.89 | 9650 | 99.28 | 9650 | 98.06 | 9650 | 96.42 | 9650 |
| 83.86 | 9650 | 84.15 | 9650 | 92.55 | 10000 | 98.62 | 10000 | 99.07 | 10000 | 97.65 | 10000 | 95.49 | 10000 |
| 80.23 | 10000 | 83.53 | 10000 | 90.43 | 10670 | 97.72 | 10670 | 98.50 | 10670 | 96.96 | 10670 | 93.42 | 10670 |
| 77.52 | 10670 | 82.43 | 10670 | 89.59 | 11000 | 97.23 | 11000 | 97.78 | 11000 | 96.61 | 11000 | 91.99 | 11000 |
| 75.30 | 11000 | 81.74 | 11000 | 89.29 | 11050 | 97.09 | 11050 | 97.64 | 11050 | 96.54 | 11050 | 91.92 | 11050 |
| 75.14 | 11050 | 81.74 | 11050 | 87.77 | 11350 | 96.47 | 11350 | 97.28 | 11350 | 96.40 | 11350 | 90.13 | 11350 |
| 73.93 | 11350 | 81.19 | 11350 | 83.43 | 12850 | 93.01 | 12850 | 95.14 | 12850 | 94.39 | 12850 | 83.33 | 12850 |
| 68.41 | 12850 | 78.45 | 12850 | 80.70 | 14000 | 89.62 | 14000 | 92.20 | 14000 | 92.39 | 14000 | 77.32 | 14000 |
| 64.27 | 14000 | 75.63 | 14000 | 78.57 | 15000 | 87.61 | 15000 | 90.27 | 15000 | 91.21 | 15000 | 73.10 | 15000 |
| 61.27 | 15000 | 73.71 | 15000 | 76.37 | 16000 | 85.88 | 16000 | 87.63 | 16000 | 89.83 | 16000 | 70.17 | 16000 |
| 58.75 | 16000 | 71.52 | 16000 | 74.47 | 17000 | 84.98 | 17000 | 85.41 | 17000 | 87.82 | 17000 | 67.74 | 17000 |
| 56.75 | 17000 | 69.66 | 17000 | 73.33 | 17500 | 83.94 | 17500 | 84.19 | 17500 | 86.99 | 17500 | 66.17 | 17500 |
| 55.74 | 17500 | 68.70 | 17500 | 73.18 | 17590 | 83.94 | 17590 | 84.05 | 17590 | 86.78 | 17590 | 66.02 | 17590 |
| 55.62 | 17590 | 68.57 | 17590 | 68.47 | 19610 | 81.87 | 19610 | 81.40 | 19610 | 82.63 | 19610 | 61.87 | 19610 |
| 52.10 | 19610 | 64.31 | 19610 | 65.96 | 21220 | 79.65 | 21220 | 79.83 | 21220 | 79.10 | 21220 | 59.29 | 21220 |
| 49.99 | 21220 | 61.08 | 21220 | 63.48 | 22700 | 77.02 | 22700 | 78.40 | 22700 | 76.06 | 22700 | 53.86 | 22700 |
| 47.75 | 22700 | 57.72 | 22700 | 60.79 | 24000 | 75.64 | 24000 | 77.61 | 24000 | 73.70 | 24000 | 51.50 | 24000 |
| 46.12 | 24000 | 55.11 | 24000 | 54.41 | 27610 | 70.10 | 27610 | 74.39 | 27610 | 69.76 | 27610 | 46.49 | 27610 |
| 41.98 | 27610 | 48.39 | 27610 | 50.00 | 30000 | 65.61 | 30000 | 72.10 | 30000 | 67.61 | 30000 | 41.77 | 30000 |
| 38.33 | 30000 | 45.16 | 30000 | 46.35 | 32500 | 61.38 | 32500 | 69.17 | 32500 | 64.98 | 32500 | 36.77 | 32500 |

**Table IV-C.1.3 Annual and Monthly Flow-Duration Data for 1640 cfs Maximum Diversion and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1640 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34.04 | 32500 | 41.39 | 32500 | 43.39 | 35000 | 57.44 | 35000 | 67.31 | 35000 | 63.25 | 35000 | 30.54 | 35000 |
| 30.56 | 35000 | 38.98 | 35000 | 40.88 | 36640 | 54.53 | 36640 | 65.74 | 36640 | 62.08 | 36640 | 27.25 | 36640 |
| 28.63 | 36640 | 37.54 | 36640 | 40.35 | 36940 | 54.33 | 36940 | 65.31 | 36940 | 60.62 | 36940 | 27.04 | 36940 |
| 28.25 | 36940 | 37.34 | 36940 | 39.29 | 37500 | 53.70 | 37500 | 63.02 | 37500 | 60.35 | 37500 | 25.68 | 37500 |
| 27.62 | 37500 | 37.06 | 37500 | 36.09 | 40000 | 50.59 | 40000 | 60.52 | 40000 | 56.54 | 40000 | 22.96 | 40000 |
| 25.49 | 40000 | 34.93 | 40000 | 34.50 | 42000 | 47.75 | 42000 | 58.94 | 42000 | 53.22 | 42000 | 20.03 | 42000 |
| 23.83 | 42000 | 32.60 | 42000 | 32.52 | 44000 | 46.02 | 44000 | 57.51 | 44000 | 49.62 | 44000 | 17.95 | 44000 |
| 22.37 | 44000 | 30.40 | 44000 | 30.47 | 46000 | 44.43 | 46000 | 56.08 | 46000 | 45.67 | 46000 | 15.59 | 46000 |
| 20.82 | 46000 | 28.21 | 46000 | 28.42 | 48000 | 41.25 | 48000 | 53.22 | 48000 | 43.25 | 48000 | 14.09 | 48000 |
| 19.33 | 48000 | 25.26 | 48000 | 26.37 | 50000 | 39.03 | 50000 | 50.14 | 50000 | 39.24 | 50000 | 12.45 | 50000 |
| 17.88 | 50000 | 23.54 | 50000 | 20.67 | 55000 | 32.25 | 55000 | 43.71 | 55000 | 32.11 | 55000 | 8.51 | 55000 |
| 14.71 | 55000 | 18.87 | 55000 | 16.41 | 60000 | 25.95 | 60000 | 36.05 | 60000 | 26.30 | 60000 | 6.94 | 60000 |
| 12.02 | 60000 | 16.33 | 60000 | 13.68 | 65000 | 20.07 | 65000 | 26.25 | 65000 | 21.80 | 65000 | 5.51 | 65000 |
| 9.56 | 65000 | 13.52 | 65000 | 11.40 | 70000 | 15.64 | 70000 | 19.03 | 70000 | 17.44 | 70000 | 3.93 | 70000 |
| 7.39 | 70000 | 10.16 | 70000 | 9.50 | 75000 | 11.35 | 75000 | 14.38 | 75000 | 14.33 | 75000 | 3.43 | 75000 |
| 5.60 | 75000 | 7.28 | 75000 | 6.16 | 85000 | 5.61 | 85000 | 9.59 | 85000 | 9.20 | 85000 | 3.08 | 85000 |
| 3.42 | 85000 | 3.71 | 85000 | 4.79 | 95000 | 2.15 | 95000 | 5.08 | 95000 | 5.40 | 95000 | 2.50 | 95000 |
| 2.08 | 95000 | 2.13 | 95000 | 3.34 | 105000 | 0.35 | 105000 | 4.08 | 105000 | 3.18 | 105000 | 2.22 | 105000 |
| 1.41 | 105000 | 1.65 | 105000 | 2.51 | 115000 | | | 3.65 | 115000 | 2.21 | 115000 | 1.93 | 115000 |
| 1.06 | 115000 | 0.69 | 115000 | 1.67 | 125000 | | | 3.22 | 125000 | 1.66 | 125000 | 1.65 | 125000 |
| 0.80 | 125000 | 0.34 | 125000 | 0.38 | 150000 | | | 1.72 | 150000 | 1.04 | 150000 | 0.93 | 150000 |
| 0.38 | 150000 | | | | | | | 1.07 | 175000 | 0.21 | 175000 | 0.64 | 175000 |
| 0.18 | 175000 | | | | | | | 0.64 | 200000 | | | 0.36 | 200000 |
| 0.08 | 200000 | | | | | | | 0.50 | 225000 | | | | |
| 0.04 | 225000 | | | | | | | 0.29 | 250000 | | | | |
| 0.02 | 250000 | | | | | | | | | | | | |

**Table IV-C.1.3 Annual and Monthly Flow-Duration Data for 1640 cfs Maximum Diversion and Simulated White River Data (1940-1986)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 5250 | 100.00 | 4258 | 100.00 | 3205 | 100.00 | 3019 | 100.00 | 2827 | 100.00 | 4525 |
| 100.00 | 5750 | 99.93 | 5250 | 98.78 | 5250 | 98.75 | 5250 | 97.42 | 5250 | 98.41 | 5250 |
| 99.65 | 6250 | 99.86 | 5750 | 97.28 | 5750 | 96.06 | 5750 | 94.13 | 5750 | 96.40 | 5750 |
| 99.17 | 6750 | 99.52 | 6250 | 94.85 | 6250 | 90.87 | 6250 | 88.27 | 6250 | 94.60 | 6250 |
| 98.82 | 7250 | 99.03 | 6750 | 92.20 | 6750 | 86.44 | 6750 | 83.98 | 6750 | 91.97 | 6750 |
| 98.27 | 7750 | 98.55 | 7250 | 89.27 | 7250 | 80.14 | 7250 | 78.61 | 7250 | 89.00 | 7250 |
| 97.44 | 8250 | 96.96 | 7750 | 85.55 | 7750 | 72.73 | 7750 | 73.89 | 7750 | 87.13 | 7750 |
| 95.99 | 8750 | 94.53 | 8250 | 81.55 | 8250 | 67.54 | 8250 | 68.96 | 8250 | 83.60 | 8250 |
| 94.46 | 9250 | 92.66 | 8750 | 77.90 | 8750 | 61.94 | 8750 | 66.31 | 8750 | 81.80 | 8750 |
| 92.60 | 9650 | 89.97 | 9250 | 72.75 | 9250 | 56.26 | 9250 | 62.66 | 9250 | 79.17 | 9250 |
| 90.80 | 10000 | 86.99 | 9650 | 69.10 | 9650 | 51.56 | 9650 | 59.87 | 9650 | 76.89 | 9650 |
| 87.96 | 10670 | 72.32 | 10000 | 56.08 | 10000 | 45.54 | 10000 | 56.72 | 10000 | 75.78 | 10000 |
| 74.60 | 11000 | 67.54 | 10670 | 50.29 | 10670 | 40.21 | 10670 | 53.51 | 10670 | 73.84 | 10670 |
| 74.46 | 11050 | 65.54 | 11000 | 48.07 | 11000 | 37.30 | 11000 | 52.00 | 11000 | 72.73 | 11000 |
| 72.32 | 11350 | 65.26 | 11050 | 48.00 | 11050 | 37.02 | 11050 | 51.65 | 11050 | 72.66 | 11050 |
| 63.46 | 12850 | 64.01 | 11350 | 46.78 | 11350 | 35.36 | 11350 | 49.36 | 11350 | 71.63 | 11350 |
| 56.26 | 14000 | 53.29 | 12850 | 38.77 | 12850 | 28.86 | 12850 | 42.70 | 12850 | 67.68 | 12850 |
| 49.83 | 15000 | 46.99 | 14000 | 33.12 | 14000 | 24.84 | 14000 | 38.77 | 14000 | 65.33 | 14000 |
| 46.78 | 16000 | 42.56 | 15000 | 29.61 | 15000 | 22.01 | 15000 | 36.05 | 15000 | 62.77 | 15000 |
| 44.22 | 17000 | 37.79 | 16000 | 26.68 | 16000 | 20.07 | 16000 | 33.69 | 16000 | 60.62 | 16000 |
| 43.25 | 17500 | 34.60 | 17000 | 24.39 | 17000 | 18.82 | 17000 | 31.76 | 17000 | 59.17 | 17000 |
| 43.25 | 17590 | 33.15 | 17500 | 23.46 | 17500 | 18.20 | 17500 | 31.26 | 17500 | 58.20 | 17500 |
| 39.31 | 19610 | 33.01 | 17590 | 23.25 | 17590 | 17.99 | 17590 | 31.26 | 17590 | 57.99 | 17590 |
| 37.92 | 21220 | 29.13 | 19610 | 20.03 | 19610 | 15.64 | 19610 | 29.11 | 19610 | 53.15 | 19610 |
| 36.89 | 22700 | 27.34 | 21220 | 18.60 | 21220 | 14.39 | 21220 | 28.11 | 21220 | 50.52 | 21220 |
| 35.92 | 24000 | 25.88 | 22700 | 17.53 | 22700 | 12.87 | 22700 | 26.75 | 22700 | 48.44 | 22700 |
| 31.76 | 27610 | 24.78 | 24000 | 16.60 | 24000 | 12.11 | 24000 | 25.04 | 24000 | 46.30 | 24000 |
| 24.08 | 30000 | 21.66 | 27610 | 15.16 | 27610 | 10.52 | 27610 | 20.67 | 27610 | 41.87 | 27610 |
| 16.06 | 32500 | 15.43 | 30000 | 13.16 | 30000 | 9.13 | 30000 | 18.03 | 30000 | 39.24 | 30000 |

**Table IV-C.1.3 Annual and Monthly Flow-Duration Data for 1640 cfs Maximum Diversion and Simulated White River Data (1940-1986)**

[redacted]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.75 | 35000 | 8.30 | 32500 | 8.01 | 32500 | 6.16 | 32500 | 14.88 | 32500 | 36.33 | 32500 |
| 4.78 | 36640 | 3.88 | 35000 | 5.51 | 35000 | 3.25 | 35000 | 12.30 | 35000 | 34.26 | 35000 |
| 4.29 | 36940 | 2.21 | 36640 | 4.01 | 36640 | 1.80 | 36640 | 11.02 | 36640 | 32.87 | 36640 |
| 4.08 | 37500 | 1.94 | 36940 | 3.93 | 36940 | 1.66 | 36940 | 10.80 | 36940 | 32.66 | 36940 |
| 2.91 | 40000 | 1.52 | 37500 | 3.72 | 37500 | 1.59 | 37500 | 10.30 | 37500 | 32.18 | 37500 |
| 2.49 | 42000 | 1.18 | 40000 | 2.29 | 40000 | 1.18 | 40000 | 7.94 | 40000 | 29.55 | 40000 |
| 2.08 | 44000 | 1.11 | 42000 | 1.43 | 42000 | 1.04 | 42000 | 6.72 | 42000 | 26.78 | 42000 |
| 1.59 | 46000 | 0.90 | 44000 | 0.79 | 44000 | 0.97 | 44000 | 6.08 | 44000 | 24.15 | 44000 |
| 1.25 | 48000 | 0.69 | 46000 | 0.43 | 46000 | 0.69 | 46000 | 4.94 | 46000 | 21.66 | 46000 |
| 1.04 | 50000 | 0.55 | 48000 | | | 0.69 | 48000 | 4.51 | 48000 | 20.28 | 48000 |
| 0.83 | 55000 | 0.28 | 50000 | | | 0.55 | 50000 | 4.15 | 50000 | 18.69 | 50000 |
| 0.62 | 60000 | | | | | 0.35 | 55000 | 3.29 | 55000 | 16.61 | 55000 |
| 0.62 | 65000 | | | | | | | 2.22 | 60000 | 13.91 | 60000 |
| 0.55 | 70000 | | | | | | | 1.86 | 65000 | 11.97 | 65000 |
| 0.48 | 75000 | | | | | | | 1.36 | 70000 | 9.69 | 70000 |
| 0.42 | 85000 | | | | | | | 0.64 | 75000 | 6.44 | 75000 |
| 0.35 | 95000 | | | | | | | 0.50 | 85000 | 3.25 | 85000 |
| 0.28 | 105000 | | | | | | | 0.36 | 95000 | 2.63 | 95000 |
| 0.21 | 115000 | | | | | | | | | 2.15 | 105000 |
| 0.14 | 125000 | | | | | | | | | 1.80 | 115000 |
| | | | | | | | | | | 1.11 | 125000 |
| | | | | | | | | | | 0.55 | 150000 |
| | | | | | | | | | | 0.28 | 175000 |

**Table IV-C.1.4 Annual and Monthly Flow-duration Data for 1800 cfs Maximum diversion and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1800 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 2827 | 100.00 | 4291 | | | | | | | | | | | | | | |
| 99.32 | 5250 | 98.49 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | | | | |
| 98.37 | 5750 | 96.98 | 5750 | 99.85 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 | | | | |
| 96.82 | 6250 | 94.92 | 6250 | 99.32 | 6250 | 99.93 | 6250 | 100.00 | 6250 | 100.00 | 6250 | 100.00 | 6250 | | | | |
| 95.34 | 6750 | 92.72 | 6750 | 98.80 | 6750 | 99.93 | 6750 | 100.00 | 6750 | 100.00 | 6750 | 100.00 | 6750 | | | | |
| 93.64 | 7250 | 91.21 | 7250 | 98.42 | 7250 | 99.93 | 7250 | 100.00 | 7250 | 100.00 | 7250 | 100.00 | 7250 | | | | |
| 91.75 | 7750 | 89.70 | 7750 | 97.52 | 7750 | 99.93 | 7750 | 100.00 | 7750 | 99.93 | 7750 | 99.71 | 7750 | | | | |
| 89.74 | 8250 | 88.40 | 8250 | 96.69 | 8250 | 99.72 | 8250 | 99.93 | 8250 | 99.58 | 8250 | 99.50 | 8250 | | | | |
| 87.93 | 8750 | 86.41 | 8750 | 95.63 | 8750 | 99.65 | 8750 | 99.86 | 8750 | 99.31 | 8750 | 98.28 | 8750 | | | | |
| 85.76 | 9250 | 85.11 | 9250 | 93.98 | 9250 | 99.58 | 9250 | 99.57 | 9250 | 98.75 | 9250 | 97.35 | 9250 | | | | |
| 83.86 | 9650 | 84.15 | 9650 | 93.30 | 9650 | 98.89 | 9650 | 99.28 | 9650 | 98.06 | 9650 | 96.42 | 9650 | | | | |
| 80.04 | 10000 | 83.53 | 10000 | 92.62 | 10000 | 98.62 | 10000 | 99.07 | 10000 | 97.65 | 10000 | 95.49 | 10000 | | | | |
| 77.46 | 10670 | 82.43 | 10670 | 90.36 | 10670 | 97.72 | 10670 | 98.50 | 10670 | 96.96 | 10670 | 93.42 | 10670 | | | | |
| 75.18 | 11000 | 81.74 | 11000 | 89.53 | 11000 | 97.23 | 11000 | 97.78 | 11000 | 96.61 | 11000 | 91.92 | 11000 | | | | |
| 75.02 | 11050 | 81.74 | 11050 | 89.23 | 11050 | 97.09 | 11050 | 97.64 | 11050 | 96.54 | 11050 | 91.85 | 11050 | | | | |
| 73.77 | 11350 | 81.19 | 11350 | 87.73 | 11350 | 96.47 | 11350 | 97.28 | 11350 | 96.40 | 11350 | 90.13 | 11350 | | | | |
| 68.25 | 12850 | 78.45 | 12850 | 83.43 | 12850 | 93.01 | 12850 | 95.14 | 12850 | 94.39 | 12850 | 83.33 | 12850 | | | | |
| 64.14 | 14000 | 75.63 | 14000 | 80.72 | 14000 | 89.62 | 14000 | 92.20 | 14000 | 92.39 | 14000 | 77.32 | 14000 | | | | |
| 61.15 | 15000 | 73.71 | 15000 | 78.61 | 15000 | 87.61 | 15000 | 90.27 | 15000 | 91.21 | 15000 | 73.03 | 15000 | | | | |
| 58.68 | 16000 | 71.52 | 16000 | 76.43 | 16000 | 85.88 | 16000 | 87.63 | 16000 | 89.83 | 16000 | 70.17 | 16000 | | | | |
| 56.70 | 17000 | 69.66 | 17000 | 74.47 | 17000 | 84.98 | 17000 | 85.41 | 17000 | 87.82 | 17000 | 67.74 | 17000 | | | | |
| 55.75 | 17500 | 68.70 | 17500 | 73.34 | 17500 | 83.94 | 17500 | 84.19 | 17500 | 86.99 | 17500 | 66.09 | 17500 | | | | |
| 55.62 | 17590 | 68.57 | 17590 | 73.19 | 17590 | 83.94 | 17590 | 84.05 | 17590 | 86.78 | 17590 | 66.02 | 17590 | | | | |
| 52.09 | 19610 | [illegible] | 19610 | 68.45 | 19610 | 81.87 | 19610 | 81.40 | 19610 | 82.63 | 19610 | 61.87 | 19610 | | | | |
| 49.96 | 21220 | 61.08 | 21220 | 65.96 | 21220 | 79.65 | 21220 | 79.83 | 21220 | 79.10 | 21220 | [illegible] | 21220 | | | | |
| 47.72 | 22700 | 57.72 | 22700 | [illegible] | 22700 | 77.02 | 22700 | 78.40 | 22700 | 76.06 | 22700 | 53.51 | 22700 | | | | |
| 46.12 | 24000 | 55.11 | 24000 | 60.84 | 24000 | 75.64 | 24000 | 77.61 | 24000 | 73.70 | 24000 | 51.29 | 24000 | | | | |
| 41.89 | 27610 | 48.39 | 27610 | 54.52 | 27610 | 70.10 | 27610 | 74.39 | 27610 | 69.76 | 27610 | 46.14 | 27610 | | | | |

**Table IV-C.1.4 Annual and Monthly Flow-duration Data for 1800 cfs Maximum diversion and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1800 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38.22 | 30000 | 45.16 | 30000 | 50.00 | 30000 | 65.61 | 30000 | 72.10 | 30000 | 67.61 | 30000 | 41.63 | 30000 |
| 33.98 | 32500 | 41.39 | 32500 | 46.31 | 32500 | 61.38 | 32500 | 69.17 | 32500 | 64.98 | 32500 | 36.48 | 32500 |
| 30.53 | 35000 | 38.98 | 35000 | 43.37 | 35000 | 57.44 | 35000 | 67.31 | 35000 | 63.25 | 35000 | 30.19 | 35000 |
| 28.59 | 36640 | 37.54 | 36640 | 40.81 | 36640 | 54.53 | 36640 | 65.74 | 36640 | 62.08 | 36640 | 27.11 | 36640 |
| 28.21 | 36940 | 37.34 | 36940 | 40.29 | 36940 | 54.33 | 36940 | 65.31 | 36940 | 60.62 | 36940 | 26.68 | 36940 |
| 27.62 | 37500 | 37.06 | 37500 | 39.23 | 37500 | 53.70 | 37500 | 62.95 | 37500 | 60.35 | 37500 | 25.68 | 37500 |
| 25.42 | 40000 | 34.93 | 40000 | 36.07 | 40000 | 50.59 | 40000 | 60.16 | 40000 | 56.26 | 40000 | 22.68 | 40000 |
| 23.76 | 42000 | 32.60 | 42000 | 34.49 | 42000 | 47.75 | 42000 | 58.80 | 42000 | 52.87 | 42000 | 19.67 | 42000 |
| 22.32 | 44000 | 30.40 | 44000 | 32.53 | 44000 | 46.02 | 44000 | 57.30 | 44000 | 49.41 | 44000 | 17.81 | 44000 |
| 20.78 | 46000 | 28.21 | 46000 | 30.42 | 46000 | 44.43 | 46000 | 56.01 | 46000 | 45.40 | 46000 | 15.52 | 46000 |
| 19.25 | 48000 | 25.26 | 48000 | 28.31 | 48000 | 41.25 | 48000 | 52.72 | 48000 | 43.11 | 48000 | 13.81 | 48000 |
| 17.84 | 50000 | 23.54 | 50000 | 26.20 | 50000 | 39.03 | 50000 | 50.07 | 50000 | 38.96 | 50000 | 12.30 | 50000 |
| 14.67 | 55000 | 18.87 | 55000 | 20.56 | 55000 | 32.25 | 55000 | 43.56 | 55000 | 31.76 | 55000 | 8.51 | 55000 |
| 11.99 | 60000 | 16.33 | 60000 | 16.34 | 60000 | 25.95 | 60000 | 35.84 | 60000 | 26.23 | 60000 | 6.94 | 60000 |
| 9.53 | 65000 | 13.52 | 65000 | 13.63 | 65000 | 20.07 | 65000 | 25.97 | 65000 | 21.66 | 65000 | 5.58 | 65000 |
| 7.38 | 70000 | 10.16 | 70000 | 11.37 | 70000 | 15.64 | 70000 | 18.96 | 70000 | 17.37 | 70000 | 3.93 | 70000 |
| 5.58 | 75000 | 7.28 | 75000 | 9.49 | 75000 | 11.35 | 75000 | 14.23 | 75000 | 14.26 | 75000 | 3.43 | 75000 |
| 3.42 | 85000 | 3.71 | 85000 | 6.10 | 85000 | 5.61 | 85000 | 9.51 | 85000 | 9.34 | 85000 | 3.08 | 85000 |
| 2.08 | 95000 | 2.13 | 95000 | 4.74 | 95000 | 2.15 | 95000 | 5.08 | 95000 | 5.33 | 95000 | 2.50 | 95000 |
| 1.41 | 105000 | 1.65 | 105000 | 3.31 | 105000 | 0.35 | 105000 | 4.08 | 105000 | 3.18 | 105000 | 2.22 | 105000 |
| 1.06 | 115000 | 0.69 | 115000 | 2.48 | 115000 | | | 3.65 | 115000 | 2.21 | 115000 | 1.93 | 115000 |
| 0.79 | 125000 | 0.34 | 125000 | 1.66 | 125000 | | | 3.22 | 125000 | 1.66 | 125000 | 1.57 | 125000 |
| 0.37 | 150000 | | | 0.38 | 150000 | | | 1.72 | 150000 | 0.97 | 150000 | 0.93 | 150000 |
| 0.19 | 175000 | | | | | | | 1.07 | 175000 | 0.21 | 175000 | 0.72 | 175000 |
| 0.08 | 200000 | | | | | | | 0.64 | 200000 | | | 0.36 | 200000 |
| 0.04 | 225000 | | | | | | | 0.50 | 225000 | | | | |
| 0.02 | 250000 | | | | | | | 0.29 | 250000 | | | | |

Table IV-C.1.4 Annual and Monthly Flow-duration Data for 1800 cfs Maximum diversion and Simulated White River Data (1940-1986)

[redacted]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100.00 | 4258 | 100.00 | 3205 | 100.00 | 3019 | 100.00 | 2827 | 100.00 | 4525 |
| 100.00 | 5250 | 99.93 | 5250 | 98.78 | 5250 | 98.75 | 5250 | 97.42 | 5250 | 98.41 | 5250 |
| 100.00 | 5750 | 99.86 | 5750 | 97.28 | 5750 | 96.06 | 5750 | 94.13 | 5750 | 96.40 | 5750 |
| 99.65 | 6250 | 99.52 | 6250 | 94.85 | 6250 | 90.87 | 6250 | 88.27 | 6250 | 94.60 | 6250 |
| 99.17 | 6750 | 99.03 | 6750 | 92.20 | 6750 | 86.44 | 6750 | 83.98 | 6750 | 91.97 | 6750 |
| 98.82 | 7250 | 98.55 | 7250 | 89.27 | 7250 | 80.14 | 7250 | 78.61 | 7250 | 89.00 | 7250 |
| 98.27 | 7750 | 96.96 | 7750 | 85.55 | 7750 | 72.73 | 7750 | 73.89 | 7750 | 87.13 | 7750 |
| 97.44 | 8250 | 94.53 | 8250 | 81.55 | 8250 | 67.54 | 8250 | 68.96 | 8250 | 83.60 | 8250 |
| 95.99 | 8750 | 92.66 | 8750 | 77.90 | 8750 | 61.94 | 8750 | 66.31 | 8750 | 81.80 | 8750 |
| 94.46 | 9250 | 89.97 | 9250 | 72.75 | 9250 | 56.26 | 9250 | 62.66 | 9250 | 79.17 | 9250 |
| 92.60 | 9650 | 88.99 | 9650 | 69.10 | 9650 | 51.68 | 9650 | 59.87 | 9650 | 76.89 | 9650 |
| 90.80 | 10000 | 70.87 | 10000 | 54.72 | 10000 | 46.23 | 10000 | 56.72 | 10000 | 75.78 | 10000 |
| 87.08 | 10670 | 66.57 | 10670 | 50.07 | 10670 | 40.76 | 10670 | 53.51 | 10670 | 73.84 | 10670 |
| 73.84 | 11000 | 64.43 | 11000 | 48.35 | 11000 | 37.65 | 11000 | 52.00 | 11000 | 72.73 | 11000 |
| 73.49 | 11050 | 64.29 | 11050 | 48.21 | 11050 | 37.44 | 11050 | 51.66 | 11050 | 72.66 | 11050 |
| 71.35 | 11350 | 62.84 | 11350 | 46.64 | 11350 | 35.85 | 11350 | 49.36 | 11350 | 71.63 | 11350 |
| 62.15 | 12850 | 52.66 | 12850 | 38.63 | 12850 | 29.07 | 12850 | 42.70 | 12850 | 67.68 | 12850 |
| 55.16 | 14000 | 46.30 | 14000 | 33.40 | 14000 | 24.84 | 14000 | 38.77 | 14000 | 65.33 | 14000 |
| 49.13 | 15000 | 41.73 | 15000 | 29.83 | 15000 | 22.01 | 15000 | 36.05 | 15000 | 62.77 | 15000 |
| 46.37 | 16000 | 37.23 | 16000 | 26.75 | 16000 | 20.07 | 16000 | 33.69 | 16000 | 60.62 | 16000 |
| 43.74 | 17000 | 34.26 | 17000 | 24.61 | 17000 | 18.82 | 17000 | 31.76 | 17000 | 59.17 | 17000 |
| 43.18 | 17500 | 33.15 | 17500 | 23.68 | 17500 | 18.20 | 17500 | 31.26 | 17500 | 58.20 | 17500 |
| 42.91 | 17590 | 33.08 | 17590 | 23.61 | 17590 | 17.99 | 17590 | 31.26 | 17590 | 57.99 | 17590 |
| 39.31 | 19610 | 29.07 | 19610 | 20.10 | 19610 | 15.64 | 19610 | 29.11 | 19610 | 53.15 | 19610 |
| 37.72 | 21220 | 27.34 | 21220 | 18.60 | 21220 | 14.33 | 21220 | 28.11 | 21220 | 50.52 | 21220 |
| 36.82 | 22700 | 25.81 | 22700 | 17.67 | 22700 | 12.87 | 22700 | 26.75 | 22700 | 48.44 | 22700 |
| 35.85 | 24000 | 25.05 | 24000 | 16.60 | 24000 | 12.11 | 24000 | 25.04 | 24000 | 46.30 | 24000 |
| 31.42 | 27610 | 21.38 | 27610 | 15.16 | 27610 | 10.52 | 27610 | 20.67 | 27610 | 41.87 | 27610 |

## Table IV-C.1.4 Annual and Monthly Flow-duration Data for 1800 cfs Maximum diversion and Simulated White River Data (1940-1986)

[redacted]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23.39 | 30000 | 15.02 | 30000 | 13.02 | 30000 | 9.20 | 30000 | 18.03 | 30000 | 39.24 | 30000 |
| 15.09 | 32500 | 8.44 | 32500 | 8.44 | 32500 | 6.16 | 32500 | 14.88 | 32500 | 36.33 | 32500 |
| 7.68 | 35000 | 3.94 | 35000 | 5.51 | 35000 | 3.25 | 35000 | 12.30 | 35000 | 34.26 | 35000 |
| 4.43 | 36640 | 2.28 | 36640 | 4.01 | 36640 | 1.80 | 36640 | 11.02 | 36640 | 32.87 | 36640 |
| 4.22 | 36940 | 1.87 | 36940 | 3.93 | 36940 | 1.66 | 36940 | 10.80 | 36940 | 32.66 | 36940 |
| 3.94 | 37500 | 1.66 | 37500 | 3.72 | 37500 | 1.59 | 37500 | 10.30 | 37500 | 32.18 | 37500 |
| 2.91 | 40000 | 1.18 | 40000 | 2.29 | 40000 | 1.18 | 40000 | 7.94 | 40000 | 29.55 | 40000 |
| 2.49 | 42000 | 1.11 | 42000 | 1.43 | 42000 | 1.04 | 42000 | 6.72 | 42000 | 26.78 | 42000 |
| 2.08 | 44000 | 0.90 | 44000 | 0.79 | 44000 | 0.97 | 44000 | 6.08 | 44000 | 24.15 | 44000 |
| 1.59 | 46000 | 0.69 | 46000 | 0.43 | 46000 | 0.69 | 46000 | 4.94 | 46000 | 21.66 | 46000 |
| 1.25 | 48000 | 0.55 | 48000 | | | 0.69 | 48000 | 4.51 | 48000 | 20.28 | 48000 |
| 1.04 | 50000 | 0.28 | 50000 | | | 0.55 | 50000 | 4.15 | 50000 | 18.69 | 50000 |
| 0.83 | 55000 | | | | | 0.35 | 55000 | 3.29 | 55000 | 16.61 | 55000 |
| 0.62 | 60000 | | | | | | | 2.22 | 60000 | 13.91 | 60000 |
| 0.62 | 65000 | | | | | | | 1.86 | 65000 | 11.97 | 65000 |
| 0.55 | 70000 | | | | | | | 1.36 | 70000 | 9.69 | 70000 |
| 0.48 | 75000 | | | | | | | 0.64 | 75000 | 6.44 | 75000 |
| 0.42 | 85000 | | | | | | | 0.50 | 85000 | 3.25 | 85000 |
| 0.35 | 95000 | | | | | | | 0.36 | 95000 | 2.63 | 95000 |
| 0.28 | 105000 | | | | | | | | | 2.15 | 105000 |
| 0.21 | 115000 | | | | | | | | | 1.80 | 115000 |
| 0.14 | 125000 | | | | | | | | | 1.11 | 125000 |
| | | | | | | | | | | 0.55 | 150000 |
| | | | | | | | | | | 0.28 | 175000 |

### Table IV-C.1.5 Annual and Monthly Flow-Duration Data for 1960 cfs Maximum Diversion and Simulated White River Data (1940-1986)

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1960 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 2827 | 100.00 | 4291 | | | | | | | | | | |
| 99.32 | 5250 | 98.49 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 |
| 98.37 | 5750 | 96.98 | 5750 | 99.85 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 |
| 96.82 | 6250 | 94.92 | 6250 | 99.32 | 6250 | 99.93 | 6250 | 100.00 | 6250 | 100.00 | 6250 | 100.00 | 6250 |
| 95.34 | 6750 | 92.72 | 6750 | 98.80 | 6750 | 99.93 | 6750 | 100.00 | 6750 | 100.00 | 6750 | 100.00 | 6750 |
| 93.64 | 7250 | 91.21 | 7250 | 98.42 | 7250 | 99.93 | 7250 | 100.00 | 7250 | 100.00 | 7250 | 100.00 | 7250 |
| 91.75 | 7750 | 89.70 | 7750 | 97.52 | 7750 | 99.93 | 7750 | 100.00 | 7750 | 99.93 | 7750 | 99.71 | 7750 |
| 89.74 | 8250 | 88.40 | 8250 | 96.69 | 8250 | 99.72 | 8250 | 99.93 | 8250 | 99.58 | 8250 | 99.50 | 8250 |
| 87.93 | 8750 | 86.41 | 8750 | 95.63 | 8750 | 99.65 | 8750 | 99.86 | 8750 | 99.31 | 8750 | 98.28 | 8750 |
| 85.76 | 9250 | 85.11 | 9250 | 93.98 | 9250 | 99.58 | 9250 | 99.57 | 9250 | 98.75 | 9250 | 97.35 | 9250 |
| 83.86 | 9650 | 84.15 | 9650 | 93.30 | 9650 | 98.89 | 9650 | 99.28 | 9650 | 98.06 | 9650 | 96.42 | 9650 |
| 79.99 | 10000 | 83.53 | 10000 | 92.62 | 10000 | 98.62 | 10000 | 99.07 | 10000 | 97.65 | 10000 | 95.49 | 10000 |
| 77.39 | 10670 | 82.43 | 10670 | 90.36 | 10670 | 97.72 | 10670 | 98.50 | 10670 | 96.96 | 10670 | 93.42 | 10670 |
| 75.07 | 11000 | 81.74 | 11000 | 89.53 | 11000 | 97.23 | 11000 | 97.78 | 11000 | 96.61 | 11000 | 91.92 | 11000 |
| 74.90 | 11050 | 81.74 | 11050 | 89.23 | 11050 | 97.09 | 11050 | 97.64 | 11050 | 96.54 | 11050 | 91.85 | 11050 |
| 73.63 | 11350 | 81.19 | 11350 | 87.73 | 11350 | 96.47 | 11350 | 97.28 | 11350 | 96.40 | 11350 | 90.13 | 11350 |
| 68.10 | 12850 | 78.45 | 12850 | 83.43 | 12850 | 93.01 | 12850 | 95.14 | 12850 | 94.39 | 12850 | 83.33 | 12850 |
| 64.06 | 14000 | 75.63 | 14000 | 80.72 | 14000 | 89.62 | 14000 | 92.20 | 14000 | 92.39 | 14000 | 77.32 | 14000 |
| 61.03 | 15000 | 73.71 | 15000 | 78.61 | 15000 | 87.61 | 15000 | 90.27 | 15000 | 91.21 | 15000 | 73.03 | 15000 |
| 58.60 | 16000 | 71.52 | 16000 | 76.43 | 16000 | 85.88 | 16000 | 87.63 | 16000 | 89.83 | 16000 | 70.17 | 16000 |
| 56.67 | 17000 | 69.66 | 17000 | 74.47 | 17000 | 84.98 | 17000 | 85.41 | 17000 | 87.82 | 17000 | 67.67 | 17000 |
| 55.72 | 17500 | 68.70 | 17500 | 73.34 | 17500 | 83.94 | 17500 | 84.19 | 17500 | 86.99 | 17500 | 66.09 | 17500 |
| 55.58 | 17590 | 68.57 | 17590 | 73.19 | 17590 | 83.94 | 17590 | 84.05 | 17590 | 86.78 | 17590 | 65.95 | 17590 |
| 52.04 | 19610 | 64.31 | 19610 | 68.45 | 19610 | 81.87 | 19610 | 81.40 | 19610 | 82.63 | 19610 | 61.87 | 19610 |
| 49.94 | 21220 | 61.08 | 21220 | 65.96 | 21220 | 79.65 | 21220 | 79.83 | 21220 | 79.10 | 21220 | [illegible] | 21220 |
| 47.70 | 22700 | 57.72 | 22700 | [illegible] | 22700 | 77.02 | 22700 | 78.40 | 22700 | 76.06 | 22700 | 53.29 | 22700 |
| 46.10 | 24000 | 55.11 | 24000 | 60.84 | 24000 | 75.64 | 24000 | 77.61 | 24000 | 73.70 | 24000 | 51.14 | 24000 |
| 41.86 | 27610 | 48.39 | 27610 | 54.52 | 27610 | 70.10 | 27610 | 74.39 | 27610 | 69.76 | 27610 | 45.92 | 27610 |

## Table IV-C.1.5 Annual and Monthly Flow-Duration Data for 19[illegible]fs Maximum Diversion and Simulated White River Data (1940-1986)

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR With 1960 cfs Pumpstation Conditions (1940-1986 Simulated Hydrology with Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

[redacted]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38.18 | 30000 | 45.16 | 30000 | 50.00 | 30000 | 65.19 | 30000 | 72.10 | 30000 | 67.61 | 30000 | 41.49 | 30000 |
| 33.95 | 32500 | 41.39 | 32500 | 46.31 | 32500 | 61.18 | 32500 | 69.17 | 32500 | 64.98 | 32500 | 36.55 | 32500 |
| 30.46 | 35000 | 38.98 | 35000 | 43.37 | 35000 | 57.09 | 35000 | 67.31 | 35000 | 63.25 | 35000 | 30.04 | 35000 |
| 28.57 | 36640 | 37.54 | 36640 | 40.81 | 36640 | 54.46 | 36640 | 65.74 | 36640 | 62.08 | 36640 | 27.18 | 36640 |
| 28.16 | 36940 | 37.34 | 36940 | 40.29 | 36940 | 54.12 | 36940 | 65.31 | 36940 | 60.48 | 36940 | 26.47 | 36940 |
| 27.56 | 37500 | 37.06 | 37500 | 39.23 | 37500 | 53.49 | 37500 | 62.88 | 37500 | 60.07 | 37500 | 25.68 | 37500 |
| 25.36 | 40000 | 34.93 | 40000 | 36.07 | 40000 | 50.31 | 40000 | 60.09 | 40000 | 56.26 | 40000 | 22.39 | 40000 |
| 23.71 | 42000 | 32.60 | 42000 | 34.49 | 42000 | 47.54 | 42000 | 58.58 | 42000 | 52.73 | 42000 | 19.67 | 42000 |
| 22.26 | 44000 | 30.40 | 44000 | 32.53 | 44000 | 45.95 | 44000 | 57.22 | 44000 | 49.00 | 44000 | 17.67 | 44000 |
| 20.73 | 46000 | 28.21 | 46000 | 30.42 | 46000 | 44.08 | 46000 | 55.94 | 46000 | 45.33 | 46000 | 15.38 | 46000 |
| 19.21 | 48000 | 25.26 | 48000 | 28.31 | 48000 | 41.11 | 48000 | 52.43 | 48000 | 43.18 | 48000 | 13.66 | 48000 |
| 17.83 | 50000 | 23.54 | 50000 | 26.20 | 50000 | 38.82 | 50000 | 50.07 | 50000 | 38.96 | 50000 | 12.30 | 50000 |
| 14.59 | 55000 | 18.87 | 55000 | 20.56 | 55000 | 31.76 | 55000 | 43.28 | 55000 | 31.70 | 55000 | 8.37 | 55000 |
| 11.95 | 60000 | 16.33 | 60000 | 16.34 | 60000 | 25.88 | 60000 | 35.55 | 60000 | 26.09 | 60000 | 7.01 | 60000 |
| 9.48 | 65000 | 13.52 | 65000 | 13.63 | 65000 | 19.72 | 65000 | 25.89 | 65000 | 21.45 | 65000 | 5.58 | 65000 |
| 7.36 | 70000 | 10.16 | 70000 | 11.37 | 70000 | 15.57 | 70000 | 18.67 | 70000 | 17.51 | 70000 | 3.93 | 70000 |
| 5.54 | 75000 | 7.28 | 75000 | 9.49 | 75000 | 11.07 | 75000 | 14.09 | 75000 | 14.19 | 75000 | 3.43 | 75000 |
| 3.43 | 85000 | 3.71 | 85000 | 6.10 | 85000 | 5.54 | 85000 | 9.44 | 85000 | 9.62 | 85000 | 3.08 | 85000 |
| 2.06 | 95000 | 2.13 | 95000 | 4.74 | 95000 | 2.08 | 95000 | 5.01 | 95000 | 5.33 | 95000 | 2.50 | 95000 |
| 1.42 | 105000 | 1.65 | 105000 | 3.31 | 105000 | 0.35 | 105000 | 4.08 | 105000 | 3.32 | 105000 | 2.22 | 105000 |
| 1.06 | 115000 | 0.69 | 115000 | 2.48 | 115000 | | | 3.65 | 115000 | 2.21 | 115000 | 1.93 | 115000 |
| 0.80 | 125000 | 0.34 | 125000 | 1.66 | 125000 | | | 3.22 | 125000 | 1.66 | 125000 | 1.65 | 125000 |
| 0.37 | 150000 | | | 0.38 | 150000 | | | 1.72 | 150000 | 0.97 | 150000 | 0.93 | 150000 |
| 0.17 | 175000 | | | | | | | 1.07 | 175000 | 0.07 | 175000 | 0.72 | 175000 |
| 0.08 | 200000 | | | | | | | 0.64 | 200000 | | | 0.36 | 200000 |
| 0.04 | 225000 | | | | | | | 0.50 | 225000 | | | | |
| 0.02 | 250000 | | | | | | | 0.29 | 250000 | | | | |

Table IV-C.1.5 Annual and Monthly Flow-Duration Data for 1960 cfs Maximum Diversion and Simulated White River Data (1940-1986)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 100.00 | 4258 | 100.00 | 3205 | 100.00 | 3019 | 100.00 | 2827 | 100.00 | 4525 |
| 100.00 | 5250 | 99.93 | 5250 | 98.78 | 5250 | 98.75 | 5250 | 97.42 | 5250 | 98.41 | 5250 |
| 100.00 | 5750 | 99.86 | 5750 | 97.28 | 5750 | 96.06 | 5750 | 94.13 | 5750 | 96.40 | 5750 |
| 99.65 | 6250 | 99.52 | 6250 | 94.85 | 6250 | 90.87 | 6250 | 88.27 | 6250 | 94.60 | 6250 |
| 99.17 | 6750 | 99.03 | 6750 | 92.20 | 6750 | 86.44 | 6750 | 83.98 | 6750 | 91.97 | 6750 |
| 98.82 | 7250 | 98.55 | 7250 | 89.27 | 7250 | 80.14 | 7250 | 78.61 | 7250 | 89.00 | 7250 |
| 98.27 | 7750 | 96.96 | 7750 | 85.55 | 7750 | 72.73 | 7750 | 73.89 | 7750 | 87.13 | 7750 |
| 97.44 | 8250 | 94.53 | 8250 | 81.55 | 8250 | 67.54 | 8250 | 68.96 | 8250 | 83.60 | 8250 |
| 95.99 | 8750 | 92.66 | 8750 | 77.90 | 8750 | 61.94 | 8750 | 66.31 | 8750 | 81.80 | 8750 |
| 94.46 | 9250 | 89.97 | 9250 | 72.75 | 9250 | 56.26 | 9250 | 62.66 | 9250 | 79.17 | 9250 |
| 92.60 | 9650 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 59.87 | 9650 | 76.89 | 9650 |
| 90.80 | 10000 | 70.03 | 10000 | 55.01 | 10000 | 46.30 | 10000 | 56.72 | 10000 | 75.78 | 10000 |
| [illegible] | [illegible] | 65.54 | 10670 | 50.43 | 10670 | 40.76 | 10670 | 53.51 | 10670 | 73.84 | 10670 |
| 72.60 | 11000 | 64.08 | 11000 | 48.71 | 11000 | 37.72 | 11000 | 52.00 | 11000 | 72.73 | 11000 |
| 72.25 | 11050 | 63.94 | 11050 | 48.43 | 11050 | 37.51 | 11050 | [illegible] | [illegible] | 72.66 | 11050 |
| 70.45 | 11350 | 61.38 | 11350 | 47.07 | 11350 | 36.12 | 11350 | 49.36 | 11350 | 71.63 | 11350 |
| 61.31 | 12850 | 51.63 | 12850 | 38.70 | 12850 | 29.20 | 12850 | 42.70 | 12850 | 67.68 | 12850 |
| 54.46 | 14000 | 46.09 | 14000 | 33.48 | 14000 | 24.71 | 14000 | 38.77 | 14000 | 65.33 | 14000 |
| 48.79 | 15000 | 40.83 | 15000 | 29.69 | 15000 | 21.87 | 15000 | 36.05 | 15000 | 62.77 | 15000 |
| 46.02 | 16000 | 36.82 | 16000 | 26.68 | 16000 | 20.00 | 16000 | 33.69 | 16000 | 60.62 | 16000 |
| 43.53 | 17000 | 34.19 | 17000 | 24.61 | 17000 | 18.75 | 17000 | 31.76 | 17000 | 59.17 | 17000 |
| 42.84 | 17500 | 33.08 | 17500 | 23.75 | 17500 | 18.20 | 17500 | 31.26 | 17500 | 58.20 | 17500 |
| 42.77 | 17590 | 32.80 | 17590 | 23.53 | 17590 | 17.99 | 17590 | 31.26 | 17590 | [illegible] | [illegible] |
| 38.82 | 19610 | 29.07 | 19610 | 20.10 | 19610 | 15.57 | 19610 | 29.11 | 19610 | 53.15 | 19610 |
| 37.58 | 21220 | 27.34 | 21220 | 18.45 | 21220 | 14.39 | 21220 | 28.11 | 21220 | 50.52 | 21220 |
| 36.82 | 22700 | 25.88 | 22700 | 17.53 | 22700 | 12.87 | 22700 | 26.75 | 22700 | 48.44 | 22700 |
| 35.78 | 24000 | 24.91 | 24000 | 16.67 | 24000 | 12.11 | 24000 | 25.04 | 24000 | 46.30 | 24000 |
| 31.21 | 27610 | 21.38 | 27610 | 15.16 | 27610 | 10.52 | 27610 | 20.67 | 27610 | 41.87 | 27610 |

Table IV-C.1.5 Annual and Monthly Flow-Duration Data for 1960 cfs Maximum Diversion and Simulated White River Data (1940-1986)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23.04 | 30000 | 15.09 | 30000 | 13.30 | 30000 | 9.27 | 30000 | 18.03 | 30000 | 39.24 | 30000 |
| 14.33 | 32500 | 8.30 | 32500 | 9.08 | 32500 | 6.16 | 32500 | 14.88 | 32500 | 36.33 | 32500 |
| 7.54 | 35000 | 3.67 | 35000 | 5.65 | 35000 | 3.25 | 35000 | 12.30 | 35000 | 34.26 | 35000 |
| 4.29 | 36640 | 2.21 | 36640 | 4.01 | 36640 | 1.80 | 36640 | 11.02 | 36640 | 32.87 | 36640 |
| 4.22 | 36940 | 1.80 | 36940 | 3.93 | 36940 | 1.66 | 36940 | 10.80 | 36940 | 32.66 | 36940 |
| 3.81 | 37500 | 1.66 | 37500 | 3.72 | 37500 | 1.59 | 37500 | 10.30 | 37500 | 32.18 | 37500 |
| 2.91 | 40000 | 1.18 | 40000 | 2.29 | 40000 | 1.18 | 40000 | 7.94 | 40000 | 29.55 | 40000 |
| 2.42 | 42000 | 1.11 | 42000 | 1.43 | 42000 | 1.04 | 42000 | 6.72 | 42000 | 26.78 | 42000 |
| 2.01 | 44000 | 0.90 | 44000 | 0.79 | 44000 | 0.97 | 44000 | 6.08 | 44000 | 24.15 | 44000 |
| 1.59 | 46000 | 0.69 | 46000 | 0.43 | 46000 | 0.69 | 46000 | 4.94 | 46000 | 21.66 | 46000 |
| 1.18 | 48000 | 0.55 | 48000 | | | 0.69 | 48000 | 4.51 | 48000 | 20.28 | 48000 |
| 1.04 | 50000 | 0.28 | 50000 | | | 0.55 | 50000 | 4.15 | 50000 | 18.69 | 50000 |
| 0.83 | 55000 | | | | | 0.35 | 55000 | 3.29 | 55000 | 16.61 | 55000 |
| 0.62 | 60000 | | | | | | | 2.22 | 60000 | 13.91 | 60000 |
| 0.62 | 65000 | | | | | | | 1.86 | 65000 | 11.97 | 65000 |
| 0.55 | 70000 | | | | | | | 1.36 | 70000 | 9.69 | 70000 |
| 0.48 | 75000 | | | | | | | 0.64 | 75000 | 6.44 | 75000 |
| 0.42 | 85000 | | | | | | | 0.50 | 85000 | 3.25 | 85000 |
| 0.35 | 95000 | | | | | | | 0.36 | 95000 | 2.63 | 95000 |
| 0.28 | 105000 | | | | | | | | | 2.15 | 105000 |
| 0.21 | 115000 | | | | | | | | | 1.80 | 115000 |
| 0.14 | 125000 | | | | | | | | | 1.11 | 125000 |
| | | | | | | | | | | 0.55 | 150000 |
| | | | | | | | | | | 0.28 | 175000 |

**Table IV-C.1.6 Annual and Monthly Flow-duration Data for No Diversions and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR Baseline Conditions (1940-1986 Simulated Hydrology with No Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

[redacted]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 2827 | 100.00 | 4291 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 | 100.00 | 5250 |
| 99.32 | 5250 | 98.49 | 5250 | 99.85 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 | 100.00 | 5750 |
| 98.37 | 5750 | 96.98 | 5750 | 99.32 | 6250 | 99.93 | 6250 | 100.00 | 6250 | 100.00 | 6250 | 100.00 | 6250 |
| 96.82 | 6250 | 94.92 | 6250 | 98.78 | 6750 | 99.93 | 6750 | 100.00 | 6750 | 100.00 | 6750 | 100.00 | 6750 |
| 95.34 | 6750 | 92.72 | 6750 | 98.40 | 7250 | 99.93 | 7250 | 100.00 | 7250 | 100.00 | 7250 | 100.00 | 7250 |
| 93.64 | 7250 | 91.21 | 7250 | 97.49 | 7750 | 99.93 | 7750 | 100.00 | 7750 | 99.93 | 7750 | 99.71 | 7750 |
| 91.75 | 7750 | 89.70 | 7750 | 96.66 | 8250 | 99.72 | 8250 | 99.93 | 8250 | 99.58 | 8250 | 99.50 | 8250 |
| 89.74 | 8250 | 88.40 | 8250 | 95.59 | 8750 | 99.65 | 8750 | 99.86 | 8750 | 99.31 | 8750 | 98.28 | 8750 |
| 87.93 | 8750 | 86.41 | 8750 | 93.92 | 9250 | 99.58 | 9250 | 99.57 | 9250 | 98.75 | 9250 | 97.35 | 9250 |
| 85.76 | 9250 | 85.11 | 9250 | 93.24 | 9650 | 98.89 | 9650 | 99.28 | 9650 | 98.06 | 9650 | 96.42 | 9650 |
| 83.86 | 9650 | 84.15 | 9650 | 92.55 | 10000 | 98.62 | 10000 | 99.07 | 10000 | 97.65 | 10000 | 95.49 | 10000 |
| 82.40 | 10000 | 83.53 | 10000 | 90.43 | 10670 | 97.72 | 10670 | 98.50 | 10670 | 96.96 | 10670 | 93.42 | 10670 |
| 79.76 | 10670 | 82.43 | 10670 | 89.59 | 11000 | 97.23 | 11000 | 97.78 | 11000 | 96.61 | 11000 | 92.13 | 11000 |
| 78.30 | 11000 | 81.74 | 11000 | 89.29 | 11050 | 97.09 | 11050 | 97.64 | 11050 | 96.54 | 11050 | 92.06 | 11050 |
| 78.08 | 11050 | 81.74 | 11050 | 87.77 | 11350 | 96.47 | 11350 | 97.28 | 11350 | 96.40 | 11350 | 90.34 | 11350 |
| 76.76 | 11350 | 81.19 | 11350 | 83.43 | 12850 | 93.01 | 12850 | 95.14 | 12850 | 94.39 | 12850 | 83.40 | 12850 |
| 70.81 | 12850 | 78.45 | 12850 | 80.70 | 14000 | 89.62 | 14000 | 92.20 | 14000 | 92.39 | 14000 | 77.40 | 14000 |
| 66.42 | 14000 | 75.63 | 14000 | 78.57 | 15000 | 87.61 | 15000 | 90.27 | 15000 | 91.21 | 15000 | 73.25 | 15000 |
| 63.15 | 15000 | 73.71 | 15000 | 76.37 | 16000 | 85.88 | 16000 | 87.63 | 16000 | 89.83 | 16000 | 70.39 | 16000 |
| 60.30 | 16000 | 71.52 | 16000 | 74.47 | 17000 | 84.98 | 17000 | 85.41 | 17000 | 87.82 | 17000 | 67.88 | 17000 |
| 57.82 | 17000 | 69.66 | 17000 | 73.33 | 17500 | 83.94 | 17500 | 84.19 | 17500 | 86.99 | 17500 | 66.31 | 17500 |
| 56.69 | 17500 | 68.70 | 17500 | 73.18 | 17590 | 83.94 | 17590 | 84.05 | 17590 | 86.78 | 17590 | 66.24 | 17590 |
| 56.54 | 17590 | 68.57 | 17590 | 68.47 | 19610 | 81.87 | 19610 | 81.40 | 19610 | 82.63 | 19610 | 61.95 | 19610 |
| 52.70 | 19610 | 64.31 | 19610 | 65.96 | 21220 | 79.65 | 21220 | 79.83 | 21220 | 79.10 | 21220 | [illegible] | 21220 |
| 50.29 | 21220 | 61.15 | 21220 | [illegible] | 22700 | 77.02 | 22700 | 78.40 | 22700 | 76.06 | 22700 | 56.58 | 22700 |
| 48.24 | 22700 | 57.79 | 22700 | 60.79 | 24000 | 75.64 | 24000 | 77.61 | 24000 | 73.70 | 24000 | 54.36 | 24000 |
| 46.62 | 24000 | 55.11 | 24000 | 54.41 | 27610 | [illegible] | 27610 | 74.39 | 27610 | 69.83 | 27610 | 48.21 | 27610 |
| 42.45 | 27610 | 48.39 | 27610 | 50.00 | 30000 | 67.06 | 30000 | 72.10 | 30000 | 67.61 | 30000 | 45.14 | 30000 |
| 39.71 | 30000 | 45.16 | 30000 | 46.43 | 32500 | 63.04 | 32500 | 69.17 | 32500 | 65.05 | 32500 | 40.06 | 32500 |

**Table IV-C.1.6 Annual and Monthly Flow-duration Data for No Diversions and Simulated White River Data (1940-1986)**

Eastern Arkansas - Grand Prairie Area Demonstration Project
White River @ Clarendon, AR Baseline Conditions (1940-1986 Simulated Hydrology with No Diversions)
DURATION CURVE (All Discharges are in cfs) (Arkansas State Water Plan Values Highlighted in Red)

[redacted]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35.45 | 32500 | 41.39 | 32500 | 43.39 | 35000 | 58.96 | 35000 | 67.31 | 35000 | 63.39 | 35000 | 34.48 | 35000 |
| 31.62 | 35000 | 39.05 | 35000 | 40.88 | 36640 | 56.06 | 36640 | 65.74 | 36640 | 62.06 | 36640 | 30.11 | 36640 |
| 29.37 | 36640 | 37.54 | 36640 | 40.35 | 36940 | 55.57 | 36940 | 65.31 | 36940 | 61.73 | 36940 | 29.33 | 36940 |
| 29.02 | 36940 | 37.34 | 36940 | 39.29 | 37500 | 54.67 | 37500 | 64.66 | 37500 | 61.31 | 37500 | 28.54 | 37500 |
| 28.43 | 37500 | 37.06 | 37500 | 36.09 | 40000 | 52.18 | 40000 | 62.52 | 40000 | 59.31 | 40000 | 24.39 | 40000 |
| 26.21 | 40000 | 35.00 | 40000 | 34.50 | 42000 | 49.13 | 42000 | 60.01 | 42000 | 56.06 | 42000 | 22.25 | 42000 |
| 24.50 | 42000 | 32.74 | 42000 | 32.52 | 44000 | 46.71 | 44000 | 58.51 | 44000 | 52.60 | 44000 | 19.60 | 44000 |
| 22.93 | 44000 | 30.47 | 44000 | 30.47 | 46000 | 45.33 | 46000 | 57.22 | 46000 | 49.00 | 46000 | 17.31 | 46000 |
| 21.45 | 46000 | 28.21 | 46000 | 28.42 | 48000 | 42.70 | 48000 | 55.94 | 48000 | 45.19 | 48000 | 15.16 | 48000 |
| 19.97 | 48000 | 25.33 | 48000 | 26.37 | 50000 | 40.21 | 50000 | 52.43 | 50000 | 42.91 | 50000 | 13.45 | 50000 |
| 18.58 | 50000 | 23.54 | 50000 | 20.74 | 55000 | 33.77 | 55000 | 45.64 | 55000 | 34.67 | 55000 | 9.30 | 55000 |
| 15.30 | 55000 | 18.87 | 55000 | 16.49 | 60000 | 27.20 | 60000 | 39.70 | 60000 | 27.68 | 60000 | 7.51 | 60000 |
| 12.60 | 60000 | 16.33 | 60000 | 13.68 | 65000 | 21.25 | 65000 | 30.11 | 65000 | 23.46 | 65000 | 6.01 | 65000 |
| 10.15 | 65000 | 13.52 | 65000 | 11.47 | 70000 | 16.33 | 70000 | 21.24 | 70000 | 18.82 | 70000 | 4.72 | 70000 |
| 7.82 | 70000 | 10.16 | 70000 | 9.50 | 75000 | 12.60 | 75000 | 15.81 | 75000 | 15.02 | 75000 | 3.51 | 75000 |
| 5.90 | 75000 | 7.28 | 75000 | 6.16 | 85000 | 6.16 | 85000 | 10.30 | 85000 | 10.17 | 85000 | 3.08 | 85000 |
| 3.60 | 85000 | 3.71 | 85000 | 4.79 | 95000 | 2.42 | 95000 | 5.72 | 95000 | 6.23 | 95000 | 2.65 | 95000 |
| 2.24 | 95000 | 2.13 | 95000 | 3.34 | 105000 | 0.35 | 105000 | 4.22 | 105000 | 3.60 | 105000 | 2.29 | 105000 |
| 1.46 | 105000 | 1.65 | 105000 | 2.51 | 115000 | | | 3.93 | 115000 | 2.35 | 115000 | 1.93 | 115000 |
| 1.10 | 115000 | 0.69 | 115000 | 1.67 | 125000 | | | 3.29 | 125000 | 1.80 | 125000 | 1.86 | 125000 |
| 0.83 | 125000 | 0.34 | 125000 | 0.38 | 150000 | | | 1.72 | 150000 | 1.04 | 150000 | 0.93 | 150000 |
| 0.38 | 150000 | | | | | | | 1.07 | 175000 | 0.21 | 175000 | 0.72 | 175000 |
| 0.19 | 175000 | | | | | | | 0.64 | 200000 | | | 0.43 | 200000 |
| 0.09 | 200000 | | | | | | | 0.50 | 225000 | | | | |
| 0.04 | 225000 | | | | | | | 0.36 | 250000 | | | | |
| 0.03 | 250000 | | | | | | | 0.07 | 275000 | | | | |
| 0.01 | 275000 | | | | | | | | | | | | |

**Table IV-C.1.6 Annual and Monthly Flow-duration Data for No Diversions and Simulated White River Data (1940-1986)**

[redacted]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100.00 | 5250 | 100.00 | 4258 | 100.00 | 3205 | 100.00 | 3019 | 100.00 | 2827 | 100.00 | 4525 |
| 100.00 | 5750 | 99.93 | 5250 | 98.78 | 5250 | 98.75 | 5250 | 97.42 | 5250 | 98.41 | 5250 |
| 99.65 | 6250 | 99.86 | 5750 | 97.28 | 5750 | 96.06 | 5750 | 94.13 | 5750 | 96.40 | 5750 |
| 99.17 | 6750 | 99.52 | 6250 | 94.85 | 6250 | 90.87 | 6250 | 88.27 | 6250 | 94.60 | 6250 |
| 98.82 | 7250 | 99.03 | 6750 | 92.20 | 6750 | 86.44 | 6750 | 83.98 | 6750 | 91.97 | 6750 |
| 98.27 | 7750 | 98.55 | 7250 | 89.27 | 7250 | 80.14 | 7250 | 78.61 | 7250 | 89.00 | 7250 |
| 97.44 | 8250 | 96.96 | 7750 | 85.55 | 7750 | 72.73 | 7750 | 73.89 | 7750 | 87.13 | 7750 |
| 95.99 | 8750 | 94.53 | 8250 | 81.55 | 8250 | 67.54 | 8250 | 68.96 | 8250 | 83.60 | 8250 |
| 94.46 | 9250 | 92.66 | 8750 | 77.90 | 8750 | 61.94 | 8750 | 66.31 | 8750 | 81.80 | 8750 |
| 92.60 | 9650 | 89.97 | 9250 | 72.75 | 9250 | 56.26 | 9250 | 62.66 | 9250 | 79.17 | 9250 |
| 90.80 | 10000 | **86.99** | **9650** | **69.10** | **9650** | **51.56** | **9650** | 59.87 | 9650 | 76.89 | 9650 |
| **87.06** | **10670** | 84.71 | 10000 | 66.45 | 10000 | 48.30 | 10000 | 56.72 | 10000 | 75.78 | 10000 |
| 85.05 | 11000 | 80.62 | 10670 | 60.87 | 10670 | 42.63 | 10670 | 53.51 | 10670 | 73.84 | 10670 |
| 84.78 | 11050 | 77.44 | 11000 | 58.66 | 11000 | 39.58 | 11000 | 52.00 | 11000 | 72.73 | 11000 |
| 82.91 | 11350 | 77.16 | 11050 | 57.94 | 11050 | 39.31 | 11050 | **51.65** | **11050** | 72.66 | 11050 |
| 73.49 | 12850 | 74.95 | 11350 | 55.72 | 11350 | 37.65 | 11350 | 49.64 | 11350 | 71.63 | 11350 |
| 66.92 | 14000 | 64.29 | 12850 | 44.49 | 12850 | 30.03 | 12850 | 42.99 | 12850 | 67.68 | 12850 |
| 59.79 | 15000 | 55.78 | 14000 | 38.13 | 14000 | 25.61 | 14000 | 38.77 | 14000 | 65.33 | 14000 |
| 54.12 | 16000 | 49.76 | 15000 | 33.69 | 15000 | 22.70 | 15000 | 36.05 | 15000 | 62.77 | 15000 |
| 48.65 | 17000 | 45.05 | 16000 | 29.61 | 16000 | 20.69 | 16000 | 33.69 | 16000 | 60.62 | 16000 |
| 46.85 | 17500 | 39.79 | 17000 | 27.04 | 17000 | 19.17 | 17000 | 31.76 | 17000 | 59.17 | 17000 |
| 46.85 | 17590 | 38.06 | 17500 | 25.89 | 17500 | 18.48 | 17500 | 31.26 | 17500 | 58.20 | 17500 |
| 42.77 | 19610 | 37.58 | 17590 | 25.68 | 17590 | 18.27 | 17590 | 31.26 | 17590 | **57.99** | **17590** |
| 39.38 | 21220 | 31.63 | 19610 | 20.96 | 19610 | 15.85 | 19610 | 29.11 | 19610 | 53.15 | 19610 |
| 37.92 | 22700 | 29.00 | 21220 | 18.81 | 21220 | 14.46 | 21220 | 28.11 | 21220 | 50.52 | 21220 |
| 37.09 | 24000 | 27.34 | 22700 | 17.88 | 22700 | 12.94 | 22700 | 26.82 | 22700 | 48.44 | 22700 |
| 34.12 | 27610 | 26.09 | 24000 | 17.10 | 24000 | 12.11 | 24000 | 25.18 | 24000 | 46.30 | 24000 |
| 29.55 | 30000 | 22.98 | 27610 | 15.24 | 27610 | 10.59 | 27610 | 20.74 | 27610 | 41.87 | 27610 |
| 21.73 | 32500 | 20.07 | 30000 | 14.59 | 30000 | 9.27 | 30000 | 18.17 | 30000 | 39.24 | 30000 |

(3)

Table IV-C.1.6 Annual and Monthly Flow-duration Data for No Diversions and Simulated White River Data (1940-1986)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.53 | 35000 | 12.73 | 32500 | 9.59 | 32500 | 6.16 | 32500 | 14.95 | 32500 | 36.33 | 32500 |
| 7.75 | 36640 | 5.67 | 35000 | 5.87 | 35000 | 3.25 | 35000 | 12.52 | 35000 | 34.26 | 35000 |
| 7.20 | 36940 | 3.74 | 36640 | 4.01 | 36640 | 1.80 | 36640 | 11.09 | 36640 | 32.87 | 36640 |
| 5.88 | 37500 | 3.46 | 36940 | 3.93 | 36940 | 1.66 | 36940 | 10.87 | 36940 | 32.66 | 36940 |
| 3.60 | 40000 | 2.98 | 37500 | 3.72 | 37500 | 1.59 | 37500 | 10.37 | 37500 | 32.18 | 37500 |
| 2.91 | 42000 | 1.25 | 40000 | 2.29 | 40000 | 1.18 | 40000 | 7.94 | 40000 | 29.55 | 40000 |
| 2.42 | 44000 | 1.11 | 42000 | 1.43 | 42000 | 1.04 | 42000 | 6.72 | 42000 | 26.78 | 42000 |
| 1.94 | 46000 | 0.90 | 44000 | 0.79 | 44000 | 0.97 | 44000 | 6.08 | 44000 | 24.15 | 44000 |
| 1.52 | 48000 | 0.69 | 46000 | 0.43 | 46000 | 0.69 | 46000 | 4.94 | 46000 | 21.66 | 46000 |
| 1.18 | 50000 | 0.55 | 48000 | | | 0.69 | 48000 | 4.51 | 48000 | 20.28 | 48000 |
| 0.97 | 55000 | 0.28 | 50000 | | | 0.55 | 50000 | 4.15 | 50000 | 18.69 | 50000 |
| 0.69 | 60000 | | | | | 0.35 | 55000 | 3.29 | 55000 | 16.61 | 55000 |
| 0.62 | 65000 | | | | | | | 2.29 | 60000 | 13.91 | 60000 |
| 0.55 | 70000 | | | | | | | 1.86 | 65000 | 11.97 | 65000 |
| 0.55 | 75000 | | | | | | | 1.36 | 70000 | 9.69 | 70000 |
| 0.42 | 85000 | | | | | | | 0.64 | 75000 | 6.44 | 75000 |
| 0.35 | 95000 | | | | | | | 0.50 | 85000 | 3.25 | 85000 |
| 0.28 | 105000 | | | | | | | 0.36 | 95000 | 2.63 | 95000 |
| 0.21 | 115000 | | | | | | | | | 2.15 | 105000 |
| 0.14 | 125000 | | | | | | | | | 1.80 | 115000 |
| | | | | | | | | | | 1.11 | 125000 |
| | | | | | | | | | | 0.55 | 150000 |
| | | | | | | | | | | 0.28 | 175000 |

**Figure IV-C.1.1 Annual and Monthly Flow-Duration Curves for 1480 cfs Maximum Diversion and Synthetic White River Data (1940-1986)**

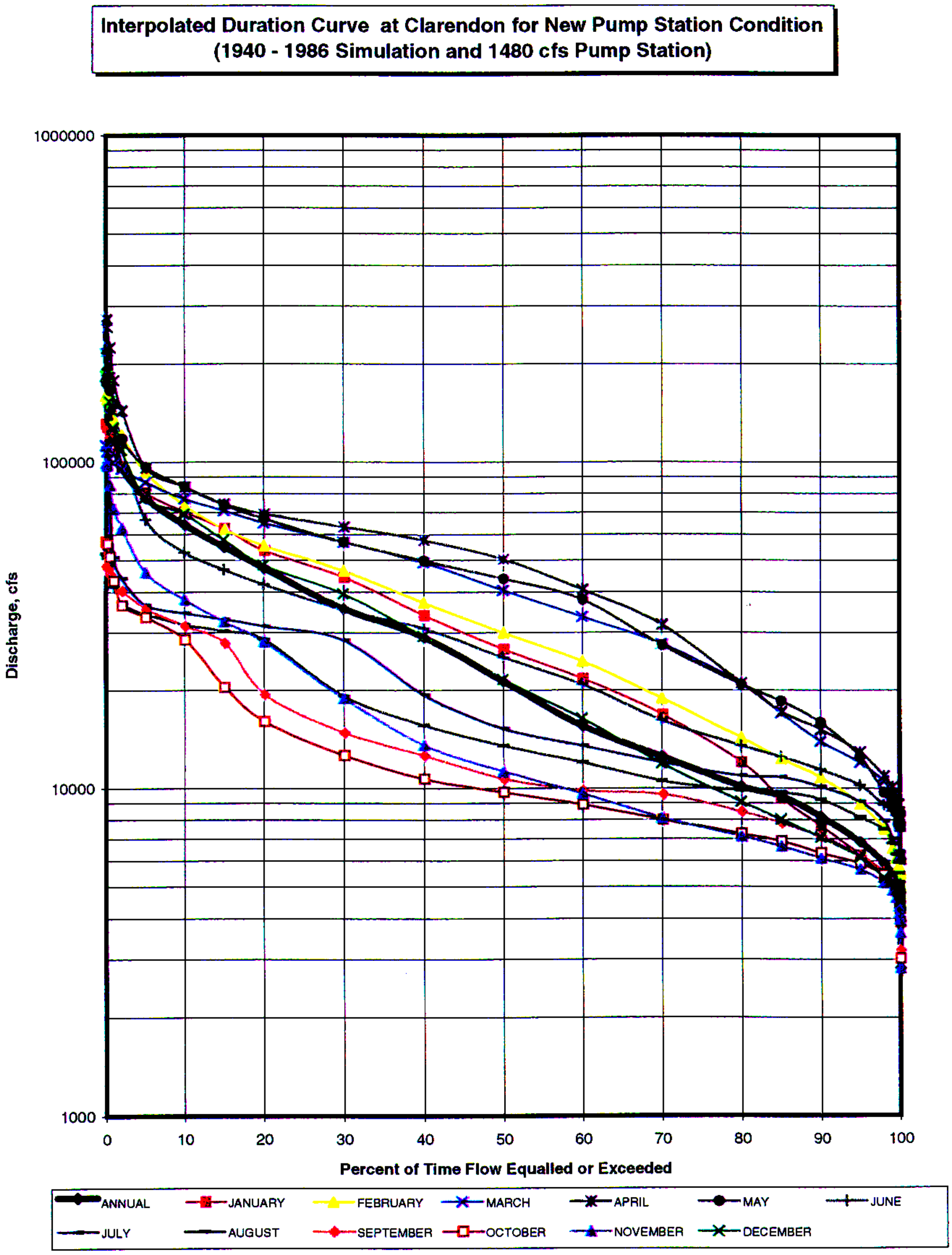


**Figure IV-C.1.2 Annual and Monthly Flow-Duration Curves for 1640 cfs Maximum Diversion and Simulated White River Data (1940-1986)**

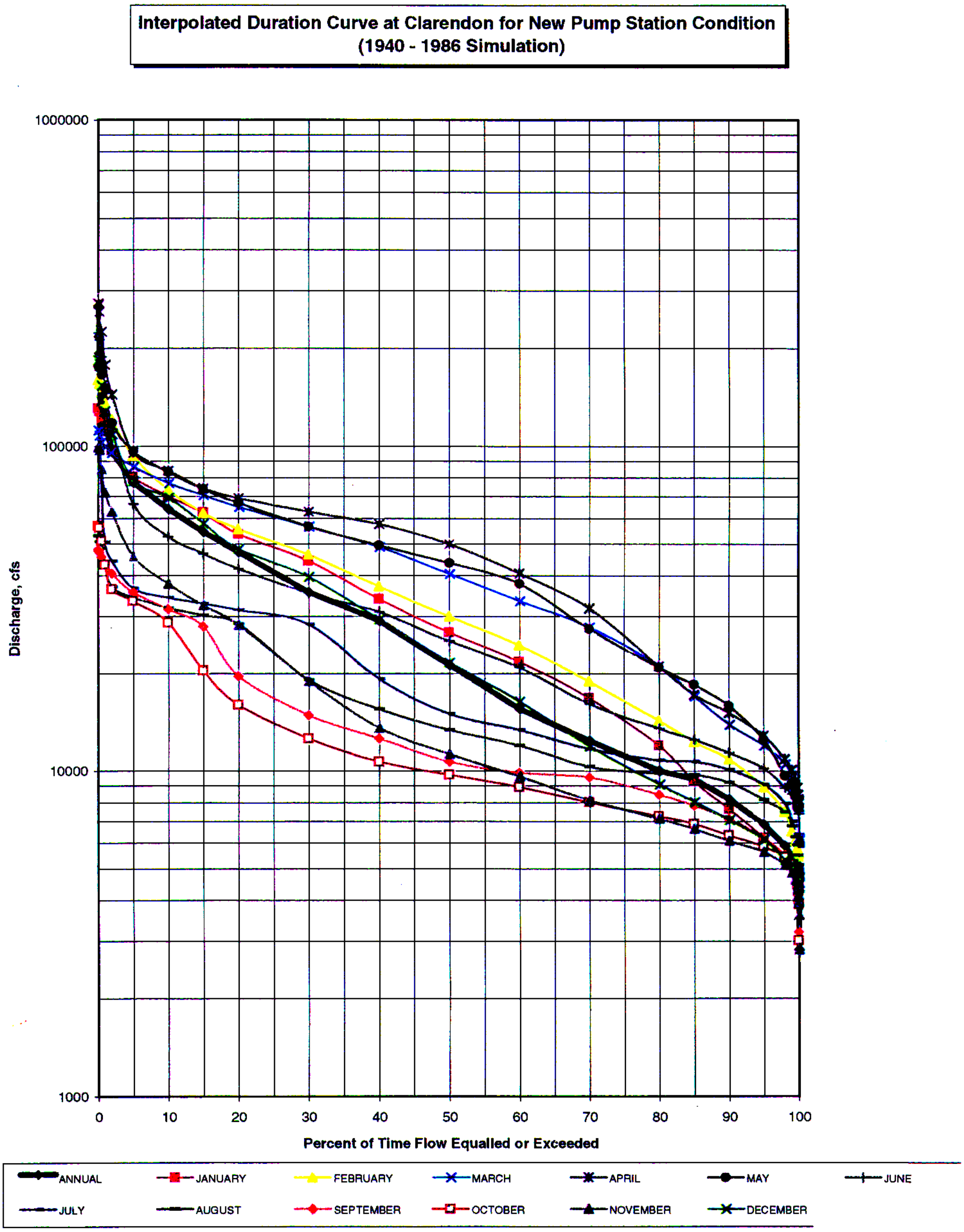


Figure IV-C.1.3 Annual and Monthly Flow-Duration Curves for 1800 cfs Maximum Diversion and Synthetic White River Data (1940-1986)

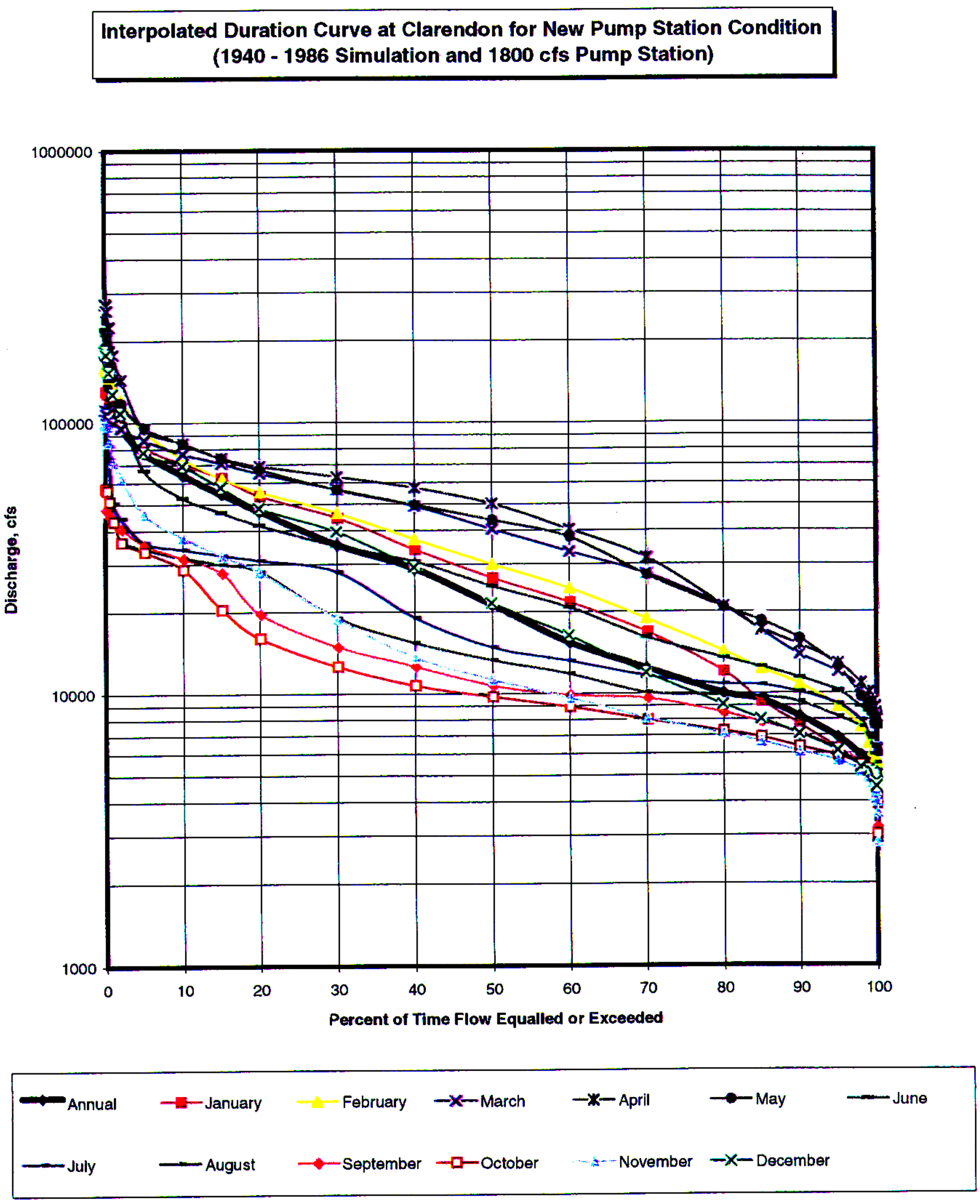


Figure IV-C.1.4 Annual and Monthly Flow-Duration Curves for 1960 cfs Maximum Diversion and Synthetic White River Data (1940-1986)

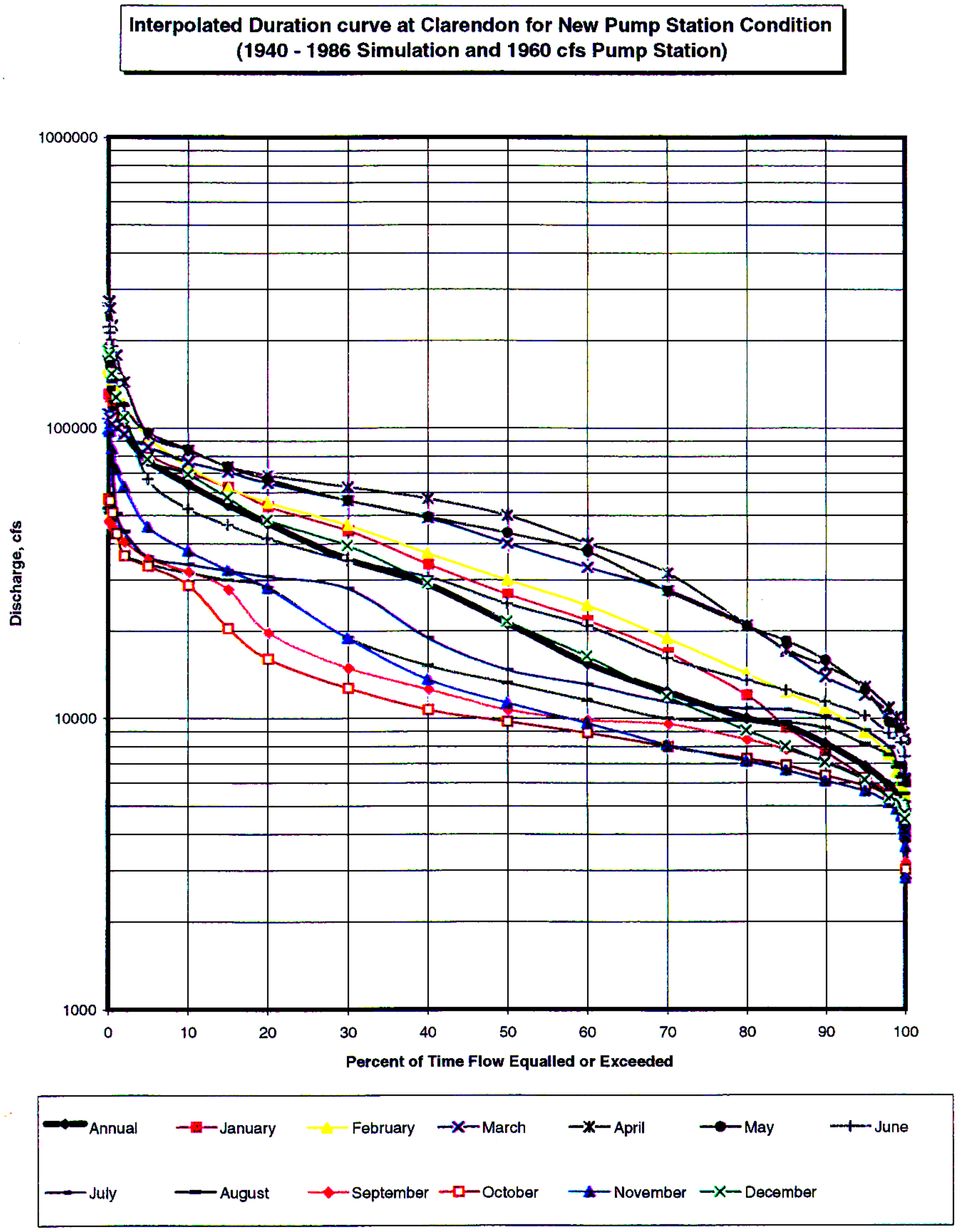
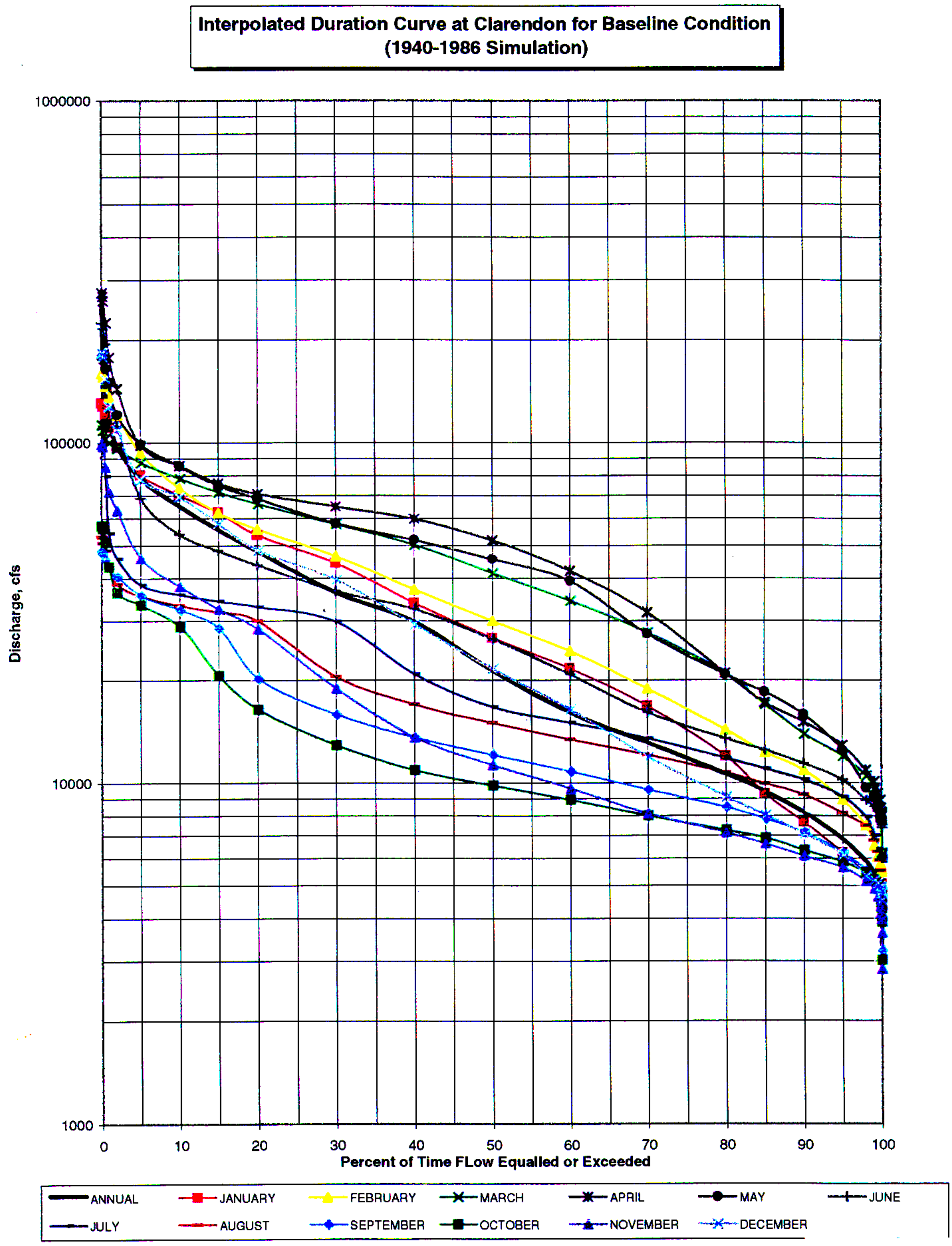
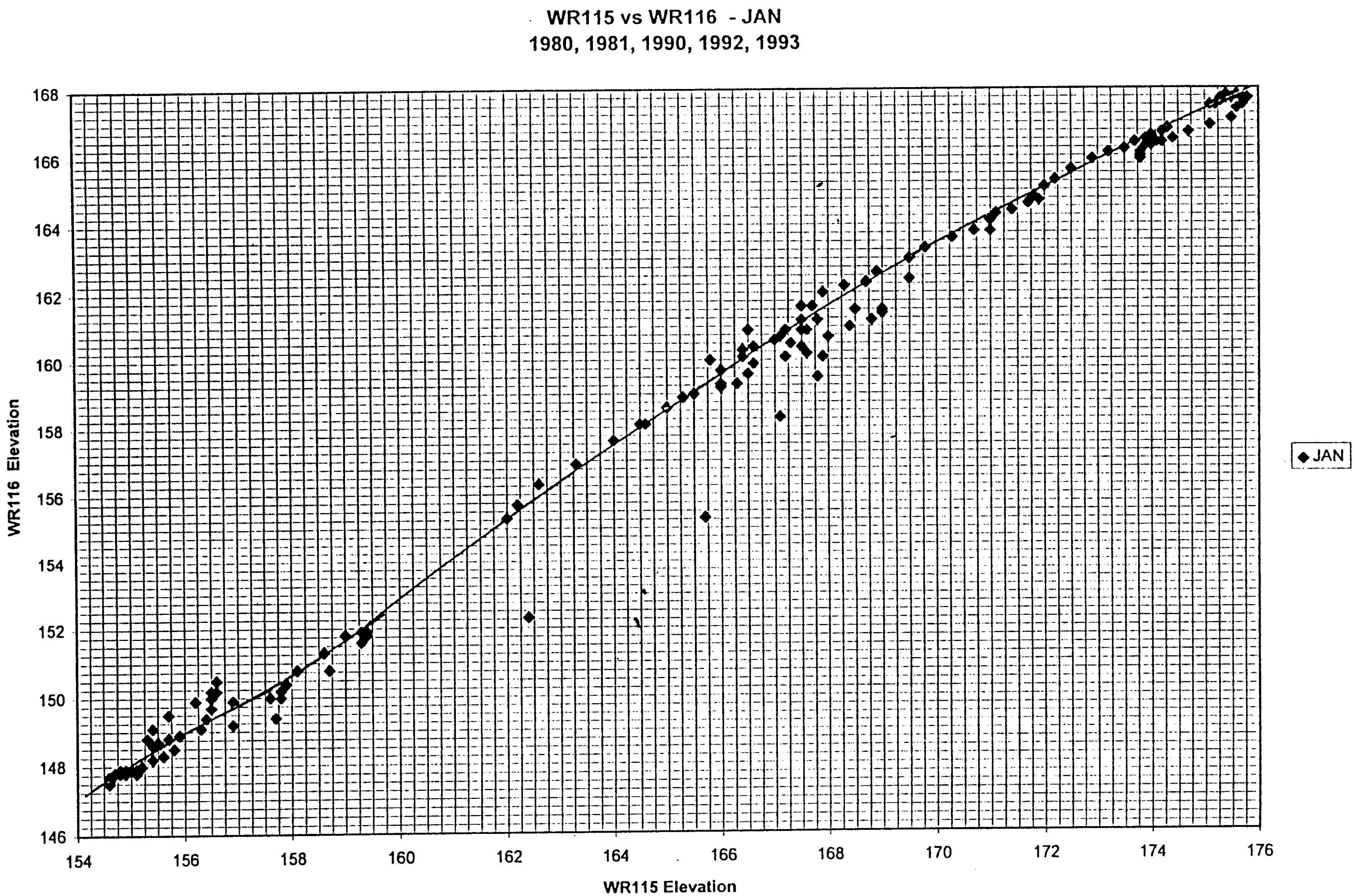
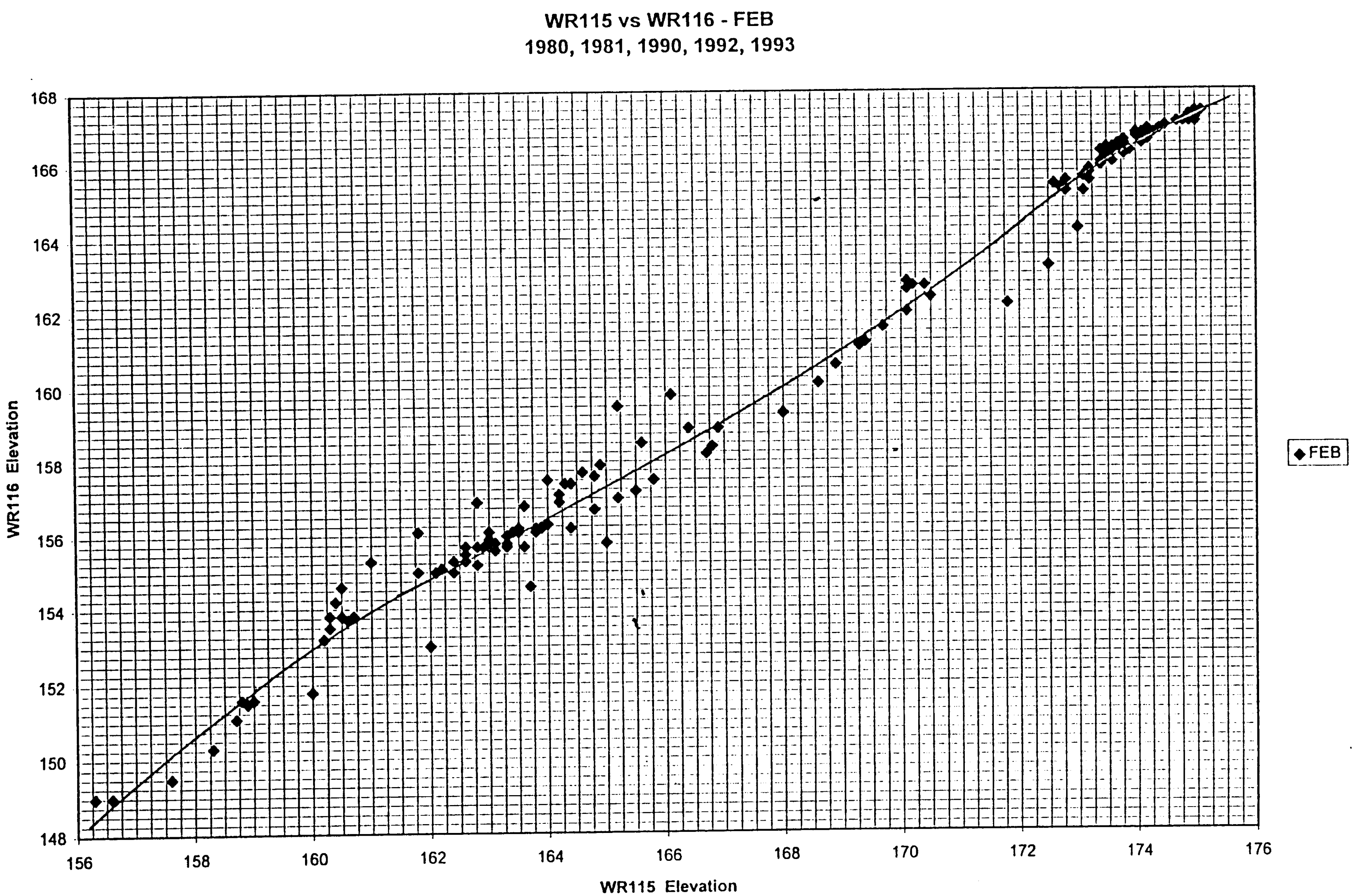


**Figure IV-C.1.5 Annual and Monthly Flow-Duration Curves for No Diversion and Simulated White River Data (1940-1986)**

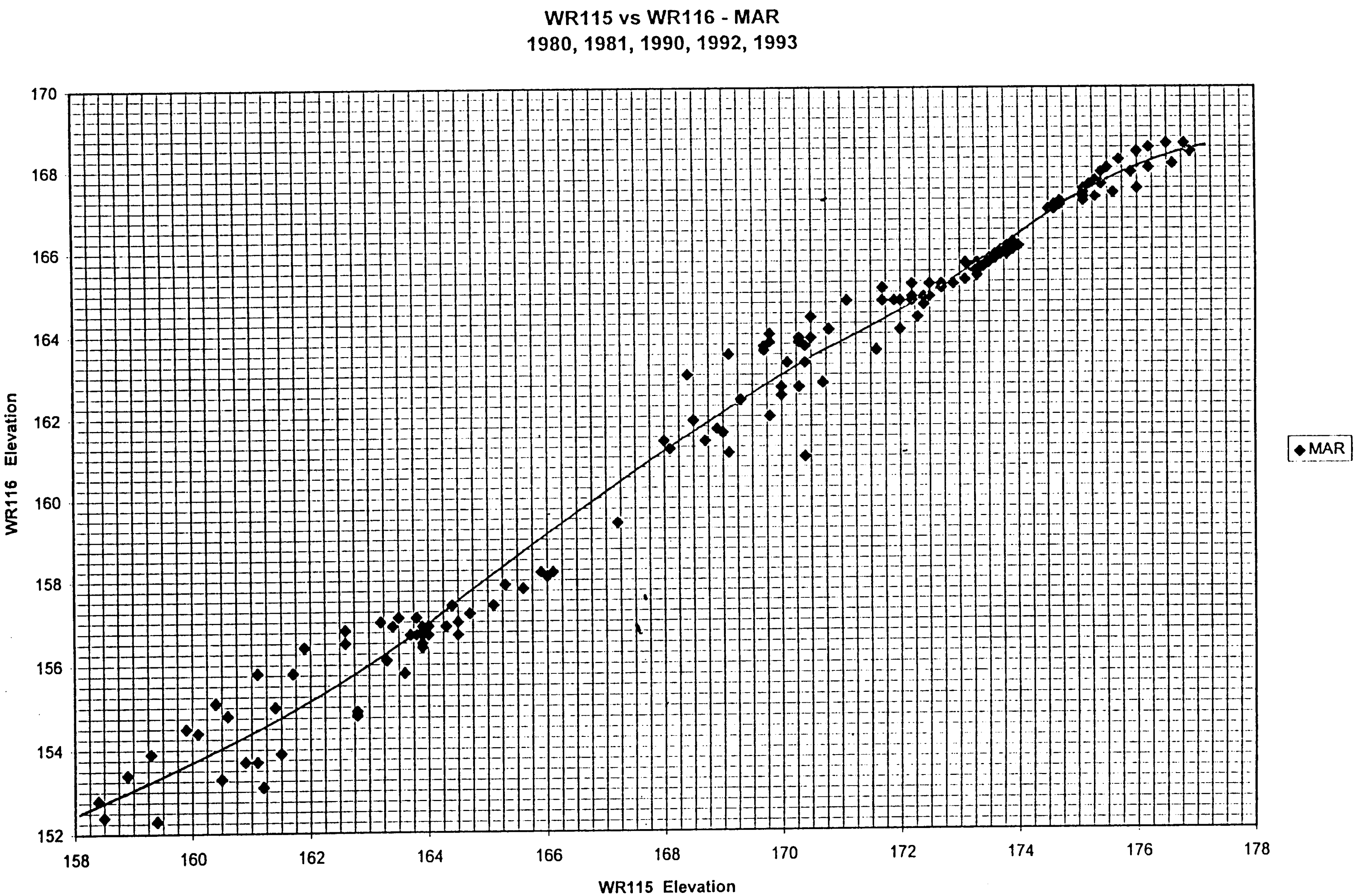



WR115 vs WR116 - JAN
1980, 1981, 1990, 1992, 1993
WR116 Elevation
WR115 Elevation
JAN
146
148
150
152
154
156
158
160
162
164
166
168
154
156
158
160
162
164
166
168
170
172
174
176



WR115 vs WR116 - FEB
1980, 1981, 1990, 1992, 1993
WR116 Elevation
WR115 Elevation
168
166
164
162
160
158
156
154
152
150
148
156
158
160
162
164
166
168
170
172
174
176
FEB


PLATE IV-61



WR115 vs WR116 - MAR
1980, 1981, 1990, 1992, 1993
170
168
166
164
162
160
158
156
154
152
WR116 Elevation
158
160
162
164
166
168
170
172
174
176
178
WR115 Elevation
MAR


PLATE IV-62

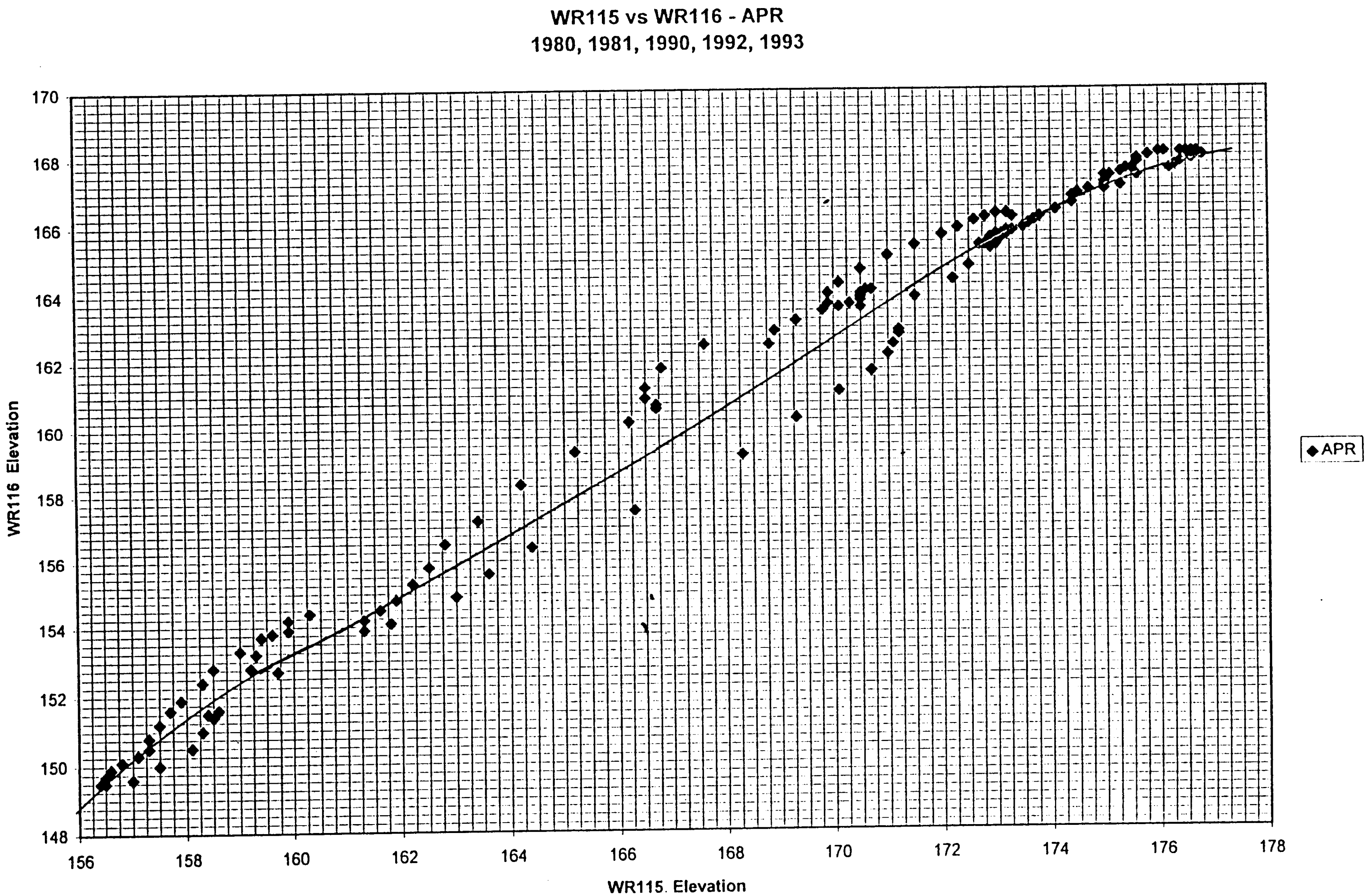

WR115 vs WR116 - APR
1980, 1981, 1990, 1992, 1993
WR116 Elevation
WR115 Elevation
APR
170
168
166
164
162
160
158
156
154
152
150
148
156
158
160
162
164
166
168
170
172
174
176
178

PLATE IV-63

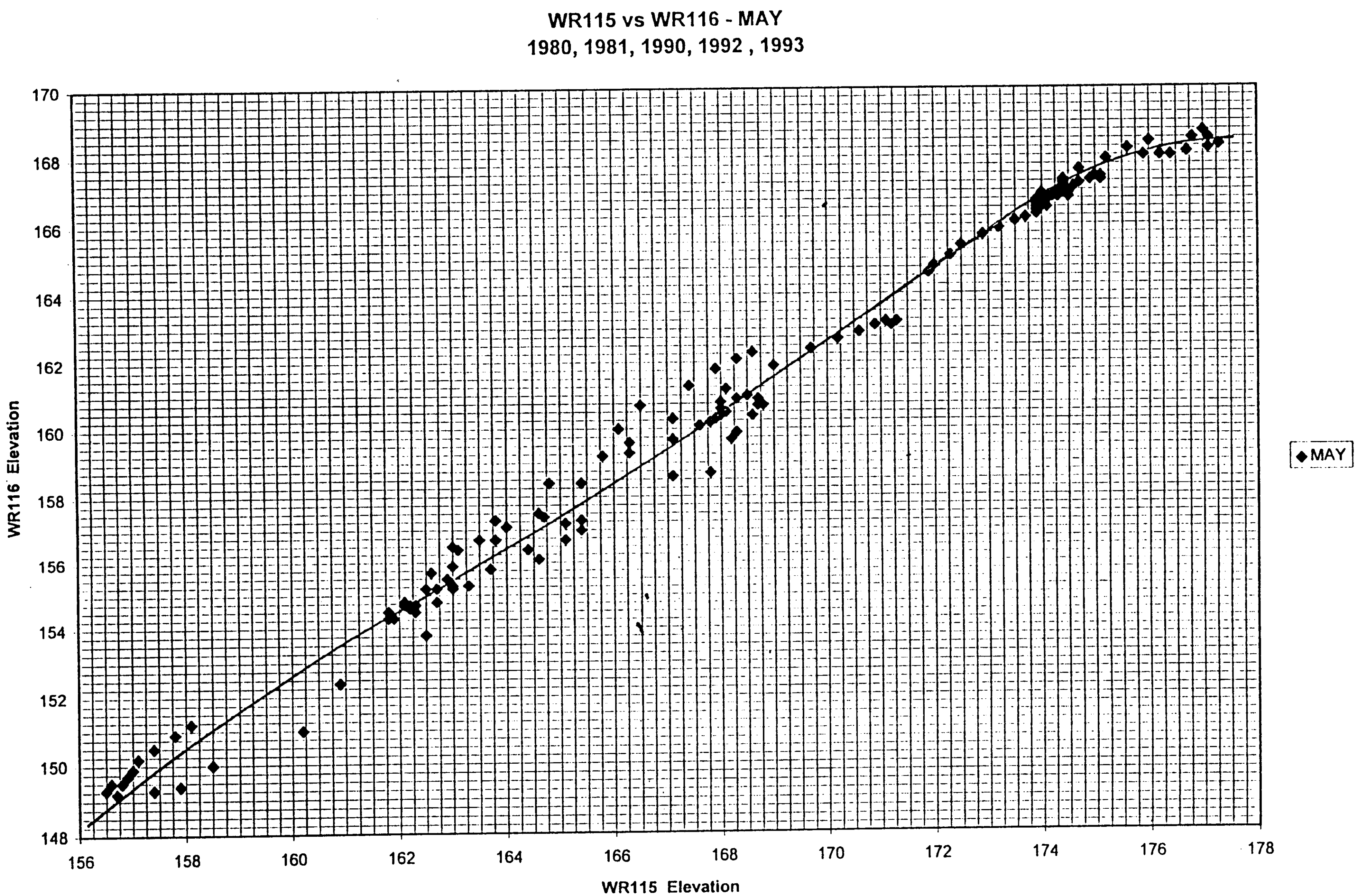
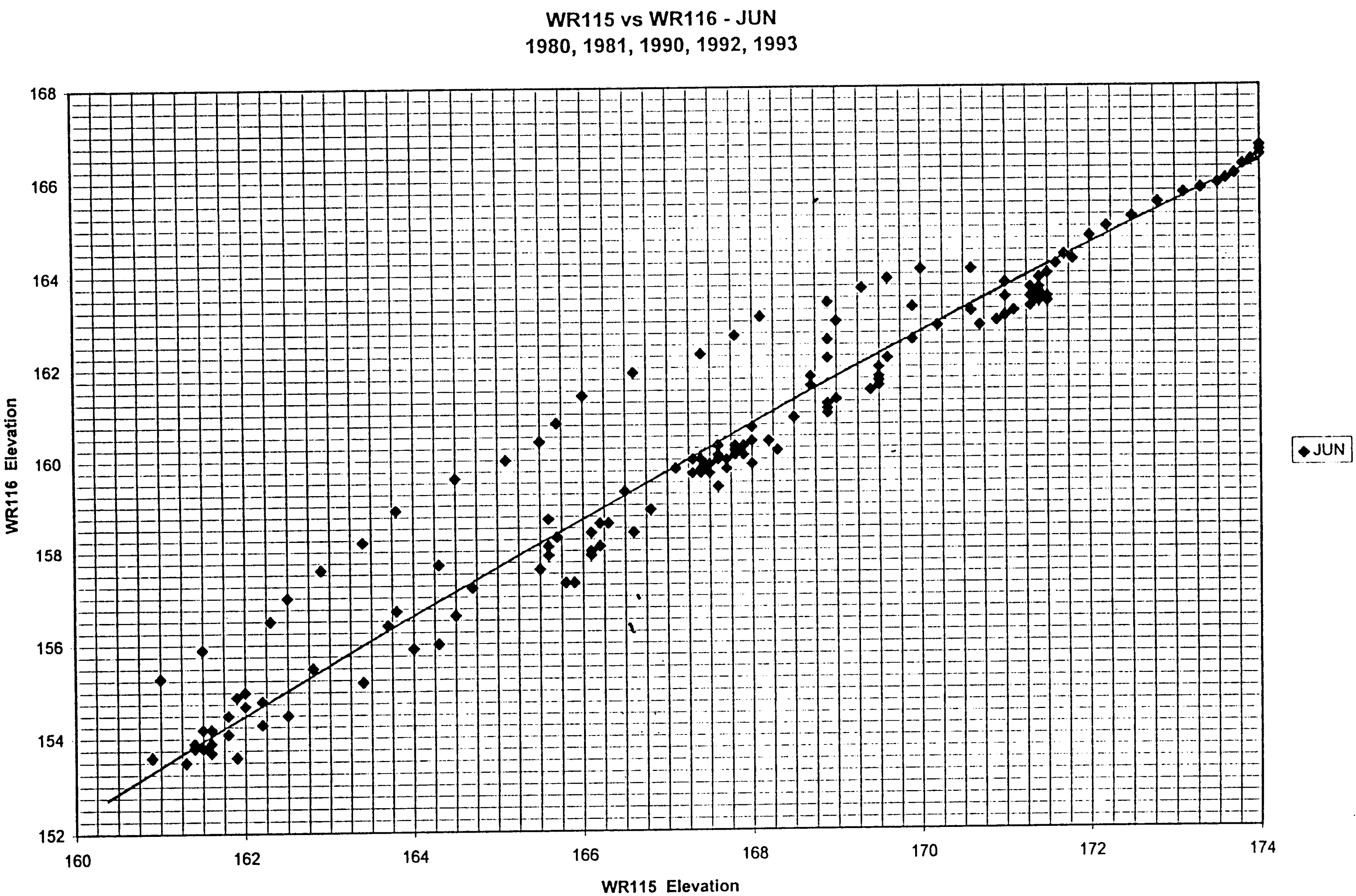

WR115 vs WR116 - MAY
1980, 1981, 1990, 1992 , 1993
170
168
166
164
162
160
158
156
154
152
150
148
156
158
160
162
164
166
168
170
172
174
176
178
WR116 Elevation
WR115 Elevation
MAY

PLATE IV-64



WR115 vs WR116 - JUN
1980, 1981, 1990, 1992, 1993
168
166
164
162
160
158
156
154
152
WR116 Elevation
160
162
164
166
168
170
172
174
WR115 Elevation
JUN


PLATE IV-65

**WR115 vs WR116 - JUL**
**1980, 1981, 1990, 1992, 1993**

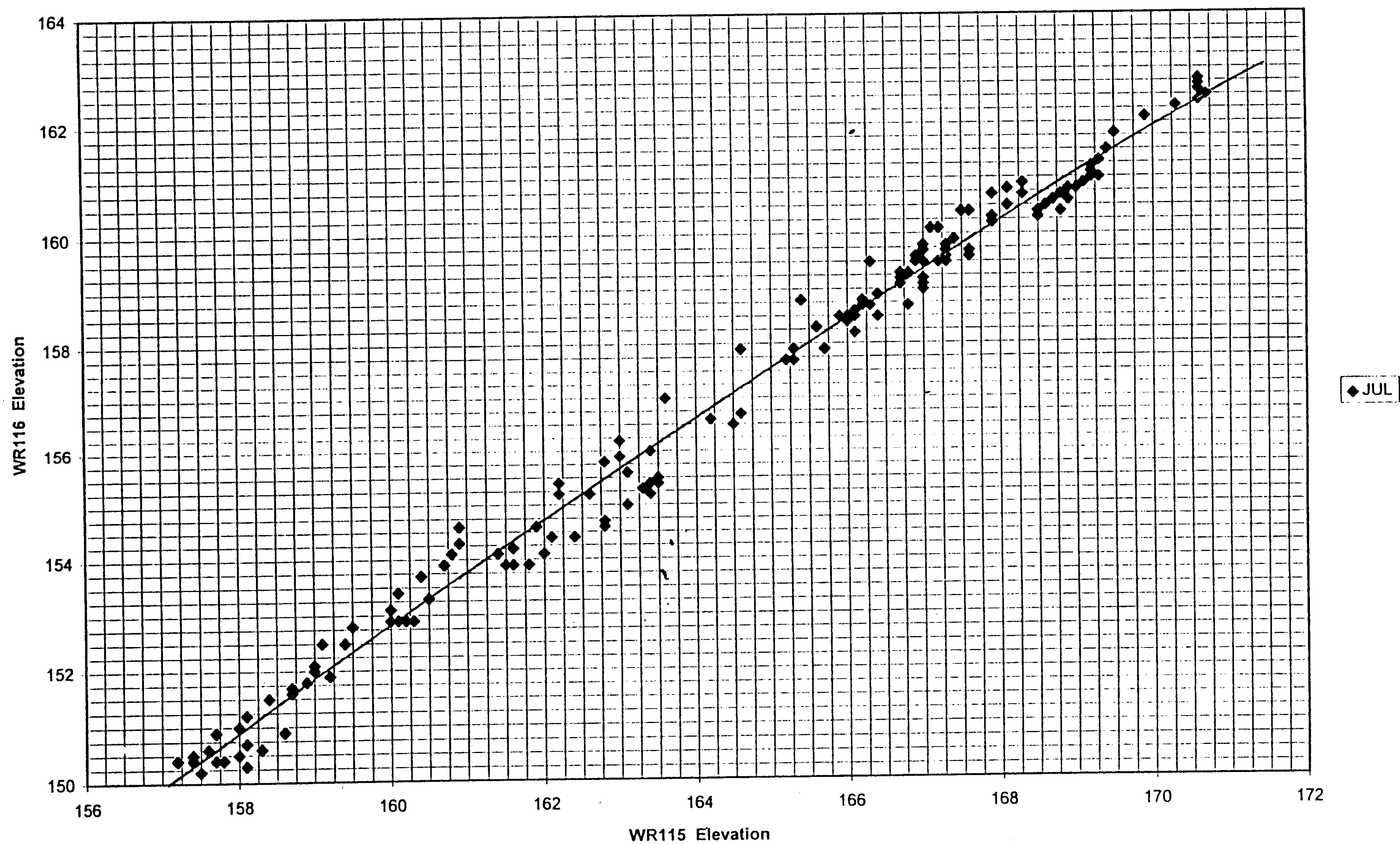
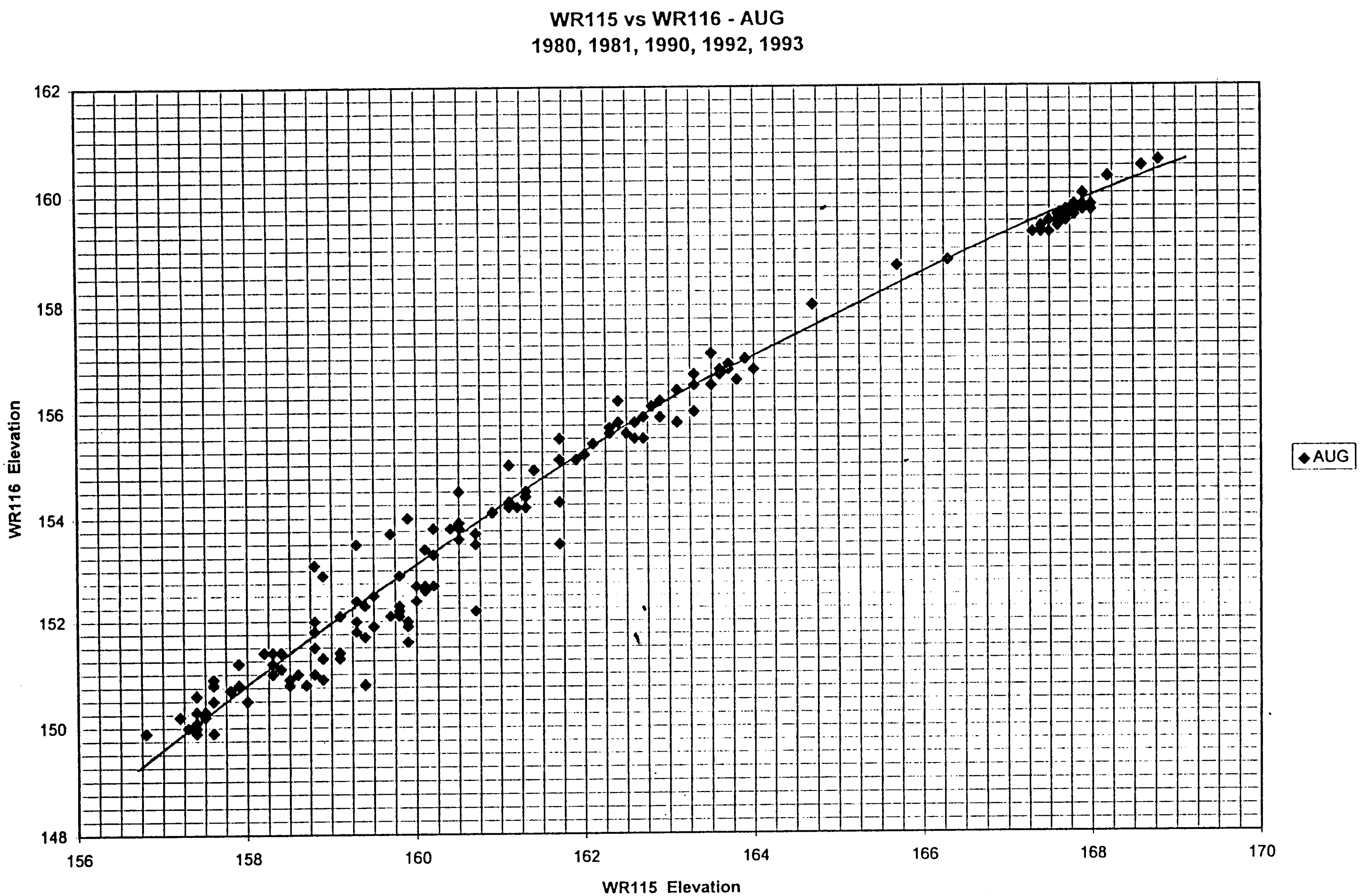
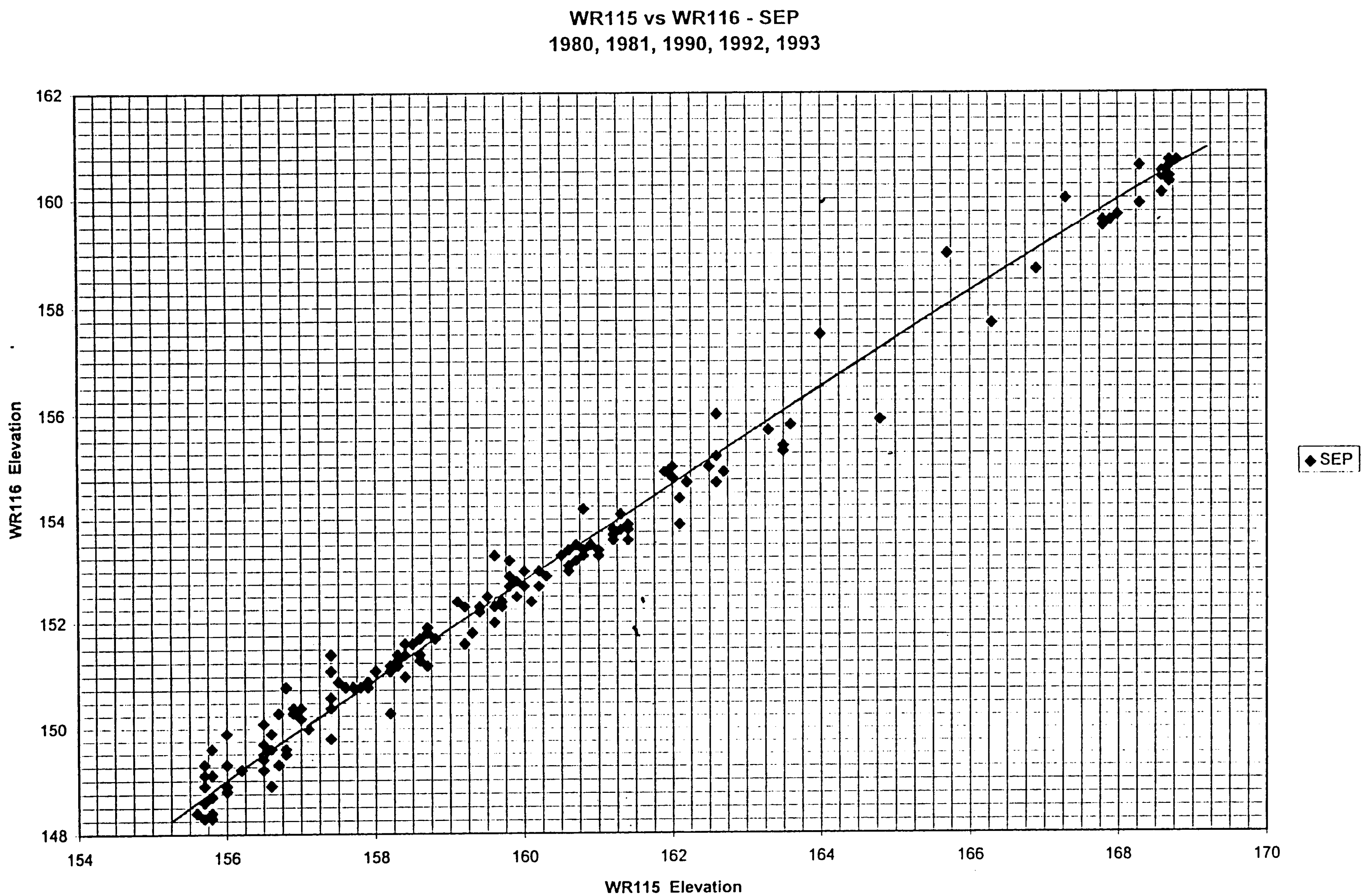



PLATE IV-66


WR115 vs WR116 - AUG
1980, 1981, 1990, 1992, 1993
WR116 Elevation
WR115 Elevation
AUG
162
160
158
156
154
152
150
148
156
158
160
162
164
166
168
170



WR115 vs WR116 - SEP
1980, 1981, 1990, 1992, 1993
162
160
158
156
154
152
150
148
WR116 Elevation
154
156
158
160
162
164
166
168
170
WR115 Elevation
SEP

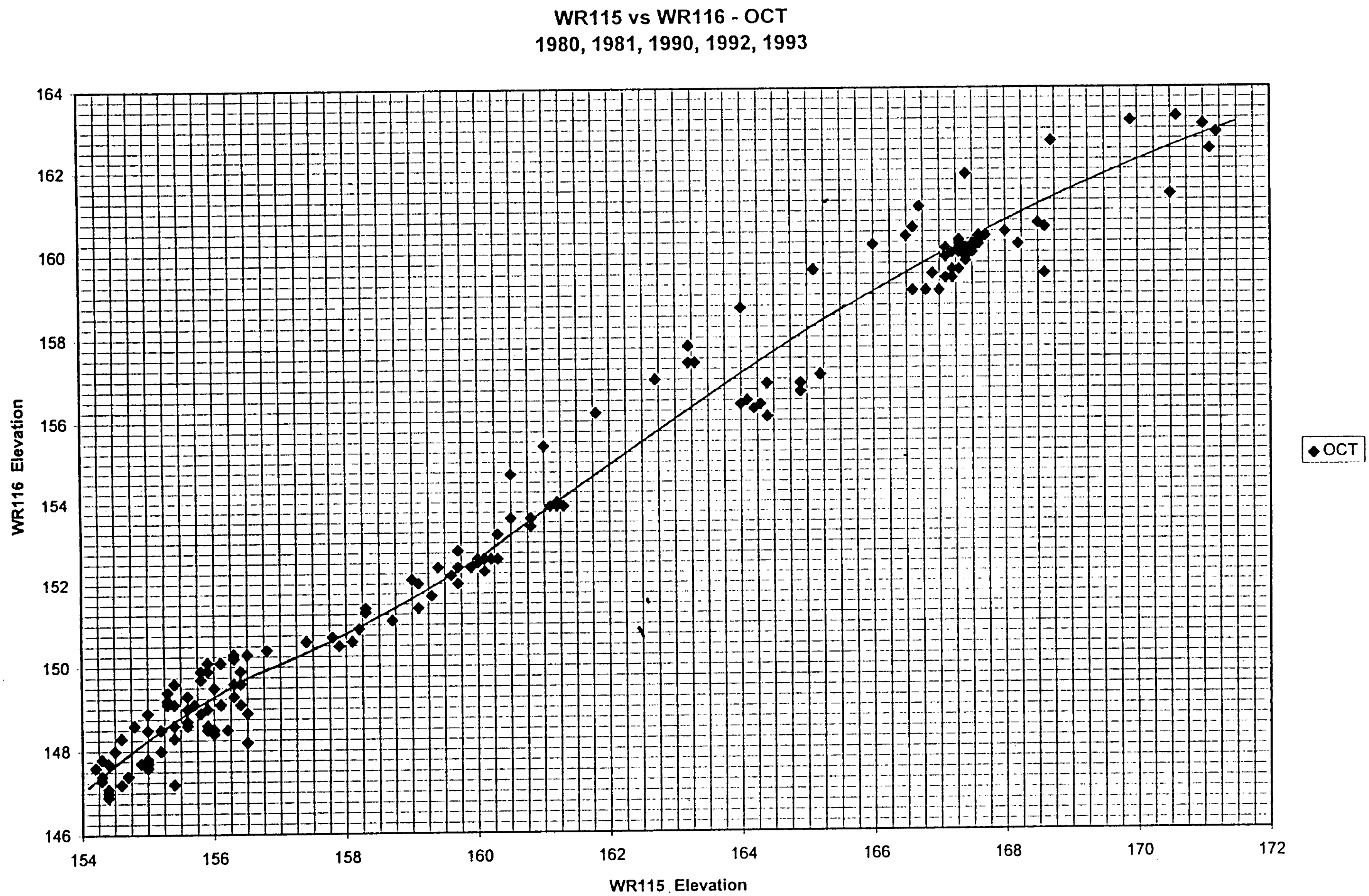
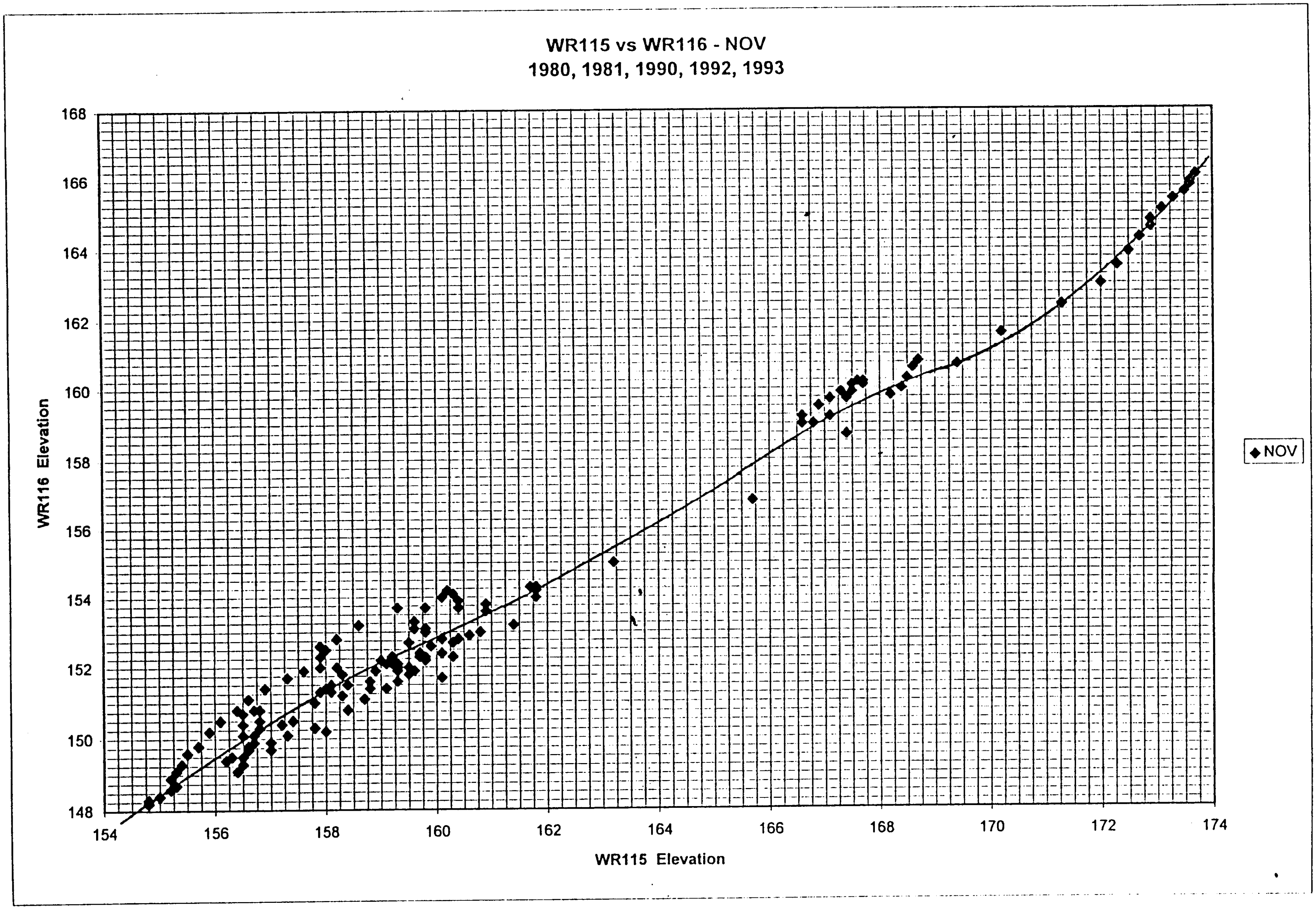
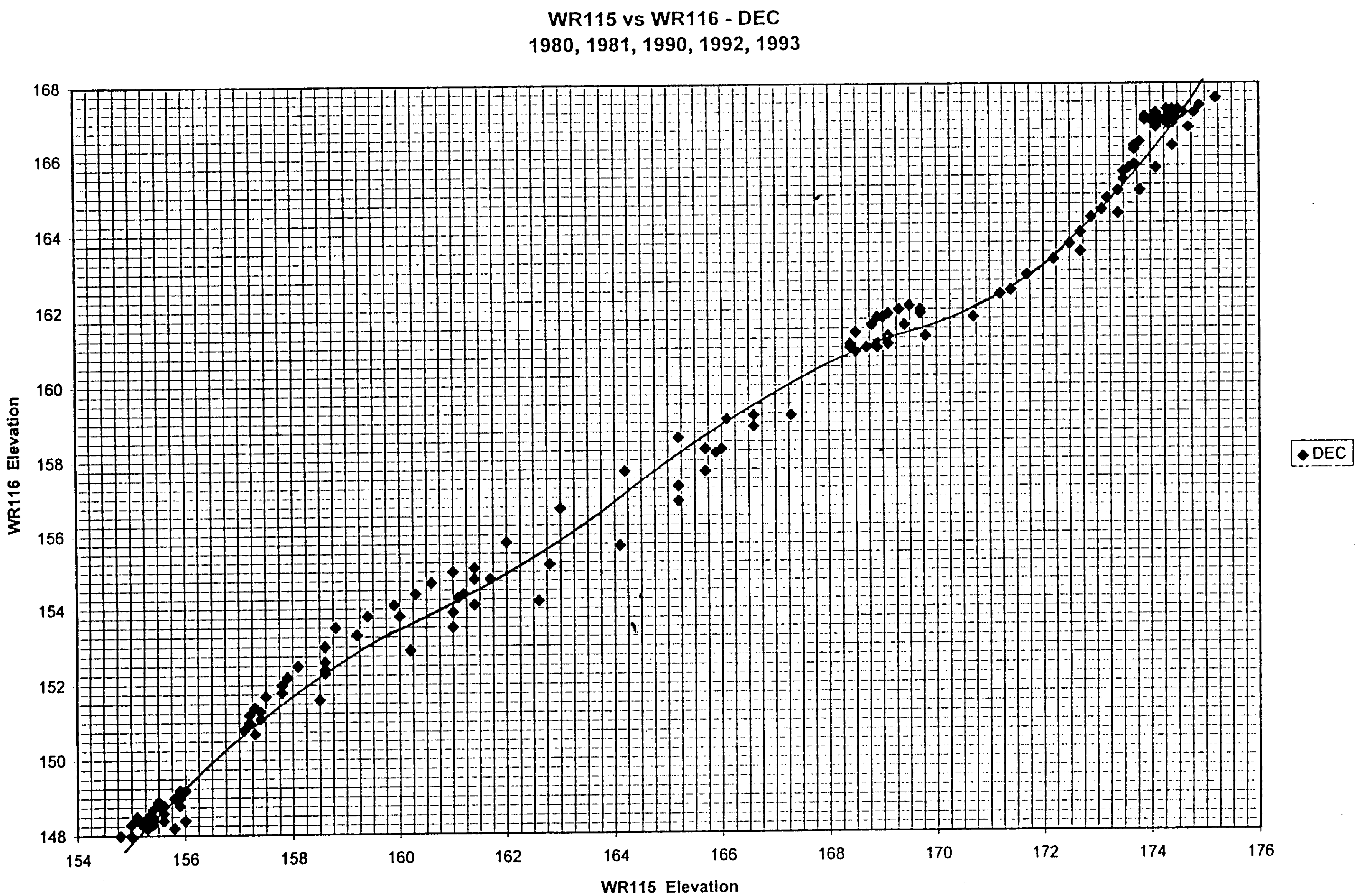

WR115 vs WR116 - OCT
1980, 1981, 1990, 1992, 1993
164
162
160
158
156
154
152
150
148
146
WR116 Elevation
154
156
158
160
162
164
166
168
170
172
WR115 Elevation
OCT

PLATE IV-69



WR115 vs WR116 - NOV
1980, 1981, 1990, 1992, 1993
WR116 Elevation
168
166
164
162
160
158
156
154
152
150
148
154
156
158
160
162
164
166
168
170
172
174
WR115 Elevation
NOV


PLATE IV-70



WR115 vs WR116 - DEC
1980, 1981, 1990, 1992, 1993
WR116 Elevation
168
166
164
162
160
158
156
154
152
150
148
154
156
158
160
162
164
166
168
170
172
174
176
WR115 Elevation
DEC


PLATE IV-71

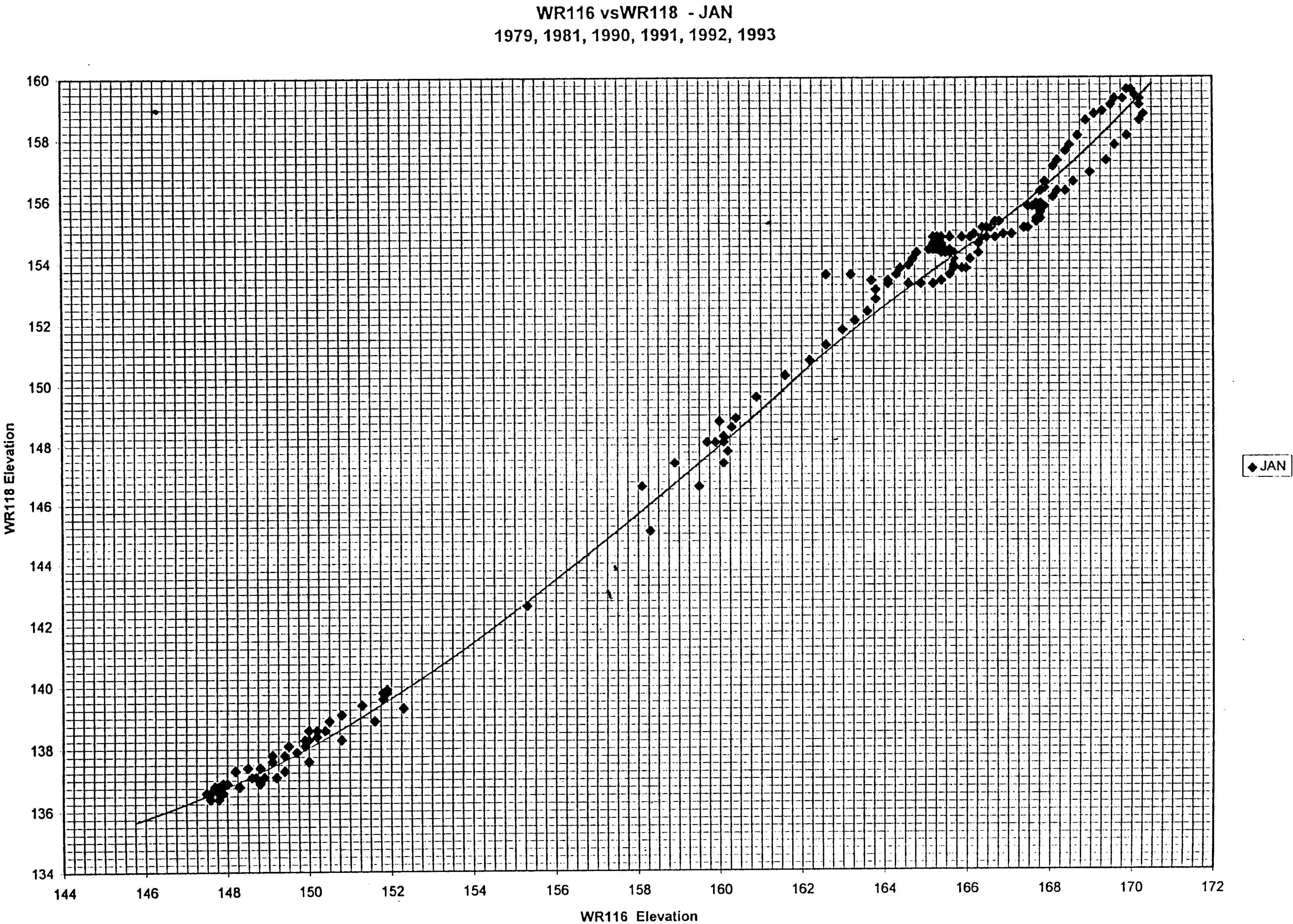
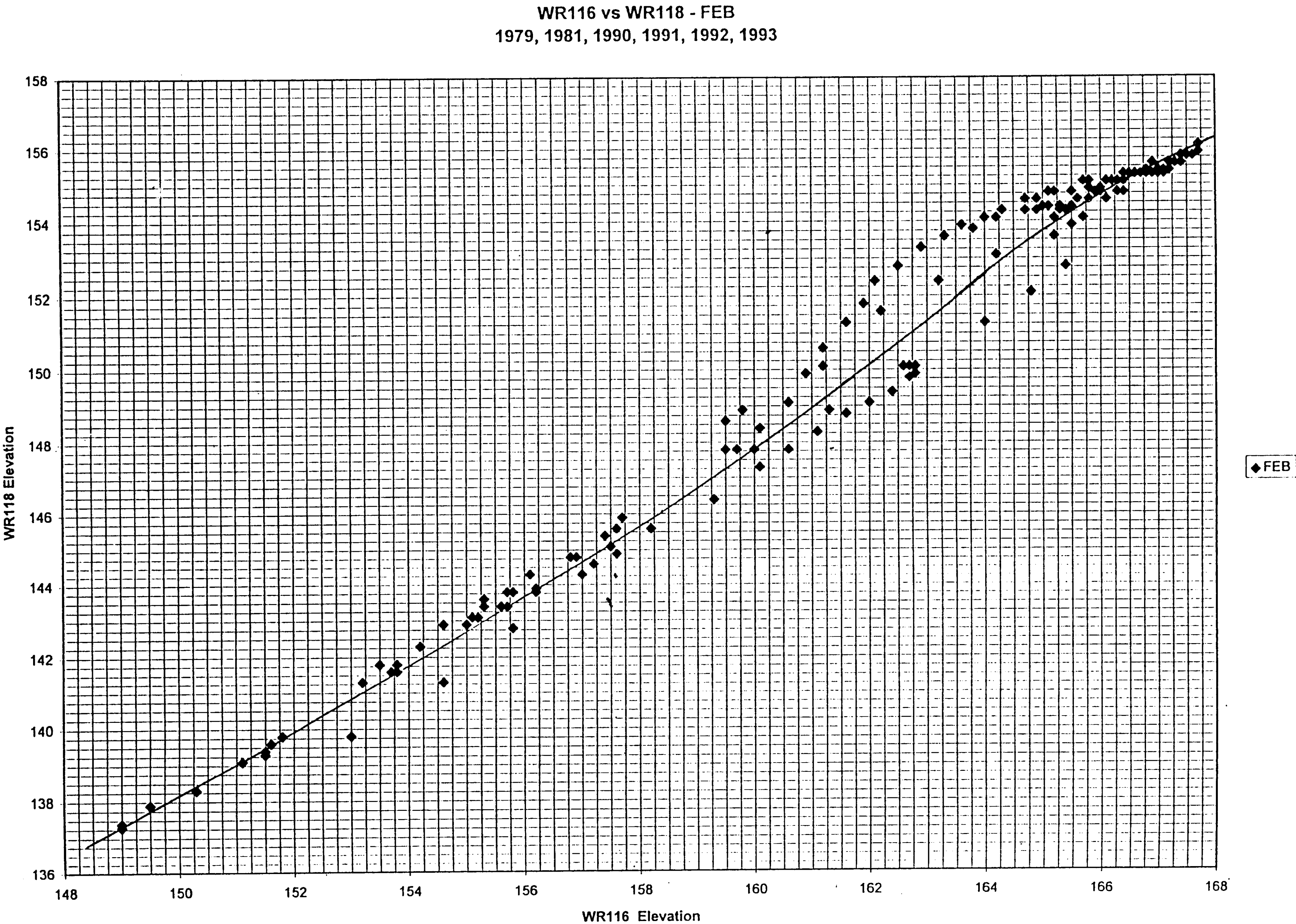

WR116 vsWR118 - JAN
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
JAN
160
158
156
154
152
150
148
146
144
142
140
138
136
134
144
146
148
150
152
154
156
158
160
162
164
166
168
170
172

PLATE IV-72



WR116 vs WR118 - FEB
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
158
156
154
152
150
148
146
144
142
140
138
136
148
150
152
154
156
158
160
162
164
166
168
FEB


PLATE IV-73

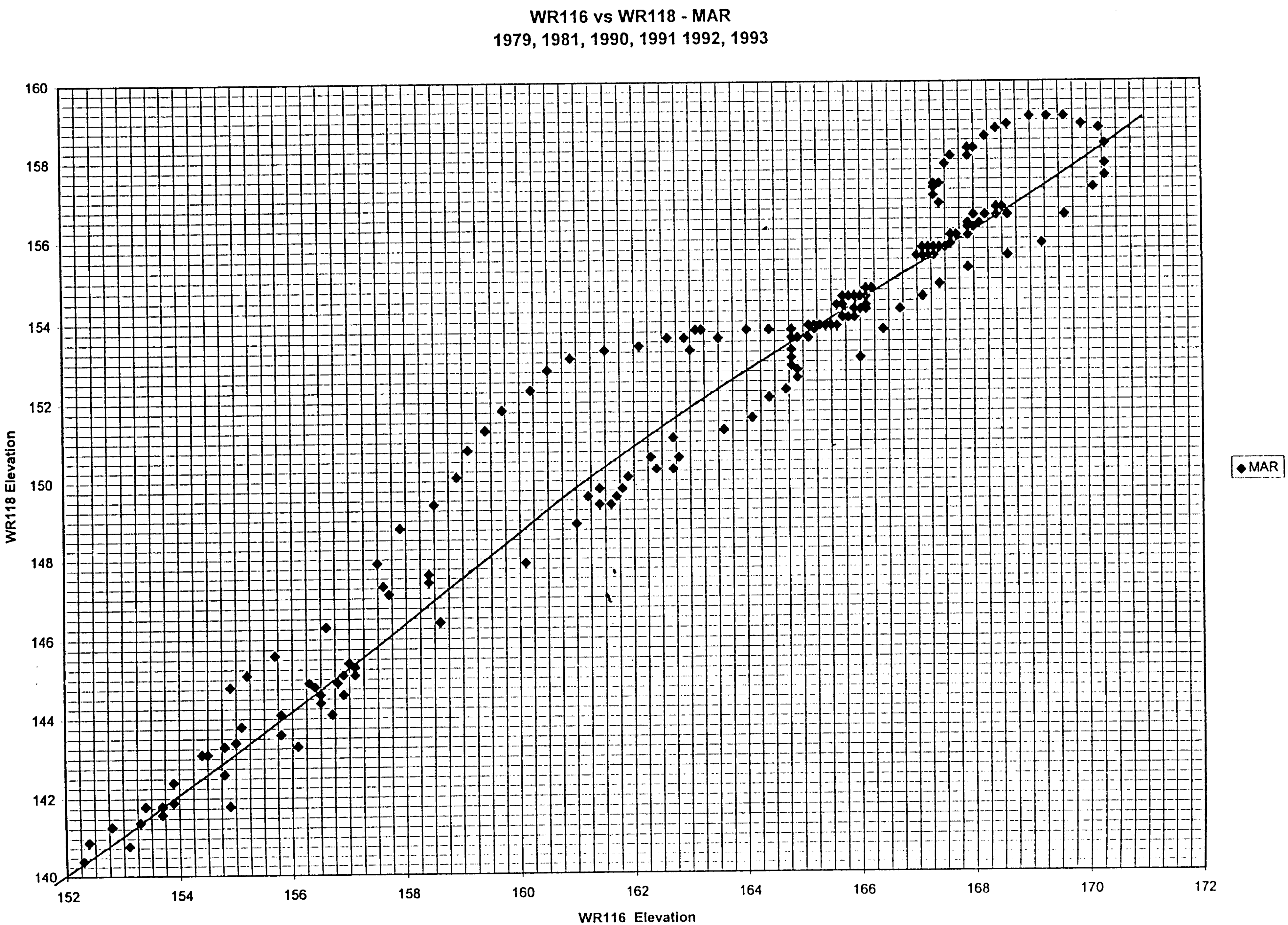
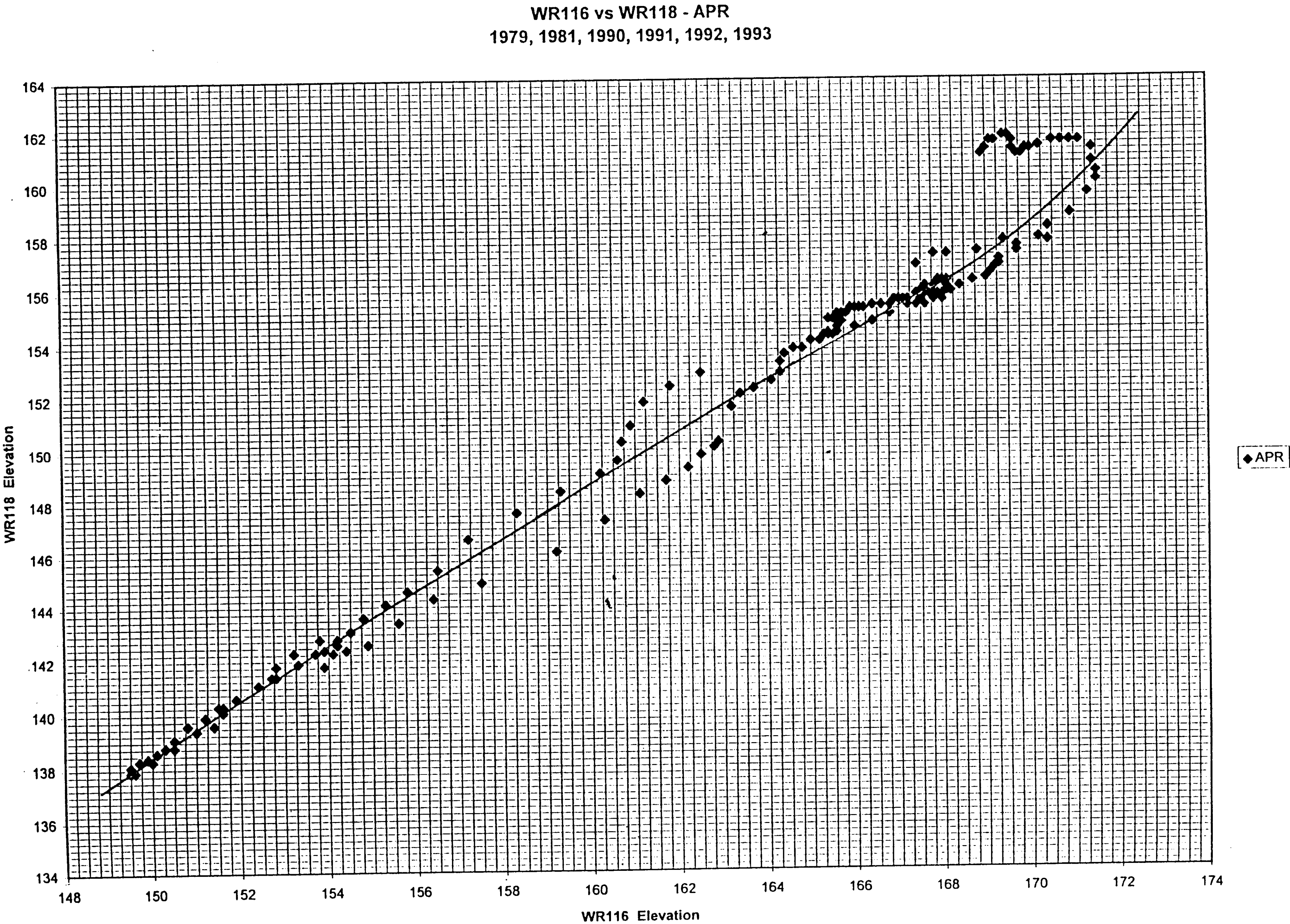

WR116 vs WR118 - MAR
1979, 1981, 1990, 1991 1992, 1993
WR118 Elevation
WR116 Elevation
MAR
140
142
144
146
148
150
152
154
156
158
160
152
154
156
158
160
162
164
166
168
170
172

PLATE IV-74



WR116 vs WR118 - APR
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
APR
164
162
160
158
156
154
152
150
148
146
144
142
140
138
136
134
148
150
152
154
156
158
160
162
164
166
168
170
172
174


PLATE IV-75

WR116 vs WR118 - MAY
1979, 1981, 1990, 1991, 1992, 1993

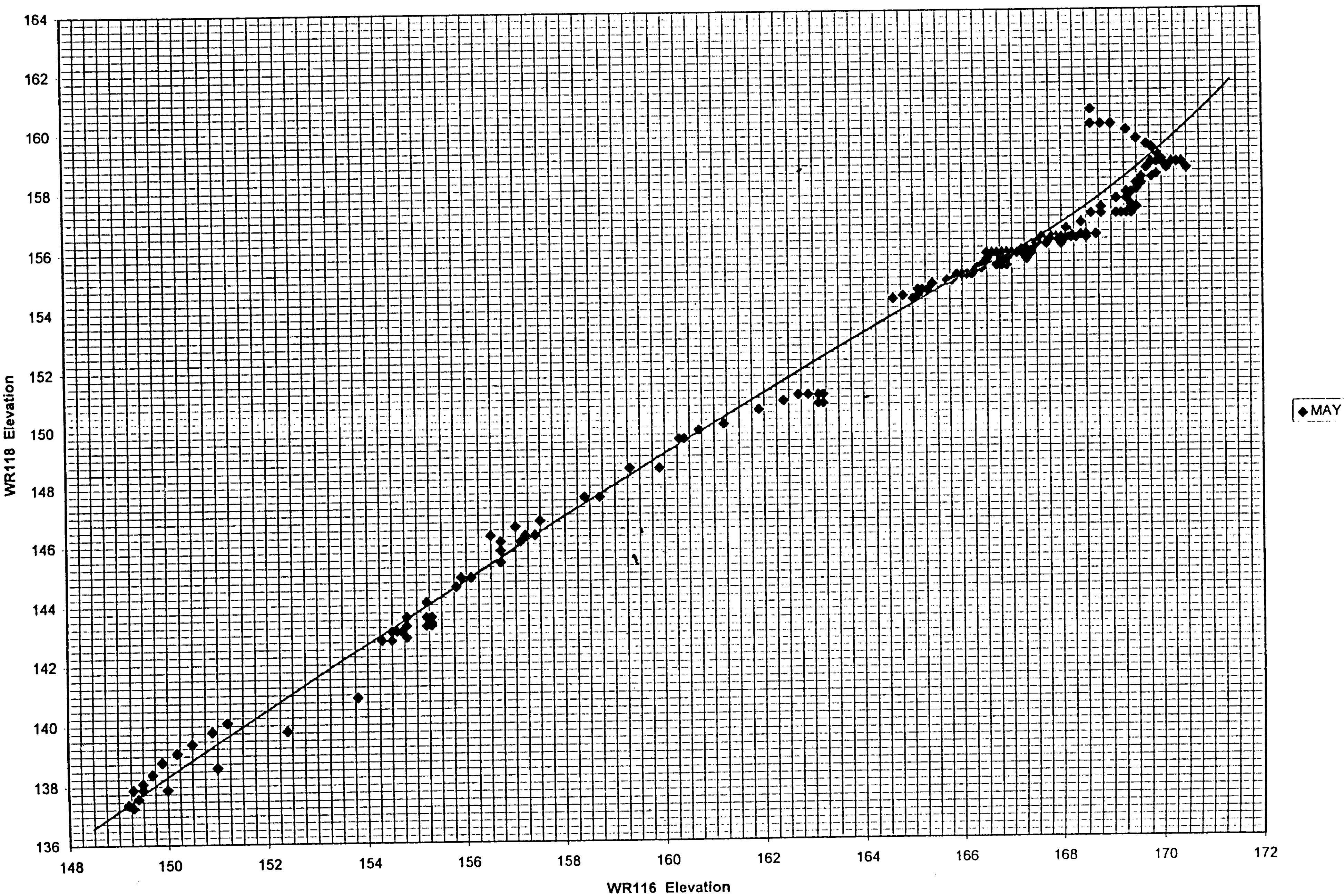



PLATE IV-76

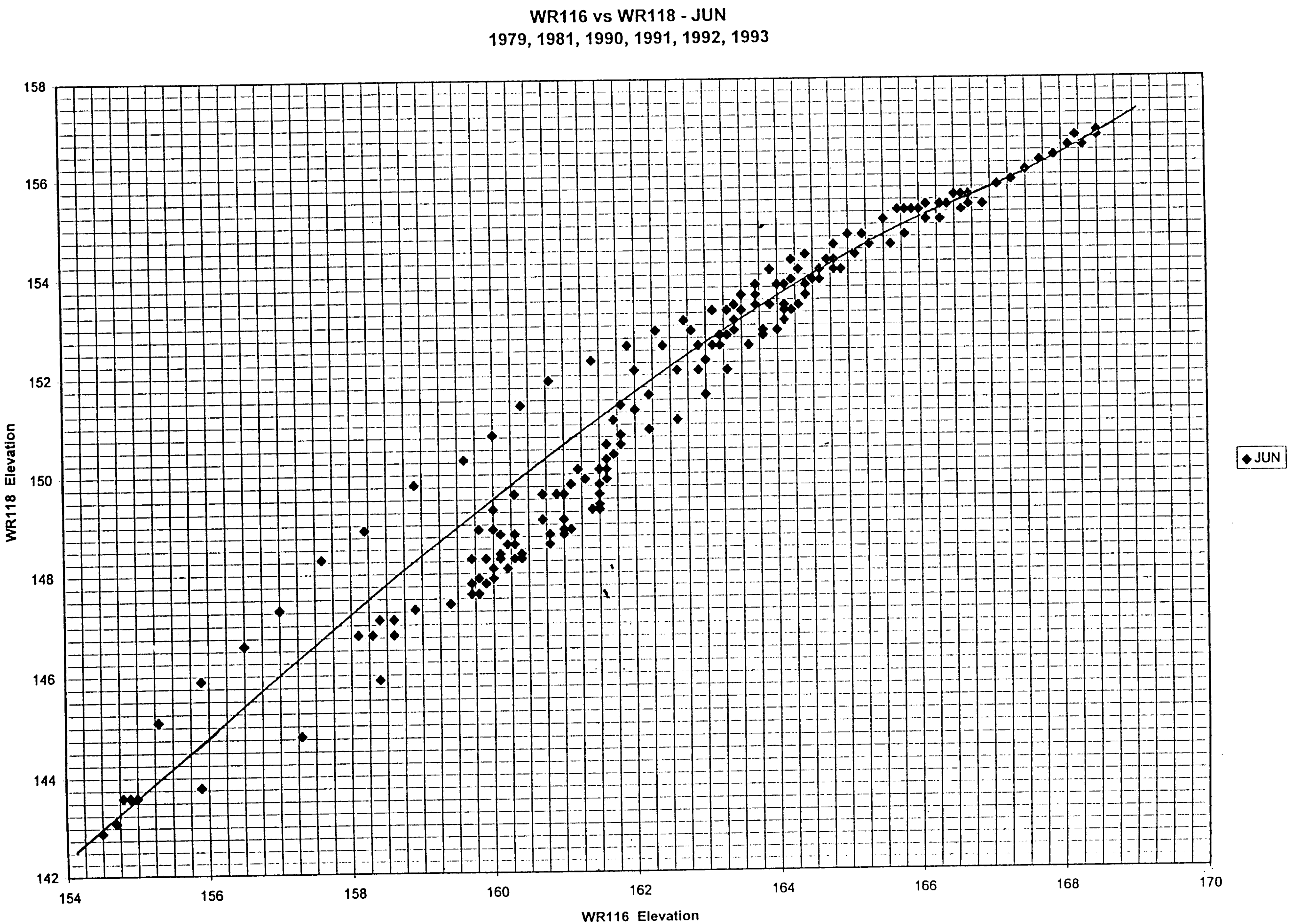

WR116 vs WR118 - JUN
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
JUN
142
144
146
148
150
152
154
156
158
154
156
158
160
162
164
166
168
170

PLATE IV-77

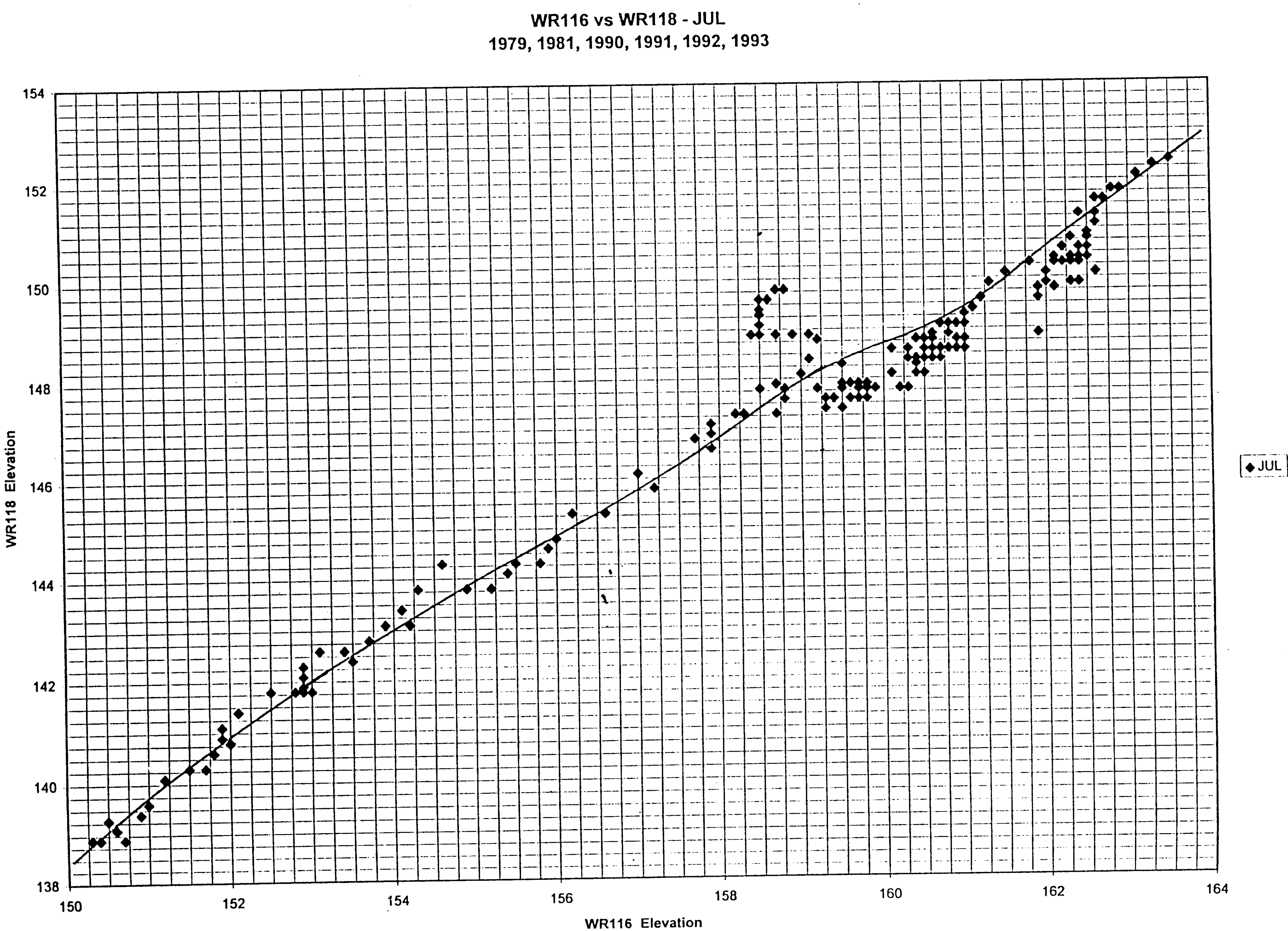
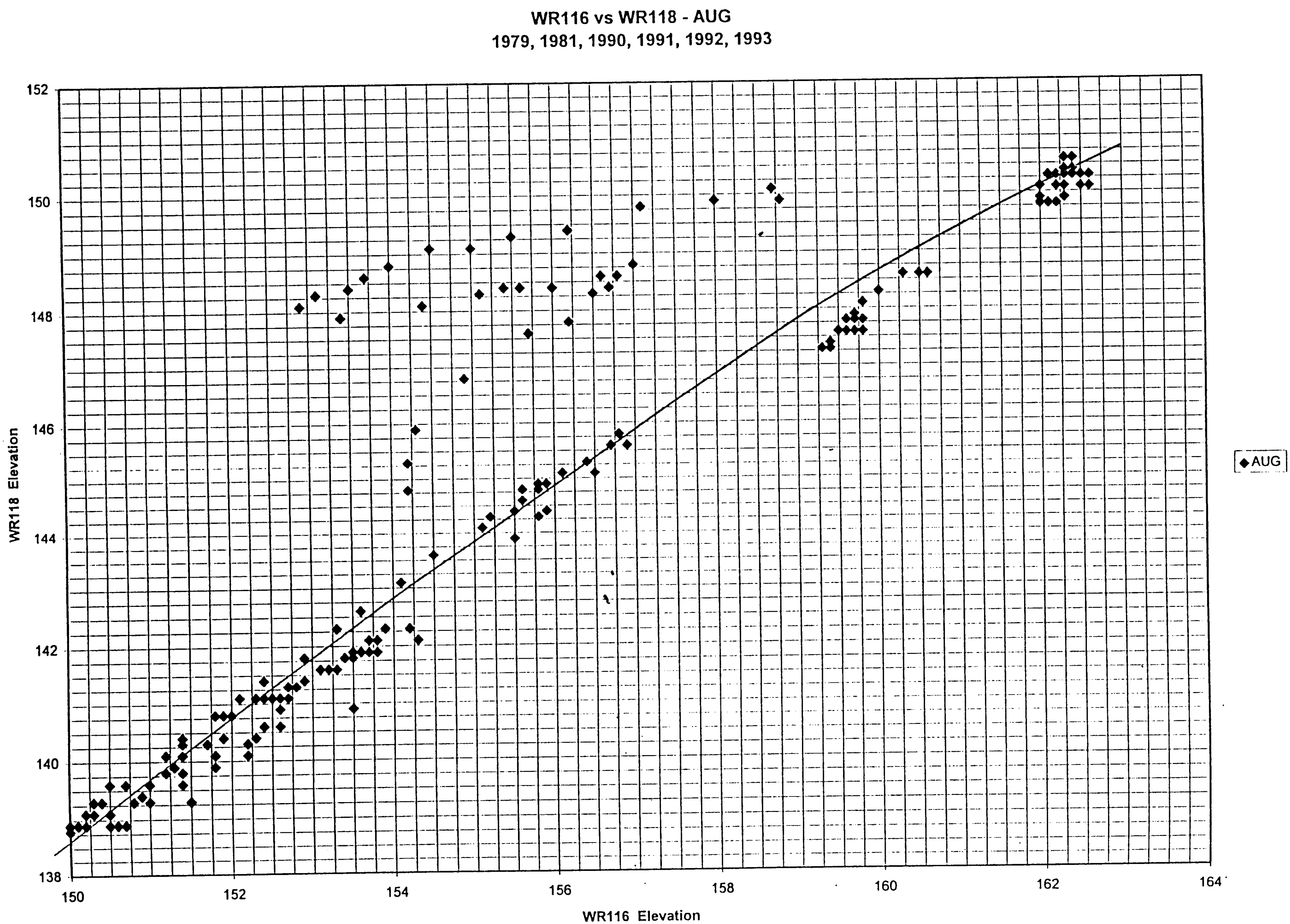
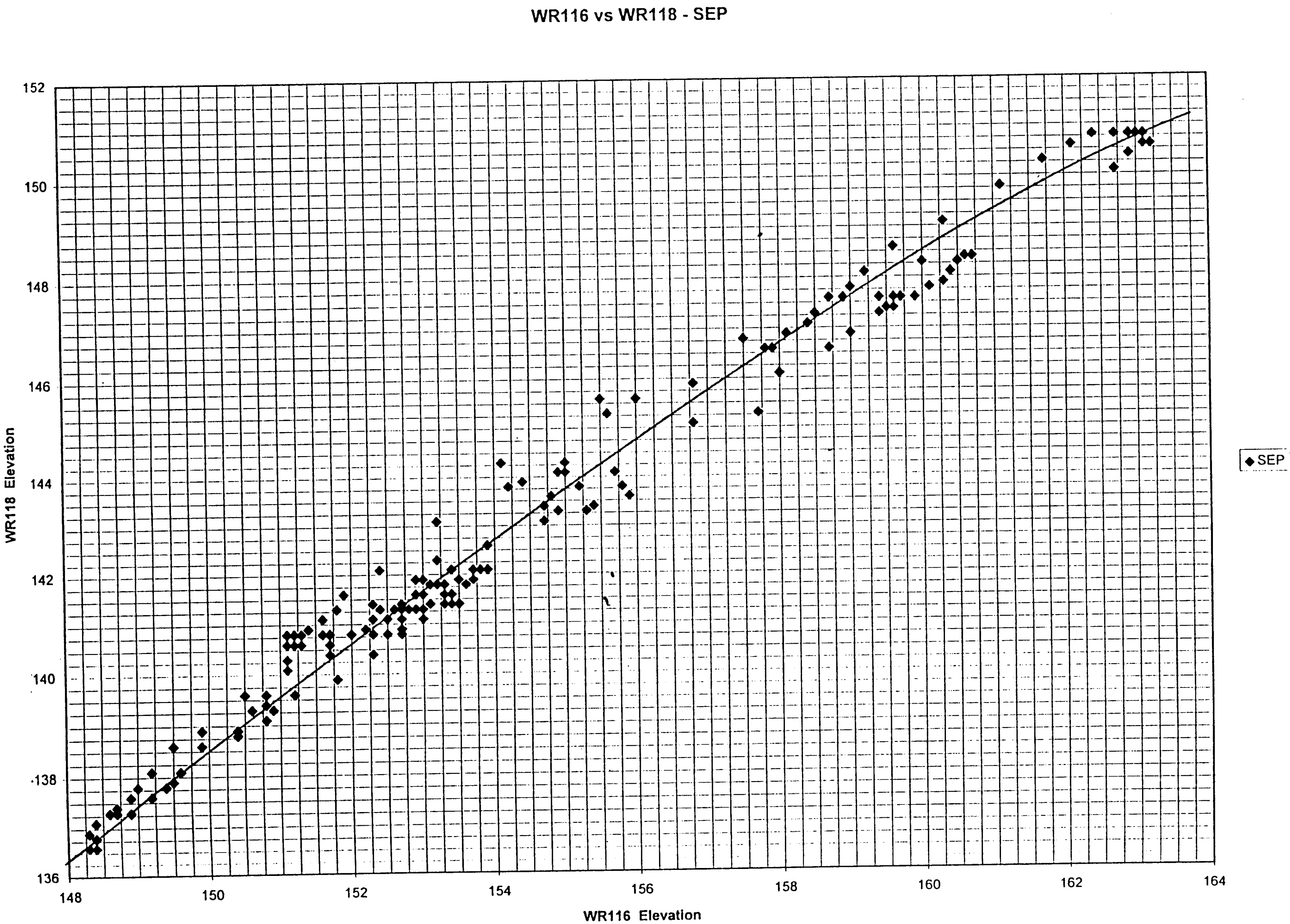

WR116 vs WR118 - JUL
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
154
152
150
148
146
144
142
140
138
150
152
154
156
158
160
162
164
WR116 Elevation
JUL

PLATE IV-78



WR116 vs WR118 - AUG
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
AUG
138
140
142
144
146
148
150
152
150
152
154
156
158
160
162
164


PLATE IV-79


WR116 vs WR118 - SEP
152
150
148
146
144
142
140
138
136
WR118 Elevation
148
150
152
154
156
158
160
162
164
WR116 Elevation
SEP

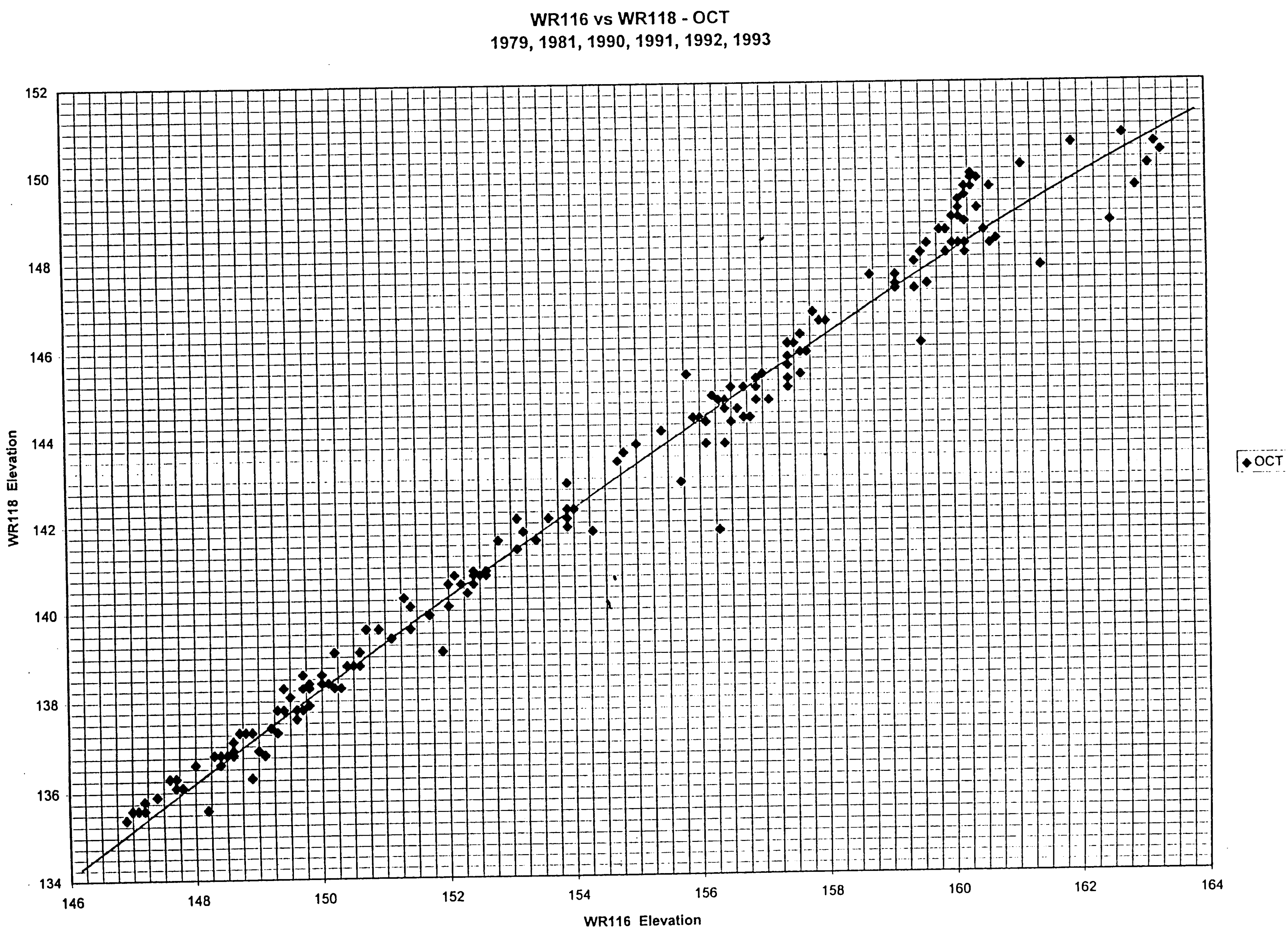

WR116 vs WR118 - OCT
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
152
150
148
146
144
142
140
138
136
134
146
148
150
152
154
156
158
160
162
164
WR116 Elevation
OCT

PLATE IV-81

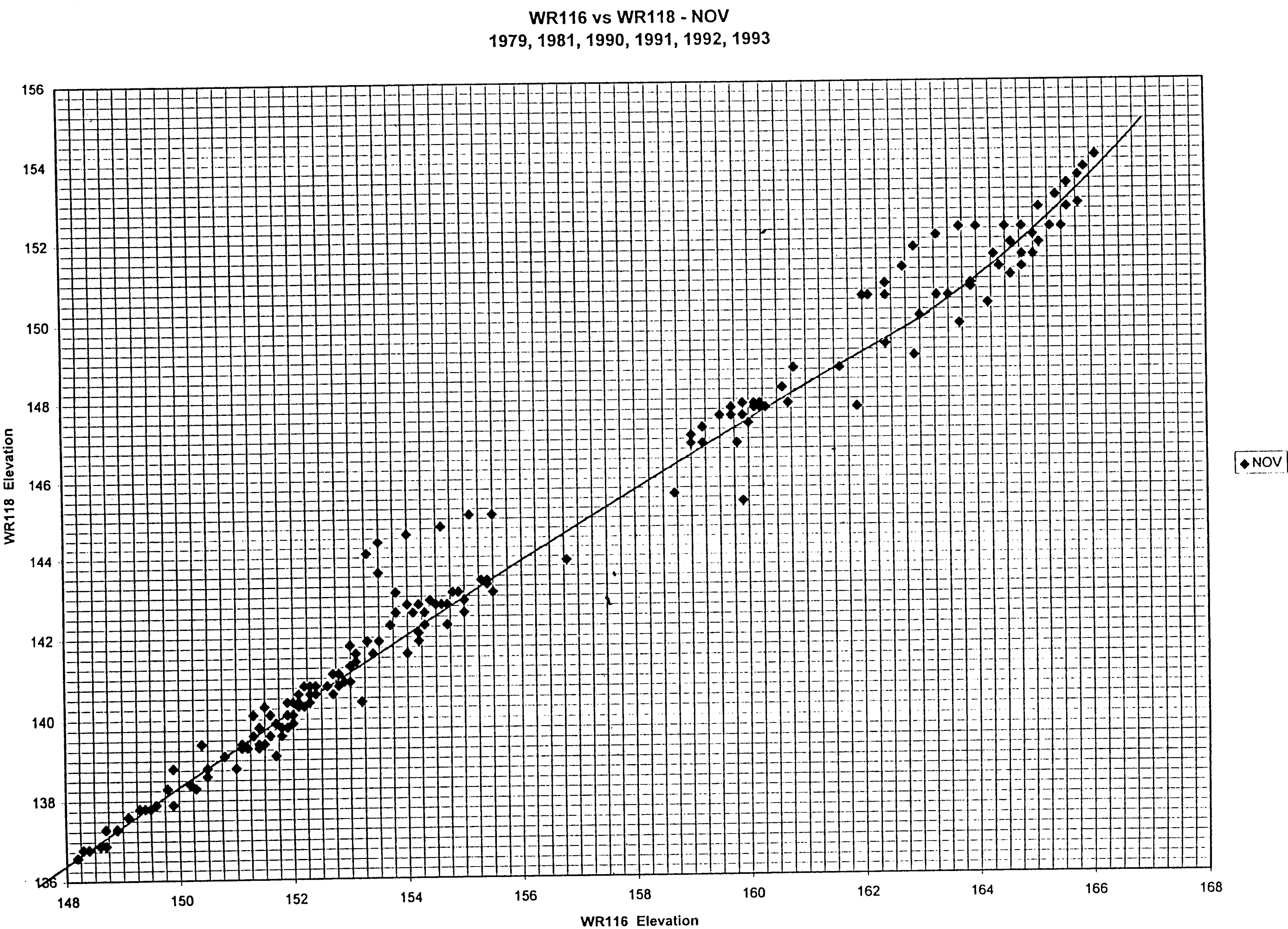
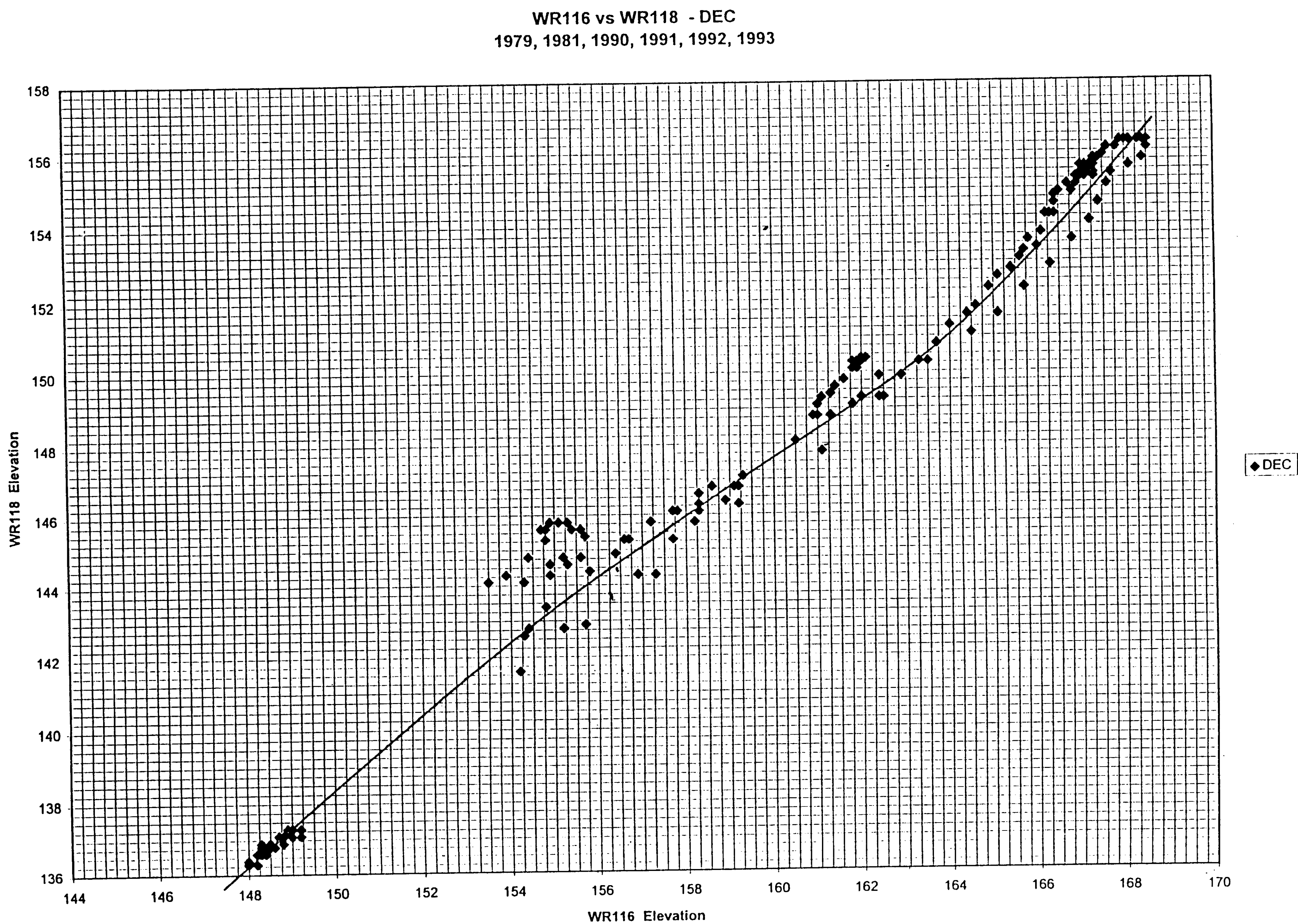

WR116 vs WR118 - NOV
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
NOV
136
138
140
142
144
146
148
150
152
154
156
148
150
152
154
156
158
160
162
164
166
168

PLATE IV-82



WR116 vs WR118 - DEC
1979, 1981, 1990, 1991, 1992, 1993
WR118 Elevation
WR116 Elevation
DEC
158
156
154
152
150
148
146
144
142
140
138
136
144
146
148
150
152
154
156
158
160
162
164
166
168
170


PLATE IV-83

WR118 vs MS136 - JAN
1979, 1981, 1990, 1991, 1992, 1993

NO SINGULAR RELATIONSHIP

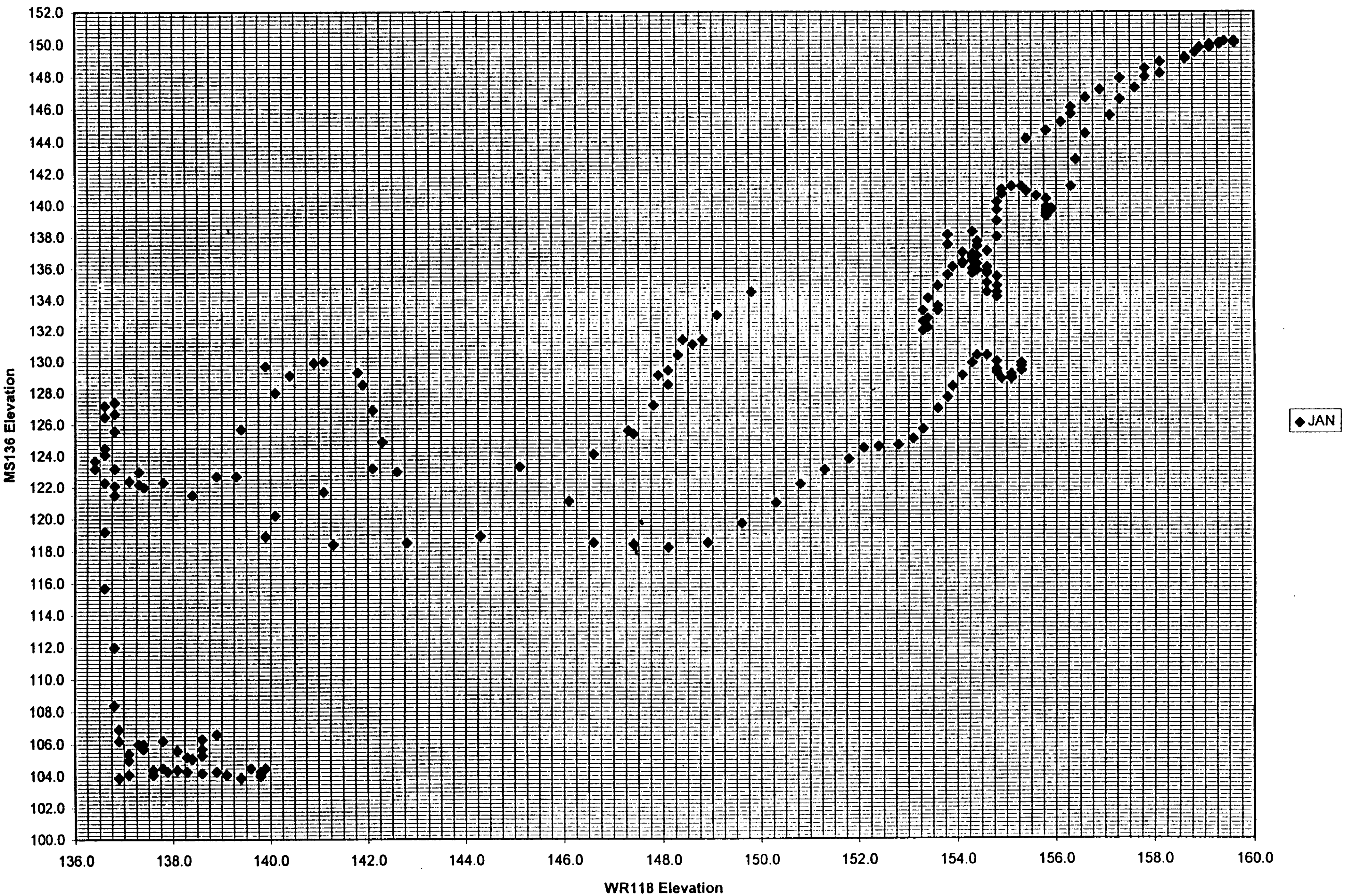
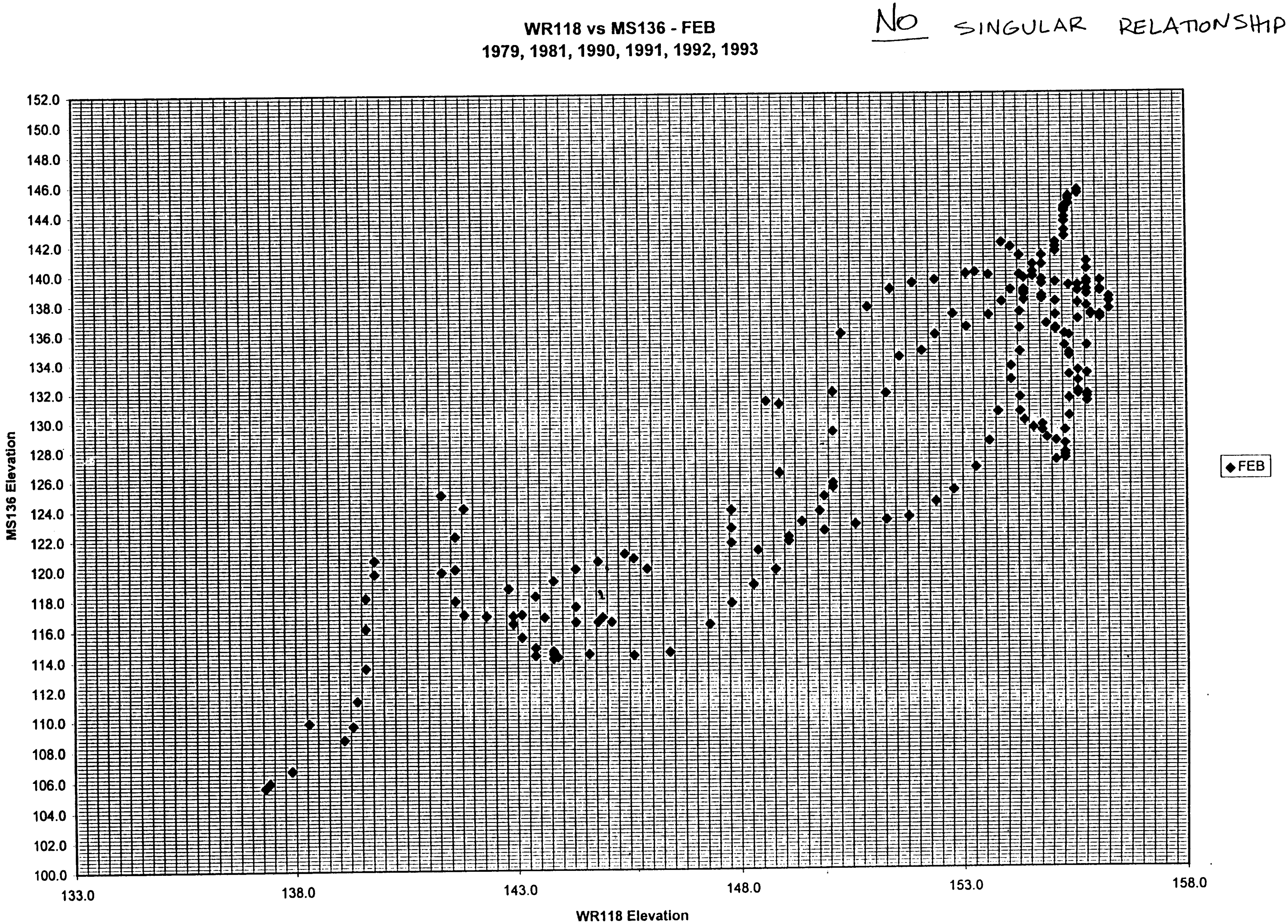



PLATE IV-84


NO SINGULAR RELATIONSHIP
WR118 vs MS136 - FEB
1979, 1981, 1990, 1991, 1992, 1993
MS136 Elevation
WR118 Elevation
FEB
152.0
150.0
148.0
146.0
144.0
142.0
140.0
138.0
136.0
134.0
132.0
130.0
128.0
126.0
124.0
122.0
120.0
118.0
116.0
114.0
112.0
110.0
108.0
106.0
104.0
102.0
100.0
133.0
138.0
143.0
148.0
153.0
158.0

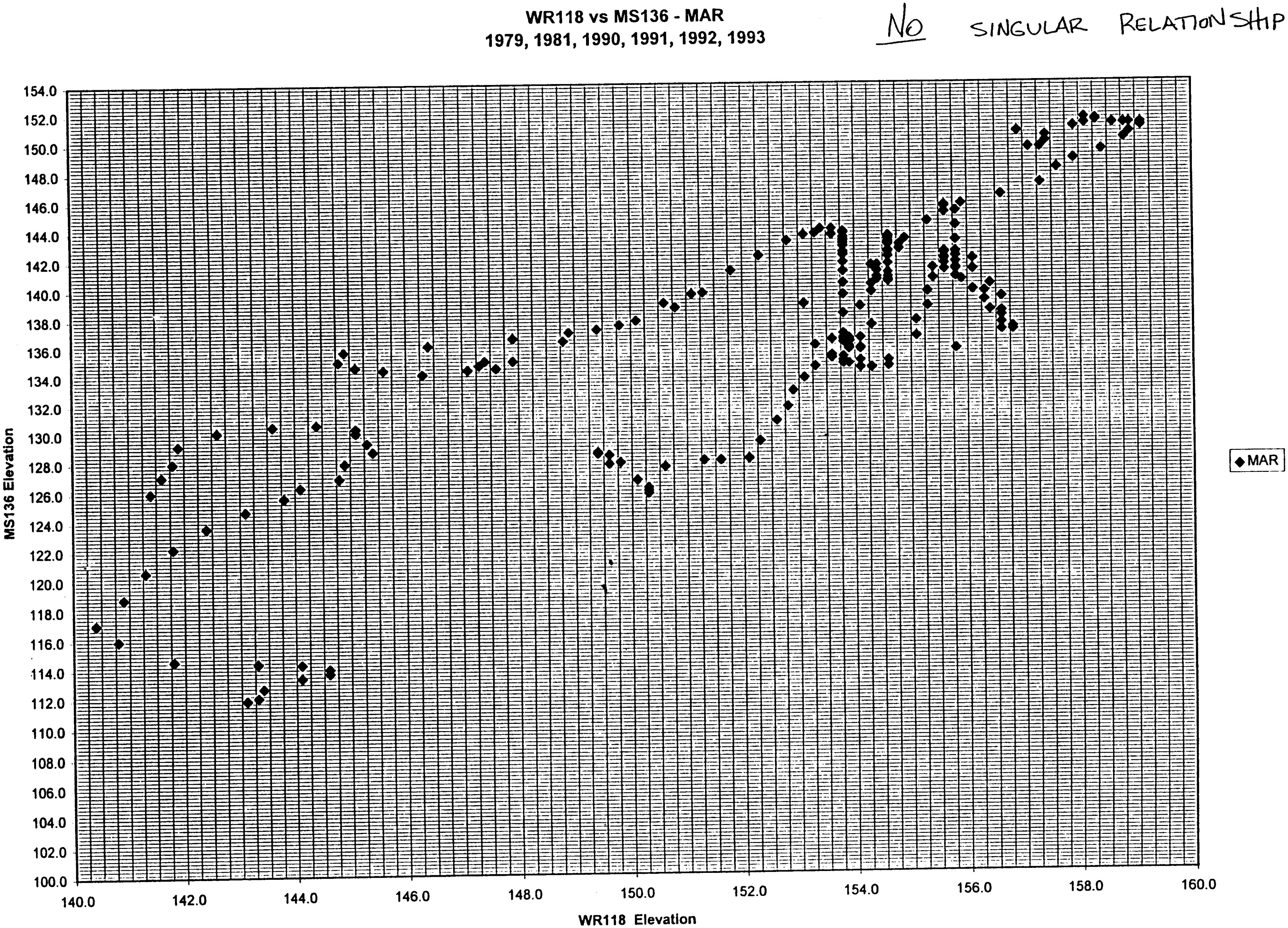

WR118 vs MS136 - MAR
1979, 1981, 1990, 1991, 1992, 1993
NO SINGULAR RELATIONSHIP
MS136 Elevation
WR118 Elevation
MAR
154.0
152.0
150.0
148.0
146.0
144.0
142.0
140.0
138.0
136.0
134.0
132.0
130.0
128.0
126.0
124.0
122.0
120.0
118.0
116.0
114.0
112.0
110.0
108.0
106.0
104.0
102.0
100.0
140.0
142.0
144.0
146.0
148.0
150.0
152.0
154.0
156.0
158.0
160.0

PLATE IV-86

NO SINGULAR RELATIONSHIP

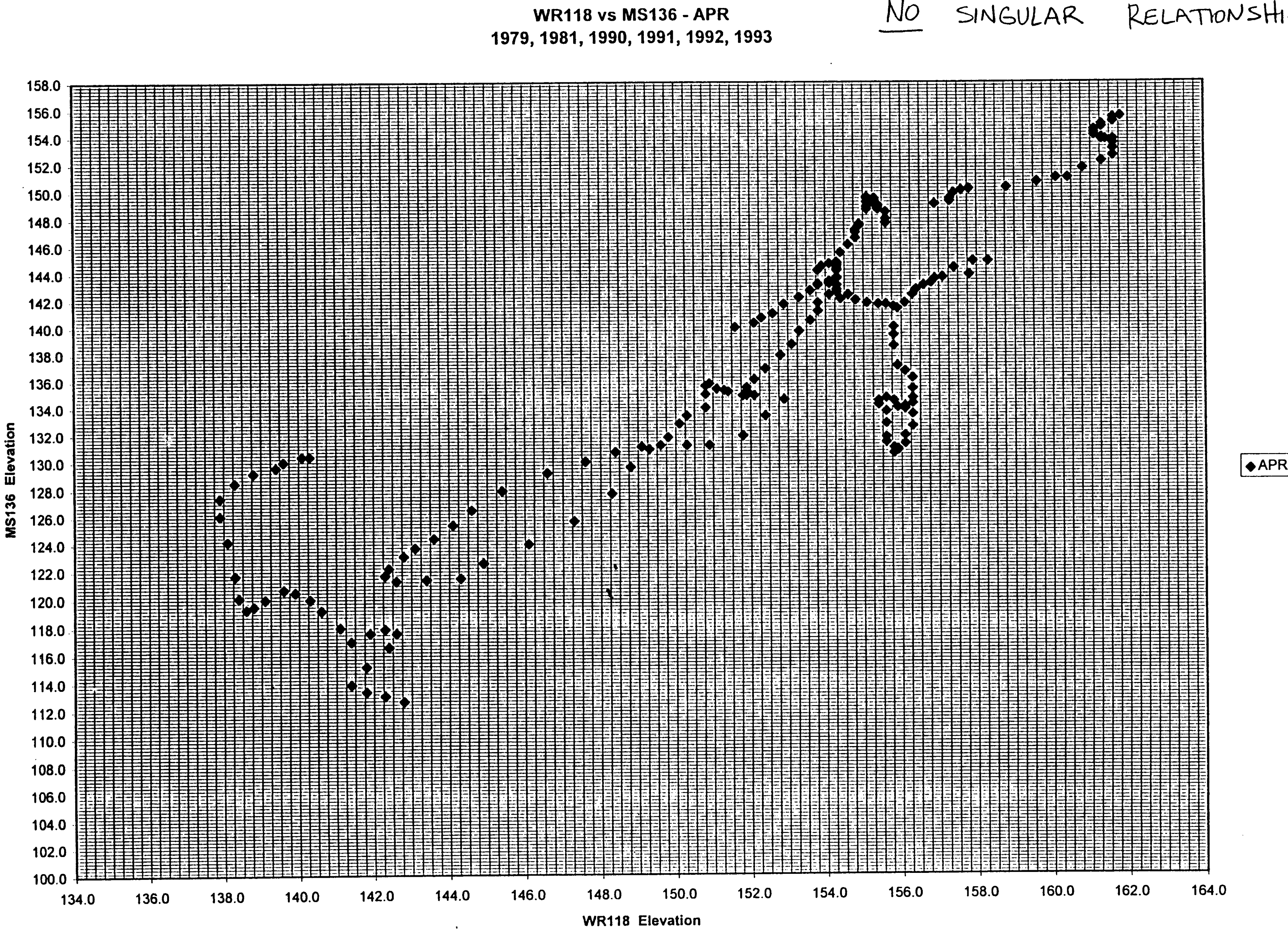



PLATE IV-87

NO SINGULAR RELATIONSHIP

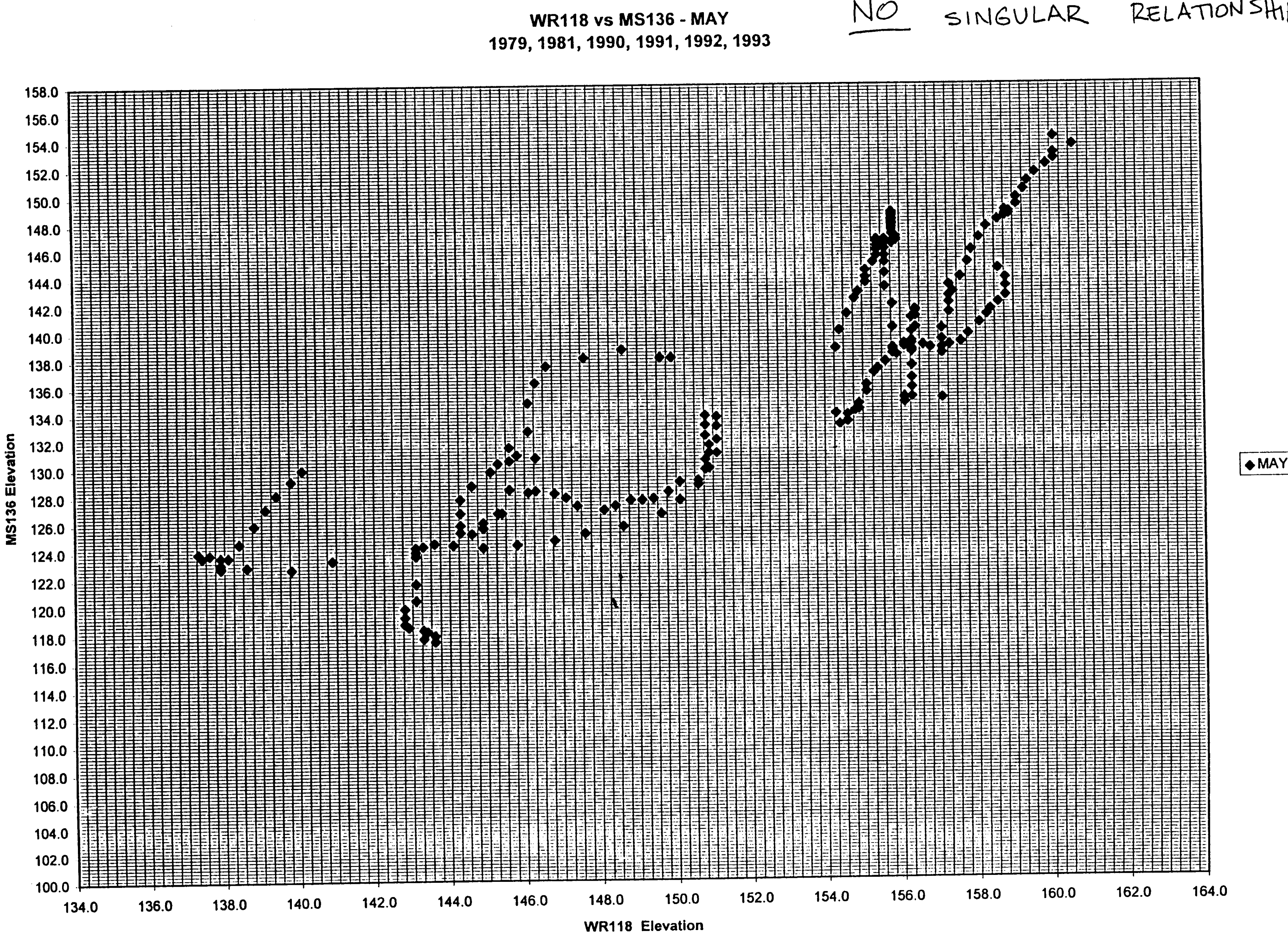
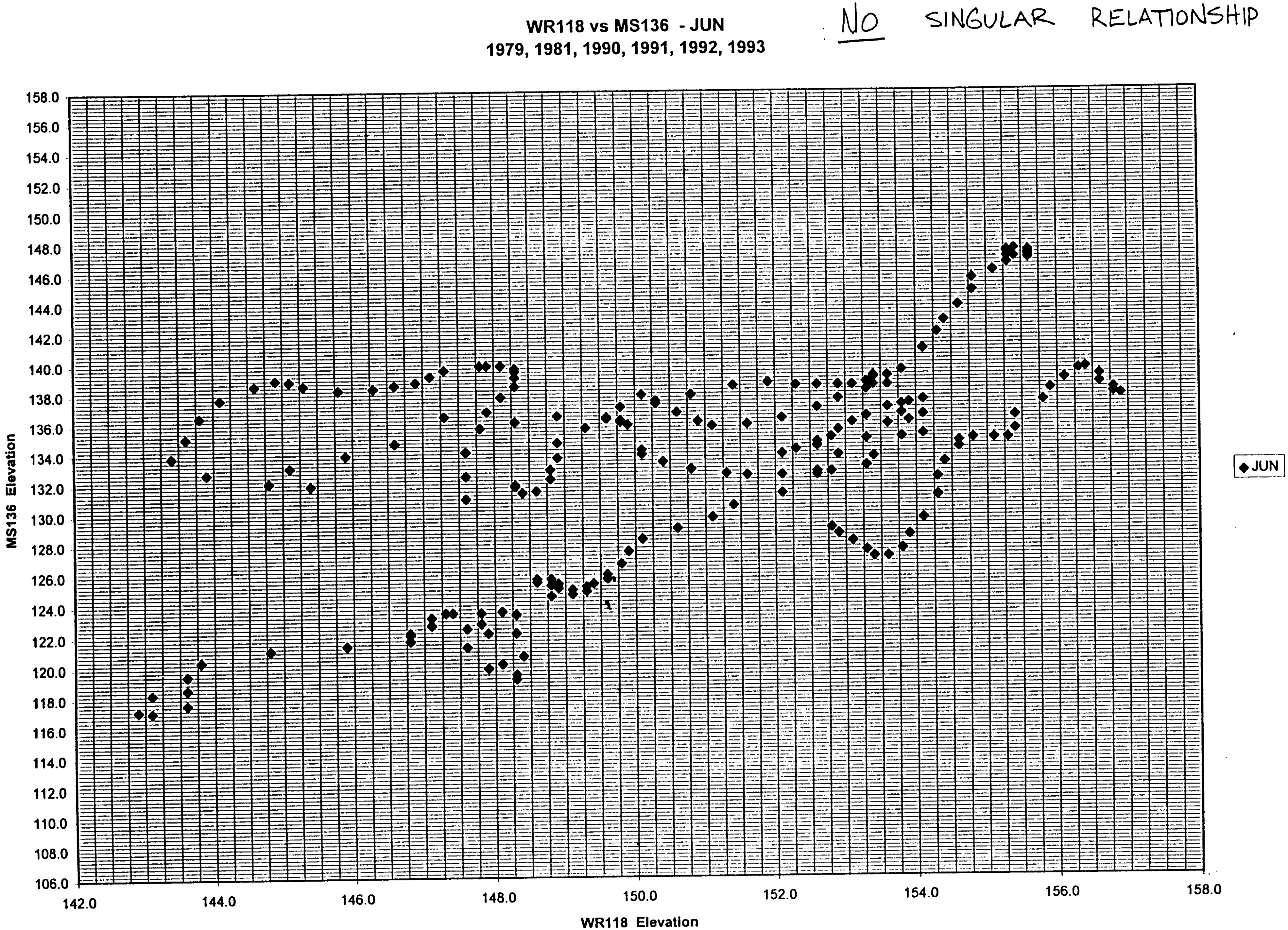



PLATE IV-88

NO SINGULAR RELATIONSHIP



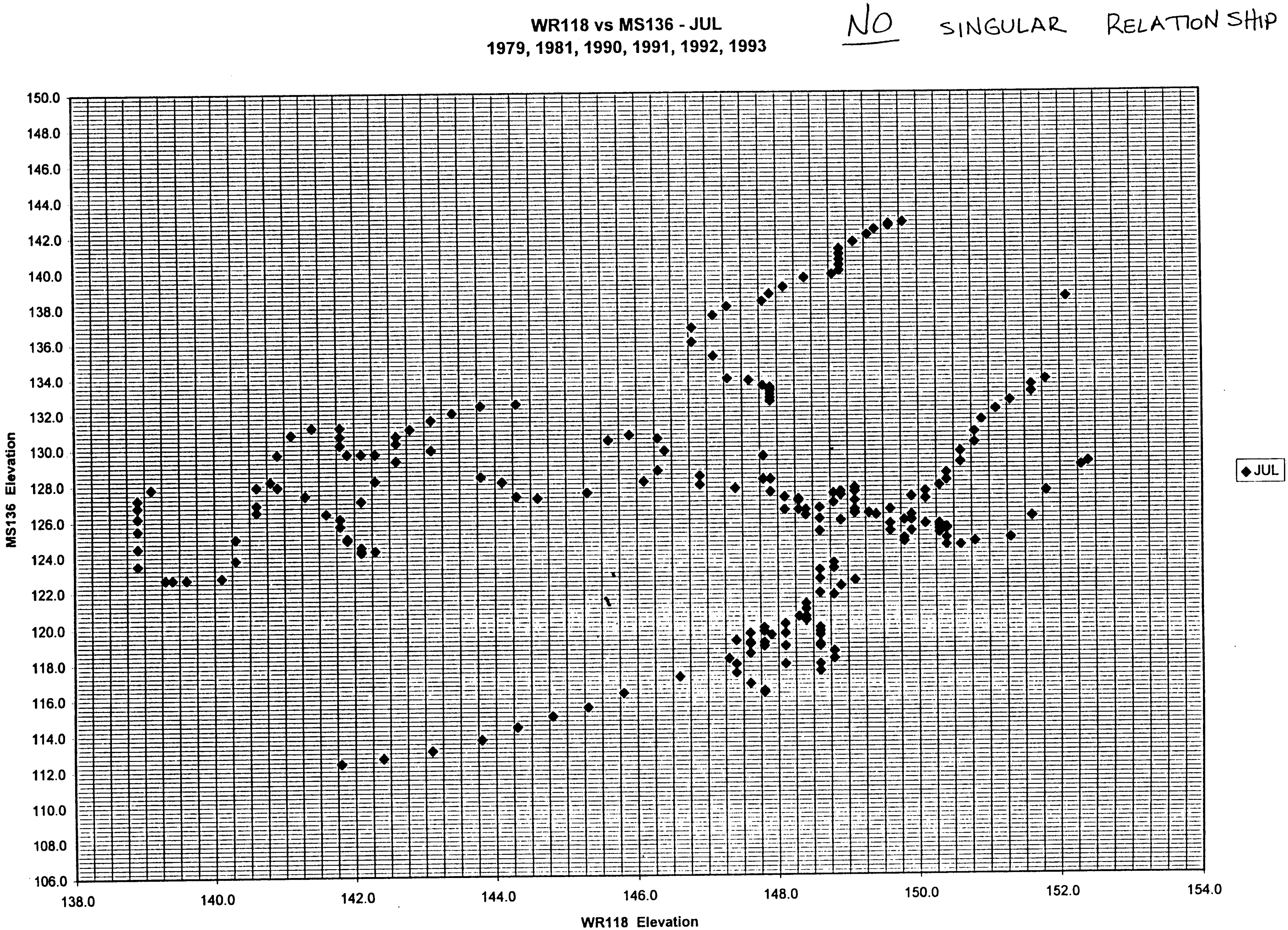

WR118 vs MS136 - JUL
1979, 1981, 1990, 1991, 1992, 1993
NO SINGULAR RELATIONSHIP
MS136 Elevation
WR118 Elevation
JUL
150.0
148.0
146.0
144.0
142.0
140.0
138.0
136.0
134.0
132.0
130.0
128.0
126.0
124.0
122.0
120.0
118.0
116.0
114.0
112.0
110.0
108.0
106.0
138.0
140.0
142.0
144.0
146.0
148.0
150.0
152.0
154.0

PLATE IV-90

WR118 vs MS136 - AUG
1979, 1981, 1990, 1991, 1992, 1993

NO SINGULAR RELATIONSHIP

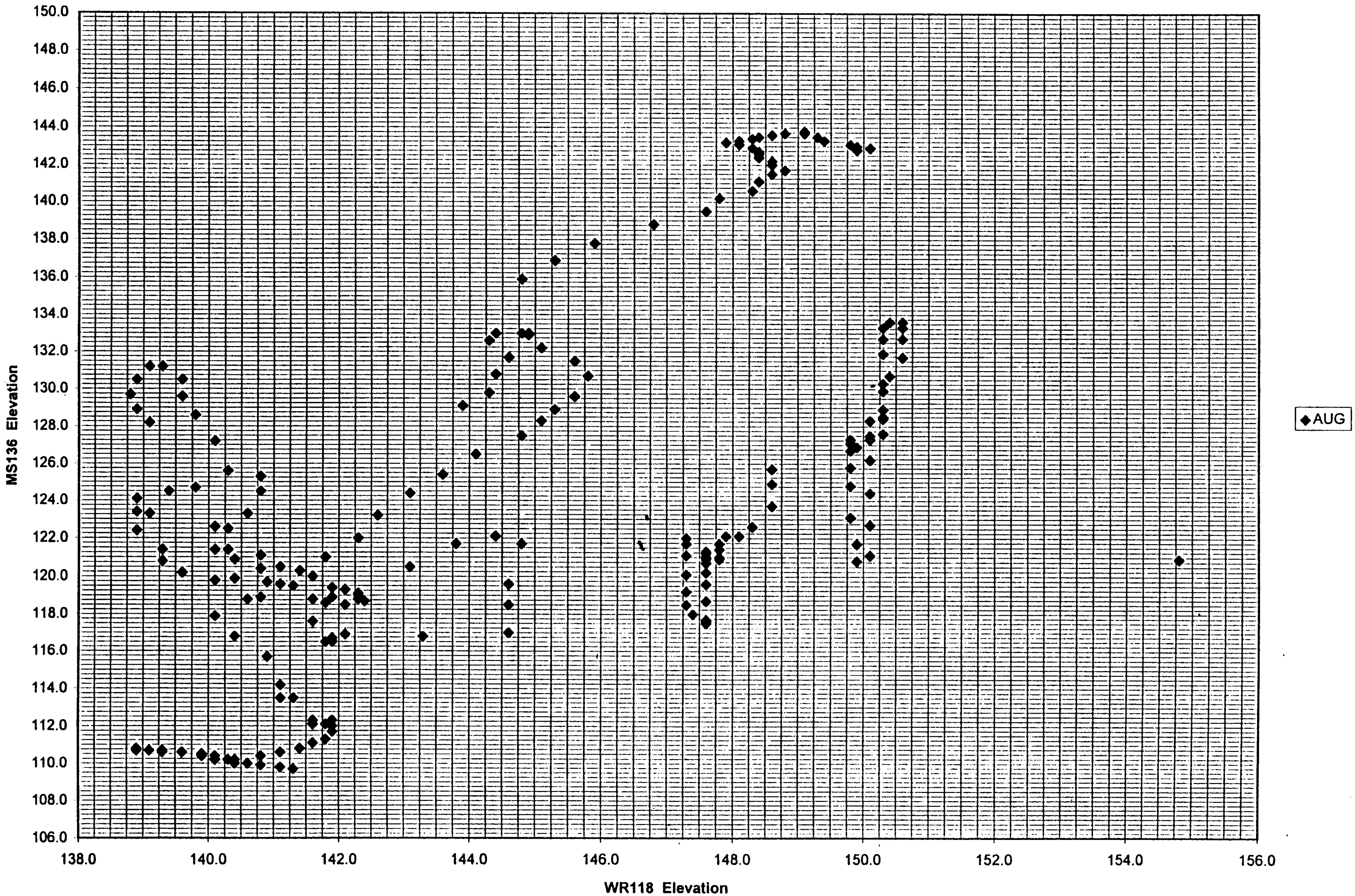



PLATE IV-91

NO SINGULAR RELATIONSHIP

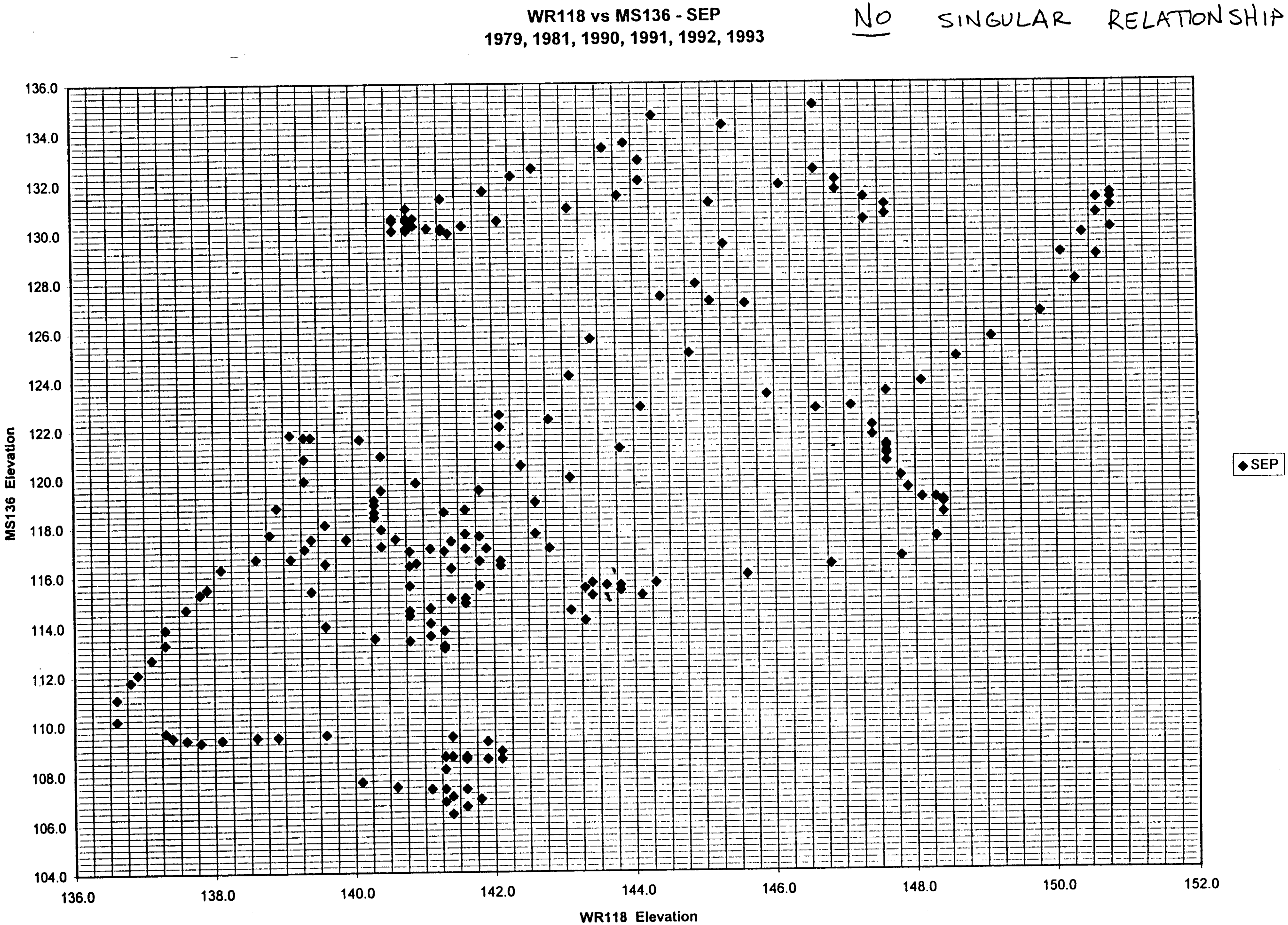



PLATE IV-92

NO SINGULAR RELATIONSHIP

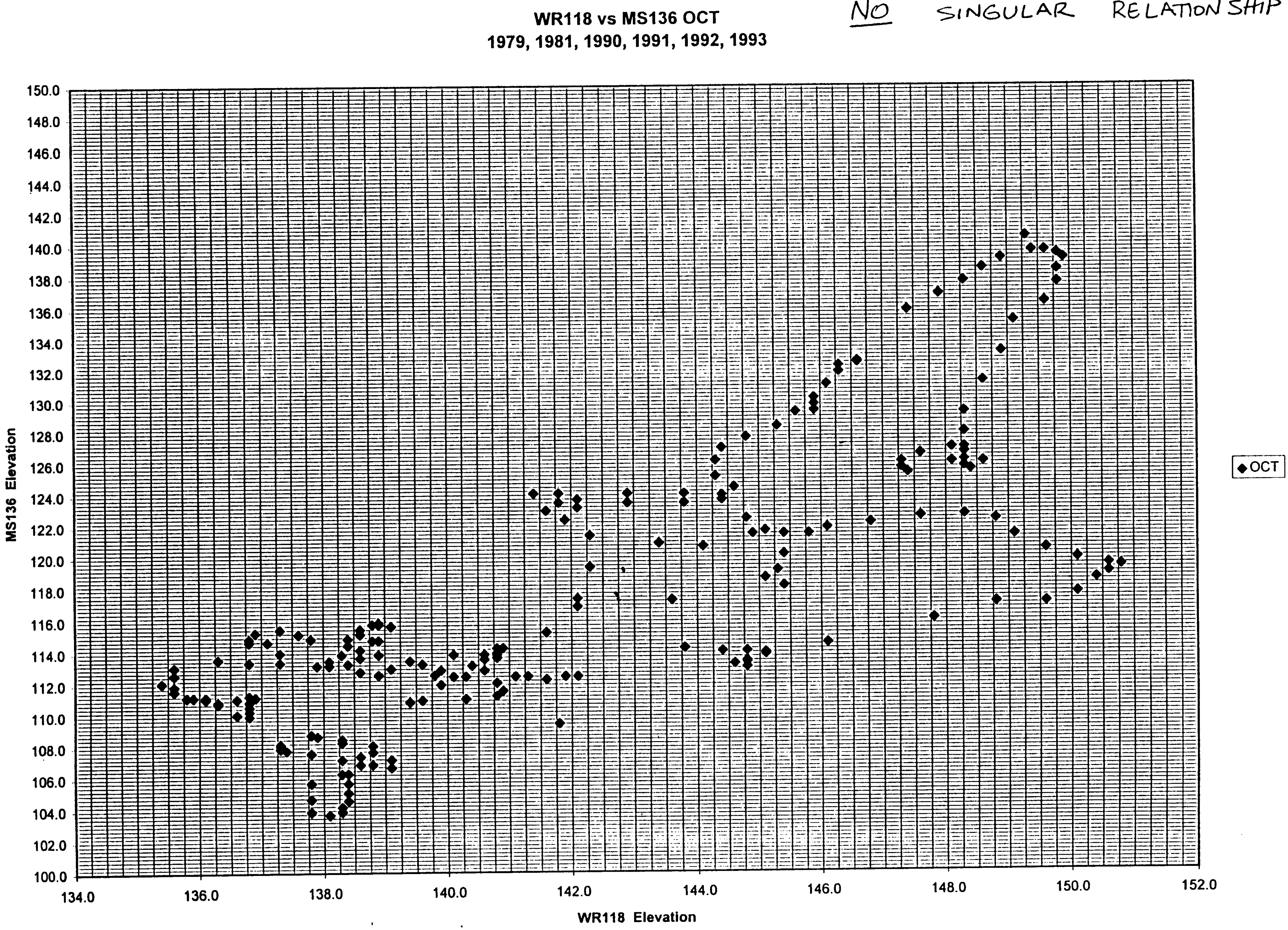



PLATE IV-93

NO SINGULAR RELATIONSHIP

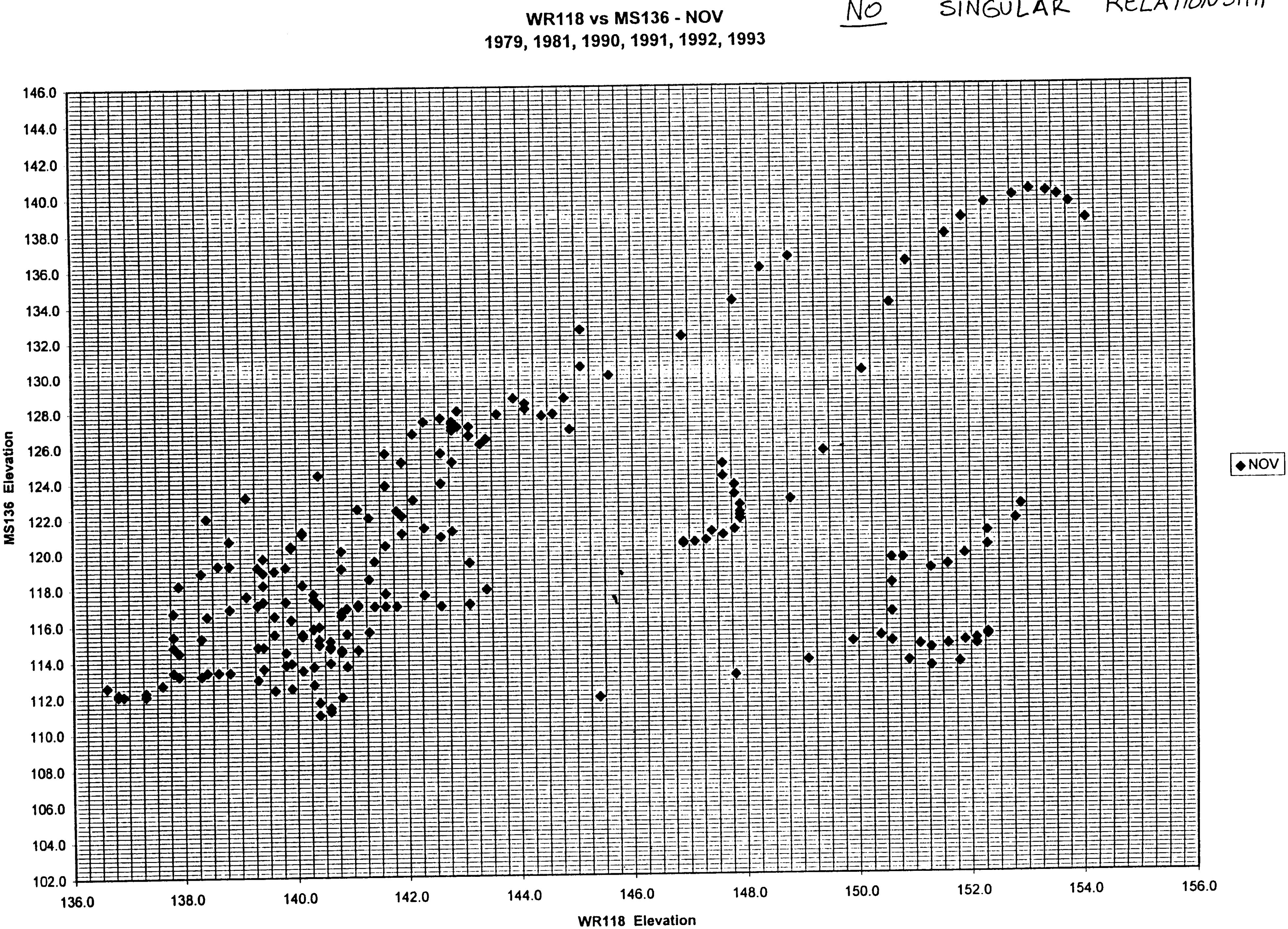
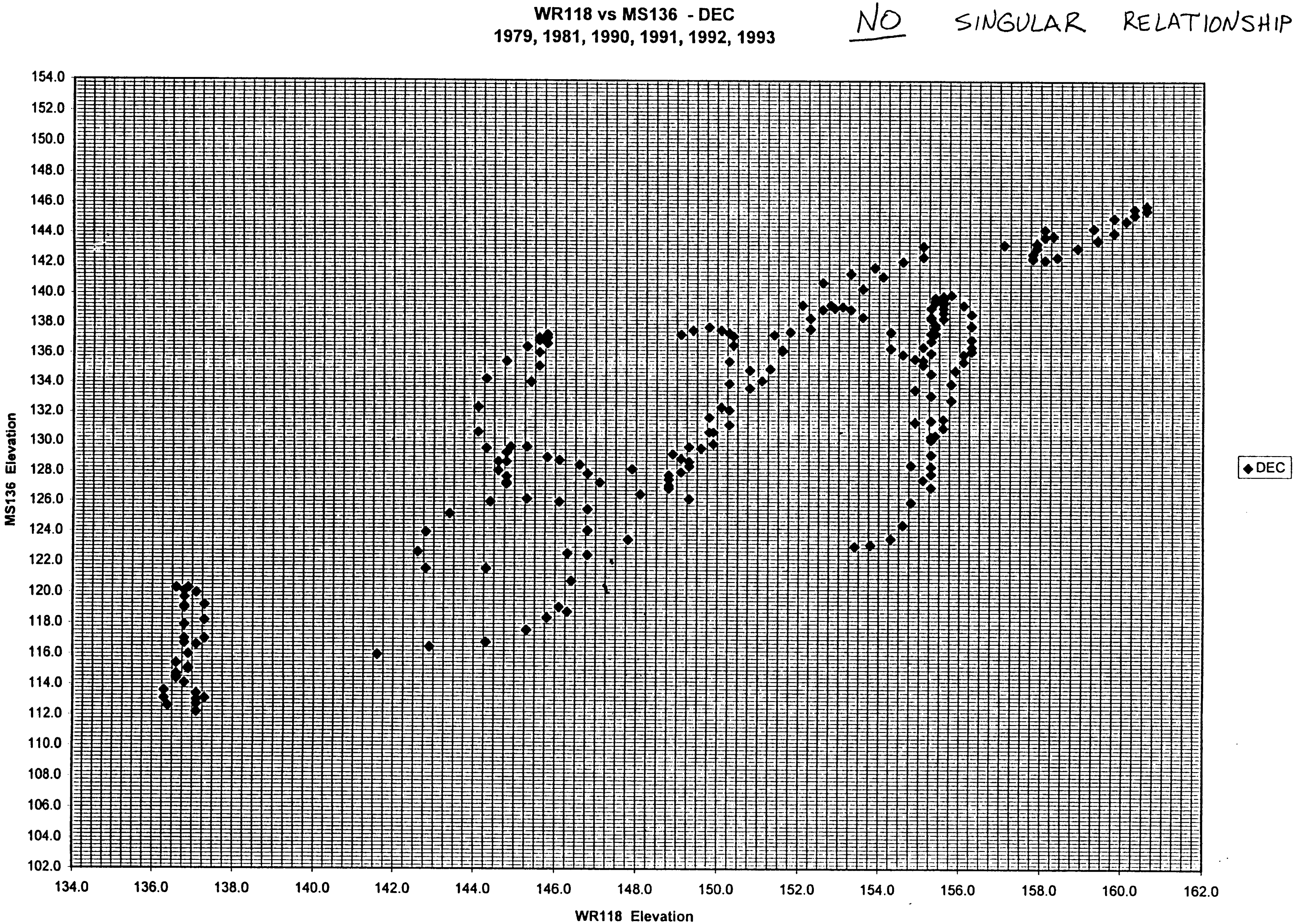



PLATE IV-94

NO SINGULAR RELATIONSHIP



## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| Annual Totals | | | | | | |
| 31-Dec-40 | 375243 | 109020 | 216747 | 225955 | 207211 | 232330 |
| 31-Dec-41 | 350291 | 115570 | 202344 | 207780 | 196368 | 210712 |
| 31-Dec-42 | 380457 | 136103 | 380457 | 380457 | 380457 | 380457 |
| 31-Dec-43 | 382840 | 93581 | 381493 | 381739 | 381247 | 381985 |
| 31-Dec-44 | 386170 | 136024 | 384290 | 384422 | 384147 | 384432 |
| 31-Dec-45 | 381102 | 157207 | 381102 | 381102 | 381102 | 381102 |
| 31-Dec-46 | 368244 | 109206 | 368244 | 368244 | 368244 | 368244 |
| 31-Dec-47 | 394191 | 111863 | 394191 | 394191 | 393988 | 394191 |
| 31-Dec-48 | 379547 | 173244 | 379547 | 379547 | 379547 | 379547 |
| 31-Dec-49 | 342056 | 119112 | 341817 | 341817 | 341666 | 341865 |
| 31-Dec-50 | 383520 | 154917 | 383520 | 383520 | 383520 | 383520 |
| 31-Dec-51 | 373371 | 103452 | 373371 | 373371 | 373371 | 373371 |
| 31-Dec-52 | 410862 | 96558 | 409186 | 409244 | 408895 | 409595 |
| 31-Dec-53 | 384516 | 184589 | 381511 | 381511 | 381383 | 381681 |
| 31-Dec-54 | 396917 | 56559 | 76583 | 78531 | 74959 | 79945 |
| 31-Dec-55 | 362589 | 113010 | 361181 | 361478 | 361032 | 361776 |
| 31-Dec-56 | 377308 | 93955 | 314037 | 331097 | 293470 | 341044 |
| 31-Dec-57 | 368204 | 195678 | 368204 | 368204 | 368204 | 368204 |
| 31-Dec-58 | 355889 | 206502 | 355889 | 355889 | 355889 | 355889 |
| 31-Dec-59 | 390143 | 104573 | 356869 | 371588 | 334891 | 389613 |
| 31-Dec-60 | 398823 | 119149 | 409708 | 409966 | 409580 | 410379 |
| 31-Dec-61 | 398823 | 135656 | 398823 | 398823 | 398823 | 398823 |
| 31-Dec-62 | 453559 | 79522 | 372606 | 394614 | 344217 | 421019 |
| 31-Dec-63 | 455274 | 79546 | 262957 | 275437 | 246061 | 289185 |
| 31-Dec-64 | 451438 | 155336 | 367335 | 381013 | 349709 | 390576 |
| 31-Dec-65 | 506523 | 70964 | 353099 | 377610 | 325742 | 401389 |
| 31-Dec-66 | 444373 | 86341 | 440844 | 441362 | 413419 | 441565 |
| 31-Dec-67 | 413099 | 111774 | 342701 | 361898 | 322820 | 377873 |
| 31-Dec-68 | 422194 | 129966 | 420759 | 420868 | 420529 | 421441 |
| 31-Dec-69 | 537375 | 58368 | 446527 | 477091 | 410032 | 511761 |
| 31-Dec-70 | 393689 | 137522 | 393296 | 393555 | 393023 | 393689 |
| 31-Dec-71 | 441090 | 104317 | 289953 | 301607 | 273829 | 316989 |
| 31-Dec-72 | 489420 | 57098 | 258448 | 274488 | 241563 | 286568 |
| 31-Dec-73 | 504291 | 155697 | 504291 | 504291 | 504282 | 504291 |
| 31-Dec-74 | 319372 | 143917 | 319372 | 319372 | 319372 | 319372 |
| 31-Dec-75 | 487079 | 125944 | 485358 | 485494 | 485077 | 485604 |
| 31-Dec-76 | 450179 | 92633 | 335340 | 355399 | 314267 | 374099 |
| 31-Dec-77 | 489292 | 88986 | 264980 | 277365 | 249434 | 291209 |
| 31-Dec-78 | 443861 | 116022 | 442863 | 442898 | 442766 | 443249 |
| 31-Dec-79 | 339687 | 170034 | 339687 | 339687 | 339687 | 339687 |
| 31-Dec-80 | 618054 | 123565 | 243129 | 255912 | 230017 | 269607 |
| 31-Dec-81 | 522522 | 104235 | 297871 | 314262 | 280296 | 327323 |
| 31-Dec-82 | 588003 | 111713 | 380128 | 393576 | 360146 | 412386 |
| 31-Dec-83 | 513199 | 129042 | 511736 | 512585 | 511513 | 512946 |

# Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Dec-84 | 559002 | 130191 | 558090 | 558282 | 537636 | 558396 |
| 31-Dec-85 | 512267 | 92243 | 511576 | 511705 | 511317 | 511932 |
| 31-Dec-86 | 583141 | 57567 | 392841 | 416797 | 364577 | 438554 |
| Monthly Totals | | | | | | |
| 31-Jan-40 | 165 | 165 | 165 | 165 | 165 | 165 |
| 29-Feb-40 | 175 | 175 | 175 | 175 | 175 | 175 |
| 31-Mar-40 | 333 | 333 | 333 | 333 | 333 | 333 |
| 30-Apr-40 | 7870 | 7870 | 7870 | 7870 | 7870 | 7870 |
| 31-May-40 | 43577 | 43577 | 43577 | 43577 | 43577 | 43577 |
| 30-Jun-40 | 89353 | 21295 | 86202 | 89353 | 80063 | 89353 |
| 31-Jul-40 | 98331 | 20352 | 38089 | 42918 | 35991 | 48942 |
| 31-Aug-40 | 91962 | 3382 | 22501 | 23546 | 21464 | 24024 |
| 30-Sep-40 | 34719 | 5138 | 11101 | 11284 | 10839 | 11157 |
| 31-Oct-40 | 2146 | 2146 | 2146 | 2146 | 2146 | 2146 |
| 30-Nov-40 | 6613 | 4588 | 4588 | 4588 | 4588 | 4588 |
| 31-Dec-40 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-41 | 198 | 198 | 198 | 198 | 198 | 198 |
| 28-Feb-41 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-41 | 321 | 321 | 321 | 321 | 321 | 321 |
| 30-Apr-41 | 6288 | 6288 | 6288 | 6288 | 6288 | 6288 |
| 31-May-41 | 24615 | 24615 | 24615 | 24615 | 24615 | 24615 |
| 30-Jun-41 | 88905 | 39312 | 51729 | 52516 | 50943 | 53030 |
| 31-Jul-41 | 88270 | 19440 | 49355 | 50735 | 47774 | 51324 |
| 31-Aug-41 | 93624 | 15483 | 51392 | 53612 | 48623 | 54844 |
| 30-Sep-41 | 39078 | 3273 | 10869 | 11919 | 10036 | 12510 |
| 31-Oct-41 | 1978 | 1978 | 1978 | 1978 | 1978 | 1978 |
| 30-Nov-41 | 6833 | 4482 | 5419 | 5419 | 5413 | 5424 |
| 31-Dec-41 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-42 | 153 | 153 | 153 | 153 | 153 | 153 |
| 28-Feb-42 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-42 | 373 | 373 | 373 | 373 | 373 | 373 |
| 30-Apr-42 | 6625 | 6625 | 6625 | 6625 | 6625 | 6625 |
| 31-May-42 | 41147 | 41147 | 41147 | 41147 | 41147 | 41147 |
| 30-Jun-42 | 92037 | 57215 | 92037 | 92037 | 92037 | 92037 |
| 31-Jul-42 | 97841 | 3382 | 97841 | 97841 | 97841 | 97841 |
| 31-Aug-42 | 91680 | 10421 | 91680 | 91680 | 91680 | 91680 |
| 30-Sep-42 | 41105 | 9480 | 41105 | 41105 | 41105 | 41105 |
| 31-Oct-42 | 2741 | 2741 | 2741 | 2741 | 2741 | 2741 |
| 30-Nov-42 | 6575 | 4385 | 6575 | 6575 | 6575 | 6575 |
| 31-Dec-42 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-43 | 224 | 224 | 224 | 224 | 224 | 224 |
| 28-Feb-43 | 278 | 278 | 278 | 278 | 278 | 278 |
| 31-Mar-43 | 436 | 436 | 436 | 436 | 436 | 436 |
| 30-Apr-43 | 6575 | 6575 | 6575 | 6575 | 6575 | 6575 |

# Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-May-43 | 54966 | 54966 | 54966 | 54966 | 54966 | 54966 |
| 30-Jun-43 | 92551 | 15454 | 92551 | 92551 | 92551 | 92551 |
| 31-Jul-43 | 92384 | 3382 | 92384 | 92384 | 92384 | 92384 |
| 31-Aug-43 | 92765 | 3382 | 92765 | 92765 | 92765 | 92765 |
| 30-Sep-43 | 33679 | 3273 | 33679 | 33679 | 33679 | 33679 |
| 31-Oct-43 | 2339 | 2339 | 2339 | 2339 | 2339 | 2339 |
| 30-Nov-43 | 6643 | 3273 | 5296 | 5542 | 5050 | 5788 |
| 31-Dec-43 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-44 | 200 | 200 | 200 | 200 | 200 | 200 |
| 29-Feb-44 | 157 | 157 | 157 | 157 | 157 | 157 |
| 31-Mar-44 | 397 | 397 | 397 | 397 | 397 | 397 |
| 30-Apr-44 | 4739 | 4739 | 4739 | 4739 | 4739 | 4739 |
| 31-May-44 | 44154 | 44154 | 44154 | 44154 | 44154 | 44154 |
| 30-Jun-44 | 95254 | 53942 | 95254 | 95254 | 95254 | 95254 |
| 31-Jul-44 | 108089 | 3382 | 108089 | 108089 | 108089 | 108089 |
| 31-Aug-44 | 91232 | 5484 | 91232 | 91232 | 91232 | 91232 |
| 30-Sep-44 | 32640 | 17000 | 32640 | 32640 | 32640 | 32640 |
| 31-Oct-44 | 2991 | 2561 | 2991 | 2991 | 2991 | 2991 |
| 30-Nov-44 | 6317 | 4009 | 4437 | 4569 | 4294 | 4580 |
| 31-Dec-44 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-45 | 194 | 194 | 194 | 194 | 194 | 194 |
| 28-Feb-45 | 153 | 153 | 153 | 153 | 153 | 153 |
| 31-Mar-45 | 409 | 409 | 409 | 409 | 409 | 409 |
| 30-Apr-45 | 6768 | 6768 | 6768 | 6768 | 6768 | 6768 |
| 31-May-45 | 43283 | 43283 | 43283 | 43283 | 43283 | 43283 |
| 30-Jun-45 | 93271 | 68611 | 93271 | 93271 | 93271 | 93271 |
| 31-Jul-45 | 105269 | 14928 | 105269 | 105269 | 105269 | 105269 |
| 31-Aug-45 | 93586 | 3382 | 93586 | 93586 | 93586 | 93586 |
| 30-Sep-45 | 29070 | 11678 | 29070 | 29070 | 29070 | 29070 |
| 31-Oct-45 | 2864 | 2864 | 2864 | 2864 | 2864 | 2864 |
| 30-Nov-45 | 6236 | 4937 | 6236 | 6236 | 6236 | 6236 |
| 31-Dec-45 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-46 | 87 | 87 | 87 | 87 | 87 | 87 |
| 28-Feb-46 | 208 | 208 | 208 | 208 | 208 | 208 |
| 31-Mar-46 | 409 | 409 | 409 | 409 | 409 | 409 |
| 30-Apr-46 | 6819 | 6819 | 6819 | 6819 | 6819 | 6819 |
| 31-May-46 | 45140 | 45140 | 45140 | 45140 | 45140 | 45140 |
| 30-Jun-46 | 88635 | 26861 | 88635 | 88635 | 88635 | 88635 |
| 31-Jul-46 | 91898 | 12478 | 91898 | 91898 | 91898 | 91898 |
| 31-Aug-46 | 93915 | 6546 | 93915 | 93915 | 93915 | 93915 |
| 30-Sep-46 | 31533 | 3273 | 31533 | 31533 | 31533 | 31533 |
| 31-Oct-46 | 3138 | 2874 | 3138 | 3138 | 3138 | 3138 |
| 30-Nov-46 | 6460 | 4512 | 6460 | 6460 | 6460 | 6460 |
| 31-Dec-46 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-47 | 182 | 182 | 182 | 182 | 182 | 182 |
| 28-Feb-47 | 208 | 208 | 208 | 208 | 208 | 208 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Mar-47 | 458 | 458 | 458 | 458 | 458 | 458 |
| 30-Apr-47 | 6397 | 6397 | 6397 | 6397 | 6397 | 6397 |
| 31-May-47 | 41107 | 41107 | 41107 | 41107 | 41107 | 41107 |
| 30-Jun-47 | 93812 | 39838 | 93812 | 93812 | 93812 | 93812 |
| 31-Jul-47 | 113147 | 3382 | 113147 | 113147 | 113147 | 113147 |
| 31-Aug-47 | 97783 | 3382 | 97783 | 97783 | 97783 | 97783 |
| 30-Sep-47 | 31999 | 9495 | 31999 | 31999 | 31999 | 31999 |
| 31-Oct-47 | 2501 | 2501 | 2501 | 2501 | 2501 | 2501 |
| 30-Nov-47 | 6595 | 4913 | 6595 | 6595 | 6392 | 6595 |
| 31-Dec-47 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-48 | 111 | 111 | 111 | 111 | 111 | 111 |
| 29-Feb-48 | 129 | 129 | 129 | 129 | 129 | 129 |
| 31-Mar-48 | 333 | 333 | 333 | 333 | 333 | 333 |
| 30-Apr-48 | 7870 | 7870 | 7870 | 7870 | 7870 | 7870 |
| 31-May-48 | 46875 | 46875 | 46875 | 46875 | 46875 | 46875 |
| 30-Jun-48 | 88861 | 73404 | 88861 | 88861 | 88861 | 88861 |
| 31-Jul-48 | 100750 | 13374 | 100750 | 100750 | 100750 | 100750 |
| 31-Aug-48 | 91474 | 20796 | 91474 | 91474 | 91474 | 91474 |
| 30-Sep-48 | 34140 | 3273 | 34140 | 34140 | 34140 | 34140 |
| 31-Oct-48 | 2160 | 2160 | 2160 | 2160 | 2160 | 2160 |
| 30-Nov-48 | 6843 | 4918 | 6843 | 6843 | 6843 | 6843 |
| 31-Dec-48 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-49 | 75 | 75 | 75 | 75 | 75 | 75 |
| 28-Feb-49 | 236 | 236 | 236 | 236 | 236 | 236 |
| 31-Mar-49 | 321 | 321 | 321 | 321 | 321 | 321 |
| 30-Apr-49 | 6288 | 6288 | 6288 | 6288 | 6288 | 6288 |
| 31-May-49 | 25535 | 25535 | 25535 | 25535 | 25535 | 25535 |
| 30-Jun-49 | 86388 | 43723 | 86388 | 86388 | 86388 | 86388 |
| 31-Jul-49 | 86331 | 14840 | 86331 | 86331 | 86331 | 86331 |
| 31-Aug-49 | 92045 | 15692 | 92045 | 92045 | 92045 | 92045 |
| 30-Sep-49 | 35453 | 6433 | 35453 | 35453 | 35453 | 35453 |
| 31-Oct-49 | 2005 | 2005 | 2005 | 2005 | 2005 | 2005 |
| 30-Nov-49 | 7379 | 3963 | 7140 | 7140 | 6989 | 7188 |
| 31-Dec-49 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-50 | 85 | 85 | 85 | 85 | 85 | 85 |
| 28-Feb-50 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-50 | 373 | 373 | 373 | 373 | 373 | 373 |
| 30-Apr-50 | 6625 | 6625 | 6625 | 6625 | 6625 | 6625 |
| 31-May-50 | 43547 | 43547 | 43547 | 43547 | 43547 | 43547 |
| 30-Jun-50 | 94034 | 29515 | 94034 | 94034 | 94034 | 94034 |
| 31-Jul-50 | 103458 | 11519 | 103458 | 103458 | 103458 | 103458 |
| 31-Aug-50 | 89633 | 20662 | 89633 | 89633 | 89633 | 89633 |
| 30-Sep-50 | 35845 | 35845 | 35845 | 35845 | 35845 | 35845 |
| 31-Oct-50 | 2755 | 2755 | 2755 | 2755 | 2755 | 2755 |
| 30-Nov-50 | 6984 | 3810 | 6984 | 6984 | 6984 | 6984 |
| 31-Dec-50 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Jan-51 | 121 | 121 | 121 | 121 | 121 | 121 |
| 28-Feb-51 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-51 | 436 | 436 | 436 | 436 | 436 | 436 |
| 30-Apr-51 | 6575 | 6575 | 6575 | 6575 | 6575 | 6575 |
| 31-May-51 | 50168 | 30099 | 50168 | 50168 | 50168 | 50168 |
| 30-Jun-51 | 89141 | 15110 | 89141 | 89141 | 89141 | 89141 |
| 31-Jul-51 | 87717 | 24189 | 87717 | 87717 | 87717 | 87717 |
| 31-Aug-51 | 94703 | 7704 | 94703 | 94703 | 94703 | 94703 |
| 30-Sep-51 | 35028 | 11597 | 35028 | 35028 | 35028 | 35028 |
| 31-Oct-51 | 2372 | 2372 | 2372 | 2372 | 2372 | 2372 |
| 30-Nov-51 | 6928 | 5068 | 6928 | 6928 | 6928 | 6928 |
| 31-Dec-51 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-52 | 177 | 177 | 177 | 177 | 177 | 177 |
| 29-Feb-52 | 230 | 230 | 230 | 230 | 230 | 230 |
| 31-Mar-52 | 417 | 417 | 417 | 417 | 417 | 417 |
| 30-Apr-52 | 4739 | 4739 | 4739 | 4739 | 4739 | 4739 |
| 31-May-52 | 45374 | 45374 | 45374 | 45374 | 45374 | 45374 |
| 30-Jun-52 | 100225 | 20948 | 100225 | 100225 | 100225 | 100225 |
| 31-Jul-52 | 121287 | 3382 | 121287 | 121287 | 121287 | 121287 |
| 31-Aug-52 | 94383 | 8328 | 94383 | 94383 | 94383 | 94383 |
| 30-Sep-52 | 34050 | 6343 | 34050 | 34050 | 34050 | 34050 |
| 31-Oct-52 | 3080 | 2622 | 3080 | 3080 | 3080 | 3080 |
| 30-Nov-52 | 6900 | 3999 | 5225 | 5282 | 4933 | 5633 |
| 31-Dec-52 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-53 | 216 | 216 | 216 | 216 | 216 | 216 |
| 28-Feb-53 | 194 | 194 | 194 | 194 | 194 | 194 |
| 31-Mar-53 | 409 | 409 | 409 | 409 | 409 | 409 |
| 30-Apr-53 | 6768 | 6768 | 6768 | 6768 | 6768 | 6768 |
| 31-May-53 | 48857 | 48857 | 48857 | 48857 | 48857 | 48857 |
| 30-Jun-53 | 98416 | 98416 | 98416 | 98416 | 98416 | 98416 |
| 31-Jul-53 | 94542 | 16693 | 94542 | 94542 | 94542 | 94542 |
| 31-Aug-53 | 90125 | 3382 | 90125 | 90125 | 90125 | 90125 |
| 30-Sep-53 | 34683 | 3273 | 34683 | 34683 | 34683 | 34683 |
| 31-Oct-53 | 3205 | 3108 | 3205 | 3205 | 3205 | 3205 |
| 30-Nov-53 | 7101 | 3273 | 4096 | 4096 | 3968 | 4266 |
| 31-Dec-53 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-54 | 155 | 155 | 155 | 155 | 155 | 155 |
| 28-Feb-54 | 250 | 250 | 250 | 250 | 250 | 250 |
| 31-Mar-54 | 458 | 458 | 458 | 458 | 458 | 458 |
| 30-Apr-54 | 6397 | 6397 | 6397 | 6397 | 6397 | 6397 |
| 31-May-54 | 37436 | 30058 | 37436 | 37436 | 37436 | 37436 |
| 30-Jun-54 | 91880 | 3273 | 15161 | 17164 | 13537 | 18632 |
| 31-Jul-54 | 121968 | 3382 | 3382 | 3382 | 3382 | 3382 |
| 31-Aug-54 | 93249 | 3382 | 3382 | 3382 | 3382 | 3382 |
| 30-Sep-54 | 35732 | 3273 | 3273 | 3273 | 3273 | 3273 |
| 31-Oct-54 | 2674 | 2660 | 2666 | 2666 | 2666 | 2666 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 30-Nov-54 | 6718 | 3273 | 4024 | 3970 | 4024 | 3915 |
| 31-Dec-54 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-55 | 216 | 216 | 216 | 216 | 216 | 216 |
| 28-Feb-55 | 153 | 153 | 153 | 153 | 153 | 153 |
| 31-Mar-55 | 409 | 409 | 409 | 409 | 409 | 409 |
| 30-Apr-55 | 6819 | 6819 | 6819 | 6819 | 6819 | 6819 |
| 31-May-55 | 45542 | 45542 | 45542 | 45542 | 45542 | 45542 |
| 30-Jun-55 | 85271 | 35790 | 85271 | 85271 | 85271 | 85271 |
| 31-Jul-55 | 89292 | 10674 | 89292 | 89292 | 89292 | 89292 |
| 31-Aug-55 | 91323 | 3382 | 91323 | 91323 | 91323 | 91323 |
| 30-Sep-55 | 34106 | 3273 | 34106 | 34106 | 34106 | 34106 |
| 31-Oct-55 | 3142 | 3142 | 3142 | 3142 | 3142 | 3142 |
| 30-Nov-55 | 6315 | 3610 | 4907 | 5205 | 4758 | 5502 |
| 31-Dec-55 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-56 | 141 | 141 | 141 | 141 | 141 | 141 |
| 29-Feb-56 | 133 | 133 | 133 | 133 | 133 | 133 |
| 31-Mar-56 | 395 | 395 | 395 | 395 | 395 | 395 |
| 30-Apr-56 | 6668 | 6668 | 6668 | 6668 | 6668 | 6668 |
| 31-May-56 | 51562 | 42111 | 51562 | 51562 | 51562 | 51562 |
| 30-Jun-56 | 80148 | 9243 | 48243 | 50598 | 43764 | 55086 |
| 31-Jul-56 | 105594 | 5376 | 86974 | 92128 | 79927 | 95940 |
| 31-Aug-56 | 90974 | 12901 | 83628 | 89913 | 75894 | 90974 |
| 30-Sep-56 | 32380 | 9576 | 28574 | 31812 | 27330 | 32380 |
| 31-Oct-56 | 3053 | 2844 | 3025 | 3053 | 2961 | 3053 |
| 30-Nov-56 | 6260 | 4567 | 4695 | 4695 | 4695 | 4713 |
| 31-Dec-56 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-57 | 149 | 149 | 149 | 149 | 149 | 149 |
| 28-Feb-57 | 153 | 153 | 153 | 153 | 153 | 153 |
| 31-Mar-57 | 327 | 327 | 327 | 327 | 327 | 327 |
| 30-Apr-57 | 5474 | 5474 | 5474 | 5474 | 5474 | 5474 |
| 31-May-57 | 45848 | 45848 | 45848 | 45848 | 45848 | 45848 |
| 30-Jun-57 | 85129 | 85129 | 85129 | 85129 | 85129 | 85129 |
| 31-Jul-57 | 94983 | 24192 | 94983 | 94983 | 94983 | 94983 |
| 31-Aug-57 | 92263 | 12772 | 92263 | 92263 | 92263 | 92263 |
| 30-Sep-57 | 35536 | 14539 | 35536 | 35536 | 35536 | 35536 |
| 31-Oct-57 | 2523 | 2523 | 2523 | 2523 | 2523 | 2523 |
| 30-Nov-57 | 5820 | 4572 | 5820 | 5820 | 5820 | 5820 |
| 31-Dec-57 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-58 | 161 | 161 | 161 | 161 | 161 | 161 |
| 28-Feb-58 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-58 | 246 | 246 | 246 | 246 | 246 | 246 |
| 30-Apr-58 | 5802 | 5802 | 5802 | 5802 | 5802 | 5802 |
| 31-May-58 | 39217 | 39217 | 39217 | 39217 | 39217 | 39217 |
| 30-Jun-58 | 71736 | 71736 | 71736 | 71736 | 71736 | 71736 |
| 31-Jul-58 | 100036 | 51834 | 100036 | 100036 | 100036 | 100036 |
| 31-Aug-58 | 94233 | 10903 | 94233 | 94233 | 94233 | 94233 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

**Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project**

| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
|---|---|---|---|---|---|---|
| 30-Sep-58 | 34651 | 19126 | 34651 | 34651 | 34651 | 34651 |
| 31-Oct-58 | 3340 | 3326 | 3340 | 3340 | 3340 | 3340 |
| 30-Nov-58 | 6286 | 3970 | 6286 | 6286 | 6286 | 6286 |
| 31-Dec-58 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-59 | 157 | 157 | 157 | 157 | 157 | 157 |
| 28-Feb-59 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-59 | 488 | 488 | 488 | 488 | 488 | 488 |
| 30-Apr-59 | 7652 | 7652 | 7652 | 7652 | 7652 | 7652 |
| 31-May-59 | 53340 | 53340 | 53340 | 53340 | 53340 | 53340 |
| 30-Jun-59 | 94836 | 7391 | 94836 | 94836 | 94836 | 94836 |
| 31-Jul-59 | 99459 | 13552 | 99459 | 99459 | 93003 | 99459 |
| 31-Aug-59 | 92696 | 3382 | 60404 | 74583 | 46010 | 92595 |
| 30-Sep-59 | 31305 | 9759 | 30750 | 31291 | 29622 | 31305 |
| 31-Oct-59 | 3864 | 3864 | 3864 | 3864 | 3864 | 3864 |
| 30-Nov-59 | 6167 | 4809 | 5739 | 5739 | 5739 | 5737 |
| 31-Dec-59 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-60 | 202 | 202 | 145 | 145 | 145 | 145 |
| 29-Feb-60 | 206 | 175 | 171 | 171 | 171 | 171 |
| 31-Mar-60 | 904 | 881 | 315 | 315 | 315 | 315 |
| 30-Apr-60 | 9025 | 9025 | 8684 | 8684 | 8684 | 8684 |
| 31-May-60 | 49652 | 49652 | 46790 | 46790 | 46790 | 46790 |
| 30-Jun-60 | 99300 | 27339 | 91216 | 91216 | 91216 | 91216 |
| 31-Jul-60 | 108464 | 5129 | 123223 | 123223 | 123223 | 123223 |
| 31-Aug-60 | 87320 | 9778 | 94447 | 94447 | 94447 | 94447 |
| 30-Sep-60 | 31962 | 9366 | 35379 | 35379 | 35379 | 35379 |
| 31-Oct-60 | 6073 | 3443 | 4034 | 4034 | 4034 | 4034 |
| 30-Nov-60 | 5712 | 4158 | 5304 | 5562 | 5175 | 5975 |
| 31-Dec-60 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-61 | 202 | 202 | 202 | 202 | 202 | 202 |
| 28-Feb-61 | 194 | 194 | 194 | 194 | 194 | 194 |
| 31-Mar-61 | 482 | 482 | 482 | 482 | 482 | 482 |
| 30-Apr-61 | 8128 | 8128 | 8128 | 8128 | 8128 | 8128 |
| 31-May-61 | 47330 | 47330 | 47330 | 47330 | 47330 | 47330 |
| 30-Jun-61 | 98342 | 47008 | 98342 | 98342 | 98342 | 98342 |
| 31-Jul-61 | 109779 | 5456 | 109779 | 109779 | 109779 | 109779 |
| 31-Aug-61 | 89435 | 9778 | 89435 | 89435 | 89435 | 89435 |
| 30-Sep-61 | 32973 | 9305 | 32973 | 32973 | 32973 | 32973 |
| 31-Oct-61 | 6018 | 3505 | 6018 | 6018 | 6018 | 6018 |
| 30-Nov-61 | 5939 | 4267 | 5939 | 5939 | 5939 | 5939 |
| 31-Dec-61 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-62 | 113 | 113 | 113 | 113 | 113 | 113 |
| 28-Feb-62 | 208 | 208 | 208 | 208 | 208 | 208 |
| 31-Mar-62 | 595 | 595 | 595 | 595 | 595 | 595 |
| 30-Apr-62 | 9166 | 9166 | 9166 | 9166 | 9166 | 9166 |
| 31-May-62 | 68239 | 21255 | 68239 | 68239 | 68239 | 68239 |
| 30-Jun-62 | 104005 | 20113 | 104005 | 104005 | 104005 | 104005 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Jul-62 | 136399 | 8130 | 114926 | 133905 | 89737 | 136399 |
| 31-Aug-62 | 91460 | 3382 | 34523 | 37496 | 31323 | 61330 |
| 30-Sep-62 | 29111 | 7659 | 29111 | 29111 | 29111 | 29111 |
| 31-Oct-62 | 7872 | 5478 | 7872 | 7872 | 7872 | 7872 |
| 30-Nov-62 | 6389 | 3423 | 3846 | 3902 | 3846 | 3979 |
| 31-Dec-62 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-63 | 214 | 214 | 214 | 214 | 214 | 214 |
| 28-Feb-63 | 180 | 180 | 180 | 180 | 180 | 180 |
| 31-Mar-63 | 837 | 837 | 837 | 837 | 837 | 837 |
| 30-Apr-63 | 11113 | 11113 | 11113 | 11113 | 11113 | 11113 |
| 31-May-63 | 58026 | 36757 | 58026 | 58026 | 57948 | 58026 |
| 30-Jun-63 | 108313 | 3273 | 56508 | 60992 | 48346 | 69430 |
| 31-Jul-63 | 141425 | 5804 | 61935 | 66131 | 57738 | 69062 |
| 31-Aug-63 | 92908 | 3382 | 42981 | 45919 | 39448 | 47696 |
| 30-Sep-63 | 25242 | 11331 | 24507 | 25242 | 23581 | 25242 |
| 31-Oct-63 | 10629 | 3382 | 3382 | 3509 | 3382 | 4110 |
| 30-Nov-63 | 6385 | 3273 | 3273 | 3273 | 3273 | 3273 |
| 31-Dec-63 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-64 | 216 | 216 | 216 | 216 | 216 | 216 |
| 29-Feb-64 | 143 | 143 | 143 | 143 | 143 | 143 |
| 31-Mar-64 | 885 | 885 | 885 | 885 | 885 | 885 |
| 30-Apr-64 | 10302 | 10302 | 10302 | 10302 | 10302 | 10302 |
| 31-May-64 | 68434 | 68434 | 68434 | 68434 | 68434 | 68434 |
| 30-Jun-64 | 123862 | 50082 | 123862 | 123862 | 123862 | 123862 |
| 31-Jul-64 | 111886 | 3447 | 85039 | 95967 | 70158 | 103637 |
| 31-Aug-64 | 102006 | 5155 | 46283 | 49033 | 43537 | 50926 |
| 30-Sep-64 | 15235 | 3326 | 15235 | 15235 | 15235 | 15235 |
| 31-Oct-64 | 12369 | 9209 | 12369 | 12369 | 12369 | 12369 |
| 30-Nov-64 | 6101 | 4137 | 4568 | 4568 | 4568 | 4568 |
| 31-Dec-64 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-65 | 119 | 119 | 119 | 119 | 119 | 119 |
| 28-Feb-65 | 18 | 18 | 18 | 18 | 18 | 18 |
| 31-Mar-65 | 99 | 99 | 99 | 99 | 99 | 99 |
| 30-Apr-65 | 16439 | 16439 | 16439 | 16439 | 16439 | 16439 |
| 31-May-65 | 82469 | 20014 | 82469 | 82469 | 82469 | 82469 |
| 30-Jun-65 | 107619 | 3556 | 102602 | 107619 | 87396 | 107619 |
| 31-Jul-65 | 172312 | 3382 | 75957 | 91513 | 68087 | 112482 |
| 31-Aug-65 | 98586 | 3382 | 49394 | 53330 | 45112 | 56008 |
| 30-Sep-65 | 6307 | 5058 | 6307 | 6307 | 6307 | 6307 |
| 31-Oct-65 | 15503 | 15237 | 15503 | 15503 | 15503 | 15503 |
| 30-Nov-65 | 7051 | 3661 | 4193 | 4193 | 4193 | 4326 |
| 31-Dec-65 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-66 | 202 | 202 | 202 | 202 | 202 | 202 |
| 28-Feb-66 | 286 | 286 | 286 | 286 | 286 | 286 |
| 31-Mar-66 | 906 | 906 | 906 | 906 | 906 | 906 |
| 30-Apr-66 | 10911 | 5839 | 10911 | 10911 | 10911 | 10911 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-May-66 | 62089 | 40520 | 62089 | 62089 | 62089 | 62089 |
| 30-Jun-66 | 143361 | 3273 | 143361 | 143361 | 143361 | 143361 |
| 31-Jul-66 | 116723 | 3382 | 116330 | 116723 | 89056 | 116723 |
| 31-Aug-66 | 58655 | 17205 | 58655 | 58655 | 58655 | 58655 |
| 30-Sep-66 | 37337 | 5829 | 37337 | 37337 | 37337 | 37337 |
| 31-Oct-66 | 6762 | 5626 | 6762 | 6762 | 6762 | 6762 |
| 30-Nov-66 | 7140 | 3273 | 4005 | 4129 | 3854 | 4333 |
| 31-Dec-66 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-67 | 234 | 234 | 234 | 234 | 234 | 234 |
| 28-Feb-67 | 401 | 401 | 401 | 401 | 401 | 401 |
| 31-Mar-67 | 357 | 357 | 357 | 357 | 357 | 357 |
| 30-Apr-67 | 9227 | 9227 | 9227 | 9227 | 9227 | 9227 |
| 31-May-67 | 39233 | 39233 | 39233 | 39233 | 39233 | 39233 |
| 30-Jun-67 | 112391 | 35528 | 96089 | 101584 | 90146 | 106653 |
| 31-Jul-67 | 112899 | 5489 | 88821 | 96326 | 81253 | 102478 |
| 31-Aug-67 | 95980 | 3382 | 68465 | 74662 | 62142 | 79381 |
| 30-Sep-67 | 25983 | 11269 | 25983 | 25983 | 25960 | 25983 |
| 31-Oct-67 | 9312 | 3382 | 9312 | 9312 | 9312 | 9312 |
| 30-Nov-67 | 7081 | 3273 | 4578 | 4579 | 4556 | 4614 |
| 31-Dec-67 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-68 | 179 | 179 | 179 | 179 | 179 | 179 |
| 29-Feb-68 | 357 | 357 | 357 | 357 | 357 | 357 |
| 31-Mar-68 | 135 | 135 | 135 | 135 | 135 | 135 |
| 30-Apr-68 | 4911 | 4911 | 4911 | 4911 | 4911 | 4911 |
| 31-May-68 | 32120 | 32120 | 32120 | 32120 | 32120 | 32120 |
| 30-Jun-68 | 131726 | 63554 | 131726 | 131726 | 131726 | 131726 |
| 31-Jul-68 | 128555 | 4699 | 128555 | 128555 | 128555 | 128555 |
| 31-Aug-68 | 97502 | 4044 | 97502 | 97502 | 97502 | 97502 |
| 30-Sep-68 | 12071 | 8693 | 12071 | 12071 | 12071 | 12071 |
| 31-Oct-68 | 7706 | 7325 | 7706 | 7706 | 7706 | 7706 |
| 30-Nov-68 | 6932 | 3949 | 5498 | 5606 | 5267 | 6179 |
| 31-Dec-68 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-69 | 198 | 198 | 198 | 198 | 198 | 198 |
| 28-Feb-69 | 36 | 36 | 36 | 36 | 36 | 36 |
| 31-Mar-69 | 159 | 159 | 159 | 159 | 159 | 159 |
| 30-Apr-69 | 13765 | 13765 | 13765 | 13765 | 13765 | 13765 |
| 31-May-69 | 72034 | 19148 | 72034 | 72034 | 72034 | 72034 |
| 30-Jun-69 | 101879 | 3273 | 101879 | 101879 | 101879 | 101879 |
| 31-Jul-69 | 174236 | 3382 | 147945 | 171212 | 119341 | 174236 |
| 31-Aug-69 | 89284 | 8188 | 64506 | 67901 | 61096 | 89284 |
| 30-Sep-69 | 67025 | 3273 | 38289 | 42190 | 33845 | 52418 |
| 31-Oct-69 | 12184 | 3382 | 3898 | 3898 | 3897 | 3932 |
| 30-Nov-69 | 6575 | 3564 | 3819 | 3819 | 3782 | 3820 |
| 31-Dec-69 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-70 | 357 | 357 | 357 | 357 | 357 | 357 |
| 28-Feb-70 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Mar-70 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30-Apr-70 | 4592 | 4592 | 4592 | 4592 | 4592 | 4592 |
| 31-May-70 | 72950 | 70301 | 72950 | 72950 | 72950 | 72950 |
| 30-Jun-70 | 115640 | 9626 | 115640 | 115640 | 115640 | 115640 |
| 31-Jul-70 | 109067 | 4644 | 109067 | 109067 | 109067 | 109067 |
| 31-Aug-70 | 27665 | 21876 | 27665 | 27665 | 27665 | 27665 |
| 30-Sep-70 | 49452 | 17076 | 49452 | 49452 | 49452 | 49452 |
| 31-Oct-70 | 7053 | 5355 | 7053 | 7053 | 7053 | 7053 |
| 30-Nov-70 | 6912 | 3696 | 6519 | 6778 | 6246 | 6912 |
| 31-Dec-70 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-71 | 99 | 99 | 99 | 99 | 99 | 99 |
| 28-Feb-71 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Mar-71 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30-Apr-71 | 12891 | 12891 | 12891 | 12891 | 12891 | 12891 |
| 31-May-71 | 55105 | 44722 | 55105 | 55105 | 55105 | 55105 |
| 30-Jun-71 | 79589 | 12595 | 42578 | 42576 | 39011 | 48987 |
| 31-Jul-71 | 113036 | 11189 | 50108 | 52468 | 47747 | 54236 |
| 31-Aug-71 | 80610 | 12894 | 80610 | 80610 | 80610 | 80610 |
| 30-Sep-71 | 71500 | 3273 | 37948 | 46962 | 28416 | 53843 |
| 31-Oct-71 | 21537 | 3382 | 7341 | 7623 | 6677 | 7945 |
| 30-Nov-71 | 6724 | 3273 | 3273 | 3273 | 3273 | 3273 |
| 31-Dec-71 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-72 | 212 | 212 | 212 | 212 | 212 | 212 |
| 29-Feb-72 | 343 | 343 | 343 | 343 | 343 | 343 |
| 31-Mar-72 | 65 | 65 | 65 | 65 | 65 | 65 |
| 30-Apr-72 | 18678 | 12973 | 15965 | 15965 | 15965 | 15965 |
| 31-May-72 | 77461 | 9095 | 71446 | 77163 | 64820 | 77461 |
| 30-Jun-72 | 108286 | 3273 | 3569 | 3979 | 3562 | 8574 |
| 31-Jul-72 | 123719 | 4001 | 59833 | 64699 | 54639 | 68004 |
| 31-Aug-72 | 87866 | 6651 | 42671 | 46054 | 39268 | 48566 |
| 30-Sep-72 | 43779 | 11344 | 35985 | 37642 | 34416 | 38920 |
| 31-Oct-72 | 22822 | 4274 | 22822 | 22822 | 22822 | 22822 |
| 30-Nov-72 | 6188 | 4866 | 5536 | 5543 | 5451 | 5637 |
| 31-Dec-72 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-73 | 139 | 139 | 139 | 139 | 139 | 139 |
| 28-Feb-73 | 214 | 214 | 214 | 214 | 214 | 214 |
| 31-Mar-73 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30-Apr-73 | 3427 | 3427 | 3427 | 3427 | 3427 | 3427 |
| 31-May-73 | 51481 | 51481 | 51481 | 51481 | 51481 | 51481 |
| 30-Jun-73 | 125074 | 76527 | 125074 | 125074 | 125074 | 125074 |
| 31-Jul-73 | 145805 | 3382 | 145805 | 145805 | 145805 | 145805 |
| 31-Aug-73 | 122713 | 3382 | 122713 | 122713 | 122713 | 122713 |
| 30-Sep-73 | 41740 | 8555 | 41740 | 41740 | 41740 | 41740 |
| 31-Oct-73 | 7152 | 4019 | 7152 | 7152 | 7152 | 7152 |
| 30-Nov-73 | 6545 | 4571 | 6545 | 6545 | 6536 | 6545 |
| 31-Dec-73 | 0 | 0 | 0 | 0 | 0 | 0 |

# Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Jan-74 | 22 | 22 | 22 | 22 | 22 | 22 |
| 28-Feb-74 | 196 | 196 | 196 | 196 | 196 | 196 |
| 31-Mar-74 | 240 | 240 | 240 | 240 | 240 | 240 |
| 30-Apr-74 | 7658 | 7658 | 7658 | 7658 | 7658 | 7658 |
| 31-May-74 | 54833 | 54833 | 54833 | 54833 | 54833 | 54833 |
| 30-Jun-74 | 49519 | 32754 | 49519 | 49519 | 49519 | 49519 |
| 31-Jul-74 | 106647 | 13508 | 106647 | 106647 | 106647 | 106647 |
| 31-Aug-74 | 62848 | 5287 | 62848 | 62848 | 62848 | 62848 |
| 30-Sep-74 | 22334 | 20471 | 22334 | 22334 | 22334 | 22334 |
| 31-Oct-74 | 8886 | 4285 | 8886 | 8886 | 8886 | 8886 |
| 30-Nov-74 | 6188 | 4662 | 6188 | 6188 | 6188 | 6188 |
| 31-Dec-74 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-75 | 218 | 218 | 218 | 218 | 218 | 218 |
| 28-Feb-75 | 60 | 60 | 60 | 60 | 60 | 60 |
| 31-Mar-75 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30-Apr-75 | 5917 | 5917 | 5917 | 5917 | 5917 | 5917 |
| 31-May-75 | 55186 | 55186 | 55186 | 55186 | 55186 | 55186 |
| 30-Jun-75 | 86364 | 38812 | 86364 | 86364 | 86364 | 86364 |
| 31-Jul-75 | 164862 | 3382 | 164862 | 164862 | 164862 | 164862 |
| 31-Aug-75 | 91886 | 12441 | 91886 | 91886 | 91886 | 91886 |
| 30-Sep-75 | 60488 | 3273 | 60488 | 60488 | 60488 | 60488 |
| 31-Oct-75 | 14828 | 3382 | 14828 | 14828 | 14828 | 14828 |
| 30-Nov-75 | 7269 | 3273 | 5549 | 5685 | 5267 | 5794 |
| 31-Dec-75 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-76 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29-Feb-76 | 60 | 60 | 60 | 60 | 60 | 60 |
| 31-Mar-76 | 218 | 218 | 218 | 218 | 218 | 218 |
| 30-Apr-76 | 11147 | 11147 | 11147 | 11147 | 11147 | 11147 |
| 31-May-76 | 36593 | 36593 | 36593 | 36593 | 36593 | 36593 |
| 30-Jun-76 | 68001 | 23684 | 68001 | 68001 | 68001 | 68001 |
| 31-Jul-76 | 166620 | 6248 | 116962 | 131736 | 101202 | 145900 |
| 31-Aug-76 | 116652 | 3382 | 53429 | 58675 | 48178 | 63211 |
| 30-Sep-76 | 37222 | 3300 | 37222 | 37222 | 37222 | 37222 |
| 31-Oct-76 | 7140 | 3981 | 7140 | 7140 | 7140 | 7140 |
| 30-Nov-76 | 6526 | 4019 | 4567 | 4606 | 4505 | 4607 |
| 31-Dec-76 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-77 | 113 | 113 | 113 | 113 | 113 | 113 |
| 28-Feb-77 | 196 | 196 | 196 | 196 | 196 | 196 |
| 31-Mar-77 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30-Apr-77 | 6440 | 6440 | 6440 | 6440 | 6440 | 6440 |
| 31-May-77 | 95659 | 43293 | 95659 | 95659 | 95659 | 95659 |
| 30-Jun-77 | 120016 | 3273 | 45391 | 52788 | 35041 | 63766 |
| 31-Jul-77 | 114764 | 8652 | 46845 | 49455 | 44223 | 50654 |
| 31-Aug-77 | 112780 | 3382 | 31479 | 33836 | 28922 | 35363 |
| 30-Sep-77 | 22905 | 11985 | 22905 | 22905 | 22905 | 22905 |
| 31-Oct-77 | 10231 | 7388 | 10231 | 10231 | 10231 | 10231 |

**Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations**

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 30-Nov-77 | 6188 | 4262 | 5720 | 5742 | 5703 | 5882 |
| 31-Dec-77 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-78 | 28 | 28 | 28 | 28 | 28 | 28 |
| 28-Feb-78 | 428 | 428 | 428 | 428 | 428 | 428 |
| 31-Mar-78 | 393 | 393 | 393 | 393 | 393 | 393 |
| 30-Apr-78 | 16695 | 16695 | 16695 | 16695 | 16695 | 16695 |
| 31-May-78 | 32503 | 32503 | 32503 | 32503 | 32503 | 32503 |
| 30-Jun-78 | 82013 | 31784 | 82013 | 82013 | 82013 | 82013 |
| 31-Jul-78 | 201428 | 3382 | 201428 | 201428 | 201428 | 201428 |
| 31-Aug-78 | 78020 | 3929 | 78020 | 78020 | 78020 | 78020 |
| 30-Sep-78 | 12678 | 9764 | 12678 | 12678 | 12678 | 12678 |
| 31-Oct-78 | 13200 | 12806 | 13200 | 13200 | 13200 | 13200 |
| 30-Nov-78 | 6476 | 4309 | 5478 | 5513 | 5381 | 5864 |
| 31-Dec-78 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-79 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28-Feb-79 | 99 | 99 | 99 | 99 | 99 | 99 |
| 31-Mar-79 | 337 | 337 | 337 | 337 | 337 | 337 |
| 30-Apr-79 | 2761 | 2761 | 2761 | 2761 | 2761 | 2761 |
| 31-May-79 | 17790 | 17790 | 17790 | 17790 | 17790 | 17790 |
| 30-Jun-79 | 70608 | 70608 | 70608 | 70608 | 70608 | 70608 |
| 31-Jul-79 | 115956 | 54070 | 115956 | 115956 | 115956 | 115956 |
| 31-Aug-79 | 94911 | 4574 | 94911 | 94911 | 94911 | 94911 |
| 30-Sep-79 | 23651 | 11214 | 23651 | 23651 | 23651 | 23651 |
| 31-Oct-79 | 7386 | 4193 | 7386 | 7386 | 7386 | 7386 |
| 30-Nov-79 | 6188 | 4387 | 6188 | 6188 | 6188 | 6188 |
| 31-Dec-79 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-80 | 20 | 20 | 20 | 20 | 20 | 20 |
| 29-Feb-80 | 456 | 456 | 456 | 456 | 456 | 456 |
| 31-Mar-80 | 218 | 218 | 218 | 218 | 218 | 218 |
| 30-Apr-80 | 5139 | 5139 | 5139 | 5139 | 5139 | 5139 |
| 31-May-80 | 48583 | 48583 | 48583 | 48583 | 48583 | 48583 |
| 30-Jun-80 | 138054 | 46219 | 138054 | 138054 | 137766 | 138054 |
| 31-Jul-80 | 227695 | 3382 | 25795 | 35770 | 14139 | 47440 |
| 31-Aug-80 | 152089 | 3382 | 3382 | 3382 | 3382 | 3382 |
| 30-Sep-80 | 32584 | 5161 | 9541 | 12348 | 8372 | 14371 |
| 31-Oct-80 | 6980 | 6607 | 6980 | 6980 | 6980 | 6980 |
| 30-Nov-80 | 6238 | 4397 | 4962 | 4962 | 4962 | 4964 |
| 31-Dec-80 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-81 | 298 | 298 | 298 | 298 | 298 | 298 |
| 28-Feb-81 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Mar-81 | 258 | 258 | 258 | 258 | 258 | 258 |
| 30-Apr-81 | 16314 | 16314 | 16314 | 16314 | 16314 | 16314 |
| 31-May-81 | 32955 | 32955 | 32955 | 32955 | 32955 | 32955 |
| 30-Jun-81 | 103006 | 37391 | 92569 | 98530 | 86795 | 103006 |
| 31-Jul-81 | 182380 | 3382 | 32521 | 34420 | 30162 | 36968 |
| 31-Aug-81 | 113542 | 3382 | 76432 | 80278 | 70615 | 83079 |

# Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project

| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
|---|---|---|---|---|---|---|
| 30-Sep-81 | 59298 | 3273 | 38143 | 42827 | 34517 | 46054 |
| 31-Oct-81 | 7073 | 3382 | 4560 | 4560 | 4560 | 4561 |
| 30-Nov-81 | 7398 | 3600 | 3822 | 3822 | 3822 | 3831 |
| 31-Dec-81 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-82 | 129 | 129 | 129 | 129 | 129 | 129 |
| 28-Feb-82 | 97 | 97 | 97 | 97 | 97 | 97 |
| 31-Mar-82 | 448 | 448 | 448 | 448 | 448 | 448 |
| 30-Apr-82 | 12377 | 12377 | 12377 | 12377 | 12377 | 12377 |
| 31-May-82 | 56763 | 52804 | 56763 | 56763 | 56763 | 56763 |
| 30-Jun-82 | 184243 | 21109 | 103490 | 106363 | 95858 | 116673 |
| 31-Jul-82 | 184241 | 5501 | 73189 | 80009 | 66235 | 86053 |
| 31-Aug-82 | 93784 | 5840 | 79161 | 82916 | 73797 | 85246 |
| 30-Sep-82 | 40338 | 3273 | 40338 | 40338 | 40338 | 40338 |
| 31-Oct-82 | 9838 | 6596 | 9838 | 9838 | 9838 | 9838 |
| 30-Nov-82 | 5744 | 3539 | 4298 | 4298 | 4266 | 4424 |
| 31-Dec-82 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-83 | 192 | 192 | 192 | 192 | 192 | 192 |
| 28-Feb-83 | 111 | 111 | 111 | 111 | 111 | 111 |
| 31-Mar-83 | 541 | 541 | 541 | 541 | 541 | 541 |
| 30-Apr-83 | 12662 | 12662 | 12662 | 12662 | 12662 | 12662 |
| 31-May-83 | 44821 | 44821 | 44821 | 44821 | 44821 | 44821 |
| 30-Jun-83 | 156198 | 47328 | 156198 | 156198 | 156198 | 156198 |
| 31-Jul-83 | 156200 | 7514 | 156200 | 156200 | 156200 | 156200 |
| 31-Aug-83 | 89599 | 3382 | 89599 | 89599 | 89599 | 89599 |
| 30-Sep-83 | 36849 | 3880 | 36849 | 36849 | 36849 | 36849 |
| 31-Oct-83 | 10130 | 4949 | 10130 | 10130 | 10130 | 10130 |
| 30-Nov-83 | 5895 | 3661 | 4431 | 5280 | 4209 | 5642 |
| 31-Dec-83 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-84 | 159 | 159 | 159 | 159 | 159 | 159 |
| 29-Feb-84 | 186 | 186 | 186 | 186 | 186 | 186 |
| 31-Mar-84 | 365 | 365 | 365 | 365 | 365 | 365 |
| 30-Apr-84 | 12030 | 12030 | 12030 | 12030 | 12030 | 12030 |
| 31-May-84 | 48553 | 48553 | 48553 | 48553 | 48553 | 48553 |
| 30-Jun-84 | 178703 | 45313 | 178703 | 178703 | 178703 | 178703 |
| 31-Jul-84 | 178687 | 3382 | 178687 | 178687 | 174497 | 178687 |
| 31-Aug-84 | 88391 | 4786 | 88391 | 88391 | 72270 | 88391 |
| 30-Sep-84 | 36141 | 3273 | 36141 | 36141 | 36141 | 36141 |
| 31-Oct-84 | 10028 | 8420 | 10028 | 10028 | 10028 | 10028 |
| 30-Nov-84 | 5758 | 3725 | 4846 | 5038 | 4704 | 5152 |
| 31-Dec-84 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-85 | 95 | 95 | 95 | 95 | 95 | 95 |
| 28-Feb-85 | 139 | 139 | 139 | 139 | 139 | 139 |
| 31-Mar-85 | 543 | 543 | 543 | 543 | 543 | 543 |
| 30-Apr-85 | 11702 | 11702 | 11702 | 11702 | 11702 | 11702 |
| 31-May-85 | 57929 | 56898 | 57929 | 57929 | 57929 | 57929 |
| 30-Jun-85 | 155651 | 3273 | 155651 | 155651 | 155651 | 155651 |

# Table IV-C-02 Annual and Monthly Water Demands and Water Provided from HEC-5 Water Balance Model for Various Delivery System Configurations

| Water Needs and Supplied Volumes with Various Delivery System Configurations for Adjusted Project Area and Simulated White River Data, Grand Prairie Area Demonstration Project | | | | | | |
|---|---|---|---|---|---|---|
| End-of-Period Date | Demands or Base NEED, (Ac-Ft) | Exist. Storage (1992), No Import (Ac-Ft) | New Storage Added With 1640 cfs Import (Ac-Ft) | New Storage Added With 1800 cfs Import (Ac-Ft) | New Storage Added With 1480 cfs Import (Ac-Ft) | New Storage Added With 1960 cfs Import (Ac-Ft) |
| 31-Jul-85 | 155655 | 3382 | 155655 | 155655 | 155655 | 155655 |
| 31-Aug-85 | 77425 | 5774 | 77425 | 77425 | 77425 | 77425 |
| 30-Sep-85 | 36940 | 3273 | 36940 | 36940 | 36940 | 36940 |
| 31-Oct-85 | 10243 | 3517 | 10243 | 10243 | 10243 | 10243 |
| 30-Nov-85 | 5944 | 3647 | 5253 | 5382 | 4994 | 5609 |
| 31-Dec-85 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31-Jan-86 | 268 | 268 | 268 | 268 | 268 | 268 |
| 28-Feb-86 | 167 | 167 | 167 | 167 | 167 | 167 |
| 31-Mar-86 | 538 | 538 | 538 | 538 | 538 | 538 |
| 30-Apr-86 | 12649 | 11744 | 12649 | 12649 | 12649 | 12649 |
| 31-May-86 | 58165 | 13137 | 58165 | 58165 | 58165 | 58165 |
| 30-Jun-86 | 188085 | 14244 | 140299 | 155200 | 122620 | 171978 |
| 31-Jul-86 | 188077 | 3382 | 51798 | 57043 | 46400 | 60821 |
| 31-Aug-86 | 80640 | 3382 | 75040 | 78809 | 69944 | 80019 |
| 30-Sep-86 | 38644 | 3273 | 38644 | 38644 | 38644 | 38644 |
| 31-Oct-86 | 10356 | 3382 | 10315 | 10356 | 10225 | 10356 |
| 30-Nov-86 | 5554 | 4053 | 4960 | 4960 | 4960 | 4951 |
| 31-Dec-86 | 0 | 0 | 0 | 0 | 0 | 0 |

## HEC-5 Input file for Water Balance Modeling

```
T1    Eastern Arkansas Region Comprehensive Study          RAG:10/96
C
C ==========================================================================
C
C    THIS MODEL (NPS1960.DAT) REFLECTS CHANGES TO THE PROJECT AREA, A
C    REDUCTION IN AREAS IRRIGATED AND DEVOTED TO ON-FARM STORAGE.
C    MINIMUM WHITE RIVER FLOWS ARE BASED ON THE ASWCC WATER PLAN.
C
C    This model also uses revised maximum pumping station capacity.
C    All fractional values (losses, seepage, etc.) are adjusted from
C    the original model by ratioing 1640 to 1960 and multiplying the
C    number to be adjusted.
C
C    RUN DATE:   19 SEPTEMBER 1996
C
C ==========================================================================
T2
T3    Grand Praire Irrigation Model
J1   0    1    4    3    4    1
C  *  CHANGE 4 IN FIELD J2.8  TO A 5
J2   24    1.0    1.0    32                        5
J3    4                              1
J8299.11  299.13  299.12  299.10 299.109  299.24 299.249 299.039  299.00 299.099
J8100.11  100.13  100.09 100.099  100.10 100.109 199.109 399.109    2.99
J8100.11 100.109 100.219 199.109 399.109 299.109
C 299.13  100.13  299.10  100.10  299.12  100.12  110.05  110.04  110.06  199.10
C 100.11  100.13  100.12  100.10  100.09  105.03
C 299.11  299.13  299.12  299.10  299.09  105.03
C 399.10  299.10  100.10   3.99  110.04  110.05  110.06  299.12  100.12  105.03
C   3.03  111.09  111.10  100.10  111.13  100.13  100.12  199.10
C
C  *  ENTRIES MADE FOR WRITING WHITE RIVER AND DIVERSION DATA TO DSS
JZ  4.02    3.03   3.039  399.10 399.109  299.10 299.109
JZ199.10 100.109  111.10 111.109    4.04    4.22    1.04  105.04 105.049
JZ100.11  100.09 100.099  100.37  110.05  110.04 100.059 100.049  110.06 110.069
C
C     ----- White River at Clarendon -----
RL    1
RO
RS    2      1  99999
RQ    2  99999     -1
CP    1  999999
IDWHITE RIVER
RT    1     2
C
C     ----- By Pass the Required Navigation Flow Arround the GPI Pumps -----
CP    2  999999
IDNAV REQUIREMENT
RT    2     3
C     ----- Minimum Navigation/Instream Flow Varies Monthly -----
DR    2     4                             1
```

## HEC-5 Input file for Water Balance Modeling Continued

```
C  CHANGE MINIMUM W. RIV. Q TO  REFLECT THE AR STATE WATER PLAN (TABLE 3-11)
C
QD   12  19610  22700  27610  36940  36640  21220  10670   9650   9650
QD 9650   11050  17590
C

C
C      ----- Precipitation Addition to Crops (245,558 Acres) -----
RL  399 245558 245557 245558 245558 245568
RO
RS    4 245557 245558 245558 245568
RQ    4    9999  99999  99999     -1
RA    4 245557 245558 245558 245568
CP  399   99999
IDCROP-RAIN
RT  399     100
C
C      ----- Precipitation Addition to Storage Reservoir 100 -----
RL  199  24416  24415  24416  24417  24416
RO
RS    3  24415  24416  24416
RQ    3   9999  99999     -1
RA    3  24415  24416  24416
CP  199  99999
IDRES-RAIN
RT  199    100
C
C      ----- Total ON FARM Storage = 173,018 Ac-Ft -----
RL  111   17000  17300 173018 173019 173400
RL    1   111     -1      0  17300
RL    2   111      6      0  17302  86509 173015 173015  17302  17302
RL    3   111      6      0  17400  86600 173018 173018  17400  17400
RL    4   111     -1      0 183500
RO    1   100
RS    4    10  17300 173018 173400
RQ    4    99   5000   5100   5200
RA    4    10  24415  24416  24417
RE    4   223  223.7  225.7    226
CP  111   5000
IDGPI-STORAGE
RT  111    105
C      ----- Maximum Diversion Capacity = 1960 cfs -----
C
C     * MODIFY PUMPING FOR 0 cfs CAPACITY FOR DEC
C
DR  111     3                            -4
QD   12   -597   -597  -1195  -1960  -1960  -1960  -1960  -1960  -1960
QD -1960  -1076     0
```

## HEC-5 Input file for Water Balance Modeling Continued

```
CS   6    60    61    105    227    300    365
C
C     ----- Diversion Represents Conveyence Losses -----
C  Assumption used for this run  : 25% Adds to Ground Water (Reservoir 299)
C    NOTE: This assumption assumes that 50% of the canal seepage loss
C          (15% of capacity) goes back to the alluvial aquifer.  Total
C          canal losses were estimated to be 30% (seepage is 50% of this).
C          [ 50% of 30% = 15%;  50% of 15% = 7.5%; OR 50% of 50% of 30% =
C          7.5%  (50% of 50% = 25%)]  USE 25% of value on QD (30% loss)
C          going back to the alluvial aquifer.
C  This is the original assumption:  50% Adds to Ground Water (Reservoir 299)
C
CP  105  99999
IDLOSSES
RT  105    100
DR  105    299                    .25    -1
QS   3    .1   1960   5000
QD   3    .03    490    490
C
C  >>>>>>>>>>>>>>>>>> <<<<<<<<<<<<<<<<<<<<<<
C  40,000 AC FT OF RECHARGE TO GROUND WATER AVAILABLE ON SUSTAINABLE BASIS
C  40,000/365 = 109.6 AC FT/DAY RECHARGE ON AVERAGE DAILY BASIS
C  109.6 (AC.FT.)/ 1.9835 (AC.FT./DAY  /  CFS) =  55 CFS RECHARGE RATE
C
C     ----- Ground Water Storage -----
RL  299  20000     1     2   40000 9999999
RO   1    110
RS   2      1 9999999
RQ   2   1960    1960
C  ----- Assume Max Withdrall Rate = 729 CFS -----
CP  299    729
IDGW-STORAGE
RT  299    110
C
C     ----- Total ON FARM Storage = 173,018 Ac-Ft -----
RL  100  17000  17300  173018  173019  173400
RL   1   100    -1     0  17300
RL   2   100     6     0  17302   86509  173015  173015   17302   17302
RL   3   100     6     0  17400   86600  173018  173018   17400   17400
RL   4   100    -1     0  173400
RO   1   110
RS   4    10   17300  173018  173400
RQ   4    99   5000   5100   5200
RA   4    10  24415  24416  24417
RE   4   223  223.7  225.7    226
CP  100   5000
IDGPI-STORAGE
RT  100    110
CS   6    60    61    105    227    300    365
C     ----- Farms -----
C     Irrigation Demand Specified by MR Data (BF-EJ Records)
```

## HEC-5 Input file for Water Balance Modeling Continued

```
CP  110  99999
IDFARMS
RT  110    999
C      ----- Pump Location -----
CP   3  99999
IDGPI-PUMP
RT   3     4
C      ----- White River Net Flow (MIN INSTREAM + BYPASS Q) -----
CP   4  99999
IDWR NET Q
RT   4   999
C      ----- QS-EL Rating Curve for White River Total Flow -----
QS   18   2725   7125   9875  11350  12850  14350  15900  17500  19200
QS 21200  23300  25400  27600  29900  35900  49200  102000 269000
EL   18  144.9  148.9  150.9  151.9  152.9  153.9  154.9  155.9  156.9
EL 157.9  158.9  159.9  160.9  161.9  163.9  165.9  169.9  177.9
C
C     ---- System End -----
CP  999  99999
ID END
RT  999
ED
C  BEGIN READING IN SIMULATION DATA
C
C  1940
BF   2   366              40010100           24
C  ----- Starting Storage for GPI ON FARM Storage -----
SS  100   8795
C  ----- Starting Storage for GPI Ground Water STORAGE -----
SS  299   12000
C  -----  ASSUMED Average Ground Water Recharge = 55 cfs
C IN  299    -1     0     0    189    55
ZR=IN299 A=GP PRJ B=GW C=FLOW F=CONST GW FLOW
C  ----- White River Flow Data -----
ZR=IN1  A=WHITE B=CLARENDON C=FLOW F=W93X09
C  ----- Evaporative Loss from GPI ON FARM Storage -----
ZR=EV100  A=STUT B=STUTTGART 9 ESE C=EVAP-INC F=DAILY INTER
C  ----- Precipitation Addition to GPI ON FARM Storage -----
ZR=EV199  A=RESERVOIR B=STUTTGART 9 ESE C=PRECIP-INC F=DAILY HEC5
C  ----- Precipitation Addition for Crops -----
ZR=EV399  A=ACT PRECIP B=CAPTURE C=PRECIP-INC F=PRECIP CAPTURE FIELDS
C  ----- Net Crop Requirement -----
ZR=MR110  A=GP PRJ B=PS C=FLOW F=NPS1960 DEMAND
ZW     A=NPS1960 F=NPS1960
C ========  INACTIVE DSS READ RECORDS   ========
C ZR=QD1  A=WHITE B=CLARENDON C=FLOW-NAV DIV F=W93X09
EJ
C
```

***Repeat above BF through EJ records for each year in the simulation***

```
C
ER
```

# SECTION I

# PART E - (5)

# SEDIMENT TRANSPORT

# PART E - (5) - SEDIMENT TRANSPORT

## TOPIC A - INLET CHANNEL

### 5-A-01. OVERVIEW.

a. General. Excess sediment accumulation at river diversionary canal headworks can interfere with canal operation, resulting in reduced conveyance capacity or requiring dredging maintenance. The purpose of this overview is to qualitatively characterize the nature and location of these sediment deposits and the mechanics for their formation. In addition, a limited literature search verified existence of models to predict stream sedimentation, although no model was found which professed to accurately predict sedimentation at intake structures. And, finally, research on sediment diversion vanes at channel inlets indicates that these structures work effectively to prevent sediment accumulation. A computer program was found to design the vane arrangement required for a specific geometry and flow profile.

b. Qualitative Assessment. Two types of sediment transport can be defined: bed load and suspended load. Bed load is sediment in contact with the bed during transport. Suspended load is sediment moving together with the water flow without contact with the bottom. Wash load is a subset of suspended load, and consists of cohesive and very fine sediments.

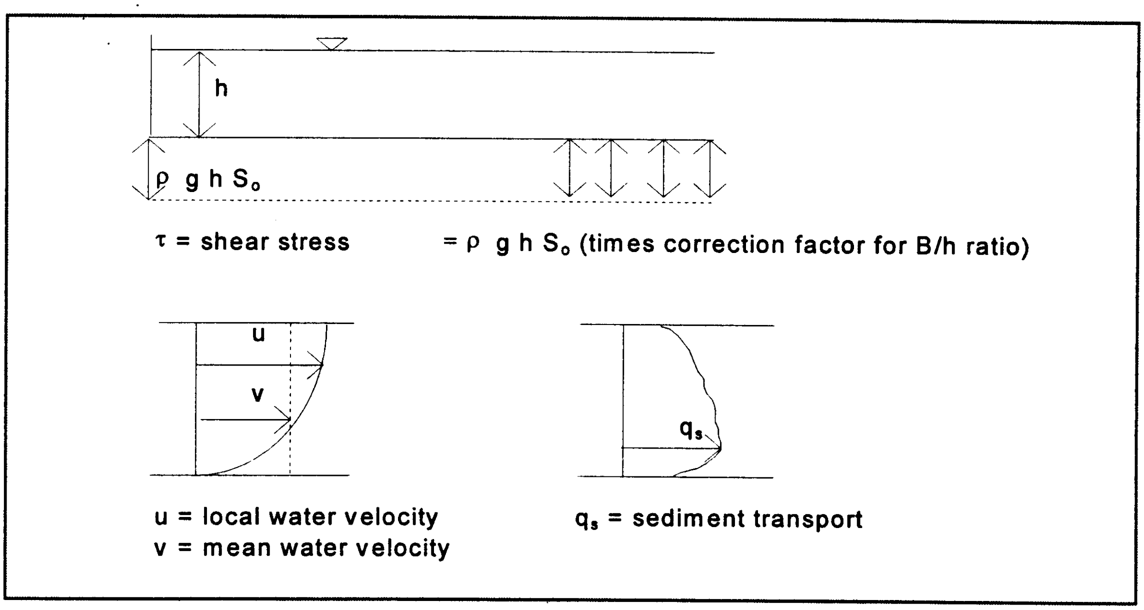



Figure V-A-1: Water and Sediment Transport Profiles [Mendez, 1996]

At a diversion channel intake, there is a flow separation boundary between downstream and diversion channel streamlines. This dividing stream-surface extends further out into the main channel near the bed than near the surface. Since most of the suspended sediment is carried in the lower 1/3 of the vertical flow [ASCE, 1977], as shown in Figure V-A-1, this results in a disproportionate volume of sediment being carried with the flow into the diversionary channel. Flow structure of the water-sediment fluid is three-dimensional, with centrifugal forces acting on the non-uniform flow profile in the main channel and on the flow diverted into the canal [Neary et al., 1994]. A stagnation point tends to occur at the downstream face of the canal intake such that the pressure at that point is similar to upstream pressure. A separation zone in the diversion channel is caused by a secondary circulation pattern--a recirculating eddy causing velocity reduction and associated settling out of sediments (see Figure V-A-2).

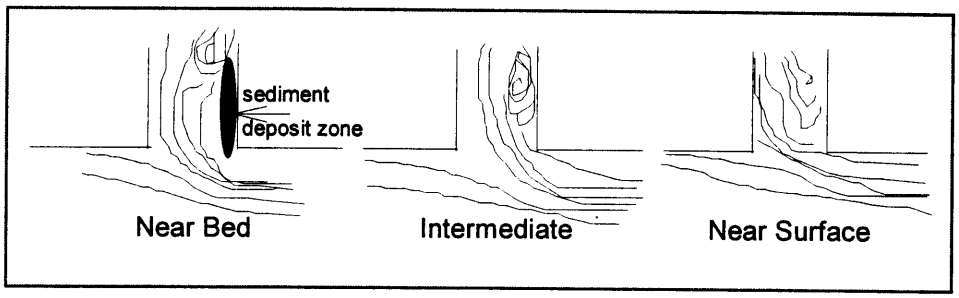



Figure V-A-2: Velocity-Vector Measurements and Particle Trace Plots [Neary et al., 1994]

Jacob Odgaard, professor of Hydraulics at the University of Iowa, has conducted extensive research on sediment transport and deposits in diversionary channels. His research indicates that there is a direct relationship between the angle of the diversionary channel and the ratio of sediment transported into the intake. Research results show that a diversion operating within a Q2/Q1 range of 0.05 to 0.13 can reduce sand bar growth rates by roughly 70% by diverting water at 45-degrees instead of 90-degrees (where Q2 is diversionary channel discharge and Q1 is stream discharge) [Neary et al., 1994].

Model experimentation conducted by Odgaard et al. showed that streamwise convection dominated for a 90-degree diversion channel when the separation zone in the diversion channel was largest, suggesting a "squeezing" effect in which the transverse migration of deposited sediment bars toward the separation zone increased with increasing discharge ratio, roughness and diversion angle. The elliptical sediment bars normally reached their equilibrium position just within the near-bed boundary of the separation zone.

According to Melone, et al. [1975], velocity fluctuations in open channel flow, especially in the vicinity of the diversion headworks, are of the same magnitude as the settling velocities of silt and clay particles, thus the fine material load will remain in suspension and be transported with the diversion water. Heavier particles will tend to settle as described above.

c. Quantitative Measurement. Research for this analysis focused on identifying quantitative methods to determine the following four items:

1) Sediment movement. Identification of conditions for sediment movement in streams and quantification of the amount of sediment to expect in transport

2) Sediment distribution. Analysis of vertical distribution pattern of sediment in streams

3) Width of flow separation zone. Characterization of the flow separation zone at diversionary inlets

4) Sediment deposit at diversion channel inlet. Analysis of how much of the sediment carried into the diversionary channel could be expected to be deposited as sediment bars at the inlet.

1. Sediment Movement. The presence of sediment in stream flow is a function of the tractive force of the water on the channel as related to the conditions for bed material transport. Tractive force is shown by Chow [1959] to be:

$$\tau = \gamma RS \qquad (1)$$

g = unit weight of water
R = hydraulic radius = P/A
P = wetted perimeter
A = cross-sectional area of water
S = friction slope

Actual field measurements are the most reliable source of data for sediment movement. A suspended load sampler is most common. Measurements are taken to within 0.3 ft of the bed, and an estimate is made of the lowest 0.3 ft, generally assuming that 5 - 10% of bed material is carried in this regime. Wide, shallow channels typically carry more bed load than deep narrow channels. Streams with high turbulence tend to have a smaller bed load.[Melone, et al. 1975]

Many authoritative references are available concerning sediment transport in channels. The ASCE Manual on Sedimentation Engineering [1977] and the US Army Corps of Engineers Engineer Manual, Sedimentation Investigations of Rivers and Reservoirs [1989] provide a general treatment of the subject.

David T. Williams [1995] identified and conducted a comprehensive, well-documented comparison of four sediment transport relations which predict total bed material load in sand-bed channels. The results of this investigation show that no one sediment transport relationship is best for all applications. It is possible, however, to judiciously select the best sediment transport model for any known set of conditions.

Williams reconstructed the original data sets used in development and evaluation of each of the four selected sediment transport relations, then tested all methods using each of the input data sets. It should be noted that data were excluded which were outside the applicable ranges cited by the developers of the relations, so that only appropriate results were used in comparison of the methods. The four methods, and results of Williams' comparison are as follows:

1) Ackers and White (1973). This transport function is based upon three dimensionless parameters: particle size, mobility and transport. The method is based upon total stream power for fine sediments, and on the product of net grain shear and stream velocity for coarse sediments and assumes that transport efficiency increases as sediment mobility increases.

2) Brownlie (1981). This method is based upon a relation between depth, discharge and bed slope developed over a wide range of uniform flow situations, then applied to unsteady, non-uniform flow. The method was calibrated based upon laboratory and field data and statistical analysis. Brownlie based his analytic approach on the recognition that flow depth is a critical factor in sediment transport predictions. His method was developed by comparing the methods of Ackers and White (1973); Bagnold (1966); Bishop, Simons, and Richardson (1965); Einstein (1950); Engelund and Fredsoe (1976); Engelund and Hansen (1967); Graf (1971); Laursen (1958); Ranga Raju, Garde, and Bhardwaj (1981); Rottner (1959); Shen and Hung (1971); Toffaleti (1968); and Yang (1973). These methods were compared for laboratory and field results in development of the Brownlie relation.

3) Engelund and Hansen (1967). This method is based upon the postulate that bed load results from effective bed shear acting directly on the bed surface, and that suspended load results from agitation by fluid turbulence. Wash load (very fine suspended particles) is considered negligible and is not included in the model. Engelund and Hansen utilize equilibrium of exposed grains to determine whether sediment motion will occur. Mobility of grains depends on relative size of the drag force, lifting force, and immersed grain weight. Horizontal drag force on each particle, $\tau_*$, induced by the flow is proportional to bed shear. Vertical forces include lifting force due to hydrostatic pressure distribution around the grain and the immersed weight of the grain. In summary, the method relies upon classic soil mechanics theory.

4) Yang (1973). The Yang unit stream power sediment transport relation is based upon the hypothesis that the rate at which energy is dissipated in an open channel is related to the concentration of sediment being transported. This is expressed as a velocity-slope product, which physically can be considered the rate of potential energy

dissipation per unit weight of water. The Yang relation is derived from basic fluid mechanics and turbulence theories. The Yang dimensionless unit stream power equations can be expressed in a manner that includes criteria for incipient motion.

Williams' evaluation produced the following four general conclusions:

1) The Ackers and White relation is fairly good for laboratory data but tends to slightly over predict for most cases. However, it under predicts for field data, especially for rivers with medium sand (0.25 - 0.5 mm) and small flow depths (less than 1 foot). The method is not applicable for fine sediment sizes (<0.125 mm) or for large flow depths.

2) The Brownlie relation is at its best for low flow velocities and small depths with medium sands (0.25 - 0.5 mm). This method over predicts for laboratory data with concentrations less than 50 ppm.

3) The Engelund and Hansen relation over predicts at low shear values and generally over predicts for field data except for medium sands (0.25-0.5 mm) where the results under predict actual sediment transport. The relation does well for light weight sediments (specific gravity, $G_s$, less than 2.65).

4) The Yang relation is not applicable for fine sediments (<0.125 mm). It is good for flume and small rivers, although it under predicts for large flow depths. It is highly applicable for medium sands (0.25 - 0.5 mm), but does not do well for lightweight sediment ($G_s$ less than 2.65), and over predicts for coarse sands (>1.0 mm).

Williams developed a method that numerically rates the predictability of these four commonly used sediment transport relations for given hydraulic and sediment conditions. This method is used to select the appropriate sediment transport relation for any laboratory or field data based upon an assessment of dimensionless parameters for grain diameter, $D_{gr}$; grain Froude number, $F_{gr}$; stream power, P; and flow depth, Z.

2. Sediment distribution. Vertical distribution of sediment was shown by Rouse [1950] as :

$$C/C_a = [\{(D - y)/y\}\{a/(D-a)]^z \quad (2)$$

C = concentration at a distance y from the bed
$C_a$ = concentration at a point a above the bed
D = depth of flow
$z = \omega/\beta K v^*$ = Rouse number
$\omega$ = particle fall velocity
$\beta$ = coefficient relating diffusion coefficients
K = von Karman velocity coefficient (often 0.4)

$$v^* = \text{shear velocity} = (gRS)^{1/2}$$

Small values of Rouse number correspond with small particles and turbulent flow, tending toward uniform sediment distribution. Large values of Rouse number produce sediment concentrations in the lower 1/3 of the flow depth, with little sediment at the water surface. This is characteristic for larger particles and less turbulent conditions.

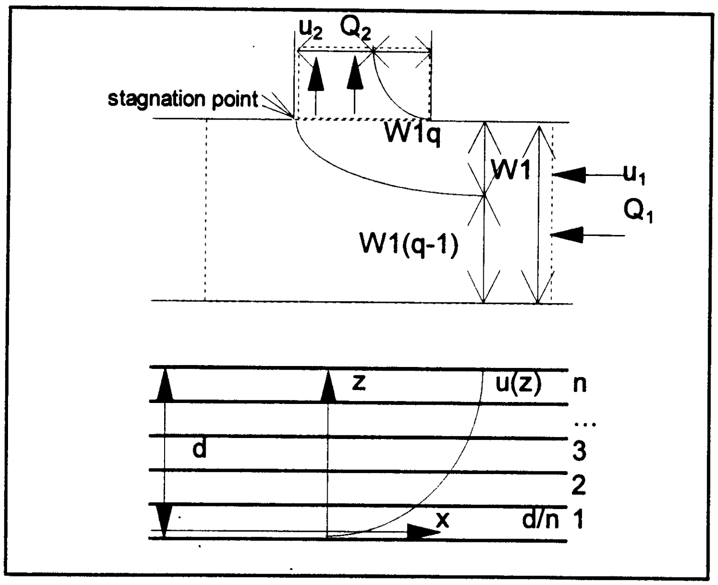



Figure V-A-3: Definition of Control Volume, Flow Strata (1992)

3. Width of Flow Separation Zone: Neary [1992] uses mass, momentum and energy conservation laws to predict the maximum width of the separation zone at a diversionary channel and the distance that the dividing streamline extends into the main channel (see Figure V-A-3).

Governing equations:

$$q = Q_2/Q_1 \tag{3}$$

$Q_1$ = main channel discharge
$Q_2$ = diversion channel discharge

$$S = W_1 \times q \tag{4}$$

$W_1$ = Width of streamline (main channel width)
S = Distance the stream line extends into the main channel

$p$= pressure at a section = $p_{(hydrostatic)}/(\rho g)$ (5)

$p_s$ = stagnation pressure = $p_1 + Q_1^2/(2gW_1^2)$ (6)

(stagnation pressure is approximately the same as pressure immediately upstream of the flow division)

$\omega = \tan^{-1}[(u_2 \sin \delta)/u_1]$ (7)

$\omega$ = diversion channel stream inflow deflection

$\delta$ = diversion angle (angle of departure from main channel centerline)

$u_1$ = main stream velocity in the direction of the main channel

$u_2$ = diversion stream velocity in the direction of the diversion channel

Applying the momentum equation in the direction of the lateral branch and substituting for stagnation pressure yields

$$p1 - p2 = Q_2^2/(g\mu W_2^2) - (Q_1 Q_2 \cos \varepsilon)/gW_1W_2 - (1/4)(Q_1^2/W_1^2) \qquad (8)$$

$\mu$ = contraction ratio (fraction of the branch channel not occupied by the separation zone)

$\varepsilon$ = the angle $\delta - \omega$

Applying the energy equation and substituting for stagnation pressure yields

$$p1 - p2 = Q_2^2/2g\{(1/\mu^2 W_2^2) - [(3/2)(1/q^2 W_1^2)]\} \qquad (9)$$

Setting (8) and (9) equal and simplifying yields the quadratic equation

$$(1/\mu)^2 - 2(1/\mu) + 2(w/q)\cos \varepsilon - (w/q)^2 = 0 \qquad (10)$$

This is solved for $\mu$. The maximum width of the separation zone, H, is

$$H = W_2(1 - \mu) = S_{max} \qquad (11)$$

This set of equations must be solved for each of the vertical flow strata, considering the effect of differential sediment load from surface to stream bed, to arrive at an estimate of the three-dimensional flow separation boundary and width of the separation zone at the midpoint of each stratum.

4. Sediment Deposit at Diversion Channel Inlet. Having calculated the sediment load in the main channel (selecting the transport model per Williams), the vertical sediment distribution (per Rouse), and the width of the separation zone at each of the flow strata (per Neary), another analytic step is required to assess how much of the sediment could be expected to be deposited at the inlet. No relation was found which modeled the recirculating eddy current which is responsible for streamflow velocity reduction and consequent sediment deposition at the inlet. There is evidence that a 90-degree diversion angle exacerbates the

conditions for sediment deposit, and an adverse slope for the diversion canal would also contribute to these conditions.

d. Available Sediment Transport Methods. Mathematical relations for the simulation of non-equilibrium, suspended sediment transport in open channels are based on the solution of 2-D or 3-D convection-diffusion equation and depth integrated models. Several of these relations have been incorporated into computer programs and are available on the market. The previously mentioned Williams [1995] method could be used to select the best analytic model for the conditions at the inlet. Mendez [1996] cites several available mathematical models for analyzing suspended sediment transport. He compared 5 methods (Ackers-White, Brownlie, Engelund-Hansen, Van Rijn, and Yang) and found that the Ackers-White and Brownlie methods seem best suited to predict sediment transport rate in irrigation canals. It was noted that all methods performed better for high sediment concentrations than for concentrations lower than 500 ppm.

e. Cross-section Analysis. The WinXSPRO channel cross-section analyzer software program has capability for estimating sediment transport at a stream cross-section using the Ackers & White transport relation [WEST, 1996].

The USCOE Sediment Analysis Method , SAM, [Copeland et al., 1996] provides a methodology for assessing sediment transport relations for stable channel design. The SAM package provides the computation capability to perform a channel assessment incorporating four sedimentation processes at a cross-section: erosion, entrainment., transportation and deposition. The package is intended to be used as a planning tool. A brief summary of SAM capabilities follows:

SAM.hyd - Calculates normal depth and composite hydraulic parameters for a cross section with variable roughness. It will calculate stable channel dimensions -- channel width, depth and slope-- for a prescribed discharge and sediment load.

SAM.sed - Calculates the bed material sediment discharge rating curve by size class using hydraulic parameters calculated in SAM.hyd or user specified input. SAM.sed applies the sediment transport functions at a point, with no temporal or special variability in the size class distribution.

SAM.yld - Calculates sediment yield passing a cross-section during a period of time. The time period can be a single event or an entire year. Flow input can be a flow duration curve or a hydrograph. Sediment discharge rating curve can be specified as either a ratio of sediment vs water discharge or as a concentration.

SAM.aid - Guides the user in selection of the proper transport functions based upon mean grain diameter, bed slope, velocity, channel width and flow depth.

SAM.avg - Allows for the creation of input files for SAM.sed using an HEC-2 TAPE95 input file.

f. Hydrodynamic models. HEC-6 [USACOE, 1991] is a one-dimensional numerical model that computes scour and deposition by simulating the interaction between the hydraulics of the flow and the rate of sediment transport. HEC-6 simulates the ability of a stream to transport sediment, using various sediment transport functions. The model was designed to simulate long term river and reservoir behavior rather than the response of stream systems to short-term, single event, floods.

MIKE 11 is a 1-D hydrodynamic model developed by the Danish Hydraulic Institute, which permits the computation of non-cohesive sediment transport capacity together with corresponding accumulated erosion/sedimentation rate using several transport and calculation models. The model does not take into account topographical changes during the simulation period, with no feed back from the sediment transport computation to the hydrodynamic computations. MIKE 11 allows prediction using 5 sediment transport methods: Engelund-Hansen, Ackers-White, Smart-Jaeggi, Engelund-Fredsoe and van Rijn [Mendez, 1996].

SOBEK is a 1-D open channel dynamical numerical modeling system developed by Delft Hydraulics and the Institute for Inland Water Management and Waste Water Treatment of the Netherlands. The SOBEK system can be used to study the effect of proposed river training works, dredging optimization, indication of initial aggradation and degradation reaches, long term morphological changes [Mendez, 1996].

g. Diversionary Structures. Sediment can be diverted away from intake structures by means such as training walls, skimming weirs, guide vanes, or tunnel type sediment diverters. Odgaard et al. have conducted extensive research on use of guide vanes in combination with training walls. The theory consists of solving the equations of the motion of water and sediment using appropriate boundary conditions. Vane-induced bed-shear stresses are calculated using airfoil theory [Wang, et al. 1996]. For fully developed flow at the equilibrium state the equations are reduced to

$$\rho g S d = \tau_{bs} + \tau_{vs} \quad (12)$$
$$\rho g S_n d = \tau_{bn} - \tau_{vn} - \rho u^2 d/r \quad (13)$$
$$d(d)/dn = -[m/\{\rho \kappa u B(\theta \Delta\ gD)^{1/2}]\ \tau_{bn} \quad (14)$$

s and n = streamwise and transverse coordinates
r = radius of channel curvature
d = flow depth
u = depth-averaged velocity
S, $S_n$ = water surface slopes in s and n directions,

$\tau_{bs}$, $\tau_{bn}$ = bed shear stresses in s and n directions

$\tau_{vs}$, $\tau_{vn}$ = vane induced shear stresses in s and n directions

$\rho$ = density of water

m = flow resistance factor = $\kappa\,(8/f)^{1/2}$

$\kappa$ = Karman constant

$f$ = Darcy Weisbach friction factor

D = median grain diameter

$\theta$ = Shields parameter

$\Delta = (\rho_s - \rho)/\rho$

$\rho_s$ = density of sediment

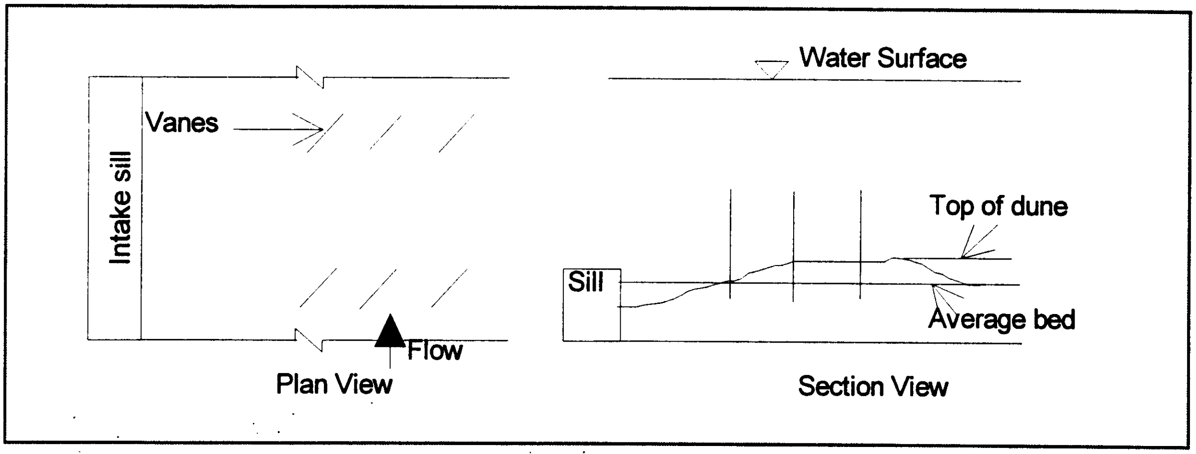



Figure V-A-4: Sediment Diversion Submerged Vanes

g = acceleration due to gravity

B = function of Coulomb friction and of the ratio of lift-force to drag-force for a bed particle.

The diagram in Figure V-A-4 shows vane arrangement. A computer program was developed at the University of Iowa to design vane arrangement for an intake sill based upon the following basic flow and sediment parameters: (1) Pre-vane average flow depth, $d_o$; (2) velocity $u_o$ and resistance parameter m; (3) the channel's width-depth ratio $b/d_o$ and radius-width ratio r/b; and (4) the sediment Froude number $F_D$, which is defined as

$$F_D = u_o / (gd)^{1/2} \tag{15}$$

Input to the computer program includes mean flow velocity, mean depth, sediment properties, and vane dimensions and spacing. The output is velocity and depth distributions.

Odgaard has collected data for several applications including the water intake at the Duane Arnold Energy Center on the Cedar River in Palo, Iowa. These results demonstrate that submerged vanes serve as an effective sediment management tool at water intakes. By introducing relatively small changes in the bed-shear stresses, arrays of vanes can generate significant changes in the distributions of velocity and depth in river channels. These changes can be calculated. The calculations apply only when the intake flow is small enough that the withdrawal causes little change in the river flow velocity in front of the intake (e.g., ratio of withdrawal velocity to river flow velocity less than 0.2).

h. Summary. Sediment is likely to accumulate at the intake of a 90-degree diversionary channel, especially if the diversion canal is at an adverse slope. 1-D and 2-D models exist to analyze sediment transport, and models exist to predict the flow separation at a branch channel, but no model was found which specifically addresses sediment in separated flow at diversionary channels. Submerged guide vanes have been shown as effective in diverting sediment, thereby avoiding accumulation at intake structures. Design charts and a computer design aid are available to assist in designing guide vanes.

## 5-A-02. INLET CHANNEL SEDIMENT ASSESSMENT.

a. General. A channel scour/deposition analysis was conducted for the inlet channel leading up to the pump station based on information developed for the White River. This analysis was used to quantitatively estimate the amount of scour or deposition in the inlet channel with the project in place.

b. Design Data. An HEC-2 model of the White River in the vicinity of Clarendon, AR to Des Arc, AR was constructed with historic cross section supplemented with recent hydrographic survey data at DeValls Bluff, AR. The historic cross section data were from a LR-1 backwater computer model. The more recent hydrographic survey data were digitized to supplement channel cross-section information. The HEC-2 model extends from river mile 80.8 to 143.2.

Manning's n values were 0.037 for the channel and 0.135 for the left and right overbanks. With discharges between 5,000 cfs and 16,000 cfs, the HEC-2 results were between 0.2 feet less to 0.6 feet greater than the target elevations from the 1993 rating curve at Clarendon, AR (Plate V-A-1). HEC-2 results at DeValls Bluff, AR ranged from 0.4 feet less to 1.6 feet less than the target elevation at DeValls Bluff using the stage-stage relationship shown in Plate V-A-2.

The scour/deposition analysis was performed on the inlet channel using channel geometry was obtained from the HEC-2 file developed for the inlet. The HEC-2 model contains 17 cross sections labeled from 0 to 17 spaced 100 feet apart. Section 0 is located at the pump inlet and has an invert elevation of 144 ft. Section 17 is located at the confluence with the White River and has an invert elevation of 137.2 ft. The channel longitudinal slope is -0.004. All sections had a 100 ft. bottom width and 3.5:1 (Horizontal:Vertical) bank slopes.

c. <u>Method</u>. Due to the adverse slope of -0.004 in the inlet channel the WES program SAM was not applicable. The channel was studied using a settling tank analysis method. The inflowing sediment concentration and gradations were assumed to be evenly mixed and to be the same as the White River as reported in the canal sedimentation section of this report.

The settling tank method determines the distance a particle can travel laterally before falling out due to gravitational effects. The controlling properties are the overflow rate $V_o$ (sometimes called surface loading or critical velocity) determined by dividing the water discharge by the surface area of the "tank", and by the velocity in the vertical direction, (settling velocity), which is determined using Plate V-A-3. If it is assumed that the horizontal water velocity, $V_f$, is uniform then all particles with a fall velocity greater than $V_o$ will settle out. The procedure to calculate the quantity of material deposited is described below:

1) Inlet channel discharges of 2,570 cfs, 1,780 cfs and 450 cfs were based on the discharges for canal C1000 as presented in the Canal Sedimentation Analysis section of this report. The discharges represent bank full, high flow and low flow conditions of canal reach C1000, respectively. The water surface in the inlet channel will maintain the same elevation as the White River with the exception of the localized effects caused by pump drawdown. Since the discharge and water surface elevation will remain constant through the channel velocity will increase as the flow area decreases. This will cause the channel velocity to be lowest at the White River and highest at the pump inlet (Plate V-A-4). However, because even the highest velocities are relatively small (less than one ft/s), the uniform horizontal velocity assumption described above is reasonable.

2) The White River HEC-2 model was run with a discharge of 12,500 cfs which is the average discharge during the pump on period (see Canal Sedimentation Analysis section in this report). The water surface elevation at section 122.19 (inlet section) in the White River model was determined to be 159.54 feet. Given the water surface elevation at the White River and the inlet canal geometry provided, the surface area was calculated for the inlet canal (the area did not vary by flow rate since the river water surface elevation was assumed constant). The discharge divided by the surface area yielded the overflow rate $V_o$.

3) The fall velocities were determined using Plate V-A-3 based on a $D_{84}$ of 0.062 mm and a $D_{92}$ of 0.15 mm. These grain size diameters were based on the canal sedimentation analysis presented in this report.

4) Using the overflow rate, $V_o$, and the vertical velocity the percent removed was determined by the equation ( $\omega/V_o$)*100%. This equation makes the simplifying assumption of a horizontal flow tank which will tend to slightly underestimate the sediment deposition. A minimum and maximum percent removed was calculated for each discharge.

5) Once the percent removed was determined, the sediment discharge ($Q_s$) was found by converting the concentration to tons/day. The conversion was based on the following equation where C (mgl) is 74 mgl and Q (cfs) is equal to one of the three

$$C(mg/l) = \frac{Q_s(tons/day)}{Q(cfs)} * \frac{2000lbs}{ton} * \frac{1day}{86400\sec} * \frac{10^6}{62.4lb/ft^3}$$

discharges above. The quantity $Q_s$ was then multiplied by the percent of total material, i.e., 84% or 16%. The results are presented in Plate V-A-5. The total amount deposited presented in the Summary Table of Plate V-A-5 was determined by adding the amount deposited in each size class for a given discharge.

d. Conclusions. The inlet channel scour/deposition analysis results are presented in Plate V-A-5 where the amount deposited is reported for each of the three discharges for two size classes. The Summary Table presents the total amount expected to deposit for each of the three discharges in tons/day and tons/year. This analysis is based on the pump on period only and does not account for the deposition which will occur during the pump off period. The results indicate that all sediment drawn into the inlet canal from the river will deposit; therefore, the pumps would deliver clear water to the irrigation delivery canals. However, if the intake canal is not maintained, it is likely that some equilibrium condition would be reached where the pumped water would contain some fine sediments. A more detailed sedimentation analysis would need to be performed to fully analyze the quantity of deposition.

Further discussion pertaining to sedimentation within the inlet channel was presented in a review of literature written about diversionary channels and a qualitative assessment was made to characterize the nature and location of deposition. The adverse slope of the inlet channel served a two-fold purpose: 1) to enhance deposition trends near the White River while decreasing deposition near the pump intake, and 2) to substantially reduce the probability or larval fish being trapped in the inlet channel by reducing velocities. As current literature indicated, deposition would be primarily at the upstream (White River) bank of the inlet channel near its convergence with the White River (Figure V-A-2). No quantitative estimate of this sediment could be made with available data. Periodic removal of shoaling in this area of the inlet channel will be necessary; however, the adverse slope should significantly extend the period of such maintenance. Dredging operations on the White River could be utilized to complete required maintenance.

Because of the wide variability in White River discharges and pumping station diversions, a quantitative estimate for annual maintenance was not possible with available data. The settling basin approach presented provided an estimate of potential daily deposition rates for several discharges. Since the White River stage greatly impacts the inlet channel velocities (inlet channel velocities could potentially be reversed for out-of-bank White River discharges [the inlet channel sweeps toward the downstream direction of White River flow] even with peak pumpage at the pumping station). An average daily rate of deposition was estimated as 9.5 t/day from available data.

Riprap bank and toe protection, 24 inches of R200 riprap, for the inlet channel will be required at the White River to ensure bank stability, particularly for high White River discharges.

# TOPIC B - CANAL SEDIMENTATION

## 5-B-01. CANAL SCOUR / DEPOSITION ANALYSIS.

A channel scour/deposition analysis was performed on canal reaches C1000, C2000, C3000 and C4000. Canal limits and geometry were obtained from the UNET geometry file for the main canal system. The Stable Channel routine in the HYDRAULIC DESIGN PACKAGE FOR CHANNELS (SAM) computer program was used to evaluate the potential for scour or deposition within each canal reach. SAM Model input requirements were determined as follows:

1) Canal geometry from the UNET model was extracted and analyzed for average geometric conditions. Channel slope, bank slope, area and roughness were considered in the selection of break points. However, canal reaches were uniform and did not require further subdivision (break points were set at the limits between canal reaches). Average channel parameters were then determined for each canal reach (Plate V-B-1).

2) Channel discharges representing high flow, low flow and bank full conditions were run in each canal reach. High and low flow discharges were estimated from the delivery system demands. Bank full discharges were calculated using Manning's equation (Plate V-B-1).

3) The stable channel routine in SAM calculated the equilibrium inflowing sediment concentration for each canal reach. These equilibrium conditions are reported in Plate V-B-2. For the high and intermediate flows for each canal reach, the energy slope input for SAM was equal to the canal slope (0.00005). However, for the low flows, backwater due to intermediate controls (gates) becomes important, and the normal depth assumption is no longer valid. To model this situation with SAM (which always

assumes normal depth), energy slopes were approximated using water surface slopes from the UNET model output for the main canal system. Results using the UNET information are presented in Plate V-B-3.

4) SAM models were set up to run fixed inflowing sediment concentrations of 20 milligrams/liter (mgl), 40 mgl and 60 mgl and the results were tabulated and plotted (Plate V-B-2, Plates V-B-4 through V-B-7, and Plates V-B-8 through V-B-19). Design channel conditions (Plate V-B-2) were compared to these curves to determine the amount of canal scour or deposition.

5) SAM offers nine different methods for n-value calculation on the channel bed (Keulegan, Strickler, Limerinos, Brownlie, SCS A-E). The Brownlie bed roughness equations were chosen due to applicability to project conditions and minimal sediment information requirements compared to the other methods (which require a gradation curve). When using the Brownlie method SAM requires $D_{50}$ and the geometric standard deviation of the bed sediment (computed using $D_{84}$ and $D_{16}$). These grain size diameters were estimated by extracting the values from the White River sediment data that were within ±2,000 cfs from the average discharge for the pump on period of 12,500 cfs. The variability of ±2,000 cfs was based on variations in discharge during pump on period. The resulting 16 data points were plotted to determine the average percentage of material less than 0.062 mm. This average of 82% was used as the $D_{84}$ input value in SAM. $D_{50}$ and $D_{16}$ were estimated as 0.02 mm and 0.006 mm respectively.

6) A canal sediment sensitivity analysis was performed to determine the effects of different gradations on the SAM output. Canal C1000 with the bank full discharge of 2,570 cfs was chosen for the analysis. The $D_{84}$, $D_{50}$ and $D_{16}$ were varied ±30% in 10% increments (Plate V-B-20, Plate V-B-21). The resulting plot exhibits the effects that variations in grain size have on the stable channel dimensions reported by SAM. The sensitivity of the output to changes in grain size is representative of the other channel reaches as well.

## 5-B-02. CANAL SCOUR/ DEPOSITION ANALYSIS RESULTS.

SAM stable channel routine output represents equilibrium channel conditions, i.e., no channel scour or deposition. Plates V-B-8 through V-B-19, Plate V-B-2, and Plates V-B-4 through V-B-7 present these conditions for inflowing concentrations of 20 mgl, 40 mgl and 60 mgl. The existing channel conditions were plotted on these figures for determination of potential scour or deposition. Any inflowing concentration curve that plots above the existing channel condition will result in channel deposition and conversely, any curve below the existing channel condition will result in channel scour. Actual inflowing sediment concentration for the canal cannot be determined from the data available.

An estimate of the inflowing sediment concentration can be made if the flow in the canal is assumed to carry the same concentration as the White River. The sediment data from the USGS gage #07077800 at Clarendon was used to determine the sediment concentration in the White River during the months of canal inlet pump operation. The canal inlet pump operation period was determined from the delivery system requirements (Plate V-B-22). This operation period was plotted on the White River flow hydrograph in order to determine an average discharge for the months May through August (Plate V-B-23). The average discharge was found to be 12,500 cfs at the Clarendon gage. To determine the concentration for a discharge of 12,500 cfs, a plot of sediment discharge vs. water discharge was prepared using White River sediment data from the Clarendon gage (Oct. 1974 - Sept. 1975). An average concentration of 2,500 tons/day was found to correlate to the average discharge of 12,500 cfs (Plate V-B-24). It is assumed that the canals will have the same concentration as the White River. This assumption does not account for any filtering of sediment at the canal inlet. A conversion from tons/day to milligrams/liter (mgl) was required due to the input requirements of SAM. The following conversion equation was used:

$$C_{(mgl)} = \frac{Q_{s\,(tons/day)}}{Q_{(cfs)}} * \frac{2000\,lbs}{ton} * \frac{1\,day}{86400\,sec} * \frac{10^6}{62.4\,{}^{lb}/_{ft^3}}$$

Using the conversion equation, the concentration was found to be approximately 74 mgl. Referring to Plates V-B-8 through V-B-19, Plate V-B-21, and Plate V-B-2, all canals will experience deposition at this concentration level. By observing the results of the sensitivity to grain size analysis (Plate V-B-20, Plate V-B-21) it becomes evident that the canals will still have deposition at this concentration even if the grain sizes are off by ±30%.

Plate V-B-3 shows information from the UNET output file in columns (1) through (3), the computed energy slope in column (4) and the equilibrium concentration calculated with SAM in column (5). Column (6) contains the inflowing concentration entering from upstream; for reach C1000 the inflowing concentration is assumed to be zero, i.e., clear water is entering the canal system (note that this differs from the assumption for Plate V-B-2). Column (7) then presents the calculated scour or deposition for each canal reach.

A sedimentation basin analysis was performed on Canal 1000 using a discharge of 450 cfs to see how the results compared to the output from the stable channel analysis for low flows performed with SAM. The results of the sedimentation basin analysis are presented in Plate V-B-25. SAM predicted 33,293 tons/year, as presented in Plate V-B-2, while the sedimentation basin analysis predicted about half as much, 17,868 tons/year.

**5-B-03. SUMMARY.**

The deposition/scour results presented in Plate V-B-2 predict deposition in all canals for the White River concentration level of 74 mgl. As the concentration level is decreased, the probability of deposition also decreases. If clear water is input to the system, the potential for scour exists as shown in Table h2B. In addition, as the particle size decreases the probability of deposition also decreases. The analysis did not consider inflowing sediment from outside sources nor outflows of sediment along the canal at diversions. Results presented in Plate V-B-2 consider canal reaches treated individually while Plate V-B-3 links the canal segments, the outflow from one segment being the inflow to the next downstream reach.

The potential for deposition, as presented, represents worst-case conditions. Limited sediment data in the White River indicates suspended sediment concentrations of approximately 74 mg/l. Inlet channel deposition was predicted to remove virtually all of this material; therefore, water actually entering the canal system should be relatively sediment free. As such, deposition rates shown for concentrations of 40 mg/l and 60 mg/l would significantly overstate depositional tendencies. Actual deposition within the canal system should be minimal. Any scour potential should be limited by the cohesive nature of the canal banks (constructed to minimize seepage) and vegetative cover above the waterline. Additionally, the canal system will function as a series of pools, between check structures, except when at peak capacity. Average canal velocities at peak capacity will be 1.6 feet per second or less.

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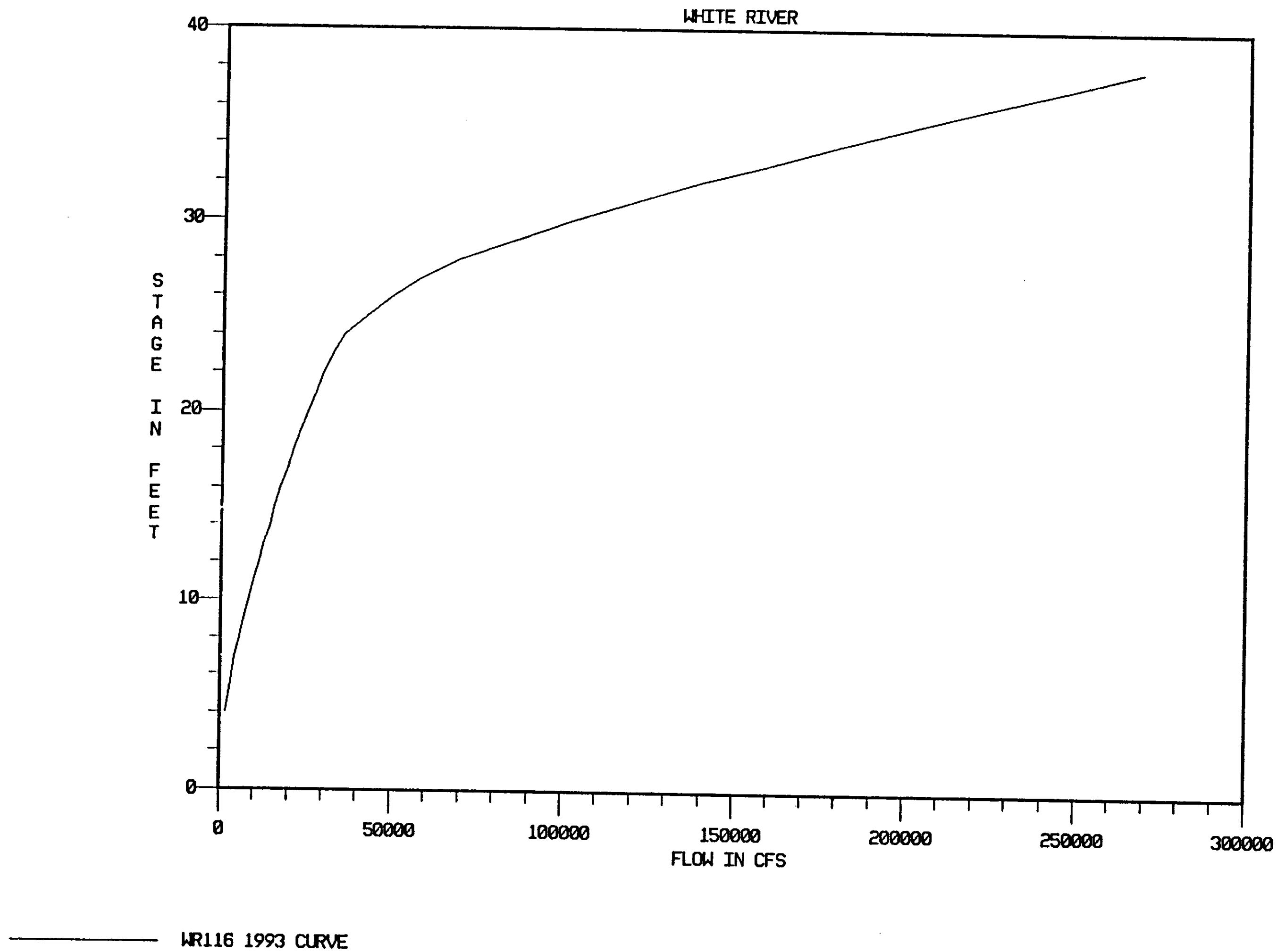
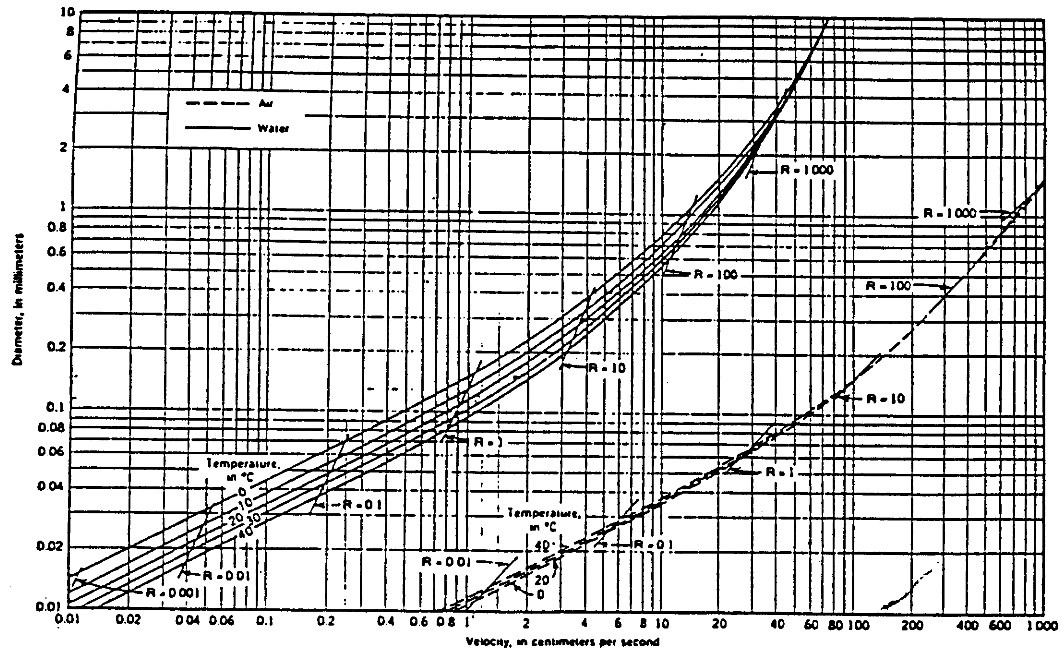



**RATING CURVE AT CLARENDON, AR GAGE**

PLATE V-A-1

# WHITE RIVER, AR
# STAGE vs STAGE RELATIONSHIP

GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
Fall Velocity of Quartz and Spheres in Air and Water (Rouse, 1937b)



**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Inlet Channel Sedimentation Analysis**

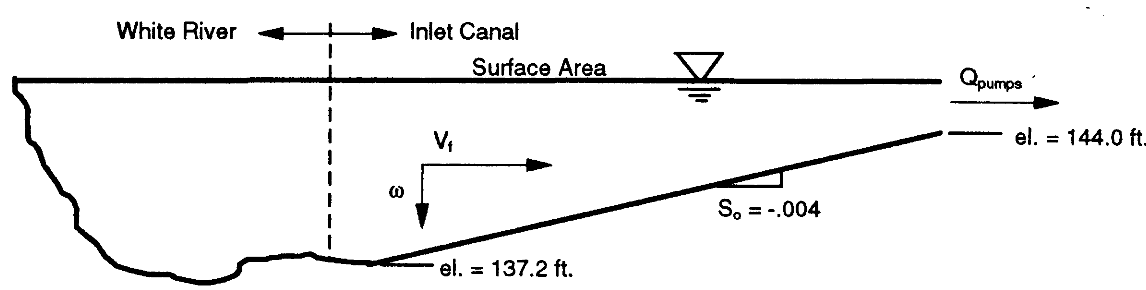



**PLATE V-A-4**

GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
Pump Inlet Channel Deposition Quantities

| (1) | (2) | (3) | (4) | (5) | (6) | (7)=(6)/(3)*100 | (8)=74*(1)/371 | (9)=(8)*(7)*(4)/1E4 |
|---|---|---|---|---|---|---|---|---|
| Discharge (cfs) | Surface Area (sq. ft.) | $V_O$ (ft/s) | % of Total Material | Particle Size (mm) | Settling Velocity (ft/s) | % Removed | Qs (t/day) for C=74mgl | Amount Deposited (t/day) |
| 2570 | 282268 | 0.009 | 16 | 0.15 | 0.0410 | 100 | 512.61 | 82.0 |
| 1780 | 282268 | 0.006 | 16 | 0.15 | 0.0410 | 100 | 355.04 | 56.8 |
| 450 | 282268 | 0.002 | 16 | 0.15 | 0.0410 | 100 | 89.76 | 14.4 |
| 2570 | 282268 | 0.009 | 84 | 0.064 | 0.0098 | 100 | 512.61 | 430.6 |
| 1780 | 282268 | 0.006 | 84 | 0.064 | 0.0098 | 100 | 355.04 | 298.2 |
| 450 | 282268 | 0.002 | 84 | 0.064 | 0.0098 | 100 | 89.76 | 75.4 |

Column Description

(1) Discharges from Canal C1000 analysis
(2) Assumes constant WSEL of 159.54 in canal
(3) Column (1) divided by column (2)
(4) % of material represented by particle size (5)
(5) Material particle size
(6) Settling velocity for particle size (5) ref: Fig. 2.2 ASCE Man. & Reports in Eng. Practice #54

| Summary Table | | |
|---|---|---|
| Q | Amt. Deposited | |
| | min (t/day) | (t/yr) |
| 2570 | 512.6 | 187,228 |
| 1780 | 355.0 | 129,676 |
| 450 | 89.8 | 32,783 |

**GRAND PRAIRIE DEMONSTRATION PROJECT (White River)**
**Canal Sedimentation Analysis, Average Channel Properties**
**Table h1**

| CHANNEL PROPERTY | CANAL | | | |
|---|---|---|---|---|
| | C1000 | C2000 | C3000 | C4000 |
| Slope | 5.00E-05 | 5.00E-05 | 5.00E-05 | 4.80E-05 |
| Avg. Bottom Width (ft.) | 58.4 | 55.1 | 46.9 | 46.0 |
| Avg. Depth (ft.) | 16.3 | 16.3 | 16.3 | 15.4 |
| $Q_{bank\ full}$ (cfs) | 2570 | 2478 | 2241 | 1930 |
| $Q_{high}$ (cfs) | 1780 | 1675 | 1350 | 1220 |
| $Q_{low}$ (cfs) | 450 | 400 | 300 | 250 |
| Manning's n | 0.035 | 0.035 | 0.035 | 0.035 |
| Side Slope | 3 | 3 | 3 | 3 |
| $D_{85}$ (mm) | 0.062 | 0.062 | 0.062 | 0.062 |
| $D_{50}$ (mm) | 0.020 | 0.020 | 0.020 | 0.020 |
| $D_{16}$ (mm) | 0.006 | 0.006 | 0.006 | 0.006 |

## GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
### Table h2A - Canal Scour/Deposition Results

| CANAL | Discharge (cfs) | Equilibrium Condition (mgl)[1] | Inflowing Conc. (mgl) | + Deposit -Scour (tons/year) | Inflowing Conc. (mgl) | + Deposit -Scour (tons/year) | Inflowing Conc. (mgl) | + Deposit -Scour (tons/year) | Inflowing Conc. (mgl) | + Deposit -Scour (tons/year) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | 2570 | 47.09 | 20 | -68541 | 40 | -17939 | 60 | 32664 | 74 | 68085 |
| 1000 | 1780 | 41.3 | 20 | -37326 | 40 | -2278 | 60 | 32769 | 74 | 57303 |
| 1000 | 457 | 0 | 20 | 8998 | 40 | 17996 | 60 | 26994 | 74 | 33293 |
| 2000 | 2478 | 44.63 | 20 | -60086 | 40 | -11295 | 60 | 37496 | 74 | 71649 |
| 2000 | 1675 | 38.82 | 20 | -31034 | 40 | 1946 | 60 | 34926 | 74 | 58012 |
| 2000 | 410 | 0 | 20 | 8073 | 40 | 16145 | 60 | 24218 | 74 | 29869 |
| 3000 | 2241 | 38.38 | 20 | -40550 | 40 | 3574 | 60 | 47698 | 74 | 78586 |
| 3000 | 1350 | 31.99 | 20 | -15935 | 40 | 10646 | 60 | 37227 | 74 | 55833 |
| 3000 | 307 | 8.1 | 20 | 3597 | 40 | 9641 | 60 | 15686 | 74 | 19917 |
| 4000 | 1930 | 35.99 | 20 | -30382 | 40 | 7619 | 60 | 45620 | 74 | 72221 |
| 4000 | 1220 | 30.28 | 20 | -12347 | 40 | 11674 | 60 | 35696 | 74 | 52511 |
| 4000 | 237 | 20.3 | 20 | -70 | 40 | 4596 | 60 | 9263 | 74 | 12529 |

[1] Equilibrium concentrations calculated with SAM. For high and intermediate flows energy slope = channel slope = 5E-5. For low flows, slope is equal to water surface slope from District UNET model (see Table h2B)

Example calculation

$$C(mgl) = 371\left(\frac{Q_s}{Q}\right) \qquad where \qquad 371 = \frac{2000\ lbs}{ton}\,\frac{1\ day}{86400\sec}\,\frac{10^6}{62.4\ lb/ft^3}$$

$$Q_s(tons/year) = \frac{C\,Q}{371}\,\frac{365.24\,days}{year}$$

$$68085\ tons/year = \frac{(74-47.09)\,mgl * 2570\,cfs}{371} * \frac{365.24\ days}{year}$$

## GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
## Table h2B - Canal Scour/Deposition Results

| Canal Reach | (1) Cross Section | (2) Discharge (cfs) | (3) Water Surface El. (ft.) | (4) Computed Energy Slope | (5) Equilibrium Condition (mgl) | (6) Inflowing Conc. (mgl) | (7) + Deposit -Scour (tons/year) |
|---|---|---|---|---|---|---|---|
| | 0.31 | 1649 | 232.5 | | | | |
| 1000 | Ave.Q = | 1646 | | 6.00E-05 | 58.6 | 0 | -94930 |
| | 4.35 | 1642 | 231.22 | | | | |
| 2000 | Ave.Q = | 1567 | | 7.21E-05 | 80.25 | 58.6 | -33399 |
| | 12.31 | 1492 | 228.19 | | | | |
| 3000 | Ave.Q = | 1322 | | 5.61E-05 | 40.67 | 80.25 | 51513 |
| | 24.77 | 1152 | 224.5 | | | | |
| 4000 | Ave.Q = | 1069 | | 6.06E-05 | 44.48 | 40.67 | -4008 |
| | 35.3 | 985 | 221.13 | | | | |
| | | | | | | | |
| | 0.31 | 1115 | 230.42 | | | | |
| 1000 | Ave.Q = | 1103 | | 4.83E-05 | 30.64 | 0 | -33271 |
| | 4.35 | 1091 | 229.39 | | | | |
| 2000 | Ave.Q = | 1031 | | 4.59E-05 | 26 | 30.64 | 4710 |
| | 12.31 | 971 | 227.46 | | | | |
| 3000 | Ave.Q = | 847 | | 4.50E-05 | 20.19 | 26 | 4845 |
| | 24.77 | 723 | 224.5 | | | | |
| 4000 | Ave.Q = | 667 | | 6.21E-05 | 37.51 | 20.19 | -11365 |
| | 35.3 | 610 | 221.05 | | | | |
| | | | | | | | |
| | 0.31 | 458 | 227.99 | | | | |
| 1000 | Ave.Q = | 457 | | 1.45E-05 | 0 | 0 | 0 |
| | 4.35 | 456 | 227.68 | | | | |
| 2000 | Ave.Q = | 410 | | 1.05E-05 | 0 | 0 | 0 |
| | 12.31 | 363 | 227.24 | | | | |
| 3000 | Ave.Q = | 307 | | 4.16E-05 | 8.1 | 0 | -2448 |
| | 24.77 | 251 | 224.5 | | | | |
| 4000 | Ave.Q = | 237 | | 6.28E-05 | 20.3 | 8.1 | -2841 |
| | 35.3 | 222 | 221.01 | | | | |

(1)-(3) = Information from canal UNET model provided by Memphis District
(4) = (Delta Water Surface Elevation ) / (Canal Reach Length), Energy slope input for SAM
(5) = Computed equilibrium condition from SAM stable channel analysis
(6) = Inflowing sediment concentration from previous canal reach (0 for first reach)
(7) = (2) * ((6)-(5)) * (365 days/year) * (1/371)

$$where \quad 371 = \frac{2000\,lbs}{ton}\,\frac{1\,day}{86400\sec}\,\frac{10^6}{62.4\,{}^{lb}\!/\!_{ft^3}}$$

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal Sedimentation Analysis**
**Canal C1000**

| Bank full Q=2570cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 10 | 0.000070 | 10 | 0.000099 | 10 | 0.000122 |
| 20 | 0.000051 | 20 | 0.000071 | 20 | 0.000087 |
| 30 | 0.000043 | 30 | 0.000059 | 30 | 0.000073 |
| 40 | 0.000038 | 40 | 0.000053 | 40 | 0.000064 |
| 51 | 0.000035 | 51 | 0.000049 | 51 | 0.000059 |
| 61 | 0.000033 | 61 | 0.000046 | 61 | 0.000056 |
| 71 | 0.000032 | 71 | 0.000044 | 71 | 0.000053 |
| 81 | 0.000031 | 81 | 0.000042 | 81 | 0.000051 |
| 91 | 0.000030 | 91 | 0.000041 | 91 | 0.000050 |
| 101 | 0.000029 | 101 | 0.000040 | 101 | 0.000049 |
| 111 | 0.000029 | 111 | 0.000040 | 111 | 0.000048 |
| 121 | 0.000028 | 121 | 0.000039 | 121 | 0.000048 |
| 131 | 0.000028 | 131 | 0.000039 | 131 | 0.000048 |
| 141 | 0.000028 | 141 | 0.000039 | 141 | 0.000048 |
| 152 | 0.000028 | 152 | 0.000039 | 152 | 0.000047 |
| 162 | 0.000028 | 162 | 0.000039 | 162 | 0.000048 |
| 172 | 0.000028 | 172 | 0.000039 | 172 | 0.000048 |
| 182 | 0.000028 | 182 | 0.000039 | 182 | 0.000048 |
| 192 | 0.000028 | 192 | 0.000039 | 192 | 0.000048 |
| 202 | 0.000028 | 202 | 0.000039 | 202 | 0.000049 |

| Q = 1780 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 8 | 0.000079 | 8 | 0.000111 | 8 | 0.000137 |
| 17 | 0.000058 | 17 | 0.000080 | 17 | 0.000098 |
| 25 | 0.000049 | 25 | 0.000067 | 25 | 0.000082 |
| 34 | 0.000044 | 34 | 0.000060 | 34 | 0.000073 |
| 42 | 0.000040 | 42 | 0.000055 | 42 | 0.000067 |
| 50 | 0.000038 | 50 | 0.000052 | 50 | 0.000063 |
| 59 | 0.000036 | 59 | 0.000049 | 59 | 0.000060 |
| 67 | 0.000035 | 67 | 0.000047 | 67 | 0.000058 |
| 76 | 0.000034 | 76 | 0.000046 | 76 | 0.000056 |
| 84 | 0.000033 | 84 | 0.000045 | 84 | 0.000055 |
| 92 | 0.000032 | 92 | 0.000044 | 92 | 0.000054 |
| 101 | 0.000032 | 101 | 0.000044 | 101 | 0.000054 |
| 109 | 0.000032 | 109 | 0.000044 | 109 | 0.000053 |
| 118 | 0.000032 | 118 | 0.000043 | 118 | 0.000053 |
| 126 | 0.000032 | 126 | 0.000043 | 126 | 0.000053 |
| 134 | 0.000032 | 134 | 0.000043 | 134 | 0.000053 |
| 143 | 0.000032 | 143 | 0.000043 | 143 | 0.000053 |
| 151 | 0.000032 | 151 | 0.000044 | 151 | 0.000053 |
| 160 | 0.000032 | 160 | 0.000044 | 160 | 0.000054 |
| 168 | 0.000032 | 168 | 0.000044 | 168 | 0.000054 |

| Q = 450 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 4 | 0.00013 | 4 | 0.00018 | 4 | 0.00021 |
| 8 | 0.00009 | 8 | 0.00013 | 8 | 0.00015 |
| 13 | 0.00008 | 13 | 0.00011 | 13 | 0.00013 |
| 17 | 0.00007 | 17 | 0.00010 | 17 | 0.00012 |
| 21 | 0.00007 | 21 | 0.00009 | 21 | 0.00011 |
| 25 | 0.00006 | 25 | 0.00008 | 25 | 0.00010 |
| 29 | 0.00006 | 29 | 0.00008 | 29 | 0.00009 |
| 34 | 0.00006 | 34 | 0.00008 | 34 | 0.00009 |
| 38 | 0.00006 | 38 | 0.00007 | 38 | 0.00009 |
| 42 | 0.00005 | 42 | 0.00007 | 42 | 0.00009 |
| 46 | 0.00005 | 46 | 0.00007 | 46 | 0.00008 |
| 50 | 0.00005 | 50 | 0.00007 | 50 | 0.00008 |
| 55 | 0.00005 | 55 | 0.00007 | 55 | 0.00008 |
| 59 | 0.00005 | 59 | 0.00007 | 59 | 0.00008 |
| 63 | 0.00005 | 63 | 0.00007 | 63 | 0.00008 |
| 67 | 0.00005 | 67 | 0.00007 | 67 | 0.00008 |
| 71 | 0.00005 | 71 | 0.00007 | 71 | 0.00008 |
| 76 | 0.00005 | 76 | 0.00007 | 76 | 0.00008 |
| 80 | 0.00005 | 80 | 0.00007 | 80 | 0.00008 |
| 84 | 0.00005 | 84 | 0.00007 | 84 | 0.00008 |

Table h3

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal Sedimentation Analysis**
**Canal C2000**

| Bank full Q=2478 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 10 | 0.000070 | 10 | 0.000099 | 10 | 0.000123 |
| 20 | 0.000051 | 20 | 0.000072 | 20 | 0.000088 |
| 30 | 0.000043 | 30 | 0.000060 | 30 | 0.000073 |
| 40 | 0.000039 | 40 | 0.000053 | 40 | 0.000065 |
| 50 | 0.000036 | 50 | 0.000049 | 50 | 0.000060 |
| 60 | 0.000034 | 60 | 0.000046 | 60 | 0.000056 |
| 70 | 0.000032 | 70 | 0.000044 | 70 | 0.000054 |
| 80 | 0.000031 | 80 | 0.000042 | 80 | 0.000052 |
| 90 | 0.000030 | 90 | 0.000041 | 90 | 0.000050 |
| 100 | 0.000029 | 100 | 0.000041 | 100 | 0.000049 |
| 110 | 0.000029 | 110 | 0.000040 | 110 | 0.000049 |
| 120 | 0.000029 | 120 | 0.000040 | 120 | 0.000048 |
| 130 | 0.000028 | 130 | 0.000039 | 130 | 0.000048 |
| 140 | 0.000028 | 140 | 0.000039 | 140 | 0.000048 |
| 150 | 0.000028 | 150 | 0.000039 | 150 | 0.000048 |
| 160 | 0.000028 | 160 | 0.000039 | 160 | 0.000048 |
| 170 | 0.000028 | 170 | 0.000039 | 170 | 0.000048 |
| 180 | 0.000028 | 180 | 0.000039 | 180 | 0.000049 |
| 190 | 0.000029 | 190 | 0.000040 | 190 | 0.000049 |
| 200 | 0.000029 | 200 | 0.000040 | 200 | 0.000049 |

| Q=1675 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 8 | 0.000080 | 8 | 0.000113 | 8 | 0.000139 |
| 16 | 0.000059 | 16 | 0.000082 | 16 | 0.000100 |
| 25 | 0.000050 | 25 | 0.000068 | 25 | 0.000083 |
| 33 | 0.000044 | 33 | 0.000061 | 33 | 0.000074 |
| 41 | 0.000041 | 41 | 0.000056 | 41 | 0.000068 |
| 49 | 0.000039 | 49 | 0.000053 | 49 | 0.000064 |
| 57 | 0.000037 | 57 | 0.000050 | 57 | 0.000061 |
| 66 | 0.000035 | 66 | 0.000048 | 66 | 0.000059 |
| 74 | 0.000034 | 74 | 0.000047 | 74 | 0.000057 |
| 82 | 0.000034 | 82 | 0.000046 | 82 | 0.000056 |
| 90 | 0.000033 | 90 | 0.000045 | 90 | 0.000055 |
| 98 | 0.000033 | 98 | 0.000045 | 98 | 0.000055 |
| 107 | 0.000032 | 107 | 0.000044 | 107 | 0.000054 |
| 115 | 0.000032 | 115 | 0.000044 | 115 | 0.000054 |
| 123 | 0.000032 | 123 | 0.000044 | 123 | 0.000054 |
| 131 | 0.000032 | 131 | 0.000044 | 131 | 0.000054 |
| 139 | 0.000032 | 139 | 0.000044 | 139 | 0.000054 |
| 148 | 0.000032 | 148 | 0.000044 | 148 | 0.000054 |
| 156 | 0.000032 | 156 | 0.000045 | 156 | 0.000055 |
| 164 | 0.000033 | 164 | 0.000045 | 164 | 0.000055 |

| Q=400 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 4 | 0.000130 | 4 | 0.000181 | 4 | 0.000222 |
| 8 | 0.000097 | 8 | 0.000132 | 8 | 0.000160 |
| 12 | 0.000082 | 12 | 0.000111 | 12 | 0.000134 |
| 16 | 0.000074 | 16 | 0.000099 | 16 | 0.000119 |
| 20 | 0.000068 | 20 | 0.000091 | 20 | 0.000109 |
| 24 | 0.000064 | 24 | 0.000085 | 24 | 0.000102 |
| 28 | 0.000061 | 28 | 0.000081 | 28 | 0.000097 |
| 32 | 0.000059 | 32 | 0.000078 | 32 | 0.000094 |
| 36 | 0.000057 | 36 | 0.000076 | 36 | 0.000091 |
| 40 | 0.000055 | 40 | 0.000074 | 40 | 0.000089 |
| 44 | 0.000054 | 44 | 0.000072 | 44 | 0.000087 |
| 48 | 0.000054 | 48 | 0.000071 | 48 | 0.000086 |
| 52 | 0.000053 | 52 | 0.000071 | 52 | 0.000085 |
| 56 | 0.000052 | 56 | 0.000070 | 56 | 0.000084 |
| 60 | 0.000052 | 60 | 0.000070 | 60 | 0.000084 |
| 64 | 0.000052 | 64 | 0.000070 | 64 | 0.000084 |
| 68 | 0.000052 | 68 | 0.000070 | 68 | 0.000084 |
| 72 | 0.000052 | 72 | 0.000070 | 72 | 0.000084 |
| 76 | 0.000052 | 76 | 0.000070 | 76 | 0.000084 |
| 80 | 0.000052 | 80 | 0.000070 | 80 | 0.000085 |

Table h4

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal Sedimentation Analysis**
**Canal C3000**

| Bank full Q=2241cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 10 | 0.000073 | 10 | 0.000103 | 10 | 0.000127 |
| 19 | 0.000053 | 19 | 0.000074 | 19 | 0.000091 |
| 29 | 0.000045 | 29 | 0.000062 | 29 | 0.000076 |
| 38 | 0.000040 | 38 | 0.000055 | 38 | 0.000067 |
| 48 | 0.000037 | 48 | 0.000051 | 48 | 0.000062 |
| 57 | 0.000035 | 57 | 0.000048 | 57 | 0.000058 |
| 67 | 0.000033 | 67 | 0.000045 | 67 | 0.000055 |
| 76 | 0.000032 | 76 | 0.000044 | 76 | 0.000053 |
| 86 | 0.000031 | 86 | 0.000043 | 86 | 0.000052 |
| 95 | 0.000031 | 95 | 0.000042 | 95 | 0.000051 |
| 105 | 0.000030 | 105 | 0.000041 | 105 | 0.000050 |
| 114 | 0.000030 | 114 | 0.000041 | 114 | 0.000050 |
| 124 | 0.000029 | 124 | 0.000041 | 124 | 0.000050 |
| 133 | 0.000029 | 133 | 0.000040 | 133 | 0.000049 |
| 143 | 0.000029 | 143 | 0.000040 | 143 | 0.000049 |
| 152 | 0.000029 | 152 | 0.000040 | 152 | 0.000050 |
| 162 | 0.000029 | 162 | 0.000041 | 162 | 0.000050 |
| 171 | 0.000029 | 171 | 0.000041 | 171 | 0.000050 |
| 181 | 0.000030 | 181 | 0.000041 | 181 | 0.000050 |
| 190 | 0.000030 | 190 | 0.000041 | 190 | 0.000051 |

| Q=1350 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 7 | 0.000087 | 7 | 0.000122 | 7 | 0.000150 |
| 15 | 0.000064 | 15 | 0.000088 | 15 | 0.000107 |
| 22 | 0.000054 | 22 | 0.000074 | 22 | 0.000090 |
| 29 | 0.000048 | 29 | 0.000066 | 29 | 0.000080 |
| 37 | 0.000044 | 37 | 0.000060 | 37 | 0.000073 |
| 44 | 0.000042 | 44 | 0.000057 | 44 | 0.000069 |
| 51 | 0.000040 | 51 | 0.000054 | 51 | 0.000065 |
| 58 | 0.000038 | 58 | 0.000052 | 58 | 0.000063 |
| 66 | 0.000037 | 66 | 0.000050 | 66 | 0.000061 |
| 73 | 0.000036 | 73 | 0.000049 | 73 | 0.000060 |
| 80 | 0.000036 | 80 | 0.000049 | 80 | 0.000059 |
| 88 | 0.000035 | 88 | 0.000048 | 88 | 0.000058 |
| 95 | 0.000035 | 95 | 0.000048 | 95 | 0.000058 |
| 102 | 0.000035 | 102 | 0.000047 | 102 | 0.000058 |
| 110 | 0.000035 | 110 | 0.000047 | 110 | 0.000058 |
| 117 | 0.000035 | 117 | 0.000047 | 117 | 0.000058 |
| 124 | 0.000035 | 124 | 0.000047 | 124 | 0.000058 |
| 131 | 0.000035 | 131 | 0.000047 | 131 | 0.000058 |
| 139 | 0.000035 | 139 | 0.000048 | 139 | 0.000058 |
| 146 | 0.000035 | 146 | 0.000048 | 146 | 0.000059 |

| Q=300 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 4 | 0.000143 | 4 | 0.000198 | 4 | 0.000242 |
| 7 | 0.000106 | 7 | 0.000145 | 7 | 0.000175 |
| 11 | 0.000091 | 11 | 0.000122 | 11 | 0.000147 |
| 14 | 0.000081 | 14 | 0.000109 | 14 | 0.000130 |
| 18 | 0.000075 | 18 | 0.000100 | 18 | 0.000120 |
| 21 | 0.000071 | 21 | 0.000094 | 21 | 0.000112 |
| 25 | 0.000067 | 25 | 0.000089 | 25 | 0.000107 |
| 28 | 0.000065 | 28 | 0.000086 | 28 | 0.000103 |
| 32 | 0.000063 | 32 | 0.000083 | 32 | 0.000099 |
| 35 | 0.000061 | 35 | 0.000081 | 35 | 0.000097 |
| 39 | 0.000060 | 39 | 0.000080 | 39 | 0.000095 |
| 42 | 0.000059 | 42 | 0.000078 | 42 | 0.000094 |
| 46 | 0.000058 | 46 | 0.000078 | 46 | 0.000093 |
| 49 | 0.000058 | 49 | 0.000077 | 49 | 0.000093 |
| 53 | 0.000058 | 53 | 0.000077 | 53 | 0.000092 |
| 56 | 0.000057 | 56 | 0.000076 | 56 | 0.000092 |
| 60 | 0.000057 | 60 | 0.000076 | 60 | 0.000092 |
| 63 | 0.000057 | 63 | 0.000077 | 63 | 0.000092 |
| 67 | 0.000057 | 67 | 0.000077 | 67 | 0.000092 |
| 70 | 0.000058 | 70 | 0.000077 | 70 | 0.000093 |

Table h5

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal Sedimentation Analysis**
**Canal C4000**

| Bank full Q=1930cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 9 | 0.000077 | 9 | 0.000108 | 9 | 0.000133 |
| 18 | 0.000056 | 18 | 0.000078 | 18 | 0.000095 |
| 26 | 0.000047 | 26 | 0.000065 | 26 | 0.000080 |
| 35 | 0.000042 | 35 | 0.000058 | 35 | 0.000071 |
| 44 | 0.000039 | 44 | 0.000053 | 44 | 0.000065 |
| 53 | 0.000037 | 53 | 0.000050 | 53 | 0.000061 |
| 62 | 0.000035 | 62 | 0.000048 | 62 | 0.000058 |
| 70 | 0.000034 | 70 | 0.000046 | 70 | 0.000056 |
| 79 | 0.000033 | 79 | 0.000045 | 79 | 0.000055 |
| 88 | 0.000032 | 88 | 0.000044 | 88 | 0.000054 |
| 97 | 0.000032 | 97 | 0.000043 | 97 | 0.000053 |
| 106 | 0.000031 | 106 | 0.000043 | 106 | 0.000052 |
| 114 | 0.000031 | 114 | 0.000042 | 114 | 0.000052 |
| 123 | 0.000031 | 123 | 0.000042 | 123 | 0.000052 |
| 132 | 0.000031 | 132 | 0.000042 | 132 | 0.000052 |
| 141 | 0.000031 | 141 | 0.000042 | 141 | 0.000052 |
| 150 | 0.000031 | 150 | 0.000042 | 150 | 0.000052 |
| 158 | 0.000031 | 158 | 0.000043 | 158 | 0.000052 |
| 167 | 0.000031 | 167 | 0.000043 | 167 | 0.000053 |
| 176 | 0.000031 | 176 | 0.000043 | 176 | 0.000053 |

| Q=1220 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 7 | 0.000089 | 7 | 0.000125 | 7 | 0.000154 |
| 14 | 0.000066 | 14 | 0.000091 | 14 | 0.000111 |
| 21 | 0.000055 | 21 | 0.000076 | 21 | 0.000092 |
| 28 | 0.000050 | 28 | 0.000068 | 28 | 0.000082 |
| 35 | 0.000046 | 35 | 0.000062 | 35 | 0.000075 |
| 42 | 0.000043 | 42 | 0.000058 | 42 | 0.000071 |
| 49 | 0.000041 | 49 | 0.000056 | 49 | 0.000067 |
| 56 | 0.000040 | 56 | 0.000054 | 56 | 0.000065 |
| 63 | 0.000038 | 63 | 0.000052 | 63 | 0.000063 |
| 70 | 0.000038 | 70 | 0.000051 | 70 | 0.000062 |
| 77 | 0.000037 | 77 | 0.000050 | 77 | 0.000061 |
| 84 | 0.000036 | 84 | 0.000050 | 84 | 0.000060 |
| 91 | 0.000036 | 91 | 0.000049 | 91 | 0.000060 |
| 98 | 0.000036 | 98 | 0.000049 | 98 | 0.000060 |
| 105 | 0.000036 | 105 | 0.000049 | 105 | 0.000059 |
| 112 | 0.000036 | 112 | 0.000049 | 112 | 0.000060 |
| 119 | 0.000036 | 119 | 0.000049 | 119 | 0.000060 |
| 126 | 0.000036 | 126 | 0.000049 | 126 | 0.000060 |
| 133 | 0.000036 | 133 | 0.000049 | 133 | 0.000060 |
| 140 | 0.000036 | 140 | 0.000050 | 140 | 0.000061 |

| Q=250 cfs | | | | | |
|---|---|---|---|---|---|
| Bottom Width | Slope Conc.=20 mgl | Bottom Width | Slope Conc.=40 mgl | Bottom Width | Slope Conc.=60 mgl |
| 3 | 0.000152 | 3 | 0.000211 | 3 | 0.000257 |
| 6 | 0.000113 | 6 | 0.000154 | 6 | 0.000186 |
| 10 | 0.000097 | 10 | 0.000130 | 10 | 0.000156 |
| 13 | 0.000087 | 13 | 0.000116 | 13 | 0.000139 |
| 16 | 0.000080 | 16 | 0.000106 | 16 | 0.000127 |
| 19 | 0.000075 | 19 | 0.000100 | 19 | 0.000119 |
| 22 | 0.000072 | 22 | 0.000095 | 22 | 0.000113 |
| 26 | 0.000069 | 26 | 0.000091 | 26 | 0.000109 |
| 29 | 0.000067 | 29 | 0.000088 | 29 | 0.000106 |
| 32 | 0.000065 | 32 | 0.000086 | 32 | 0.000103 |
| 35 | 0.000064 | 35 | 0.000085 | 35 | 0.000101 |
| 38 | 0.000063 | 38 | 0.000083 | 38 | 0.000100 |
| 42 | 0.000062 | 42 | 0.000082 | 42 | 0.000099 |
| 45 | 0.000062 | 45 | 0.000082 | 45 | 0.000098 |
| 48 | 0.000061 | 48 | 0.000081 | 48 | 0.000098 |
| 51 | 0.000061 | 51 | 0.000081 | 51 | 0.000097 |
| 54 | 0.000061 | 54 | 0.000081 | 54 | 0.000097 |
| 58 | 0.000061 | 58 | 0.000081 | 58 | 0.000098 |
| 61 | 0.000061 | 61 | 0.000081 | 61 | 0.000098 |
| 64 | 0.000061 | 64 | 0.000082 | 64 | 0.000098 |

Table h6

**PLATE V-B-7**

**GRAND PRARIE AREA DEMONS RATION PROJECT (White River)**
**Canal C1000, Sedimentation Analysis**
**Q = 2570 cfs**

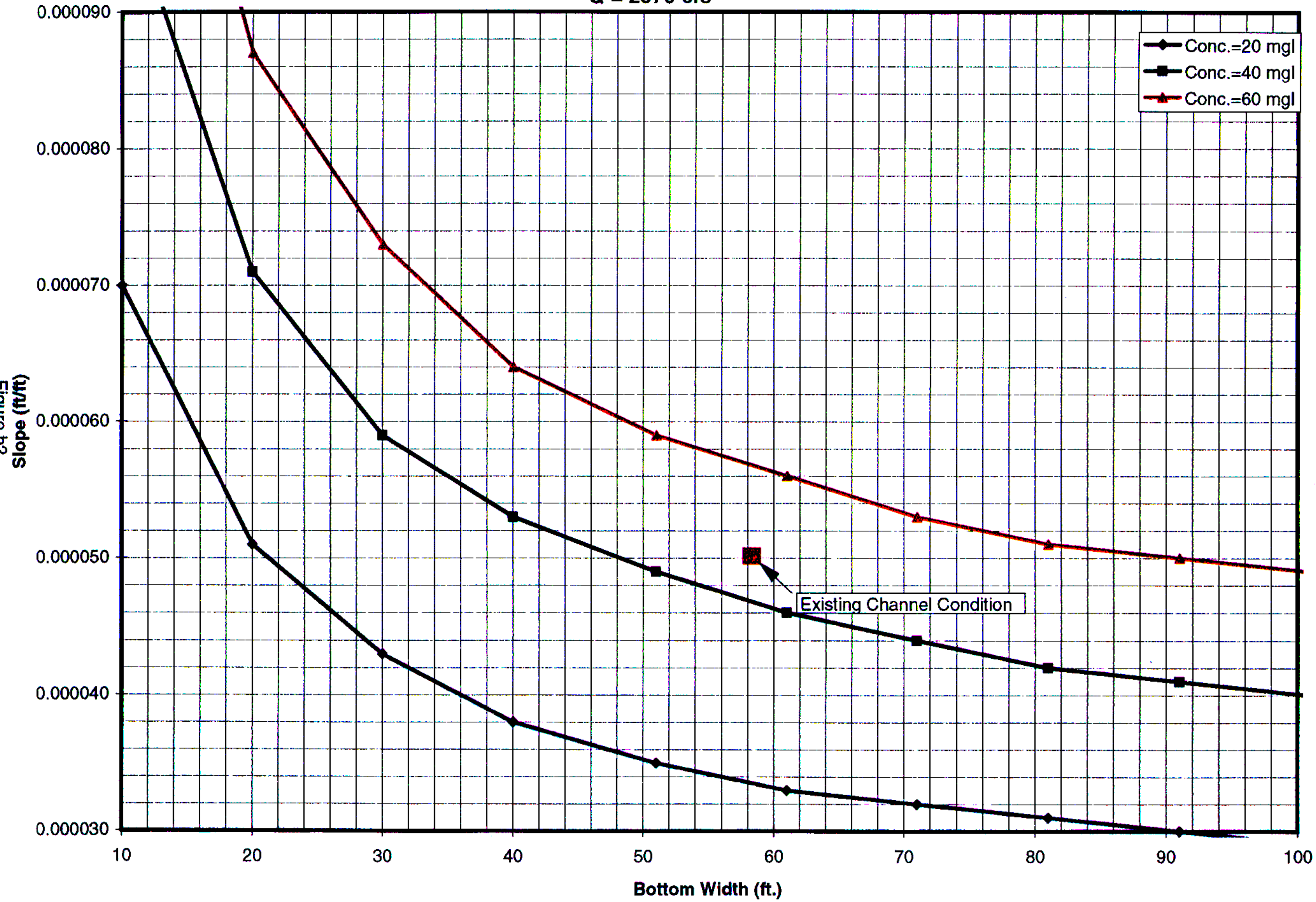



Figure h2

PLATE V-B-8

**GRAND PRARIE AREA DEMONSTRATION PROJECT (White River)**
**Canal C1000, Sedimentation Analysis**
**Q = 1780 cfs**

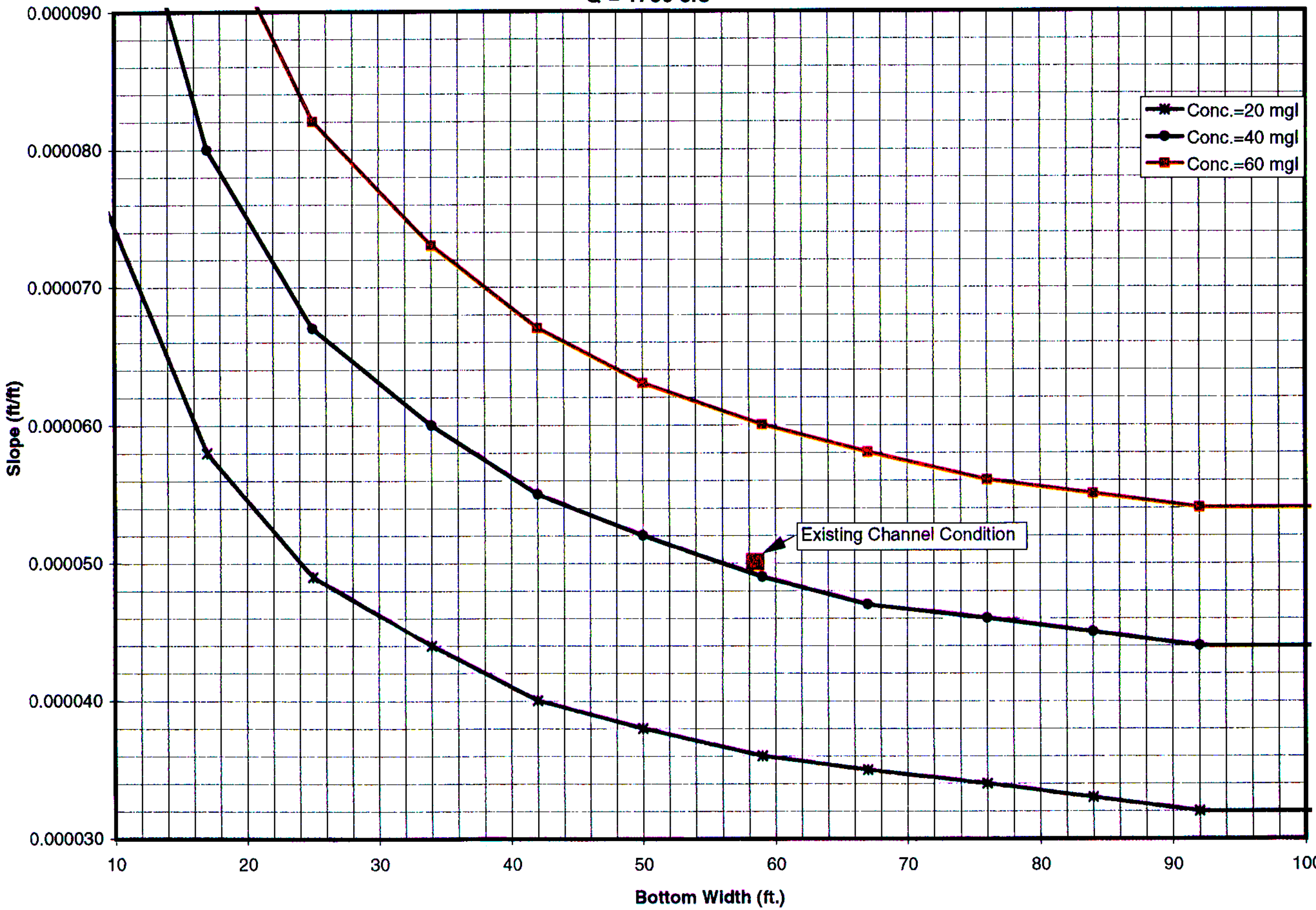



Figure h3

PLATE V-B-9

## GRAND PRARIE AREA DEMONSTRATION PROJECT (White River)
## Canal C1000, Sedimentation Analysis
## Q = 450 cfs

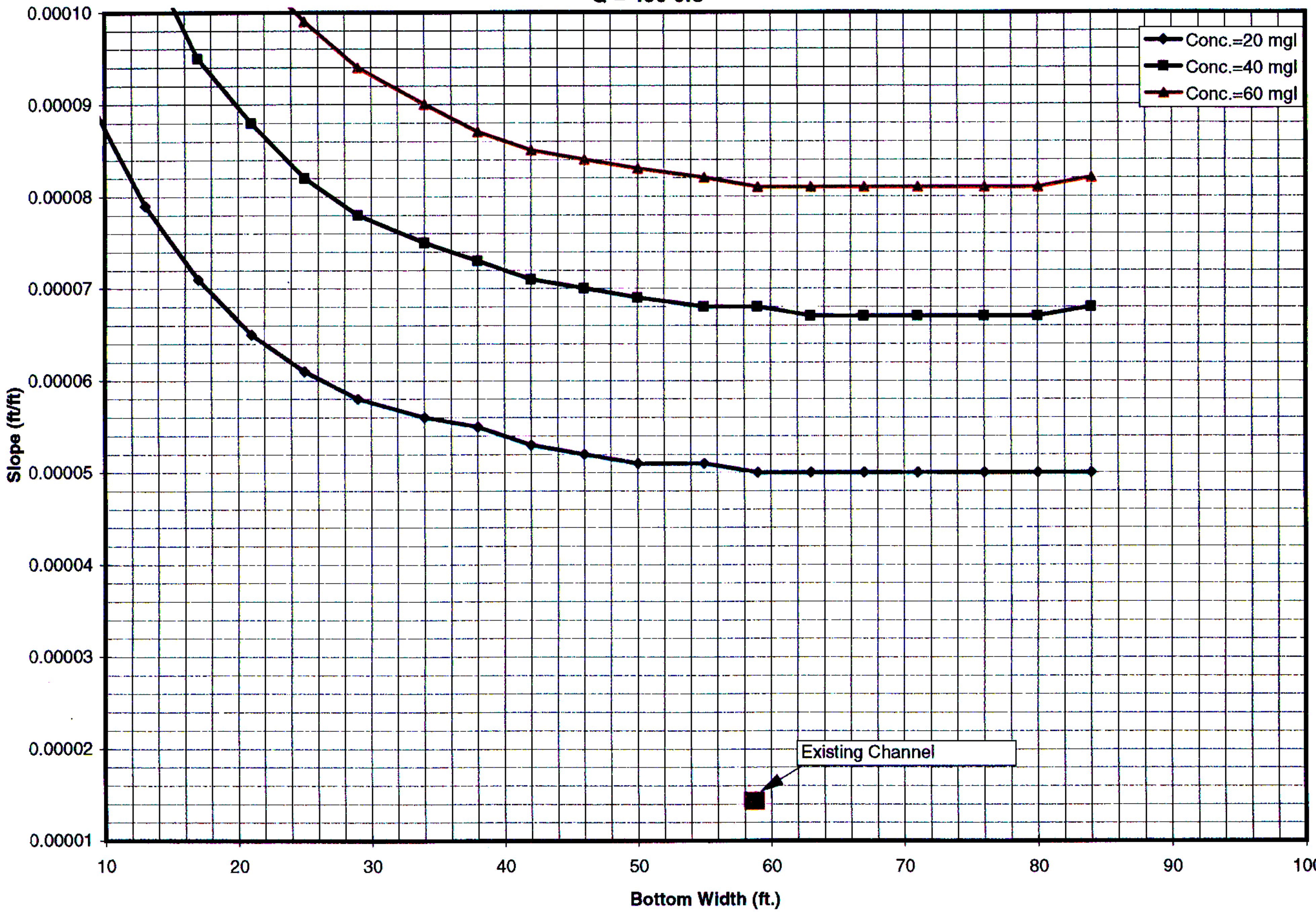



Figure h4

PLATE V-B-10

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal C2000, Sedimentation Analysis**
**Q = 2478 cfs**

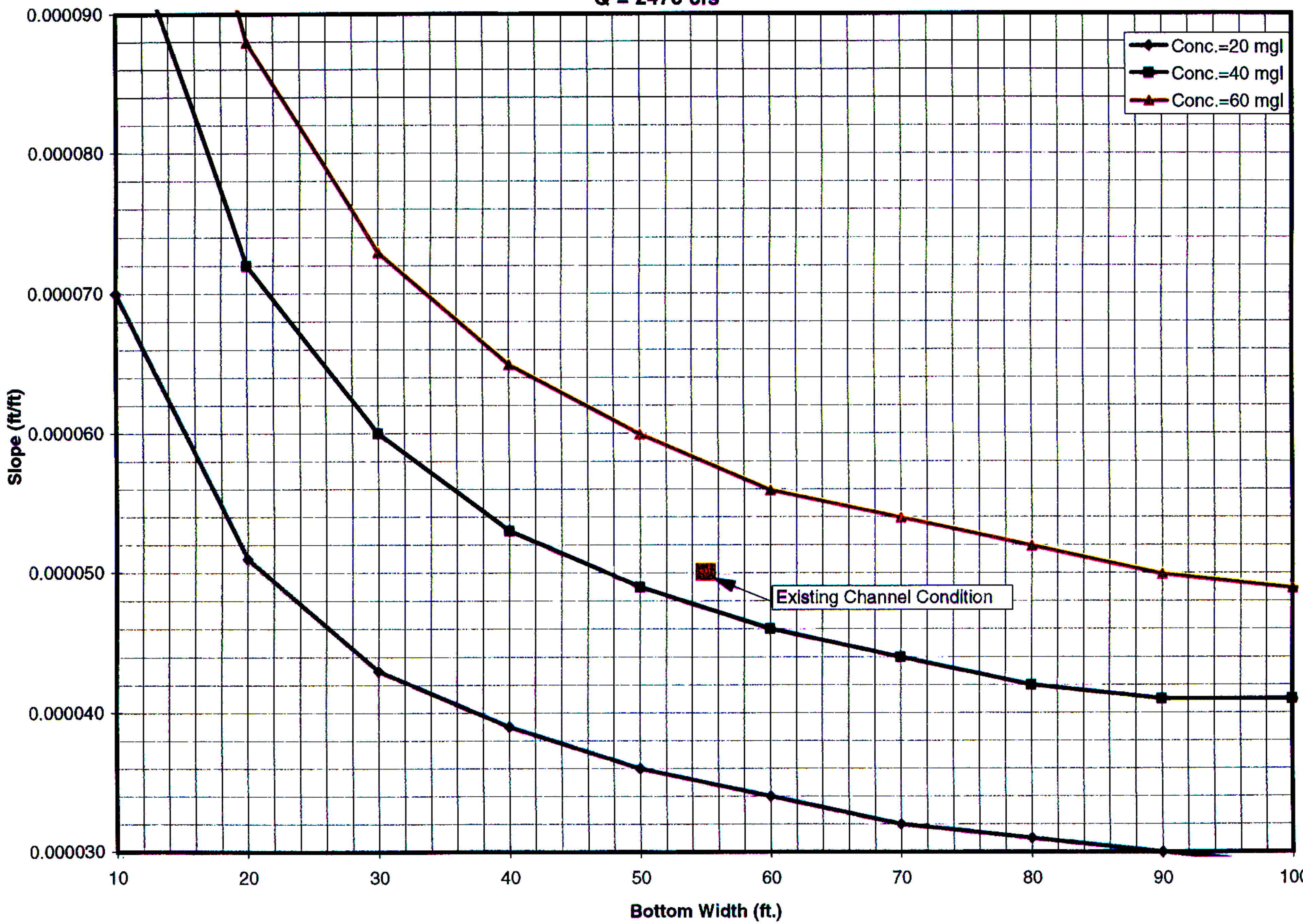



Figure h5

PLATE V-B-11

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal C2000, Sedimentation Analysis**
**Q = 1675 cfs**

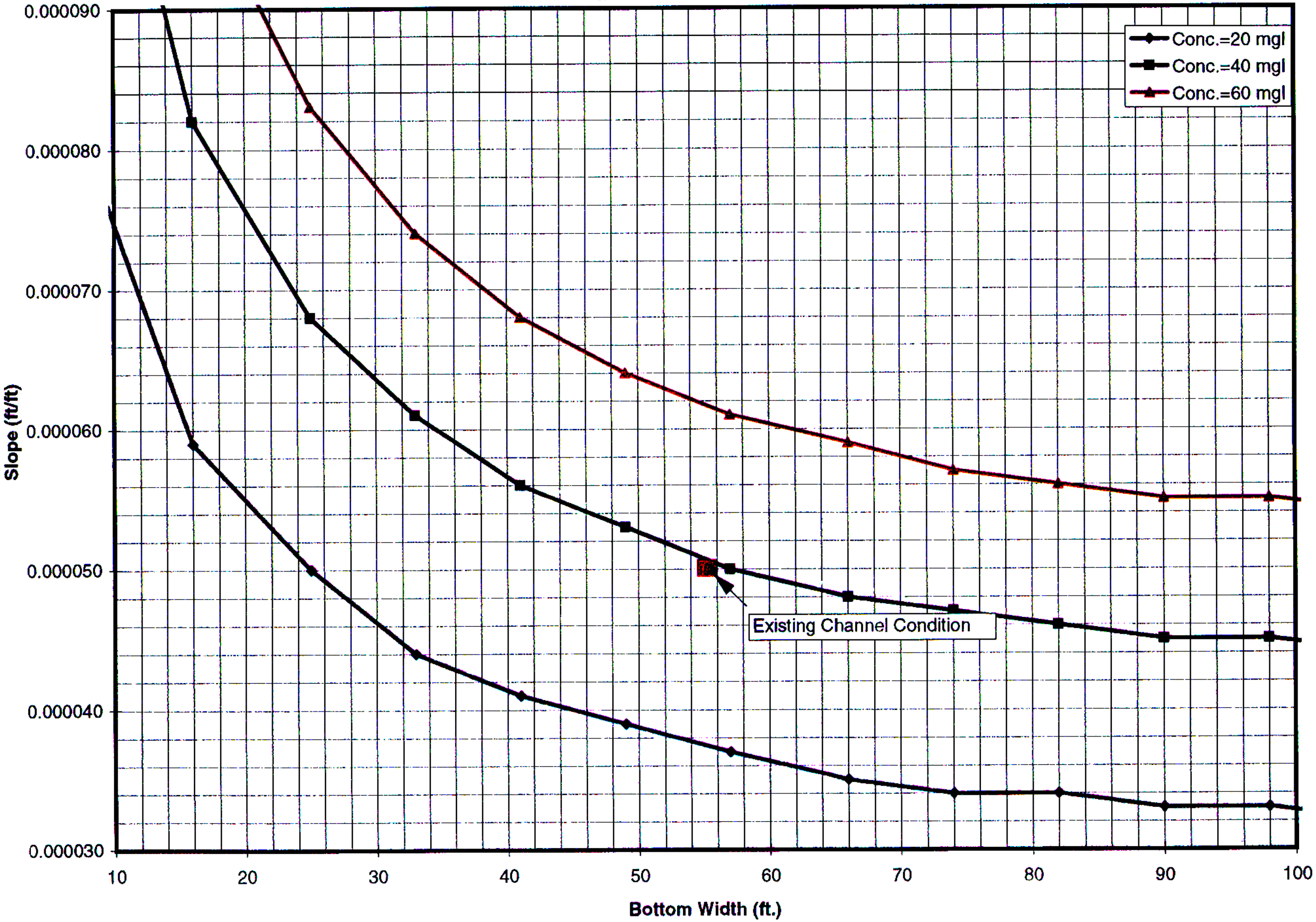



Figure h6

PLATE V-B-12

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal C2000, Sedimentation Analysis**
**Q = 400 cfs**

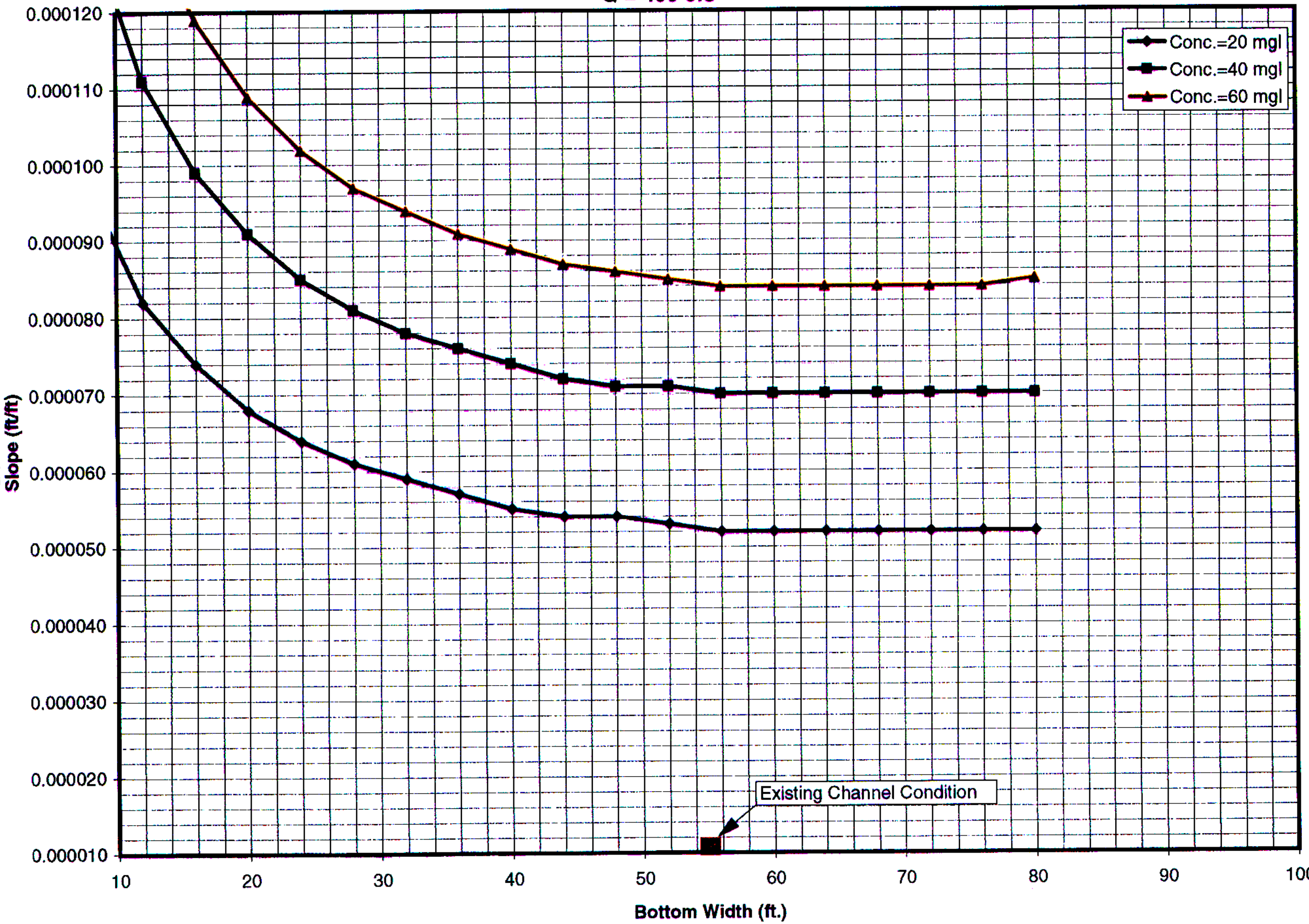



Figure h7

PLATE V-B-13

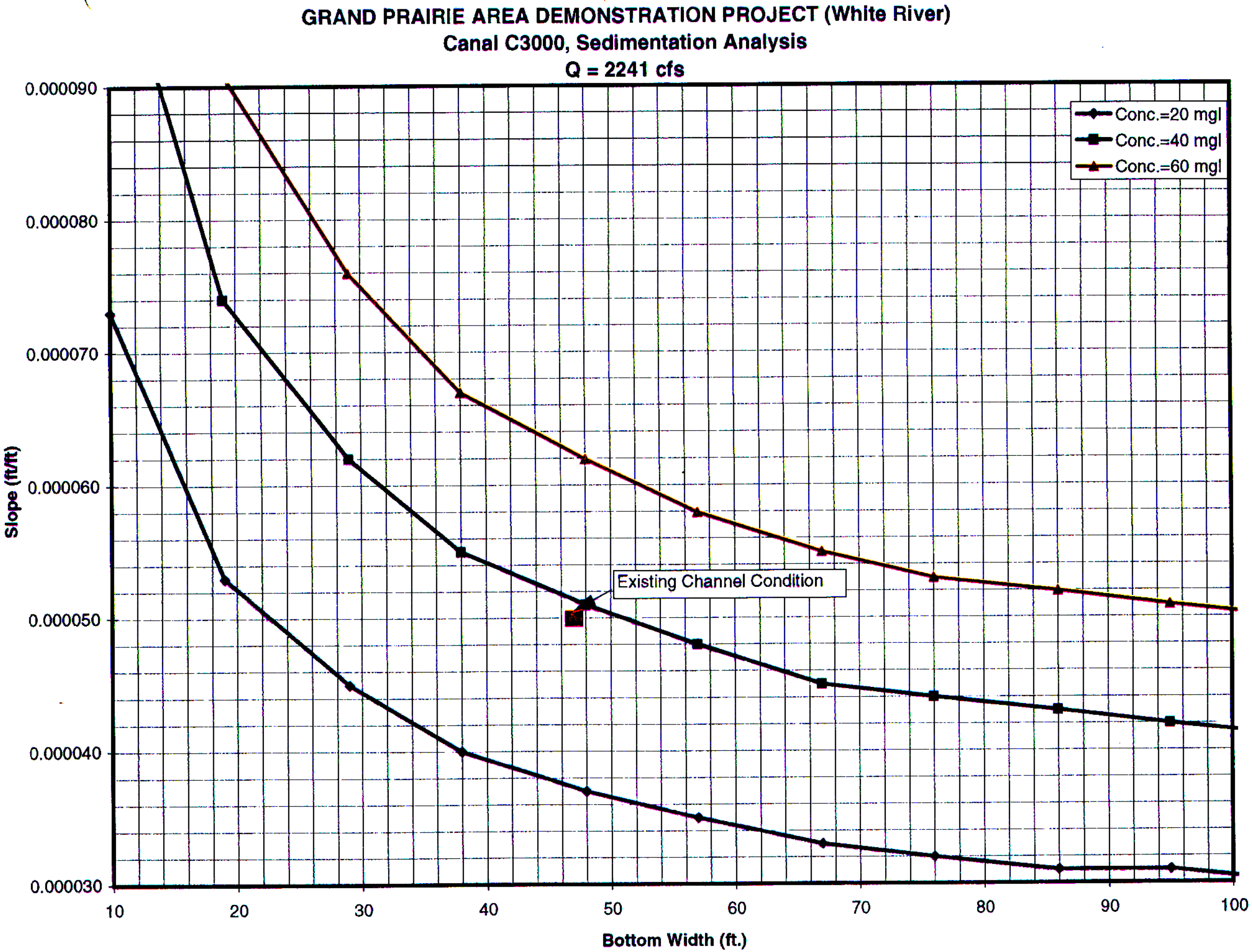



Figure h8

PLATE V-B-14

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal C3000, Sedimentation Analysis**
**Q = 1350 cfs**

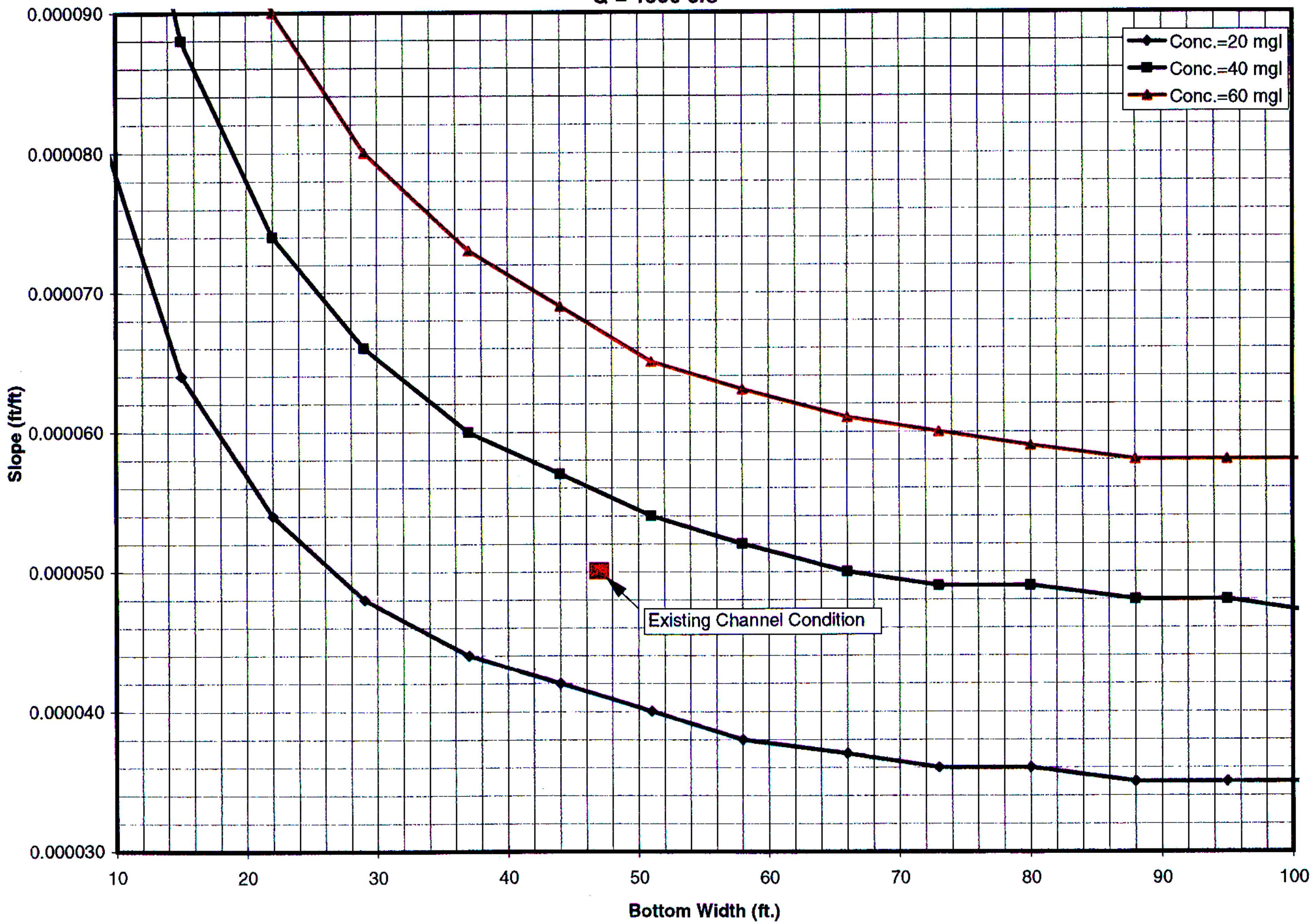



Figure h9

PLATE V-B-15

GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
Canal C3000, Sedimentation Analysis
Q = 300 cfs

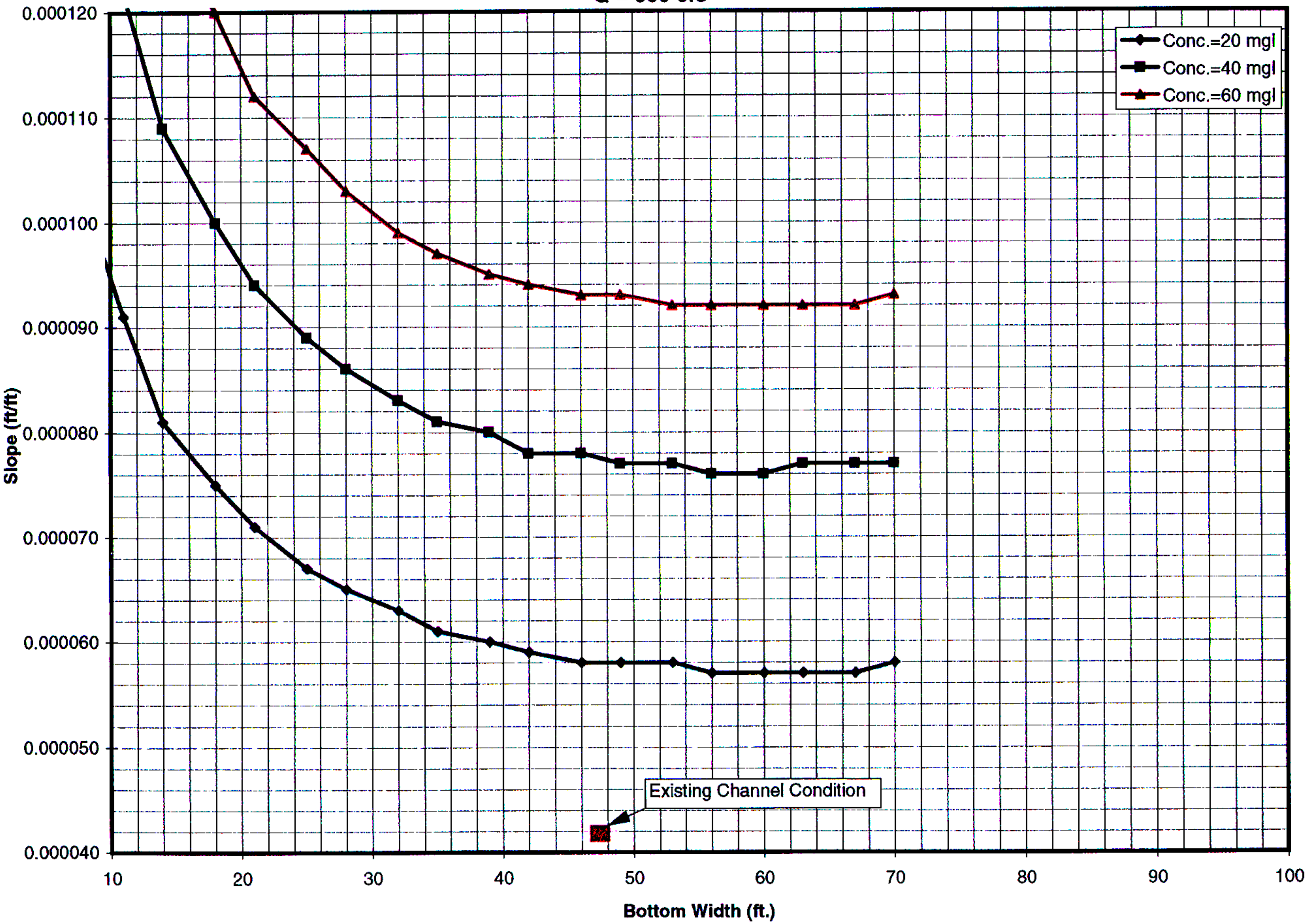



Figure h10

PLATE V-B-16

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal 4000, Sedimentation Analysis**
**Q = 1930 cfs**

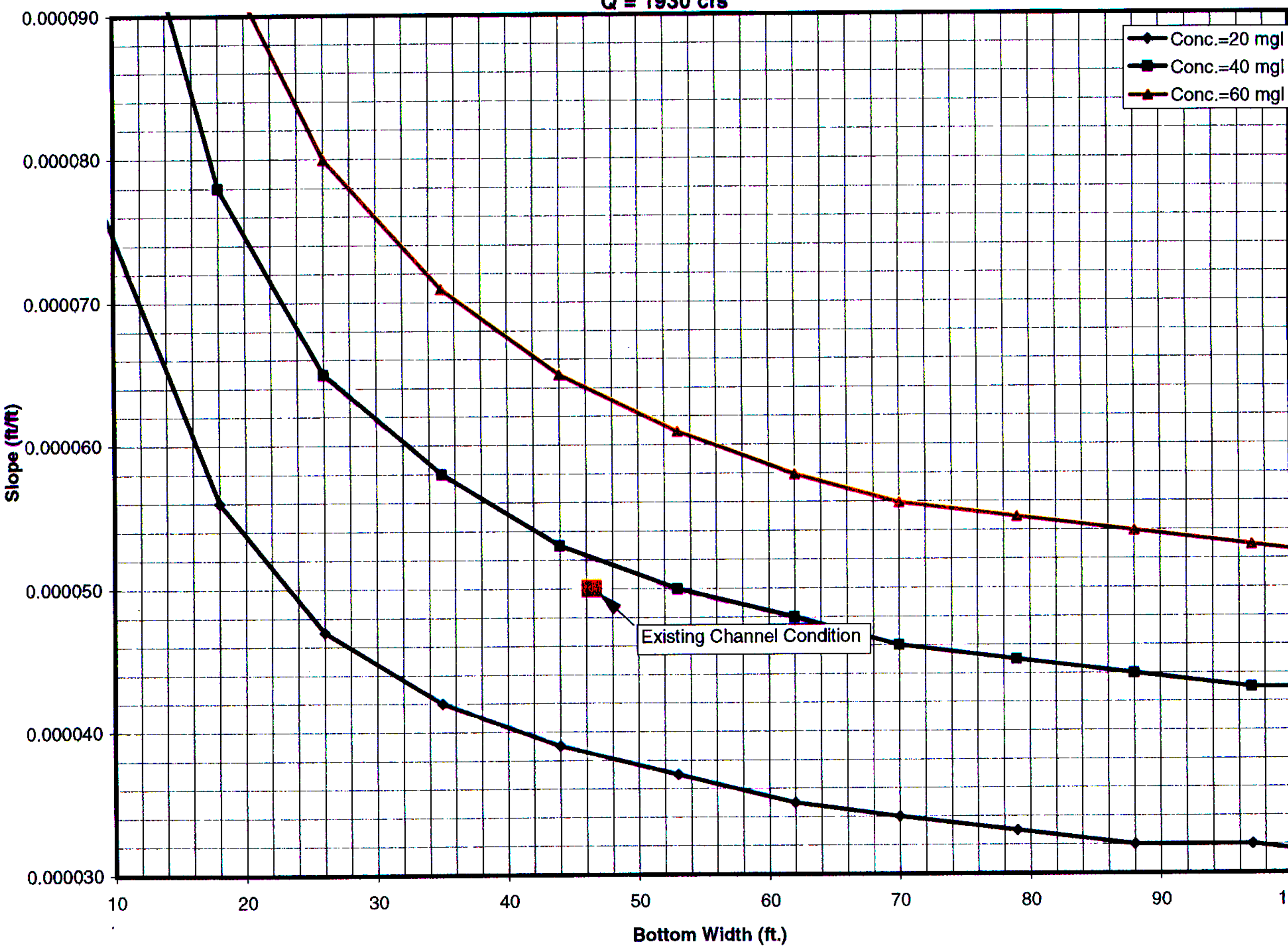



Figure h11

PLATE V-B-17

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal 4000, Sedimentation Analysis**
**Q = 1220 cfs**

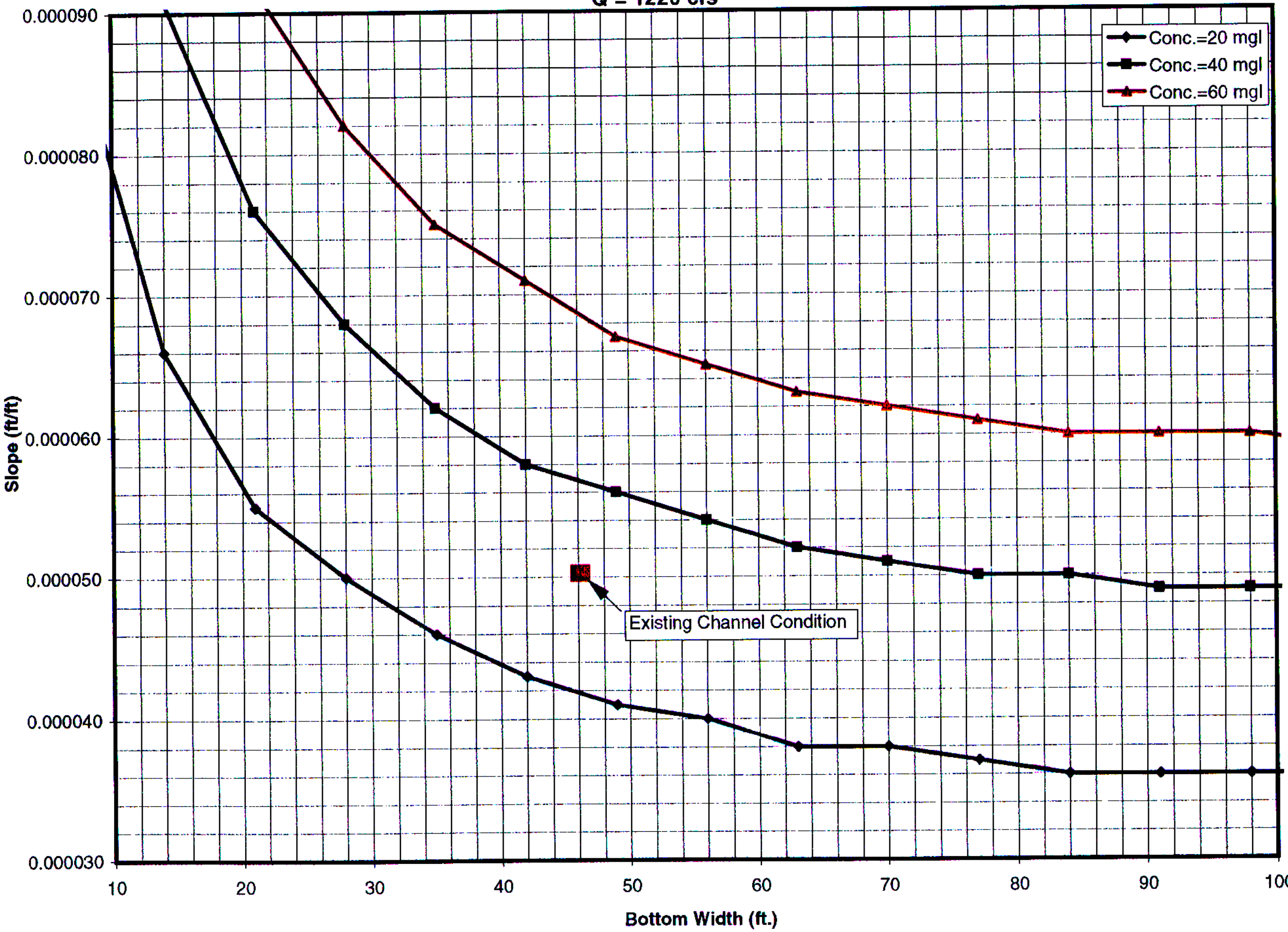



Figure h12

## GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
### Canal 4000, Sedimentation Analysis
### Q = 250 cfs

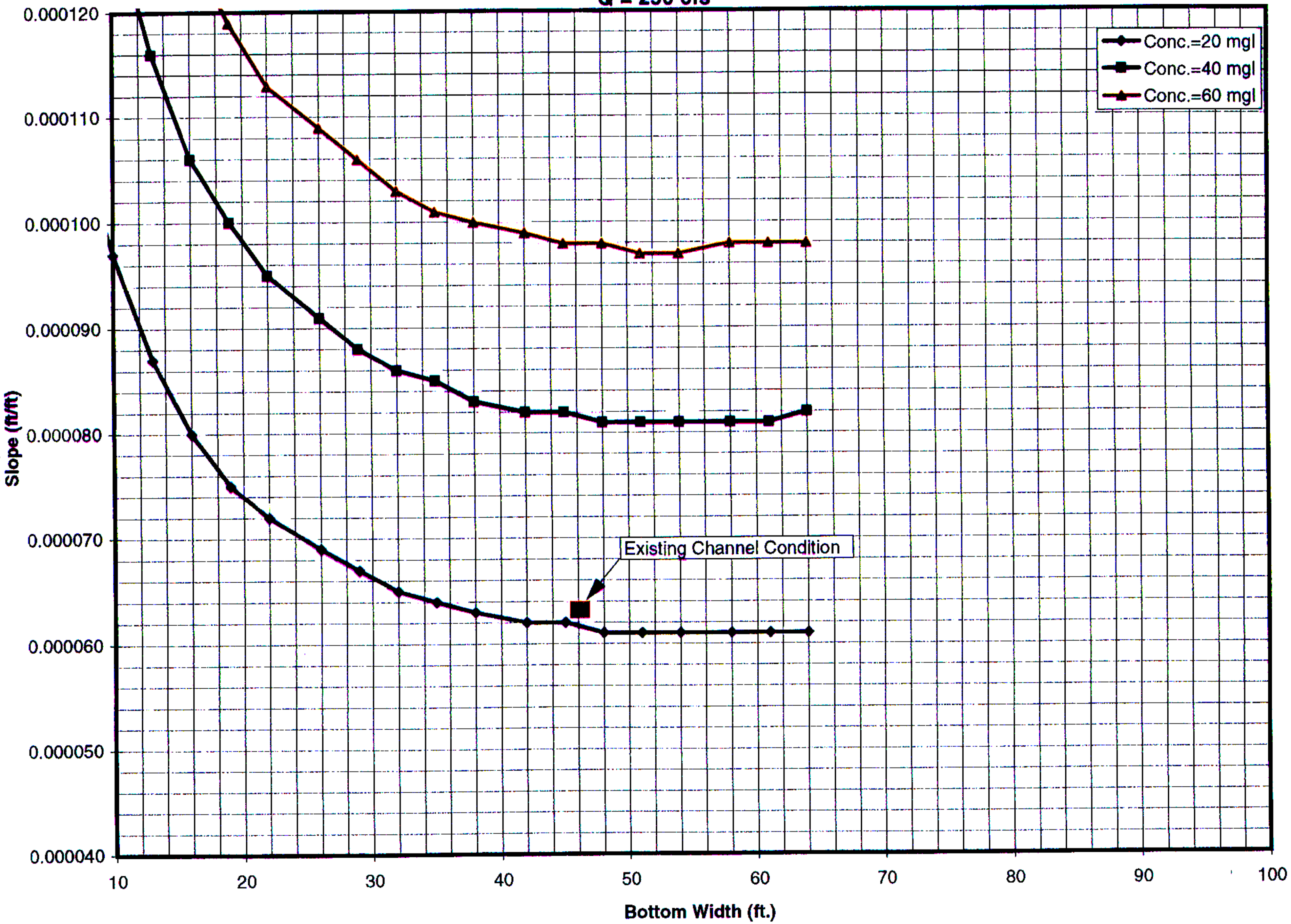



Figure h13

PLATE V-B-19

**GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)**
**Canal Sediment Sensitivity Analysis**
**Canal C1000, Q=2570cfs, C=20mgl**

| | Initial Condition | +10% | +20% | +30% | -10% | -20% | -30% |
|---|---|---|---|---|---|---|---|
| $D_{84}$= | 0.062 | 0.068 | 0.074 | 0.081 | 0.056 | 0.050 | 0.043 |
| $D_{50}$= | 0.020 | 0.022 | 0.024 | 0.026 | 0.018 | 0.016 | 0.014 |
| $D_{16}$= | 0.006 | 0.007 | 0.007 | 0.008 | 0.005 | 0.005 | 0.004 |

| Bottom Width | Slope | Slope | Slope | Slope | Slope | Slope | Slope |
|---|---|---|---|---|---|---|---|
| 10 | 0.000070 | 0.000072 | 0.000074 | 0.000076 | 0.000067 | 0.000065 | 0.000062 |
| 20 | 0.000051 | 0.000053 | 0.000054 | 0.000056 | 0.000049 | 0.000047 | 0.000045 |
| 30 | 0.000043 | 0.000044 | 0.000046 | 0.000047 | 0.000042 | 0.000040 | 0.000038 |
| 40 | 0.000038 | 0.000040 | 0.000041 | 0.000042 | 0.000037 | 0.000036 | 0.000034 |
| 51 | 0.000035 | 0.000037 | 0.000038 | 0.000039 | 0.000034 | 0.000033 | 0.000032 |
| 61 | 0.000033 | 0.000034 | 0.000035 | 0.000036 | 0.000032 | 0.000031 | 0.000030 |
| 71 | 0.000032 | 0.000033 | 0.000034 | 0.000035 | 0.000031 | 0.000030 | 0.000028 |
| 81 | 0.000031 | 0.000032 | 0.000033 | 0.000033 | 0.000030 | 0.000029 | 0.000027 |
| 91 | 0.000030 | 0.000031 | 0.000032 | 0.000032 | 0.000029 | 0.000028 | 0.000027 |
| 101 | 0.000029 | 0.000030 | 0.000031 | 0.000032 | 0.000028 | 0.000027 | 0.000026 |
| 111 | 0.000029 | 0.000030 | 0.000030 | 0.000031 | 0.000028 | 0.000027 | 0.000026 |
| 121 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 131 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 141 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 152 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 162 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 172 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 182 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 192 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |
| 202 | 0.000028 | 0.000029 | 0.000030 | 0.000031 | 0.000027 | 0.000026 | 0.000025 |

GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
Canal Sediment Sensitivity Analysis
Q = 2570 cfs, C = 20 mgl

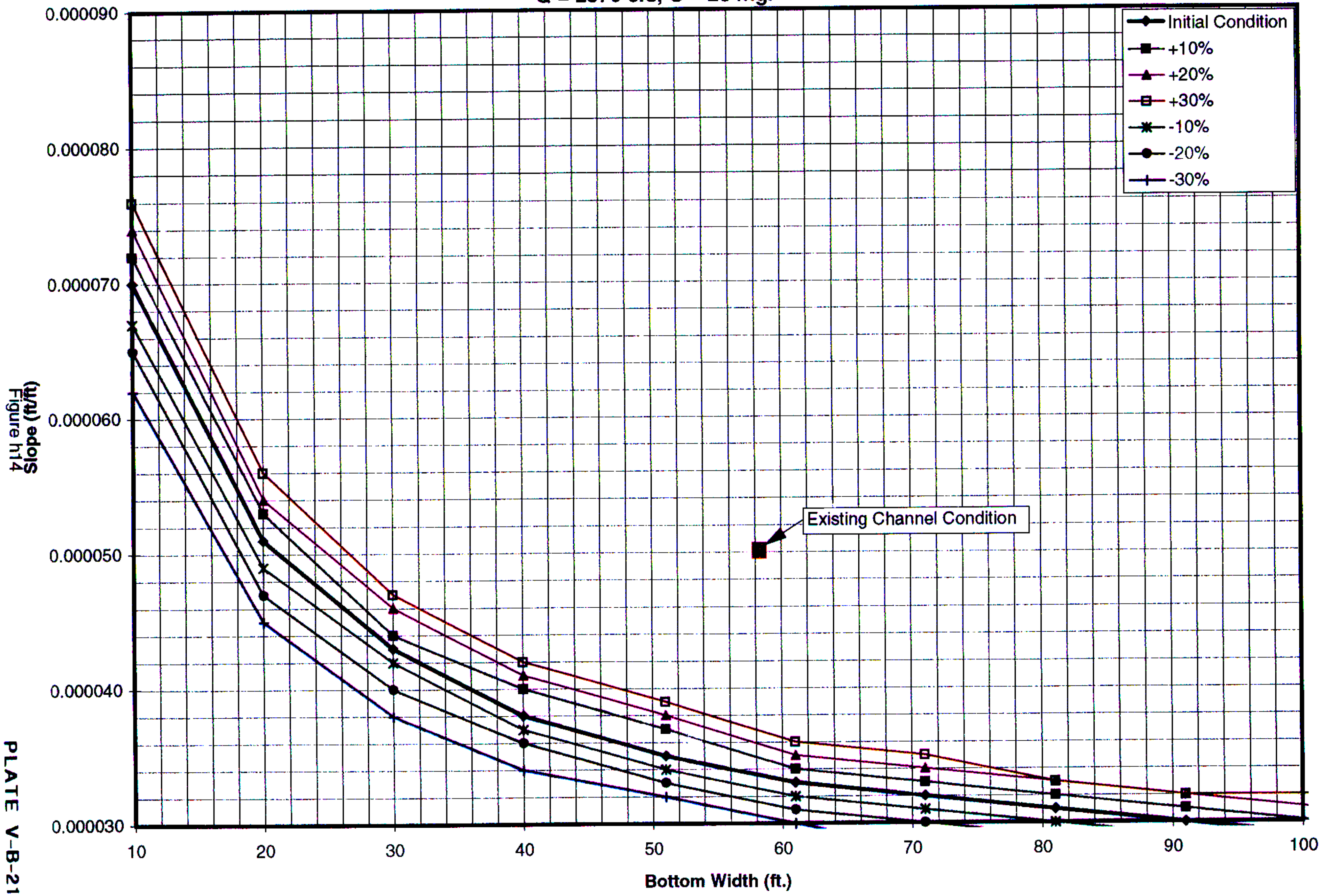
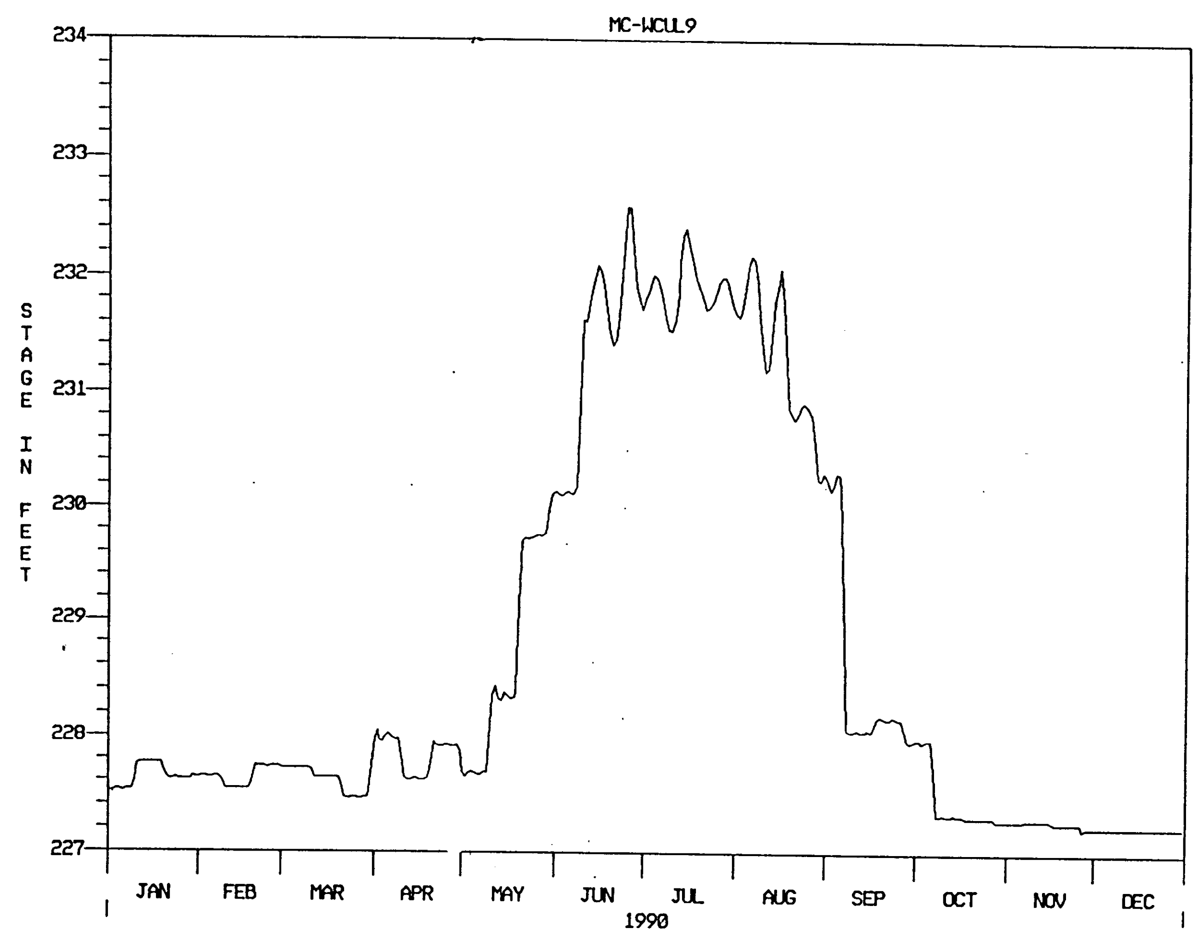


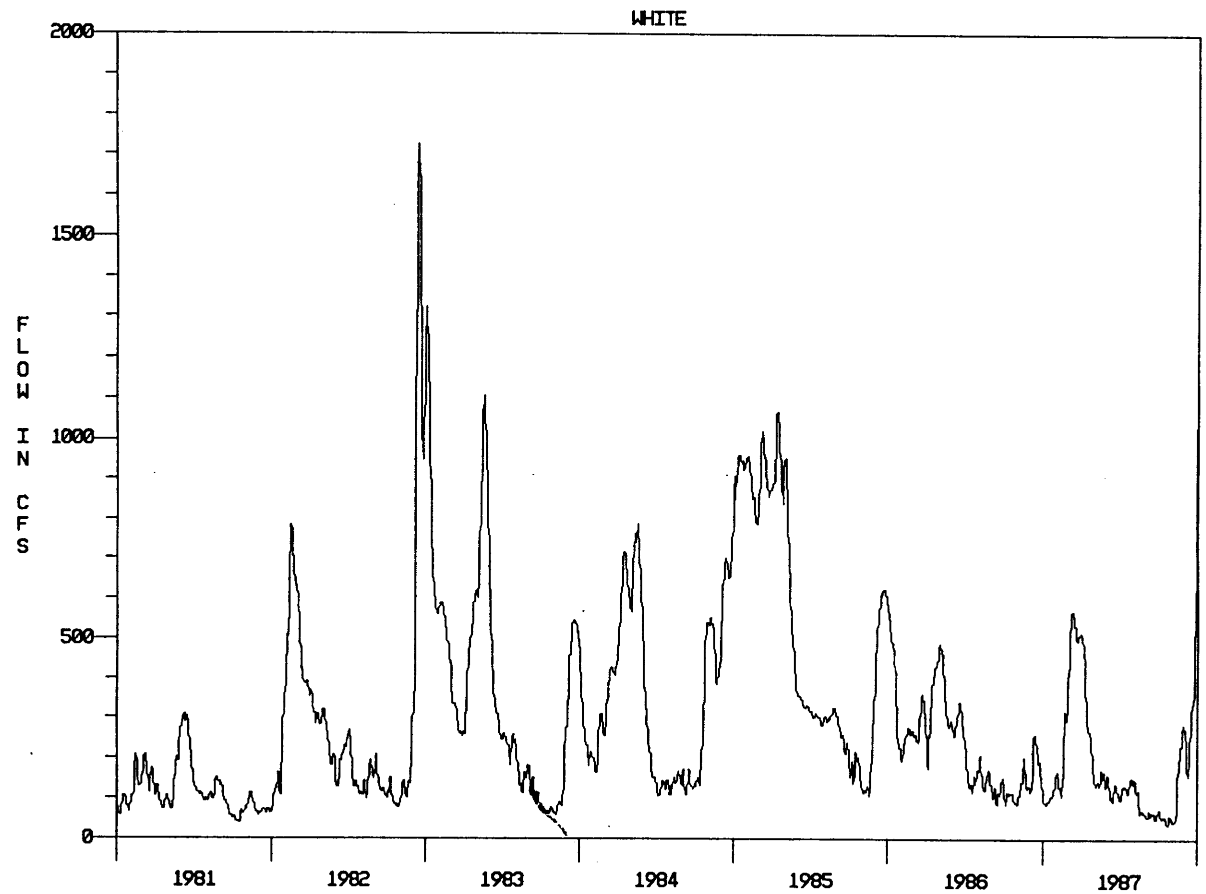

Figure h14

PLATE V-B-21




4.35 JUN 3 #1 STAGE

PLATE V-B-22




WHITE RIVER AT CLARENDON GAGE - FLOW HYDROGRAPH

* FLOW IN 100 CFS

PLATE V-B-23

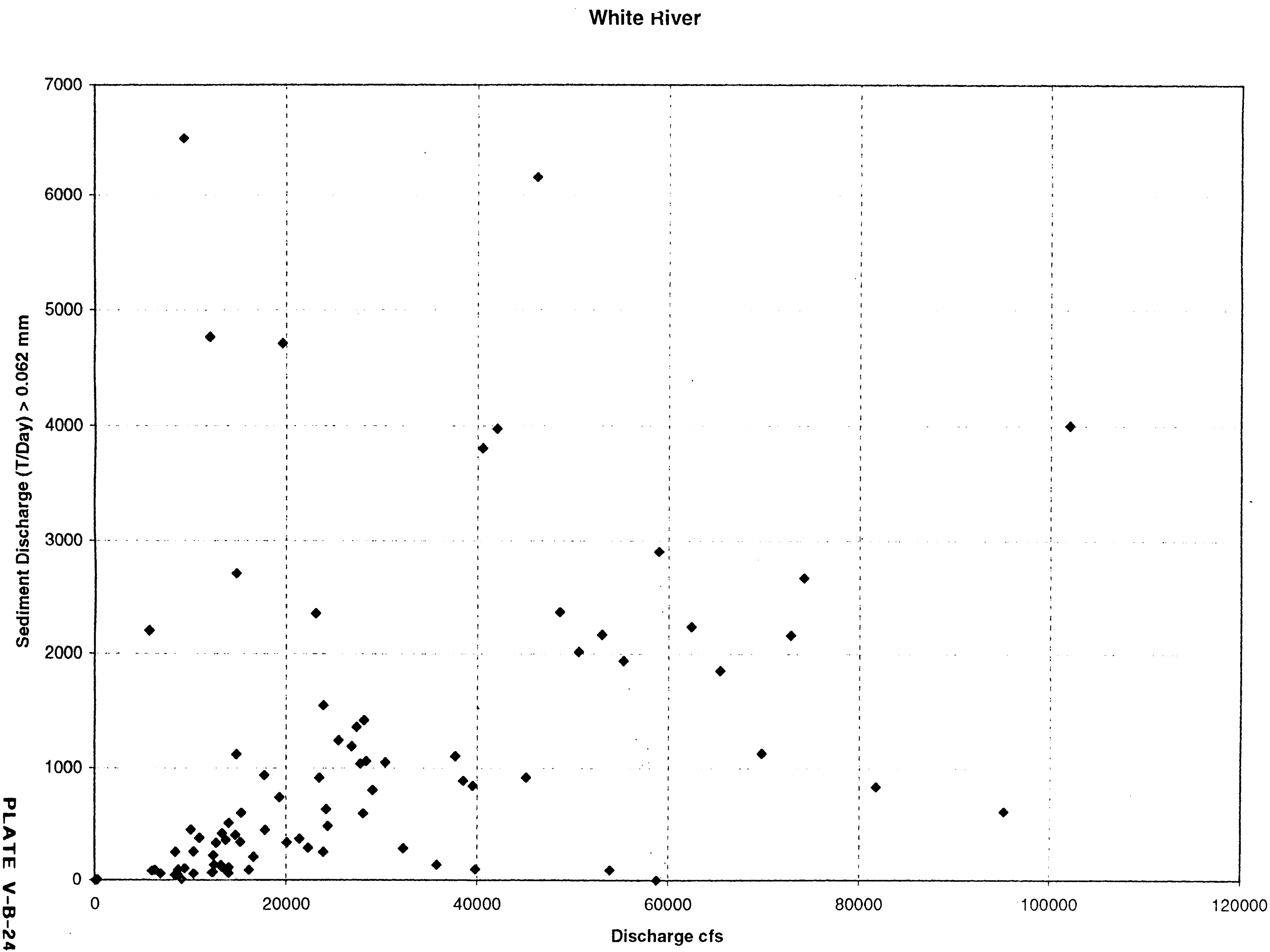

White River
Sediment Discharge (T/Day) > 0.062 mm
7000
6000
5000
4000
3000
2000
1000
0
0
20000
40000
60000
80000
100000
120000
Discharge cfs

PLATE V-B-24

## GRAND PRAIRIE AREA DEMONSTRATION PROJECT (White River)
### Table h2C - Canal C1000 Sediment Basin Analysis

| (1) | (2) | (3)=(1)/(2) | (4) | (5) | (6) | (7)=(6)/(3)*100 | (8)=74*(1)/371 | (9)=(8)*(7)*(4)/1E4 | |
|---|---|---|---|---|---|---|---|---|---|
| Discharge (cfs) | Surface Area (sq. ft.) | $V_o$ (ft/s) | %.of Total Material | Particle Size (mm) | Settling Velocity (ft/s) | % Removed | Qs (t/day) for C=74mgl | Amount Deposited (t/day) | Amount Deposited (t/yr) |
| 450 | 21067.20 | 0.02 | 16 | 0.15 | 0.0410 | 100.0 | 89.76 | 14.4 | 5241.8329 |
| 450 | 21067.20 | 0.02 | 84 | 0.064 | 0.0098 | 45.9 | 89.76 | 34.6 | 12625.915 |

Column Description
- (1) Discharges from Canal C1000
- (2) Surface area for canal reach 1000
- (3) Overflow rate
- (4) % of material represented by particle size (5)
- (5) Material particle size
- (6) Settling velocity for particle size (5) ref: Fig. 2.2 ASCE Man. & Reports in Eng. Practice #54

| Summary Table | | |
|---|---|---|
| | Amt. Deposited | |
| Q | Avg (t/day) | Avg (t/yr) |
| 450 | 49 | 17,868 |

# SECTION I

# PART F - (6)

# WATER QUALITY

# PART F - (6) - WATER QUALITY

## TOPIC A - OVERVIEW

### 6-A-01. BASIS OF ANALYSES.

Most irrigation water used to irrigate cropland in the Grand Prairie area is pumped from ground water sources. As these ground water sources become depleted, future farming practices will change in the area and could be detrimental to the economy. Future conditions with the project in place insures that water will be available for irrigation purposes and there will be no significant change in farming practices.

Because water from the White River is used in the delivery system for the project, it was important that the quality of the water analyzed in order qualify and possibly quantify impacts to farmland benefiting from the irrigation water. Organics, as well as inorganics, in the White River are at concentrations that, even after deposition in the inlet channel, would need to be addressed as these irrigation flows are carried to the individual farms.

A sediment analysis was performed by the Corps on the delivery system handling the pumped White River flows and the reaches of canal where deposition would occur was determined. Even though the fallout of suspended load was quantifed, it was agreed upon that additional suspended organics and inorganics would remain in the irrigation flow until reaching the farms but should not signifiicantly impact water quality.

To determine the effect to existing water quality in the area, the University of Memphis' Ground Water Institute, led by Dr. John Smith, conducted studies of the area to determine water quality of existing streams, wells, and tailwater recovery systems [1]. This report is located in Appendix C - Environmental, Section III - Water Quality of the Eastern Arkansas Grand Prairie Demonstration Project design document. Conclusions from this study showed that replacing irrigation water pumped from ground water sources with diverted water from the White River will have positive impacts on the area. The surface water has a lower hardness and alkalinity and will place inorganics in the soil. This should increase the long term productivity and have no adverse effects to the natural streams used as part of the delivery system.

A water quality sampling program would need to be initiated as part of a environmental management portion of the project. This sampling program should include sampling stations on the main canal at turnout locations that will eventually feed existing streams.

## REFERENCES

[1] ________. *Eastern Arkansas Ground Water Quality Assessment*, Herff College of Engineering Ground Water Institute, Memphis, Tennessee, February 1997

# SECTION I

# PART G - (7)

# OPERATION MANUAL

# PART G - (7) OPERATION MANUAL

This section presents as an exhibit a preliminary project operation manual.

# OPERATION MANUAL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Grand Prairie Area Water Supplies

The Need and Demand for Water

Will There Be Enough Water?

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Allocation and Management of Arkansas' Water Supplies

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**16. Reporting Requirements**

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Use of Existing and Planned Storage

**18. Emergency Procedures**

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# PRELIMINARY DRAFT OF THE GRAND PRAIRIE ARKANSAS PROJECT OPERATION MANUAL

## PART I INTRODUCTION

### 1. Summary

Institutional Framework

The White River Regional Irrigation Water Distribution District, is a public non-profit corporation organized under Arkansas law. The co-operative plans to provide local sponsorship for the construction, operation, and maintenance of the Grand Prairie Arkansas Project (GPAP). The GPAP consists of canals, pumping stations, check structures, and turnout structures designed to divert water from the White River north of DeValls Bluff, AR for the purpose of agricultural water supply. By the Act under which the District is incorporated, sale of water constitutes its only source of revenue. Water will be sold to landowners through water-use contracts. These executed contracts to buy water will be the basis for the District's assurances for payment of construction, operation, and maintenance of the project.

For the GPAP diversion channels to be built, receive diversion waters, and legally carry those waters for irrigation purposes, certain permits must be granted and certified by select state and federal agencies. The Corps of Engineers has federal oversight through the issuance of Section 404 and Section 10 permits. The Arkansas Soil and Water Conservation Commission (ASWCC) has legislative empowerment to issue non-riparian water-use permits. Other possible applicable state review or permit requirements could include Water Plan Compliance Review, determination of minimum instream flows, and dam safety permit issuances for on-farm reservoirs.

Grand Prairie Area Water Supplies

Sources of water in the GPAP area consist of an alluvial aquifer, several confined aquifers, abundant rainfall, and two major river systems. Additional water is available to downstream users when irrigation water is released from fields. Historically, the majority of irrigation water was taken from the alluvial aquifer. Heavy use of this ground water resource has resulted in a decline of up to _____ feet within the GPAP.

Declining aquifer levels has spurred farmers to construct numerous storage reservoirs and lakes to augment ground water supplies. An average annual rainfall of 48 inches, although unevenly distributed through the year, provides ample opportunities to capture large quantities of runoff. Currently, 14 percent of the average annual crop demands are provided from stored water. Increased storage is projected for the future. Where the alluvial aquifer no longer provides sufficient quantities for pumping, deep wells, penetrating the underlying confined aquifer, have been constructed. Municipal and Industrial water supplies typically come from the confined aquifers.

The Need and Demand for Water

The need for agricultural water stems from the fact that rainfall, although abundant, is unevenly distributed throughout the year--greater rainfall depths generally occur in the winter to early-spring and lesser rainfall depths occur during the cropping season. Demands for water increased historically as additional acreage was placed under irrigation. Future demands for irrigation water are limited by the type of crops raised. Essentially all of irrigatable acres are currently irrigated; therefore, additional increases in demand are unlikely. Municipal and industrial (M&I) water demands continue to grow as population increases. M&I needs are significantly less than agricultural needs. Confined aquifers in the region provide most M&I users needs. As more of the confined aquifer is developed for agricultural use, competition for this source will become acute.

Will There Be Enough Water?

## 2. Institutional Framework for Water Resource Management

Allocation and Management of Arkansas' Water Supplies

Allocation and management of Arkansas' water resources falls under the auspices of the Arkansas Soil and Water Conservation Commission. Current regulatory and legislative statutes are described as follows.

> Arkansas Water Law (Common Law Roots). The Arkansas General Assembly, by statute, adopted the common law of England, including the English Doctrine of Riparian Rights for surface water, as law governing water usage in the State. The Arkansas Supreme Court indicated a preference for the reasonable use theory of Riparian Rights. Under the reasonable use framework, the court stated:

(i) the right to use water for strictly domestic purposes is superior to many other uses of water; (ii) other than the use mentioned above, all other uses of water are equal. Some of the lawful uses of water recognized by the State are fishing, swimming, recreation, and irrigation; (iii) when one lawful use of water is destroyed by another lawful use, the latter must yield, or it may be enjoined; (iv) when one lawful use interferes with or detracts from another lawful use, then a question arises as to whether, under all the facts and circumstances of that particular case, the interfering use shall be declared unreasonable and as such enjoined, or whether a reasonable and equitable adjustments should be made, having due regard to the reasonable rights of each.

Concerning ground water usage, the reasonable use rule provides that if two or more persons are pumping from a common aquifer, "each has a common and correlative right to use of this water on his land, to the full extent of his needs if the common supply is sufficient, and to the extent of a reasonable share thereof, if the supply is so slant that the use by one will affect the supply of the others."

<u>Registration of Withdrawals ACA 15-22-302</u>. Reporting of withdrawals to the Arkansas Soil and Water Conservation Commission is required for all persons who withdraw underground water except for individual household wells and except from wells having a maximum flow rate of less than fifty thousand gallons per day. ACA 15-22-215 requires the registration of diversion of surface waters.

<u>Right To Take Impounded Water ACA 15-22-216</u>. Any person constructing a dam shall have the exclusive right to take water from the reservoir so long as the dam is maintained and operated under permit from the Arkansas Soil and Water Conservation Commission.

<u>Allocation During Shortages ACA 15-22-217</u>.

a. Whenever a shortage of water exists to the extent that there is not sufficient water to meet the requirements of all water needs, the

Arkansas Soil and Water Conservation Commission may allocate the available water among the uses of water affected by the shortage of water in a manner that each of them may obtain an equitable portion of the available water.

b. In allocating water, the Commission may consider the use that each person involved is to make of the water allocated.

c. In making such allocations of water, reasonable preference should be given to different uses in the following order of preference:

1) Sustaining life;
2) maintaining health; and
3) increasing wealth

d. Water needs shall include domestic and municipal water supply needs, agriculture and industrial water needs, navigation, recreational, fish and wildlife, and other ecological needs.

e. The following priorities shall be reserved prior to allocation:

1) Domestic and municipal domestic
2) Minimum streamflow
3) Federal water rights

Permit Required for Dam Construction ACA 15-22-210. No person shall have the right to construct or own a dam to impound water until he obtains a permit from the Arkansas Soil and Water Conservation Commission. ACA 15-22-214 exempts dams meeting the following conditions:
a. Impounds less than fifty (50) acre-feet of water or is of a height less than twenty-five (25') feet.

b. The height of which is at or below the ordinary high water mark on the stream.

Transfer of Excess Surface Water To Non-Riparian ACA 15-22-304. The Arkansas Soil and Water Conservation Commission may authorize the transportation of excess surface water to non-riparians for their use. "Excess surface water" means twenty-five percent (25%) of that amount of water available on an average annual basis from any watershed amount, as determined by the Commission, required to satisfy all of the following:

a. Existing riparian rights as of June 28, 1985;

b. The water needs of federal projects existing on June 28, 1985;

c. The firm yield of all reservoirs in existence on June 28, 1985;

d. Maintenance of instream flows for fish and wildlife, water quality, and aquifer recharge requirements; and

e. Future water needs of the basin of origin as projected in the state water plan developed pursuant to ACA 15-20-207 and 15-22-501 et seq.

Delegation Of Allocation Authority ACA 15-22-221. The Arkansas Soil and Water Conservation Commission may delegate the power to allocate water during times of shortage to conservation districts and regional water districts.

Establishment of Minimum Stream Flows ACA 15-22-222. The Arkansas Soil and Water Conservation Commission shall establish and enforce minimum streamflows for the protection of instream water needs.

Surface Water Management--Regulatory and Permit Requirements

Various State and Federal permits must be obtained prior to construction and operation of the GPAP. Specific requirements are outlined as follows.

Section 404. The authority to regulate discharges of dredged (excavated) or fill material in waters of the United States (including wetlands) was given to the Corps of Engineers with the passage of the Federal Water Pollution Control Act Amendments. This act later was changed to the Clean Water Act in 1977. The regulation of materials into or from rivers, streams, lakes, and wetlands is intended to "restore and maintain the integrity of the Nation's waters".

Section 10. Since 1899, the Corps has had authority to regulate any work activity performed over our Nation's navigable waters. Structures, intakes, and any other impact is included under this jurisdictional mandate.

Non-Riparian Permit. Upon completion of an application by a non-riparian, the ASWCC can authorize the transportation of "excess surface waters" to non-riparians under the provisions of Statute 15-22-304. Procedures for application as well as delineation of "excess surface waters" are contained in this statute.

Water Plan Compliance Review. Under Title VI in the ASWCC's "Rules For Water Development Project Compliance With The Arkansas Water Plan", all water development "projects", excluding sewage disposal, industrial waste, or other waste treatment systems, shall be subject to review and approval by ASWCC. A written application in accordance with Subtitle II must accompany the filing correspondence.

Dam Safety Permit. If a dam or levee is 25 feet or more in height and impounds 50 acre-feet or more, issuance of a dam permit is required by the ASWCC. The permit should be obtained before actual construction begins on the dam.

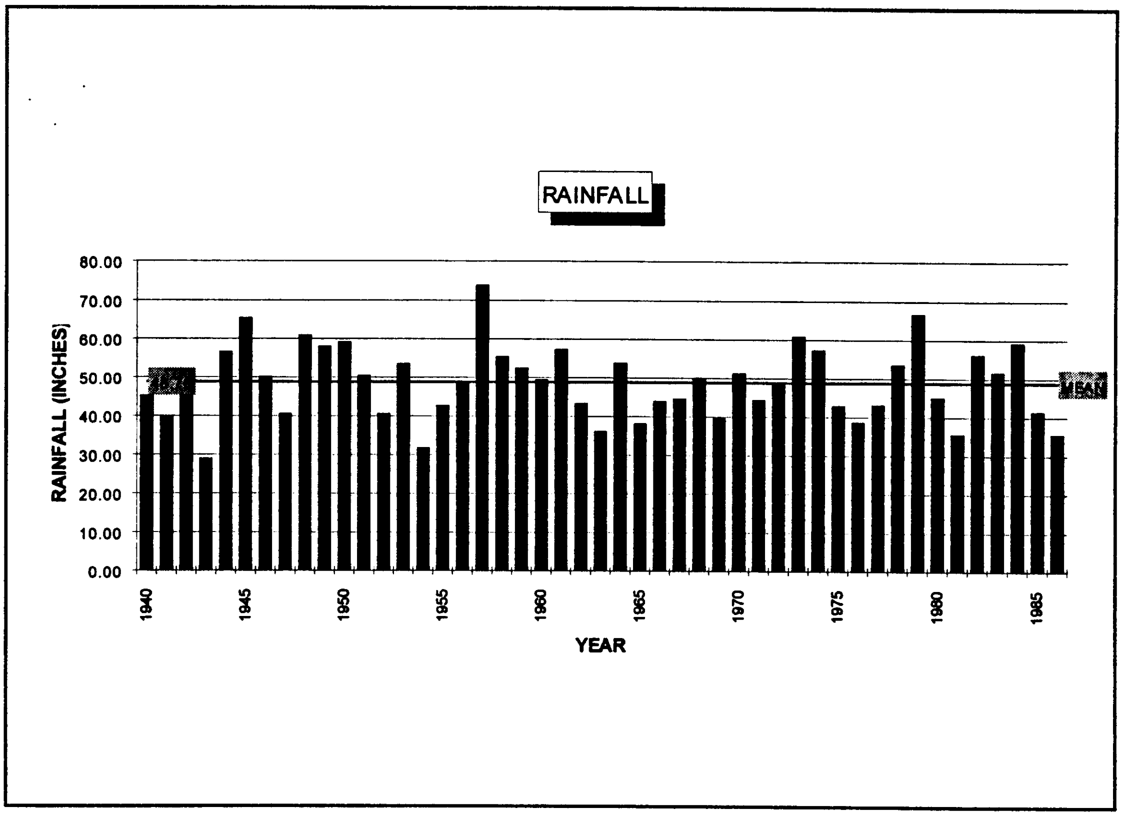
## PART II WATER SOURCES

### 3. Surface Water Supply

Rainfall

Rainfall occurring over the GPAP is abundant with an annual average rainfall of 48 inches. Although abundant, rainfall is unevenly distributed throughout the year as illustrated in Figure 3-1. This results in excess water during the winter and early spring months and a deficit during the summer and early fall months. The deficit through the summer and early fall months significantly affects crop yields. Surface reservoirs of have been constructed to capture a portion of the excess runoff, especially during late winter and early spring months. Tailwater recovery systems have been installed to further enhance capture of runoff and to re-capture water released from irrigated fields. Surface diversions from natural streams have increased dramatically in recent years.

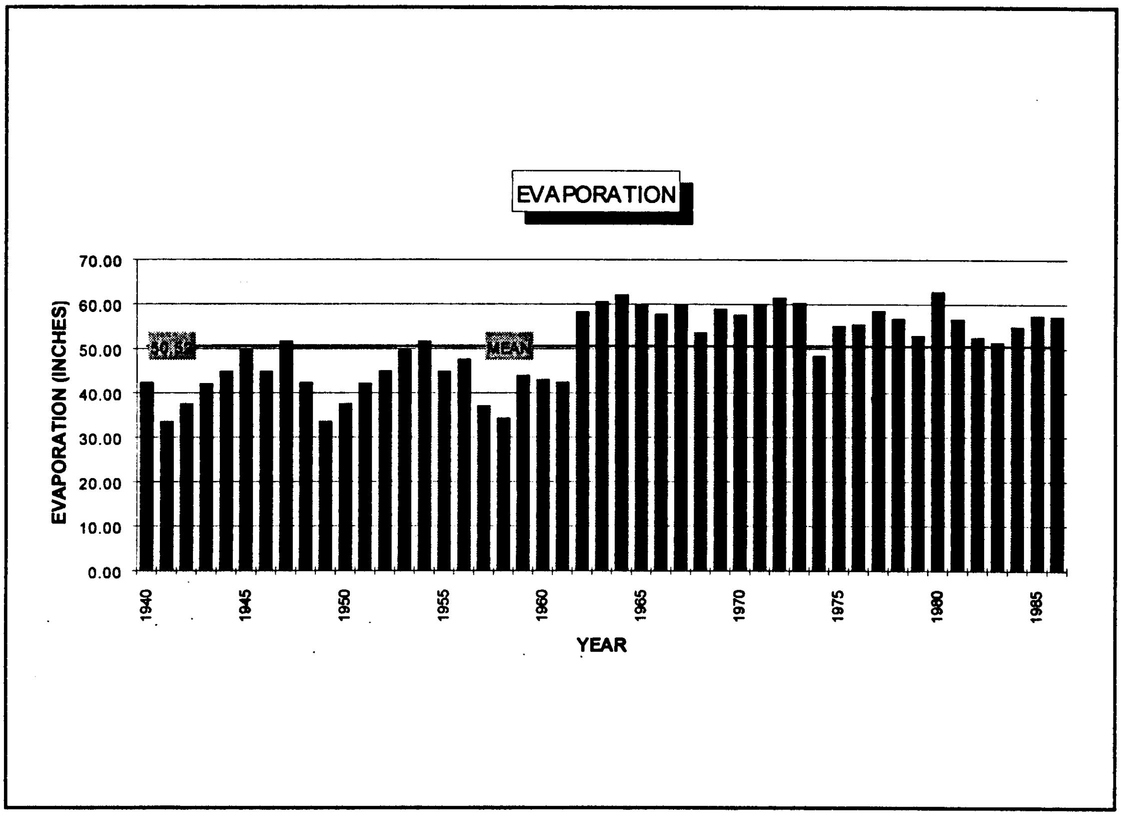
Figure 3-1 Historic Rainfall Amounts for Stuttgart, AR




Evaporation

Evaporation from the Grand Prairie Area is extensive, especially in the summer months. Although mean annual rainfall is 48 inches, total evaporation, as shown in Figure 4-1, often produces a net loss in available water.

Figure 4-1 Historic Evaporation Amounts for Stuttgart, AR




Import

Importation of water from external sources (water diverted from watersheds outside the GPAP) currently constitutes only a very small fraction of water used for irrigation in the White River Regional Irrigation Water Distribution District. The GPAP will divert up to 1800 cfs from the White River from a point upstream of DeValls Bluff, AR.

## 4. Ground Water Supplies

Ground Water Defined

Ground Water is subsurface water occurring in a zone of saturation. In that zone, water fills the pore spaces in sediment. The sediments are randomly interspersed mixtures of fine to coarse-grained material and constitute the aquifers within a zone of saturation. Several distinct aquifers exist in the GPAP area, the alluvial aquifer and various confined aquifers. The alluvial aquifer is a relatively shallow unconfined aquifer most commonly used for irrigation. The confined aquifers are deeper and are used primarily for municipal and industrial purposes.

Historical decline of the alluvial aquifer has resulted from pumpage in excess of recharge capacity. This has led to use of the confined aquifers for irrigation. Ground water currently provides approximately 86 percent of irrigation water. Water quality within the alluvial aquifer is generally good. However, in some areas within the GPAP, ground water quality has declined due to increased salinity concentrations caused by overdraft. Water quality within the confined aquifers is generally much superior to that of the alluvial aquifer. The ASWCC requires wells to be registered and permitted.

Safe Sustained Ground Water Yield

Short-term and long-term ground water yields were projected from finite difference groundwater models developed by the USGS and the University of Arkansas. Simulations were conducted utilizing present and projected water needs. An estimate of the minimum saturated thickness of the alluvial aquifer was made during development of the ground water model. A minimum saturated thickness of 20 feet was estimated as the minimum to sustain the aquifer characteristics. Based on a 20 foot saturated thickness as a minimum, long-term sustained yield from the alluvial aquifer was estimated to be approximately 40,000 acre-feet per year.

## 5. Conservation Measures

Tailwater Recovery Systems

Installation of tailwater recovery systems greatly reduces the amount of water released from fields directly as stream runoff. Tailwater recovery systems can typically increase irrigation efficiencies by 10 percent or more. Tailwater recovery systems also increase the volume of rainfall captured and stored in reservoirs thereby reducing the quantity of imported water.

Irrigation Methods

Different irrigation techniques can greatly affect irrigation efficiencies. Various irrigation methods commonly used in other parts of the US are center pivot, furrow irrigation, surge irrigation (a variation of furrow irrigation), drip irrigation, and flood irrigation. Flood irrigation generally is the least efficient method of irrigating row crops such as corn, milo, soybeans, etc. Where topography permits, furrow irrigation is a more efficient method of irrigating row crops. Surge irrigation simply increases the efficiency of furrow irrigation by reducing the travel time down the furrow and by reducing water lost at the end of the row. Sprinkler, center pivot, and drip irrigation typically reduce water demands further, however, at a much increased cost due to higher head requirements. With each increase in efficiency, system installation costs increase. Selection of appropriate irrigation methods must balance cost effectiveness.

## PART III WATER USES

### 6. Water Demands

Average Year

The average year, for determining demands, was determined by averaging total rainfall depths for the months of July and August for the period 1965 to 1981. Ten-day crop demands were computed utilizing ten-day average temperature, evapo-transpiration, and rainfall data at the NWS gaging station at Stuttgart, AR. Crop patterns were assumed to be consistent with current rotation practices.

Drought Year

The average drought demand was estimated from climate data for 1981. Ten-day crop demands were computed for current crop rotation patterns.

### 7. Operations for Enhancing Water Supply Reliability

Farmer Owned Storage Reservoirs

Water available in the area is abundant from a variety of sources. Capture of surface runoff is accomplished by diversions into elevated reservoirs and lakes. Historical trends show that surface storage has increased as aquifer levels drop (and pumping costs escalate). Increased storage also increases supply reliability. As an integral component of the GPAP, surface storage will utilized to reduce the peak diversion rate thereby increasing the reliability of the system to deliver full demands. The reliability of the system, from the perspective of an individual water contractor, depends on the amount of time that water is available for use. Limits imposed by available flows from the White River require a minimum of twenty-five percent of the total average year demand to be stored. At the twenty-five percent storage level White River flows are projected to provide full diversions ____ percent of the time; Lesser diversions will be available for a larger percent of the time. Increasing storage beyond the twenty-five percent level will yield even greater reliability. Increased storage will serve to augment less than full diversions in the late-summer time period.

Reallocation of Existing Storage in White River Basin

Reallocation of existing storage in the White River Basin could increase reliability of the GPAP. Should projected water demands change due to extended drought periods, reallocation of upstream pools may prove effective in augmenting White River low flows. Significant problems would have to be addressed as part of any upstream reallocations. First, with present riparian law, it is difficult to insure delivery of the allocated water from the release point to the diversion point without some form of diversion regulation in place. Second, the cost of reallocated storage would increase the net cost of water delivered to the customer.

Likely sources for storage reallocation are several Corps of Engineers reservoirs located within the Upper White River basin. These lakes are Norfork, Bull Shoals, and Greers Ferry Lakes. The combined storage capacity of these three lakes is 10.24 million acre-feet. Of this amount, 2.7 million acre-feet is reserved for the conservation pool, which is the amount of water necessary to provide the head for hydro power generation. The remaining 7.53 million acre-feet is divided into different authorized purposes such as power generation, flood control, water supply, and recreation. All three lakes have been authorized for flood control and power generation. Water supply was added to Norfork and Greers Ferry lakes under the authority of the Water Supply Act of 1958.

Reallocation of storage may be considered in one of two ways. Reallocation of storage from 1)additional project purposes, or 2)existing project purposes. Reallocation of storage as an added purpose requires economic justification, cost-sharing, and congressional authorization. In most cases, reallocation of storage is from existing project purposes.

## 8. Balancing Water Supply and Demands

Average Year Supply

Drought Supply

**Water Supply Availability**

**Average year supply:** the average annual supply of a water development system over a long period. For the GPAP average year supply is the average annual delivery capability of the White River over a 28-year study period (1965-1993).

**Drought year supply:** the average annual supply of a water development system during a defined drought period. For the GPAP the drought period is 1980 and 1981. For dedicated natural flow, it is environmental flows as required under specific agreements or state mandated minimum in-stream flows.

## PART IV GRAND PRAIRIE ARKANSAS PROJECT OPERATION PROCEDURES

### 9. General Organization

District Headquarters

The GPAP will establish a central headquarters facility where operations and maintenance activities will be coordinated and administered. Primary operations activities will consist of the following: all operations of the White River pumping station, full operation of all check structures located on the main canal (major check structures) and lateral canals (minor check structures), complete monitoring of water levels and gate openings at all check and turnout structures throughout the system. All Water Demands from Sub-districts will be consolidated and Diversion rates from the White River and check gate openings modified accordingly to provide the required flow, if available. Primary maintenance activities will consist of the following: budgeting of necessary resources, finances and manpower; conducting ordinary maintenance of canal embankments and access roadways; maintaining electronic devices (computers, gate controllers, and water level monitors) for the entire delivery system; scheduling major maintenance activities at the White River Pumping Station, check structures, and turnout structures; and conducting annual inspections of canals and periodic inspections of canal and pumping station structures.

Sub-District Structure

The GPAP will be further subdivided into sub-districts to facilitate calls for water. Each sub-district will consist of one or more lateral canals including check structures and farmer turnouts and will provide water for approximately 400 water contracts or customers. Each sub-district will consist of at least one ditch rider who will be responsible for coordinating water demands with the headquarters office and for monitoring operation of farmer-operated field turnouts. The ditch rider will also make monthly flow-meter readings and report the findings to the headquarters for billing. The ditch rider will also provide continuous visual observation of canal and structure status relaying maintenance requirements to the headquarters office.

### 10. System Controls and Water Level Monitoring

## Computerized System Controls

Computers will be utilized for monitoring of all canal and stream water levels. Both upstream and downstream water levels will be monitored at each check and turnout structure. Communications will utilize either buried cable or radio transmitter/receiver(s). Data will be collected at regular intervals. All water level readings will be stored in a permanent database to be used in establishing delivery efficiencies, for billing verification, and for other future archival purposes. Current status at each structure (gate or pump) will be actively displayed and updated on the operators screen or system board to facilitate operations and system performance. Displays will consist of tabular (tables) and graphics (bar charts, Icons, etc) data to reflect the functional status of gates and pumps (on, off, open, closed, error) and the water levels upstream and downstream of all canal and major turnout structures. This data will also be available from each field location where computer operated controls are installed. Actual pumping station delivery rates and check structure and major turnout gate settings may be controlled remotely through computer controls. Complete automatic control by computers, both flow and water levels controlled by software logic, is not anticipated. Computer actuation of pump operation and gate opening and closing sequences entered into the computer by the operator is anticipated. Gate opening and closing sequences will consist of the desired gate opening for each gate at a structure and the time that the gate change will occur. Pump operation will be programmed to coincide with gate changes. Gate opening changes are generally expected to occur only once each day. Maximum gate opening changes will be dictated by maximum changes allowed in the canal or stream. Audible alarms should activate within the control room to indicate gate failure, pump failure, extreme water levels, monitoring system error, or critical situations of other system components. The alarms should indicate the individual structure and the cause of the alarm(s). The alarms are essential to real-time monitoring of the delivery system.

## Manual System Controls

Each structure will have the capability for manual operations. Farmer-operated field turnouts will be operated manually. All manual operations will be coordinated with the sub-district or headquarters office prior to implementation. Maximum gate opening changes will be dictated by maximum changes allowed in the canal or stream.

## 11. Pumping Station Operations

Main Pumping Plant

The White River Pumping Station will be operated continuously to provide the demands through the system. The number of pumps operating will depend on the actual system demand. Pumps should operate on an alternating schedule to evenly distribute run-time and maintenance. Since White River stages may change by several feet from one day to the next thus affecting the pumping head, constant monitoring of water levels at the pump intake is essential to maintain required deliveries. A flow measuring device will be required at or near the pumping station outlet to adequately assess the quantity of water pumped in a 24 hour period. The flow measurement near the head of the canal will be necessary to adequately adjust pump operations for daily fluctuations of the White River.

Lateral Pumped Diversions

Because upstream and downstream water levels are fairly constant, lateral pumped diversions are much more predictable than White River Stages; therefore, operation of the small pumps will be based on the actual demand. If electric pumps are used, the pumps will be operated in cycles to provide equitable distribution of the water. Since these pumps generally operate at a single capacity the cycles will consist of on and off periods to provide the equivalent volume of water that would be provided by continuous delivery of the demand. Variable speed pumps may be operated to provide the actual demand.

## 12. Check Structure Operations/Major Turnout Structures

Maximum Allowable Water Level Changes

Maximum allowable water level changes in canals while filling pools will be 0.25 foot per hour until sufficient tailwater is established to completely submerge the hydraulic jump below the gates; after the jump becomes submerged, the rate can be increased to 0.5 foot per hour. Gates will not be operated in a manner that creates excessive velocities in the downstream canal.

Maximum allowable water level changes in the Main Canal will be 1 foot per day.

Maximum allowable water level changes in the

Lateral Canals will be 1 foot per day if greater than 5 feet in normal water depth and 0.5 foot per day if less than or equal to 5 feet in normal water depth.

Gate Settings

Gate Settings will be made to evenly distribute flow through the structure. Individual gates may not be operated more than 0.5 foot per hour subject to the limits set by water level changes in the canal. Special exceptions are permitted for emergency conditions. Gates will not be operated in a manner that creates excessive velocities in the downstream canal at any time.

## 13. Turnout Structure Operations

The responsibility for turnout structure operations varies. For major turnouts, those diverting water to lateral canals, the GPAP headquarters office has jurisdiction. Setting changes at the major turnout structures must be coordinated with the requested deliveries. Gate changes will be initiated by the headquarters office via computer controls or by direction of the appropriate ditch rider. Individual farmer-operated turnouts, likewise, must be coordinated prior to gate changes, first with the sub-district (ditch rider) who then contacts the headquarters office to schedule water delivery. The farmer will then make gate adjustments at his turnout at the direction of the ditch rider. Maximum water level changes and gate operations will be in accordance with requirements for the check structures.

Timing of Deliveries

Timing of deliveries will vary slightly from one end of the system to the other. Deliveries made along the canals will generally take less lead time than those made along natural streams.

## 14. Water Delivery Scheduling

Water Call Procedures

Delivery scheduling will require an advance notice or "Water Call" from the customer to the Ditch Rider in each sub-district.

For canal deliveries, a **1 to 2** day advance Water Call will be required.

For Stream deliveries, varying advance notice will be required. See Table **14-1** for Water Call notice.

Delivery Projections

Actual delivery projections may be made from previous day(s) deliveries, Water Calls, and amount of previous day(s) rainfall totals ratioed to the average year rainfall totals (average year is defined as the average year rainfall data used for developing the average year demand curve). In general, water will be delivered at the rate projected by the ten-day average year demand curves for each canal segment. Water delivery may be reduced below that projected by the average year demand depending on flow availability from the White River. Water delivery may be increased during the early spring up to the maximum projected by the average year demand if flow is available from the White River.

Deliveries will generally follow the schedule shown in Table **14-2**. Specific deliveries will generally be programmed using the average year ten-day demand values adjusted for actual rainfall amounts. Deliveries will also be based on Water Calls. However, for optimum performance of the GPAP, the system cannot function strictly as an on-demand system. Water must be delivered when most readily available; The water may in turn be applied directly to crops, if needed, or placed into storage at the discretion of the

**Table 14-1 Advance Notice Requirements**

| Canal or Stream Name | Days Notice Required |
|---|---|
| Main Canal | 1 |
| Canal 6200 | - |
| LaGrue Bayou and Minor Tribs | - |
| Little LaGrue Bayou and Minor Tribs | - |
| Mill Bayou and Minor Tribs | - |
| Hurricane Bayou | - |
| Elm Prong Mill Bayou | - |
| Stuttgart King Bayou | - |
| Honey Creek | - |
| Hurricane Creek | - |
| Buck Creek | - |

## Table 14-2 General Operation Scheduling

| Step | Management Concept | Month(s) of Operation | General Procedure |
|---|---|---|---|
| 1 | Fill Storage Prior to irrigation season if it has not already been filled. | Mar - Apr | Diversion pumps operate as needed. Water is released to customers as needed. |
| 2 | Irrigation season begins. Use canal water first. Use stored water only if canal capacity does not meet crop demands. | May - Jun | Water released to customer upon demand for use directly on crops or to fill storage. Diversion pumps are operated continuously to meet demand. Volume pumped may be determined by the demand or by other operation tools such as a "Water Budget". |
| 3 | Middle of irrigation season. Continue using canal water first then stored water. Water use is at maximum. If canal capacity and stored water do not meed full demand, ground water may be utilized. | Jul - Aug | Continue as in Step 2. The diversion system will be at full capacity during this period. Actual diversions may be dictated by White River Conditions. |
| 4 | | Sep-mid Oct | Continue as in Step 3. |
| 5 | Late irrigation season. Rice irrigation has ended. Soybeans and other row crops continue to be irrigated. | Mid Oct- Nov | Operate diversion pumps according to needs for special purposes such as wildlife or other environmental needs. |
| 6 | End of irrigation Season. | Dec | No system operations. |

customer. If a customer (or customers) does not need water forcrops and does not have storage available, the water being delivered through the GPAP will be reduced accordingly. The customer must realize that water foregone early during the year may result in their experiencing a water shortage later during the irrigation season. If storage is utilized early in the irrigation season for deliveries (while canals are operating at less than full capacity and additional White River flow is available for diversion), shortages in surface water imports will likely result, particularly in late July through September.

## 15. Water Shortage Procedures

White River Availability

Full deliveries will be provided to the customers, up to the maximum projected by the average year demand, provided flows are available from the White River. When the White River discharge at
the Clarendon Gage falls to 9,650 cfs (based on the rating curve at Clarendon, AR), no flow is available for diversion. For White River discharges greater than 9,650 cfs, flow may be diverted. The peak demand projection of 1,800 cfs would, therefore, require 11,450 cfs for full diversions to occur. The percentage that diversions must be reduced on a given day will be computed from the ratio of the available 8:00 am flow (the present White River discharge less 9,650 cfs) and the required diversion (or average year demand) for the date. During critical periods, the actual delivery may be adjusted each 12 hour period, beginning at 8:00 am. Representative percentage delivery reductions are shown in Table ______. Deliveries will be reduced based on the actual computed percent reduction uniformly for all customers. Exchange or sale of water between customers will be permitted to maximize use of available diversions during drought conditions.

Existing Stream Riparian Users

Restrictions to be imposed on pre-project riparian users along natural streams will be limited to historically available flows for similar climatic conditions.

## 16. Reporting Requirements

Internal Reports

Daily reports will be maintained of gate operations and flowrates through check and major turnout structures (based on rating curves for each structure).

Monthly Reports to ASWCC

Monthly reports of the daily diversion rates, White River stages and discharges (based on the gage and rating curve at Clarendon, AR), and the total volume of water diverted will be provided to the ASWCC.

Monthly Billing Reports to Customers

Monthly reports of water usage will be provided to the customer. Billing procedures and payment will depend on the contract established between the customer and the White River Regional Irrigation Water Distribution District.

## 17. Expectations for Farmer Owned Reservoirs

Use of Existing and Planned Storage

Storage available from existing reservoirs will continue to be filled from natural runoff and tailwater recovery systems as much as practible. New storage constructed as a project feature will also be filled from natural runoff and tailwater recovery as much as practible. The combination of existing and new storage should approximate twenty-five percent of the average annual demand volume. Should rainfall be insufficient to fill all on-farm storage, imported water will be used to complete filling reservoirs. To maximize water availability and system reliability during the summer months, storage should not be used until crop demands exceed available diversions. Should customers use stored water while diversions can supply the full crop needs, those customers will experience less system dependability (from their point of reference) than those customers that utilize storage as late as possible. To yield the highest system reliability crop needs must be taken first from the canals then reservoirs. However, if storage is depleted at any time during the year, the customer may, at their discretion, use purchased water to replenish the storage.

## 18. Emergency Procedures

Drowning Incidents and Reports

Incidents involving the public will be documented by a permanent electronic report filed immediately after the occurrence. The electronic report will include the time of the report, time logged by the computer system, and will be structured such that no editing may be done to the report. A written report will also be completed and filed.

Canal Failure

Canal failure will be prevented by regular maintenance and inspection. Should canal failure occur, several procedures must be followed.

a. If catastrophic failure of an embankment occurs, emergency shutdown of the pumping station is implemented immediately and gates just upstream and downstream of the failure are closed completely. Water deliveries may continue through the system upstream of the failure. Repairs are made before placing the canal back in service.

b. If severe failure of an embankment occurs such that immediate failure is not expected, partial shutdown of the pumping station is implemented and gates just upstream and downstream of the failure are closed to reduce the flow through the failed canal segment. Full deliveries may continue through the system upstream of the failure while partial deliveries may be made downstream of the failure. Complete system shutdown of the canal below the failure may be required temporarily to inspect the damage. Should damage require immediate repair, repairs are made before placing the canal back in service.

c. If minor failure of an embankment occurs such that no additional failures will result, the system continues to operate at full delivery. Repairs are delayed until the non-irrigation season.

Gate Failure

Gate failure will be prevented by regular maintenance and inspection. Should gate failure occur, several procedures must be followed.

a. If complete failure of the gate or operating mechanism occurs in the down position, limited operation of the canal can continue by use of the remaining gates, if any. Gate repair should be accomplished by use of stoplogs to evacuate water from the gate bay. Failure of single gated structures will require removing the downstream canal from service until gate repairs can be completed.

b. If complete failure of the gate or operating mechanism occurs in the full open position, operation of the canal can continue by use of the remaining gates, if any, and stop logs for flow regulation. Gate repair should be accomplished as above. Failure of single gated structures will require removing the downstream canal from service until gate repairs can be completed.

c. If complete failure of the gate or operating mechanism occurs in a partially open position, operation of the canal can continue by use of the remaining gates, if any. Repairs should be accomplished as above. Failure of single gated structures will require removing the downstream canal from service until gate repairs can be completed.

d. Failure of automated control mechanisms require the gates to be operated manually until repairs can be implemented.

Weather Forecasts

Problems induced by rainfall will generally consist of rising stages in natural streams, particularly severe rainfall events. Accurate advance weather information--extending over days, weeks, or months--would be invaluable in adjusting water operations in all types of years whether wet, dry, or normal. Potential benefits of dependable weather forecasts could be a reduction in water diversions and, to some degree, flooding impacts. Long-term weather forecasts could result in considerable savings in operation costs and in greater system reliability. The National Weather Service routinely issues both short-term and long-term weather forecasts. However, current predictions are not sufficiently reliable for project operation. Operations must, therefore, react to actual weather conditions rather than anticipate conditions based on predictions. Best-management practice will involve close monitoring of water levels at all times.

**19. Policing**

Water Usage

Unauthorized water use must be minimized to allow equitable distribution and billing of imported water. Primary policing will be the responsibility of Ditch Riders. Users found making unauthorized withdrawals will be subject to penalties that increase with number of occurrences and the volume and rate of water illegally diverted. Individual customers will also be responsible for reporting suspected illegal diversions.

Trespass/Vandalism

Arrangements with local police and sheriff departments will be made for patrolling headquarters facilities, Sub-district offices and maintenance facilities, the White River Pumping Station, and other structures. Fencing will be constructed in appropriate locations around building compounds.

# SECTION I

# PART H - (8)

# GENERAL DESIGN GUIDELINES

# PART H - (8) - GENERAL DESIGN GUIDELINES

This section presents the quality assurance plan document used to guide the hydrology and hydraulics design process.

# General Design Guidelines

## Hydraulic and Hydrologic Design Criteria

### Eastern Arkansas - Grand Prairie Area Demonstration Project

I. FLOODING IMPACTS

A. Hydrology - Standard (Traditional) methodology

B. Hydraulics - Standard (Traditional) methodology

C. Duration - Standard (Traditional) methodology

D. With Project Conditions - HEC-2 used to evaluate changes in Water Surface Elevations with Weirs in place.

II. CANAL HYDRAULIC DESIGN

A. Design Bottom Grade - Mean Velocity to be less that 2.0 feet per second. Slopes ranged from 0.00005 ft/ft to 0.0002 ft/ft.

B. Bottom Width - Use HDC computer program H6110 for various widths (W) to obtain a depth (D) which satisfies the following Regime conditions (Lacy's Methods):

2 þ W/D þ 3 for Q þ 400 cfs
3 þ W/D þ 5 for Q > 400 cfs

C. Side Slopes - As specified by Geotechnical Design Section

D. Minimum Operating Range - US Bureau of Reclamation Nomograph from Design Standard No. 3 used which varies based on canal capacity.

E. Location of Check Structures - Based on a spacing of 5 to 10 miles between controls. Also based on required minimum upstream pool elevations to feed all laterals under peak turnout deliveries.

F. Location of Alignment - Alignment followed the highest ground to provide maximum use of gravity flow to turnouts. Also attempted to follow property boundaries, to minimize the number of structures impacted (houses, farmsteads, etc), and to minimize the number of road crossings.

G. Minimum and Maximum Water Surface Elevations - Minimum water surface elevations were based on level pool elevations upstream of check structures. Maximum water surface elevations based on unsteady flow model, UNET, results for individual canals. Pumping station input flow was increased as required to meet downstream demands (adjusted for timing of lateral demands throughout the system).

## III. STRUCTURES

### A. Inverted Siphons

1. Locations were determined based on where natural drainage would be disturbed due to the canal system.

2. The project life is about 50 years; therefore, 100-year discharges were used to size the inverted siphons.

3. Tailwater on the siphons would, at least, submerge the outlets.

4. A static head of 0.3' above the top of the siphon was the maximum used to pass the 100-year event to minimize upstream impacts due to the siphon.

5. The length of the siphons were set at 250' long. This length would be adequate to go under any of the canals. This would give a more conservative design.

6. Friction losses were computed using the Hazen-Williams formula. Entrance, exit, and bend losses where computed using the minor loss formula $h_f = K(v^2/2g)$, where K is a loss coefficient. Pertinent factors were as follows:

Kbend = 0.16
Kentrance = 0.80
Kexit = 1.00
Roughness, C = 60

7. Siphons would be used to convey flow under road crossings where canal water surface elevations were near or above natural ground.

8. Canals would cross under Natural Drainage where canal discharges were less than that projected for the natural drainage.

9. Natural Drainage would cross under Canals where canal discharges

were greater than that projected for the natural drainage.

B. Turnout Structures

1. Materials and Type - Corrugated metal pipe (CMP) structure was considered to be less expensive than a structural concrete structure and was the controlling factor in material selection. The turnout structure consists of CMP horizontal conduit and a vertical riser pipe which houses a vertical slide gate used to deliver flows to receiving canals.

2. Sizing - Design sizing of the horizontal conduit was accomplished using guidance from the "Design of Small Canal Structures" published by the USBR. Turnout design sizes and inlet inverts were set to deliver demand flows from the supply channel to a smaller channel. When tailwater was computed in the receiving channel to exceed the downstream invert of the horizontal conduit, sizing was conducted using the CULVERW program developed by the St. Louis District.

3. Rip-rap Protection - Rip-rap limits needed for outlet protection to prevent erosion was conducted with Waterways Experiment Station guidance entitled Lined Channel Expansions at Culvert Outlets. The thicknesses were determined using EM-1601, Design of Flood Control Channels, and designed to protect against exit throat velocities produced by the demand flows.

C. Main Canal Gated Check Structures

1. Gated Check Structures - Gated Check Structures were designed to regulate the canal water surface upstream of the structure and to control the downstream flow. Vertical lift gates were recommended by Mechanical and Electrical Engineering Section based on past experience. Gate sizing was conducted using the appropriate orifice flow coefficient and the minimum head across the structure. Minimum head occurs with the regulated maximum control elevations exist on both the upstream and downstream sides of the check structure.

2. Stilling Basin Design - A hydraulic jump stilling basin was designed to dissipate energy downstream of the gated check structure. Stilling basin design was conducted with the maximum head across the structure. This occurs with the maximum control elevation on the upside and the minimum control elevation on the downstream side. The USBR "Hydraulic Design of Stilling Basins and Energy Dissipators" was used to determine basin lengths, depths, and end sill dimensions for a Type III hydraulic jump stilling basin. Additional rip-rap downstream of the stilling basin was designed using EM-1601.

3. Gated Conduit Check Structures - The CULVERW computer program developed by St. Louis District was used to size the gated horizontal conduit for check structures for submerged conditions. The analysis was conducted with the minimum head across the structure. The structure also contains a vertical riser pipe which

houses the gate used to regulate upstream water surface elevations and downstream flow rates.

4. Rip-rap Protection - Rip-rap limits needed for outlet protection to prevent erosion was conducted with Waterways Experiment Station guidance entitled Lined Channel Expansions at Culvert Outlets. The thicknesses were determined using EM-1601, Design of Flood Control Channels, and designed to protect against exit throat velocities produced by the demand flows.

D. Secondary Canal Gated Check Structures

1. Gated Conduit Check Structures - The CULVERW computer program developed by St. Louis District was used to size the gated horizontal conduit for check structures for submerged conditions. The analysis was conducted with the minimum head across the structure. The structure also contains a vertical riser pipe which houses the gate used to regulate upstream water surface elevations and downstream flow rates.

2. Rip-rap Protection - Rip-rap limits needed for outlet protection to prevent erosion was conducted with Waterways Experiment Station guidance entitled Lined Channel Expansions at Culvert Outlets. The thicknesses were determined using EM-1601, Design of Flood Control Channels, and designed to protect against exit throat velocities produced by the demand flows.

E. Tentative Guidelines for Controls

1. Major check structures will be operated remotely to maintain maximum system flexibility and control.

2. Minor check structures will be operated manually, but will have the capability for installation of electronic controls at a later time.

3. Major turnouts (Maximum Q greater than 100 cfs) will be remotely operated.

4. Minor turnouts (Maximum Q less than or equal to 100 cfs) will be manually operated.

5. Anticipate contracting with an irrigation consultant at the University of Memphis to review any proposed automation plans and to help develop/apply appropriate methodology and technology (whether remote computer gate operations, self operating gates, etc).

F. Pumping Stations

1. Pumping Station pumps will have the flexibility to match varying demands throughout the year (i.e. various pump capacities to allow combinations of pumps to meet variable demands).

2. Inlet channel bottom grade was established from the pumping station intake floor to the river average bed elevation at the inlet channel entrance.

3. Inlet channel velocities were to be very low, less than 1 foot per second, to minimize fish entrainment.

4. Inlet channel designed for full pumping station capacity at historic low stage on the DeValls Bluff gage.

G. Rock Weirs

1. Weir location hierarchy:

a. Provide pool access to all land tracts along the natural waterway that are not serviced by the canal and/or pipe system.

b. Upstream of bridge locations, when possible.

c. Intermediate locations whereby providing the deepest pool to as many tracts as possible.

d. Locations where the pool from the next downstream weir ends, provided that location is not in the middle of a tract already supplied.

2. Weir depth:

a. Use HEC-2 to determine the bankfull discharge at the location chosen.

b. Set top of weir elevation at 1 foot below top of bank using the sedimentation option in HEC-2.

c. Run the bankfull discharge (at the weir location) through the model with & without the weir in place and compare the differences in water surface elevations (at the weir location). If difference is zero, weir height is acceptable, if not, lower weir height and repeat.

3. Weir dimensions and Rip-Rap:

a. The dimensions of the weirs and stilling basins were obtained based on methods being used on the Demonstration of Erosion Control (DEC) Projects in North Mississippi Ref "Design and Construction of Low Drop Structures" by W. C. Little - Research Hydraulic Engineer, Erosion and Channels Research Unit, USDA Sedimentation Laboratory, Oxford MS. and Robert C. Daniel - Civil Engineer, State Design Unit, Soil Conservation Service, University, MS.

b. Rip-Rap thickness and gradations are according to Standard LMVD Gradation Tables, HDC, and EM-1110-2-1601.

IV. PIPELINES

A. Lengths were based on alignments that generally followed property boundaries or roads and provided water delivery to the required locations.

B. Pipe/pump sizes were determined using the CYBERNET AutoCAD add-in by Haestad Methods. Mechanical and Electrical Branch made spot checks and the results matched within a few horsepower for the pumps and/or a standard pipe size for the pipe.

C. The systems were designed to allow for pipe depth of 5 feet for cover and delivered water to an elevation 5 feet above natural ground at the outlet.

D. The criteria in the original design was to keep pump horsepower at a minimum and increase pipe size to provide the discharge/velocity required. Pipe material was Poly-Vinyl Chloride (PVC) for diameters up to 18" and Reinforced Concrete (RCP) for diameters larger than 18". Cost Engineering requested that the RCP pipes be redesigned using PVC because of significant cost savings. Further investigation revealed that larger size PVC pipe is readily available in this area due to the wide use in irrigation, and it is preferred by the locals. A redesign was done using PVC in the following standard diameters (in inches): 6, 8, 10, 12, 14, 15, 16, 18, 20, 24, 27, 30, and 36.

E. SELECTED MINOR LOSS COEFFICIENTS - From Cybernet Reference Manual and Engineering Experience

| Fitting | Coefficient | |
|---|---|---|
| | Recommended | Used (10% increase) |
| 45° Elbow | 0.40 | 0.44 |
| 90° Elbow | 0.50 | 0.55 |
| Tee, Line Run | 0.30 | 0.33 |
| Tee, Branch Run | 1.80 | 1.98 |
| 45° Wye, Line Run | 0.30 | 0.88 |
| 45° Wye, Branch Run | 0.80 | 0.88 |
| Coupling | 0.33 | 0.33 |
| Squared Entrance | 0.50 | 1.1 |
| Exit | 1.0 | 1.1 |

F. HAZEN-WILLIAMS PIPE FRICTION FACTOR - From Cybernet Reference Manual and Engineering Experience.

| Pipe Material | Factor | |
|---|---|---|
| | Recommended | Used (w/10% increase) |
| Poly-Vinal Chloride Pipe | 130 | 117 |
| Reinforced Concrete | 100 | 90 |

G. PUMP AND PIPE CRITERIA - (Based on discussions with Mechanical & Electrical

Motor Efficiency . . . . . . . . . . . . . . . . . . . . 90%
Pump Efficiency . . . . . . . . . . . . . . . . . . . . 75%
Minimum Pipe Diameter . . . . . . . . . . . . . . 6"
Minimum Motor Horse Power . . . . . . . . . . . 5 hp
Minimum Velocity in Pipe . . . . . . . . . . . . . 3-5 fps
Maximum Velocity in Pipe . . . . . . . . . . . . . 10 fps
Kinematic Viscosity . . . . . . . . . . . . . . . . . $1 \times 10^{-5}$
$\epsilon$ . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.0018

## V. SYSTEM OPERATION

A. The proposed operation manual documents operation criteria for gates, water level monitoring, and structure controls.

B. Wasteways

1. Wasteways will be located in all canal segments (between check structures) where a portion of the canal will have normal water levels above natural ground.

2. Wasteways will be located such that they discharge into a natural water course that has sufficient capacity to convey "spilled" water without significant impacts to the receiving stream.

3. Wasteways may consist of a small gated structure or a lowered section of the canal bank to serve as an emergency spillway.

4. Wasteways will be located to prevent the canal discharge from exceeding the design capacity (discharge conveyance plus an allowance for a normal operation range volume), thereby protecting the next downstream canal.

## VI. WHITE RIVER

### A. Water Balance

1. Demands - Ten day demands were based on projected crop and other water needs for 47 years of hydrologic conditions.

2. Rainfall Runoff - Runoff was estimated by NRCS experience as a percentage of rainfall amounts. The percentages varied by month.

3. Rainfall Capture - Capture was estimated by NRCS experience as a percentage of rainfall runoff amounts. The percentages varied by month.

4. Evaporation - Evaporative losses were based on 47 years of measured pan evaporation amounts at Stuttgart, AR.

5. On-Farm Storage - Storage was estimated using estimated volumes for present reservoirs and new reservoirs. Storage was "filled" first with available rainfall then import water. Available rainfall was rainfall captured directly or from tailwater recovery systems that exceeded the need for any given day.

6. Tailwater Recovery - Recovery was based on a percentage of rainfall by NRCS experience.

7. System Losses - System losses consisted of evaporative losses, conveyance system seepage losses, and operational losses (gate leakage, gate operations, etc). Losses were estimated to be 30 percent of the delivery system's capacity. Seepage losses were assumed unrecoverable except that approximately

7.5 percent of this loss was allowed to recharge the alluvial aquifer and become available for irrigation use in the water balance.

8. Groundwater - Groundwater supplies were limited to the sustainable rate projected from extensive groundwater modeling. This rate was estimated to be 40,000 AC-FT per year. Additional groundwater was utilized in the water balance to account for canal system seepage losses infiltrating back to the water table.

9. White River Diversions - Diversions were allowed to provide the additional water not provided from rainfall (all sources), storage, or groundwater. Diversions were limited based on flow levels in the river. Several minimum White River flow conditions (cut-off levels) were evaluated since the State of Arkansas is presently attempting to establish minimum allowable levels for resource allocation. The cut-off levels were analyzed to evaluate their effect on delivery system reliability, navigation, and fish and wildlife. White River flows at Clarendon, AR were used in the analysis due to the stability of the rating curve and long, reliable data record at that location. All with project plan analyses utilized outputs from the Little Rock District's White River Super Model which provides a consistent base for comparisons. Direct use of actual historic gage data was limited to computing statistics, and in developing the Super Model due to the varying degree of reservoir operations throughout the observed data set.

10. Reliability - Irrigation system reliability was evaluated using the results from the 47 year simulations and 7 cut-off levels on the White River. Additionally, statistics computed from these results were used as input for a risk-based simulation using @Risk.

B. Navigation Impacts - Hydraulic effects to water depths available for navigation were evaluated for several minimum in-stream flows (cut-off levels). Because maintenance dredging occurs during part of the year, two average bottom elevations were used to compute the available depths, before dredging and after dredging, respectively. Water balance simulations conducted for a 47 year period projected flow conditions in the river for various cut-off levels. These flow conditions were translated to stages using the rating curve at the Clarendon gage. The resulting stages were converted to elevation by adding the gage zero. Water depths were computed throughout the 47 year simulation period by subtracting the appropriate bottom elevation from the calculated water surface elevations and compared to the base, no diversion, condition. These computed water depths were utilized by Economics Branch to evaluate economic impacts to navigation.

C. Fish and Wildlife Impacts - Fish and Wildlife impacts were evaluated similarly to navigation impacts except that the resulting water surface elevation for the 7 cut-off levels was the desired output. The computed water surface elevations were then compared to the base condition (no diversions).

D. Minimum In stream Flows for the White River - The Arkansas Soil and Water Conservation Commission is presently attempting to establish acceptable minimum levels for water resource allocation purposes. Since no minimum is presently set, several minimum scenarios were evaluated. Minimum in-stream flows of 5,250 cfs (7Q10 flow); 7125 cfs (Stage of 5.0 at Clarendon Gage); 9,650 cfs (navigation requirement in current AR State Water Plan); 11,350 cfs (Stage of 12.0 at Clarendon Gage and reference for 8 foot channel maintenance); 12,850 cfs ( Stage of 13.0 at Clarendon Gage); 17,500 cfs (Stage of 16.0 at Clarendon Gage and point where local navigation interest identify no depth restrictions occur to river traffic); and minimum flows outlined in the current AR State Water Plan which vary by month (Minimums set for Water Quality, Fish and Wildlife needs, and Navigation).

# SECTION I

# PART I - (9)

# GLOSSARY

# PART I - (9) - GLOSSARY

Volume II of this report makes use of special irrigation and water-supply industry terminology, and also uses terms and abbreviations specific to the Eastern Arkansas Grand Prairie Demonstration Project. Selected terms and abbreviations are defined below.

aquifer
: A water-bearing geologic formation able to yield water in usable quantities.

ASCS
: See FSA.

ASWP
: Arkansas State Water Plan.

automatic control
: A procedure or method used to regulate mechanical or electrical equipment without human observation, effort, or decision.

automation
: A procedure or method used to regulate a water system by mechanical or electronic equipment that takes the place of human observation, effort and decision; the condition of being automatically controlled.

balanced operation
: Operation of a canal system where the water supply exactly matches the total flow demanded.

canal
: A man-made open channel delivering water to subsidiary components of the delivery system.

canal check gate structure
: A structure designed to control the water surface level and flow in a canal, maintaining a specified water depth or head on outlets or turnout structures. Most canal check structures have moveable gates.

canal freeboard

The vertical distance from the top of bank to the maximum design water surface elevation.

canal lining

A layer of material intended to enhance the performance of the canal by reducing seepage, resisting erosion, etc. A lining is often made of concrete, but in some instances may be a layer of specially compacted earth. The project canals are unlined.

canal pool

That portion of a canal between check structures.

canal prism

The cross sectional shape of a canal.

canal reach

Segment of main canal system consisting of a series of canal pools between major flow control structures.

canal system control concepts

The fundamental strategy of canal flow control--either upstream or downstream control.

canal system control methods

The way in which the selected control concept is implemented--local manual, local automatic, or supervisory control.

canal system operation

Water transfer from its source to points of diversion for irrigation, municipal and industrial, fish and wildlife, and drainage purposes.

canal system operation concepts

Downstream operation or upstream operation.

canal system operation methods

Constant downstream depth, constant upstream depth, constant volume, controlled volume.

CE

U. S. Army Corps of Engineers.

centralized control

Control of a canal project from a central location generally by a master station, communications network, and one or more remote terminal units (RTU's).

centralized headquarters

Control of a canal project from a central location by the watermaster.

check gate

A gate located at a check structure used to control flow.

classification of a water conveyance system

A general classification based on the objective of the system. Water conveyance systems may be classified as delivery systems, collector systems, or connector systems.

constant volume operation method

A canal operation that maintains a relatively constant water volume in each canal pool.

control

To exercise restraining or directing influence over: a mechanism used to regulate or govern operation of a system.

control element

A part of a control system through which the system's process is regulated.

control system

An arrangement of electronic, electrical, and mechanical components that commands or directs the regulation of a canal system.

controlled volume operation method

An operation in which the volume of water within a canal reach between two check structures is controlled in a prescribed manner for time variable inflows and outflows such as off-peak pumping or canal side deliveries.

conventional method

The control of a canal system onsite by operations personnel (ditchrider and watermaster). Labor saving devices and machinery may be used to assist in the control of the canal facilities.

crop distribution

For the project area, the percentage of cropland area devoted to the production of each crop species.

CRP

Conservation Reserve Program; A USDA program of contracts with landowners to keep designated tracts of land out of crop production and in good vegetative cover for a period of a few years.

delivery system

Conveys water from a single source such as a storage reservoir to a number of individual points of use. The delivery system is a common water conveyance system classification. It is associated with irrigation, municipal and industrial, and fish and wildlife canal systems.

demand delivery

Unrestricted use of the available water supply with limitations imposed only by maximum design flow rate and total water allotment, i.e. the availability of water at the source is not the limiting factor.

distribution system

Delivers water from the main canalside turnout to individual water users or to other smaller distribution systems.

ditchrider

A member of the canal system operation personnel. The person responsible for controlling the canal system onsite, based upon the flow schedule established by the watermaster.

downstream control

Canal control structure adjustments are based upon information from downstream. The required information is measured by a sensor located downstream or based upon the downstream water schedule established by the watermaster.

evapotranspiration

The loss of water from topsoil to the atmosphere, due to the combined effects of evaporation from the ground surface and from the transpiration of water by vegetation.

farm base acreage

Under the USDA farm program, and based on the cropping history of a given farm, the reference or "base" acreage of cropland for selected crop species used to determine crop subsidy payments by the FSA.

farm number

A number assigned by FSA that identifies a given farm in a given county for the administration of the USDA farm program. For the project the standard farm number has been adapted to accommodate farms from the four counties involved.

FSA

Farm Service Agency (formerly ASCS--the Agricultural Stabilization and Conservation Service). The USDA agency responsible for the administration of the federal farm program.

fish reservoir

In the project area, ponds or reservoirs designed and operated for commercial production of fish.

gate position sensor

A device, such as an analog or digital sensor, that can measure the mechanical position of a gate and provide a signal representing the position.

hydraulic gradient pivot point

A location along the water surface in a canal reach where the water level remains essentially constant during changes in flow.

imported water

Surface water pumped from the White River to satisfy water demand and to reduce withdrawals from groundwater.

inlet channel

A short open channel connecting the White River to the intakes of the main pump station.

inline reservoir

A large pool comprising an enlarged segment of the canal, used to regulate flow for balanced operation.

inverted siphon

A pipe used to convey a canal under drainage channels, depressions, roadways, or other structures. Alternately, the siphon may conduct natural drainageways under a canal. The term "siphon" is slightly misleading, since there is no actual siphon action in this type of structure; the term siphon is adopted because it is commonplace. Inverted siphons are also referred to as sag pipes.

irrigation efficiency

An expression of the amount of delivered water that actually benefits the irrigated crop. It is the ratio of the amount of irrigation water that actually benefits the crop to the gross amount of water at a point of reference in the delivery or distribution system. The efficiency will always be less than 100%, due to losses.

lateral

A branch in a canal or pipeline system that diverges from the main canal or other branches.

local automatic control

Onsite control by control equipment without human intervention.

local manual control

Onsite control by a human operator (ditchrider).

main canal system

Delivers water from a primary source of supply to several points of diversion or turnouts to smaller distribution systems.

manual control

Control of equipment requiring direct intervention of a human operator.

master station

The centralized facility with communications to remote terminal units for the purpose of information retrieval, control of apparatus, system control, and operation optimization.

mismatch

A condition in which water supplied to a given point in a conveyance or distribution system does not equal the demand for water at that point.

natural stream

Existing drainageways, natural or modified, in the project area that will be incorporated into the delivery system.

normal year (climatic)

NRCS

Natural Resources Conservation Service (formerly the SCS--Soil Conservation Service). The USDA agency responsible for providing soil and water conservation technical assistance to landowners.

offline reservoir

Constructed to the side of the main canal usually in a natural drainage channel. In canal system, used to store surplus water runoff during the winter season for use during the irrigation season.

operational spill

A loss or waste of water in an irrigation system occurring during operation and caused by operator error or by insufficient control capability.

Peralta cell

Groundwater levels for the entire Eastern Arkansas Region were modeled by the researcher Peralta. Peralta divided the region into a grid of squares three miles on a side (nine square miles in area) and used a finite-difference groundwater computer program to produce output for each square. Afterwards the squares have been referred to as "Peralta cells".

pipeline

Closed-conduit components of the delivery system, operating under either gravity flow or pressure flow provided by pump turnouts.

pump station

An installation housing pumps, motors, controls, and appurtenances required to accomplish the lifting of water to an elevation high enough to permit gravity flow to points downstream.

regime

For a stream or canal conveying a given discharge, the attainment of an equilibrium or stable condition with respect to bed slope and cross-section. Canals may be designed with slopes and cross-sectional dimensions anticipated to satisfy regime requirements so the canal does not experience unacceptable changes in dimensions due to operation at design flow.

remote monitoring

Periodic or continuous measuring of quantities at remote sites for transmission and dissemination at another location.

remote terminal unit (RTU)

Supervisory control equipment at the remote site that performs data collection, executes control commands, performs automatic control functions, and communicates with a master station.

response time

The time required for a desired result (such as attaining a specified canal water depth) to occur after a control correction has been initiated to obtain that result.

riparian

The condition of being located along the bank of a river or stream. An owner of riparian land may have rights to water in the adjacent stream, depending on state law.

riprap

Stone placed in a layer to provide protection to hydraulic structures from erosion or scour. Typical locations include bridges, culverts, siphons, check structures, and turnouts.

safe yield

The maximum rate at which groundwater may be removed from an aquifer without causing unacceptable results. For example, if it were desired to maintain the level of groundwater in an aquifer, then the safe yield might be set equal to the expected rate of groundwater replenishment.

sag pipe
: See inverted siphon.

scheduled delivery
: Operation of a water delivery system to meet predetermined needs, generally based upon user water orders.

SCS
: See NRCS.

seepage
: The loss of water from the delivery system due to the downward movement of water through the earth.

segment
: That length of a canal, stream, or pipeline extending from one delivery system discharge point to the next delivery system discharge point. For example, a segment of a main canal would exist between one two laterals off the main canal.

self regulation
: A controlled system requiring virtually no operator intervention (see automatic control).

sensor
: A device for measuring water level, flow, gate position, etc., for input to a local automatic controller or RTU.

setpoint
: A value of water level, flow, etc., that the control system maintains, also called the target.

soil association
: A group of two or more soil series present in typical proportions that, together with minor inclusions of other soil series, constitute a characteristic landscape. Typically, a detailed county soil survey may be condensed into a county soil association map, which locates the dominant landscapes present in the county.

steady flow
: If at a specified location along a water conveyance, there is no change in flow rate (e.g. in cubic feet per second) over time, then the flow is steady at that location.

stilling basin

A downstream-end component of an hydraulic structure, such as a check structure or weir, that allows the destructive energy of the flow to be dissipated harmlessly before release to the channel downstream.

storage reservoir

The project term for off-line reservoirs.

supervisory control

The control of a canal system from a centralized location (master station) over a communication system and using remote terminal units (RTU's) at the canal structure sites.

tailwater recovery

The collection and directing to reservoir storage of water that has reported to the downstream end or borders of irrigated land. The water may be runoff from rainfall or may be excess water applied for irrigation. Typically, the landowner must pump the recovered water uphill to the reservoir.

target

A value of water level, flow, etc., that a control system maintains, also called the setpoint.

telemeter

To sense, encode, and transmit data to a distant point.

tract

An area of farmland identified by the FSA as a being part of a farm. The project associates demand for water with tracts.

turnout

A structure provided to divert water from a main or primary irrigation canal to a distribution canal or farm delivery point. For example, turnouts are used at the head of canal laterals.

unsteady flow

If at a specified location along a water conveyance, there is a change in flow rate (e.g. in cubic feet per second) over time, then the flow is unsteady at that location.

upstream control

Control structure adjustments based upon information from upstream. The required information is measured by a sensor located upstream, or based upon the upstream water schedule established by the watermaster.

USGS

United States Geological Survey.

water budget

An accounting of water inflows, losses, and productive uses based on a selected time span, such as one year.

wasteway

In a case where the water level in a canal is rising and is threatening to overtop and damage the top of the canal, a wasteway is a structure that diverts the excess water harmlessly out of the canal pool and into a natural or constructed drainage channel. The wasteway may consist of an open channel spillway or a conduit. The wasteway may be feature a gate, permitting control over the quantity of water to be wasted.

waterfowl flooding

The intentional shallow flooding in Autumn of project land area for the benefit of waterfowl.

water level pivot point

A location along the water surface in a canal reach where the water level remains essentially constant during changes in flow.

watermaster

The person responsible for operation of the entire canal project.

wave erosion

The removal of earth from canal inside slopes due to the lapping of waves in the zone just above and below the canal pool elevation. The waves may be caused by wind or by operation of the canal system. In extreme cases the wave erosion may compromise the integrity of the canal embankment.

wedge storage

The volume of water contained between two different water surface profiles (flow changes) within a canal pool.

weir, riprap

A riprap chute designed to maintain water levels in the project natural stream segment immediately upstream of the weir. The weir is essentially a small hump in the bed of the chute that pools water upstream. The weir maintains the water depth required by the turnout(s) to divert water at design peak discharge.

WRID

White River Irrigation District; formerly the WRRIWDD.

WRRIWDD

White River Regional Irrigation Water Distribution District; now the WRID.