Special Assessment District #23, ARROWCREEK PARKWAY
Hydraulic Report
Whites Creek Branches 1, 2 and 3
RETURN TO WASHOE COUNTY ENGINEERING

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Prepared for submittal to:

Washoe County Dept. of Public Works
1001 E. Ninth Street
Reno, Nevada 89520

Prepared For:

CFA
1150 Corporate Boulevard
Reno, Nevada 89502

HLA Project No. 37957

Mark E. Forest, P.E.
Associate Engineer

Bruce A. Krater, P.E.
Consulting Principal

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Harding Lawson Associates
Infrastructure Inc.
Alpha Engineering Group
961 Matley Lane Suite 110
Reno, Nevada 89502 - (702) 329-6123
FAX (702) 322-9380

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APPENDICES

1.1 INTRODUCTION

Special Assessment District #23 includes the construction of Arrow Creek Parkway from Zolezzi Lane to the Arrow Creek Development. The focus of this study is the portion of the roadway that is impacted by Whites Creek Branches 1, 2 and 3 within the area shown on Figure 1. The study area includes only the central portion of the roadway improvements included in SAD #23.

The purpose of this report is to present the approximate limits of flooding associated with the "design" and "floodplain management" events on Whites Creek Branches 1, 2 and 3 in the vicinity of the proposed roadway improvements and evaluate the project impacts to those floodplains. The flow rates for these two events were defined in the *Preliminary Whites Creek Basin Management Study* (CBA, 1994) prepared for Washoe County and are currently being used by Washoe County as a basis for drainage design in the Whites Creek area. Based on the CBA study, the project will be subject to flooding from these three branches of Whites Creek.

This report describes the methods of analysis and assumptions employed and presents the results of the analysis for both pre- and post-project conditions. The report addresses only Whites Creek flows and does not address roadway drainage or drainage from other smaller watersheds impacting this segment of the roadway. Preparation of the plans and specifications and all other roadway drainage elements are being performed by CFA.

This report was originally submitted to Washoe County Department of Public Works on June11, 1997. As a result of comments provided by Washoe County, this revised report includes the following revisions:

- At the request of Washoe County, the concrete pipe culverts located in the eastern overbank area of Whites Creek Branch 1 were increased in size from 48" to 60". The results of the revised HEC-RAS analysis is contained in Appendix C, Subsection 2. This revision resulted in a 0.6' decrease in water surface elevations at the upstream face of the roadway.

- The post-project flood limits were added to the construction drawings that are contained in Appendix B.
  ↳ TOO SMALL TO READ. WANT THIS INFO ON FIGURES 3+4

- Rip-rap lined pre-formed splash pools were added at the culvert outlets. The rip-rap sizing calculations were added in Appendix F.

- A water surface profile through the Branch 2 box culvert was plotted using HEC-RAS and is included in Appendix D.

1.2 SCOPE OF SERVICES

This report includes the following analyses:

- Hydraulic analysis of Whites Creek Branch 1 for a distance of approximately 500' upstream and downstream of the proposed roadway using the floodplain management event (CBA, 1994) of 3,000 cfs. This analysis was performed for the pre- and post-project conditions. The post-project condition analysis also includes an evaluation of potential abutment scour at the abutments of the proposed concrete arch bridge structure that will be constructed over Whites Creek Branch 1.

- Hydraulic analysis of Whites Creek Branch 2 from the southern boundary of the Wedge Meadows subdivision to a point approximately 1000' upstream of the proposed Arrow Creek Parkway which is a reach length of one mile. This analysis was performed for the "design" and "floodplain management" events defined by CBA of 1,950 and 3,000 cfs. This analysis was performed for pre- and post-project conditions. Arrow Creek Parkway will continue through the Wedge Meadows Subdivision to Zolezzi Lane. In this segment, Arrow Creek Parkway crosses Whites Creek Branch 2 again within the Wedge Meadows Subdivision north of this study area. It was determined by CFA that this segment of roadway would be designed based upon the recommendations of previous studies for Wedge Meadows and is not included in the scope of this study.

- Hydraulic analysis of Whites Creek Branch 3 from a point that is approximately 100 feet east of the proposed extension of Wedge Parkway to a point upstream approximately 1000' upstream of the proposed Arrow Creek Parkway. This analysis was performed for the "design" and "floodplain management" events defined by CBA of 1,100 and 3,000 cfs

1.3 DESCRIPTION OF PROJECT AREA

The project is located in Washoe County. The proposed roadway is located on the section line between Sections 19 and 30 and 20 and 29, T18N, R20E. At a point that is approximately 700' east of the corner of Sections 19, 20, 29 and 30, the roadway alignment changes to proceed northeasterly. Just beyond the intersection with the extension of Wedge Parkway, the roadway turns north to intersect with Zolezzi Lane.

Wedge Parkway will also be extended from where it ends at Whites Creek Lane north to intersect with Arrow Creek Parkway.

The plan and profile of the roadway and design of the culvert improvements evaluated as a part of this study are based on the Arrow Creek SAD #23 Roadway Improvement Plans prepared by CFA on May 30, 1997.

Grades in the study area fall toward the east and northeasterly directions at an average grade of approximately 4 to 5%. Most of the study area is irrigated pasture. The area has been subject to residential development in recent years.

1.4 COORDINATION

Two meetings were held with Washoe County staff, HLA, and CFA to review the preliminary findings of this analysis and proposed design concepts. After submittal of the first draft of this report on June 11, 1997, two additional meetings were held with Washoe County to review comments and clarify the results.

1.5 LIMITATIONS OF THIS STUDY

This study was prepared for the limited purpose of evaluating the impacts of flooding associated with Whites Creek on the proposed Arrow Creek Parkway roadway improvements based on flow rates defined for Washoe County (CBA, 1994), and evaluation of the impacts of roadway on the 3,000 cfs floodplains as well as recommendations for additional design considerations for the roadway drainage structures related to scour and erosion at the inlets and outlets of the culverts and bridge. The analysis is based on the proposed roadway improvement plans prepared CFA. HLA has not reviewed the drainage design for the remainder of the roadway and is not making any statements or assurances regarding the adequacy of the drainage design prepared by CFA.

HLA also used the discharge values presented by CBA in the *Preliminary Whites Creek Basin Management Study* as required by Washoe County. HLA does not make any assurances regarding the adequacy of these values to represent a specific recurrence interval. HLA is not assuming that these flows are representative of a 100-year design event. Should the design flows be modified as a result of more detailed studies, or construction or grading occur in or near the Whites Creek floodplain resulting in a change to flow patterns or depth of flow, the conclusions of this report may no longer be applicable.

The results and conclusions of this study should not be relied upon for any other purposes other than those expressly stated herein without written verification from Harding Lawson Associates (HLA).

The floodplains associated with Whites Creek Branches 1, 2 and 3 were originally defined by FEMA in the late 1970's. This floodplain is shown on the current FEMA Flood Insurance Rate Map (FIRM) Panel 3170E dated September 29, 1994 (Figure 2). The FEMA analysis was based on approximate methods and defined relatively narrow floodplains for each of the four branches of Whites Creek. Later studies were performed for the Nevada Department of Transportation (NDOT) that suggested that the 100-year discharge estimate for Whites Creek was much greater than the flow rates used by FEMA for the approximate analyses shown on the FIRM.

NDOT and Washoe County attempted to plan and design a detention basin to reduce the Whites Creek 100-year peak flows. The detention basin concept was opposed by area land owners and the concept was abandoned. Washoe County then hired CBA to prepare a basin management study for Whites Creek to identify the potential hazards associated with the larger flow estimate and develop a floodplain management strategy for the Whites Creek area. This report, titled *Preliminary Whites Creek Basin Management Study, Final Report* was completed in April 1994. This document is currently being used by Washoe County as the basis of floodplain management in the Whites Creek area. Related portions of this study are included in Appendix A showing the approximate flood limits identified by CBA and other design criteria recommendations made by CBA.

This section describes the existing drainage facilities, design criteria for this project, existing sources of data and other design factors.

2.1 FEMA FLOODPLAIN MAPS

The Federal Emergency Management Agency (FEMA) prepares floodplain maps for the most significant flooding hazards in the communities that participate in the National Flood Insurance Program (NFIP). As a condition of participation in the NFIP, the community must adopt a floodplain ordinance which enforces the minimum requirements of the NFIP. Washoe County entered the regular program of the NFIP on August 1, 1984. At that time a set of Flood Insurance Rate Maps (FIRM) were published.

The first set of FIRMs published in 1984 showed an approximate 100-year floodplain analysis for Whites Creek. Since that date, the Washoe County FIRMs have been revised several times, but the Whites Creek floodplain is still shown as an approximate study. The current FEMA FIRMs for the project area became effective on September 30, 1994.

The current FIRM for the project area, shown as Figure 2, shows an approximate flood zone for each branch of Whites Creek. The approximate location of Arrow Creek Parkway is shown on this map. Because the flood zone information is approximate, FEMA has not published estimated peak discharges or water surface elevations associated with these flood zones. Arrow Creek Parkway is impacted by the three northern branches and is not impacted by the southern most branch as shown on this map.

2.2 DESIGN CRITERIA

The design criteria for this project includes:

- The "design" and "floodplain management" discharge values for each of Whites Creek branches have been defined in the *Whites Creek Basin Management Study* (CBA, 1994). The "design" values are recommended for the design of channels, culverts and other related drainage improvements. The "design" values are based on an approximate split flow analysis performed by Nimbus Engineers for the location where the four branches of Whites Creek separate from the main channel. Because of the potential for sediment and debris loading that could make the flow paths uncertain, CBA recommended a "floodplain management" discharge for each branch that is assumed to represent the potential flow rate that could result from one or more of the branches being obstructed at the split location by debris. The "floodplain management" discharge is recommended by CBA for setting finished floor elevations. The CBA recommended "design" discharges for Whites Creek Branches 1, 2 and 3 are 700, 1,950 and 1,100 cfs, respectively.

- The "floodplain management" event discharge is 3,000 cfs for each branch. This criteria was reviewed with Washoe County. The recommended course of action was to design the roadway to accommodate the 3,000 cfs event because of the location of the roadway within the floodplains of these three branches in order to minimize project impacts for this flow magnitude. The discharge values recommended in the *Whites Creek Basin Management Study* are based upon approximate methods of analysis and are considered to be approximate values that may be very conservative. Since these are the values recommended by Washoe County for use until a more detailed study is performed, they were used in this study. These values may not be representative of a 100-year event. HLA does not make any assurances regarding the adequacy of these values to represent a specific recurrence

interval. HLA is not assuming that these flows are representative of a 100-year design event.

- Earlier studies identified jurisdictional wetlands for Whites Creek Branch 1. In order to minimize the impacts to these existing wetlands, CFA has designed the crossing at this location with a precast Con Span Bridge System. This type of bridge requires the construction of a footing on each side of the channel. The concrete arch bridge structure spans the channel between the footings and does not require any disturbance of the channel area. The key concern in this instance is the potential for scour at the abutments resulting from the flow contraction at the bridge opening. Scour estimates and recommendations for scour countermeasures are based upon the Federal Highway Administration's Hydraulic Engineering Circular No. 18 (HEC-18).

- The profile of the box culvert that is required at Whites Creek Branch 2 is constrained by the need for a box culvert for Steamboat Ditch that must pass over the Branch 2 culvert.

- Hydraulic analyses of the box and pipe culverts is based upon the methods described by the Federal Highway Administration in Hydraulic Design Series No. 5 (1986).

- Hydraulic analyses of the natural channels and the concrete arch bridge have been performed using the Corps of Engineers water surface profile programs HEC-RAS (VER. 1.2) and HEC-2 (VER. 4.6.2). The goal of the project is to minimize the impacts to adjoining properties for the 3,000 cfs event.

2.3 EXISTING DRAINAGE FACILITIES

Within the project area, the floodplains associated with the 3,000 cfs event are primarily agricultural (pasture) areas. Whites Creek Branches 2 and 3 are crossed by Whites Creek Lane and Steamboat Ditch in the project area. Both of these features have some impact on the distribution of the flow. The impact of Whites Creek Lane was quantified in three earlier studies that are described in the next section (Kennedy/Jenks Consultants, 1993 and 1994, HLA 1995).

The impact of Steamboat Ditch on Branch 2 is described in this report.

At the lower end of the study area, improvements are being planned and constructed for the Wedge Meadows Subdivision. This subdivision is located in the Whites Creek Branch 2 floodplain. The analysis for Wedge Meadows showed that the floodplain for Branch 2 was relatively narrow and could be easily intercepted with channel improvements at the southern boundary of Wedge Meadows. The analysis in this study, and the analysis contained in the CBA report, suggest a wider floodplain for the 3,000 cfs event. The impacts associated with the construction of Wedge Meadows was not part of the scope of this study. However, these impacts should be considered with the development of Wedge Meadows.

2.4 TOPOGRAPHIC DATA

Topographic mapping for the project site and surrounding area was prepared by Nevada Aerial Mapping based on aerial photographs taken on November 13, 1996. This mapping was prepared with a contour interval of one foot. Additional spot elevations were obtained by CFA to define the topography in and around Steamboat Ditch.

2.5 EXISTING STUDIES

Several previous studies have been performed that are relevant to this project. These studies are as follows:

- CBA, 1994 - Whites Creek Basin Management Study. The relevance of this study was described in Sections 1 and 2.

- Kennedy/Jenks, October 1993 - This study estimated the location of the pre-development condition floodplain associated with the design flow rates of 1,100 and 1,350 cfs for Whites Creek Branches 3 and 4 based upon five foot contour interval topographic mapping. This study was performed for Merit Homes as a preliminary study for Pine Tree Ranch Units 1 and 2.

- Kennedy/Jenks, June 1994. - This study was performed for Mountain View Development (Sterling Ranch Subdivision). It expanded the analysis for Whites Creek Branch 4 performed as a part of the October 1993 study for Merit Homes to include the floodplain associated with a 3,000 cfs event on Whites Creek Branch 4. A portion of the overflow from this event is directed toward the intersection of Whites Creek Lane and Wedge Parkway. This study estimated the flow rate from Branch 4 that was directed to this location was approximately 890 cfs.

- Kennedy/Jenks, July 1994 - This study evaluated the post-project conditions for Pine Tree Ranch Units 1 and 2. The analysis for Units 1 and 2 was based on an assumed overflow rate from Whites Creek Branch 4 of 890 cfs. The grading for Pine Tree Ranch Units 1 and 2 would direct this flow to the southwest corner of Whites Creek Lane and Wedge Parkway.

- Harding Lawson Associates, December 1995 - This report evaluated the post-project conditions for Sterling Ranch and refined the overflow analysis for Whites Creek Branch 4 and extended the analysis for Whites Creek Branch 3.

- Nimbus Engineers - Wedge Meadows Subdivision, Hydraulic Report. This report describes the results of the analysis of Whites Creek Branch 2 in the vicinity of the Wedge Meadows Subdivision. As described in Section 2.3, the analysis for Wedge Meadows showed that the floodplain for Branch 2 was relatively narrow and could be easily intercepted with channel improvements at the southern boundary of Wedge Meadows. The analysis in this study, and the analysis contained in the CBA report, suggest a wider floodplain for the 3,000 cfs event. The impacts associated with the construction of Wedge Meadows was not part of the scope of this study. However, these impacts should be considered with the development of Wedge Meadows.

- Harding Lawson Associates, April 1996 - This report evaluated the post-project conditions for Pine Tree Ranch and Sterling Ranch subdivisions and refined the overflow analysis for Whites Creek Branch 3. Based upon better topographic data and more detailed analyses, the estimated overflow from Whites Creek Branch 4 that reaches the intersection of Whites Creek Lane and Wedge Parkway was reduced to approximately 435 cfs. The remainder of the flow that was previously assumed to be directed toward this location was found to directed into Whites Creek Branch 3. The 435 cfs at this location will need to be considered in the design of Wedge Parkway.

2.6 IMPROVEMENT PLANS

Selected sheets from the Arrow Creek SAD #23 Roadway Improvement Plans, as prepared by CFA (May 30, 1997) are included in Appendix B for reference.

3.0 HYDRAULIC ANALYSIS

3.1 WHITES CREEK BRANCH 1

The proposed Arrow Creek Parkway crosses Branch 1 approximately 10 to 15' above existing grade. Therefore, it was necessary to design the drainage structures for this crossing to accommodate the 3,000 cfs event rather than the 700 cfs event. As stated earlier, the secondary goal of the improvements is to minimize the impacts to existing wetlands areas adjoining the primary channel. CFA has designed an arch culvert to span the existing channel at Station 68+62.

Three additional overflow channels exist just east of the main channel. Overflow from the main channel will spill into the next channel to the east. At this location a two cell 8' X 10' concrete box culvert is proposed at Station 70+20. Flow in excess of the capacity of the arch bridge and box culvert with spill into the secondary channels on the eastern edge of the floodplain. At these locations a set of two 48" concrete pipe culverts are proposed at Stations 71+40 and 72+45. The combined capacity of the four sets of structures is in excess of 3,000 cfs.

HEC-RAS (VER. 1.2) was selected as the best tool currently available for performing the analysis of pre- and post-project conditions because of its ability to model multiple bridge or culvert openings and its ability to model the arch bridge structure with a greater level of accuracy as compared to HEC-2 (VER. 4.6.2). The analysis is based on the following assumptions and boundary conditions:

- The flow regime is assumed to be subcritical. Even though the average slope is approximately 5%, flows in natural channels are rarely supercritical, especially when the flow is wide and shallow. The impacts on the flow profile that results from dune and antidune formations, debris and sediment movement and other factors often keep the flow depths near critical depth. The analysis results in flow depths that are typically computed at critical depth. Therefore, the analysis is not highly sensitive to estimates of roughness.

- Flow depths at the first section are based on the slope-area method.

- HEC-RAS (VER. 1.2) is a one dimensional model. Since the flow interactions between channel braids may be dynamic, a one dimensional model only yields approximate results. The flow profile in each braid may differ from one another slightly. Modeling a lower flow rate would require a more complex analysis of the interaction of the channel braids and would require that the analysis be carried further upstream.

- It is assumed that 3,000 cfs can be contained in Branch 1 before it reaches this location. It is possible that breakout into Branch 2 could result in the upstream reach that would reduce the potential flow rate at this location.

- Manning's roughness values are based on field review.

A set of 12 cross sections were defined at an average spacing of approximately 100 feet as shown on Figure 3. The cross sections geometry and lengths between sections were obtained from the topographic maps using a digital terrain model. The orientation of the cross sections was selected to best describe the flow patterns associated with a 3,000 cfs event. For the proposed condition analysis, the cross sections were modified to reflect the impacts of the roadway fill and associated bridge and culvert structures.

The results of the analysis are contained in Appendix C with a summary table showing the comparison between pre- and post-project conditions. The results show that there is in increase in the upstream water surface elevation of 2.5' immediately upstream of the roadway , but because of the steep topography, this impact diminishes within 200' upstream of the roadway and is less than 1' within 100' upstream of the roadway.

3.2 WHITES CREEK BRANCH 2

Whites Creek Branch 2 is located east of Branch 1. A reach length of 5200' was analyzed for Branch 2 extending from the southern side of the Wedge Meadows subdivision to a point approximately 1000' upstream of the proposed Arrow Creek Parkway. Flow patterns for Whites Creek Branch 2 are complex during the 3,000 cfs event. In order to define the limits of flooding associated with this Branch, 38 cross sections were defined with an average spacing of 140'.

The existing condition analysis shows that several potential breakout locations exist within the southern and northern fringes of the floodplain. Many of these breakouts would result in a different water surface profile since the breakout flow is isolated from the primary portion of the floodplain. Both HEC-RAS (VER. 1.2) and HEC-2 (VER. 4.6.2) were used to analyze this segment of Branch 2. HEC-2 (VER. 4.6.2) was used to quantify the split flows. HEC-RAS (VER. 1.2) was used for the pre- and post-project floodplain analyses.

The post-project condition analysis includes the 3 cell 8' X 10' RCB for Branch 2 and the encroachment analysis of the roadway fill.

The analyses for Branch 2 are based on the following assumptions and boundary conditions:

- The flow regime is assumed to be subcritical. Even though the average slope ranges from approximately 4 to 7%, flows in natural channels are rarely supercritical, especially when the flow is wide and shallow. The impacts on the flow profile that results from dune and antidune formations, debris and sediment movement and other factors that often keep the flow depths near critical depth. The analysis using the subcritical flow regime results in flow depths that are typically computed at critical depth. Therefore, the analysis is not highly sensitive to estimates of roughness. The subcritical flow regime is also required for use with the culvert analyses methods employed for the post-project condition. In this instance, the magnitude of breakout computed based on this assumption may be conservative. If the actual flow depths are less than critical depth at the breakout locations, a lower magnitude of breakout might be realized.

- Flow depths at the first section are based on the slope-area method.

- HEC-RAS (VER. 1.2) is a one dimensional model. Since the flow interactions between channel braids may be dynamic, a one dimensional model only yields approximate results. The flow profile in each braid may differ from one another slightly.

- It is assumed that 3,000 cfs can be contained in Branch 2 before it reaches the upstream limit of the study. It is possible that breakout into Branch 2 could result in the upstream reach that would reduce the potential flow rate at this location.

- Manning's roughness values are based on field review.

- The minor breakouts identified on Figures 4 and 5 are ignored in the analysis but are considered in the delineation of flood limits. The primary portion of the floodplain for both pre-and post-project conditions, ignores many of these breakouts where they do not directly impact the design of the roadway. This approach yields conservative results since the flow rate in the central portion of the floodplain would actually be reduced by the magnitude of the breakouts that occur on the fringes of the floodplain.

- The encroachment analysis is based on the use of a block obstruction at the location of the toe of the fill. This is conservative approach since there is slightly more cross sectional area associated with the slope of the fill.

Two breakouts on the southern edge of the floodplain upstream of Arrow Creek Parkway were estimated since the breakout was more significant at this location and the flow that leaves the main channel impacts other segments of the roadway. These breakouts are shown on Figure 4. The first breakout is located between Cross Sections 36 and 38 and is estimated to be approximately 400 cfs. The second breakout is located at Steamboat Ditch.

3.3 WHITES CREEK BRANCH 3

Whites Creek Branch 3 is located immediately east of Branch 2. A reach length of approximately 1000' was analyzed for Branch 3 extending from the eastern side of the Wedge Parkway alignment to a point approximately 1000' upstream of Wedge Parkway. Flow patterns for Whites Creek Branch 3 are the most complex of the three branches analyzed for the 3,000 cfs event. In order to define the limits of flooding associated with this Branch, 9 cross sections were defined with an average spacing of 120'.

Overflows from Branches 2 and 4 interact with Branch 3 at many locations along Branch 3 within and upstream of the study area. However, based on the assumptions by CBA, 3,000 cfs would not be expected in more than one branch at a given point in time. Therefore, each branch analysis must be considered independently from the other.

Only an existing condition analysis has been performed for Branch 3. A supplemental report will be prepared for the design of Wedge Parkway. HEC-RAS (VER. 1.2) was used to analyze this segment of Branch 3 for the existing condition.

The analyses for Branch 3 are based on the following assumptions and boundary conditions:

- The flow regime is assumed to be subcritical. Even though the average slope is approximately 3%, flows in natural channels are rarely supercritical, especially when the flow is wide and shallow. The impacts on the flow profile that results from dune and antidune formations, debris and sediment movement and other factors often keep the flow depths near critical depth. The analysis using the subcritical flow regime results in flow depths that are typically computed at critical depth. Therefore,

the analysis is not highly sensitive to estimates of roughness. The subcritical flow regime is also required for use with the culvert analyses methods that will need to be employed for the post-project condition for Wedge Parkway that will be included with a future report.

- Flow depths at the first section are based on the slope-area method.
- HEC-RAS (VER. 1.2) is a one dimensional model. Since the flow interactions between channel braids may be dynamic, a one dimensional model only yields approximate results. The flow profile in each braid may differ from one another slightly.
- It is assumed that 3,000 cfs can be contained in Branch 3 before it reaches the upstream limit of the study.
- Manning's roughness values are based on field review.

3.4 WHITES CREEK BRANCH 4

As discussed in Section 2, the previous studies identified and quantified the potential breakout from Branch 4 during a 3,000 cfs event. The latest report (HLA, 1995) estimated this breakout at 450 cfs which is concentrated at the intersection of Whites Creek Lane and Wedge Parkway. This flow will need to be considered in the design of Wedge Parkway.

3.5 SCOUR ESTIMATE

The potential scour at the proposed Con Span Arch bridge is primarily the scour associated with the contraction at the bridge opening and abutment. The scour of greatest concern in this instance is the potential scour at the abutment. This scour estimate is based on the guidelines in the FHWA's HEC-18. The HEC-18 guidelines provide an estimate of potential scour based upon depths and velocities in the bridge opening and average grain size of the bed sediment. The hydraulic parameters were derived from the HEC-RAS (VER. 1.2) results. The sediment size for the channel bed material is unknown. Based on observed conditions, the D50 in the channel is estimated to be approximately 0.20 feet. It is likely that the channel bed is armored and the average grain size is much larger in the channel bed. Since the results are not highly sensitive to this input parameter, a more refined estimate of grain size was not deemed necessary.

Due to the multiple openings, the use of HEC-18 guidelines are not easily applied to this condition. Estimates were made based on the portion of the left side of the channel that leads to the proposed bridge. Conservative assumptions were typically applied.

Based on this approach, the estimated contraction and abutment scour is 4.1 and 4.4 feet, respectively. HEC-18 guidelines tend to yield conservative results, especially where the natural channel is somewhat armored by large cobbles and boulders, as is typical of this setting.

3.6 RECOMMENDED SCOUR COUNTERMEASURES

HEC-18 recommends that the footing of the bridge extend below the depth of maximum scour and that the structure be designed to withstand this degree of scour for the duration of the peak flow. In addition to extending the footings to this depth, the FHWA recommends that rip-rap be placed around the abutments to provide additional protection against scour. The size of the rip-rap is estimated with equations presented in HEC-18 that are based on the anticipated depths and velocities at the edge of the abutment. Application of the HEC-18 equations for rip-rap sizing yielded a D50 for the scour countermeasure rip-rap of 0.7 feet. A D50 of 1.0' is recommended.

4.1 WHITES CREEK BRANCH 1 BRANCH 4

As described in Section 3, the project results in a minor increase in the flow depths at the upstream side of the roadway. Due to the steepness of the channel grade and shallow nature of the flow, this impact diminishes rapidly upstream of the roadway.

It is recommended that rip-rap with a D50 of 1.4' be placed on the stream side of the wingwalls of the Con Span Arch bridge extending from 3' beyond the end of the wingwall to a location approximately 5' to 10' inside of the face of the culvert on the upstream side.

It is recommended that a rip-rap apron be constructed at the outlets of the box and pipe culverts. The plans include a rip-rap pre-formed scour hole at the outlet of each of the three culverts on Branch 1. The rip-rap sizing calculations are contained in Appendix F. Rip-rap and scour hole outlet sizing calculations are based on the guidelines contained in the Draft Washoe County Hydrologic Criteria and Drainage Design Manual.

4.2 WHITES CREEK BRANCH 2

Flows associate with Branch 2 are contained in a 3 cell 8' X 10' concrete box culvert at Arrow Creek Parkway. The box culvert is designed to prevent the breakout that currently exists at Steamboat Ditch. The water surface elevation at the inlet of the box culvert is at the elevation of 4766.6 as compared to the top of the wingwall at 4768.7. The impacts of this containment are evaluated downstream and found to have a very minor impact on depths of flow downstream of the roadway in the segment between where this flow left the channel and rejoined it further downstream.

The impact of the encroachment results in a minor rise in water surface elevation between Sections 17 and 20. The maximum increase in the water surface elevation of 0.55' occurs at Cross Sections 17. This elevation increase results in a minor increase in the width of the 3,000 cfs floodplain at Section 17 on the opposite bank of approximately 10'. At the other three sections (18 - 20), the rise is between 0.2 and 0.4'.

It is recommended that a rip-rap apron be constructed at the outlet of the proposed box culvert that extends beyond the ends of the wingwalls.

Rip-rap sizing calculations are contained in Appendix F. A d50 of 24" was recommended based on two sources. The proceedures outlined in the Washoe County Hydrologic Criteria and Drainage Design Manual include three different culvert outlet rip-rap sizing equations. The first equation is for aprons such as the one shown on the detail by CFA. This equation suggests a d50 of 40". The second equation is for a preformed scour hole with a depth equal to half the culvert height. This equation yeilds a d50 of 24". An independant check was performed using the rip-rap sizing techniques described by the Corps of Engineers in *Hydraulic Design of Flood Control Channels*. The COE document suggests that the 24" d50 is a reasonable size for a velocity of 14 ft/s which is at the outlet of the culvert and decreases to 10 to 12 ft/s a short distance downstream of the outlet.

During the review of the comments, Washoe County requested a review of the erosion potential of the toe of the roadway embankment where the roadway encroaches into the floodplain. The depth of flow at the edge of the roadway fill is typically less than 1'. The average velocity over the entire cross section in this reach below the culvert ranges from 4 to 8 ft/s. Velocity at the fringe of the floodplain would be expected to be 2 to 4 ft/s. Therefore, the erosion potential is relatively low. The duration of flow associated with a 3,000 cfs event would also be very short. The roadway should be inspected periodically and measures taken if local erosion becomes a concern.

4.3 WHITES CREEK BRANCH 3

Wedge Parkway will need to be designed in a manner that minimizes the impacts to both upstream and downstream properties. The analysis for this portion of the project will be addressed in a subsequent report.

5.0 REFERENCES

Sources of information used in this analysis included the following references:

Cella Barr Associates, April 17, 1994, Preliminary Whites Creek Basin Management Study, Final Report.

Clark County Regional Flood Control District, 1990, Hydrologic Criteria and Drainage Design Manual.

Cooper Aerial of Nevada. June 1993. Reno Photos, Scale 1"=400'.

Federal Emergency Management Agency. September 30, 1994. Flood Insurance Study, Washoe County, Nevada.

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Kennedy/Jenks Consultants. October 1993. "Whites Creek Floodplain Analysis," letter report to Merit Homes.

Kennedy/Jenks Consultants. June 14, 1994. "Floodplain Mapping - Whites Creek, Sterling Ranch Subdivision," letter report to Mountain View Development.

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FIGURES

Arrow Creek Parkway - Special Assessment District #23
Branch1 - Pre- and Post Project Water Surface Profile Comparison

Cross Section	Discharge (cfs)	Pre-Project Water Surface Elevation	Post-Project Water Surface Elevation	Difference in Pre- & Post Project WSE
1	3000	4866.95	4866.95	0.00
2	3000	4861.29	4861.29	0.00
3	3000	4864.57	4864.57	0.00
4	3000	4867.64	4867.64	0.00
5	3000	4869.34	4869.34	0.00
6	3000	4871.09		
7	3000	4875.03	4876.96	3.93
8	3000	4879.96	4879.96	0.00
9	3000	4885.22	4885.22	0.00
10	3000	4889.75	4889.75	0.00
11	3000	4892.32	4892.32	0.00
12	3000	4896.36	4896.36	0.00

WHITES CREEK BRANCH #1

PROPOSED ARROW CREEK PARKWAY

EXISTING CONDITION FLOOD LIMITS (3000 CFS)

40 0 40 80
SCALE IN FEET
1" = 40'-0"

1	9/4/97	MODIFY EAST FLOOD LIMIT	MEF	MEF

DRAWN: KRP	PROJECT NO.: 37957.1	FILE NAME: BRAN1.DWG
ENGINEER: MEF	SCALE: 1"=40'	
CHECKED:	APPROVED:	
DATE:	DATE:	

Harding Lawson Associates
Infrastructure, Inc.
Alpha Engineering Group
961 Matley Lane Ste. 110
Reno, Nevada 89502
(702) 329-6123

SPECIAL ASSESSMENT DISTRICT #23

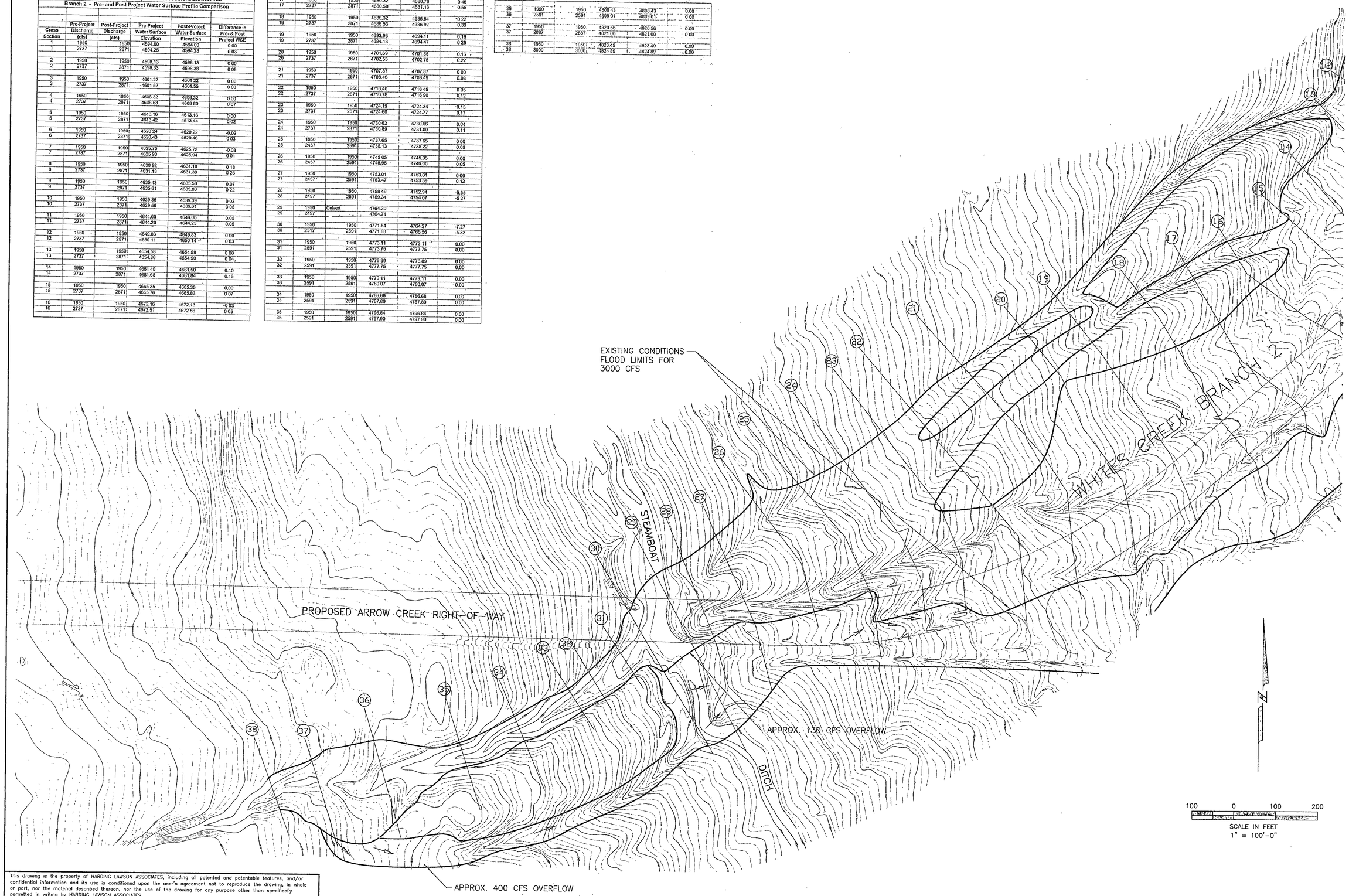
CFA
1150 CORPORATE BLVD.
RENO, NV 89502

FIGURE 3
FLOODPLAIN MAP
WHITES CREEK BRANCH #1

DRAWING:	
SHEET:	OF
REVISION NUMBER:	
DATE:	

Arrow Creek Parkway - Special Assessment District #23
Branch 2 - Pre- and Post Project Water Surface Profile Comparison

Cross Section	Pre-Project Discharge (cfs)	Post-Project Discharge (cfs)	Pre-Project Water Surface Elevation	Post-Project Water Surface Elevation	Difference in Pre- & Post Project WSE
1	1950	1950	4594.00	4594.00	0.00
1	2737	2871	4594.25	4594.28	0.03
2	1950	1950	4598.13	4598.13	0.00
2	2737	2871	4598.33	4598.38	0.05
3	1950	1950	4601.22	4601.22	0.00
3	2737	2871	4601.52	4601.55	0.03
4	1950	1950	4606.32	4606.32	0.00
4	2737	2871	4606.53	4606.60	0.07
5	1950	1950	4613.16	4613.16	0.00
5	2737	2871	4613.42	4613.44	0.02
6	1950	1950	4620.24	4620.22	-0.02
6	2737	2871	4620.43	4620.46	0.03
7	1950	1950	4625.75	4625.72	-0.03
7	2737	2871	4625.93	4625.94	0.01
8	1950	1950	4630.92	4631.10	0.18
8	2737	2871	4631.13	4631.39	0.26
9	1950	1950	4635.43	4635.50	0.07
9	2737	2871	4635.61	4635.83	0.22
10	1950	1950	4639.36	4639.39	0.03
10	2737	2871	4639.56	4639.61	0.05
11	1950	1950	4644.00	4644.00	0.00
11	2737	2871	4644.20	4644.25	0.05
12	1950	1950	4649.83	4649.83	0.00
12	2737	2871	4650.11	4650.14	0.03
13	1950	1950	4654.58	4654.58	0.00
13	2737	2871	4654.86	4654.90	0.04
14	1950	1950	4661.40	4661.50	0.10
14	2737	2871	4661.68	4661.84	0.16
15	1950	1950	4665.35	4665.35	0.00
15	2737	2871	4665.76	4665.83	0.07
16	1950	1950	4672.16	4672.13	-0.03
16	2737	2871	4672.51	4672.56	0.05
17	1950	1950	4680.32	4680.78	0.46
17	2737	2871	4680.58	4681.13	0.55
18	1950	1950	4686.32	4686.54	0.22
18	2737	2871	4686.53	4686.92	0.39
19	1950	1950	4693.93	4694.11	0.18
19	2737	2871	4694.18	4694.47	0.29
20	1950	1950	4701.69	4701.85	0.16
20	2737	2871	4702.53	4702.75	0.22
21	1950	1950	4707.87	4707.87	0.00
21	2737	2871	4708.46	4708.49	0.03
22	1950	1950	4716.40	4716.45	0.05
22	2737	2871	4716.78	4716.90	0.12
23	1950	1950	4724.19	4724.34	0.15
23	2737	2871	4724.60	4724.77	0.17
24	1950	1950	4730.62	4730.66	0.04
24	2737	2871	4730.89	4731.00	0.11
25	1950	1950	4737.65	4737.65	0.00
25	2457	2591	4738.13	4738.22	0.09
26	1950	1950	4745.05	4745.05	0.00
26	2457	2591	4745.05	4745.00	0.05
27	1950	1950	4753.01	4753.01	0.00
27	2457	2591	4753.47	4753.59	0.12
28	1950	1950	4758.49	4752.94	-5.55
28	2457	2591	4759.34	4754.07	-5.27
29	1950	Culvert	4764.30		
29	2457		4764.71		
30	1950	1950	4771.54	4764.27	-7.27
30	2517	2591	4771.88	4766.56	-5.32
31	1950	1950	4773.11	4773.11	0.00
31	2591	2591	4773.75	4773.75	0.00
32	1950	1950	4776.89	4776.89	0.00
32	2591	2591	4777.75	4777.75	0.00
33	1950	1950	4779.11	4779.11	0.00
33	2591	2591	4780.07	4780.07	0.00
34	1950	1950	4788.88	4766.68	0.00
34	2591	2591	4787.80	4787.80	0.00
35	1950	1950	4796.84	4795.84	0.00
35	2591	2591	4797.90	4797.90	0.00
36	1950	1950	4808.43	4808.43	0.00
36	2591	2591	4809.01	4809.01	0.00
37	1950	1950	4820.56	4820.56	0.00
37	2887	2887	4821.00	4821.00	0.00
38	1950	1950	4823.49	4823.49	0.00
38	3000	3000	4824.89	4824.89	0.00



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ENGINEER: MEF	SCALE: 1"=100'	
CHECKED:	APPROVED:	
DATE: 06-06-97	DATE:	

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Alpha Engineering Group

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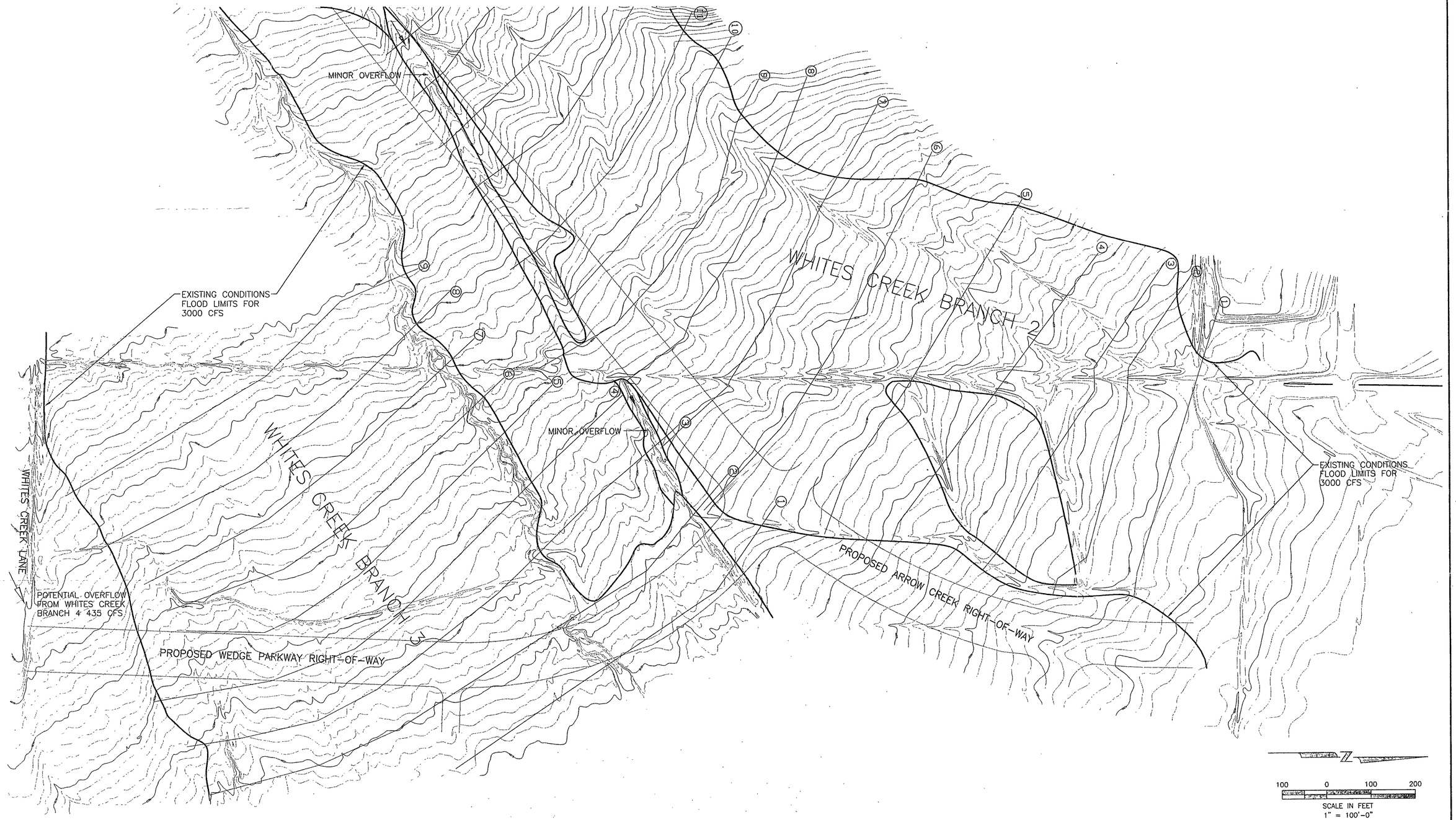
Reno, Nevada 89502
(702) 329-6123

SPECIAL ASSESSMENT DISTRICT #23
CFA
1150 CORPORATE BLVD.
RENO, NV 89502

FIGURE 4
FLOOD PLAIN MAP
WHITES CREEK BRANCHES 2 & 3

DRAWING:	
SHEET:	OF
REVISION NUMBER:	



NO.	DATE	REVISIONS	BY	CHK

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CHECKED:	APPROVED:		
DATE: 06-06-07	DATE:		

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Infrastructure, Inc.
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961 Matley Lane Ste. 110
Reno, Nevada 89502
(702) 329-6123

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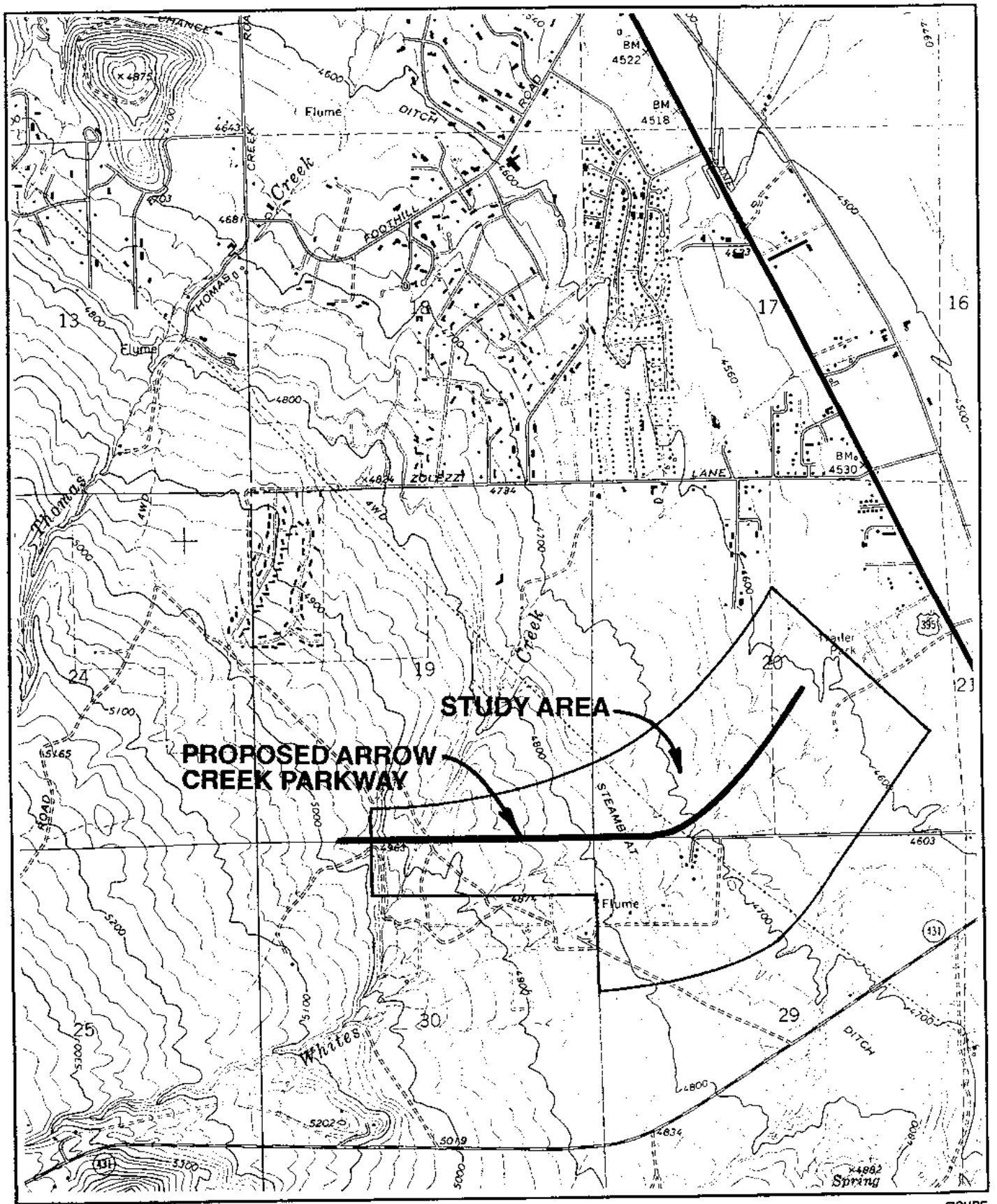
RENO, NV 89502

FIGURE 5
FLOOD PLAIN MAP
WHITES CREEK BRANCHES 2 & 3

DRAWING:	
SHEET:	OF
REVISION NUMBER:	
DATE:	

APPENDIX A

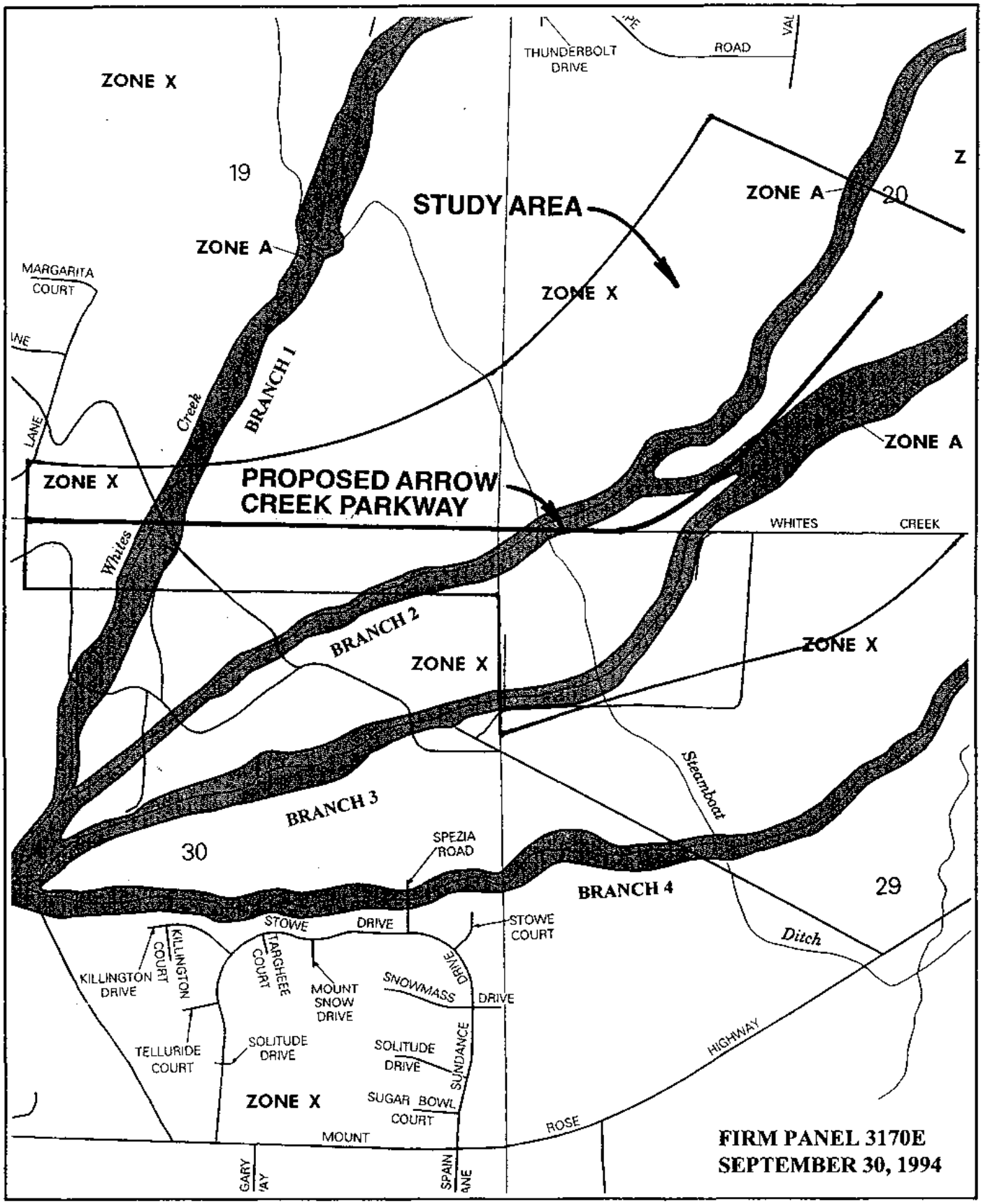


HARDING LAWSON ASSOCIATES
Engineering and Environmental Services

LOCATION MAP
SPECIAL ASSESSMENT DISTRICT #23
WASHOE COUNTY, NEVADA

FIGURE 1

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
KRP	37957		6-3-97		



HARDING LAWSON ASSOCIATES
Engineering and Environmental Services

FEMA FLOOD INSURANCE RATE MAP
SPECIAL ASSESSMENT DISTRICT #23
WASHOE COUNTY, NEVADA

FIGURE 2

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
KRP	37957		6-3-97		

PRELIMINARY WHITES CREEK BASIN MANAGEMENT STUDY

(FINAL REPORT)

Prepared For:

WASHOE COUNTY

DEPARTMENT OF PUBLIC WORKS

By:

CELLA BARR ASSOCIATES
777 Campus Commons Road, Suite 200
Sacramento, California 95825

August 17, 1994

CBA File No. 530013-01

Updated meteorological analyses are currently being performed as a part of the Washoe County Flood Control Master Plan. Upon completion of the updated meteorological analyses and their acceptance by Washoe County, it may be advantageous to revisit the adopted 5100 cfs value to determine if a revision is warranted.

B. **Distribution of the 100-Year Discharge for Whites Creek Downstream of Shadowridge Park** - Whites Creek at Shadowridge Park represents the location where flows are initially distributed across the lower Whites Creek watershed area under investigation. Flow is distributed into one or more of essentially four (4) channels that traverse the lower Whites Creek watershed, ultimately delivering proportionate runoff to the Steamboat Creek area east of U.S. 395. The flow distribution in the Shadowridge Park vicinity is impacted by the following:

1. The magnitude of the discharge collected at said location.

2. The extent to which existing vegetation within the channel becomes denuded by flood flows.

3. The existence of debris flow during a characteristic flood event.

4. The topographic definition of flow paths that exists immediately downstream prior to and during a given flood event.

During a 100-year flood event, it is CBA's opinion that, under existing conditions, it is not possible to accurately predict the distribution of the total discharge that will be allocated to each of the channels forming downstream of the Shadowridge Park area. Perhaps the most significant variable that limits the predictability of the distribution is the potential occurrence of debris flow within Whites Creek. Evidence of prior debris flows is readily identifiable in the field and is characterized by numerous residual large boulders that have been transported from the defined channel upstream of Shadowridge Park to various locations along channels and other areas downstream within the lower Whites Creek watershed. The occurrence of a debris flow will result in a slug of concentrated boulders, sediment and vegetation moving down the defined channel to be distributed at varying locations downstream of the defined channel as flow depth and velocities are diminished through expansion of the flow width.

The potential for debris flow can significantly impact the initial flow distribution originating at Shadowridge Park by effectively diverting flows in a random manner from one downstream channel to another and blocking some of the available flow areas during a given flooding event. For this reason, it is most appropriate to examine the flow distribution in terms of preferential values of proportional discharges to be applied to each downstream channel, from a future planning perspective for new development and infrastructure improvements. The flow distribution presented in the Whites Creek Detention Feasibility Study for NDOT would appear to be reasonable in this regard, as proportional discharges

are somewhat equitably allocated to each of the four (4) downstream flow paths and as these distributions have been applied to the design of downstream drainage structures at I-580.

The distribution recommended for adoption by CBA for each of the four primary channels is represented below:

Channel	Allocated Discharge
#1	700 cfs
#2	1950 cfs
#3	1100 cfs
#4	1350 cfs
Total	5100 cfs

These values may be applied to each channel as a future design capacity goal, but are not representative of actual existing conditions due to the dynamic unpredictability of the flow distribution and potential for debris flow. For floodplain management purposes, a probabilistic approach must also be applied to facilitate the selection of a 100-year discharge rate that may enter each of the four (4) channels downstream of Shadowridge Park under existing conditions.

Based on an assessment of probability, CBA has concluded that a flow of approximately 3000 cfs has a one percent (1%) chance of being delivered to any of the four (4) available flow paths in any given year (i.e., a 100-year event). This conclusion was derived as follows:

- 5100 cfs has a 1 in 100 chance of occurring at Shadowridge Park (100-year event).
- Conservatively, there is a 1 in 4 chance of the entire flow at Shadowridge Park being delivered to any of the four (4) downstream flow paths.
- 3000 cfs has a 1 in 25 chance of occurring at Shadowridge Park (25-year event).
- The product of the probabilities of the 1 in 4 chance (flow paths) and the 1 in 25 chance (25-year discharge at Shadowridge Park) is a 1 in 100 chance for 3000 cfs to be delivered to any of the four (4) flow paths, or a 100-year event.

CBA derived the 3000 cfs value for the 25-year discharge at Shadowridge Park by applying 25-year precipitation values represented on available NOAA atlases

to the HEC-1 model presented in the Whites Creek Detention Feasibility Study for NDOT. Since the standard for floodplain management in Washoe County and per FEMA is the 100-year event, floodplain conditions along each of the four (4) flow paths downstream of Shadowridge Park need to be established under the assumption that 3000 cfs is initially delivered to them. Until such time as structural measures are implemented that will serve to establish the flow distribution desired for 5100 cfs at Shadowridge Park, a flow of 3000 cfs being delivered to each flow path must be considered in the design of development projects within the lower Whites Creek watershed.

C. **Existing Problem Areas** - As a part of the field investigations performed by CBA staff and the review of available information, several problem areas or potential problem areas were identified within the lower Whites Creek watershed in terms of flooding potential associated with development projects and existing infrastructure improvements. The following listing represents a preliminary identification of potential problem locations that may merit further investigation as a part of future studies. It must be noted that CBA's conclusions are not substantiated by detailed calculations, but have been based upon engineering judgement; hence, the following listing may not be complete and/or some of the listed locations may be determined to not have problems from a flood hazard or capacity perspective upon closer, more detailed examination.

1. **Existing Culverts Along U.S. 395** - All of the existing drainage structures that drain Whites Creek flows are substantially inadequate to convey distributed discharges underneath the roadway during a 100-year flood event. The existing highway will cause upstream ponding of stormwater runoff and, when ponded flood waters reach sufficient levels, sheet flooding across the highway will occur.

2. **Old Virginia Street Culverts** - Inadequate drainage structures exist across Old Virginia Street, and similar conditions will prevail as described for U.S. 395.

3. **Zolezzi Lane Drainage Structures** - The drainage structure crossing of Zolezzi Lane that serves Channel #1 is of substantially insufficient capacity to pass the proportioned 100-year discharge. The existing roadway will divert some of the flow east along the south side of Zolezzi Lane and some of the flow will spill northerly across the roadway. At the intersection of Zolezzi Lane and U.S. 395, there is virtually no provision for accommodating runoff originating from Channel #2 (with some spillover flow from Channel #3), and flooding of this intersection will occur during a 100-year event.

4. **Existing Residential Structures Immediately Downstream of the Defined Channel at Shadowridge Park** - Several existing residential structures at this location are subject to a high flood and debris flow hazard during a 100-year flood event.

5. **Whites Creek Estates** - Some of the existing residential structures adjacent to Channel #1 have a potential for flooding during a 100-year event as induced by spillover from the channel at subdivision street crossings or by limitations in channel capacity.

6. **Lancers Estate** - Some of the residential lots backing up adjacent to the south of Channel #4 have a potential for flooding during a 100-year event.

7. **Existing Residential Structures South of Whites Creek Lane, West of the Proposed Pine Tree Ranch Subdivision** - Several of these structures have a potential for flooding from Channels #2 and #3 during a 100-year flooding event.

8. **Wedge Parkway** - Wedge Parkway is elevated from one to several feet above existing grade and crosses the lower Whites Creek watershed somewhat transversely to the direction of drainage flow. The newly constructed segment of Wedge Parkway between the Mt. Rose Highway and Whites Creek Lane will have a tendency to impound runoff in excess of the proportioned discharge of 1350 cfs for Channel #4 on the upstream side of the roadway and divert flow northeasterly along the west side of the roadway toward Whites Creek Lane. The existing drainage structure under construction across Channel #4 appears to have adequate capacity for the proportioned discharge for this flow path, provided the flow is delivered to the drainage structure itself. Currently, it is proposed that the proportioned flow within Channel #4 be channelized and delivered to the drainage structure as a part of the future development of Sterling Ranch.

It should be reiterated that the above observations and conclusions of system capacity problems are based upon preliminary investigations, only, and will require further substantiation as additional more detailed studies are performed.

III. QUALITATIVE EVALUATIONS OF FLOODING CONDITIONS

To date, floodplain administration within the lower Whites Creek watershed has been based primarily upon floodplain information presented on the FEMA Flood Insurance Rate Maps for Washoe County, Panel Numbers 1501 (Effective date: August 1, 1984) and 1463 (Effective date: April 16, 1990). The floodprone areas depicted for the lower Whites Creek watershed are represented as "Zone A" which indicates that they were originally studied using approximate methods only. Based upon CBA's experience as a Flood Insurance Study Contractor with FEMA, the degree of detail that would have been inherent to these approximate Zone A designations was undoubtedly minimal and, per FEMA guidelines, would have been limited to a cursory review of USGS quad sheets, aerial photographs, and primary low flow paths. It is CBA's professional opinion that the extent of the floodplains represented on these FEMA Flood Insurance Rate Maps for the lower Whites Creek watershed is significantly understated.

In order to accurately delineate the extent and characteristics of flood hazard areas within the lower Whites Creek watershed, a detailed hydrologic and hydraulic analysis will be needed, which is outside the scope of the current study. Such an analysis will need to include the following:

1. Refinement of the total 100-year discharge value of 5100 cfs for Whites Creek at Shadowridge Park, if appropriate.

2. Acquisition of current topographic mapping of the lower Whites Creek watershed with a minimum contour interval of two feet (2').

3. Hydraulic evaluations of flow characteristics across the lower Whites Creek watershed utilizing a combination of HEC-2 evaluations, normal depth calculations, weir flow calculations and culvert capacity calculations.

The detailed floodplain analysis should be performed at the earliest possible date in order to supplement the information contained in the current study; to more accurately define floodplain limits and characteristics; and to provide better information to be utilized in the design of new development and infrastructure projects. The analysis should consider both of the following assumptions pertinent to the flow distribution originating at Shadowridge Park:

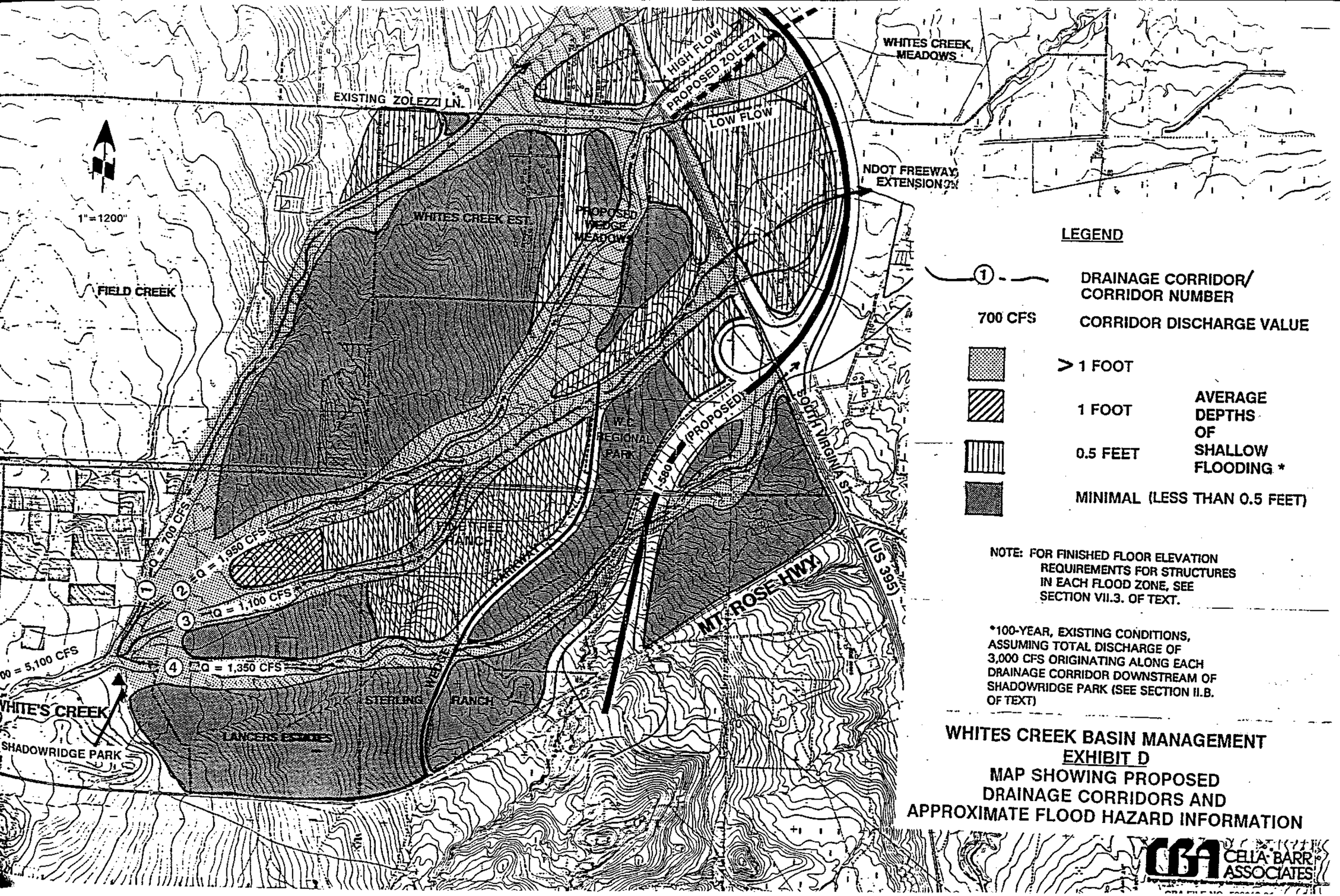
- The existing conditions which create a potential for the total discharge of 3000 cfs (or a revised number, if applicable) being delivered to any of the four (4) downstream channels (see Section II.B.).

- Future conditions that would prevail if the flow distribution becomes fixed at Shadowridge Park through the implementation of structural measures or if the overall flow in Whites Creek is attenuated through implementation of other upstream structural measures.

As a part of this study, CBA performed a very preliminary analysis to estimate the extent and magnitude of flooding that currently has a potential of occurring within the lower Whites Creek watershed during a 100-year storm event. This analysis utilized USGS quad sheets, current aerial photographs, field investigations, the 1966 topographic mapping acquired from NDOT and rough normal-depth calculations performed across hypothetical flat cross sections of varying widths and slopes. Based on evaluations of the above, it is CBA's opinion that, under existing conditions, much of the lower Whites Creek watershed would be subject to "shallow sheet flooding" during a 100-year event. Approximate flood zones and average 100-year flooding depths have been delineated and are represented on Exhibit D. The flood zone designations that have been utilized in the approximate floodprone area mapping represented on Exhibit D are:

- Minimal Flooding Potential, Average Depth Less Than 0.5 feet
- Sheet flow, Average Depth = 0.5 feet
- Sheet flow, Average Depth = 1 foot
- Sheet flow, Average Depth Greater Than 1 foot

The approximate floodprone areas have attempted to account for the impacts of the construction of Wedge Parkway and I-580. In determining the shallow flooding zones, CBA assumed that a discharge of 3000 cfs may be directed to any of the four (4) primary channels originating downstream of Shadowridge Park. At such time as structural measures are implemented to attenuate the total flow or define the flow distribution for the downstream flow paths originating near Shadowridge Park, the extent and severity of flooding for the downstream areas within the lower watershed will be appreciably reduced.



LEGEND

①	DRAINAGE CORRIDOR/ CORRIDOR NUMBER
700 CFS	CORRIDOR DISCHARGE VALUE
	> 1 FOOT
	1 FOOT
	0.5 FEET
	MINIMAL (LESS THAN 0.5 FEET)

AVERAGE DEPTHS OF SHALLOW FLOODING *

NOTE: FOR FINISHED FLOOR ELEVATION REQUIREMENTS FOR STRUCTURES IN EACH FLOOD ZONE, SEE SECTION VII.3. OF TEXT.

*100-YEAR, EXISTING CONDITIONS, ASSUMING TOTAL DISCHARGE OF 3,000 CFS ORIGINATING ALONG EACH DRAINAGE CORRIDOR DOWNSTREAM OF SHADOWRIDGE PARK (SEE SECTION II.B. OF TEXT)

WHITES CREEK BASIN MANAGEMENT

EXHIBIT D

MAP SHOWING PROPOSED DRAINAGE CORRIDORS AND APPROXIMATE FLOOD HAZARD INFORMATION

CBA CELIA BARR ASSOCIATES

APPENDIX B

ARROWCREEK PARKWAY

TOP OF RET. WALL ELEVATIONS			
STATION (2 PNT)	TE ELEV	TOW ELEV	
59+75	4667.25	4663.30	
60+00	4665.25	4661.30	
60+25	4663.25	4659.30	
60+50	4661.25	4657.30	
60+75	4639.25	4655.30	
61+00	4657.25	4653.30	
61+25	4655.25	4651.30	
61+50	4653.25	4649.30	
61+75	4651.25	4639.30	

DOUBLE 8X10 CULVERT HEADWALL TOP/BOTTOM ELEVATION:				
NO.	TE ● HIGH END	BW ● HIGH END	TE ● LOW END	BW ● LOW END
1	4660.10	4667.80	4671.80	4666.00
2	4660.10	4667.80	4671.00	4670.00
3	4661.90	4670.20	4673.70	4672.80
4	4661.90	4670.20	4674.70	4674.00

SHEET INDEX

VERTICAL: 1"=10'

HORIZONTAL: 1"=40'

*NOTE:
THE FLOW VALUE SHOWN IS A PORTION OF THE 3000 cfs DESIGN FLOW PER WASHOE COUNTY POLICY.

BENCH MARK:
THE MONUMENT IS A NDOWA HIGHWAY SURVEY DISC, SET IN A CONCRETE POST WHICH PROJECTS 3 INCHES ABOVE THE GROUND AT STATION WA-028-1-110. ELEVATION = 4646.67

cfa PLANNERS
1150 CORPORATE BLVD. RENO, NV 89502 (702) 688-1160

ARROWCREEK SAD # 23
PLAN & PROFILE
ARROWCREEK PARKWAY
TAHOE AREA
WASHOE COUNTY

JOB NO. 98-003.27
DATE 6/30/00

SHEET 10 OF 29

ARROWCREEK PARKWAY

CAUTION — NOTICE TO CONTRACTOR

CONSTRUCTION NOTES:

1. CONSTRUCT 36L, 48W RCP VERT VANE A HDWL WALL CONFIGURATION AS SHOWN ON THIS SHEET AND AS SHOWN ON SHEET 9A. CONCRETE EAVE AT INLET.
2. S4 SLOPE SHALL RECEIVE 6"-48" RIPRAP.
3. VERTICAL DEFLECTION OF SEWER LINE SHALL NOT EXCEED 5 DEGREES PER JOINT.
4. CONSTRUCT 6' BLACK VINYL COATED CHAIN LINK FENCE ALONG R.O.W. SEE DETAIL, SHT. 20A.
5. REFER TO CONSTRUCTION NOTE 5, SHEET 10.
6. REFER TO CONSTRUCTION NOTE 6, SHEET 10.
7. REFER TO CONSTRUCTION NOTE 10, SHEET 10.
8. PLACE 12"-48" RIPRAP 2' 0" FROM R/W TO VANE WALLS 3, SCHEDULE, SHOWN RIPRAP ACROSS END OF VANE WALLS.
9. NO FENCING SHALL BE CONSTRUCTED IN DRAINAGE. STOP AND START FENCING AT VANEWALL LOCATIONS. PLACE ADDITIONAL FENCING AS REQUIRED TO CONNECT FENCING TO VANEWALLS.
10. CONSTRUCT PREFINISHED SCREW HOLE PER DETAIL ON SHEET 20A, USE 6'-0"H RIP RAP WITH D_{50}=12"

CURVE TABLE "C"			
NO.	DELTA	RADIUS	LENGTH / TANGENT
1	04°12'05"	2000.00'	146.85' / 73.43'
2	02°26'17"	2000.00'	71.14' / 35.58'

EFFLUENT LINE CURVE TABLE "C"			
NO.	DELTA	RADIUS	LENGTH / TANGENT
1	04°12'05"	2000.00'	146.85' / 73.36'

DOUBLE 8x10 CULVERT HEADWALL WINGWALL ELEVATIONS				
NO.	W1 @ MIN END	W2 @ HIGH END	W3 @ LOW END	W4 @ LOW END
1	4677.80	4688.70	4672.00	4671.00
2	4677.60	4688.70	4671.80	4671.00
3	4676.00	4686.40	4668.30	4667.30
4	4676.40	4686.40	4668.60	4668.60
5	4676.60	4688.60	4671.60	4671.00
6	4676.60	4688.60	4671.20	4670.60
7	4673.30	4686.00	4668.10	4667.00
8	4673.20	4686.00	4668.60	4667.00

SHEET INDEX

VERTICAL: 1"=4'

HORIZONTAL: 1"=40'

NOTE:
THE FLOW SHOWN IS A PORTION OF THE 3000 cfs DESIGN FLOW PER WASHOE COUNTY POLICY.

BENCH MARK:
THE BENCHMARK IS A NEVADA HIGHWAY SURVEY DISC, SET IN A CONCRETE POST WHICH PROJECTS 3 INCHES ABOVE THE GROUND AT STATION WA-028-1-116.
ELEVATION = 4666.67

cfa — 1150 CORPORATE BLVD, RENO, NV 89502 — (702) 688-1180

ARROWCREEK RAD # 23
PLAN & PROFILE
ARROWCREEK PARKWAY
WASHOE COUNTY

JOB NO. 98-003.27
DATE 5/20/97

SHEET 11 OF 29

CURVE TABLE C				
NO.	DELTA	RADIUS	LENGTH	TANGENT
1	04°34'16"	500.00'	39.89'	19.96'
2	09°28'49"	200.00'	12.00'	6.00'
3	01°10'31"	1961.50'	40.65'	20.33'
4	180°00'00"	7.50'	23.56'	INFINITE
5	03°13'21"	2000.00'	112.41'	56.22'
6	03°13'13"	2000.00'	112.41'	56.22'
7	11°09'07"	1360.50'	998.71'	521.39'
8&9	41°09'05"	1428.00'	1025.84'	539.09'
9	41°09'05"	1392.50'	1000.13'	522.74'

SHEET INDEX

ARROWCREEK PARKWAY

VERTICAL: 1"=4'

HORIZONTAL: 1"=40'

CAUTION -- NOTICE TO CONTRACTOR

BENCH MARK:

ARROWCREEK SAD # 23
PLAN & PROFILE
ARROWCREEK PARKWAY
TRAVIS COUNTY

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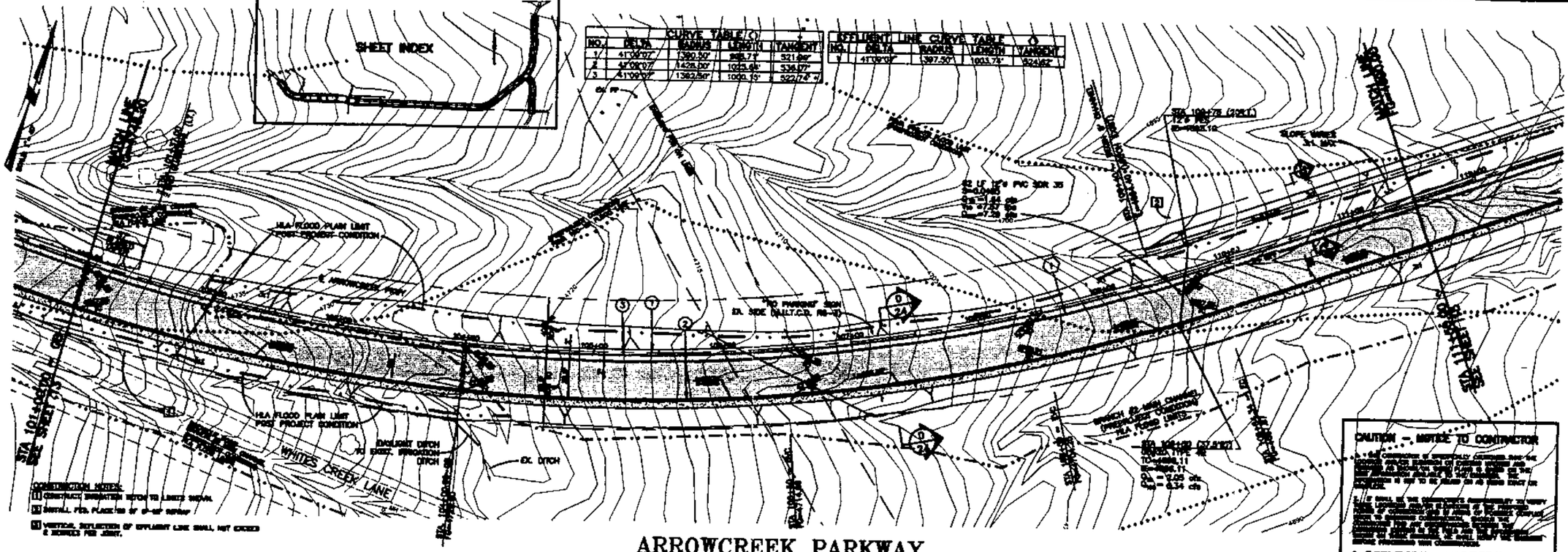
SHEET 13 OF 29

SHEET INDEX

CURVE TABLE				
NO.	DELTA	RADIUS	LENGTH	TANGENT
1	41°09'07"	1390.50'	998.71'	521.69'
2	41°09'07"	1428.00'	1025.68'	534.77'
3	41°09'07"	1362.50'	1000.15'	522.78'

EFFLUENT LINE CURVE TABLE				
NO.	DELTA	RADIUS	LENGTH	TANGENT
1	41°09'07"	397.50'	1003.75'	524.62'



BENCH MARK:
THE ESTABLISHMENT OF A HORIZONTAL CONTROL SURVEY MONUMENT SET IN A CONCRETE POST WHICH PROJECTS 3 INCHES ABOVE THE GROUND AT STATION 104+00+1.11Lt.
ELEVATION = 4694.67

DATE SURVEYED
DRAWN BY
CHECKED BY
DATE 4/16/97
DATE 6/6/97
DATE
APPROVED
DESCRIPTION
REVISIONS

cfa PLANNING • LANDSCAPE ARCHITECTURE
1160 CORPORATE BLVD., RENO, NV 89502 (702) 856-1160

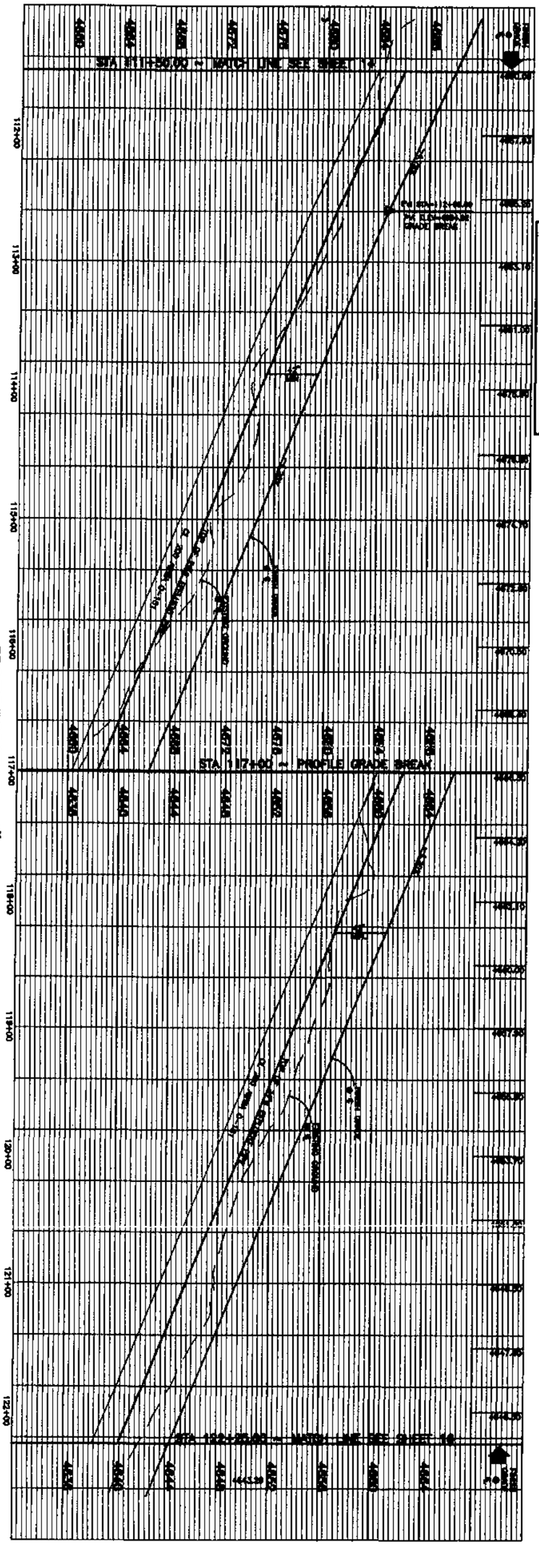
ARROWCREEK SAD # 23
PLAN & PROFILE
ARROWCREEK PARKWAY
WASHOE COUNTY, NEVADA

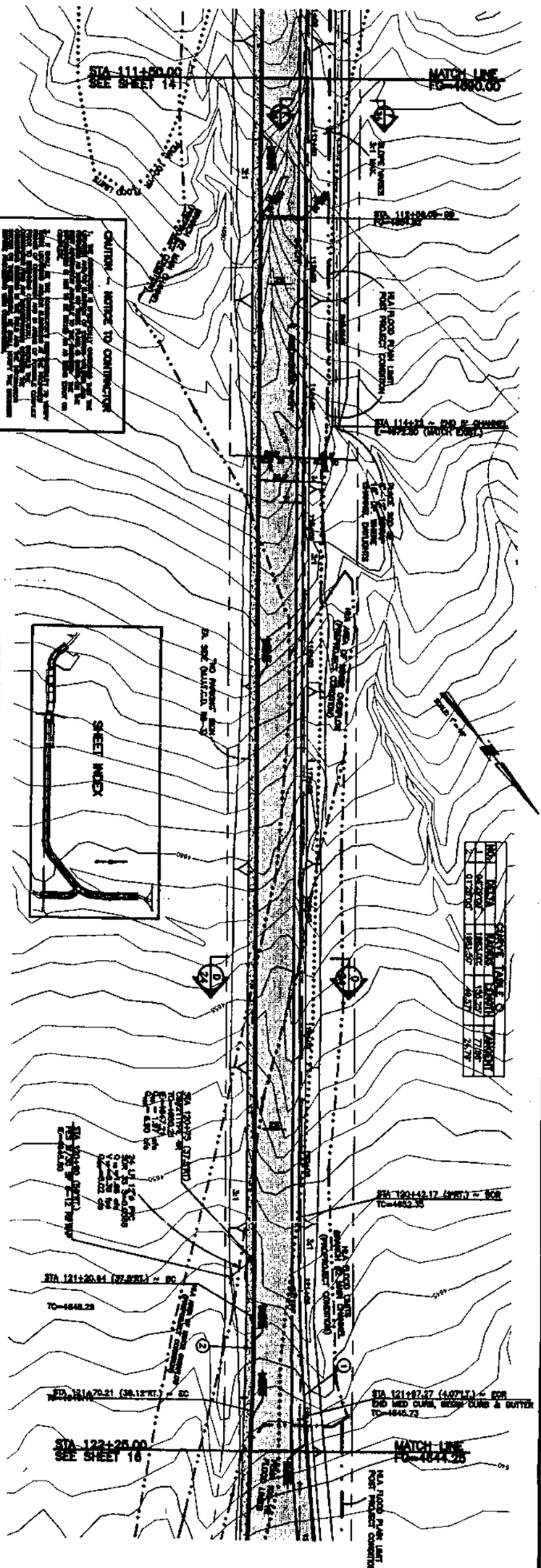
JOB NO. 96-008.07
DATE 5/29/97

SHEET 14 OF 29

VERTICAL: 1" = 4'

HORIZONTAL: 1" = 40'





ARROWCREEK SAD # 23

PLAN & PROFILE

ARROWCREEK PARKWAY

YAMHILL COUNTY OREGON

SHEET 15 OF 29

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1180 CORPORATE DRIVE, SUITE 225, HILLSBORO, OREGON 97123 (503) 627-0705 FAX (503) 627-0709

DESIGNED BY: DS — DATE SURVEYED:
DRAWN BY: MS/KC — DATE: 4/10/97
CHECKED BY: DMS — DATE:
APPROVED BY:
DATE:

DATE	MARK	REVISIONS	BY

CONSTRUCTION NOTES:

1. 2:1 SLOPES SHALL RECEIVE MINIMUM 6"-12" RIPRAP
2. VERTICAL DEFLECTION OF EFFLUENT LINE SHALL NOT EXCEED 3 DEGREES PER JOINT.
3. INSTALL (2) 3" SCHEDULE 40 GRAY CONDUITS WITH PULL BOXES & STRING.
4. REFERENCE DETAIL SHEET 23B FOR LANDSCAPE ISLAND REQUIREMENTS. ISLAND AREAS ARE TO BE REGRADED PER LANDSCAPE SEEDING NOTE #331.04 ON SHEET 1A

CAUTION – NOTICE TO CONTRACTOR

SAD #23 IMPROVEMENTS

WA CO IMPROVEMENTS

ARROWCREEK PARKWAY

WEDGE PARKWAY

CURVE TABLE C				
NO.	DELTA	RADIUS	LENGTH	TANGENT
1	04°29'05"	2018.00'	157.99'	78.94'
2	180°00'00"	13.00'	40.84'	INFINITE
3	06°56'15"	200.00'	24.22'	12.12'
4	06°56'15"	200.00'	24.22'	12.12'
5	06°56'15"	200.00'	24.22'	12.12'
6	06°56'15"	200.00'	24.22'	12.12'
7	49°07'10"	1320.00'	1131.63'	603.22'
8	04°33'14"	6338.50'	105.69'	53.02'
9	08°49'28"	6340.50'	206.48'	103.43'
10	04°33'14"	7352.50'	107.10'	53.58'
11	04°32'12"	1395.00'	110.46'	55.28'
12	180°00'00"	7.00'	21.99'	INFINITE
13	84°05'28"	60.00'	88.08'	54.13'
14	01°26'00"	2018.50'	50.50'	25.25'

SHEET INDEX

VERTICAL: 1"=4'

HORIZONTAL: 1"=40'

BENCH MARK:
THE MONUMENT IS A MISSOULA COUNTY SURVEY DISC, SET IN A CONCRETE POST WHICH PROJECTS 2 INCHES ABOVE THE GROUND AT STATION MA-0120-1-116. ELEVATION = 4346.67

ARROWCREEK SAD # 23
PLAN & PROFILE
ARROWCREEK PARKWAY
MISSOULA COUNTY
MONTANA

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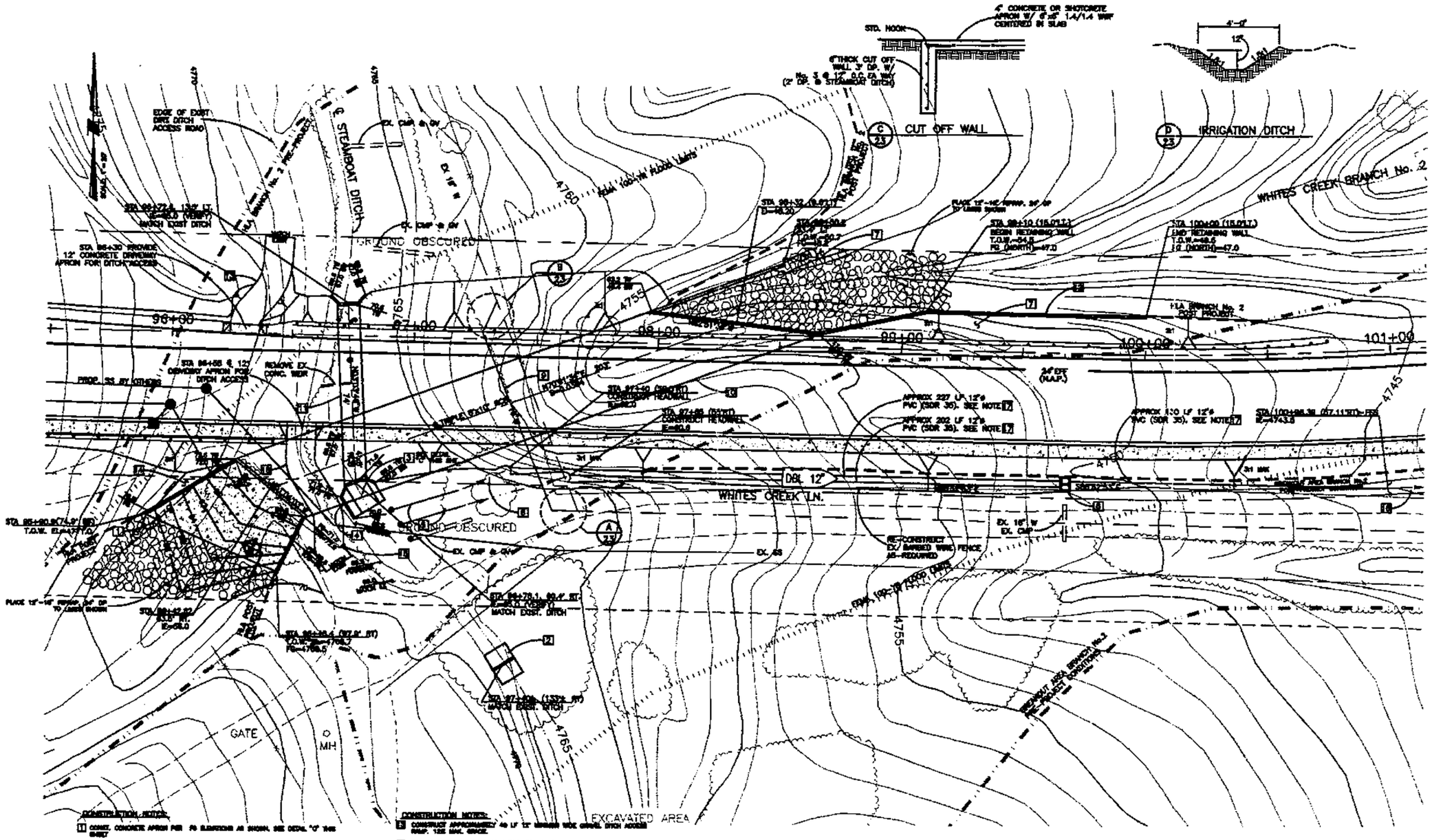
1180 CORPORATE BLVD, RENO, NV 89502 (702) 856-1150

JOB NO. 99-008.10
DATE 6/30/00

SHEET 16 OF 29

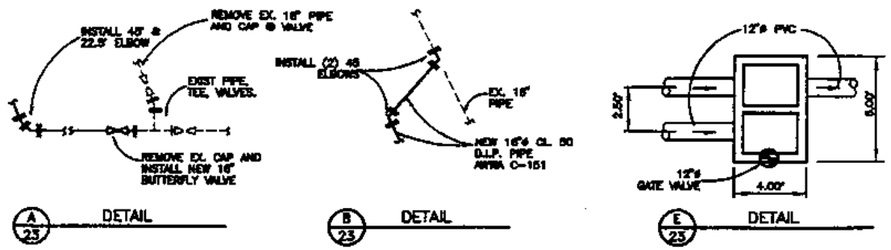


CONSTRUCTION NOTES:

1. CONST. CONCRETE APRON PER PLAN ELEVATIONS AS SHOWN, SEE DETAIL "C" THIS SHEET
2. CONSTRUCT CONCRETE RECTANGULAR WEIR CRESTED WEIR AND SLAB BELOW WITH DIRECTION DELINEATED EDGE. FLARE TO FINISH SIDE OF WEIR AND SLOPE FOR REMOVABLE 24 BOARDS. SEE MATERIAL, CONSTRUCTION, AND GEOMETRY FOR STEAMBOAT DITCH IMPROVEMENT DIRECTION.
3. EXCAVATE DITCH APPROX. 12 LF BEYOND HEADWALL, SEE STA=97+10/97+85 WEIR REINFORCING. CONSTRUCT 3' DEEP CUT OFF WALL AT END OF CONCRETE APRON, SEE DETAIL "C" THIS SHEET, SIMILAR.
4. CONSTRUCT APPROXIMATELY 15 LF 3' HIGH CONCRETE RETAINING WALL . SEE DETAIL "E" SHEET 23 FOR STRUCTURAL REQUIREMENTS.
5. INSTALL 12"ø GATE VALVE WITH APPROXIMATELY 28LF OF 12"ø CMP AT DITCH.
6. CONSTRUCT 4'x6' CONCRETE JUNCTION BOX WITH 12"ø GATE VALVE AS SHOWN IN DETAIL "A". USE 8" CONCRETE WALLS AND SLAB WITH #4 @ 12" O.C. EA WAY. BOWEL INFO WALLS. FIELD LOCATE TO ALIGN WITH EXISTING DITCH AND CROSSING UNDER TIMBER CREEK LANE
7. 2:1 SLOPES TO RESTORE 6'-12" RIPRAP
8. CONSTRUCT IRRIGATION DITCH FROM CMP TO HEADWALL, SEE DETAIL "D" THIS SHEET.
9. RELOCATE EXISTING 18"ø SLIP LINED PROPOSED BOX AS SHOWN. USE A MINIMUM 18" HORIZONTAL OFFSET FROM EXISTING LINE. USE 45° ELBOWS WITH THRUST BLOCKS AS NECESSARY TO ACHIEVE GRADE BELOW ROD. MINIMUM COVER IS 48". COORDINATE CONSTRUCTION WITH TIMBER COUNTY UTILITY DIVISION.
10. CONSTRUCT (2) 5'x10' C.I.P. OR PRE-CAST RCB WITH WING WALL AND END CONFIGURATIONS AS SHOWN. CONTRACTOR SHALL PROVIDE SHOP DRAWINGS. DESIGN LOADING OF HS20-44. ALLOWABLE SOIL BEARING PRESSURE OF 3000 PSF.
11. CONSTRUCT 4'x8' C.I.P. OR PRE-CAST RCB WITH MINIMAL CONFIGURATIONS AS SHOWN. CONTRACTOR SHALL PROVIDE SHOP DRAWINGS. DESIGN LOADING OF HS20-44. ALLOWABLE SOIL BEARING PRESSURE OF 3000 PSF.
12. CONST. CONCRETE RETAINING WALL TO LIMITS SHOWN, SEE DETAIL "E" SHEET 23.

CONSTRUCTION NOTES:

5. CONSTRUCT APPROXIMATELY 40 LF 12" MINIMUM WIDE GRAVEL DITCH ACCESS RAMP. 12% MAX. GRADE.
6. FILL ADJACENT WING WALL AS SHOWN TO ACHIEVE POSITIVE DRAINAGE AROUND WING WALL.
7. GRADE AREA TO FINISH GRADE ELEVATIONS AS SHOWN.
8. CONSTRUCT APPROXIMATELY 30 LF IRRIGATION DITCH FROM FES TO EXISTING IRRIGATION DITCH . SEE DETAIL "D" THIS SHEET. REFER TO SHEET 14 FOR ADDITIONAL INFORMATION.
9. FLATTEN ADJACENT FILL SLOPE 3:1 AS TO ACHIEVE A MINIMUM OF 1' OF COVER OVER 12" PVC IRRIGATION PIPES.
10. CONSTRUCT APPROXIMATELY 110 LF 12" MINIMUM WIDE GRAVEL DITCH ACCESS. AS SHOWN. 12% MAX GRADE.



A 23 DETAIL

B 23 DETAIL

E 23 DETAIL

DESIGNED BY: KB DATE: 4/14/97
DRAWN BY: KB DATE: 4/14/97
CHECKED BY: BW DATE:
APPROVED BY: DATE:

NO.	REVISIONS	DATE	MARK

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LANDSCAPE ARCHITECTS
1190 CORPORATE BLVD. RENO, NEVADA 89502 (702) 856-1150 FAX (702) 856-1159

ARROWCREEK SAD # 23

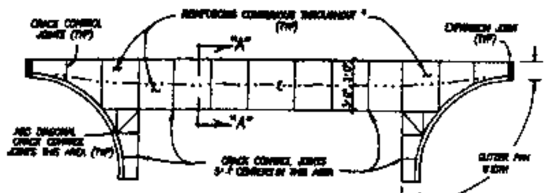
PLAN 3-8'x10' RCB

TIMBER COUNTY NEVADA

JOB NO. 96-005.07
DATE 4/8/97

SHEET 23 OF 29

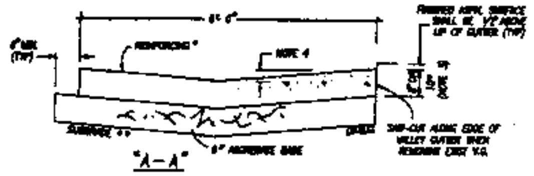
FILE NO. N:\PROJECTS\96-005.07\EXHIBITS\



NOTES:

* REINFORCING SHALL CONSIST OF COLLATED-FIBRILLATED POLYPROPYLENE FIBERS AS MANUFACTURED BY FIBERMESH OR APPROVED EQUAL. USE 1 1/2 LBS PER CU.YD. OF CONC.

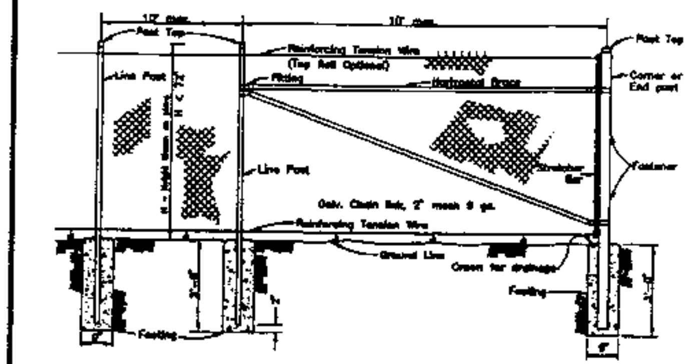
** SUBGRADE SHALL BE OVEREXCAVATED IN AREAS OF UNSTABLE OR FINE GRAINED EXPANSIVE SOILS. DEPTH OF OVEREXCAVATION SHALL BE DETERMINED BY SOILS ENGINEER OR AGENCY.

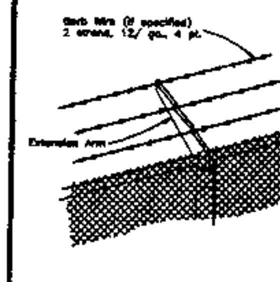


NOTES

1. AGG. BASE SHALL BE TYPE 2, CLASS B AND SHALL BE COMPACTED TO 95% OF MAX. DENSITY.
2. AN APPROVED MIX DESIGN SHALL BE SUBMITTED BEFORE PLACING CONCRETE.
3. 8" PORTLAND CEMENT CONC. TO BE USED IN RESIDENTIAL AREAS WHERE TRUCK OR BUS TRAFFIC IS LESS THAN 5% OF TOTAL TRAFFIC, 10" PORTLAND CEMENT CONC TO BE USED FOR COMMERCIAL DRIVEWAYS, ROADS OR STREETS WHERE TRUCK OR BUS TRAFFIC EXCEEDS 5% OF TOTAL TRAFFIC.
4. FLOWLINE VARIES TO MATCH GUTTER.
5. PORTLAND CEMENT CONC. SHALL HAVE A MIN. COMPRESSIVE STRENGTH OF 4000psi @ 28 DAYS W/ A MIN OF 6.35 SACKS OF CEMENT PER CU. YD. OF CONC., AIR ENTRAINMENT TO BE 4.5-7.5%. MAX. SLUMP SHALL BE 4".
6. EVAPORATION REDUCERS & CURING AGENTS SHALL CONFORM TO THE REQUIREMENTS OF SEC.[illegible]
7. ALL CONCRETE SHALL BE MECHANICALLY VIBRATED.
8. NO EQUIPMENT SHALL BE PERMITTED ADJACENT TO OR ACROSS V.G. UNTIL THE FOURTH DAY FOLLOWING PLACEMENT OF CONC OR UNTIL THE CONC HAS REACHED A MIN. COMPRESSIVE STRENGTH OF 3000psi.
9. VALLEY GUTTER NOT PERMITTED ACROSS COLLECTOR OR ARTERIAL STREETS.

P.C.C. VALLEY GUTTER





EXTENSION ARM AND BARBED WIRE

NOTES:

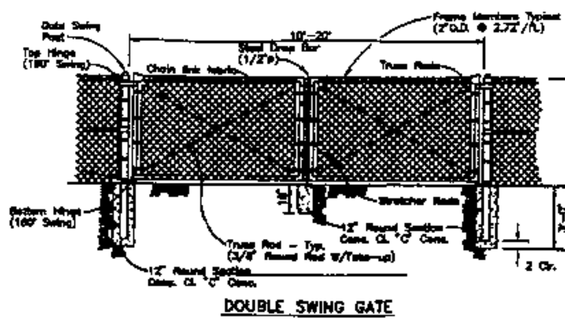
1. Fencing shall be chain link and shall consist of black vinyl coated galvanized chain link fabric on steel posts.
   (a) All post tops shall be fitted with suitable finials.
   (b) Braces shall be spaced approximately 12" below top of terminal posts and shall extend from end, gate, or corner posts to first adjacent line post.
   (c) All fittings shall be hot dipped galvanized malleable, cast iron, or pressed steel.
   (d) Top and bottom selvages of the fence shall have a twisted and barbed finish.
2. Barbed Wire, Extension Arms, and Top Horizontal Rails shall be installed only when shown on the plans and/or called for in the special provisions.

TABLE 1

For Chain Link Fence 72" and Less

Location	Min. Size	Min. Weight(#/ft.)
End, corner & pull	2.381 O.D.	3.10
Line	1.900 O.D.	2.72
Brace	1.430 O.D.	2.27
Top Rail	1.430 O.D.	2.27

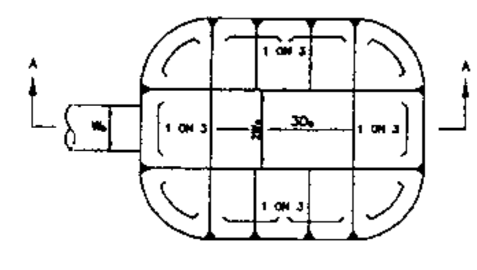
CHAIN LINK FENCE
(72" HIGH OR LESS)



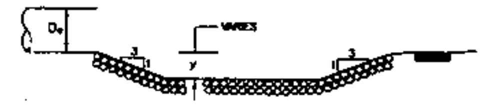
DOUBLE SWING GATE

GATE SWING POST DIA.	
Gate Size	Pipe Dia.
6' and less	3" O.D.-5.79#/ft.
6'-10'	4" O.D.-9.10#/ft.

CHAIN LINK GATES



PLAN VIEW



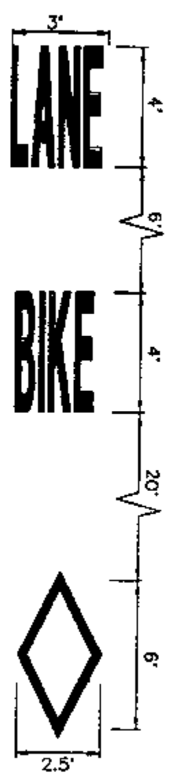
SECTION VIEW

CLASSIFICATION AND GRADATION OF LOOSE RIPRAP

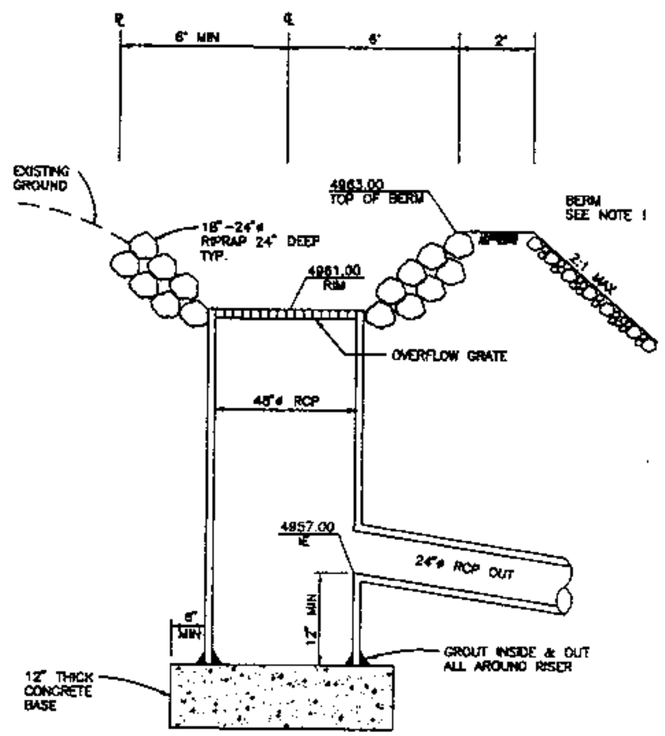
RIPRAP DESIGNATION	%SMALLER THAN GIVEN SIZE BY WEIGHT	INTERMEDIATE ROCK DIMENSION (inches)	d_{50}* (inches)
Type M	70-100 50-70 35-50 2-10	21 18 12 4	12

* d = mean particle size
** Bury types VL and L with native top soil and re-vegetate to protect from vandalism.

PREFORMED SCOUR HOLE



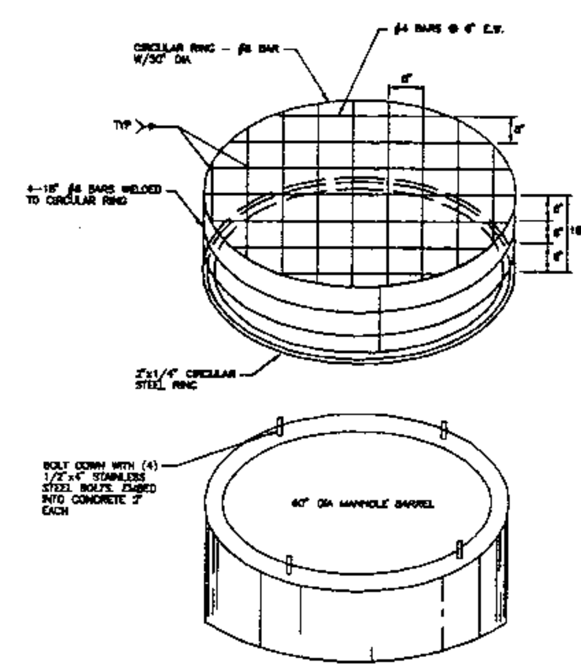
BIKE LANE DETAIL



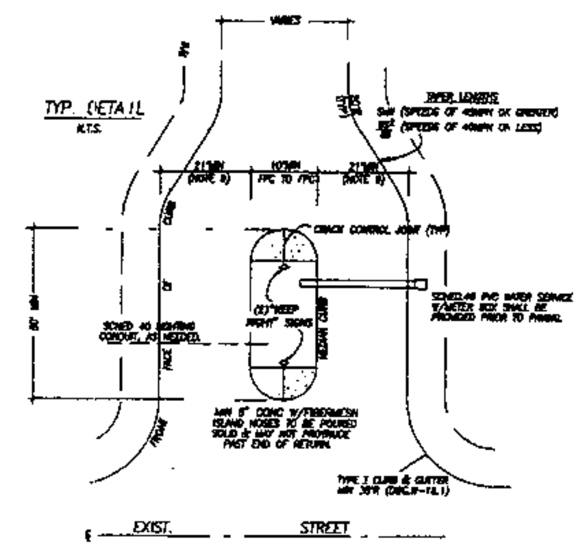
NOTE:

1. BERM TO BE PLACED IN 6" LIFTS & COMPACTED TO 95% M.D.D.
2. SEE OVERFLOW DETAIL AT RIGHT.

48"ø DROP INLET
(NOT TO SCALE)



OVERFLOW GRATE



NOTES

1. MEDIAN CURB SHALL BE WASHOE CO. TYPE 3 (DWG.#-17). REFER TO DWG #-14.1 FOR CONC REQUIREMENTS.
2. ADDITIONAL TRAFFIC CONTROL MARKINGS FOR ISLAND MAY BE REQ'D BY COUNTY ENGINEER.
3. ALL LANDSCAPING WITHIN ISLAND SHALL BE IN ACCORDANCE W/[illegible] & APPROVED BY COUNTY ENGINEER.
4. ALL LANDSCAPING SHALL BE MAINTAINED BY HOMEOWNERS OR HOMEOWNERS ASSOC.
5. NO DRIVEWAY SHALL BE ALLOWED WITHIN 100' OF ANY PORTION OF AN ISLAND.
6. AN ENCROACHMENT PERMIT FOR THE ISLAND SHALL BE OBTAINED FROM THE CO. ENGINEERS OFFICE.
7. ALL ROADWAY STRIPING FOR ISLAND SHALL BE PERFORMED BY DEVELOPER OR BUILDER.
8. COLORED CONC MAY BE USED IF APPROVED BY CO. ENGINEER. MIN CEMENT CONTENT SHALL BE [illegible]
9. ADDITIONAL WIDTH (FRONT FACE TO FRONT FACE) MAY BE REQ'D BY COUNTY ENGINEER.

LANDSCAPE DETAIL

REVISIONS			
MARK	DATE		BY

DESIGNED BY BL | DATE SURVEYED
DRAWN BY LC | DATE 6/27/96
CHECKED BY SS | DATE
APPROVED BY | R. E. NO.

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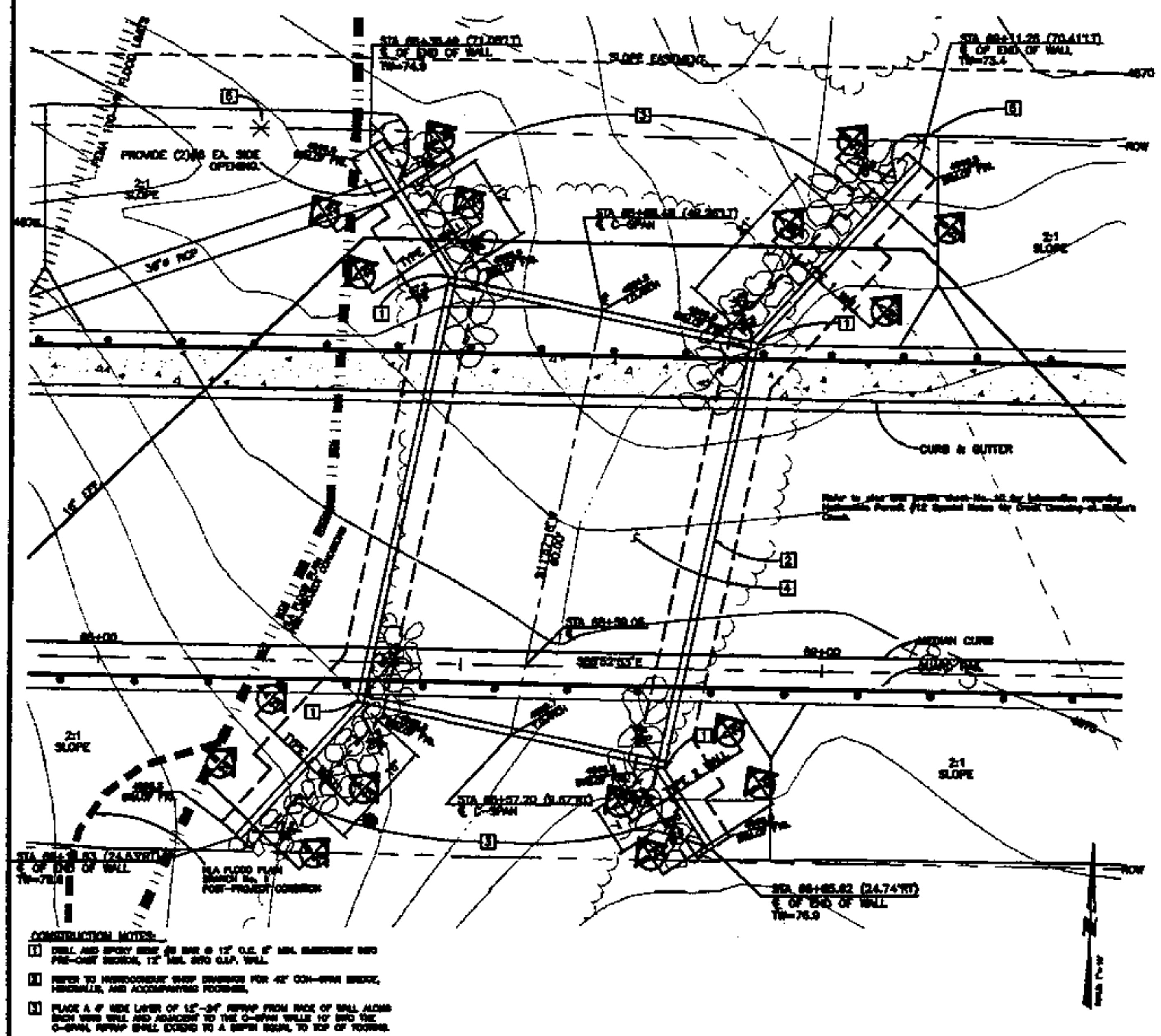
ARROWCREEK SAD#23
DETAIL SHEET
WASHOE COUNTY NEVADA

FILE NO. X:\PROJECTS\88-003.00\SAD23\DETAIL.DWG

JOB. NO. 88-003.27
DATE 6/29/97
SHEET 25B OF 29

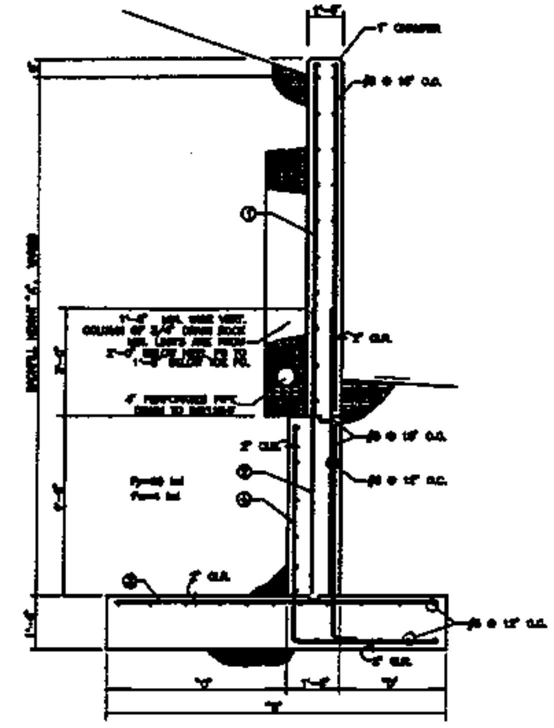


CONSTRUCTION NOTES:

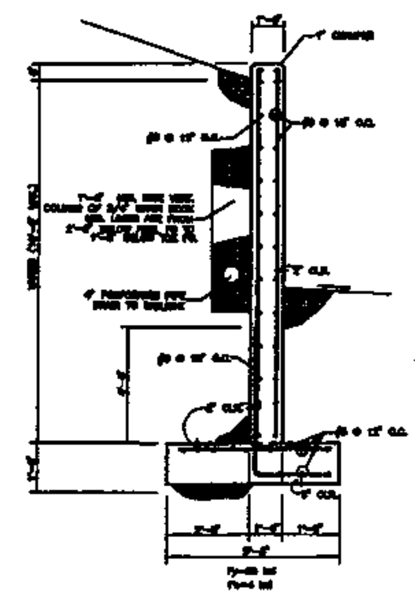
[illegible]

PLAN 42' CON-SPAN BRIDGE
WHITES CREEK BRANCH No. 1

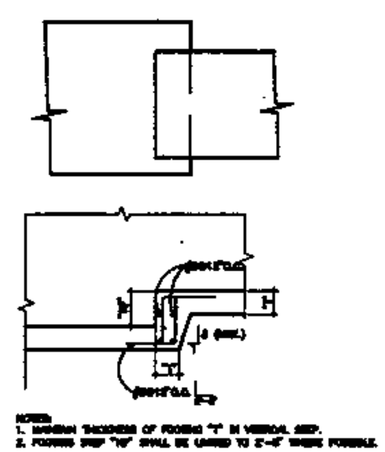
WALL TYPE	A	B	C	D	①	②	③	④
1	13' TO 19'	10'-0"	6'-6"	2'-6"	6,12	7,12	7,12	9,12
2	11'-0" TO 13'-0"	6'-6"	4'-6"	2'-6"	6,12	6,12	6,12	7,12



A — WING WALL



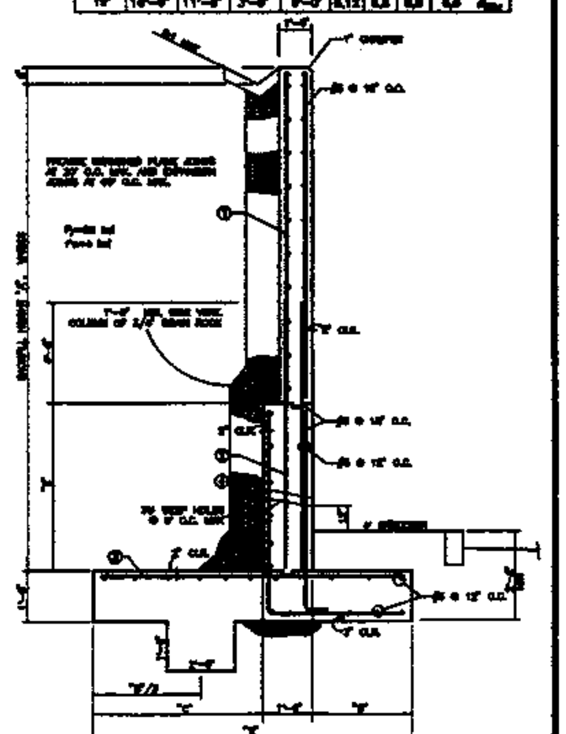
B — WING WALL



NOTES:
1. [illegible]
2. [illegible]

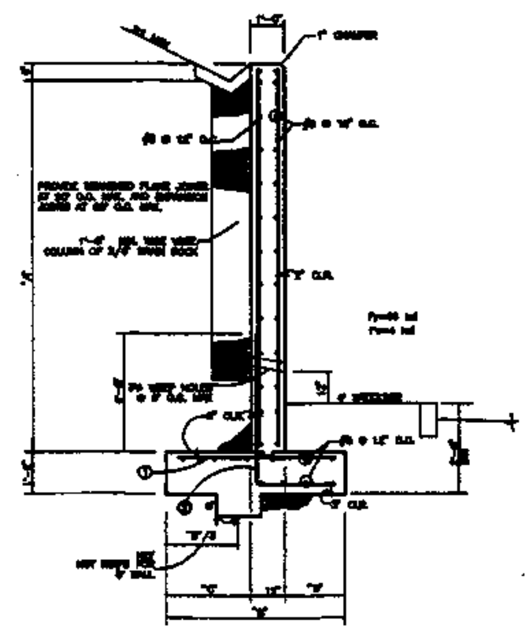
C — STEPPED FOOTING

A	B	C	D	E	①	②	③	④
13'	6'-3"	4'-6"	2'-0"	4'-0"	6,12	6,12	6,12	7,12
15'	10'-6"	8'-6"	3'-6"	4'-0"	6,12	6,12	7,12	8,12
17'	13'-3"	9'-0"	3'-6"	9'-0"	6,12	6,10	6,10	8,8
19'	16'-6"	11'-6"	3'-6"	9'-0"	6,12	8,8	8,8	8,8



D — RETAINING WALL

A	B	C	D	①	②
6'-0"	2'-3"	1'-6"	0'-6"	6,12	6,12
7'-0"	4'-0"	2'-0"	1'-0"	6,12	6,12
9'-0"	4'-3"	2'-6"	1'-6"	6,12	6,12
11'-0"	7'-0"	3'-6"	2'-6"	5,10	6,10



E — RETAINING WALL

DESIGNED BY | DRAWN BY | CHECKED BY | APPROVED BY | DATE SURVEYED 4/10/97

cfa
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ARROWCREEK SAD # 23

PLAN / DETAILS

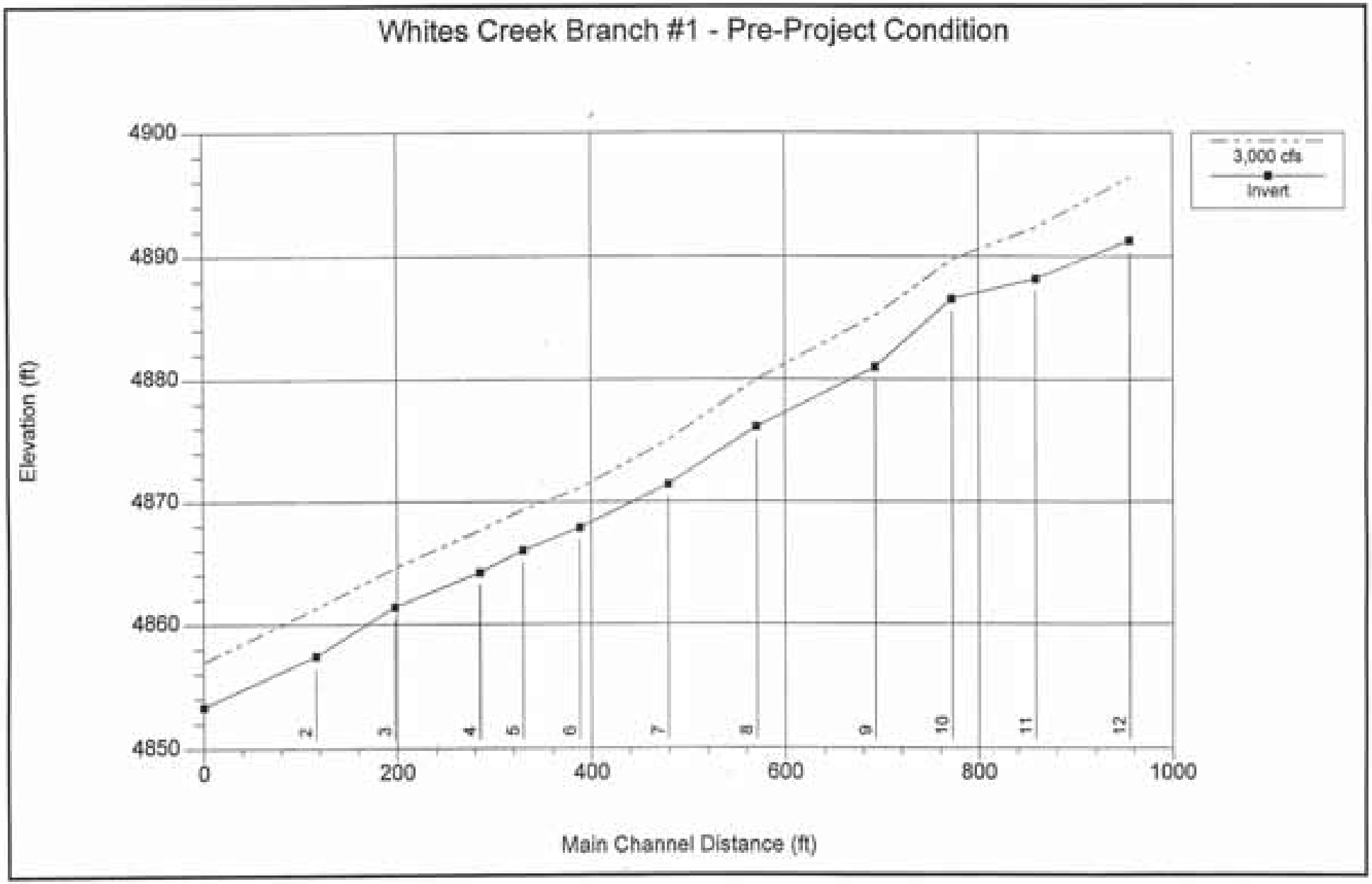
WASHOE COUNTY NEVADA

JOB NO. 68-403.27
DATE 6/6/97

SHEET 26 OF 29

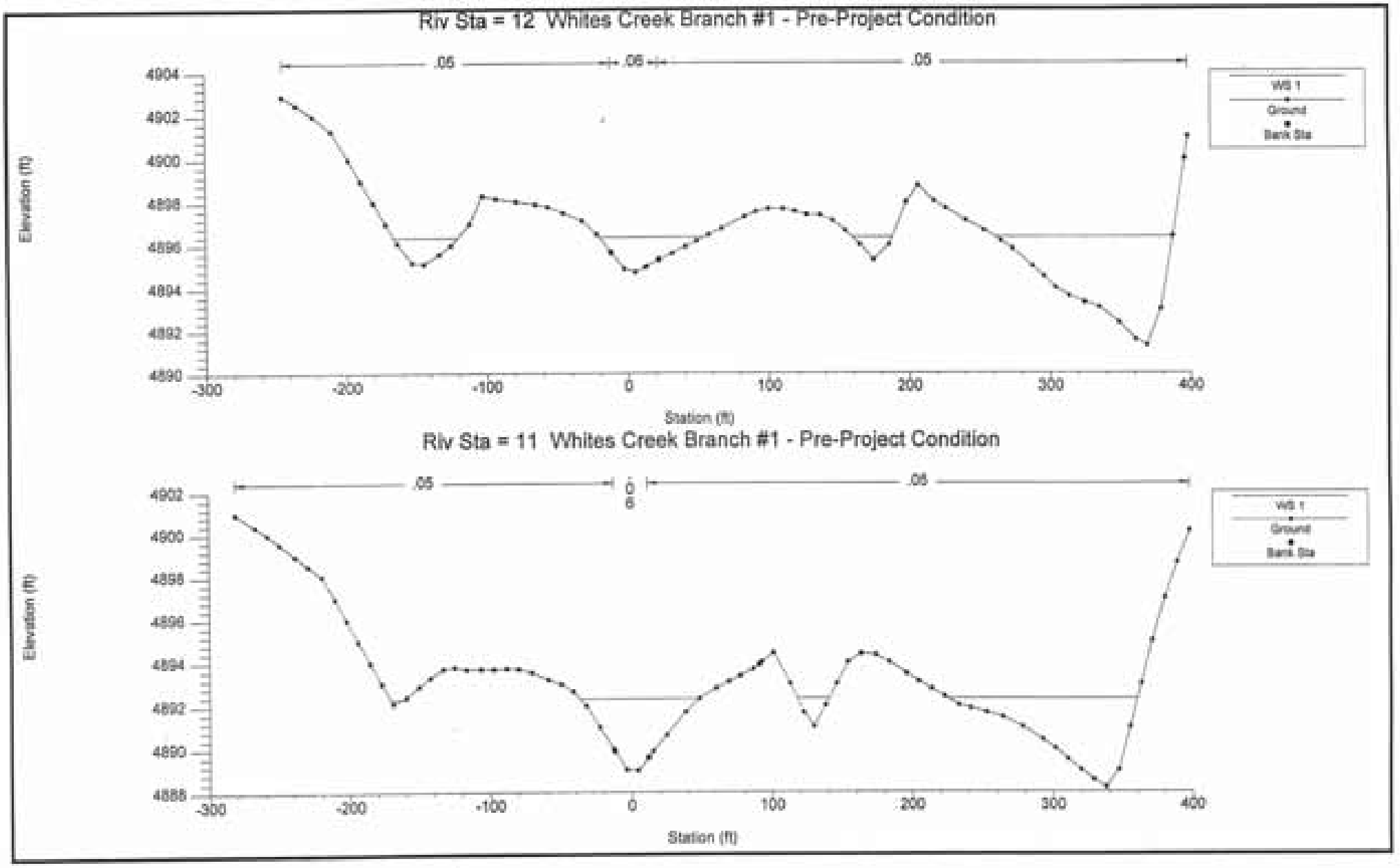
Appendix C

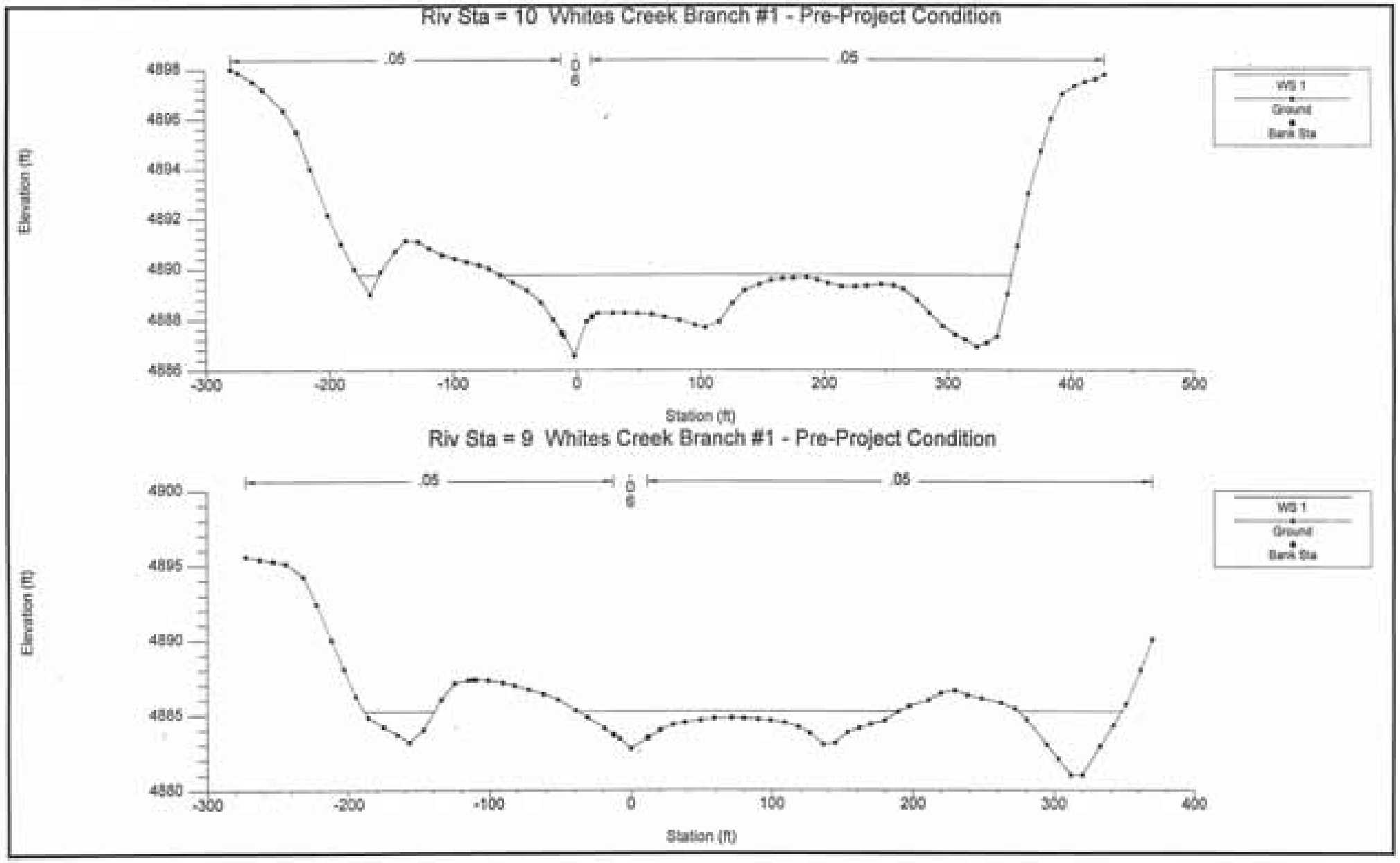
Sub-Section 1
Whites Creek Branch 1
Pre-Project Condition Analysis

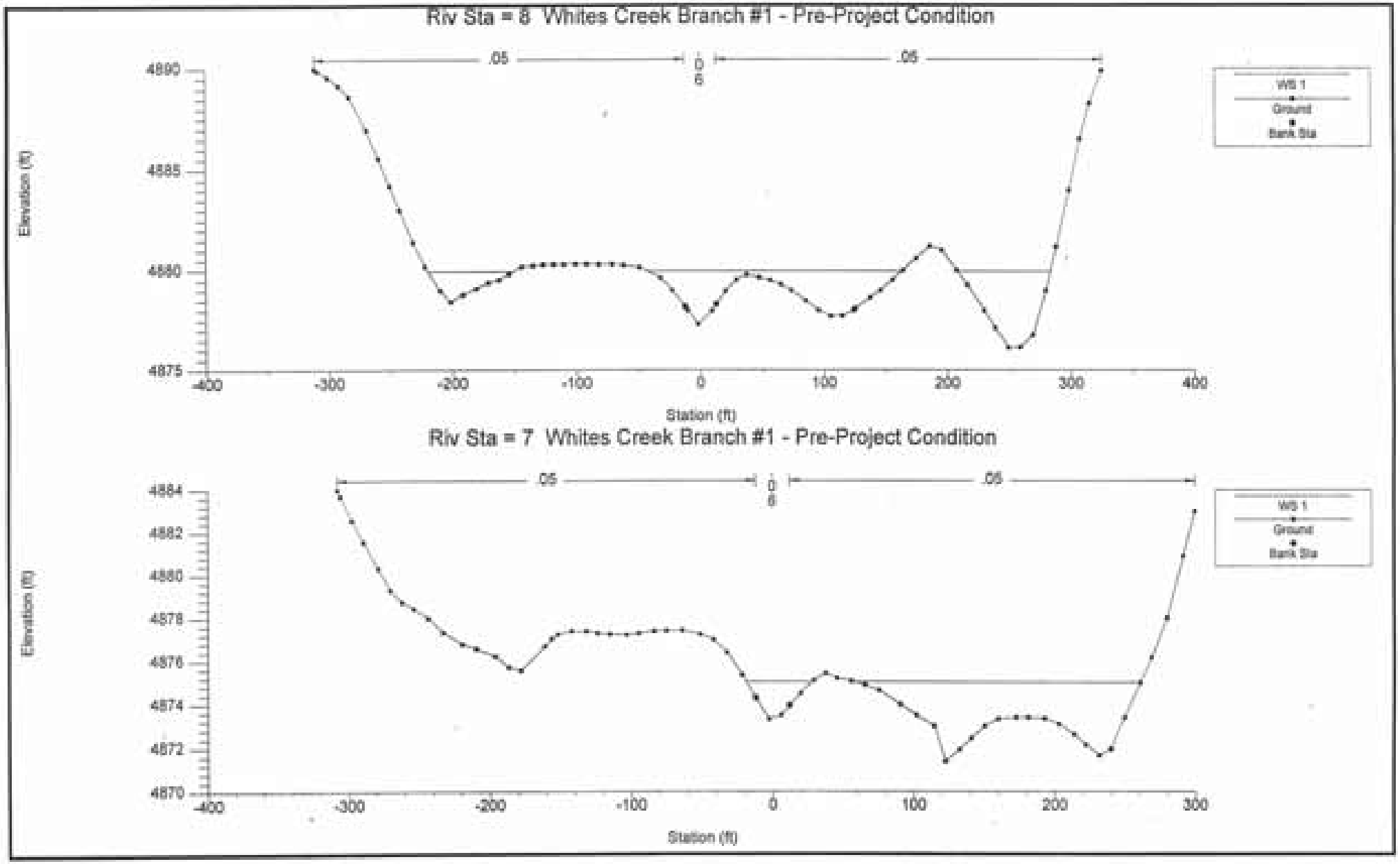

Whites Creek Branch #1 - Pre-Project Condition
4900
4890
4880
4870
4860
4850
Elevation (ft)
0
200
400
600
800
1000
Main Channel Distance (ft)
3,000 cfs
Invert
2
3
4
5
6
7
8
9
10
11
12

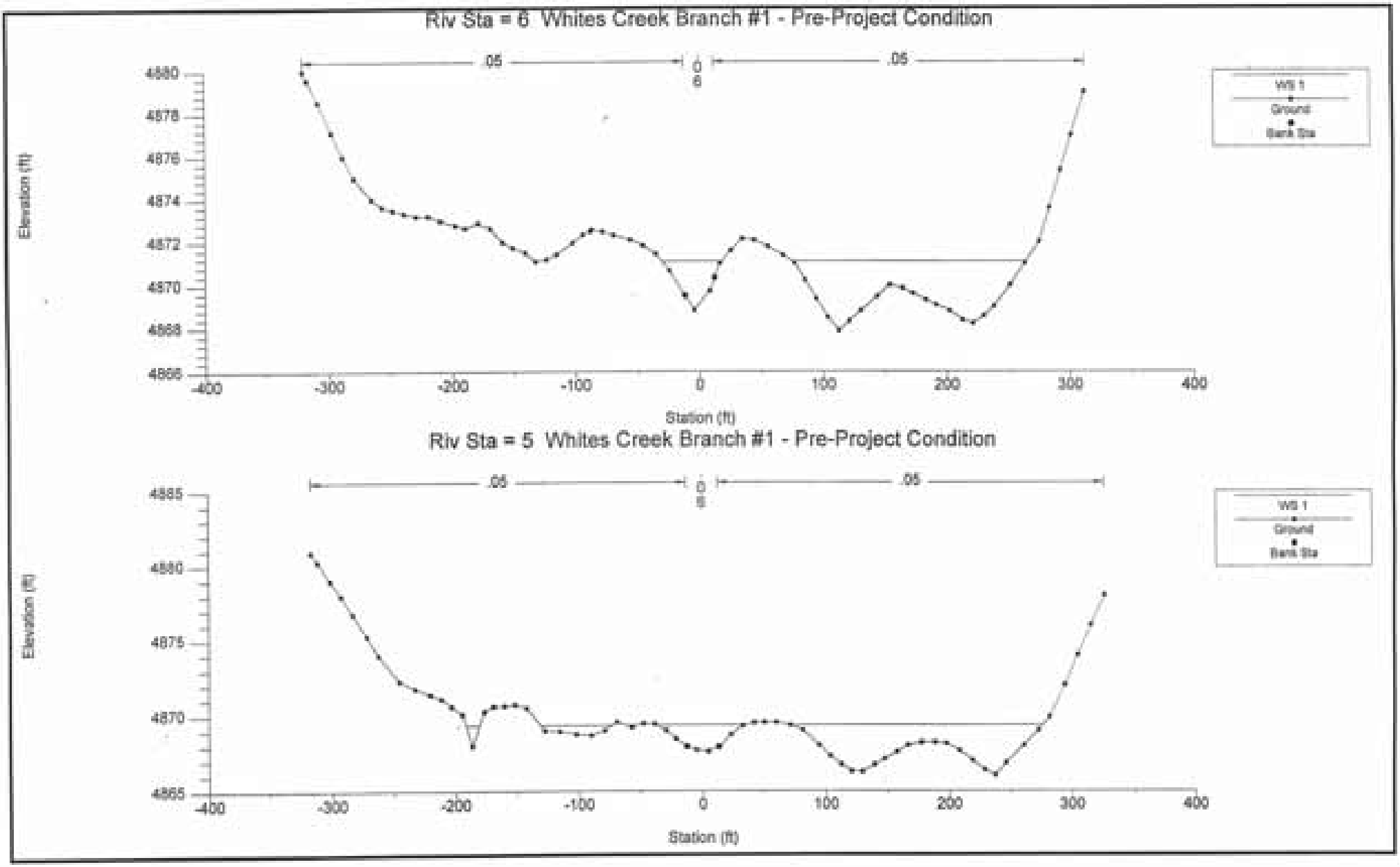
HEC-RAS Plan: Imported Pla Reach: 1

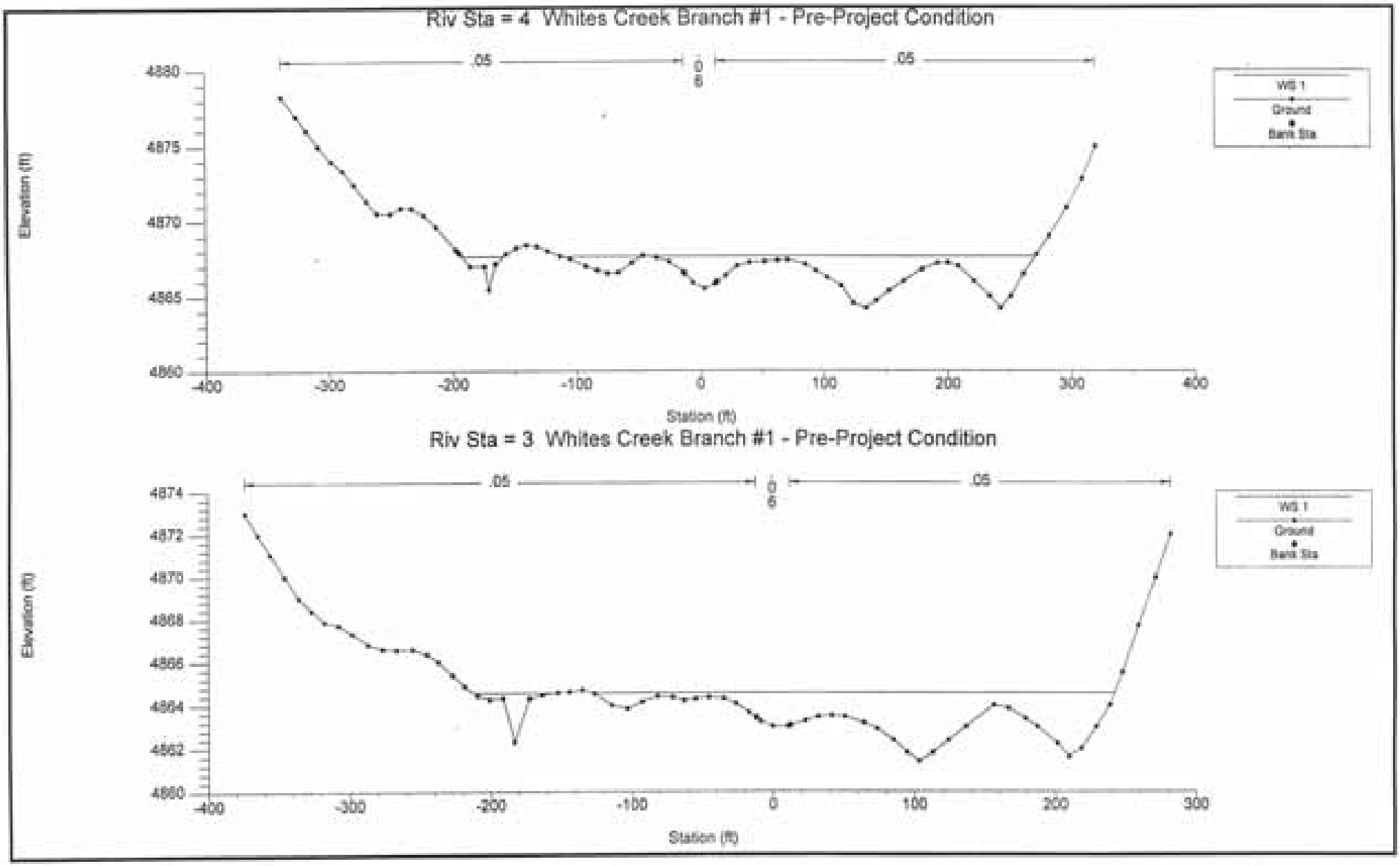
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	3000.00	4853.44	4856.95	4856.95	4857.77	0.026348	7.71	426.84	265.02	0.83
2	3000.00	4859.90	4861.29	4861.29	4861.81	0.029547	4.65	522.06	485.20	0.77
3	3000.00	4863.00	4864.57	4864.57	4865.21	0.025633	5.15	499.86	429.43	0.76
4	3000.00	4865.50	4867.64	4867.64	4868.27	0.031025	6.47	487.79	409.88	0.85
5	3000.00	4867.60	4869.34	4869.34	4870.00	0.024376	5.31	478.83	355.31	0.74
6	3000.00	4868.83	4871.09	4871.09	4871.94	0.028691	6.02	410.63	237.67	0.81
7	3000.00	4873.31	4875.03	4875.03	4875.84	0.027505	5.12	420.96	250.03	0.76
8	3000.00	4877.30	4879.96	4879.96	4880.62	0.025639	6.71	476.36	351.47	0.80
9	3000.00	4882.73	4885.22	4885.22	4885.87	0.027572	6.67	466.67	350.96	0.82
10	3000.00	4886.57	4889.75	4889.75	4890.31	0.029477	7.72	514.12	430.00	0.87
11	3000.00	4888.99	4892.32	4892.32	4893.16	0.027825	8.68	415.69	251.00	0.89
12	3000.00	4894.74	4896.36	4896.36	4897.13	0.018965	4.10	449.64	276.19	0.63

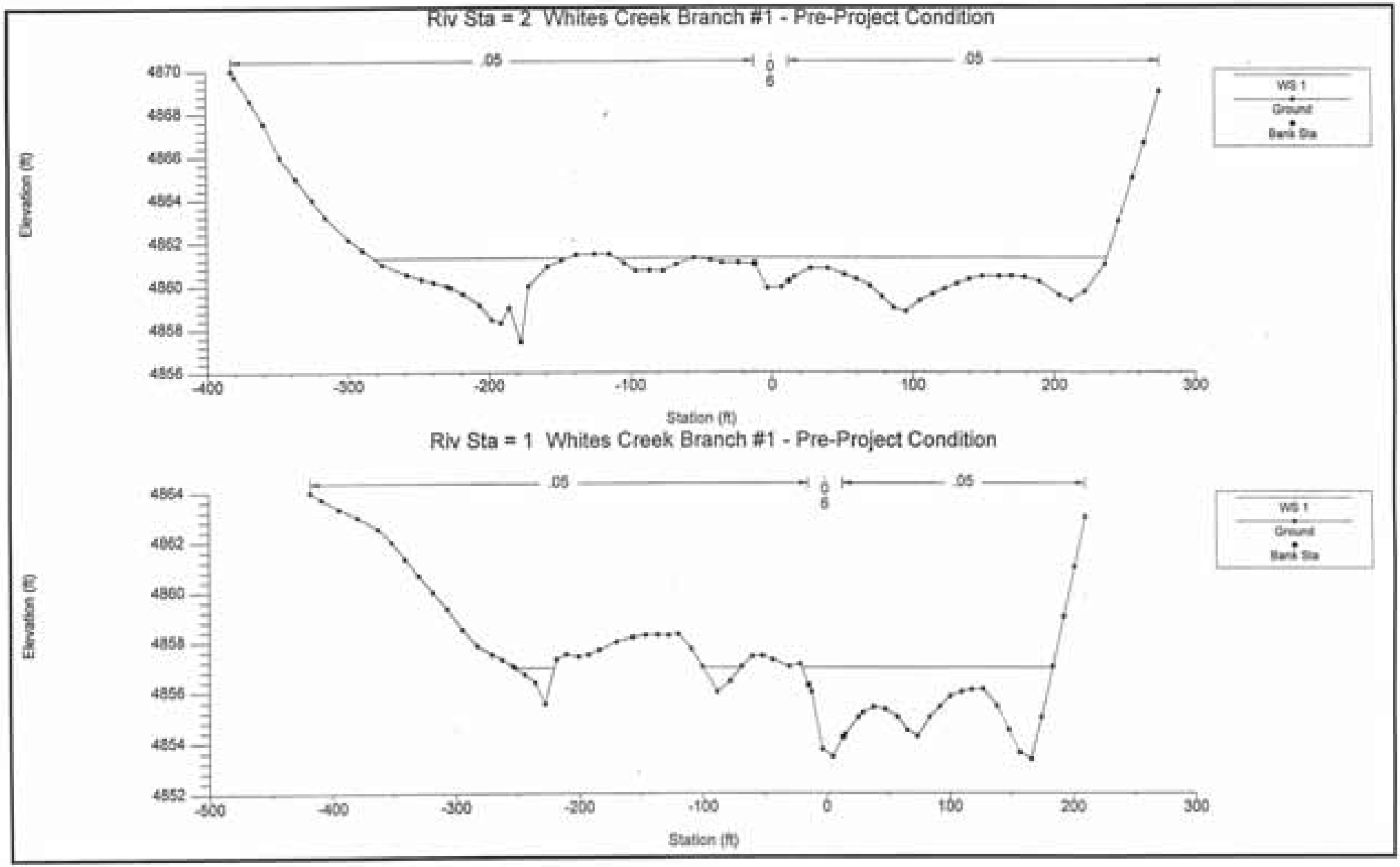

Riv Sta = 12 Whites Creek Branch #1 - Pre-Project Condition
.05
.06
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4904
4902
4900
4898
4896
4894
4892
4890
-300
-200
-100
0
100
200
300
400
Station (ft)
Riv Sta = 11 Whites Creek Branch #1 - Pre-Project Condition
.05
.06
.06
WS 1
Ground
Bank Sta
Elevation (ft)
4902
4900
4898
4896
4894
4892
4890
4888
-300
-200
-100
0
100
200
300
400
Station (ft)


Riv Sta = 10 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4898
4896
4894
4892
4890
4888
4886
-300
-200
-100
0
100
200
300
400
500
Station (ft)
Riv Sta = 9 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4900
4895
4890
4885
4880
-300
-200
-100
0
100
200
300
400
Station (ft)


Riv Sta = 8 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4890
4885
4880
4875
-400
-300
-200
-100
0
100
200
300
400
Station (ft)
Riv Sta = 7 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4884
4882
4880
4878
4876
4874
4872
4870
-400
-300
-200
-100
0
100
200
300
Station (ft)


Riv Sta = 6 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4880
4878
4876
4874
4872
4870
4868
4866
-400
-300
-200
-100
0
100
200
300
400
Station (ft)
Riv Sta = 5 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4885
4880
4875
4870
4865
-400
-300
-200
-100
0
100
200
300
400
Station (ft)

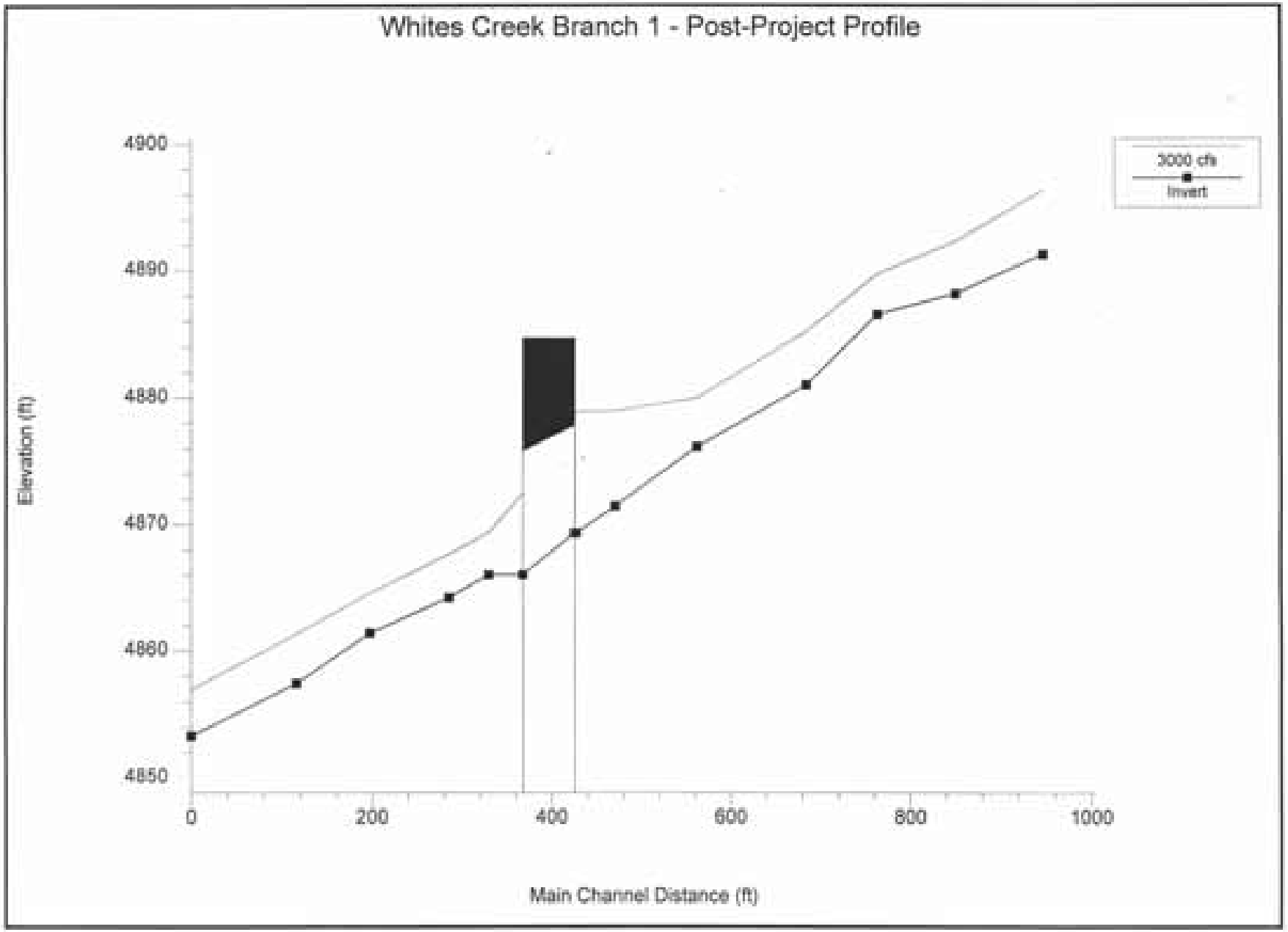

Riv Sta = 4 Whites Creek Branch #1 - Pre-Project Condition
.05
0
6
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4880
4875
4870
4865
4860
-400
-300
-200
-100
0
100
200
300
400
Station (ft)
Riv Sta = 3 Whites Creek Branch #1 - Pre-Project Condition
.05
0
6
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4874
4872
4870
4868
4866
4864
4862
4860
-400
-300
-200
-100
0
100
200
300
Station (ft)


Riv Sta = 2 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4870
4868
4866
4864
4862
4860
4858
4856
-400
-300
-200
-100
0
100
200
300
Station (ft)
Riv Sta = 1 Whites Creek Branch #1 - Pre-Project Condition
.05
.05
WS 1
Ground
Bank Sta
Elevation (ft)
4864
4862
4860
4858
4856
4854
4852
-500
-400
-300
-200
-100
0
100
200
300
Station (ft)

Appendix C

Sub-Section 2
Whites Creek Branch 1
Post-Project Condition Analysis

Arrow Creek Parkway - Special Assessment District #23				
Branch1 - Pre- and Post Project Water Surface Profile Comparison				
Cross Section	Discharge (cfs)	Pre-Project Water Surface Elevation	Post-Project Water Surface Elevation	Difference in Pre- & Post Project WSE
1	3000	4856.95	4856.95	0.00
2	3000	4861.29	4861.29	0.00
3	3000	4864.57	4864.57	0.00
4	3000	4867.64	4867.64	0.00
5	3000	4869.34	4869.34	0.00
6	3000	4871.09		
7	3000	4875.03	4878.96	3.93
8	3000	4879.96	4879.96	0.00
9	3000	4885.22	4885.22	0.00
10	3000	4889.75	4889.75	0.00
11	3000	4892.32	4892.32	0.00
12	3000	4896.36	4896.36	0.00


Whites Creek Branch 1 - Post-Project Profile
3000 cfs
Invert
4900
4890
4880
4870
4860
4850
Elevation (ft)
0
200
400
600
800
1000
Main Channel Distance (ft)

HEC-RAS Plan: Imported Pla Reach: 1 8/25/97

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
1	3000.00	4853.44	4856.95	4856.95	4857.77	0.026348	7.71	426.84	265.02	0.83
2	3000.00	4859.90	4861.29	4861.29	4861.81	0.029547	4.65	522.06	485.20	0.77
3	3000.00	4863.00	4864.57	4864.57	4865.21	0.025633	5.15	499.86	429.43	0.75
4	3000.00	4865.50	4867.64	4867.64	4868.27	0.031025	6.47	467.79	409.88	0.85
5	3000.00	4867.60	4869.34	4869.34	4870.00	0.024376	5.31	478.83	355.31	0.74
6.1	3000.00	4867.80	4872.41	4872.41	4874.80	0.044195	11.47	245.41	59.00	0.95
6.5	Mult Op									
6.9	3000.00	4869.80	4878.92	4874.82	4878.98	0.000597	2.13	1689.39	406.12	0.12
7	3000.00	4873.31	4878.96	4875.03	4879.00	0.000361	1.43	2036.12	548.60	0.11
8	3000.00	4877.30	4879.96	4879.96	4880.62	0.025639	6.71	476.36	351.47	0.80
9	3000.00	4882.73	4885.22	4885.22	4885.87	0.027572	6.67	466.87	350.96	0.82
10	3000.00	4886.57	4889.75	4889.75	4890.31	0.029477	7.72	514.12	430.00	0.87
11	3000.00	4888.99	4892.32	4892.32	4893.16	0.027825	8.68	415.69	251.00	0.88
12	3000.00	4894.74	4896.36	4896.36	4897.13	0.018965	4.10	449.64	275.19	0.63

HEC-RAS Plan: Imported Pla Reach: 1 8/25/97

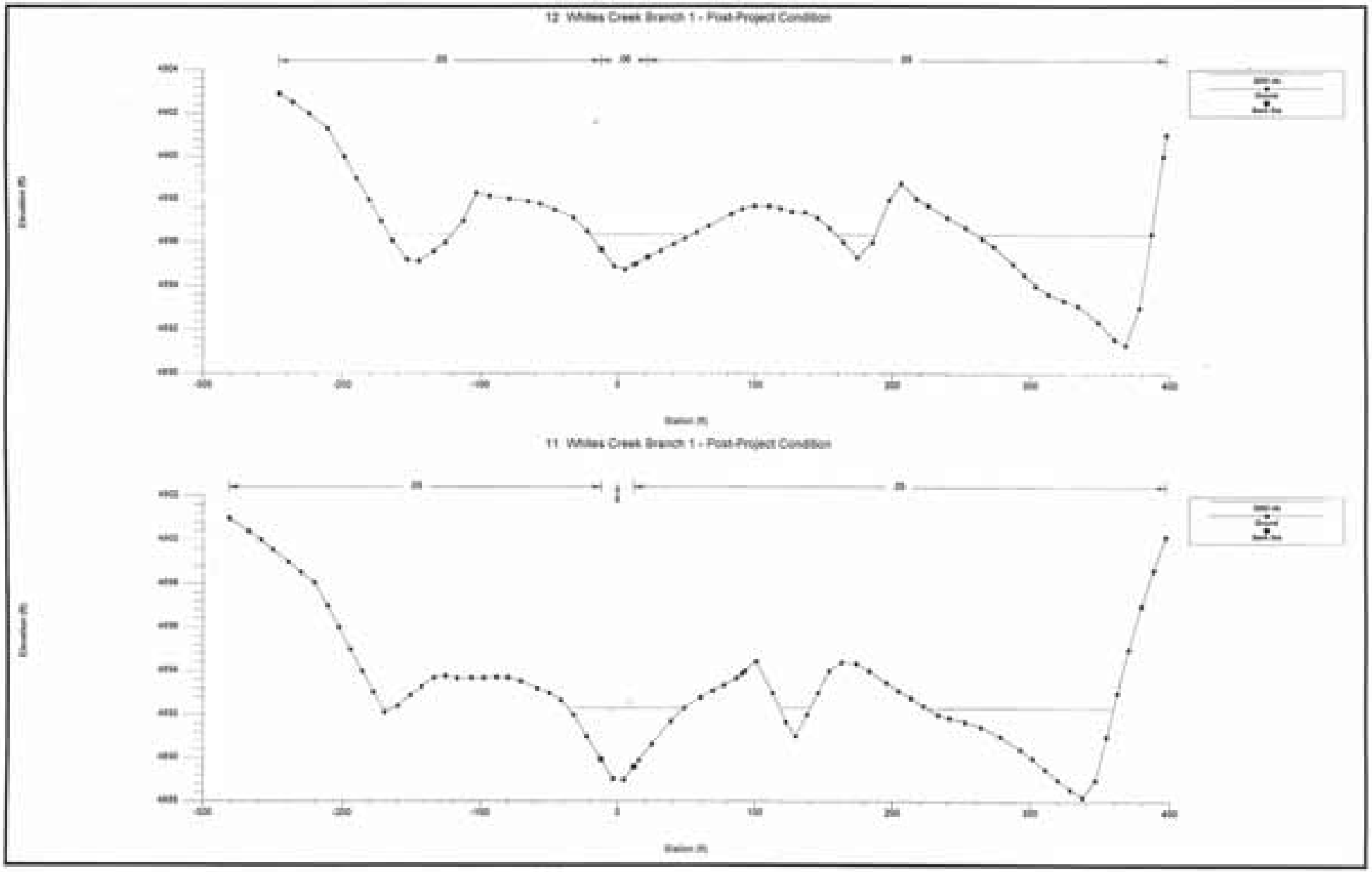
River Sta.	Culvert ID	E.G. US. (ft)	W.S. US. (ft)	E.G. IC (ft)	E.G. OC (ft)	Min Top Rd (ft)	Culv Q (cfs)	Q Weir (cfs)	Delta WS (ft)	Culv Vel In (ft/s)	Culv Vel Out (ft/s)
6.6	Culvert #1	4878.97	4878.93	4878.69	4878.97	4882.00	1487.78		5.18	13.38	12.50
6.6	Culvert #2	4878.97	4878.93	4878.98	4877.64	4882.00	492.55		5.18	13.46	12.54
6.6	Culvert #3	4878.97	4878.93	4878.96	4877.76	4882.00	499.91		5.18	13.60	12.73

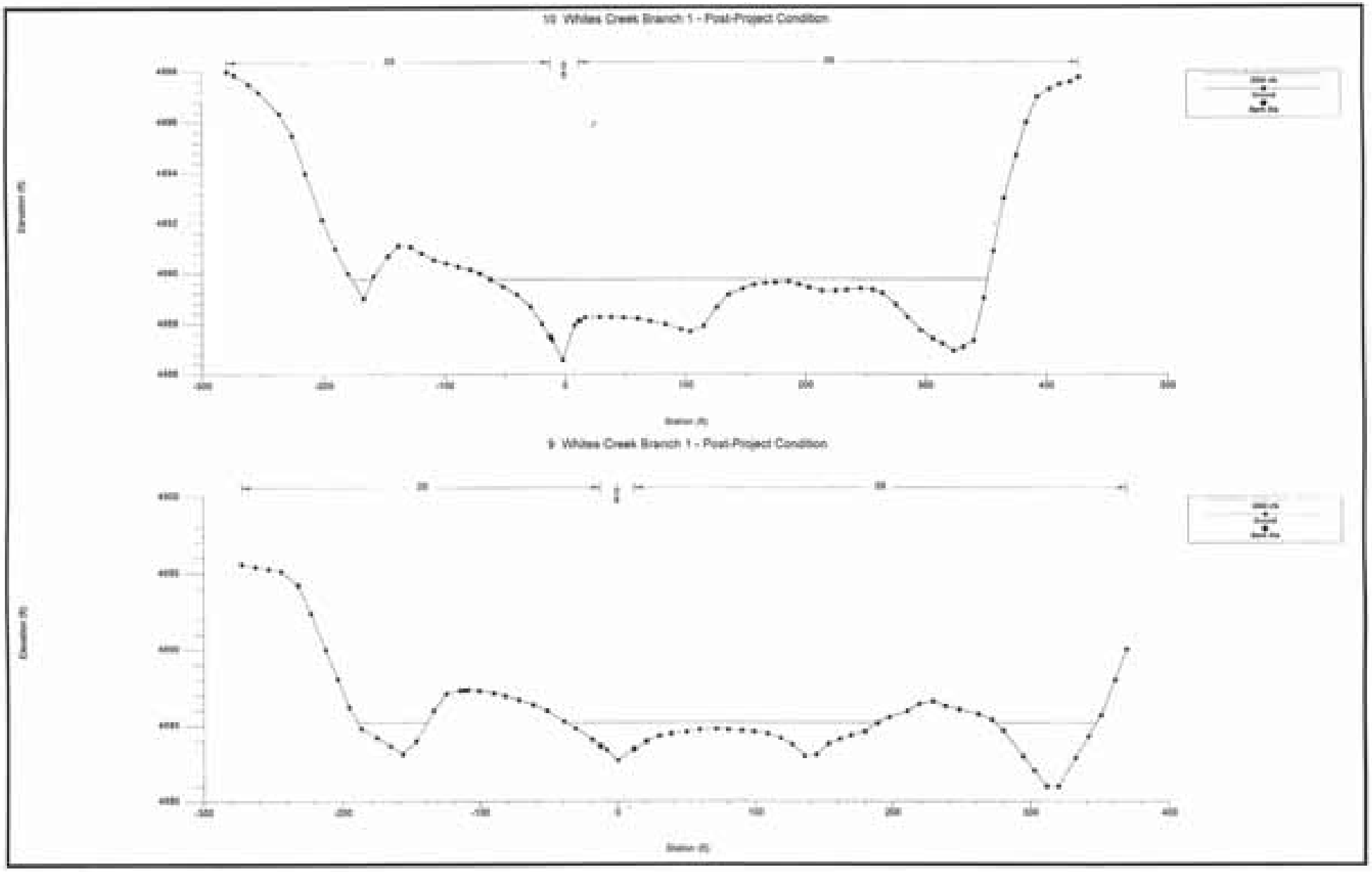
HEC-RAS Plan: Imported Pla Reach: 1 8/25/97

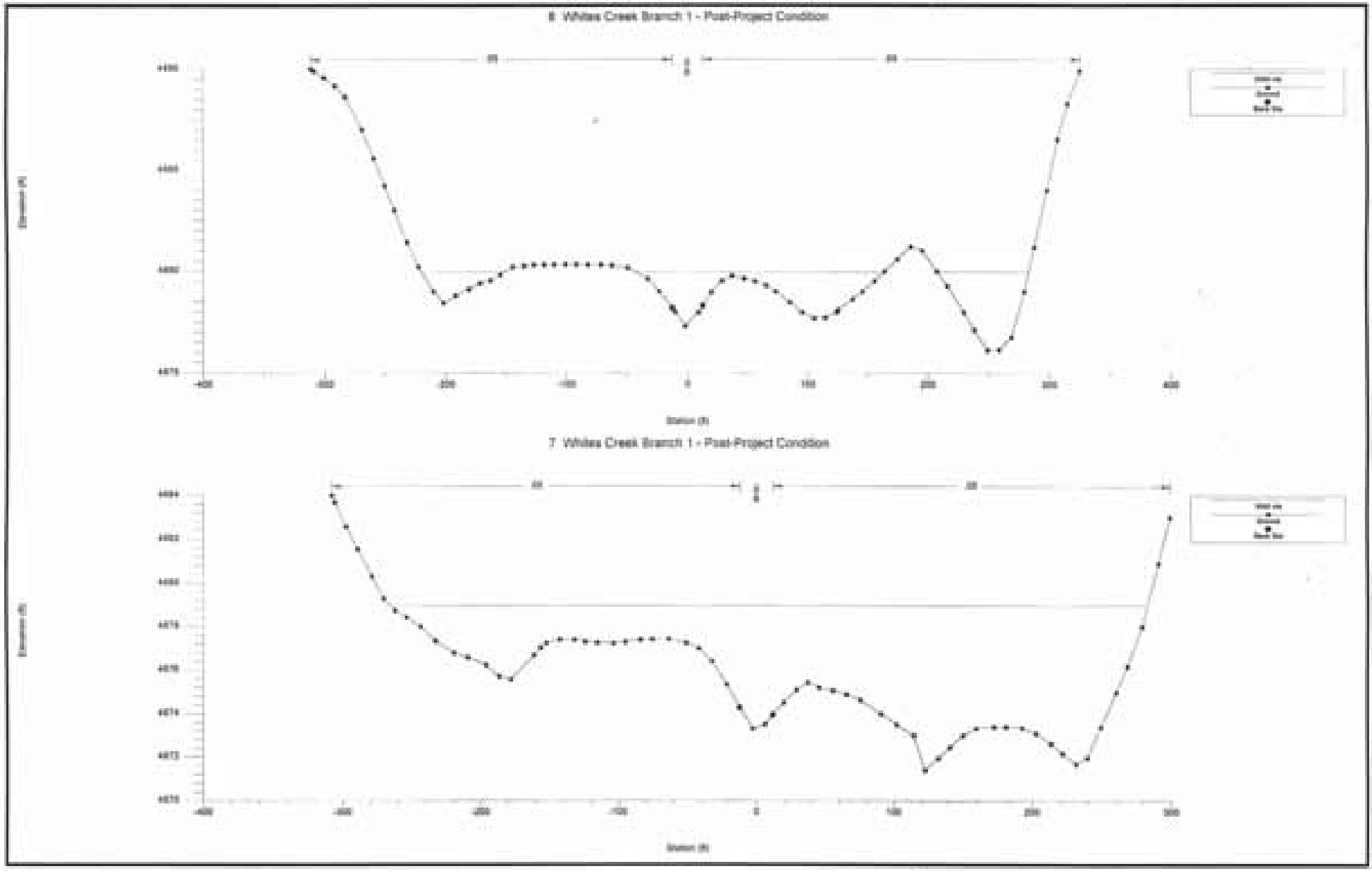
River Sta.	E.G. Elev	Min El Prs	Opening Area	Prs O WS	Q Total	Min Top Rd	Q Weir	Delta EG
	(ft)	(ft)	(sq ft)	(ft)	(cfs)	(ft)	(cfs)	(ft)
6.5 #1	4878.99	4883.50	235.16		519.76	4886.38		

HEC-RAS Plan: Imported Pla Reach: 1 8/25/97

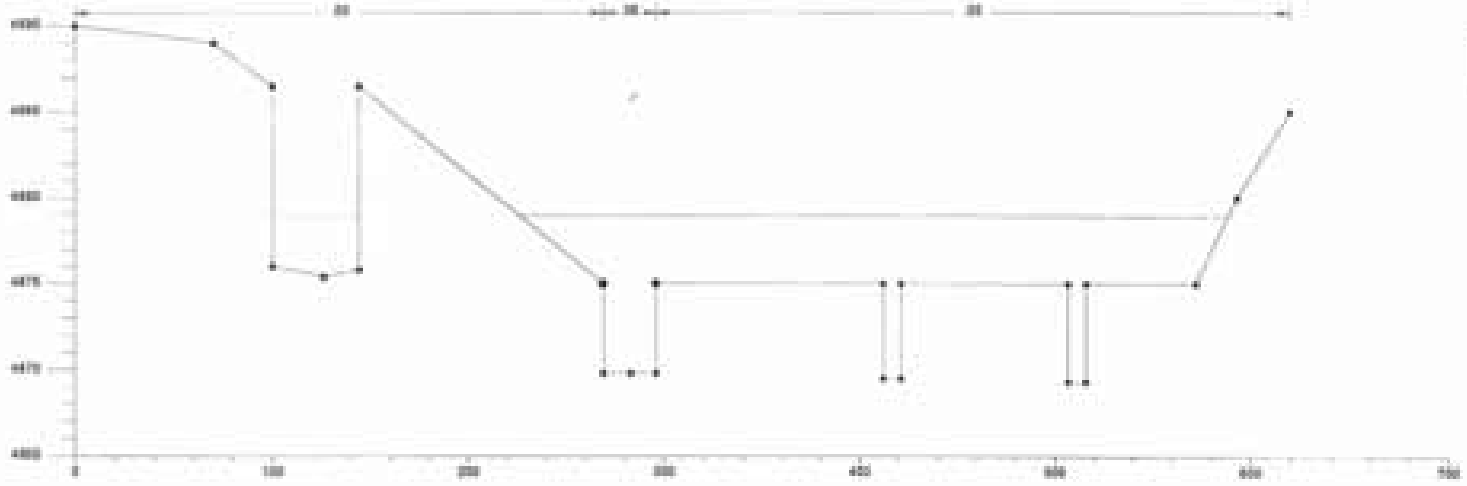
River Sta.	Opening	Q Total	Flow Area	E.G. Elev	W.S. Elev	Top Width Act	Vel Total	Crit W.S.	Left Stagn	Right Stagn
		(cfs)	(sq ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)	(ft)	(ft)
6.5	Bridge #1	519.76	136.58	4878.99	4878.76	44.00	3.81	4877.28	100.00	160.00
6.5	Culv Grp #1	2480.24	1546.79	4878.97	4878.93	362.24	1.60	4874.17	160.00	588.51


12 Whites Creek Branch 1 - Post-Project Condition
11 Whites Creek Branch 1 - Post-Project Condition

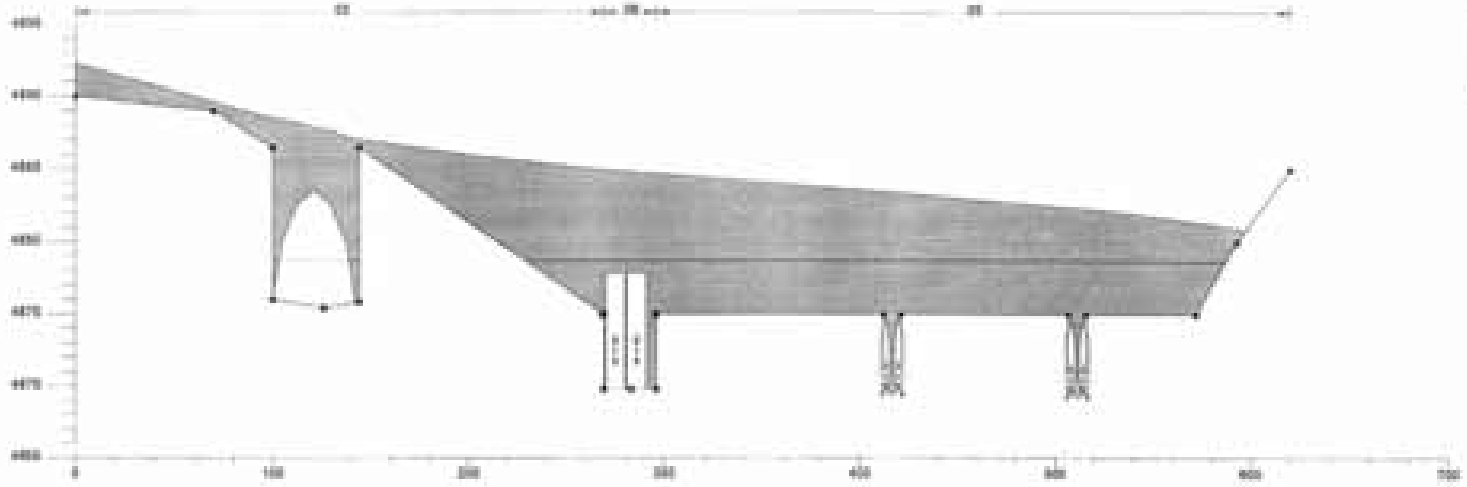

10 Whites Creek Branch 1 - Post-Project Condition
9 Whites Creek Branch 1 - Post-Project Condition

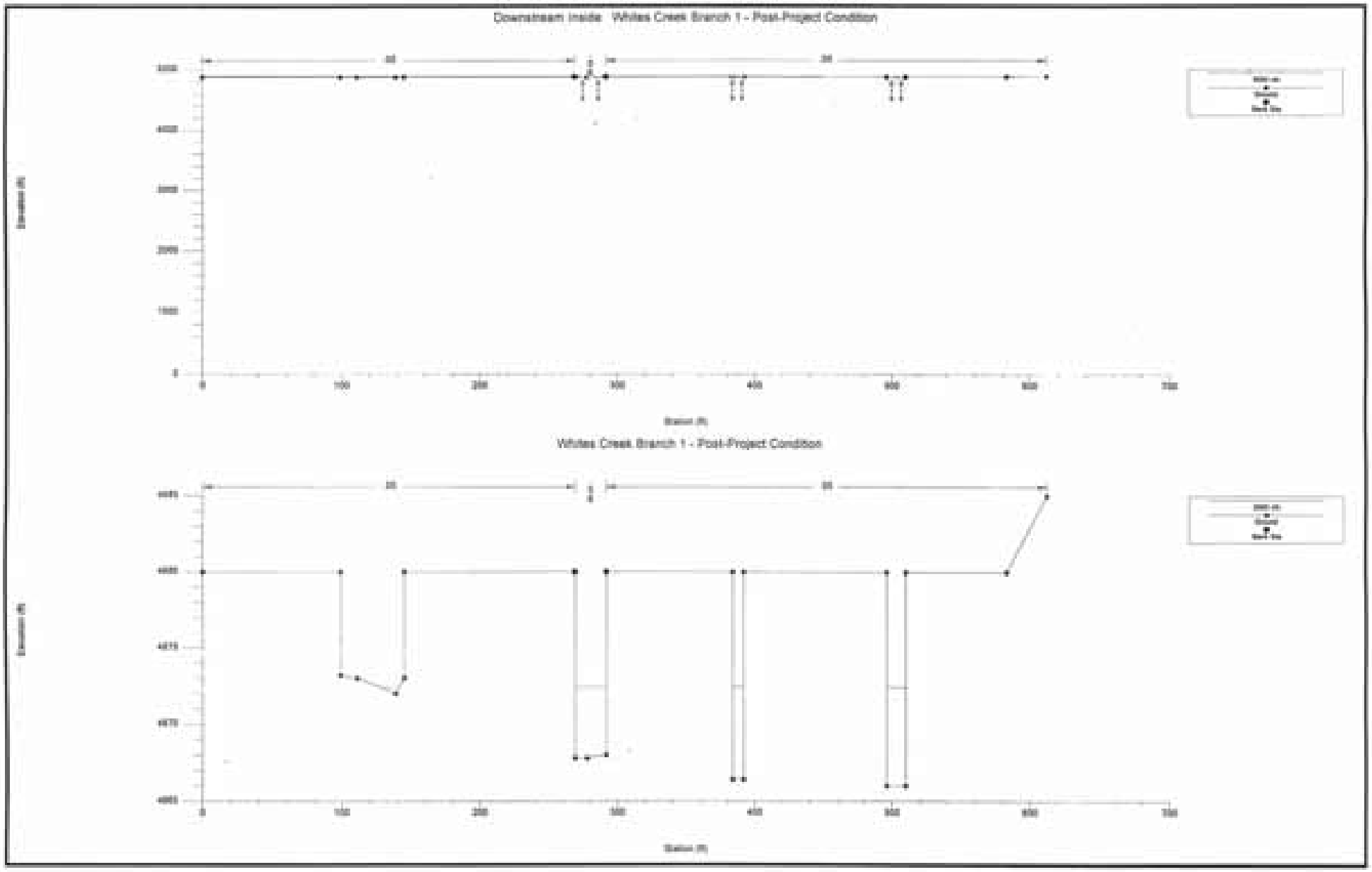

8 Whites Creek Branch 1 - Post-Project Condition
7 Whites Creek Branch 1 - Post-Project Condition

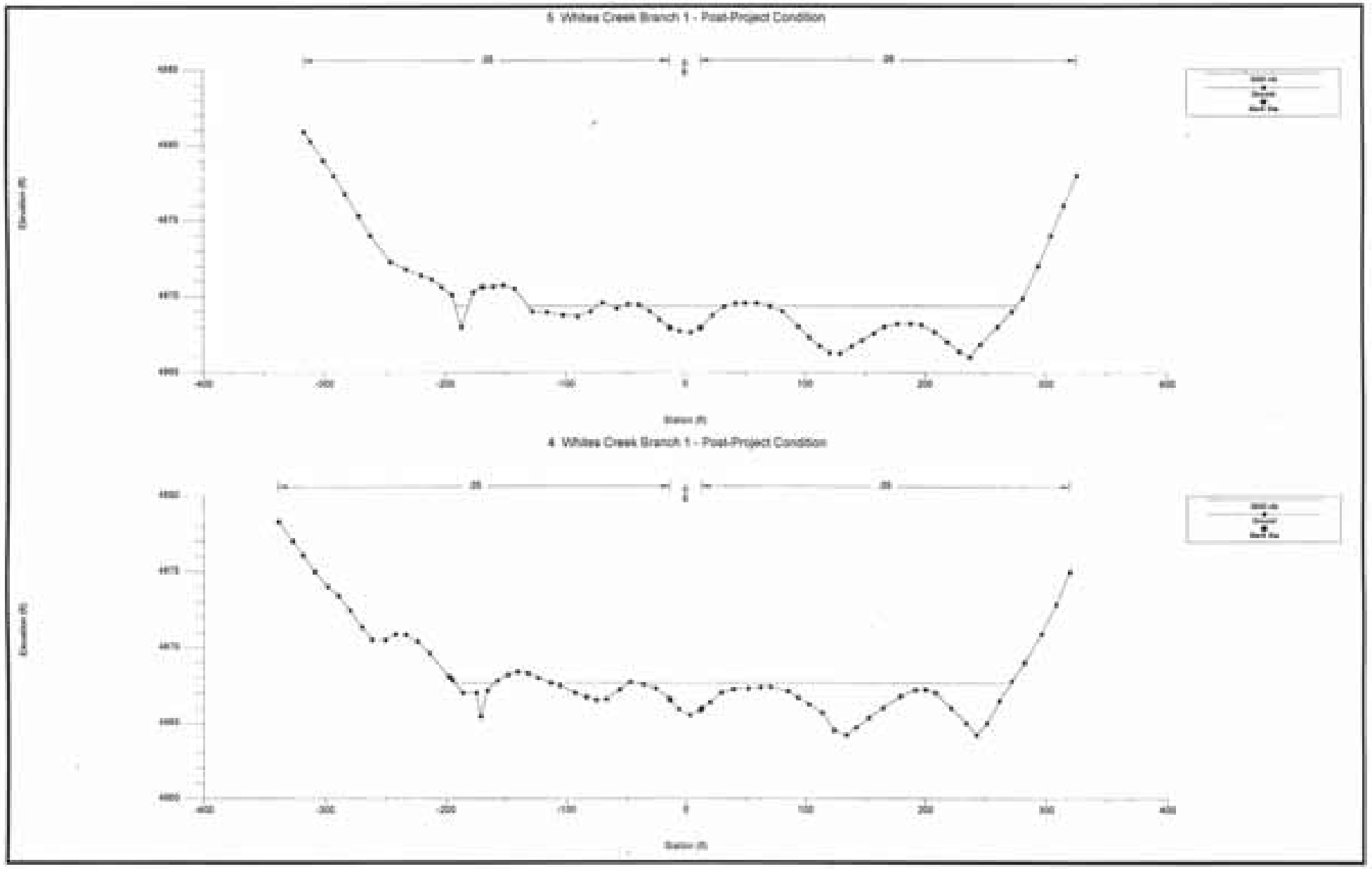
Upstream Face of Openings Whites Creek Branch 1 - Post-Project Condition

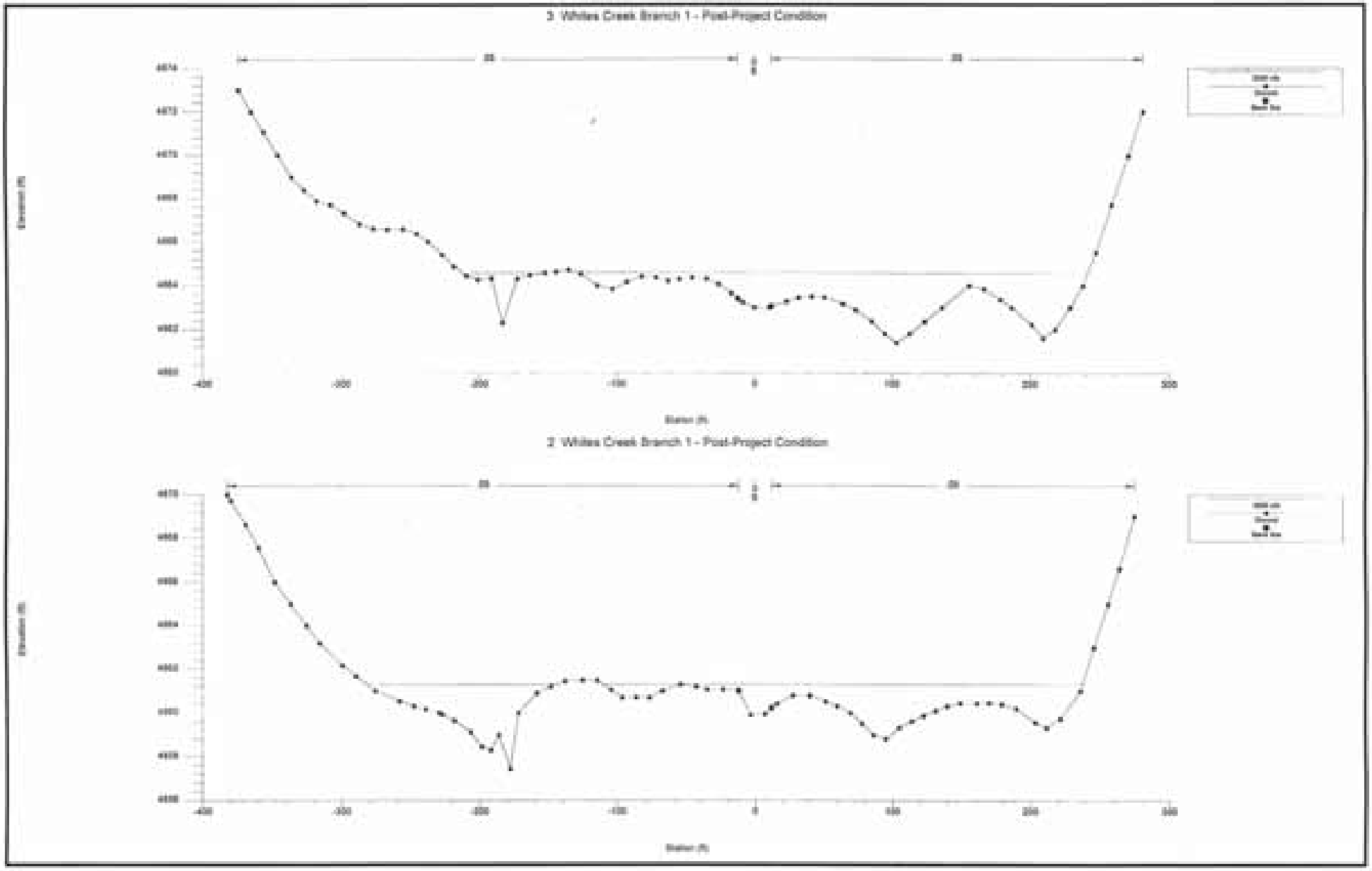


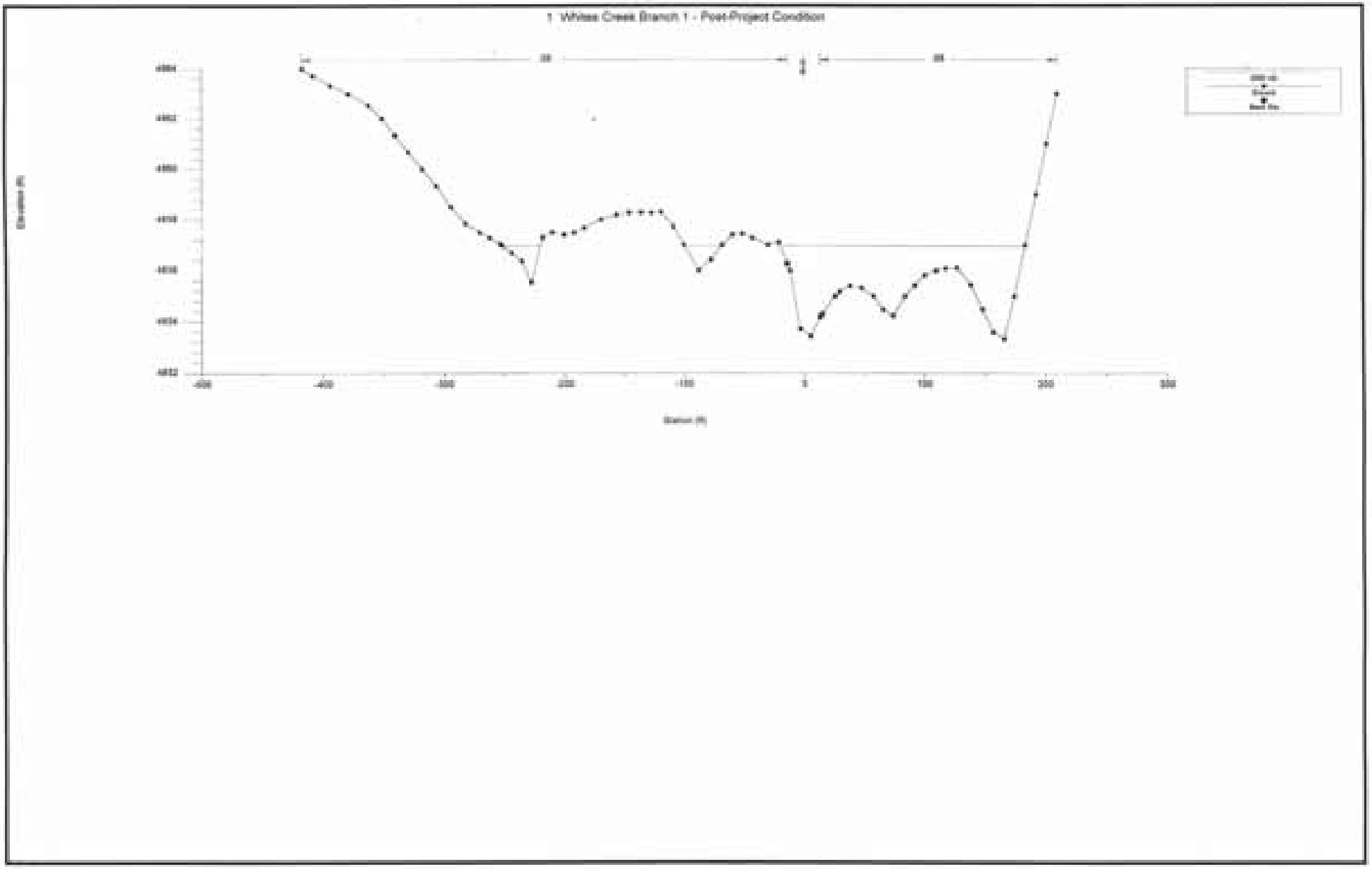
Upstream Inside Whites Creek Branch 1 - Post-Project Condition




Downstream inside Whites Creek Branch 1 - Post-Project Condition
Whites Creek Branch 1 - Post-Project Condition


5 Whites Creek Branch 1 - Post-Project Condition
4 Whites Creek Branch 1 - Post-Project Condition


3 Whites Creek Branch 1 - Post-Project Condition
2 Whites Creek Branch 1 - Post-Project Condition


1 Whites Creek Branch 1 - Post-Project Condition

APPENDIX D

Arrow Creek Parkway - Special Assessment District #23

Branch 2 - Pre- and Post Project Water Surface Profile Comparison

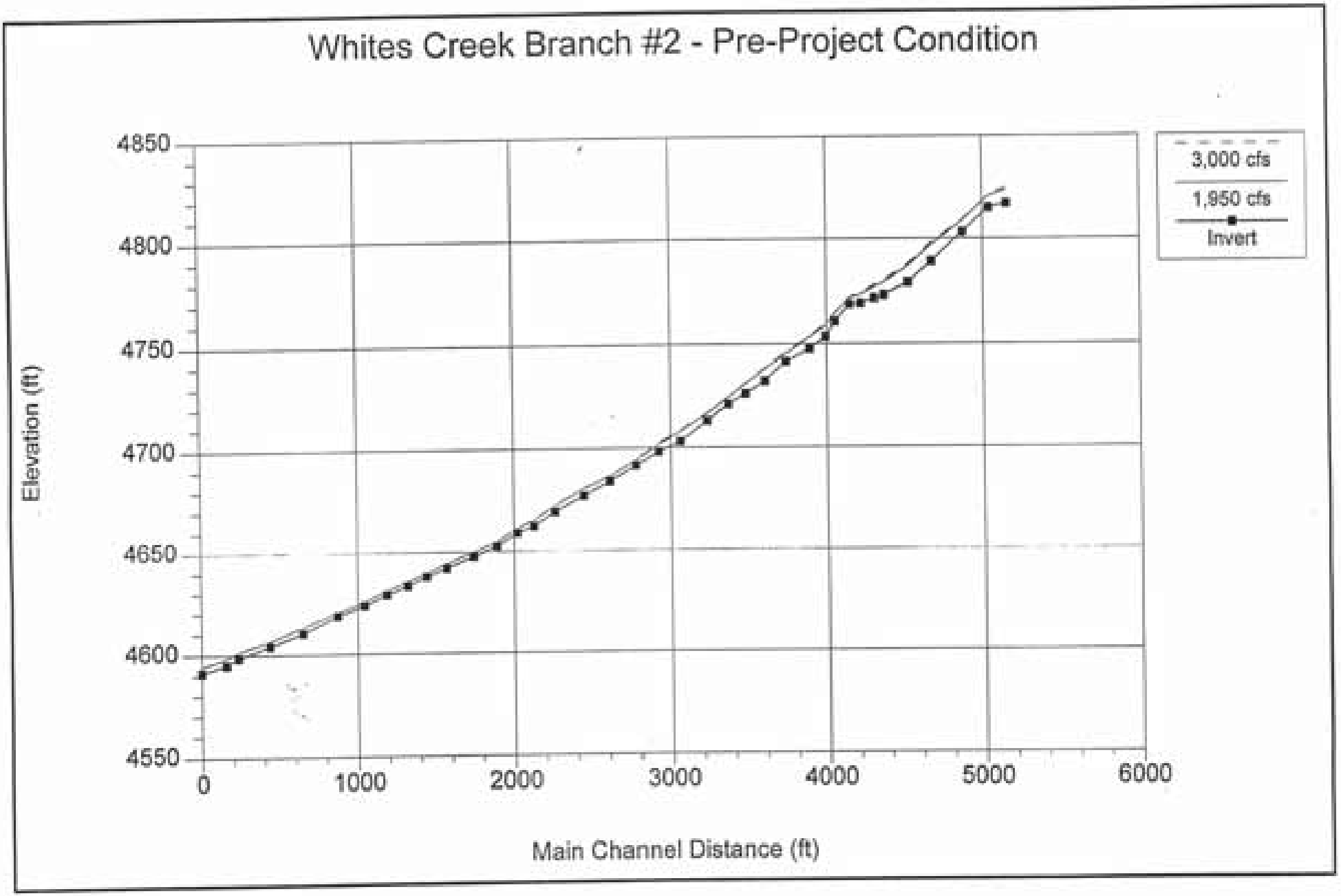
Cross Section	Pre-Project Discharge (cfs)	Post-Project Discharge (cfs)	Pre-Project Water Surface Elevation	Post-Project Water Surface Elevation	Difference in Pre- & Post Project WSE
1	1950	1950	4594.00	4594.00	0.00
1	2737	2871	4594.25	4594.28	0.03
2	1950	1950	4598.13	4598.13	0.00
2	2737	2871	4598.33	4598.38	0.05
3	1950	1950	4601.22	4601.22	0.00
3	2737	2871	4601.52	4601.55	0.03
4	1950	1950	4606.32	4606.32	0.00
4	2737	2871	4606.53	4606.60	0.07
5	1950	1950	4613.16	4613.16	0.00
5	2737	2871	4613.42	4613.44	0.02
6	1950	1950	4620.24	4620.22	-0.02
6	2737	2871	4620.43	4620.46	0.03
7	1950	1950	4625.75	4625.72	-0.03
7	2737	2871	4625.93	4625.94	0.01
8	1950	1950	4630.92	4631.10	0.18
8	2737	2871	4631.13	4631.39	0.26
9	1950	1950	4635.43	4635.50	0.07
9	2737	2871	4635.61	4635.83	0.22
10	1950	1950	4639.36	4639.39	0.03
10	2737	2871	4639.56	4639.61	0.05
11	1950	1950	4644.00	4644.00	0.00
11	2737	2871	4644.20	4644.25	0.05
12	1950	1950	4649.83	4649.83	0.00
12	2737	2871	4650.11	4650.14	0.03
13	1950	1950	4654.58	4654.58	0.00
13	2737	2871	4654.86	4654.90	0.04
14	1950	1950	4661.40	4661.50	0.10
14	2737	2871	4661.68	4661.84	0.16
15	1950	1950	4665.35	4665.35	0.00
15	2737	2871	4665.76	4665.83	0.07
16	1950	1950	4672.16	4672.13	-0.03
16	2737	2871	4672.51	4672.56	0.05

17	1950	1950	4680.32	4680.78	0.46
17	2737	2871	4680.58	4681.13	0.55
18	1950	1950	4686.32	4686.54	0.22
18	2737	2871	4686.53	4686.92	0.39
19	1950	1950	4693.93	4694.11	0.18
19	2737	2871	4694.18	4694.47	0.29
20	1950	1950	4701.69	4701.85	0.16
20	2737	2871	4702.53	4702.75	0.22
21	1950	1950	4707.87	4707.87	0.00
21	2737	2871	4708.46	4708.49	0.03
22	1950	1950	4716.40	4716.45	0.05
22	2737	2871	4716.78	4716.90	0.12
23	1950	1950	4724.19	4724.34	0.15
23	2737	2871	4724.60	4724.77	0.17
24	1950	1950	4730.62	4730.66	0.04
24	2737	2871	4730.89	4731.00	0.11
25	1950	1950	4737.65	4737.65	0.00
25	2457	2591	4738.13	4738.22	0.09
26	1950	1950	4745.05	4745.05	0.00
26	2457	2591	4745.95	4746.00	0.05
27	1950	1950	4753.01	4753.01	0.00
27	2457	2591	4753.47	4753.59	0.12
28	1950	1950	4758.49	4752.94	-5.55
28	2457	2591	4759.34	4754.07	-5.27
29	1950	Culvert	4764.30		
29	2457		4764.71		
30	1950	1950	4771.54	4764.27	-7.27
30	2517	2591	4771.88	4766.56	-5.32
31	1950	1950	4773.11	4773.11	0.00
31	2591	2591	4773.75	4773.75	0.00
32	1950	1950	4776.89	4776.89	0.00
32	2591	2591	4777.75	4777.75	0.00
33	1950	1950	4779.11	4779.11	0.00
33	2591	2591	4780.07	4780.07	0.00
34	1950	1950	4786.68	4786.68	0.00
34	2591	2591	4787.80	4787.80	0.00
35	1950	1950	4796.84	4796.84	0.00
35	2591	2591	4797.90	4797.90	0.00

36	1950	1950	4808.43	4808.43	0.00
36	2591	2591	4809.01	4809.01	0.00
37	1950	1950	4820.56	4820.56	0.00
37	2887	2887	4821.00	4821.00	0.00
38	1950	1950	4823.49	4823.49	0.00
38	3000	3000	4824.89	4824.89	0.00

Appendix D

Sub-Section 1
Whites Creek Branch 2
Pre-Project Condition Analysis


Whites Creek Branch #2 - Pre-Project Condition
4850
4800
4750
4700
4650
4600
4550
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)
3,000 cfs
1,950 cfs
Invert

HEC-RAS Plan: Imported Pla Reach: 1

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
1	1950.00	4592.18	4594.00	4594.00	4594.39	0.024684	5.51	395.63	508.79	0.93
1	2737.00	4592.18	4594.25	4594.25	4594.65	0.024207	6.25	551.30	696.37	0.95
2	1950.00	4595.00	4598.13	4598.13	4598.46	0.024933	7.10	563.19	782.47	0.99
2	2737.00	4595.00	4598.33	4598.33	4598.70	0.025854	7.83	731.02	866.25	1.03
3	1950.00	4599.00	4601.22	4601.22	4601.69	0.029433	7.12	374.79	414.42	1.05
3	2737.00	4599.00	4601.52	4601.52	4602.02	0.025608	7.54	512.01	483.12	1.01
4	1950.00	4605.00	4606.32	4606.17	4606.69	0.023218	5.43	400.92	374.83	0.90
4	2737.00	4605.00	4606.53	4606.45	4607.04	0.027078	6.53	484.14	410.69	1.00
5	1950.00	4610.32	4613.16	4613.16	4613.57	0.019731	6.50	421.02	465.36	0.89
5	2737.00	4610.32	4613.42	4613.42	4613.90	0.020403	7.29	544.17	476.70	0.93
6	1950.00	4619.44	4620.24	4620.24	4620.55	0.033900	3.45	445.91	681.00	0.93
6	2737.00	4619.44	4620.43	4620.43	4620.78	0.032122	4.17	581.18	765.63	0.95
7	1950.00	4624.00	4625.76	4625.72	4626.10	0.031059	6.54	475.72	584.32	1.06
7	2737.00	4624.00	4625.93	4625.93	4626.38	0.033445	7.46	584.18	616.96	1.12
8	1950.00	4629.07	4630.92	4630.92	4631.32	0.029034	7.25	409.64	490.12	1.06
8	2737.00	4629.07	4631.13	4631.13	4631.62	0.029106	7.93	514.10	510.29	1.08
9	1950.00	4633.57	4635.43	4635.43	4635.82	0.027233	7.58	426.81	539.76	1.04
9	2737.00	4633.57	4635.61	4635.61	4636.09	0.029508	8.48	532.51	590.20	1.10
10	1950.00	4638.62	4639.36	4639.36	4639.70	0.034842	4.50	421.03	611.15	1.00
10	2737.00	4638.62	4639.56	4639.54	4639.95	0.036109	5.49	547.09	665.70	1.07
11	1950.00	4643.58	4644.00	4644.00	4644.41	0.036171	3.07	384.05	477.04	0.93
11	2737.00	4643.58	4644.20	4644.20	4644.70	0.036070	4.20	487.28	509.30	1.00
12	1950.00	4649.40	4649.83	4649.83	4650.31	0.031174	2.72	357.81	392.48	0.85

HEC-RAS Plan: Imported Pla Reach: 1 (continued)

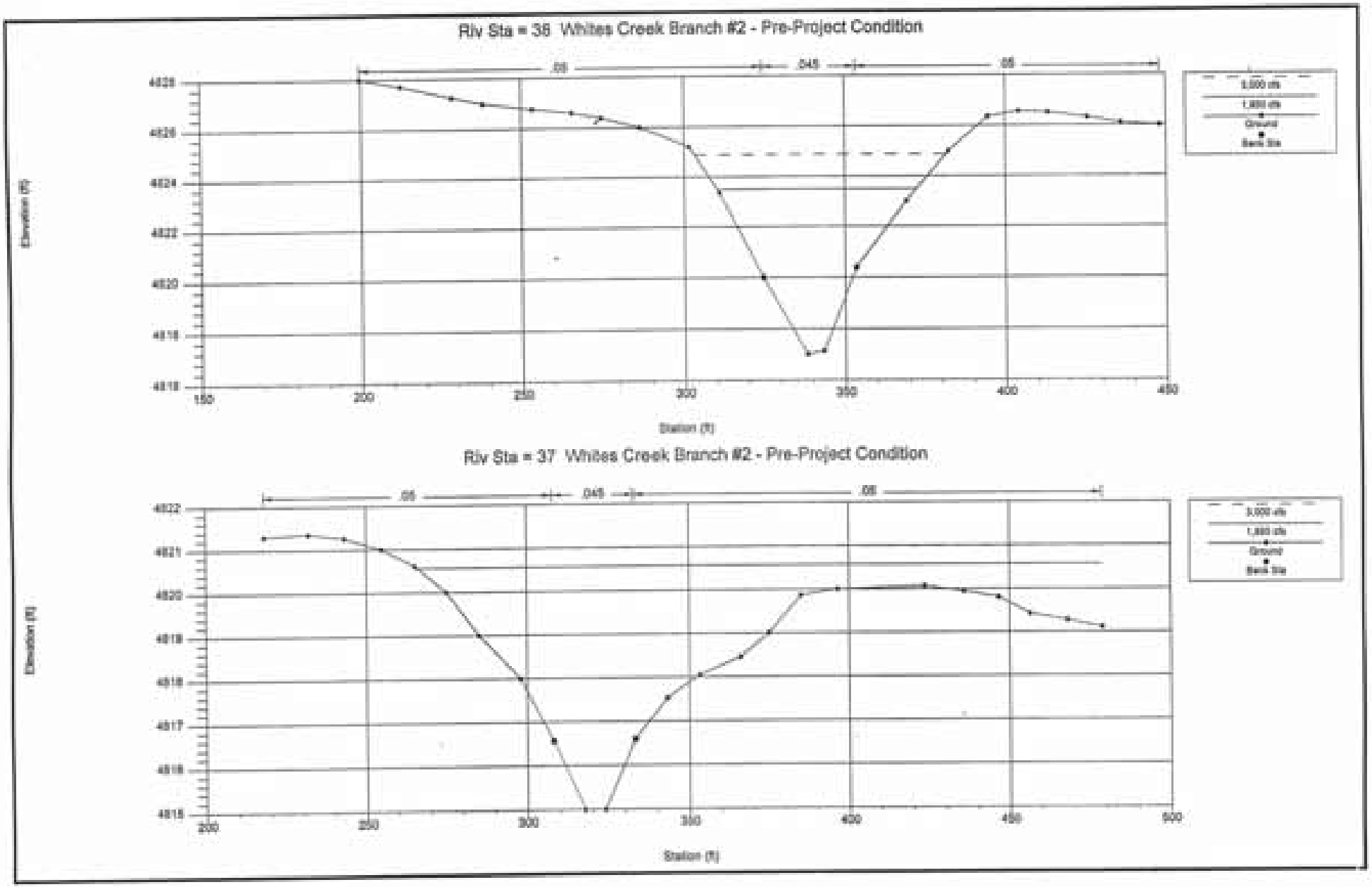
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
12	2737.00	4649.40	4650.11	4650.11	4650.64	0.031706	4.09	469.99	424.11	0.95
13	1950.00	4655.12	4654.58	4654.58	4655.13	0.033430		329.28	289.14	0.00
13	2737.00	4655.12	4654.86	4654.86	4655.55	0.032949		409.70	297.01	0.00
14	1950.00	4660.00	4661.40	4661.40	4661.90	0.033771	5.64	344.16	355.16	1.05
14	2737.00	4660.00	4661.68	4661.68	4662.27	0.031076	6.47	448.70	390.18	1.05
15	1950.00	4664.00	4665.35	4665.35	4666.05	0.027237	4.79	295.05	199.48	0.93
15	2737.00	4664.00	4665.78	4665.78	4666.57	0.026827	6.00	382.72	239.35	0.99
16	1950.00	4670.00	4672.16	4672.10	4672.79	0.026870	7.85	315.69	235.02	1.04
16	2737.00	4670.00	4672.51	4672.51	4673.28	0.025843	8.69	400.08	248.72	1.06
17	1950.00	4677.00	4680.32	4680.32	4680.79	0.016044	8.83	421.73	361.16	0.89
17	2737.00	4677.00	4680.58	4680.58	4681.15	0.016009	9.87	516.83	376.35	0.95
18	1950.00	4684.12	4686.32	4686.32	4686.75	0.030356	6.72	383.74	415.67	1.05
18	2737.00	4684.12	4686.53	4686.53	4687.08	0.031335	7.55	471.30	424.24	1.09
19	1950.00	4692.00	4693.93	4693.93	4694.42	0.031556	6.93	359.49	363.18	1.08
19	2737.00	4692.00	4694.18	4694.18	4694.78	0.030232	7.63	450.20	368.85	1.08
20	1950.00	4698.11	4701.69	4701.69	4702.47	0.017420	8.62	320.20	209.58	0.91
20	2737.00	4698.11	4702.53	4702.53	4703.05	0.009863	7.74	638.51	490.65	0.71
21	1950.00	4703.00	4707.87	4707.87	4708.86	0.013431	9.11	288.73	150.47	0.83
21	2737.00	4703.00	4708.46	4708.46	4709.59	0.013447	10.06	386.44	182.78	0.85
22	1950.00	4713.00	4716.40	4716.40	4717.07	0.016863	8.62	348.24	237.79	0.90
22	2737.00	4713.00	4716.78	4716.78	4717.56	0.017171	9.46	443.09	256.61	0.93
23	1950.00	4721.00	4724.19	4724.19	4724.74	0.016902	8.10	390.61	355.63	0.88
23	2737.00	4721.00	4724.60	4724.60	4725.15	0.014652	8.32	562.40	451.19	0.84

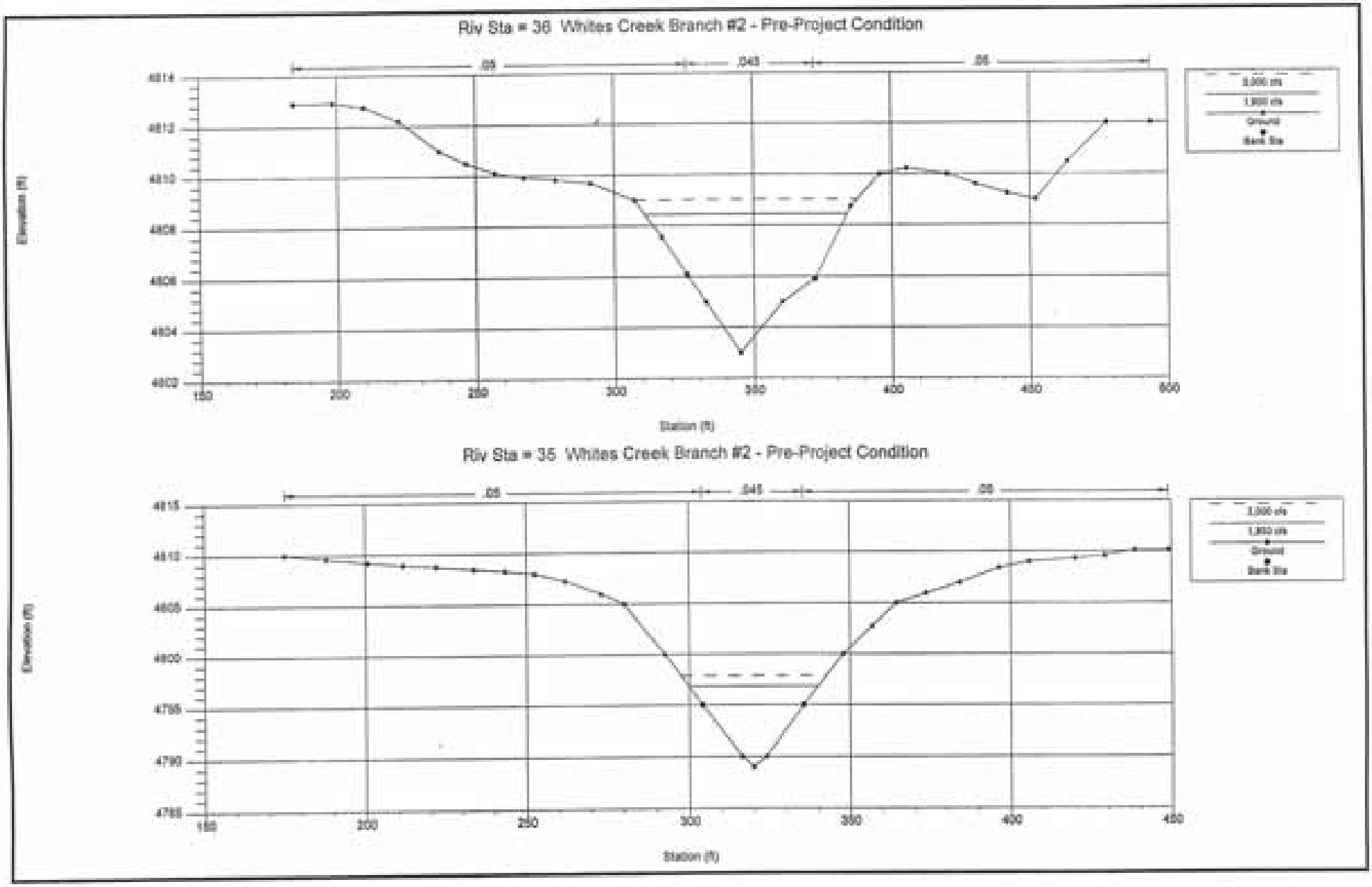
HEC-RAS Plan: Imported Pla Reach: 1 (continued)

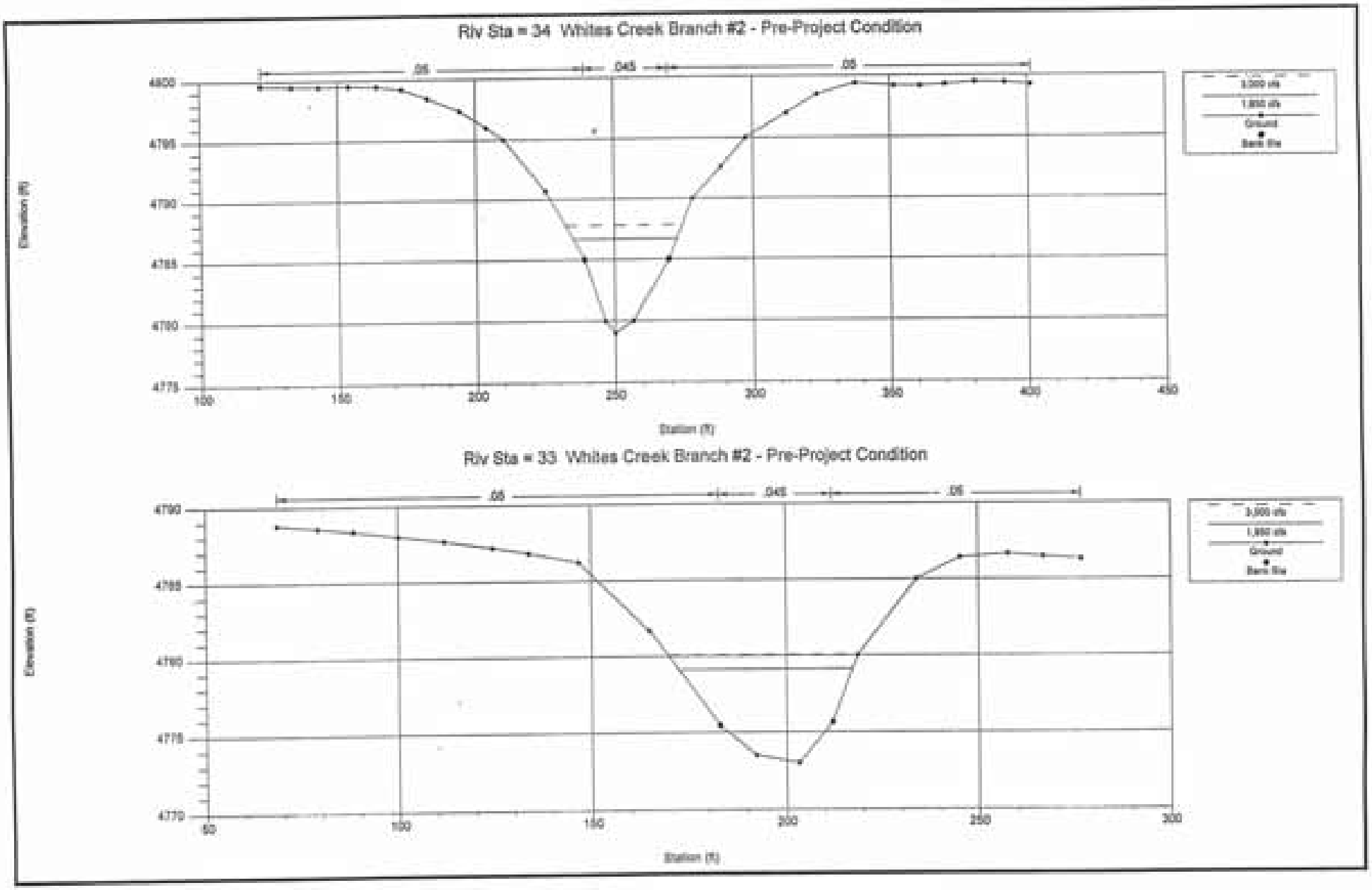
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
24	1950.00	4726.00	4730.62	4730.62	4731.12	0.009224	8.07	481.85	382.49	0.70
24	2737.00	4726.00	4730.89	4730.89	4731.48	0.010733	9.09	589.82	397.73	0.77
25	1950.00	4732.08	4737.65	4737.65	4738.41	0.010587	8.84	379.87	276.15	0.75
25	2457.00	4732.08	4738.13	4738.13	4738.76	0.008435	8.48	534.74	347.17	0.68
26	1950.00	4741.30	4745.05	4745.05	4746.16	0.019695	9.73	261.53	141.11	0.98
26	2457.00	4741.30	4745.95	4745.95	4746.62	0.009958	8.22	479.16	294.73	0.73
27	1950.00	4747.54	4753.01	4753.01	4754.09	0.012389	9.83	285.82	133.54	0.82
27	2457.00	4747.54	4753.47	4753.47	4754.64	0.012422	10.50	352.96	159.02	0.83
28	1950.00	4753.37	4758.49	4758.49	4760.02	0.014880	10.69	217.08	72.85	0.90
28	2457.00	4753.37	4759.34	4759.34	4760.74	0.011438	10.56	301.18	133.51	0.81
29	1950.00	4760.60	4764.30	4764.30	4765.42	0.017183	10.08	254.59	109.31	0.94
29	2457.00	4760.60	4764.71	4764.71	4766.03	0.017840	11.05	303.24	130.25	0.98
30	1950.00	4768.60	4771.54	4771.54	4772.42	0.019284	9.23	279.64	142.96	0.96
30	2517.00	4768.60	4771.88	4771.88	4772.93	0.019673	10.04	328.41	145.68	0.99
31	1950.00	4769.00	4773.11	4773.11	4774.53	0.017903	11.15	219.19	74.90	0.98
31	2591.00	4769.00	4773.75	4773.75	4775.42	0.017511	12.17	268.95	79.52	0.99
32	1950.00	4771.50	4776.89	4776.89	4778.69	0.014801	11.96	200.25	56.00	0.93
32	2591.00	4771.50	4777.75	4777.75	4779.81	0.014132	12.95	251.09	61.74	0.93
33	1950.00	4773.00	4779.11	4779.11	4781.20	0.015204	11.98	179.16	45.07	0.93
33	2591.00	4773.00	4780.07	4780.07	4782.49	0.014329	13.03	224.31	49.38	0.93
34	1950.00	4779.00	4786.68	4786.68	4789.01	0.017323	12.31	162.76	37.23	0.96
34	2591.00	4779.00	4787.80	4787.80	4790.45	0.015423	13.23	206.96	41.91	0.93

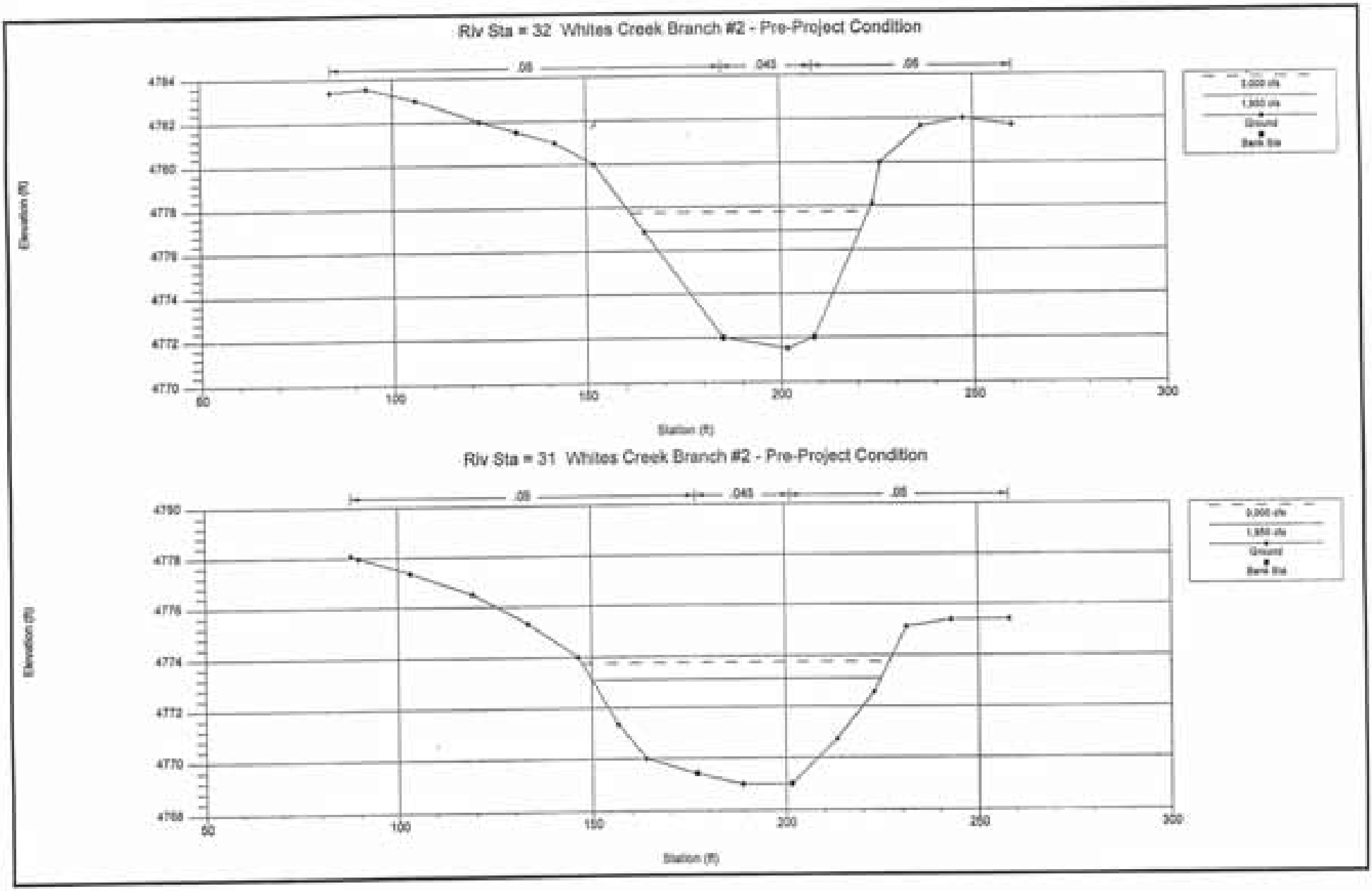
HEC-RAS Plan: Imported Pla Reach: 1 (continued)

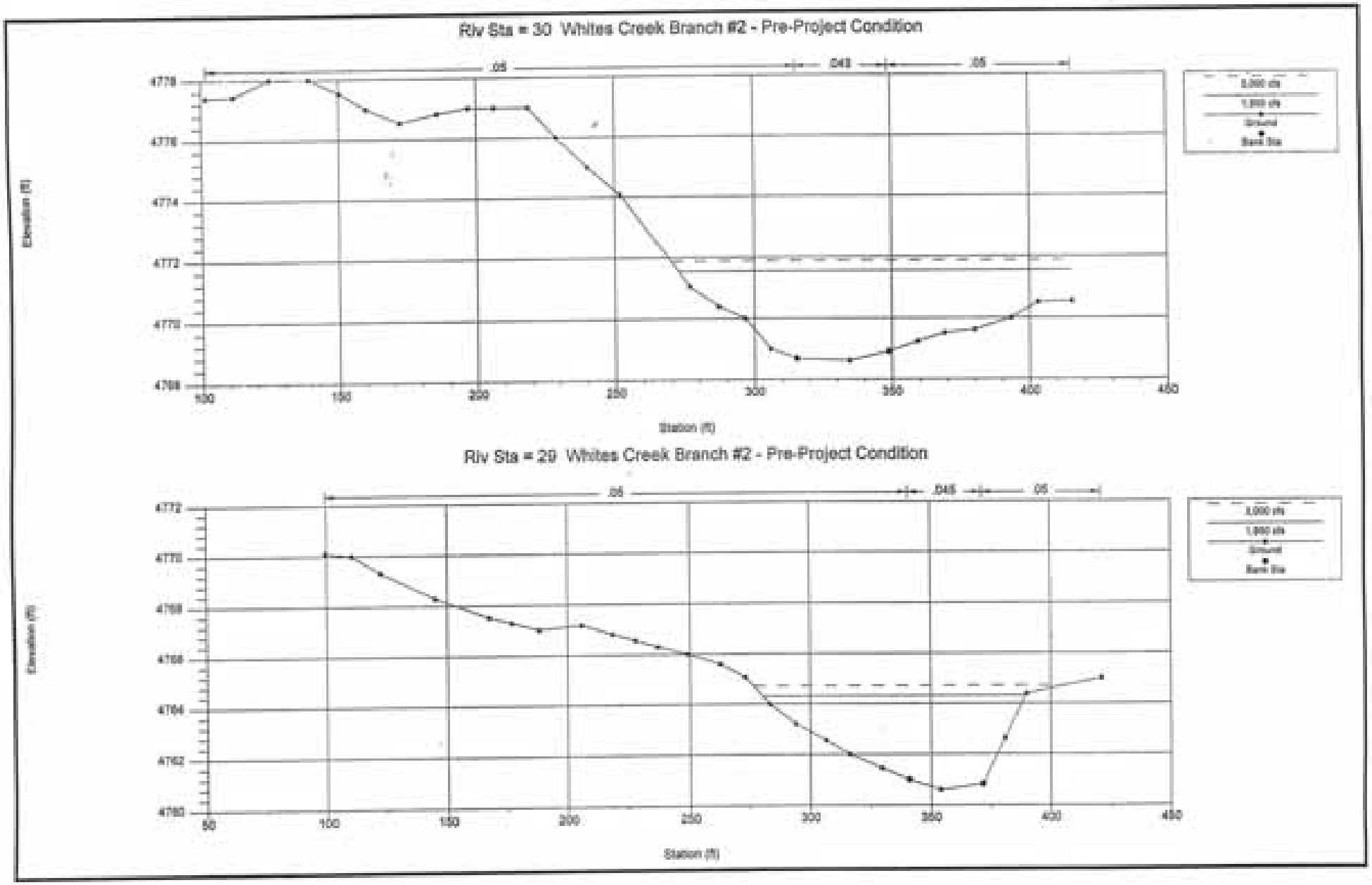
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
35	1950.00	4789.00	4796.84	4796.84	4799.08	0.016730	12.04	167.75	40.29	0.94
35	2591.00	4789.00	4797.90	4797.90	4800.43	0.015127	12.98	212.63	45.35	0.92
36	1950.00	4803.00	4808.43	4808.43	4809.96	0.016096	10.20	209.67	72.89	0.92
36	2591.00	4803.00	4809.01	4809.01	4810.90	0.016838	11.47	254.41	81.43	0.96
37	1950.00	4815.00	4820.56	4820.56	4821.25	0.007601	8.44	392.69	212.88	0.67
37	2887.00	4815.00	4821.00	4821.00	4821.90	0.009985	10.09	486.94	223.71	0.76
38	1950.00	4817.00	4823.49	4823.49	4825.27	0.013773	11.35	202.69	62.01	0.88
38	3000.00	4817.00	4824.89	4824.89	4826.92	0.012191	12.53	301.06	78.31	0.86

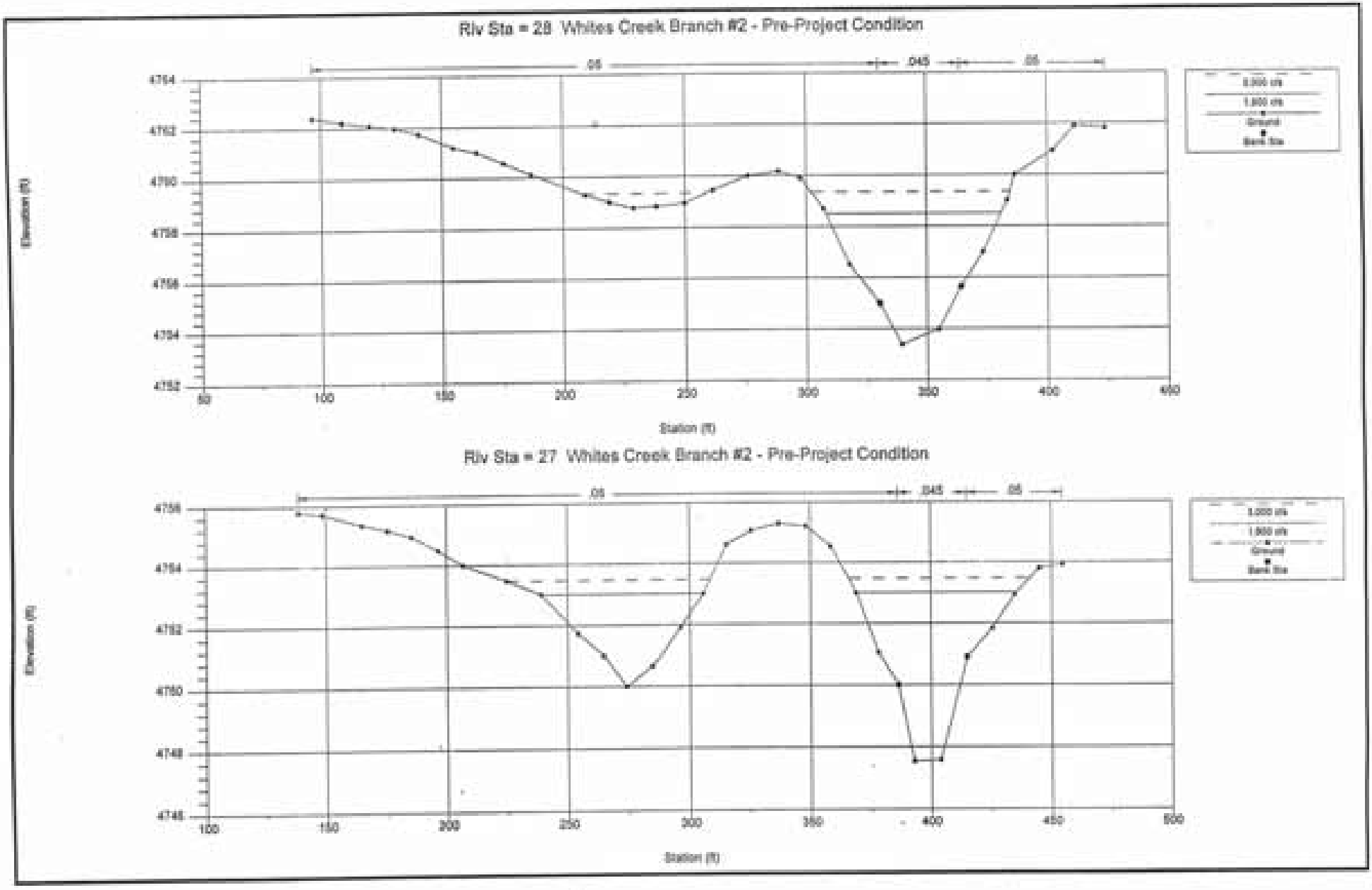

Riv Sta = 38 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
Elevation (ft)
4828
4826
4824
4822
4820
4818
4816
150
200
250
300
350
400
450
Station (ft)
Riv Sta = 37 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.08
Elevation (ft)
4822
4821
4820
4819
4818
4817
4816
4815
200
250
300
350
400
450
500
Station (ft)

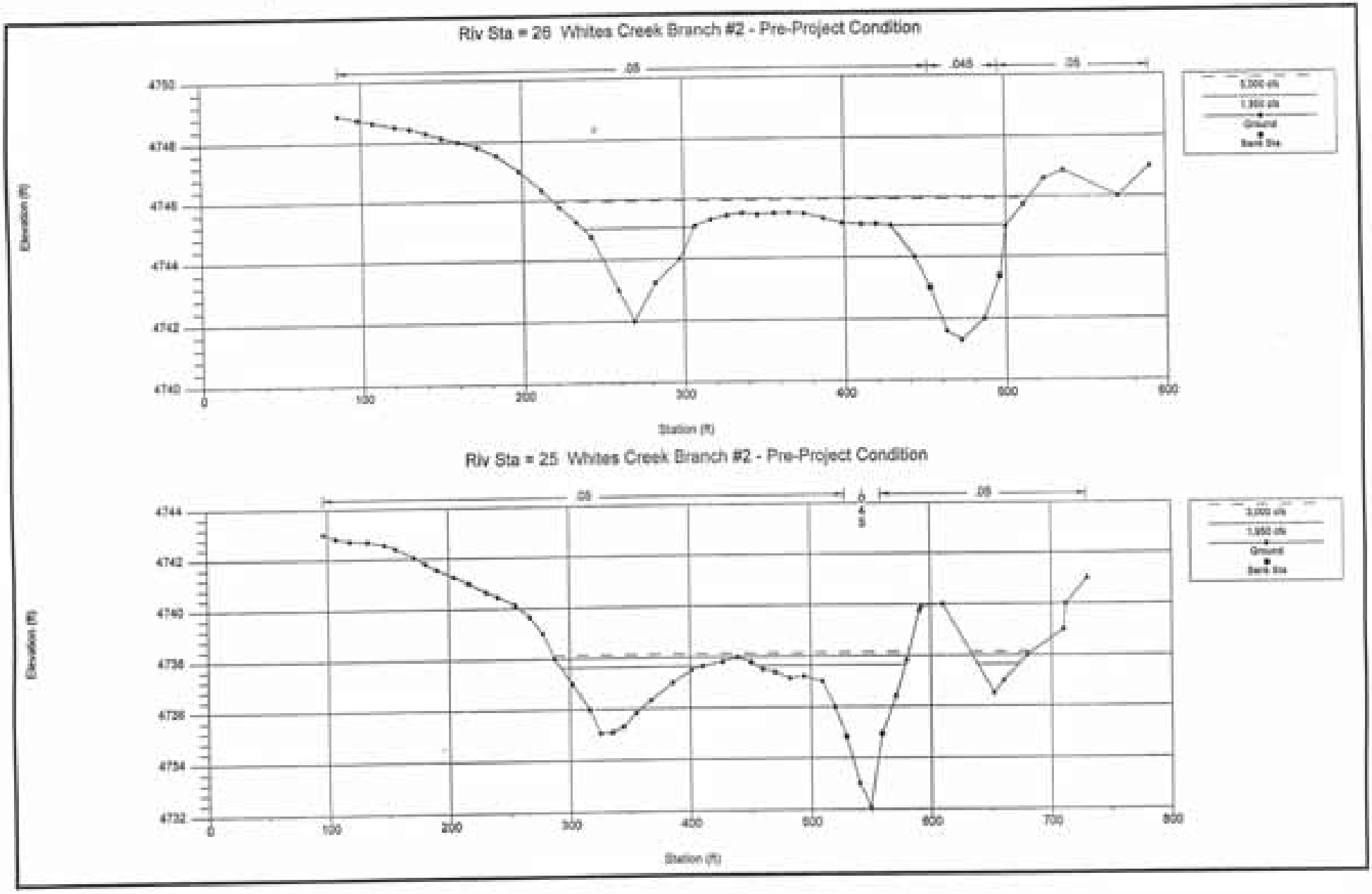

Riv Sta = 36 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4814
4812
4810
4808
4806
4804
4802
150
200
250
300
350
400
450
500
Station (ft)
Riv Sta = 35 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4815
4810
4805
4800
4795
4790
4785
150
200
250
300
350
400
450
Station (ft)

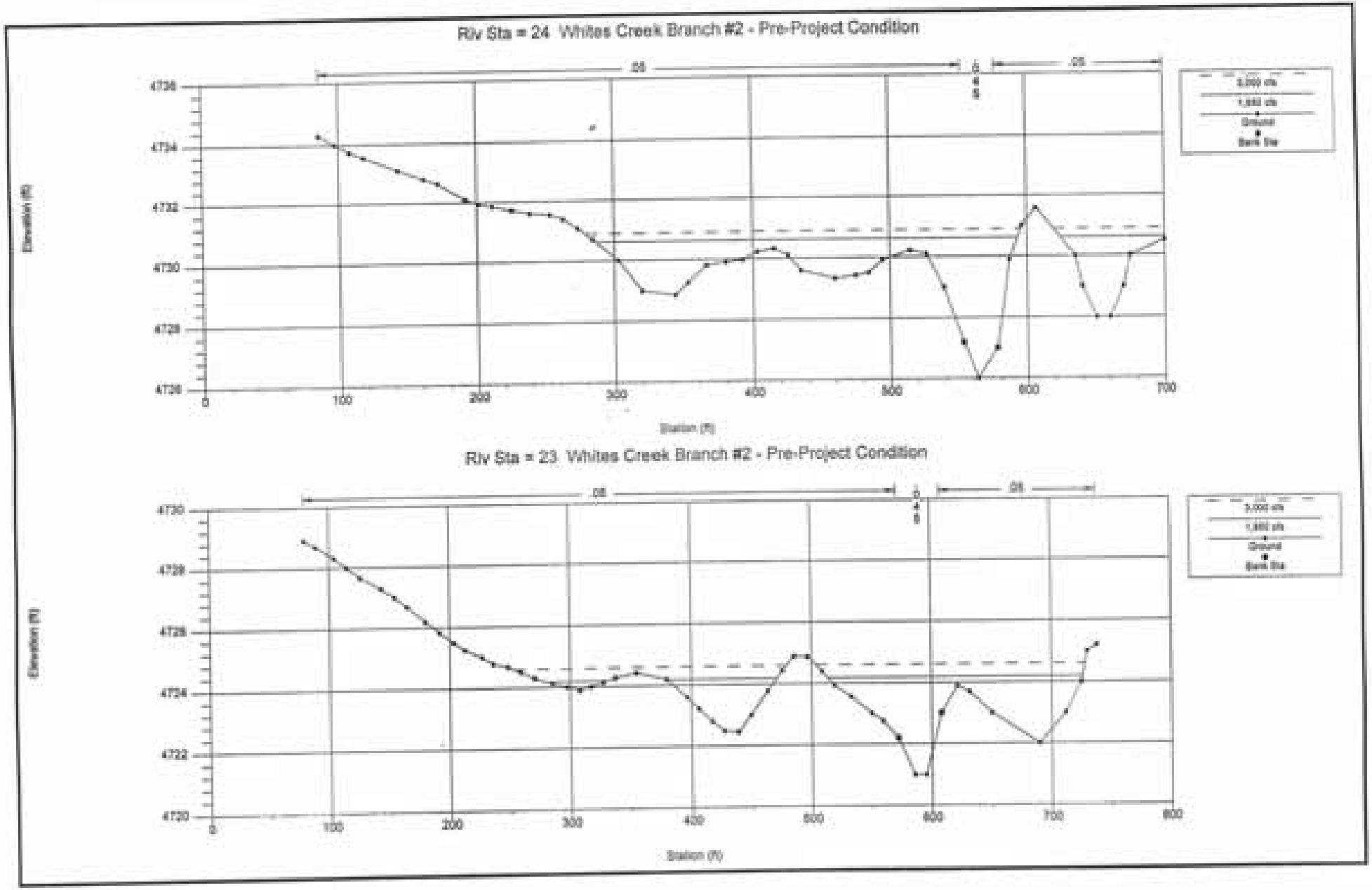

Riv Sta = 34 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4800
4795
4790
4785
4780
4775
100
150
200
250
300
350
400
450
Station (ft)
Riv Sta = 33 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4790
4785
4780
4775
4770
50
100
150
200
250
300
Station (ft)

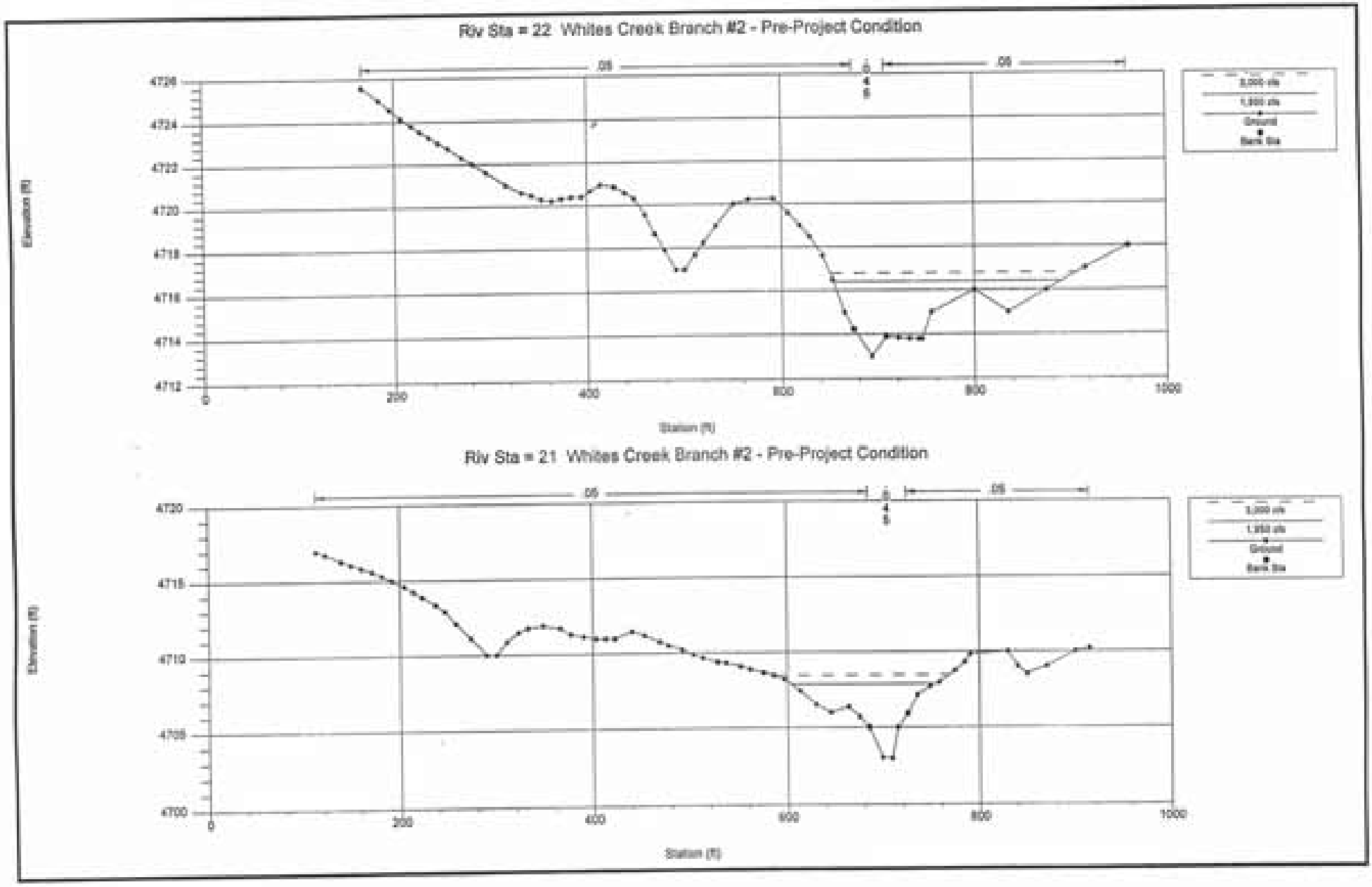

Riv Sta = 32 Whites Creek Branch #2 - Pre-Project Condition
.08
.045
.08
Elevation (ft)
Station (ft)
Riv Sta = 31 Whites Creek Branch #2 - Pre-Project Condition
.08
.045
.08
Elevation (ft)
Station (ft)

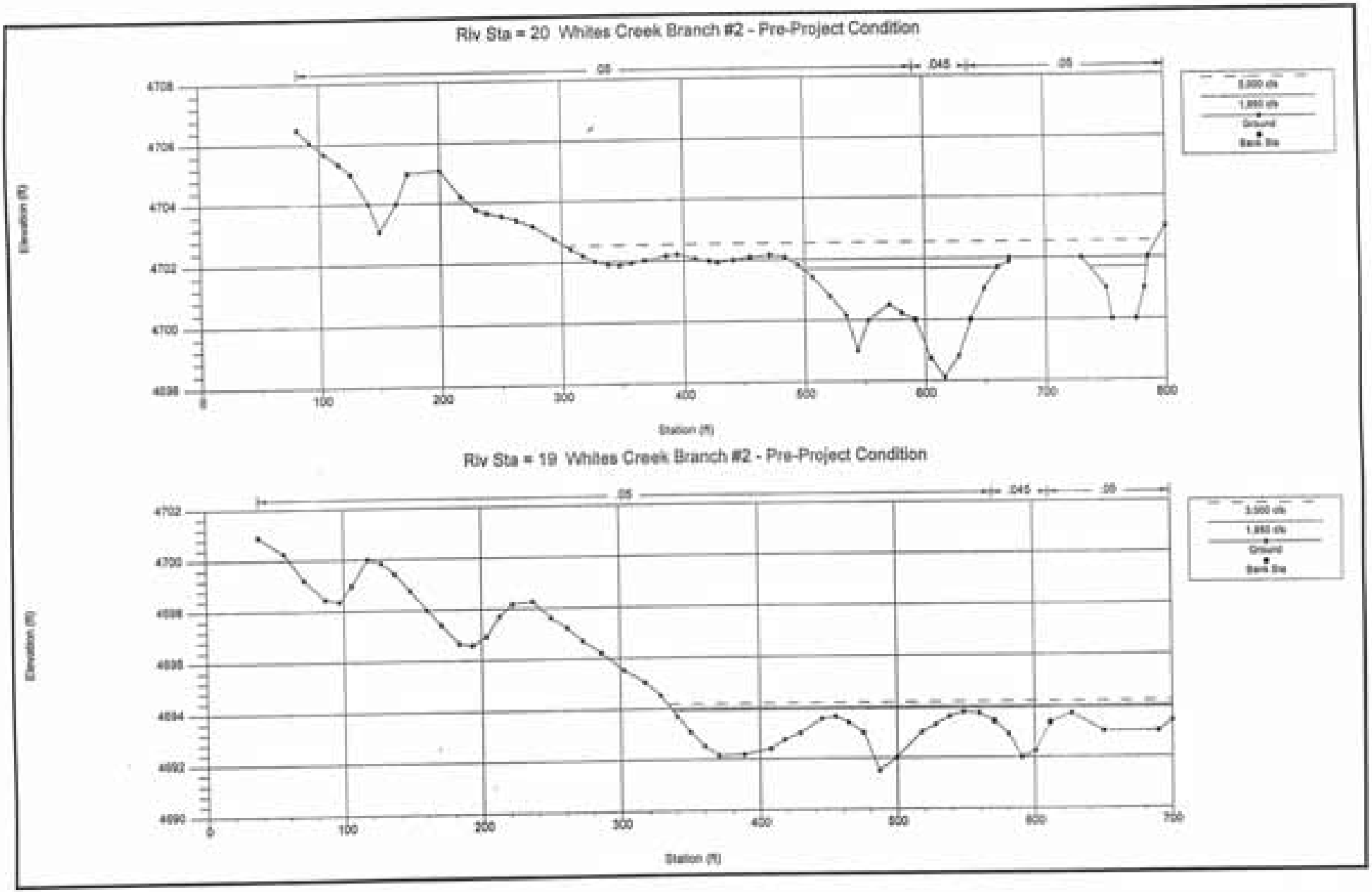

Riv Sta = 30 Whites Creek Branch #2 - Pre-Project Condition
.05
.048
.05
Elevation (ft)
Station (ft)
Riv Sta = 29 Whites Creek Branch #2 - Pre-Project Condition
.05
.048
.05
Elevation (ft)
Station (ft)

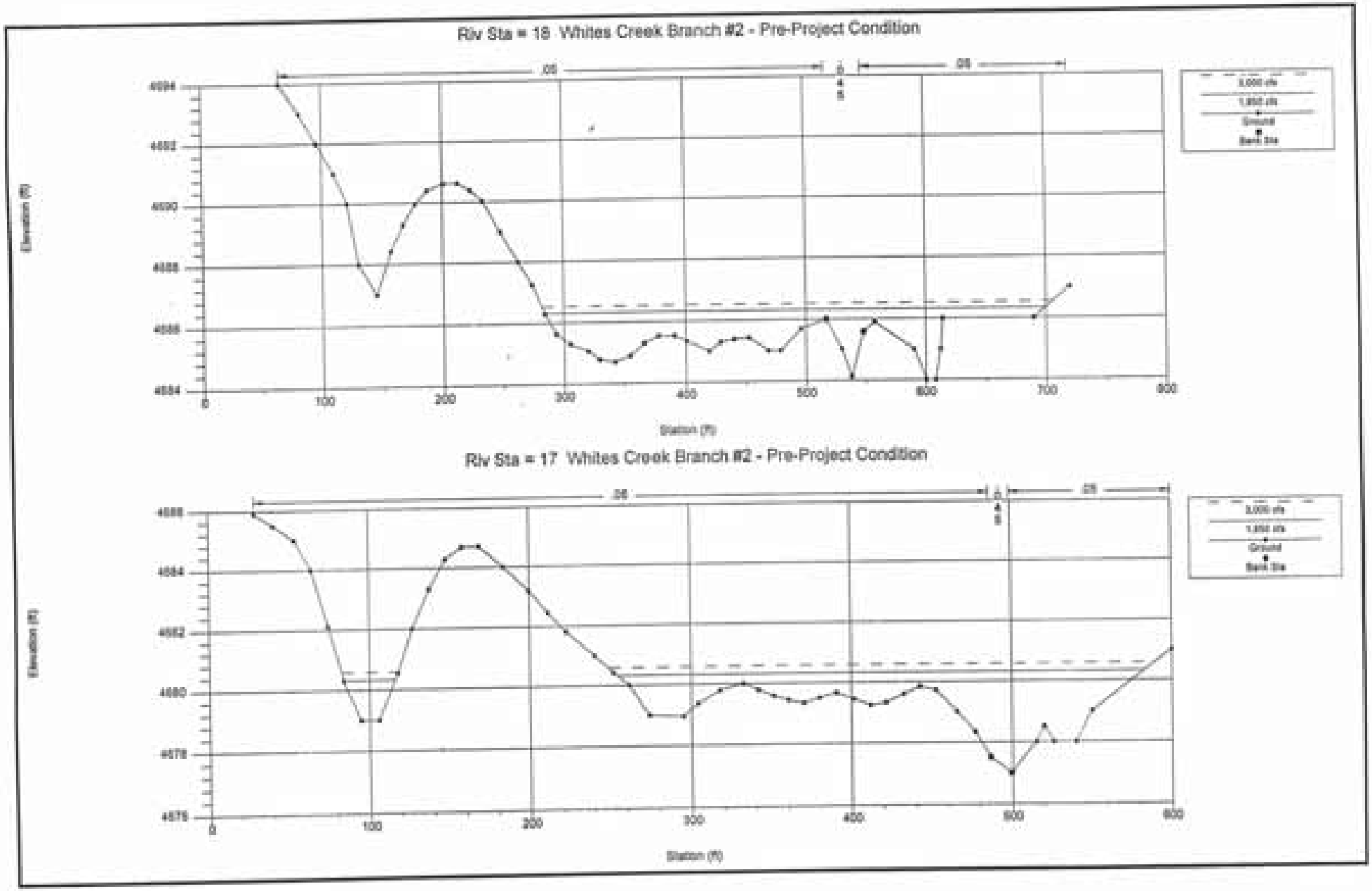

Riv Sta = 28 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4754
4752
4750
4748
4746
50
100
150
200
250
300
350
400
450
Station (ft)
Riv Sta = 27 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4756
4754
4752
4750
4748
4746
100
150
200
250
300
350
400
450
500
Station (ft)

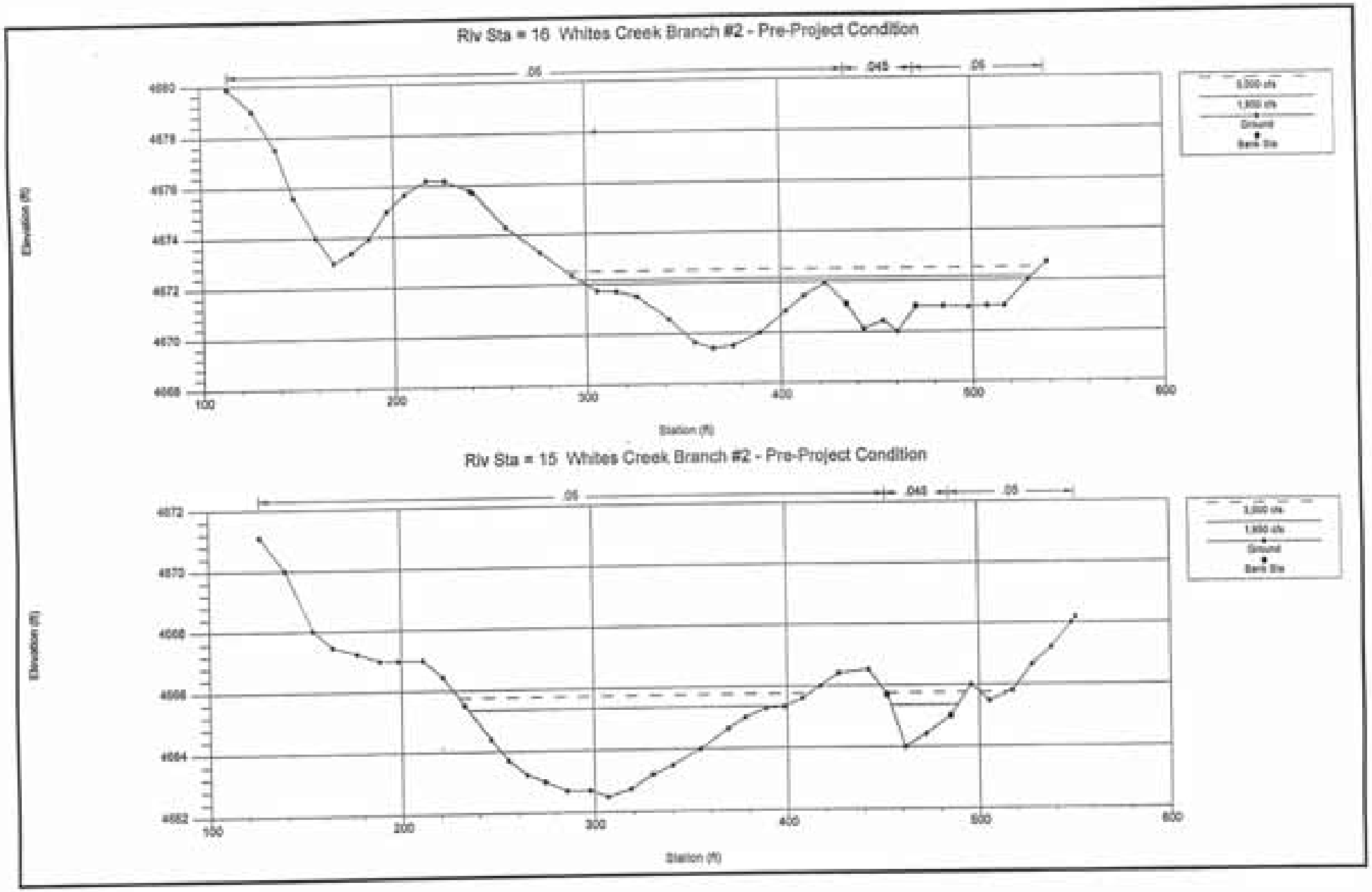

Riv Sta = 26 Whites Creek Branch #2 - Pre-Project Condition
.08
.045
.05
4750
4748
4746
4744
4742
4740
0
100
200
300
400
500
600
Station (ft)
Elevation (ft)
Riv Sta = 25 Whites Creek Branch #2 - Pre-Project Condition
.05
.05
4744
4742
4740
4738
4736
4734
4732
0
100
200
300
400
500
600
700
800
Station (ft)
Elevation (ft)

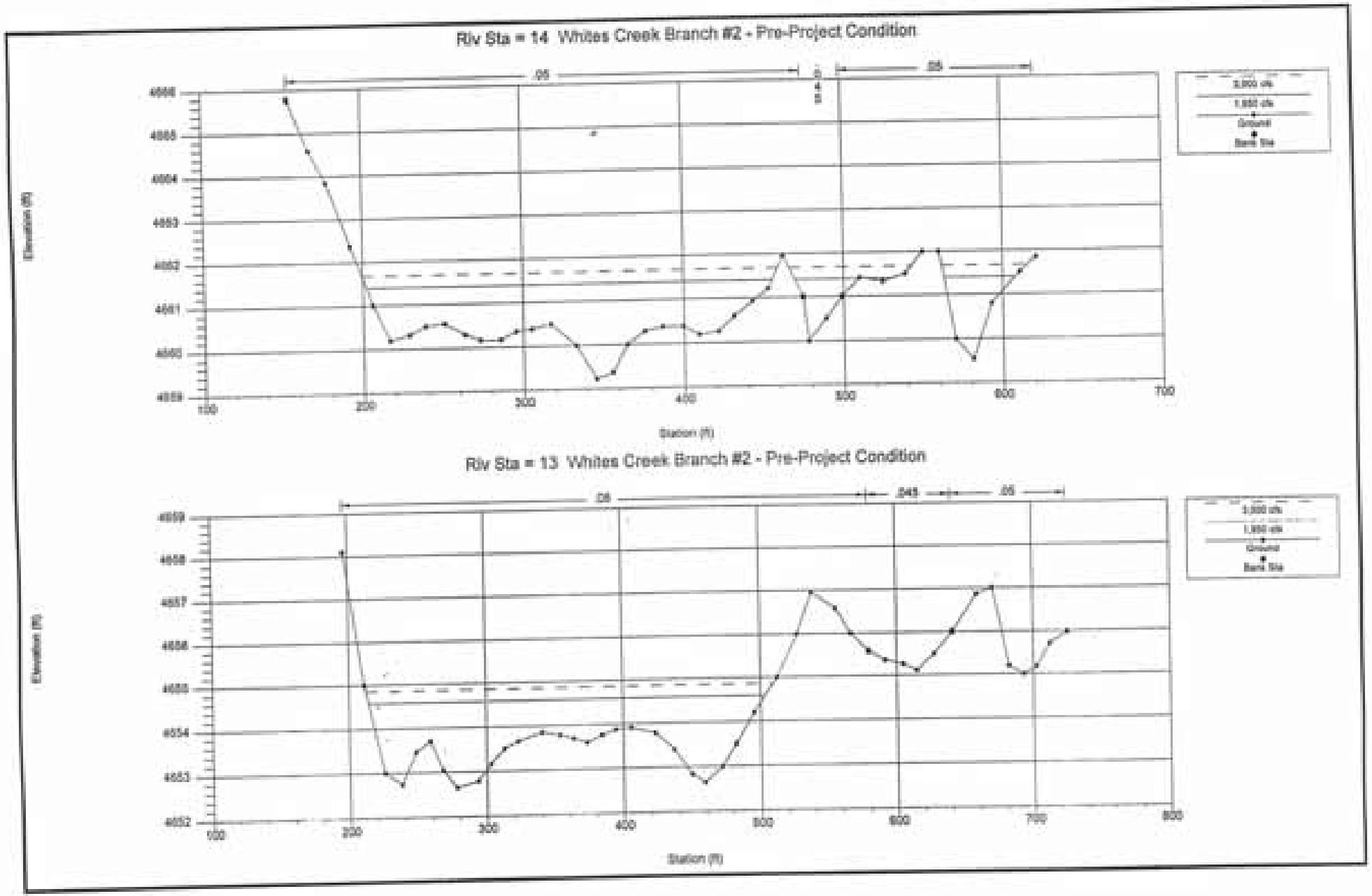

Riv Sta = 24 Whites Creek Branch #2 - Pre-Project Condition
Elevation (ft)
Station (ft)
Riv Sta = 23 Whites Creek Branch #2 - Pre-Project Condition
Elevation (ft)
Station (ft)


Riv Sta = 22 Whites Creek Branch #2 - Pre-Project Condition
.05
.05
4726
4724
4722
4720
4718
4716
4714
4712
0
200
400
600
800
1000
Station (ft)
Riv Sta = 21 Whites Creek Branch #2 - Pre-Project Condition
.05
.05
4720
4715
4710
4705
4700
0
200
400
600
800
1000
Station (ft)


Riv Sta = 20 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
3,000 cfs
1,850 cfs
Ground
Bank Sta
Elevation (ft)
4708
4706
4704
4702
4700
4698
0
100
200
300
400
500
600
700
800
Station (ft)
Riv Sta = 19 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
3,000 cfs
1,850 cfs
Ground
Bank Sta
Elevation (ft)
4702
4700
4698
4696
4694
4692
4690
0
100
200
300
400
500
600
700
Station (ft)

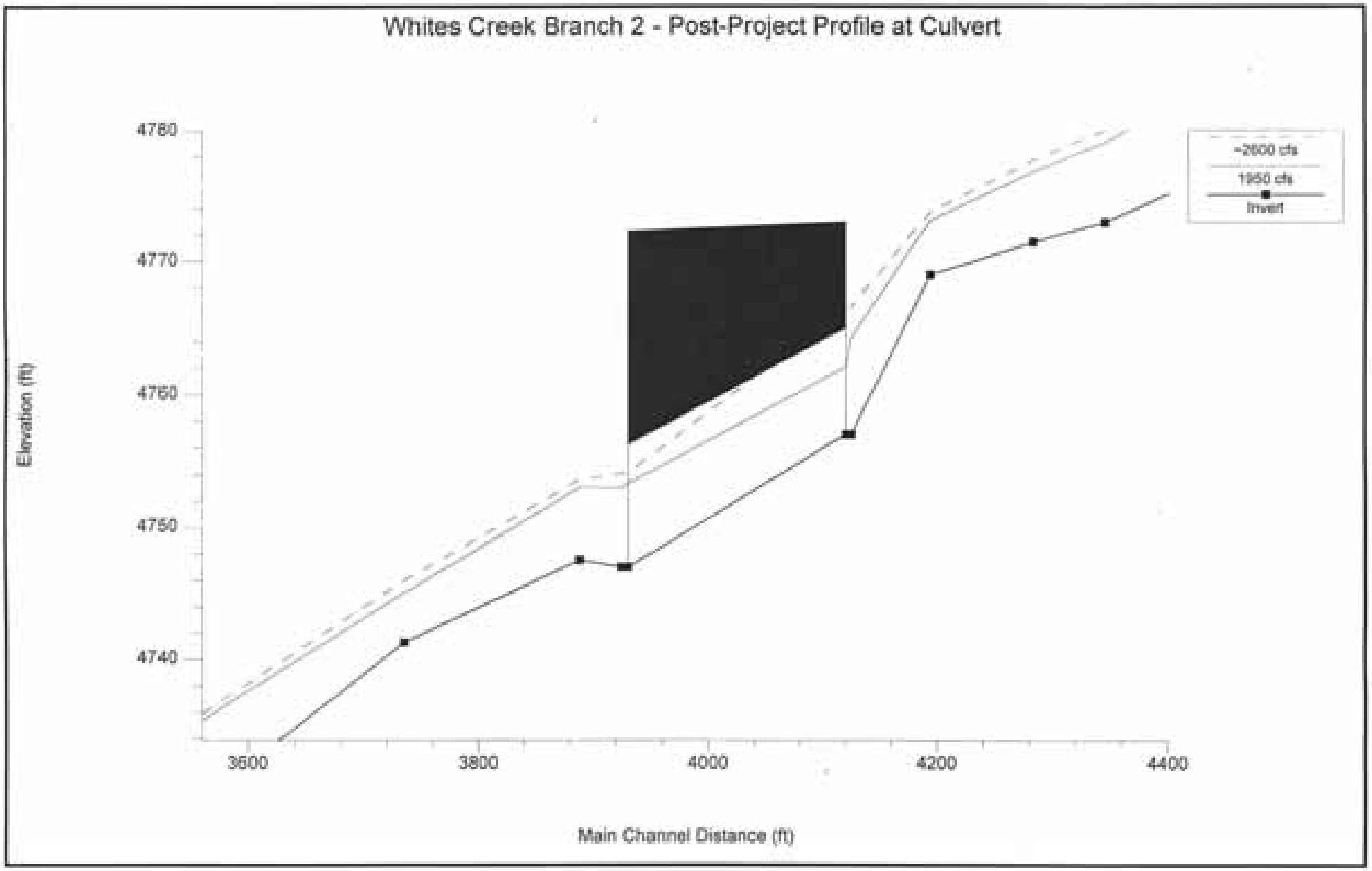

Riv Sta = 18 Whites Creek Branch #2 - Pre-Project Condition
Elevation (ft)
4594
4592
4590
4588
4586
4584
0
100
200
300
400
500
600
700
800
Station (ft)
Riv Sta = 17 Whites Creek Branch #2 - Pre-Project Condition
Elevation (ft)
4584
4582
4580
4578
4575
0
100
200
300
400
500
600
Station (ft)

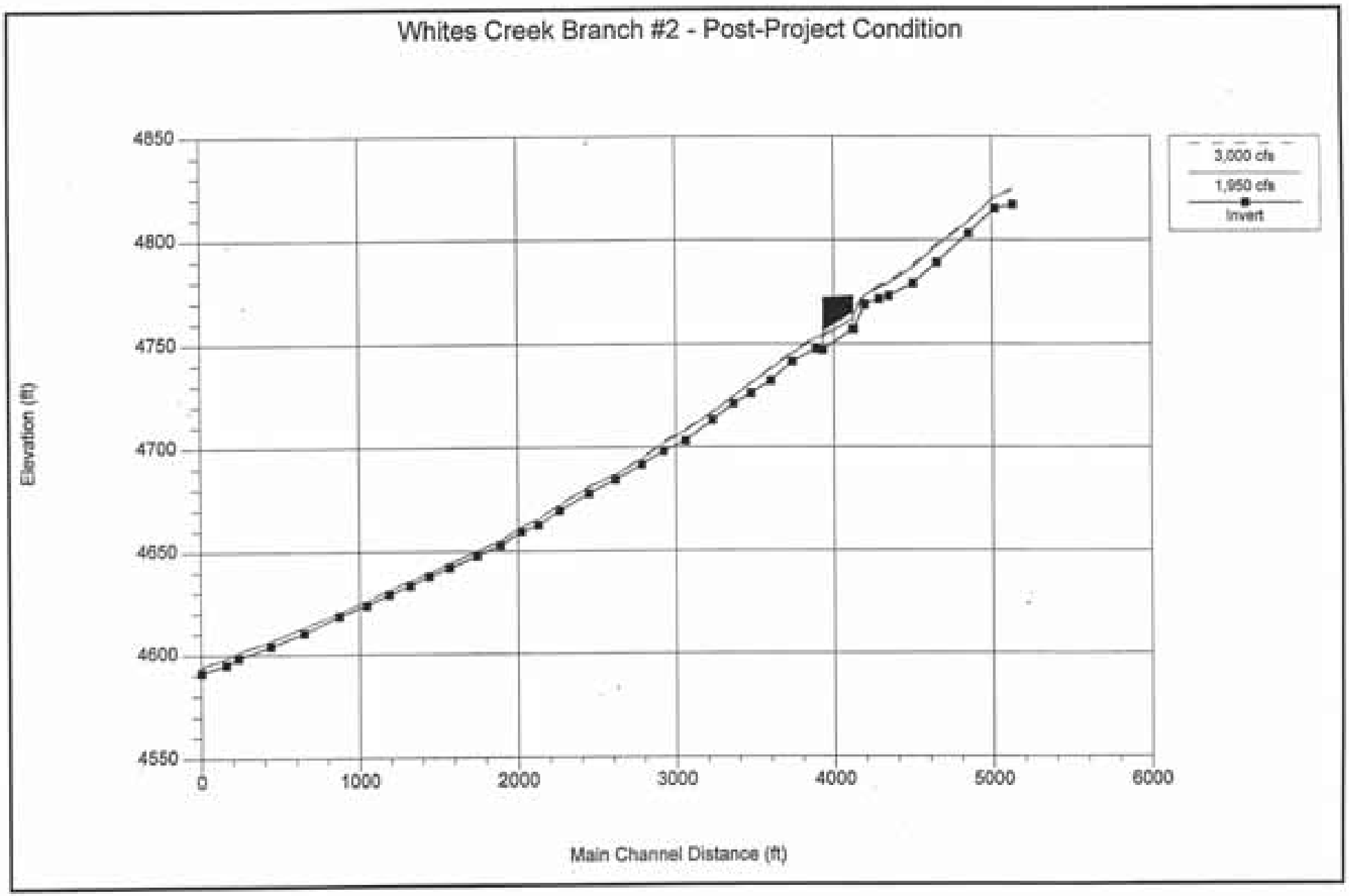

Riv Sta = 16 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4682
4678
4676
4674
4672
4670
4668
Elevation (ft)
100
200
300
400
500
600
Station (ft)
Riv Sta = 15 Whites Creek Branch #2 - Pre-Project Condition
.05
.045
.05
4672
4670
4668
4666
4664
4662
Elevation (ft)
100
200
300
400
500
600
Station (ft)


Riv Sta = 14 Whites Creek Branch #2 - Pre-Project Condition
.05
.05
4658
4657
4656
4655
4654
4653
4652
4651
4650
4649
100
200
300
400
500
600
700
Station (ft)
Riv Sta = 13 Whites Creek Branch #2 - Pre-Project Condition
.06
.045
.05
4659
4658
4657
4656
4655
4654
4653
4652
100
200
300
400
500
600
700
800
Station (ft)

Appendix D

Sub-Section 2
Whites Creek Branch 2
Post-Project Condition Analysis


Whites Creek Branch 2 - Post-Project Profile at Culvert
4780
4770
4760
4750
4740
Elevation (ft)
3600
3800
4000
4200
4400
Main Channel Distance (ft)
~2600 cfs
1950 cfs
Invert


Whites Creek Branch #2 - Post-Project Condition
4850
4800
4750
4700
4650
4600
4550
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)
3,000 cfs
1,950 cfs
Invert

HEC-RAS Plan: Imported Pla Reach: 1

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
1	1950.00	4592.18	4594.00	4594.00	4594.39	0.024884	5.51	395.63	508.79	0.93
1	2737.00	4592.18	4594.25	4594.25	4594.65	0.024207	6.25	551.30	696.37	0.95
2	1950.00	4595.00	4598.13	4598.13	4598.46	0.024933	7.10	563.19	782.47	0.99
2	2737.00	4595.00	4598.33	4598.33	4598.70	0.025854	7.83	731.02	886.25	1.03
3	1950.00	4599.00	4601.22	4601.22	4601.69	0.029433	7.12	374.79	414.42	1.05
3	2737.00	4599.00	4601.52	4601.52	4602.02	0.025608	7.54	512.01	483.12	1.01
4	1950.00	4605.00	4606.32	4606.17	4606.69	0.023218	5.43	400.92	374.83	0.90
4	2737.00	4605.00	4606.53	4606.45	4607.04	0.027078	6.53	484.14	410.69	1.00
5	1950.00	4610.32	4613.16	4613.16	4613.57	0.019731	6.50	421.02	465.36	0.89
5	2737.00	4610.32	4613.42	4613.42	4613.90	0.020403	7.29	544.17	476.70	0.93
6	1950.00	4619.44	4620.24	4620.24	4620.55	0.033900	3.45	445.91	681.00	0.93
6	2737.00	4619.44	4620.43	4620.43	4620.78	0.032122	4.17	581.18	765.63	0.95
7	1950.00	4624.00	4625.75	4625.72	4626.10	0.031059	6.54	475.72	584.32	1.06
7	2737.00	4624.00	4625.93	4625.93	4626.38	0.033445	7.46	564.18	616.96	1.12
8	1950.00	4629.07	4630.92	4630.92	4631.32	0.029034	7.25	409.64	490.12	1.06
8	2737.00	4629.07	4631.13	4631.13	4631.62	0.029106	7.93	514.10	510.29	1.08
9	1950.00	4633.57	4635.43	4635.43	4635.82	0.027233	7.58	426.81	539.76	1.04
9	2737.00	4633.57	4635.61	4635.61	4636.09	0.029508	8.48	632.51	590.20	1.10
10	1950.00	4638.62	4639.36	4639.36	4639.70	0.034842	4.50	421.03	611.15	1.00
10	2737.00	4638.62	4639.56	4639.54	4639.95	0.036109	5.49	547.09	665.70	1.07
11	1950.00	4643.58	4644.00	4644.00	4644.41	0.036171	3.07	384.05	477.04	0.93
11	2737.00	4643.58	4644.20	4644.20	4644.70	0.036070	4.20	487.28	509.30	1.00
12	1950.00	4649.40	4649.83	4649.83	4650.31	0.031174	2.72	357.81	392.48	0.85

HEC-RAS Plan: Imported Pla Reach: 1 (continued)

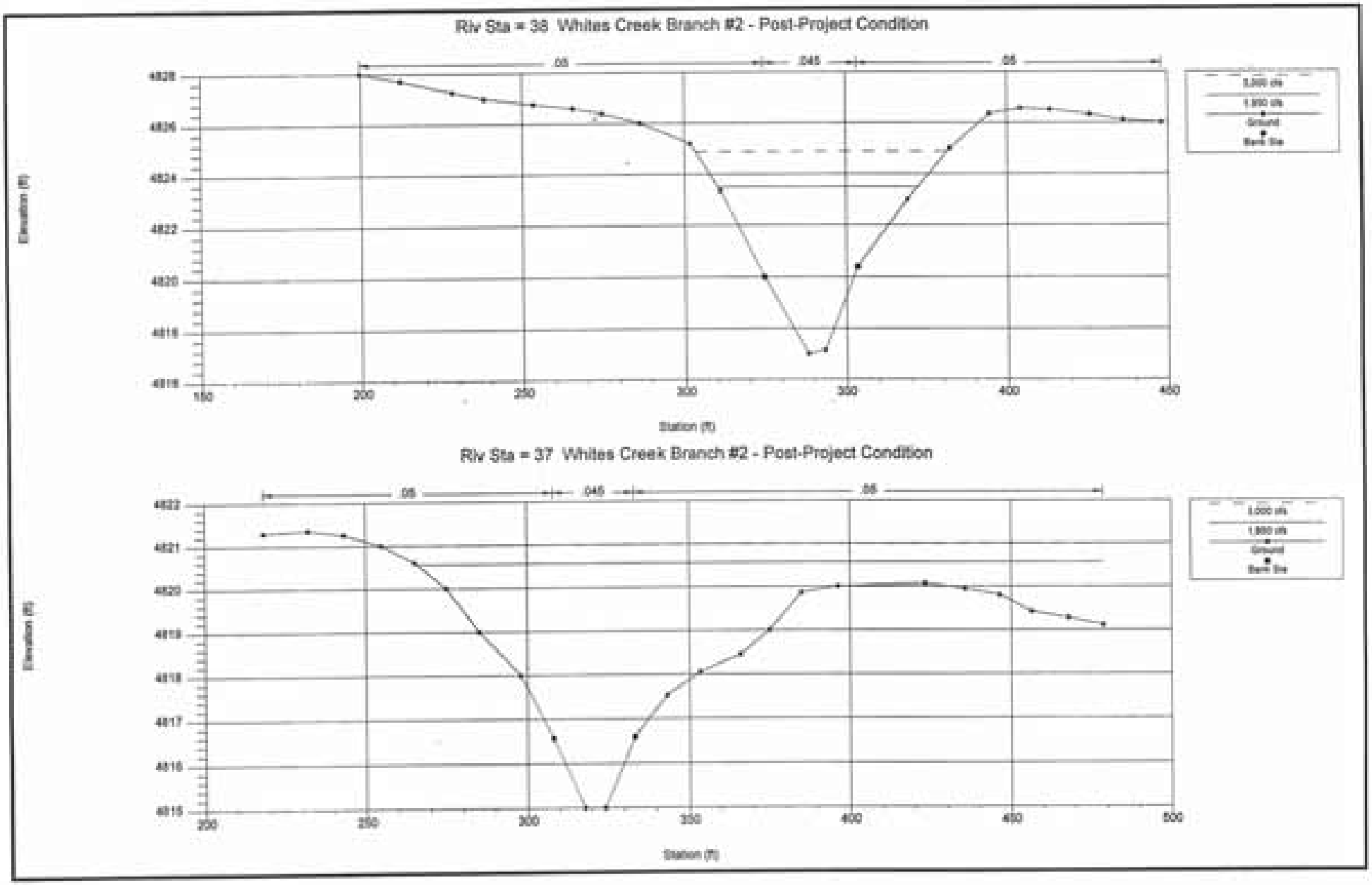
River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
12	2737.00	4649.40	4650.11	4650.11	4650.84	0.031706	4.09	469.99	424.11	0.95
13	1950.00	4655.12	4654.56	4654.56	4655.13	0.033430		329.28	289.14	0.00
13	2737.00	4655.12	4654.86	4654.86	4655.55	0.032949		409.70	297.01	0.00
14	1950.00	4660.00	4661.40	4661.40	4661.90	0.033771	5.64	344.18	355.16	1.05
14	2737.00	4660.00	4661.68	4661.68	4662.27	0.031076	6.47	448.70	380.18	1.05
15	1950.00	4664.00	4665.35	4665.35	4666.05	0.027237	4.79	295.05	199.48	0.93
15	2737.00	4664.00	4665.76	4665.76	4666.57	0.026827	6.00	382.72	239.35	0.98
16	1950.00	4670.00	4672.16	4672.16	4672.79	0.026870	7.85	315.69	235.02	1.04
16	2737.00	4670.00	4672.51	4672.51	4673.28	0.026843	8.69	400.08	246.72	1.06
17	1950.00	4677.00	4680.32	4680.32	4680.79	0.016044	8.83	421.73	361.16	0.89
17	2737.00	4677.00	4680.58	4680.58	4681.15	0.018009	9.87	516.83	376.35	0.95
18	1950.00	4684.12	4686.32	4686.32	4686.75	0.030356	6.72	383.74	415.67	1.05
18	2737.00	4684.12	4686.53	4686.53	4687.08	0.031335	7.55	471.30	424.24	1.09
19	1950.00	4692.00	4693.93	4693.93	4694.42	0.031556	6.93	389.49	383.18	1.08
19	2737.00	4692.00	4694.18	4694.18	4694.78	0.030232	7.63	450.20	386.85	1.08
20	1950.00	4698.11	4701.69	4701.69	4702.47	0.017420	8.62	320.20	209.58	0.91
20	2737.00	4698.11	4702.53	4702.53	4703.05	0.009863	7.74	638.51	490.65	0.71
21	1950.00	4703.00	4707.87	4707.87	4708.86	0.013431	9.11	288.73	150.47	0.83
21	2737.00	4703.00	4708.46	4708.46	4709.59	0.013447	10.06	386.44	182.78	0.85
22	1950.00	4713.00	4716.40	4716.40	4717.07	0.016883	8.62	348.24	237.79	0.90
22	2737.00	4713.00	4716.78	4716.78	4717.56	0.017171	9.46	443.09	256.61	0.93
23	1950.00	4721.00	4724.19	4724.19	4724.74	0.016902	8.10	390.61	355.63	0.88
23	2737.00	4721.00	4724.60	4724.60	4725.15	0.014652	8.32	562.40	451.19	0.84

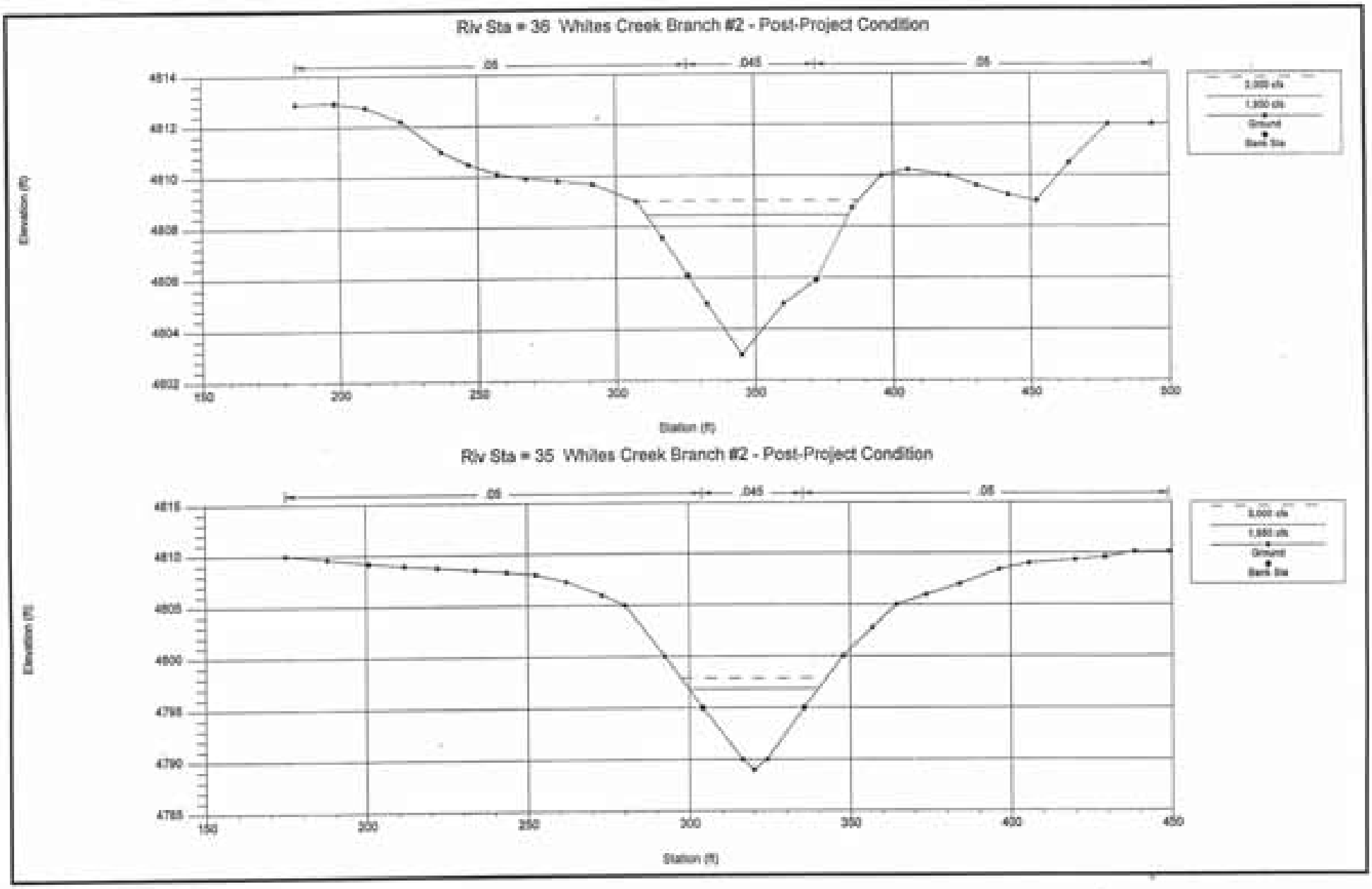
HEC-RAS Plan: Imported Pla Reach: 1 (continued)

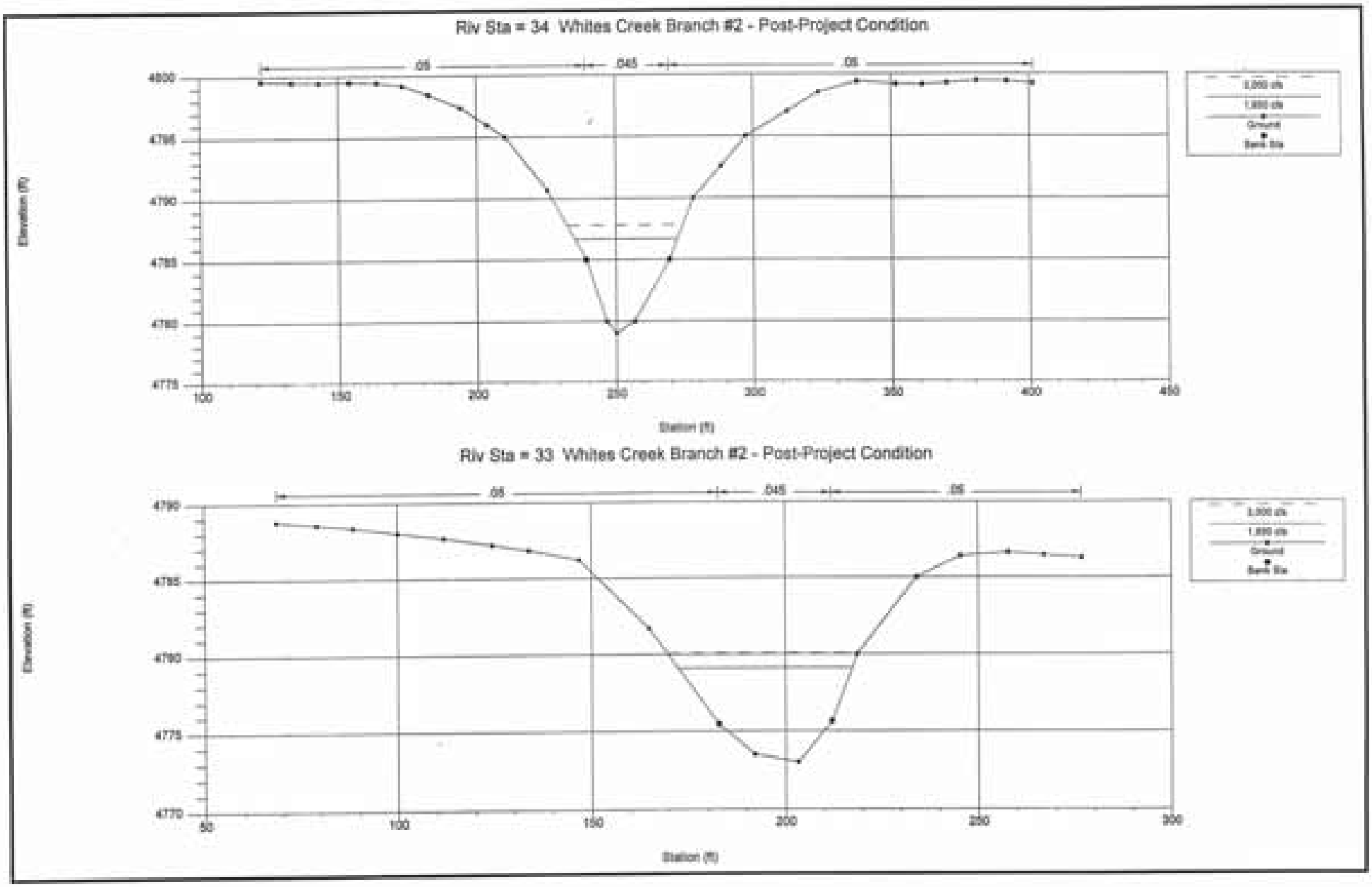
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
24	1950.00	4726.00	4730.62	4730.62	4731.12	0.009224	8.07	481.85	382.49	0.70
24	2737.00	4726.00	4730.89	4730.89	4731.48	0.010733	9.09	669.82	397.73	0.77
25	1950.00	4732.08	4737.65	4737.65	4738.41	0.010587	8.84	379.87	276.16	0.75
25	2457.00	4732.08	4738.13	4738.13	4738.76	0.008435	8.48	534.74	347.17	0.68
26	1950.00	4741.30	4745.05	4745.05	4746.16	0.019595	9.73	261.53	141.11	0.96
26	2457.00	4741.30	4745.95	4745.95	4746.62	0.009958	8.22	479.16	294.73	0.73
27	1950.00	4747.54	4753.01	4753.01	4754.09	0.012389	9.83	285.82	133.54	0.82
27	2457.00	4747.54	4753.47	4753.47	4754.64	0.012422	10.50	352.96	169.02	0.83
28	1950.00	4753.37	4758.49	4758.49	4760.02	0.014660	10.69	217.08	72.65	0.90
28	2457.00	4753.37	4759.34	4759.34	4760.74	0.011438	10.56	301.16	133.51	0.81
29	1950.00	4760.60	4764.30	4764.30	4765.42	0.017163	10.06	254.59	109.31	0.94
29	2457.00	4760.60	4764.71	4764.71	4766.03	0.017840	11.05	303.24	130.25	0.98
30	1950.00	4768.60	4771.54	4771.54	4772.42	0.019284	9.23	279.64	142.90	0.96
30	2517.00	4768.60	4771.88	4771.88	4772.93	0.019673	10.04	328.41	145.68	0.99
31	1950.00	4769.00	4773.11	4773.11	4774.53	0.017903	11.15	219.19	74.90	0.98
31	2591.00	4769.00	4773.75	4773.75	4775.42	0.017511	12.17	268.95	79.52	0.99
32	1950.00	4771.50	4776.89	4776.89	4778.69	0.014801	11.95	200.25	56.00	0.93
32	2591.00	4771.50	4777.75	4777.75	4779.81	0.014132	12.95	251.09	61.74	0.93
33	1950.00	4773.00	4779.11	4779.11	4781.20	0.015204	11.98	179.16	45.07	0.93
33	2591.00	4773.00	4780.07	4780.07	4782.49	0.014329	13.03	224.31	49.38	0.93
34	1950.00	4779.00	4786.68	4786.68	4789.01	0.017323	12.31	162.76	37.23	0.95
34	2591.00	4779.00	4787.80	4787.80	4790.45	0.015423	13.23	206.96	41.91	0.93

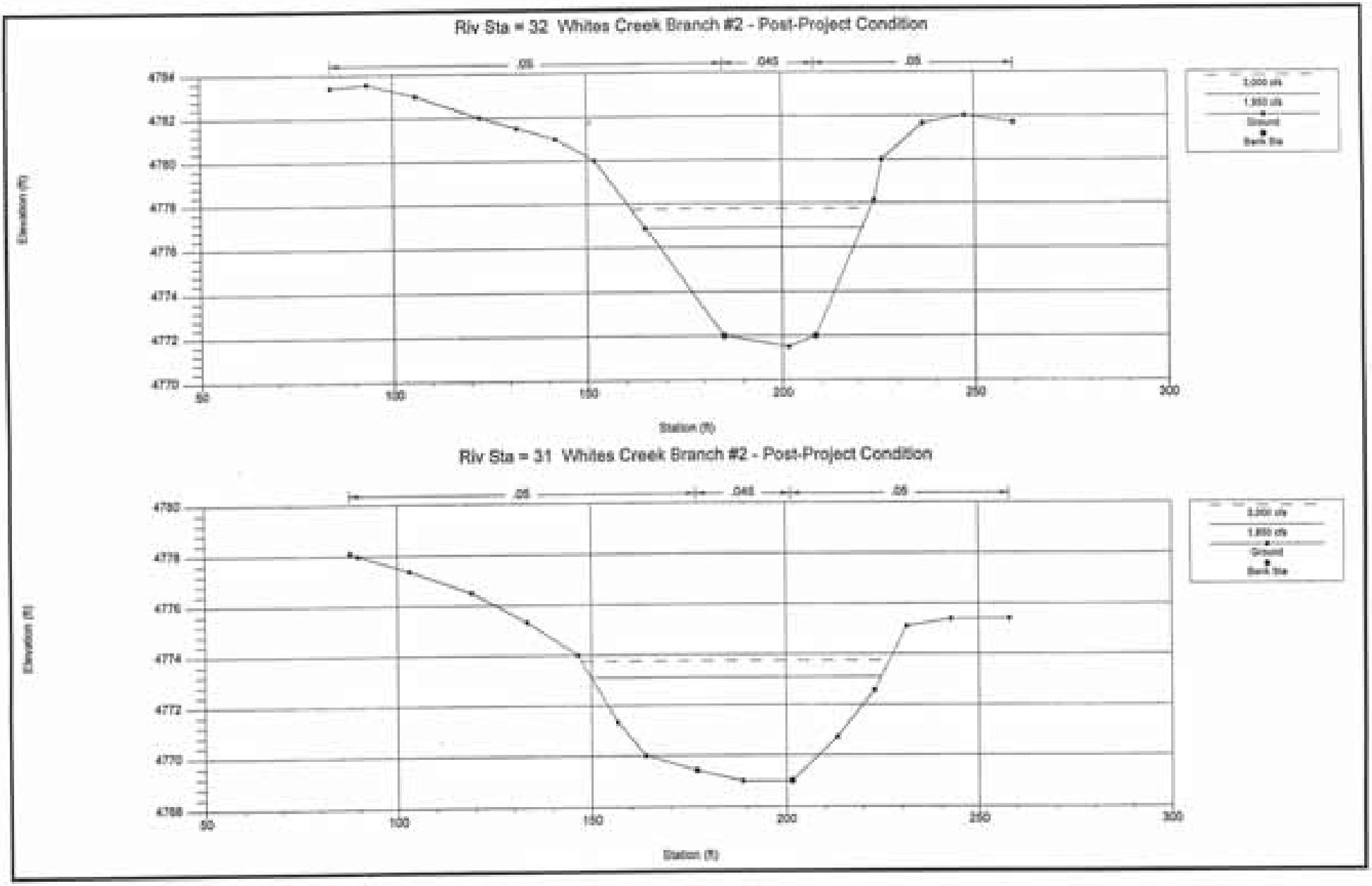
HEC-RAS Plan: Imported Pla Reach: 1 (continued)

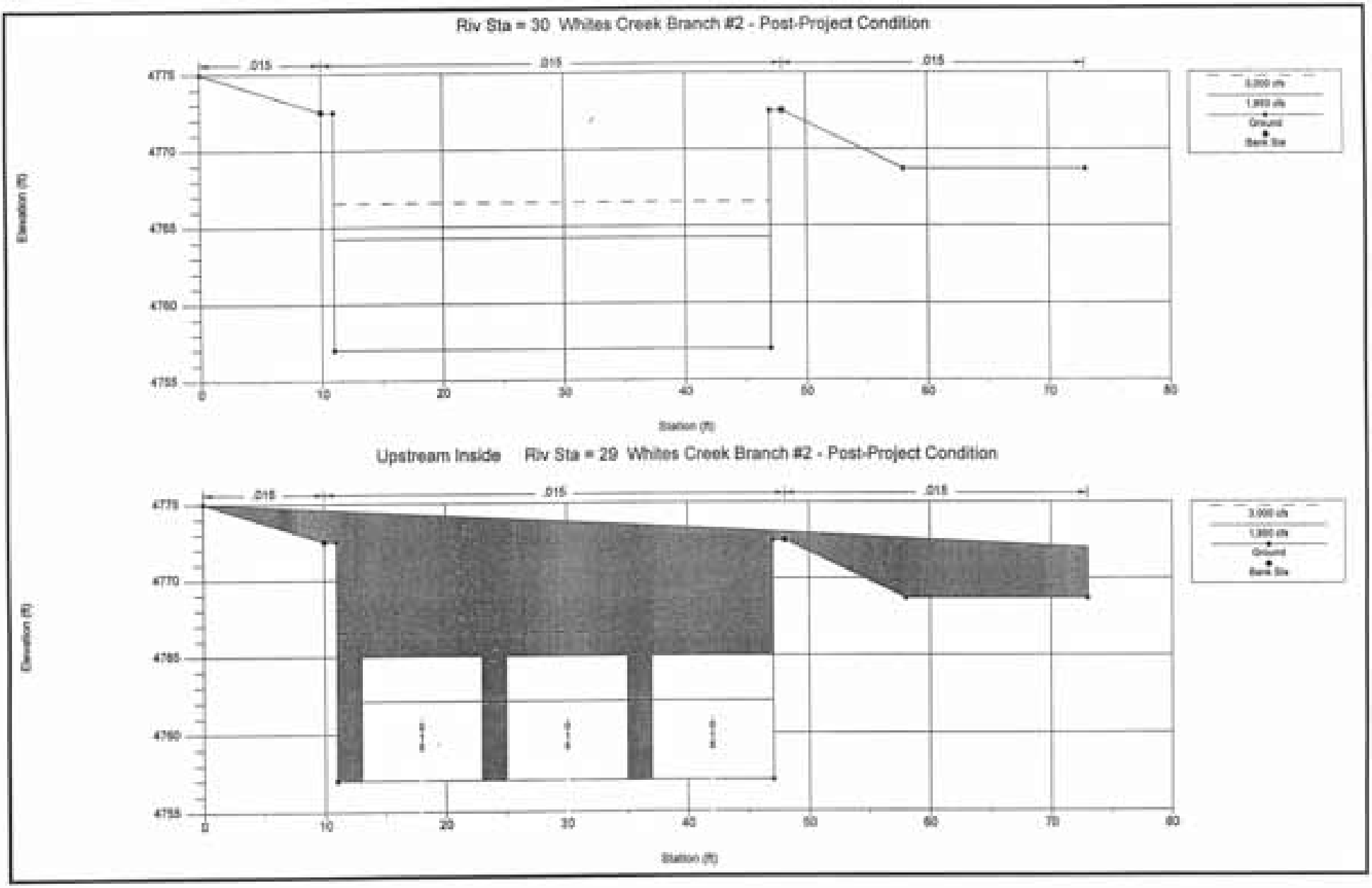
River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
35	1950.00	4789.00	4796.84	4796.84	4799.06	0.016730	12.04	167.75	40.29	0.94
35	2591.00	4789.00	4797.90	4797.90	4800.43	0.015127	12.98	212.83	45.35	0.92
36	1950.00	4803.00	4808.43	4808.43	4809.96	0.016096	10.20	209.87	72.89	0.92
36	2591.00	4803.00	4809.01	4809.01	4810.90	0.016838	11.47	254.41	81.43	0.96
37	1950.00	4815.00	4820.56	4820.56	4821.25	0.007801	8.44	392.89	212.88	0.67
37	2887.00	4815.00	4821.00	4821.00	4821.90	0.009985	10.09	486.94	223.71	0.76
38	1950.00	4817.00	4823.49	4823.49	4825.27	0.013773	11.35	202.89	62.01	0.88
38	3000.00	4817.00	4824.89	4824.89	4826.92	0.012191	12.53	301.06	78.31	0.86


Riv Sta = 38 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
4828
4826
4824
4822
4820
4818
4816
150
200
250
300
350
400
450
Elevation (ft)
Station (ft)
Riv Sta = 37 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
4822
4821
4820
4819
4818
4817
4816
4815
300
350
300
350
400
450
500
Elevation (ft)
Station (ft)

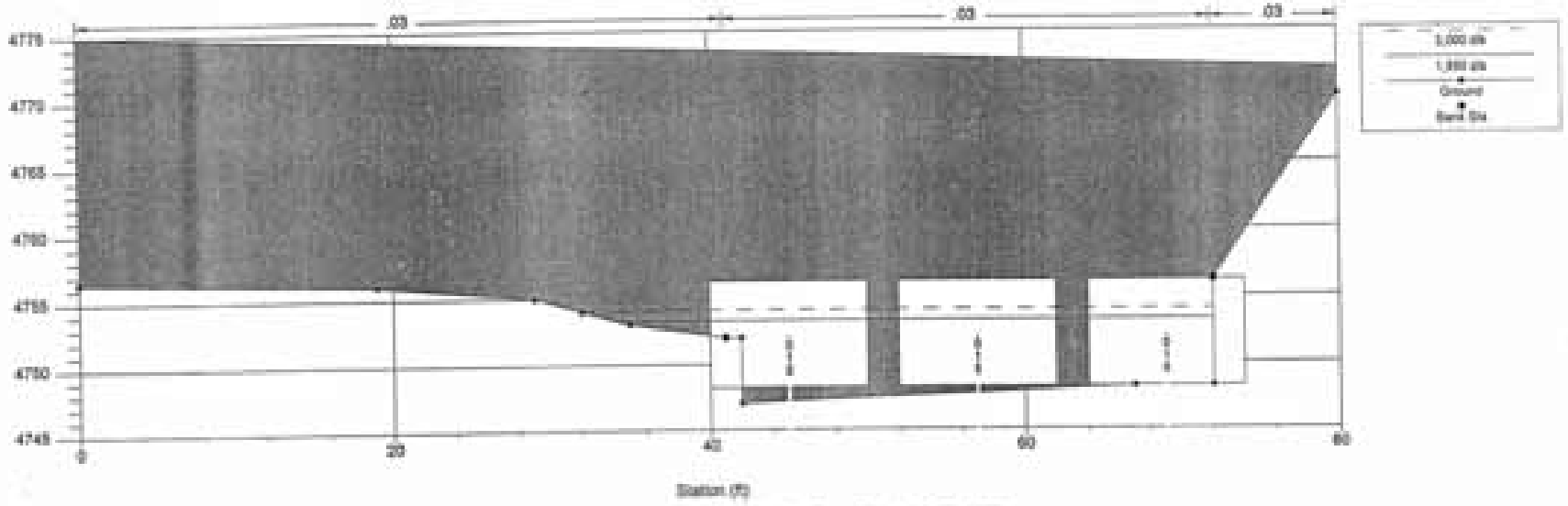

Riv Sta = 36 Whites Creek Branch #2 - Post-Project Condition
.06
.045
.06
Elevation (ft)
Station (ft)
Riv Sta = 35 Whites Creek Branch #2 - Post-Project Condition
.06
.045
.06
Elevation (ft)
Station (ft)


Riv Sta = 34 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
4800
4795
4790
4785
4780
4775
100
150
200
250
300
350
400
450
Elevation (ft)
Station (ft)
Riv Sta = 33 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
4790
4785
4780
4775
4770
50
100
150
200
250
300
Elevation (ft)
Station (ft)

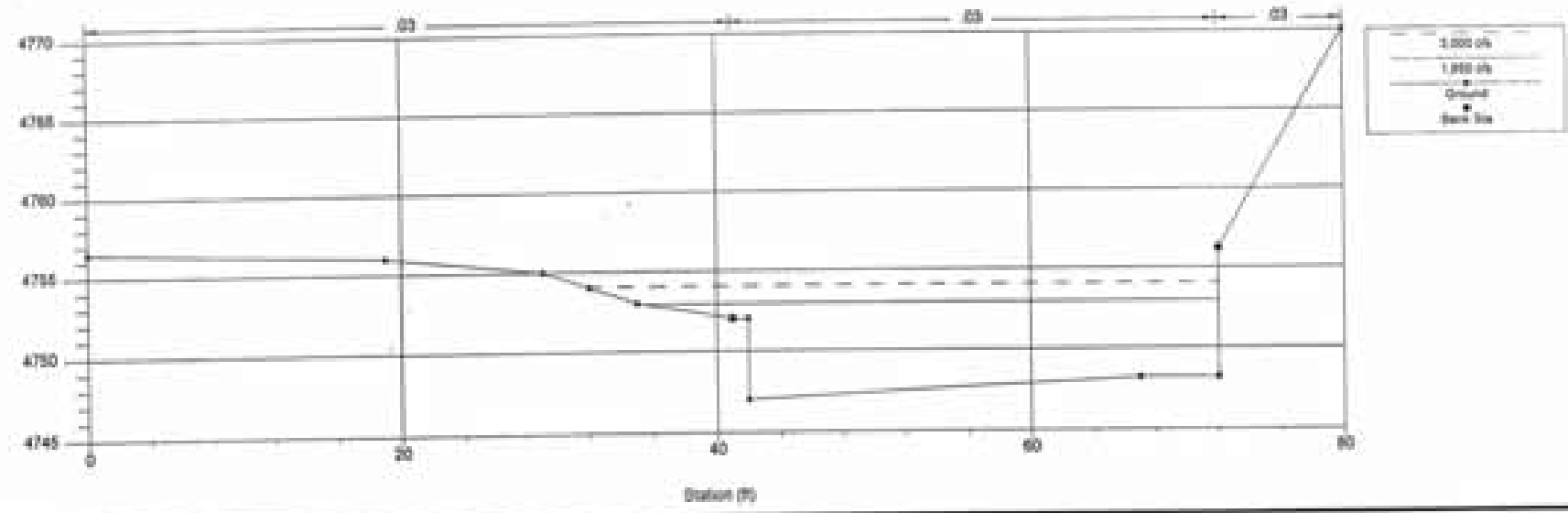

Riv Sta = 32 Whites Creek Branch #2 - Post-Project Condition
.05
.040
.05
4784
4782
4780
4778
4776
4774
4772
4770
50
100
150
200
250
300
Elevation (ft)
Station (ft)
Riv Sta = 31 Whites Creek Branch #2 - Post-Project Condition
.05
.040
.05
4782
4778
4776
4774
4772
4770
4768
50
100
150
200
250
300
Elevation (ft)
Station (ft)

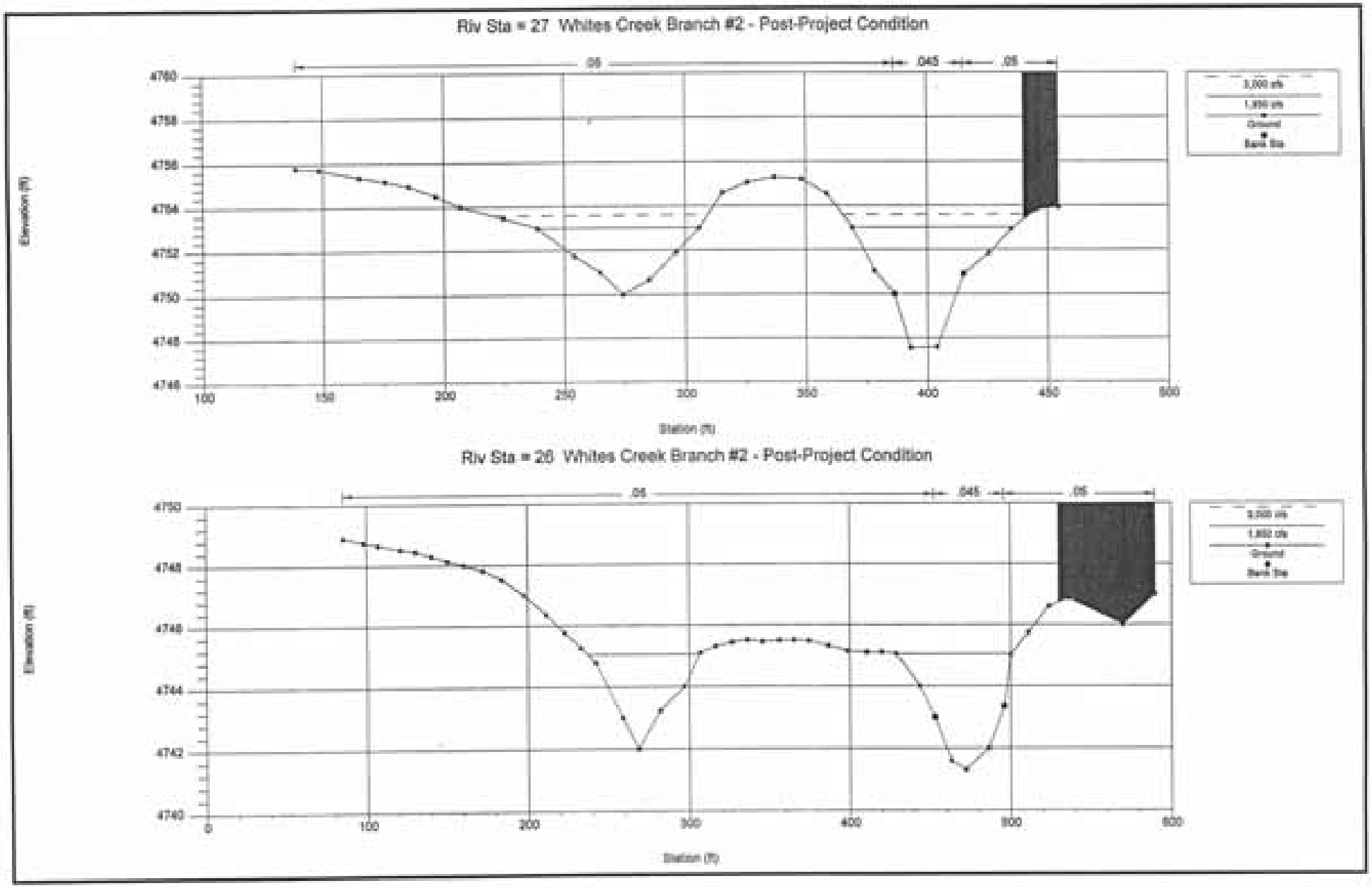

Riv Sta = 30 Whites Creek Branch #2 - Post-Project Condition
.015
.015
.015
4775
4770
4765
4760
4755
0
10
20
30
40
50
60
70
80
Elevation (ft)
Station (ft)
Upstream Inside
Riv Sta = 29 Whites Creek Branch #2 - Post-Project Condition
.015
.015
.015
4775
4770
4765
4760
4755
0
10
20
30
40
50
60
70
80
Elevation (ft)
Station (ft)

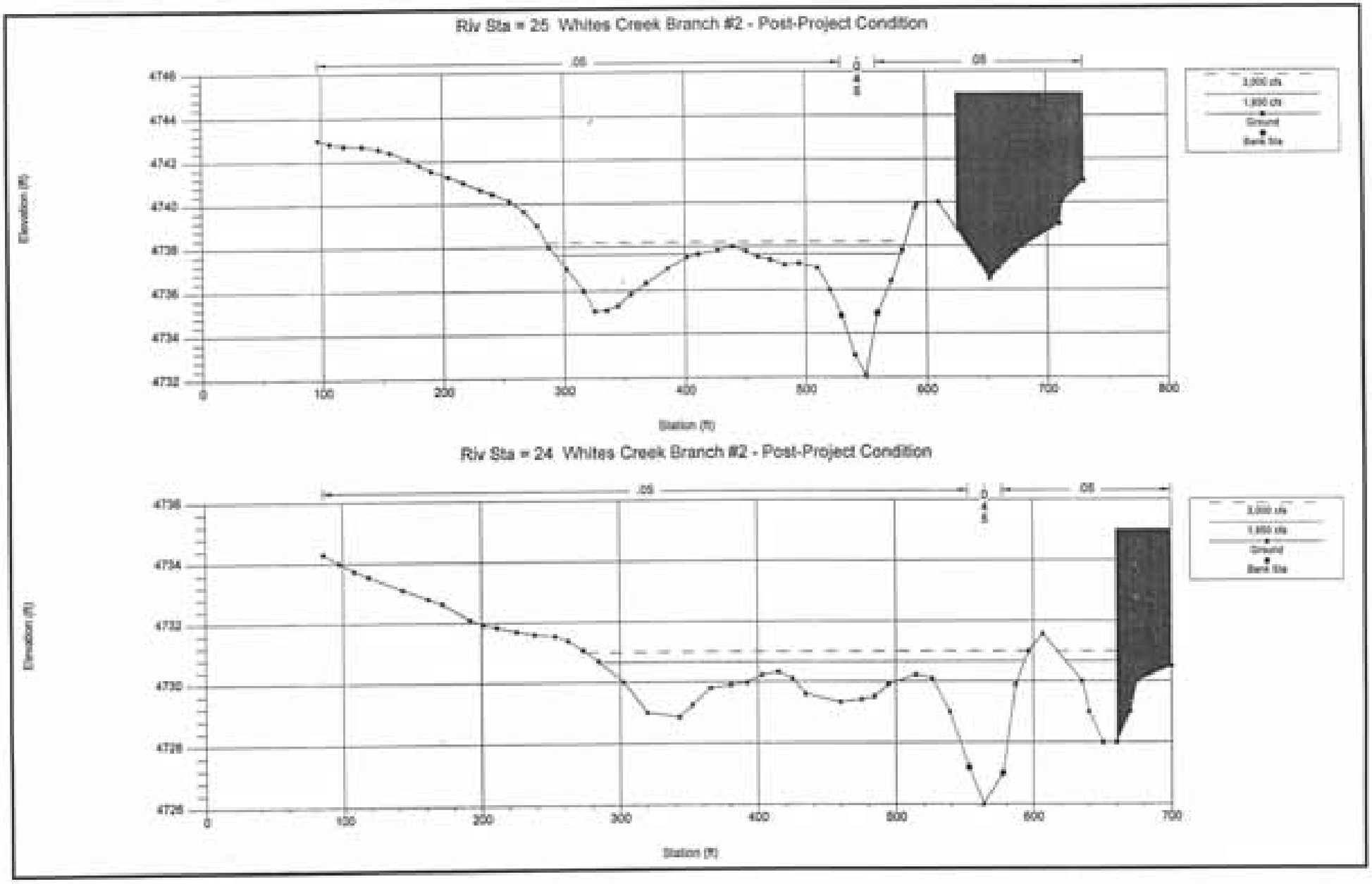
Downstream Inside Riv Sta = 29 Whites Creek Branch #2 - Post-Project Condition

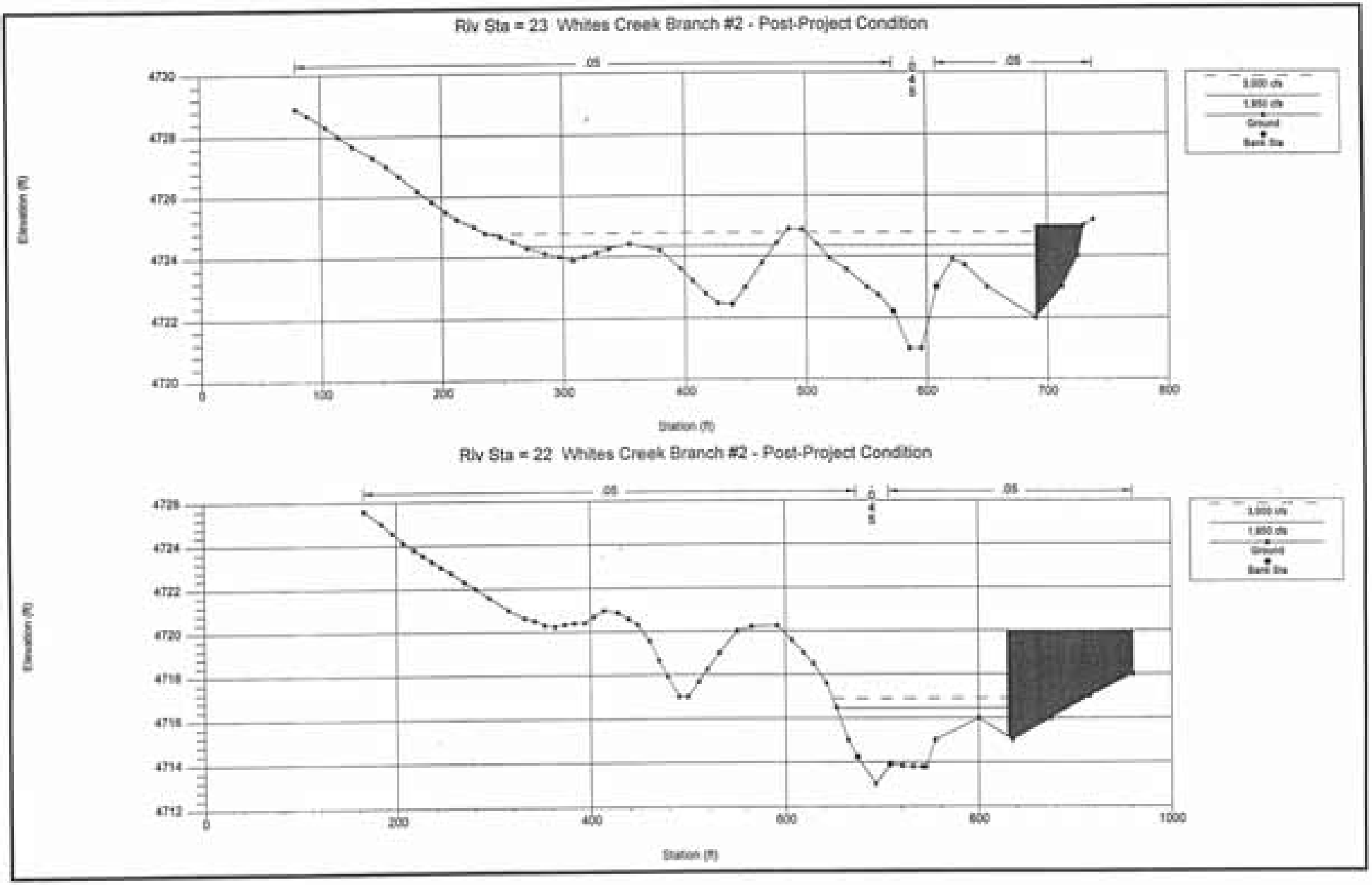


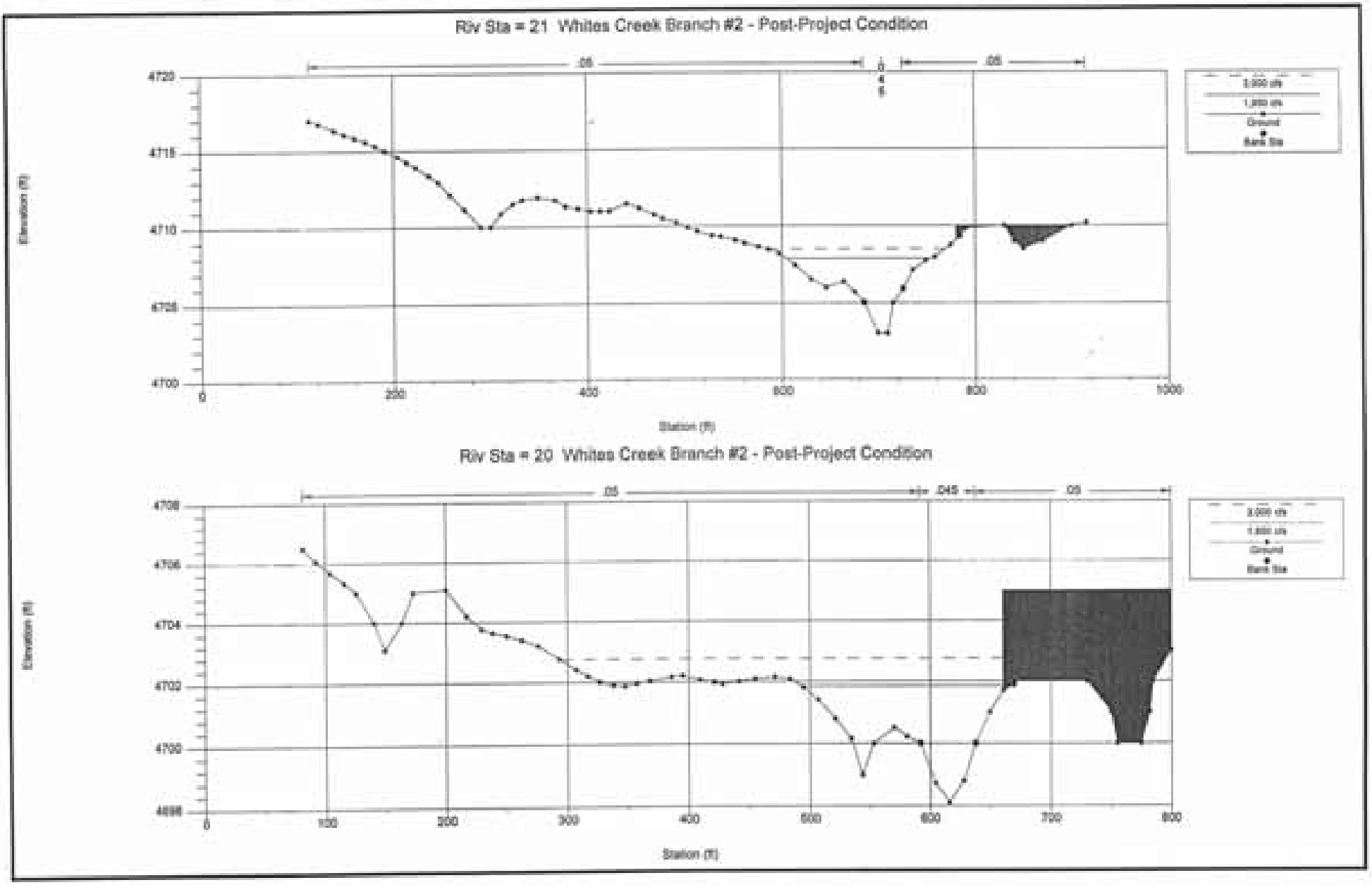
Riv Sta = 28 Whites Creek Branch #2 - Post-Project Condition

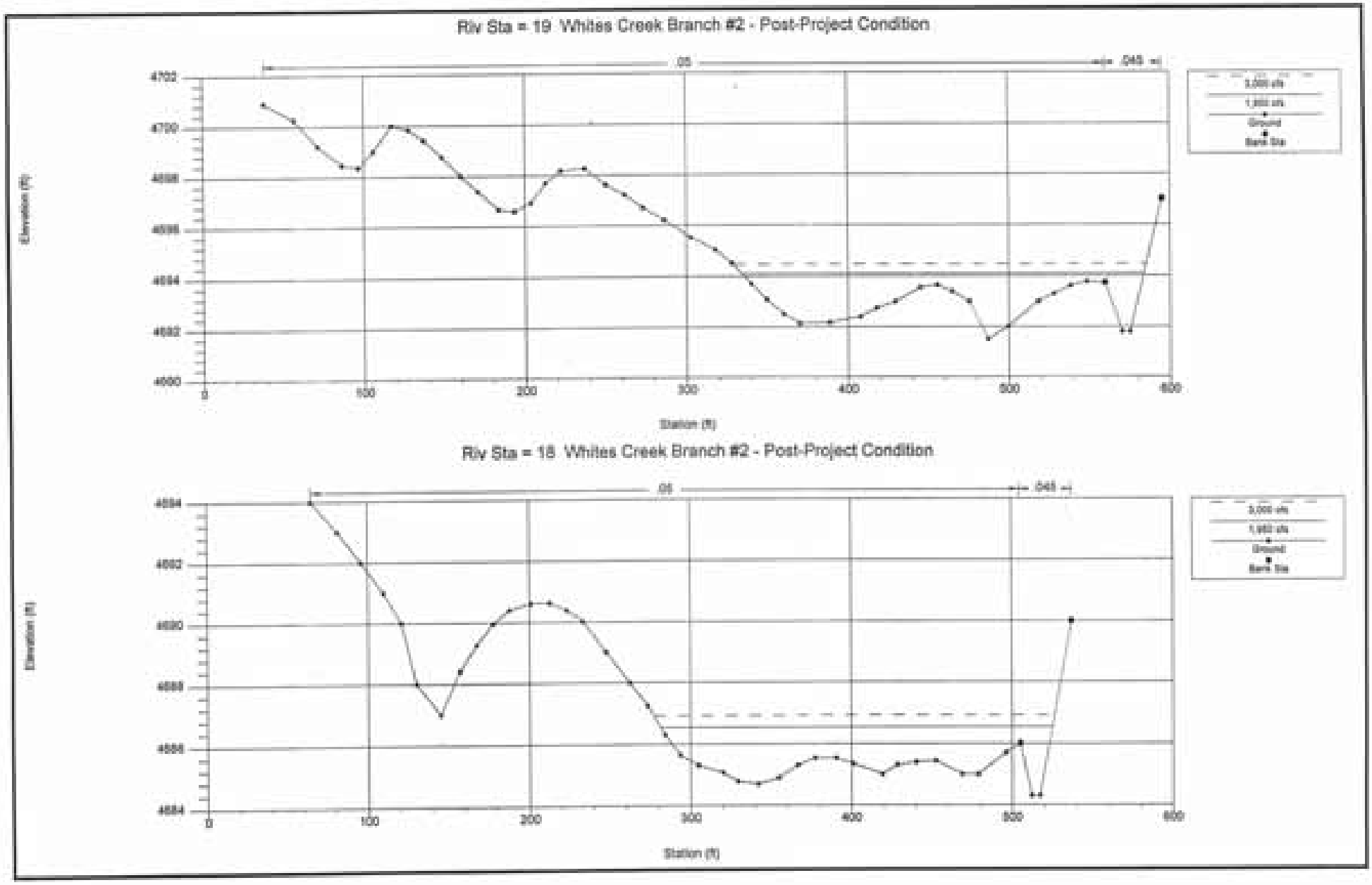


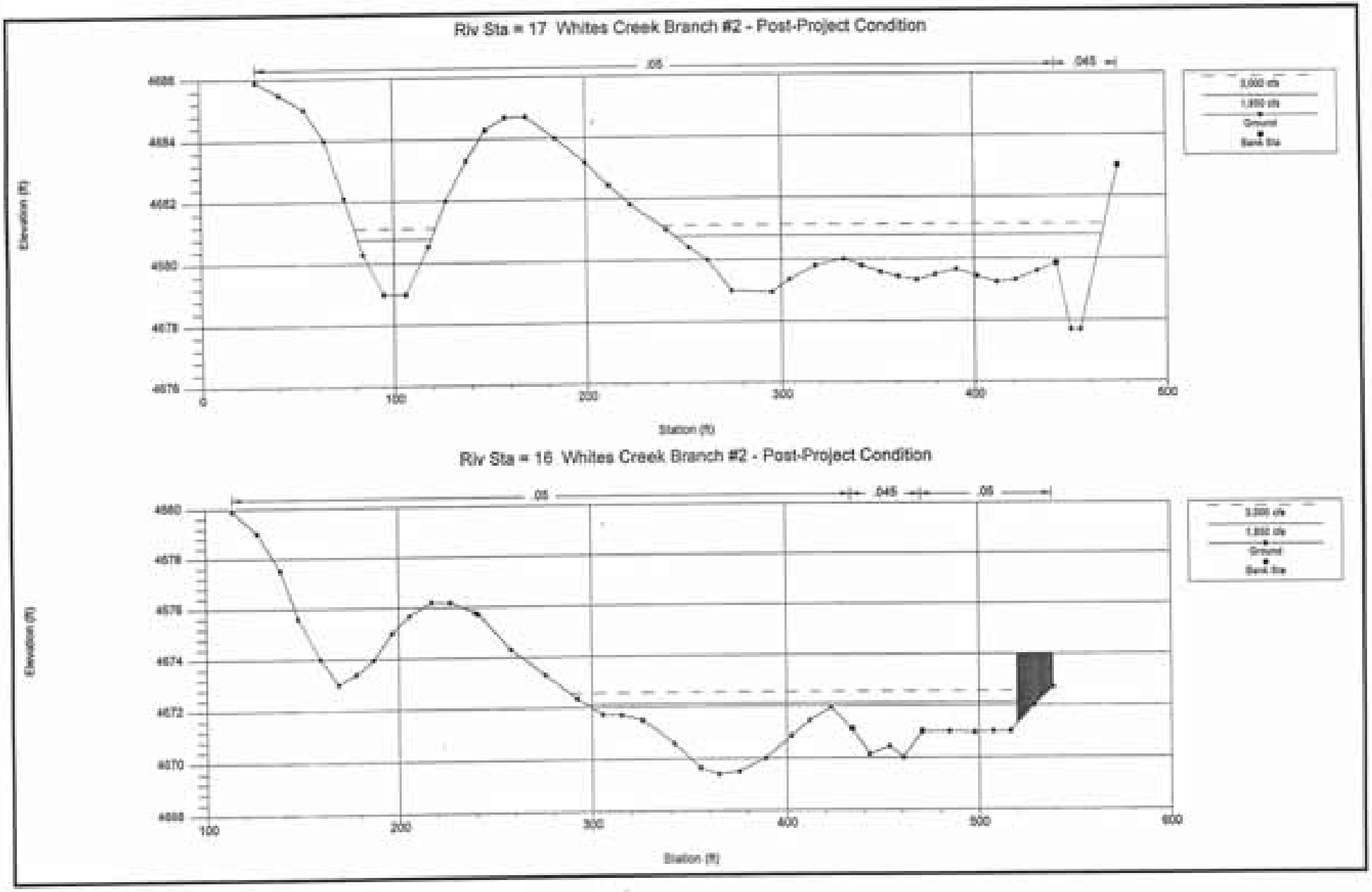

Riv Sta = 27 Whites Creek Branch #2 - Post-Project Condition
.06
.045
.05
3,000 cfs
1,850 cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)
Riv Sta = 26 Whites Creek Branch #2 - Post-Project Condition
.06
.045
.05
3,000 cfs
1,850 cfs
Ground
Bank Sta
Elevation (ft)
Station (ft)

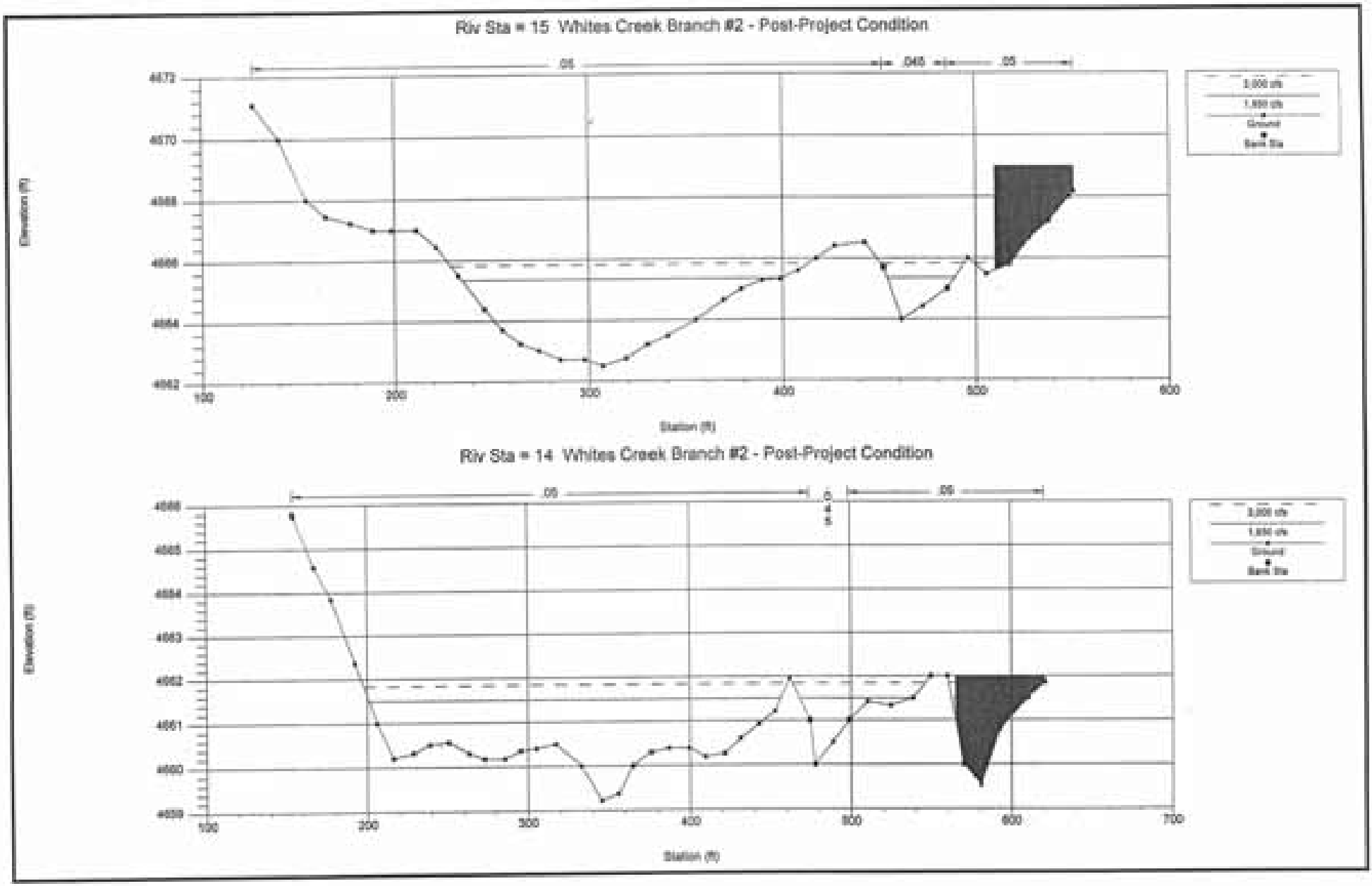

Riv Sta = 25 Whites Creek Branch #2 - Post-Project Condition
.05
0
.05
3,000 cfs
1,850 cfs
Ground
Bank Sta
Elevation (ft)
4746
4744
4742
4740
4738
4736
4734
4732
0
100
200
300
400
500
600
700
800
Station (ft)
Riv Sta = 24 Whites Creek Branch #2 - Post-Project Condition
.05
0
.05
3,000 cfs
1,850 cfs
Ground
Bank Sta
Elevation (ft)
4736
4734
4732
4730
4728
4726
0
100
200
300
400
500
600
700
Station (ft)

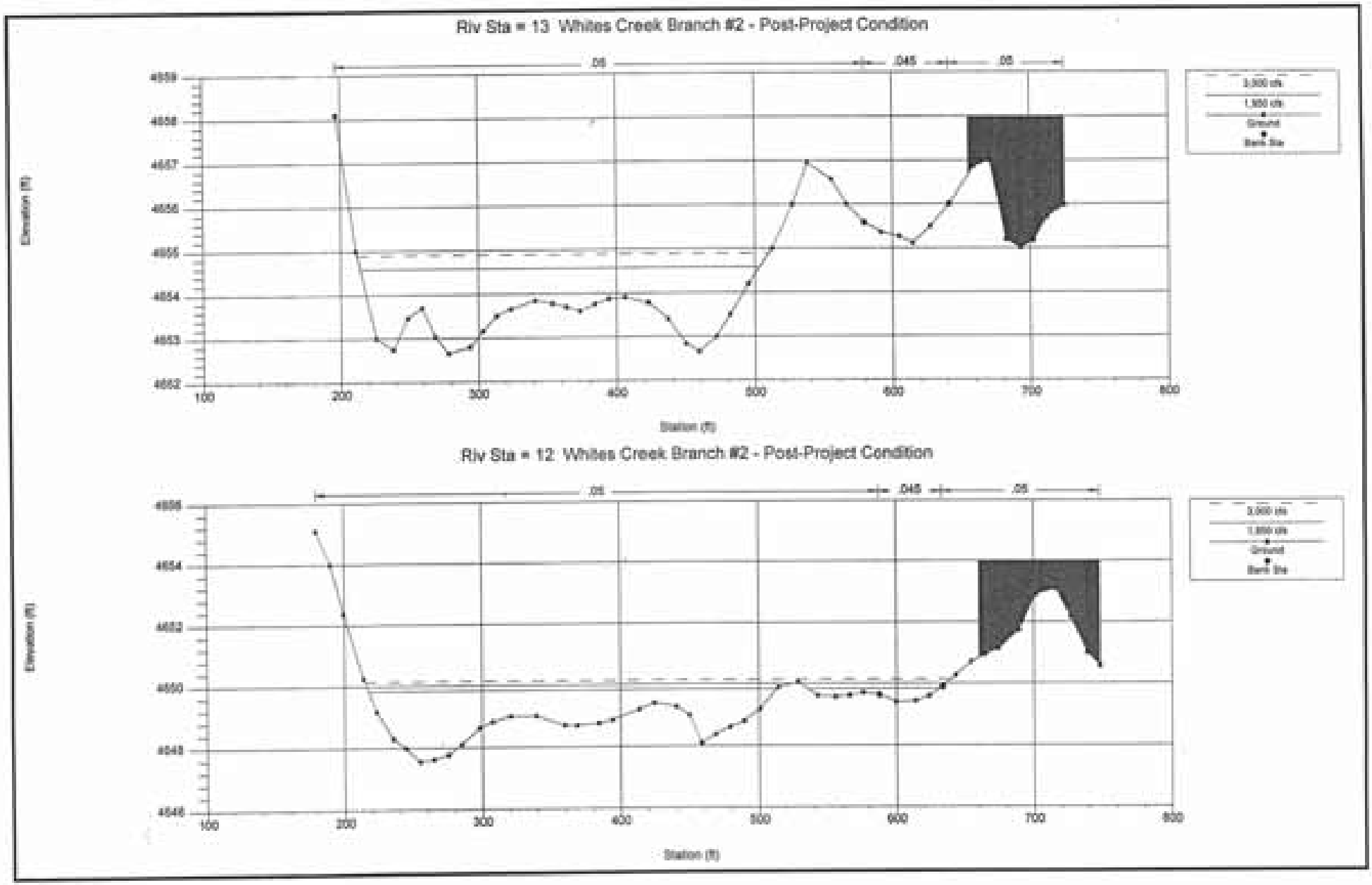

Riv Sta = 23 Whites Creek Branch #2 - Post-Project Condition
Elevation (ft)
Station (ft)
Riv Sta = 22 Whites Creek Branch #2 - Post-Project Condition
Elevation (ft)
Station (ft)

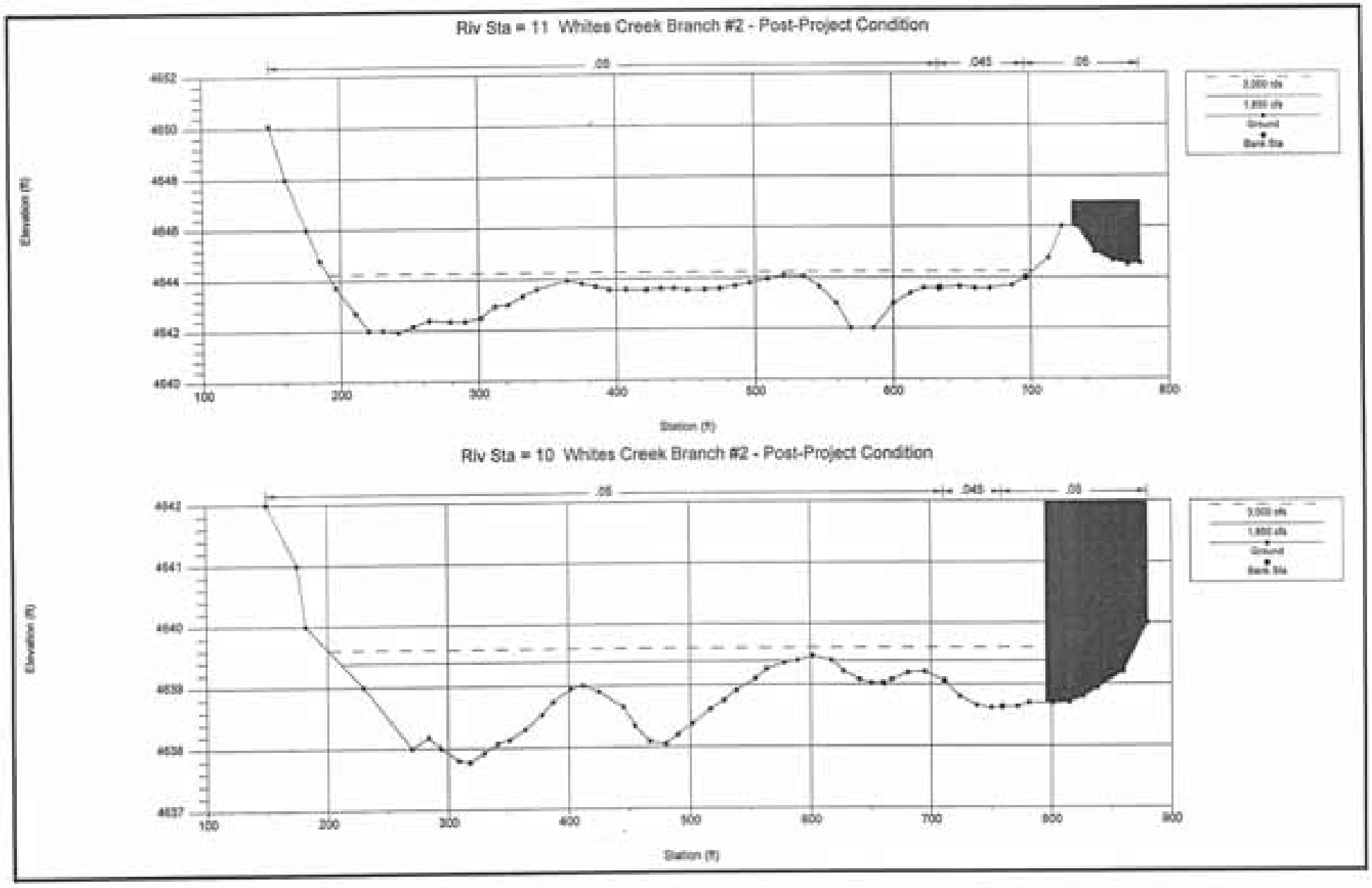

Riv Sta = 21 Whites Creek Branch #2 - Post-Project Condition
.08
.05
4720
4715
4710
4705
4700
0
200
400
600
800
1000
Elevation (ft)
Station (ft)
Riv Sta = 20 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
4708
4706
4704
4702
4700
4698
0
100
200
300
400
500
600
700
800
Elevation (ft)
Station (ft)

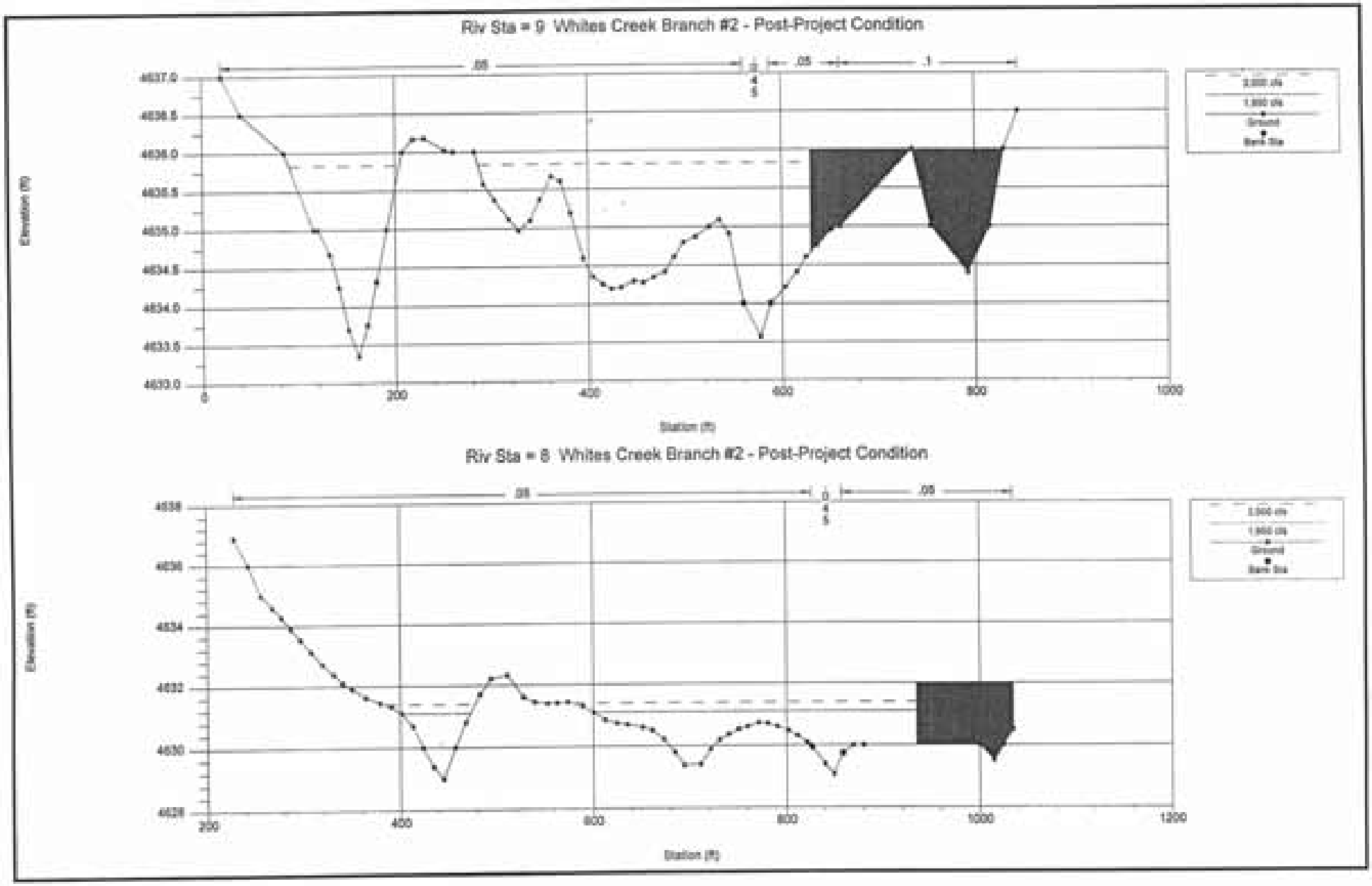

Riv Sta = 19 Whites Creek Branch #2 - Post-Project Condition
.05
.045
Elevation (ft)
4702
4700
4698
4696
4694
4692
4690
0
100
200
300
400
500
600
Station (ft)
Riv Sta = 18 Whites Creek Branch #2 - Post-Project Condition
.05
.045
Elevation (ft)
4694
4692
4690
4688
4686
4684
0
100
200
300
400
500
600
Station (ft)

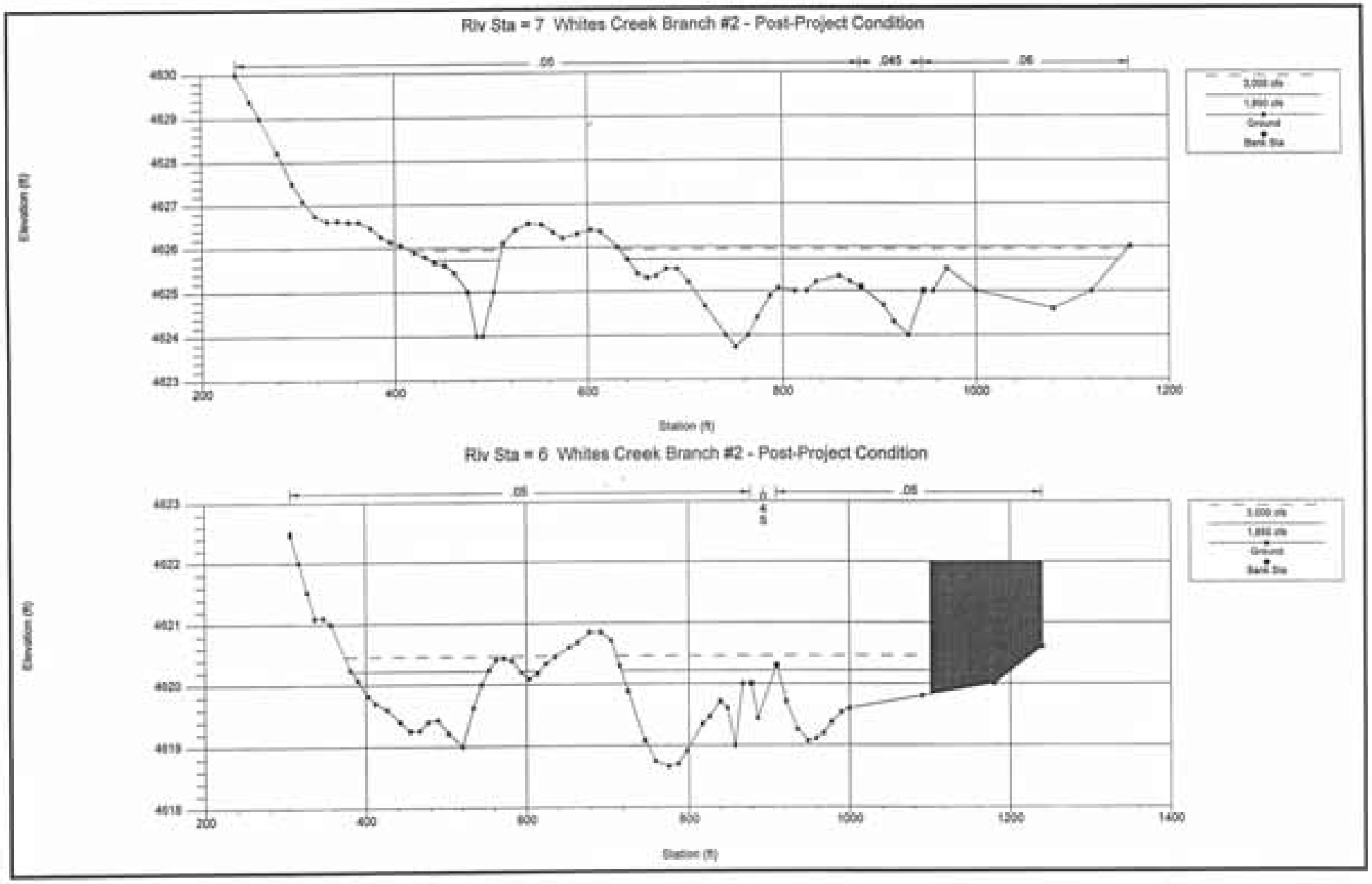

Riv Sta = 17 Whites Creek Branch #2 - Post-Project Condition
.05
.045
Elevation (ft)
4688
4684
4682
4680
4678
4676
0
100
200
300
400
500
Station (ft)
Riv Sta = 16 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
Elevation (ft)
4680
4678
4676
4674
4672
4670
4668
100
200
300
400
500
600
Station (ft)

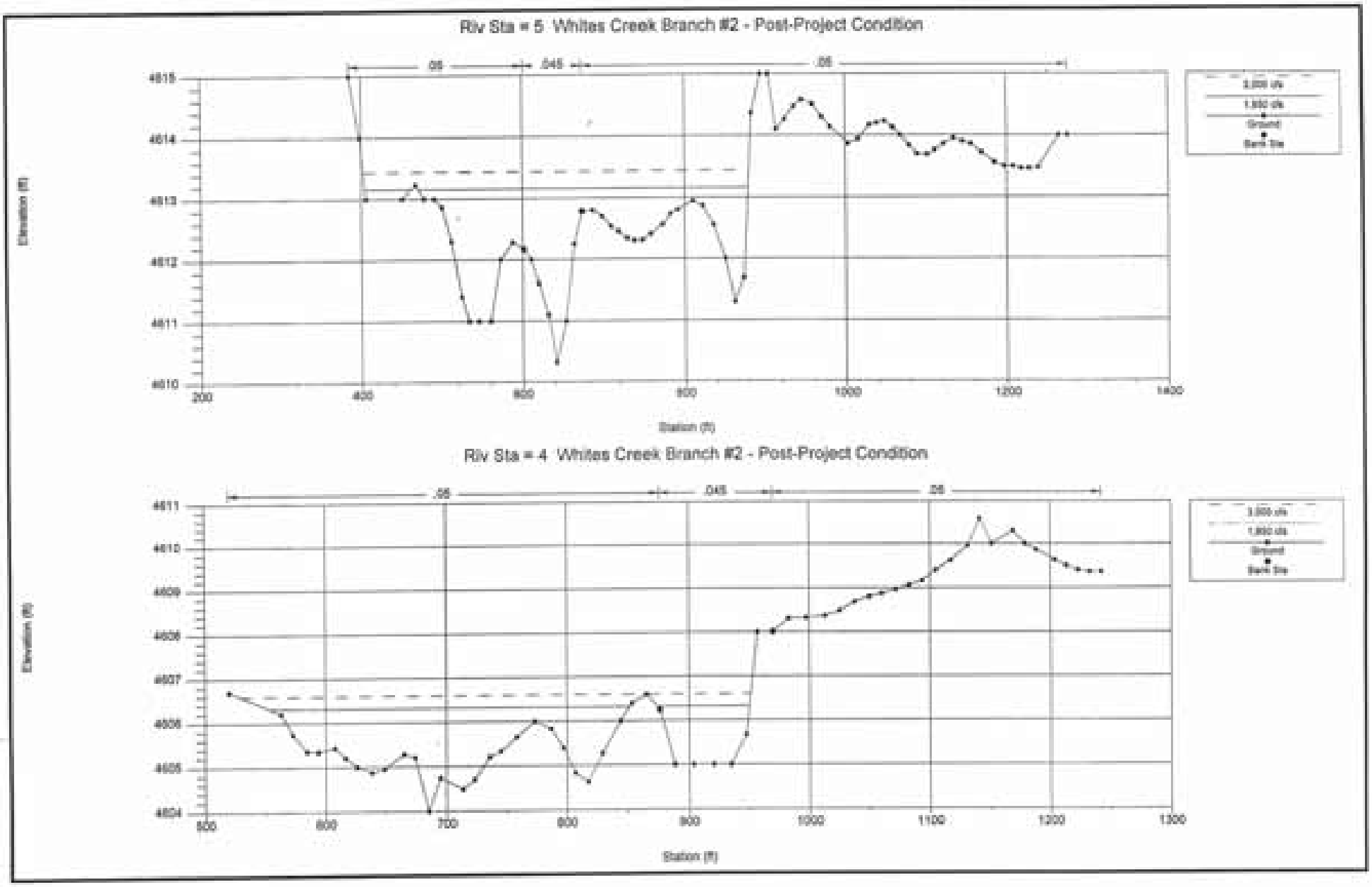

Riv Sta = 15 Whites Creek Branch #2 - Post-Project Condition
.05
.040
.05
4672
4670
4668
4666
4664
4662
100
200
300
400
500
600
Elevation (ft)
Station (ft)
Riv Sta = 14 Whites Creek Branch #2 - Post-Project Condition
.05
.05
4666
4665
4664
4663
4662
4661
4660
4659
100
200
300
400
500
600
700
Elevation (ft)
Station (ft)

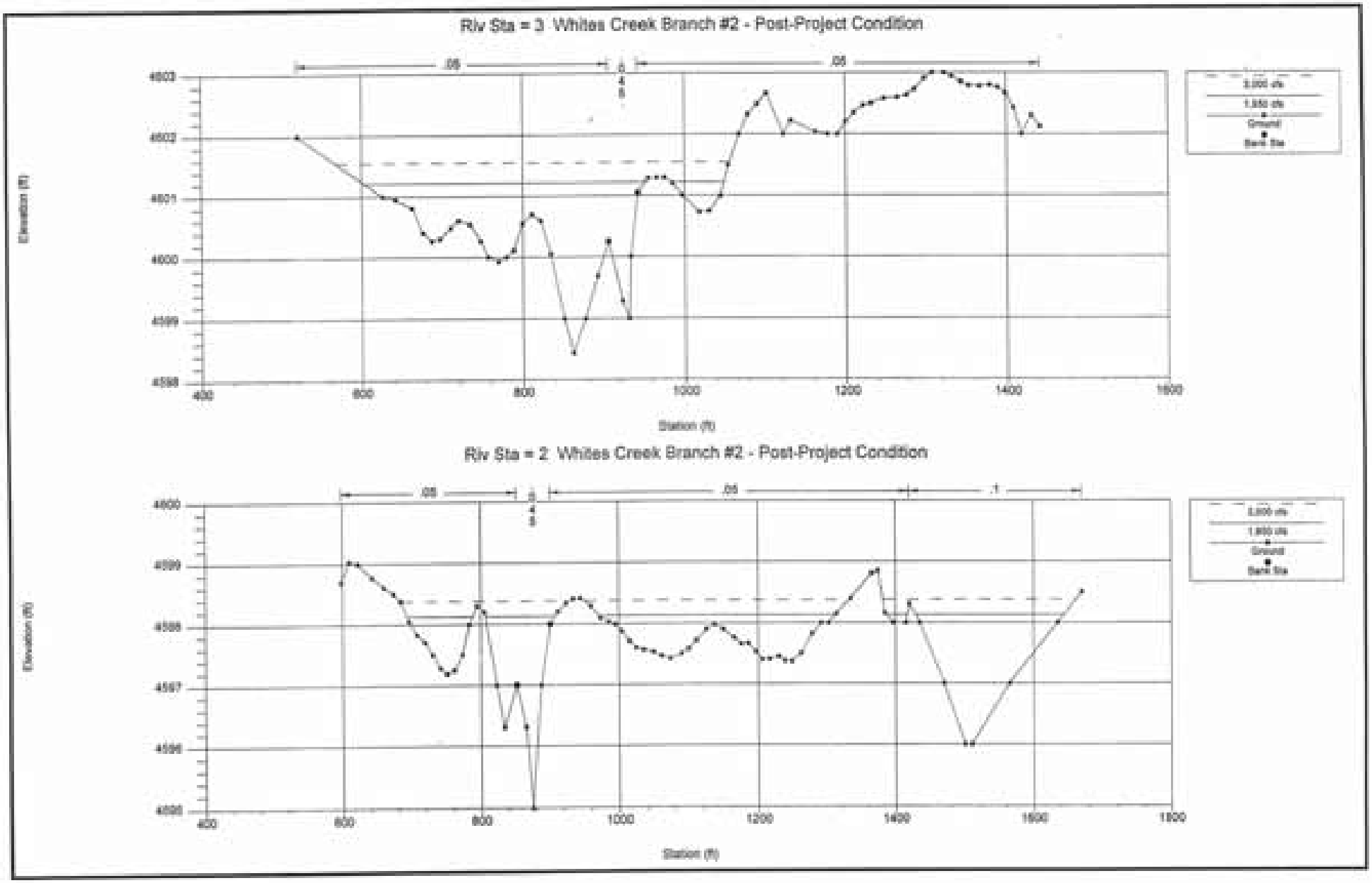

Riv Sta = 13 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
Elevation (ft)
Station (ft)
Riv Sta = 12 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
Elevation (ft)
Station (ft)

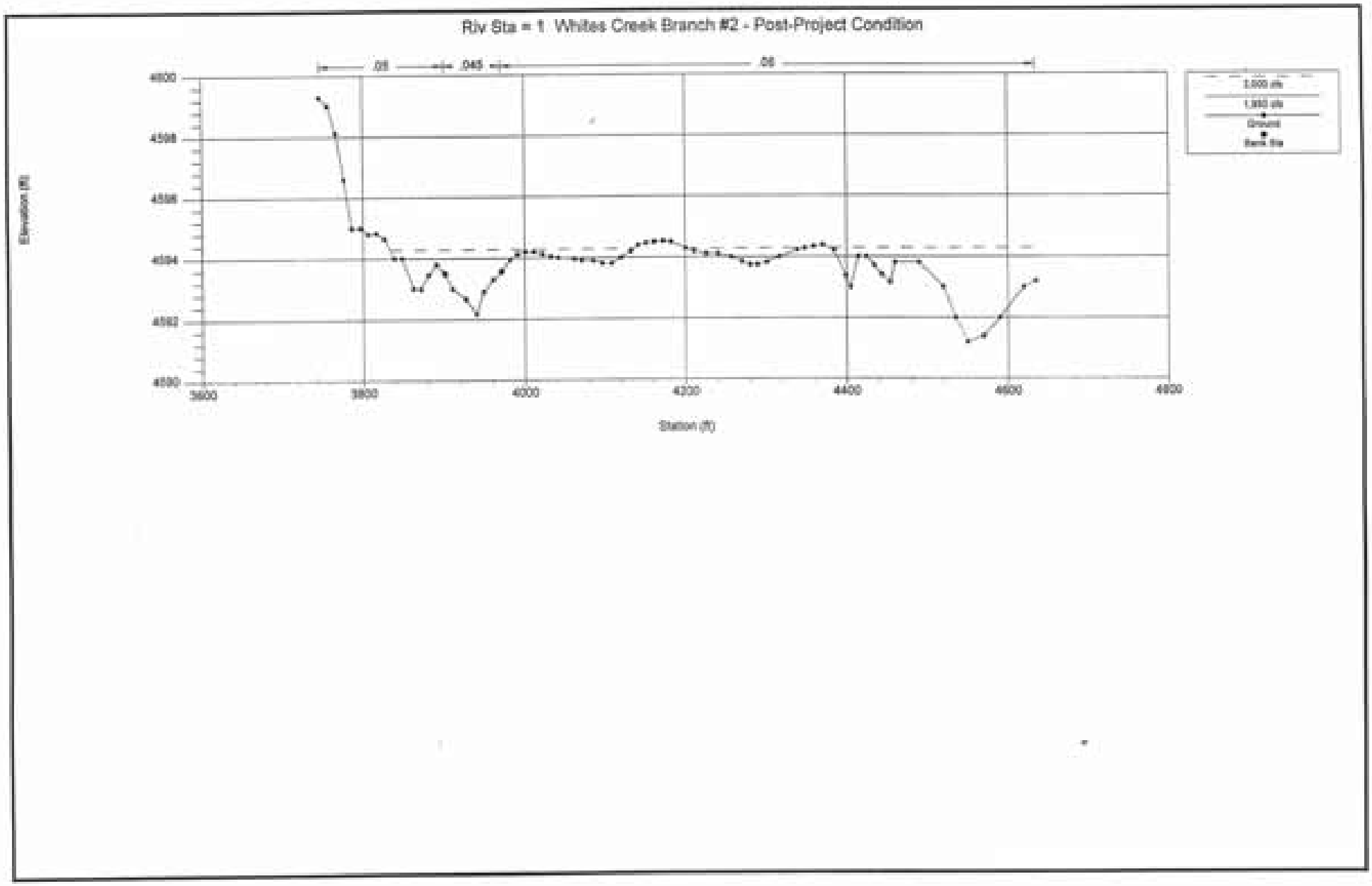

Riv Sta = 11 Whites Creek Branch #2 - Post-Project Condition
.08
.045
.05
4652
4650
4648
4646
4644
4642
4640
100
200
300
400
500
600
700
800
Station (ft)
Riv Sta = 10 Whites Creek Branch #2 - Post-Project Condition
.08
.045
.05
4642
4641
4640
4639
4638
4637
100
200
300
400
500
600
700
800
900
Station (ft)


Riv Sta = 9 Whites Creek Branch #2 - Post-Project Condition
.05
.05
.1
4637.0
4636.5
4636.0
4635.5
4635.0
4634.5
4634.0
4633.5
4633.0
0
200
400
600
800
1000
Station (ft)
Riv Sta = 8 Whites Creek Branch #2 - Post-Project Condition
.09
.09
4638
4636
4634
4632
4630
4628
200
400
600
800
1000
1200
Station (ft)


Riv Sta = 7 Whites Creek Branch #2 - Post-Project Condition
.06
.045
.06
4630
4629
4628
4627
4626
4625
4624
4623
200
400
600
800
1000
1200
Station (ft)
Riv Sta = 6 Whites Creek Branch #2 - Post-Project Condition
.05
.08
4623
4622
4621
4620
4619
4618
200
400
600
800
1000
1200
1400
Station (ft)


Riv Sta = 5 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
Elevation (ft)
Station (ft)
Riv Sta = 4 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
Elevation (ft)
Station (ft)


Riv Sta = 3 Whites Creek Branch #2 - Post-Project Condition
.05
.05
Elevation (ft)
4603
4602
4601
4600
4599
4598
400
600
800
1000
1200
1400
1600
Station (ft)
Riv Sta = 2 Whites Creek Branch #2 - Post-Project Condition
.05
.05
.1
Elevation (ft)
4600
4599
4598
4597
4596
4595
400
600
800
1000
1200
1400
1600
1800
Station (ft)


Riv Sta = 1 Whites Creek Branch #2 - Post-Project Condition
.05
.045
.05
4600
4598
4596
4594
4592
4590
Elevation (ft)
3600
3800
4000
4200
4400
4600
4800
Station (ft)
Ground
Bank Sta

Appendix D

Sub-Section 3
Whites Creek Branch 2
Pre-Project Condition Split Flow Analysis

```
**********************************************
*  HEC-2 WATER SURFACE PROFILES              *
*                                            *
*  Version  4.6.2;  May 1991                 *
*                                            *
*  RUN DATE   06JUN97   TIME   04:49:30      *
**********************************************
```


```
**********************************************
*  U.S. ARMY CORPS OF ENGINEERS              *
*  HYDROLOGIC ENGINEERING CENTER             *
*  609 SECOND STREET, SUITE D                *
*  DAVIS, CALIFORNIA 95616-4687              *
*        (916) 756-1104                      *
**********************************************
```


```
X     X  XXXXXXX   XXXXX              XXXXX
X     X  X        X     X            X     X
X     X  X        X                        X
XXXXXXX  XXXX     X          XXXXX    XXXXX
X     X  X        X                   X
X     X  X        X     X             X
X     X  XXXXXXX  XXXXX               XXXXXXX
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THIS RUN EXECUTED 06JUN97 04:49:30

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

SPLIT FLOW BEING PERFORMED

SF SPLIT FLOW ANALYSIS FOR X-SECTION 28 => 28

SC
SP 0 .3 0 0 0

TW RIGHT BANK WEIR BETWEEN SECTIONS 28 => 29
WS 5 28 29 -1 2.6
SC 0 4762 13 4763 24 4764 30 4765 54 4766

TW RIGHT BANK WEIR BETWEEN SECTIONS 29 => 30
WS 7 29 30 -1 2.6
SC 0 4766 10 4767 30 4767 37 4768 59 4769
WC 78 4770 90 4770.5

TW RIGHT BANK WEIR BETWEEN SECTIONS 30 => 31
WS 7 30 31 -1 2.6
SC 0 4770.5 9 4771 28 4772 38 4773 47 4774
WC 55 4775 62 4775.3

TW RIGHT BANK WEIR BTWN SECTIONS 36=>37 (inefficient weir - shallow flow)
WS 5 36 37 -1 2.4
SC 0 4812.5 35 4813 65 4814 85 4815 150 4819

TW RIGHT BANK WEIR BTWN SECTIONS 37=>38 (inefficient weir - shallow flow)
WS 8 37 38 -1 2.4
SC 0 4819 8 4820 28 4821 45 4822 61 4823
WC 74 4824 88 4825 102 4825.4

T1 Whites Creek Branch 2 - 3000 cfs Analysis with Split Flow
T2 Flow Split at Sections 28 to 31 and 36 to 38
T3 Existing Cond

****

Whites Creek Branch 2 - Split Flow Analysis at Steamboat Ditch

This model was developed to estimate the relative magnitude of the flow split that occurs at two locations on the south bank of Whites Creek Branch 2 in the vicinity of Steamboat Ditch and at a low point upstream of Steamboat Ditch.

Harding Lawson Associates
37957.1 Reno, Nevada
File: WCBR2SP.DAT May 1997

****

	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
			-1		0	0		3000	4738.33	

	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	-1									

NC	.05	.05	.045	.1	.3					
X1	25	44	529.34	558.82	123.59	123.32	123.24			
GR	4743.0	96.88	4742.83	106.79	4742.72	118.62	4742.69	133.47	4742.56	147.47
GR	4742.4	156.61	4742.05	171.84	4741.79	181.02	4741.54	190.57	4741.26	204.56
GR	4741.0	217.00	4740.65	231.10	4740.46	240.90	4740.13	255.01	4739.64	267.17
GR	4739.0	277.70	4738.00	287.35	4737.00	302.01	4736.00	316.06	4735.06	325.23
GR	4735.1	334.94	4735.31	344.18	4735.84	354.81	4736.33	367.43	4737.00	385.44
GR	4737.5	401.38	4737.65	410.72	4737.82	427.07	4737.99	439.41	4737.78	450.48
GR	4737.5	460.22	4737.38	470.46	4737.14	482.44	4737.21	494.41	4737.00	509.66
GR	4736.0	520.02	4734.82	529.34	4733.00	540.07	4732.08	549.04	4734.93	558.82
GR	4736.4	570.58	4737.81	579.91	4739.76	590.83	4739.93	592.22		
X1	26	42	452.64	495.84	132.62	138.04	135.08			
GR	4748.9	85.55	4748.76	98.06	4748.66	107.38	4748.52	121.24	4748.45	130.44
GR	4748.3	140.30	4748.14	150.10	4748.00	160.32	4747.82	172.22	4747.53	184.01
GR	4747.0	197.77	4746.36	211.67	4745.76	222.88	4745.26	233.17	4744.77	242.31
GR	4743.0	258.88	4742.00	268.62	4743.23	282.05	4744.00	297.21	4745.09	306.87
GR	4745.3	316.44	4745.43	326.74	4745.51	336.30	4745.45	345.79	4745.49	356.20
GR	4745.5	365.40	4745.47	374.78	4745.31	386.76	4745.14	398.55	4745.10	410.40
GR	4745.1	419.51	4745.05	428.65	4744.00	443.38	4743.00	452.64	4741.60	462.64
GR	4741.3	471.82	4742.00	486.12	4743.35	495.84	4745.00	499.74	4745.74	511.02
GR	4746.6	523.99	4746.87	536.04						

	27	30	386.36	415.00	154.60	151.34	152.83			
R	4755.8	138.72	4755.72	148.51	4755.36	165.04	4755.17	175.75	4754.95	185.59
GR	4754.5	196.46	4754.00	206.75	4753.47	224.76	4753.01	238.95	4751.73	254.29
	4751.0	264.85	4750.00	274.12	4750.66	285.01	4751.91	296.20	4753.00	305.72
	4754.6	315.38	4755.07	325.68	4755.30	336.96	4755.21	348.30	4754.54	358.55
GR	4753.0	369.09	4751.06	378.10	4750.00	386.36	4747.54	392.88	4747.58	403.75
	4750.9	415.00	4751.83	425.46	4752.93	434.83	4753.79	445.02	4753.92	454.34
	28	30	330.22	364.09	102.22	103.73	103.88			
R	4762.4	96.36	4762.22	108.69	4762.10	120.10	4761.97	130.63	4761.75	140.54
GR	4761.2	154.88	4761.00	164.40	4760.57	175.55	4760.13	186.74	4759.30	209.09
GR	4759.0	219.01	4758.77	229.11	4758.83	238.35	4758.94	249.80	4759.44	261.42
	4760.0	276.06	4760.17	288.56	4759.89	297.63	4758.69	307.24	4756.52	317.78
R	4755.0	330.22	4753.37	339.36	4753.98	354.75	4755.64	364.09	4757.00	373.29
GR	4759.0	383.40	4760.00	386.54	4760.95	402.27	4761.90	411.38	4761.82	424.09
1	29	25	341.05	371.56	62.76	58.88	59.96			
GR	4770.1	99.58	4770.00	110.56	4769.31	122.60	4768.29	145.10	4767.52	167.48
R	4767.3	176.90	4767.02	188.24	4767.19	205.85	4766.82	218.47	4766.56	228.00
R	4766.3	237.03	4766.00	249.19	4765.60	262.57	4765.06	273.06	4764.00	283.03
GR	4763.2	294.01	4762.55	306.55	4762.00	316.25	4761.45	329.77	4761.00	341.05
R	4760.6	353.88	4760.82	371.56	4762.63	380.77	4764.38	389.92	4765.00	421.05
1	30	27	315.32	348.79	94.43	93.15	94.73			
R	4777.4	101.70	4777.44	111.70	4778.00	124.89	4778.00	139.33	4777.53	150.33
GR	4777.0	160.14	4776.53	172.34	4776.82	185.87	4777.00	197.09	4777.00	206.46
GR	4777.0	218.90	4776.00	228.95	4775.00	240.10	4774.09	251.86	4771.04	276.46
R	4770.4	286.98	4770.00	296.57	4769.00	305.70	4768.67	315.32	4768.60	334.45
R	4768.9	348.79	4769.23	359.16	4769.51	368.98	4769.61	379.98	4770.00	393.20
GR	4770.5	403.06	4770.54	415.39						
1	31	16	177.02	201.53	70.56	66.77	68.87			
GR	4778.1	87.79	4777.98	89.86	4777.37	103.22	4776.51	119.25	4775.32	133.56
R	4774.0	146.45	4771.34	156.74	4770.00	163.90	4769.41	177.02	4769.00	188.83
R	4769.0	201.53	4770.72	213.27	4772.57	223.03	4775.10	231.40	4775.38	242.96
GR	4775.4	258.13								
1	32	16	184.96	208.49	89.99	90.44	90.04			
R	4783.4	83.73	4783.55	93.26	4783.00	105.96	4782.00	122.50	4781.51	132.07
R	4781.0	141.92	4780.00	151.95	4776.87	164.86	4772.00	184.96	4772.00	201.63
GR	4772.0	208.49	4778.12	223.89	4780.00	225.99	4781.66	236.64	4782.01	247.50
GR	4781.7	260.21								

[redacted]1	33	19	182.85	212.06	61.95	61.95	61.79			
[redacted]GR	4788.8	68.65	4788.58	79.20	4788.36	88.48	4788.00	100.09	4787.66	112.08
GR	4787.2	124.52	4786.83	133.90	4786.21	146.74	4781.68	164.81	4775.43	182.85
[redacted]R	4773.5	192.16	4773.00	203.33	4775.63	212.06	4780.00	218.65	4785.00	234.08
[redacted]R	4786.4	245.43	4786.63	257.84	4786.46	267.00	4786.29	276.81		
[redacted]1	34	27	239.20	269.38	150.55	156.43	152.99			
GR	4799.6	122.08	4799.51	133.29	4799.48	143.09	4799.51	154.15	4799.45	164.19
GR	4799.2	173.44	4798.43	182.77	4797.39	194.39	4796.00	203.94	4795.00	210.27
[redacted]R	4790.7	225.29	4785.00	239.20	4780.00	246.46	4780.00	256.66	4785.00	269.38
[redacted]R	4790.0	278.12	4792.60	288.38	4795.00	297.52	4797.00	312.43	4798.50	323.58
GR	4799.4	337.69	4799.18	351.68	4799.15	361.26	4799.27	370.28	4799.45	381.01
[redacted]R	4799.4	391.86	4799.23	401.26						
[redacted]1	35	27	304.12	335.55	148.02	150.36	150.20			
[redacted]R	4810.0	179.05	4809.61	187.99	4809.20	200.85	4808.94	211.86	4808.76	222.10
[redacted]GR	4808.5	233.89	4808.27	243.56	4808.00	252.65	4807.28	262.11	4806.00	273.26
GR	4805.0	280.29	4800.00	292.41	4795.00	304.12	4790.00	316.40	4790.00	324.10
[redacted]R	4795.0	335.55	4800.00	347.87	4802.75	356.94	4805.00	364.41	4805.96	373.65
[redacted]R	4807.0	384.09	4808.42	396.43	4809.00	405.73	4809.34	420.01	4809.59	429.31
GR	4810.1	438.55	4810.09	449.13						
[redacted]1	36	26	325.73	372.08	199.05	200.26	199.92			
GR	4812.9	184.22	4812.93	198.45	4812.75	209.64	4812.20	222.53	4811.00	236.85
[redacted]R	4810.5	246.60	4810.11	257.10	4809.92	267.54	4809.82	278.90	4809.68	291.56
[redacted]R	4809.0	307.28	4807.56	316.60	4806.07	325.73	4805.00	332.49	4805.00	340.17
GR	4805.9	372.08	4808.73	385.23	4810.00	395.80	4810.22	405.53	4810.00	420.11
[redacted]R	4809.6	430.36	4809.23	441.74	4809.00	452.10	4810.47	463.66	4812.00	477.84
[redacted]R	4812.0	493.82								
[redacted]1	37	24	308.15	333.45	162.10	165.25	168.00			
GR	4821.3	218.16	4821.36	232.08	4821.26	243.24	4821.00	254.91	4820.60	265.27
GR	4820.0	274.97	4819.00	285.03	4818.00	297.91	4816.57	308.15	4815.00	317.82
[redacted]R	4815.0	324.09	4816.59	333.45	4817.53	343.09	4818.05	353.30	4818.45	365.93
[redacted]R	4819.0	374.93	4819.86	384.98	4820.00	396.32	4820.07	423.38	4819.94	435.67
GR	4819.8	446.40	4819.42	456.42	4819.27	467.96	4819.11	478.72		
[redacted]1	38	22	324.43	353.46	112.46	111.59	111.84			
GR	4828.0	199.65	4827.71	212.37	4827.26	228.38	4827.00	238.14	4826.77	253.51
[redacted]R	4826.6	265.74	4826.39	274.86	4826.00	286.68	4825.20	301.66	4823.35	311.01
[redacted]R	4820.0	324.43	4817.00	338.07	4817.14	343.22	4820.38	353.46	4823.00	369.08
GR	4825.0	382.27	4826.35	394.58	4826.56	404.32	4826.51	413.46	4826.32	425.67
[redacted]R	4826.1	436.07	4826.00	448.01						

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	IW	XL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 1

CCHV= .100 CEHV= .300

SECNO 25.000

25.000	6.25	4738.33	.00	4738.33	4738.77	.44	.00	.00	4734.82
2456.8	1252.9	1040.9	162.9	363.6	146.6	43.5	.0	.0	4734.93
.00	5.45	7.10	3.74	.050	.045	.050	.000	4732.08	284.16
.005603	124.	123.	123.	0	0	0	.00	298.66	582.82

SECNO 26.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

26.000	4.33	4745.63	4745.63	.00	4746.43	.80	1.07	.11	4743.00
2456.8	1070.0	1359.5	27.3	221.3	157.2	8.7	1.4	.9	4743.35
.01	4.84	8.65	3.15	.050	.045	.050	.000	4741.30	225.58
.012324	133.	135.	138.	20	19	0	.00	283.73	509.32

SECNO 27.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

27.000	5.83	4753.38	4753.38	.00	4754.47	1.09	1.85	.09	4750.00
2456.8	907.1	1410.8	139.0	167.2	139.8	31.5	2.7	1.7	4750.90
.01	5.43	10.09	4.41	.050	.045	.050	.000	4747.54	227.69
.011781	155.	153.	151.	20	11	0	.00	153.87	440.10

SECNO 28.000

3265 DIVIDED FLOW

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

28.000	5.90	4759.27	4759.27	.00	4760.63	1.36	1.19	.08	4755.00
2456.8	421.1	1813.0	222.6	78.0	174.4	40.2	3.5	2.0	4755.64
.01	5.40	10.40	5.54	.050	.045	.050	.000	4753.37	209.95
.011284	102.	104.	104.	20	5	0	.00	129.31	384.26

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 29.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

29.000	4.05	4764.65	4764.65	.00	4765.87	1.22	.81	.01	4761.00
2456.8	965.3	1240.7	250.8	137.1	119.1	39.3	3.9	2.2	4760.82
.02	7.04	10.42	6.38	.050	.045	.050	.000	4760.60	276.90
.016189	63.	60.	59.	20	19	0	.00	126.67	403.57

*SECNO 30.000
3280 CROSS SECTION 30.00 EXTENDED 1.26 FEET

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

30.000	3.20	4771.80	4771.80	.00	4772.88	1.08	1.70	.01	4768.67
2516.7	545.6	1041.8	929.2	78.6	104.3	134.3	4.5	2.5	4768.90
.02	6.94	9.99	6.92	.050	.045	.050	.000	4768.60	270.33
.020108	94.	95.	93.	20	15	0	.00	145.06	415.39

SECNO 31.000

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

31.000	4.67	4773.67	4773.67	.00	4775.32	1.65	1.26	.17	4769.41
2591.3	719.1	1326.8	545.4	84.0	112.1	66.5	5.0	2.6	4769.00
.02	8.56	11.84	8.20	.050	.045	.050	.000	4769.00	147.72
.016945	71.	69.	67.	20	11	0	.00	78.95	226.67

SECNO 32.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

32.000	5.78	4777.78	4777.78	.00	4779.83	2.05	1.43	.12	4772.00
2591.3	536.9	1760.8	293.6	68.9	135.9	42.0	5.5	2.8	4772.00
.02	7.80	12.95	6.99	.050	.045	.050	.000	4772.00	161.12
.014847	90.	90.	90.	20	8	0	.00	61.90	223.03

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 33.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

33.000	7.08	4780.08	4780.08	.00	4782.48	2.40	.90	.10	4775.43
2591.3	186.9	2323.6	80.9	31.3	179.0	15.0	5.9	2.9	4775.63
.02	5.98	12.98	5.40	.050	.045	.050	.000	4775.00	169.42
.014147	62.	62.	62.	20	11	0	.00	49.49	218.91

*SECNO 34.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

34.000	7.91	4787.91	4787.91	.00	4790.59	2.68	2.28	.08	4785.00
2591.3	46.7	2512.5	32.1	10.3	188.6	7.4	6.6	3.0	4785.00
.03	4.54	13.32	4.39	.050	.045	.050	.000	4780.00	232.11
.015709	151.	153.	156.	20	8	0	.00	42.35	274.46

*SECNO 35.000

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

35.000	7.98	4797.98	4797.98	.00	4800.53	2.55	2.32	.01	4795.00
2591.3	46.9	2494.7	49.6	10.4	191.4	10.9	7.3	3.2	4795.00
.03	4.52	13.03	4.54	.050	.045	.050	.000	4790.00	297.15
.015220	148.	150.	150.	20	5	0	.00	45.74	342.89

*SECNO 36.000

3665 DIVIDED FLOW

3701 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

36.000	4.78	4809.78	4809.78	.00	4811.10	1.32	2.69	.12	4806.07
2591.3	251.4	2113.5	226.4	48.2	212.4	50.6	8.5	3.6	4805.90
.04	5.21	9.95	4.47	.050	.045	.050	.000	4805.00	282.93
.011975	199.	200.	200.	20	14	0	.00	143.33	458.20

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 37.000

3280 CROSS SECTION 37.00 EXTENDED 1.66 FEET

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

37.000	5.77	4820.77	4820.77	.00	4821.74	.97	1.90	.04	4816.57
2887.0	463.8	1340.7	1082.5	82.6	130.9	223.2	10.0	4.3	4816.59
.04	5.62	10.24	4.85	.050	.045	.050	.000	4815.00	260.91
.010893	162.	168.	165.	20	8	0	.00	217.81	478.72

SECNO 38.000

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL

3693 PROBABLE MINIMUM SPECIFIC ENERGY

3720 CRITICAL DEPTH ASSUMED

38.000	7.80	4824.80	4824.80	.00	4826.80	2.00	1.29	.31	4820.00
3000.0	302.0	2329.2	368.8	47.2	187.5	59.2	10.9	4.7	4820.38
.05	6.40	12.42	6.23	.050	.045	.050	.000	4817.00	303.69
.012204	112.	112.	112.	20	11	0	.00	77.25	380.94

W RIGHT BANK WEIR BETWEEN SECTIONS 28 => 29

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
.00	.00	.00	.00	.00	.00	19	4759.274	4764.652	28.000	29.000

W RIGHT BANK WEIR BETWEEN SECTIONS 29 => 30

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
59.90	60.02	.19	59.90	60.02	.19	19	4764.652	4771.800	29.000	30.000

TW RIGHT BANK WEIR BETWEEN SECTIONS 30 => 31

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
74.61	74.83	.30	134.51	134.85	.25	19	4771.800	4773.671	30.000	31.000

TW RIGHT BANK WEIR BTWN SECTIONS 36=>37 (inefficient weir - shallow flow)

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
295.74	295.27	.16	430.25	430.12	.03	19	4809.775	4820.769	36.000	37.000

W RIGHT BANK WEIR BTWN SECTIONS 37=>38 (inefficient weir - shallow flow)

ASQ	QCOMP	ERRAC	TASQ	TCQ	TABER	NITER	DSWS	USWS	DSSNO	USSNO
112.96	113.14	.16	543.21	543.26	.01	19	4820.769	4824.798	37.000	38.000

THIS RUN EXECUTED 06JUN97 04:49:46

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EC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991

****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

Existing Cond

MMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	25.000	.00	.00	.00	4732.08	2456.79	4738.33	.00	4738.77	56.03	7.10	553.72	328.23
	26.000	135.08	.00	.00	4741.30	2456.79	4745.63	4745.63	4746.43	123.24	8.65	387.20	221.31
	27.000	152.83	.00	.00	4747.54	2456.79	4753.38	4753.38	4754.47	117.81	10.09	338.45	226.35
*	28.000	103.88	.00	.00	4753.37	2456.79	4759.27	4759.27	4760.63	112.84	10.40	292.51	231.28
	29.000	59.96	.00	.00	4760.60	2456.79	4764.65	4764.65	4765.87	161.89	10.42	295.53	193.09
*	30.000	94.73	.00	.00	4768.60	2516.69	4771.80	4771.80	4772.88	201.08	9.99	317.19	177.48
	31.000	68.87	.00	.00	4769.00	2591.30	4773.67	4773.67	4775.32	169.45	11.84	262.61	199.06
	32.000	90.04	.00	.00	4772.00	2591.30	4777.78	4777.78	4779.83	148.47	12.95	246.75	212.66
	33.000	61.79	.00	.00	4773.00	2591.30	4780.08	4780.08	4782.48	141.47	12.98	225.26	217.86
	34.000	152.99	.00	.00	4780.00	2591.30	4787.91	4787.91	4790.59	157.09	13.32	206.33	206.75
*	35.000	150.20	.00	.00	4790.00	2591.30	4797.98	4797.98	4800.53	152.20	13.03	212.71	210.04
	36.000	199.92	.00	.00	4805.00	2591.30	4809.78	4809.78	4811.10	119.75	9.95	311.19	236.80
*	37.000	168.00	.00	.00	4815.00	2887.04	4820.77	4820.77	4821.74	108.93	10.24	436.71	276.61
	38.000	111.84	.00	.00	4817.00	3000.00	4824.80	4824.80	4826.80	122.04	12.42	293.97	271.57

Existing Cond

SUMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
25.000	2456.79	4738.33	.00	.00	.00	298.66	.00
26.000	2456.79	4745.63	.00	7.30	.00	283.73	135.08
27.000	2456.79	4753.38	.00	7.75	.00	153.87	152.83
28.000	2456.79	4759.27	.00	5.90	.00	129.31	103.88
29.000	2456.79	4764.65	.00	5.38	.00	126.67	59.96
30.000	2516.69	4771.80	.00	7.15	.00	145.06	94.75
31.000	2591.30	4775.67	.00	1.87	.00	78.95	68.87
32.000	2591.30	4777.78	.00	4.11	.00	61.90	90.04
33.000	2591.30	4780.08	.00	2.31	.00	49.49	61.79
34.000	2591.30	4787.91	.00	7.82	.00	42.35	152.99
35.000	2591.30	4797.98	.00	10.07	.00	45.74	150.20
36.000	2591.30	4809.78	.00	11.80	.00	143.33	199.92
37.000	2887.04	4820.77	.00	10.99	.00	217.81	168.00
38.000	3000.00	4824.80	.00	4.03	.00	77.25	111.84

SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION SECNO= 26.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 26.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 26.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 27.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 27.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 27.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 28.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 28.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 28.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 29.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 29.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 29.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 30.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 30.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 30.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 31.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 31.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 31.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 32.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 32.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 32.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 33.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 33.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 33.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 34.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 34.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 34.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 35.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 35.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 35.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

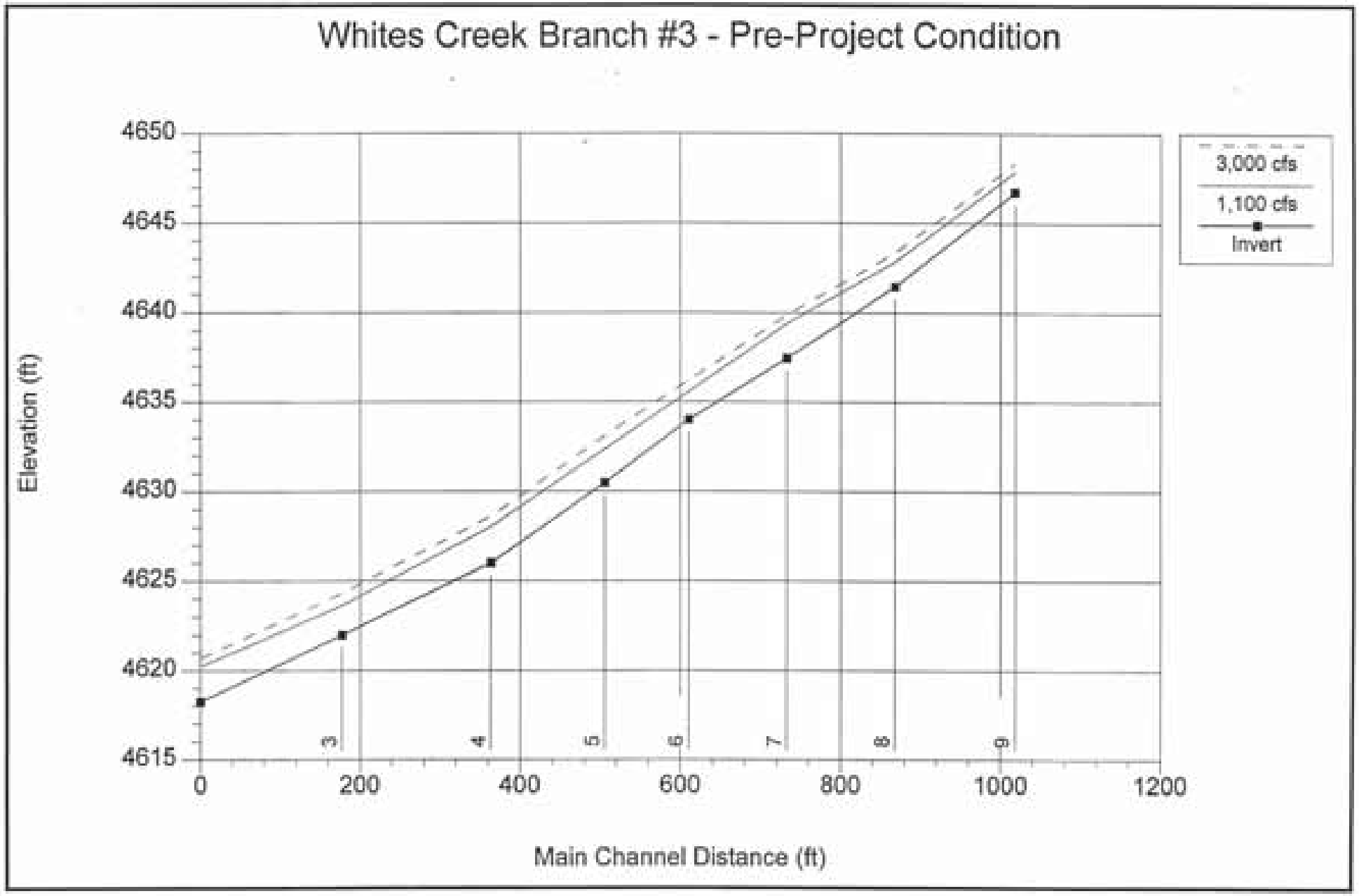
CAUTION SECNO= 36.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 36.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 36.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 37.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 37.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO= 37.000 PROFILE= 1 20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION SECNO= 38.000 PROFILE= 1 CRITICAL DEPTH ASSUMED
CAUTION SECNO= 38.000 PROFILE= 1 PROBABLE MINIMUM SPECIFIC ENERGY

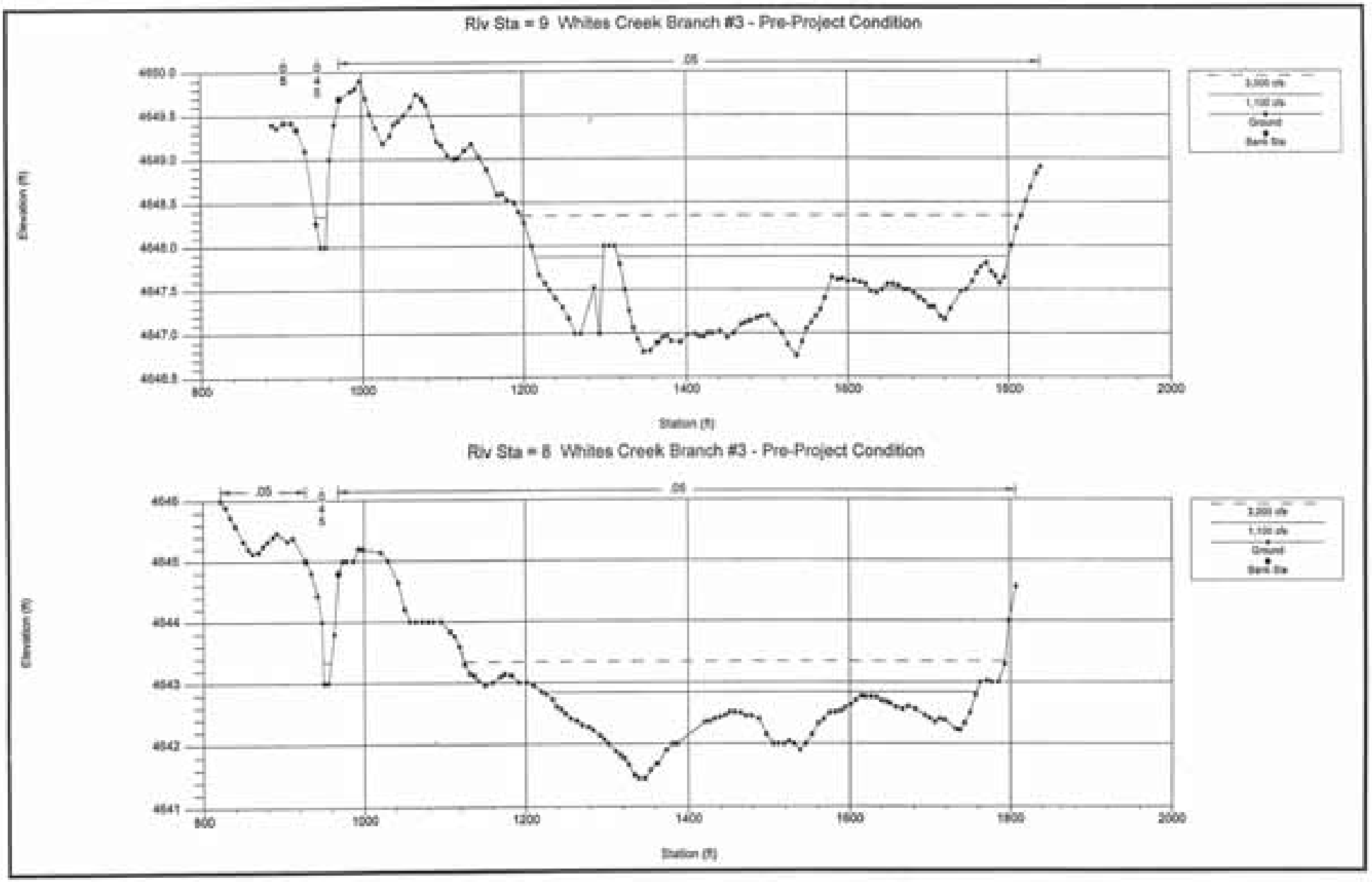
Appendix E

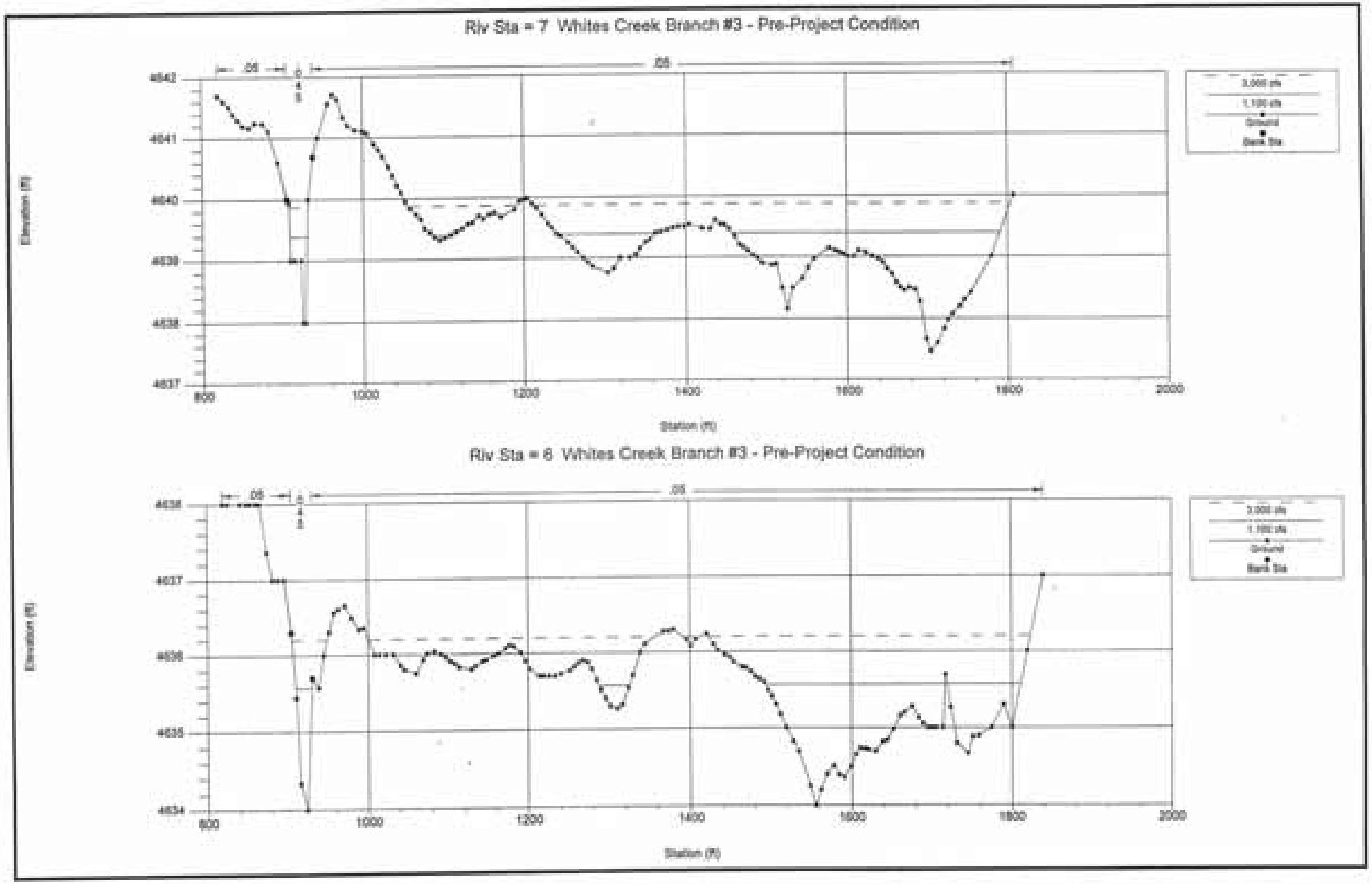
Sub-Section 1
Whites Creek Branch 3
Pre-Project Condition Analysis

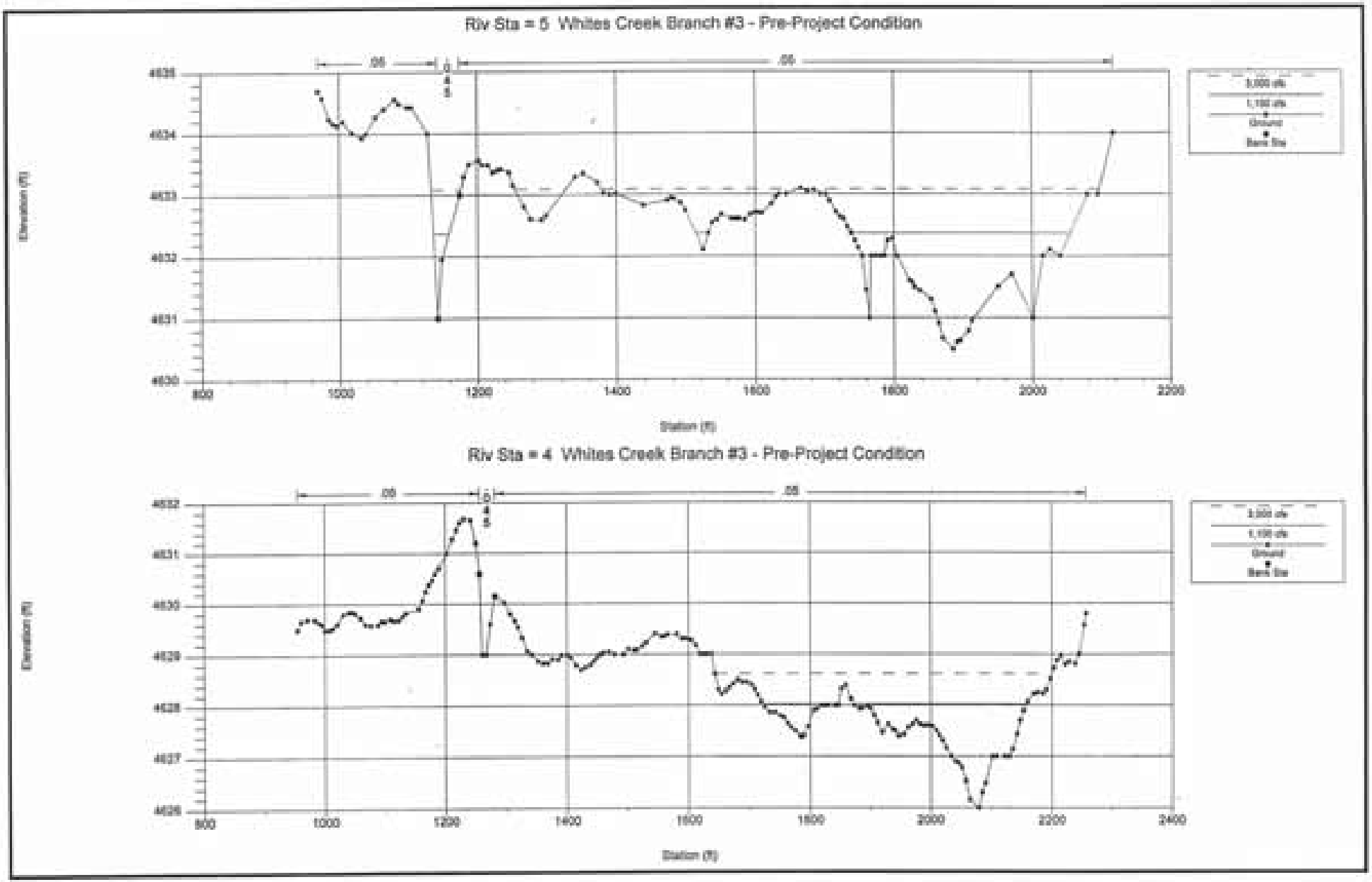

Whites Creek Branch #3 - Pre-Project Condition
Elevation (ft)
4650
4645
4640
4635
4630
4625
4620
4615
0
200
400
600
800
1000
1200
Main Channel Distance (ft)
3,000 cfs
1,100 cfs
Invert
3
4
5
6
7
8
9

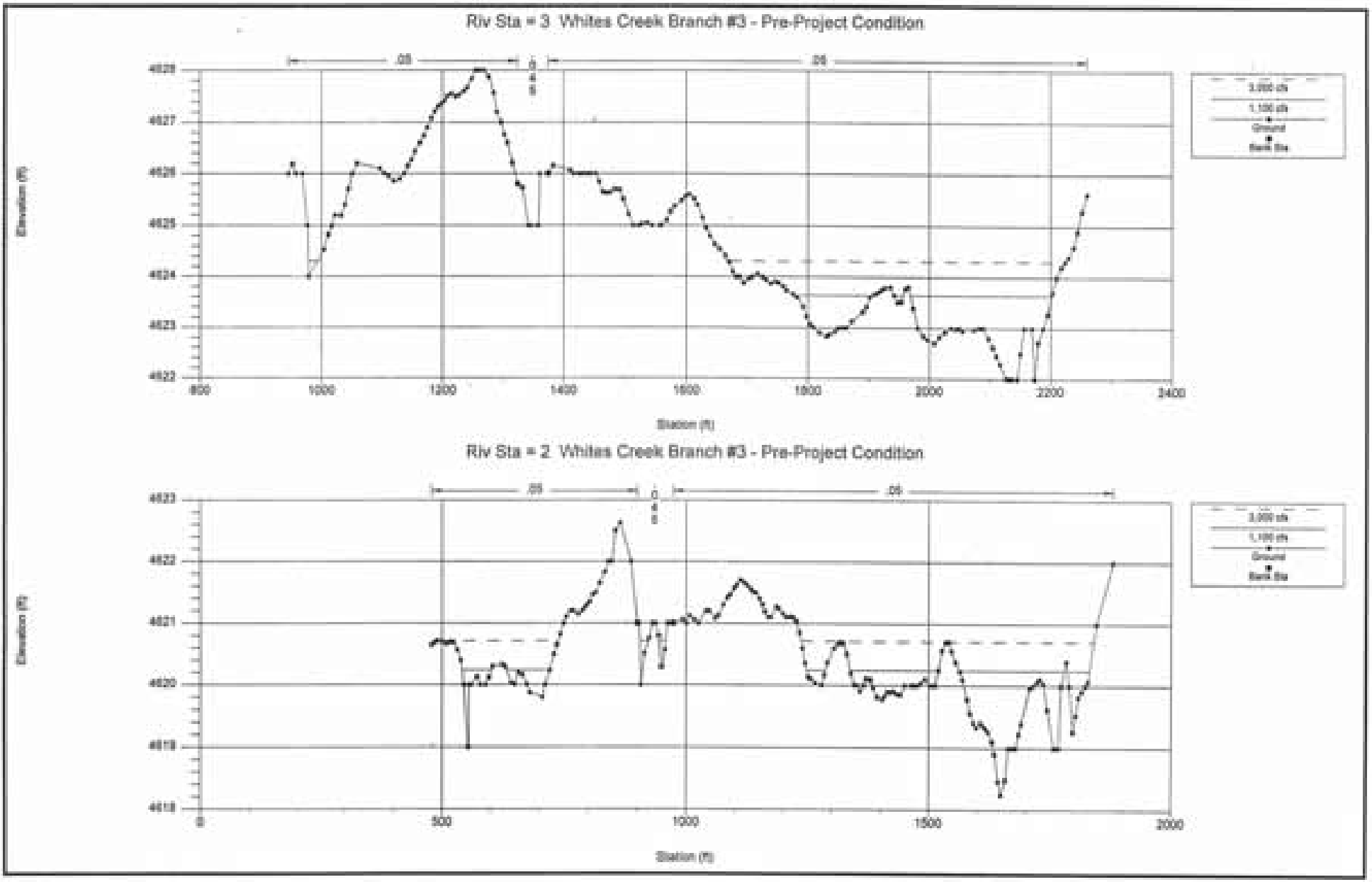
HEC-RAS Plan: Imported Pla Reach: 1

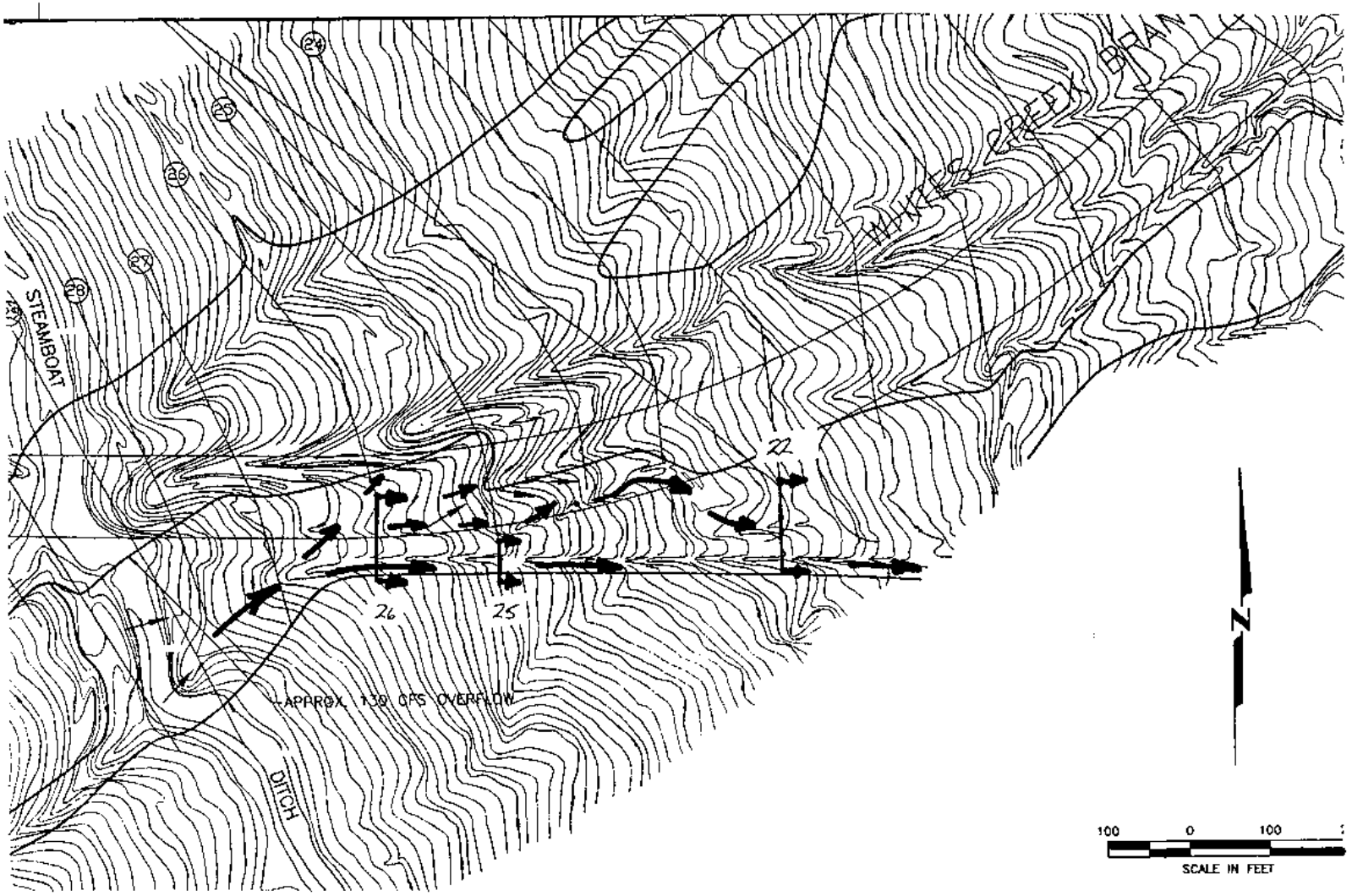
River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (fps)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
2	1100.00	4620.00	4620.25	4620.25	4620.47	0.030083	1.41	298.00	638.04	0.71
2	3000.00	4620.00	4620.71	4620.71	4621.06	0.034776	2.56	646.13	689.20	0.87
3	1100.00	4625.00	4623.64	4623.57	4623.91	0.026532		263.76	376.39	0.00
3	3000.00	4625.00	4624.31	4624.20	4624.71	0.026712		593.60	589.67	0.00
4	1100.00	4629.00	4628.03	4628.03	4628.34	0.038461		244.68	411.93	0.00
4	3000.00	4629.00	4628.61	4628.61	4629.11	0.038517		531.03	556.93	0.00
5	1100.00	4631.00	4632.37	4632.19	4632.60	0.021272	2.81	285.58	357.06	0.74
5	3000.00	4631.00	4633.09	4632.98	4633.39	0.021275	4.11	676.10	630.90	0.81
6	1100.00	4634.00	4635.56	4635.56	4635.89	0.035648	6.05	244.91	373.20	1.08
6	3000.00	4634.00	4636.21	4636.21	4636.58	0.027918	6.74	623.92	625.90	1.01
7	1100.00	4638.00	4639.39	4639.32	4639.61	0.028739	3.92	291.50	496.97	0.89
7	3000.00	4638.00	4639.87	4639.87	4640.26	0.033381	5.95	602.93	749.96	1.04
8	1100.00	4643.00	4642.84	4642.80	4643.06	0.035642		293.23	536.28	0.00
8	3000.00	4643.00	4643.34	4643.30	4643.72	0.032175	2.44	605.03	676.84	0.83
9	1100.00	4648.00	4647.88	4647.75	4648.04	0.023075		341.92	589.21	0.00
9	3000.00	4648.00	4648.35	4648.23	4648.70	0.025580	2.10	629.17	633.97	0.74


Riv Sta = 9 Whites Creek Branch #3 - Pre-Project Condition
Elevation (ft)
Station (ft)
Riv Sta = 8 Whites Creek Branch #3 - Pre-Project Condition
Elevation (ft)
Station (ft)


Riv Sta = 7 Whites Creek Branch #3 - Pre-Project Condition
.05
.05
3,000 cfs
1,100 cfs
Ground
Bank Sta
Elevation (ft)
4642
4641
4640
4639
4638
4637
800
1000
1200
1400
1600
1800
2000
Station (ft)
Riv Sta = 6 Whites Creek Branch #3 - Pre-Project Condition
.05
.05
Ground
Bank Sta
Elevation (ft)
4638
4637
4636
4635
4634
800
1000
1200
1400
1600
1800
2000
Station (ft)


Riv Sta = 5 Whites Creek Branch #3 - Pre-Project Condition
.05
.05
Elevation (ft)
Station (ft)
Riv Sta = 4 Whites Creek Branch #3 - Pre-Project Condition
.05
.05
Elevation (ft)
Station (ft)


Riv Sta = 3 Whites Creek Branch #3 - Pre-Project Condition
Elevation (ft)
Station (ft)
Riv Sta = 2 Whites Creek Branch #3 - Pre-Project Condition
Elevation (ft)
Station (ft)


STEAMBOAT
DITCH
WHITE CREEK BRANCH
APPROX. 130 CFS OVERFLOW
24
25
26
27
28
22
26
25
N
100
0
100
SCALE IN FEET

Section 22 - Right End at Whites Cr. Ln.
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 22 - Right End
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.055000	ft/ft
Water Surface Elevation	18.60	ft

Elevation range: 17.50 ft to 20.10 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	18.00	0.00	29.00	0.040
26.00	17.90	29.00	48.00	0.035
29.00	18.00	48.00	88.00	0.040
45.00	17.50			
48.00	18.00			
55.00	19.00			
60.00	20.00			
80.00	20.10			
85.00	18.00			
88.00	20.00			

Results		
Wtd. Mannings Coefficient	0.036	
Discharge	272.98	cfs
Flow Area	36.96	ft²
Wetted Perimeter	55.52	ft
Top Width	54.53	ft
Height	1.10	ft
Critical Depth	18.85	ft
Critical Slope	0.020343	ft/ft
Velocity	7.39	ft/s
Velocity Head	0.85	ft
Specific Energy	19.45	ft
Froude Number	1.58	

Flow is supercritical.
Flow is divided.
Water elevation exceeds lowest end station by 0.60 ft.

Section 22 - Right End at Whites Cr. Ln.
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 22 - Right End
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.055000	ft/ft
Water Surface Elevation	18.79	ft

Elevation range: 17.50 ft to 20.10 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	18.00	0.00	29.00	0.040
26.00	17.90	29.00	48.00	0.035
29.00	18.00	48.00	88.00	0.040
45.00	17.50			
48.00	18.00			
55.00	19.00			
60.00	20.00			
80.00	20.10			
85.00	18.00			
88.00	20.00			

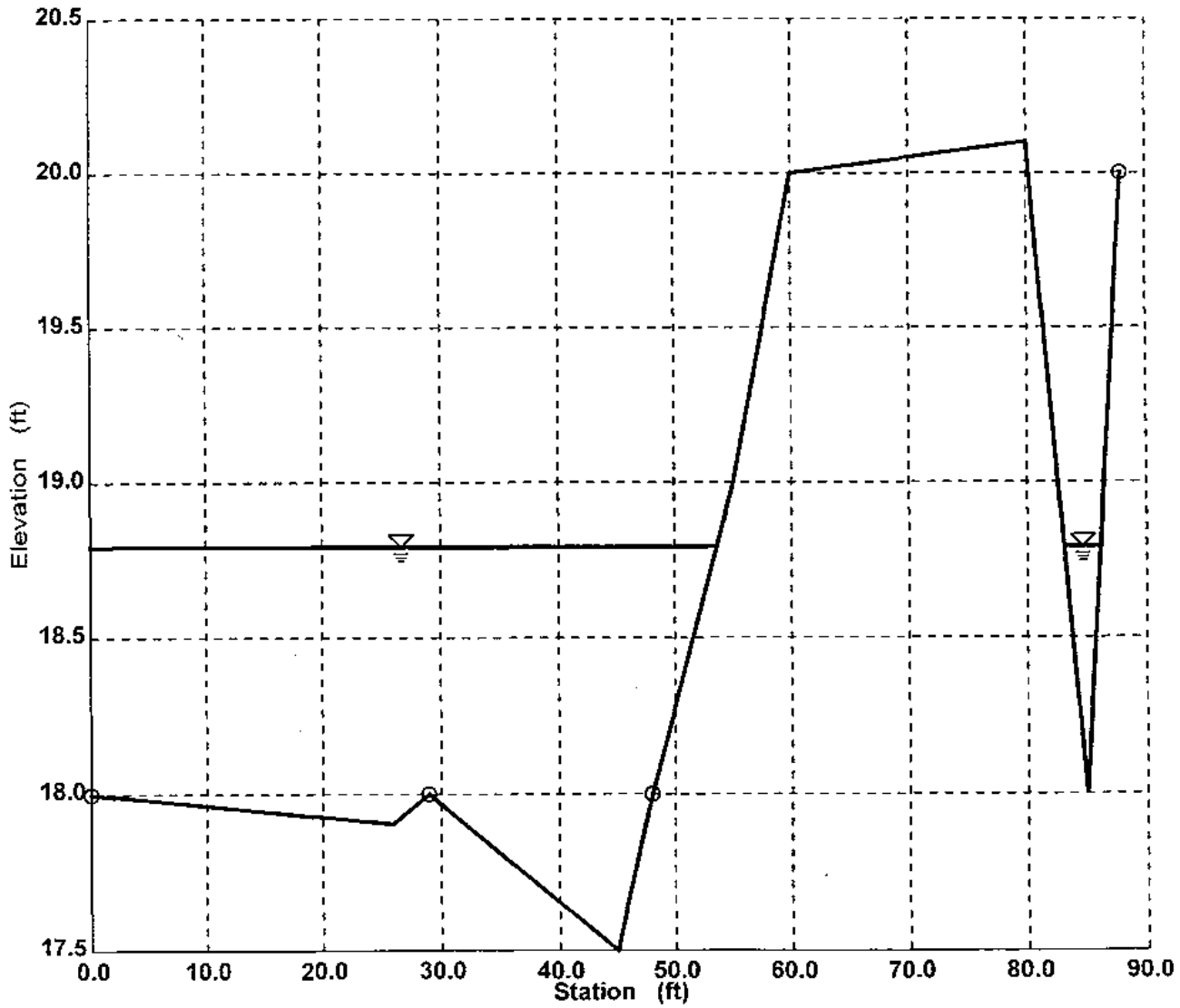
Results		
Wtd. Mannings Coefficient	0.036	
Discharge	402.56	cfs
Flow Area	47.52	ft²
Wetted Perimeter	57.89	ft
Top Width	56.60	ft
Height	1.29	ft
Critical Depth	19.13	ft
Critical Slope	0.019064	ft/ft
Velocity	8.47	ft/s
Velocity Head	1.12	ft
Specific Energy	19.91	ft
Froude Number	1.63	

Flow is supercritical.
Flow is divided.
Water elevation exceeds lowest end station by 0.79 ft.

Section 22 - Right End
Cross Section for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 22 - Right End
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Wtd. Mannings Coefficient	0.036	
Channel Slope	0.055000	ft/ft
Water Surface Elevation	18.79	ft
Discharge	402.56	cfs



Section 25 - S. Side of Whites Creek Ln
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 25 - Capacity on S side of Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data			
Channel Slope	0.066000	ft/ft	
Water Surface Elevation	40.48	ft	
Elevation range: 37.00 ft to 41.00 ft.			

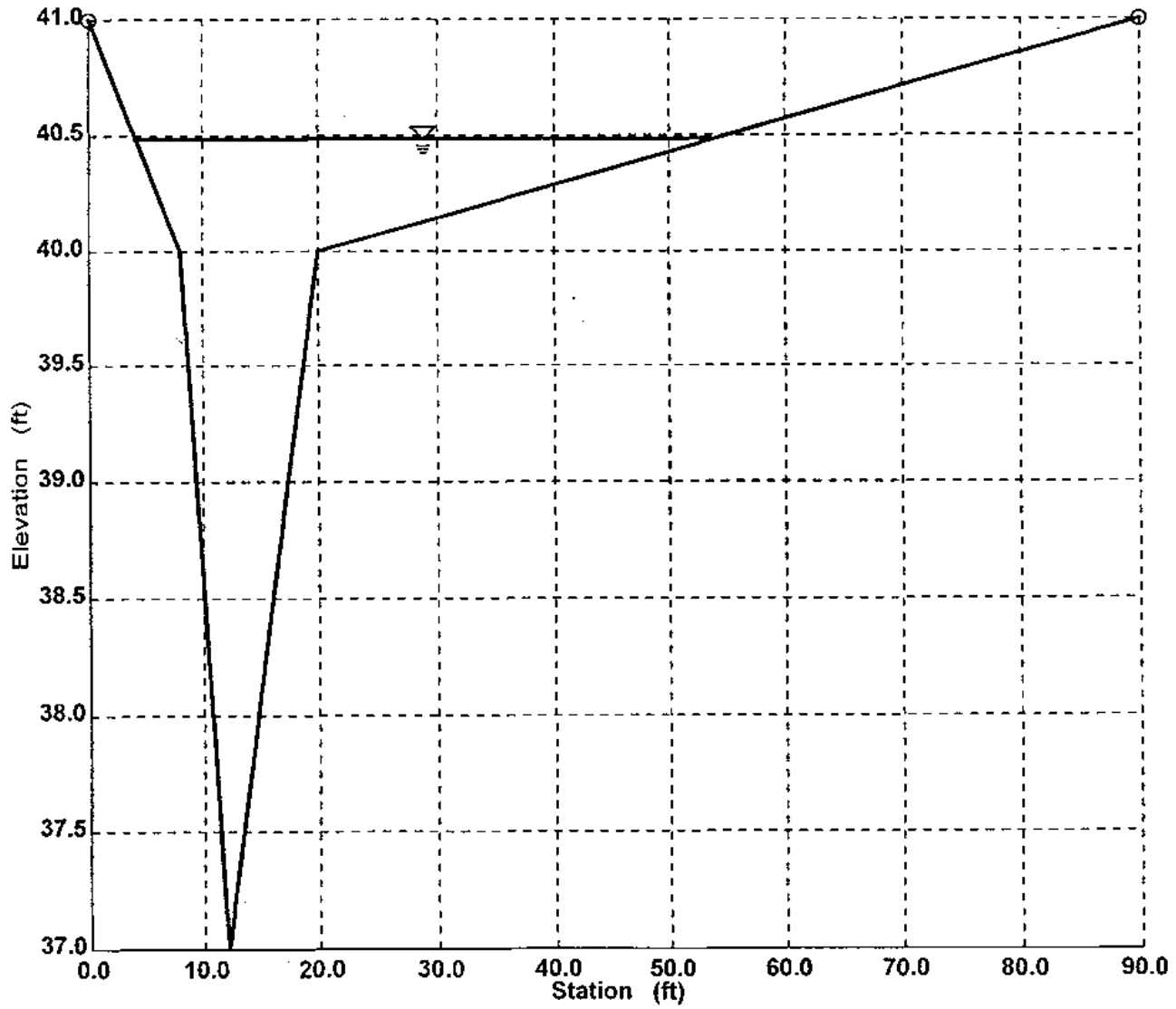
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	41.00	0.00	90.00	0.040
8.00	40.00			
12.00	37.00			
20.00	40.00			
90.00	41.00			

Results		
Wtd. Mannings Coefficient	0.040	
Discharge	232.53	cfs
Flow Area	32.75	ft^2
Wetted Perimeter	51.02	ft
Top Width	49.44	ft
Height	3.48	ft
Critical Depth	40.75	ft
Critical Slope	0.027117	ft/ft
Velocity	7.10	ft/s
Velocity Head	0.78	ft
Specific Energy	41.26	ft
Froude Number	1.54	
Flow is supercritical.		

Section 25 - S. Road Shoulder Capacity
Cross Section for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 25 - Capacity on S side of Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Wtd. Mannings Coefficient	0.040	
Channel Slope	0.066000	ft/ft
Water Surface Elevation	40.48	ft
Discharge	232.53	cfs

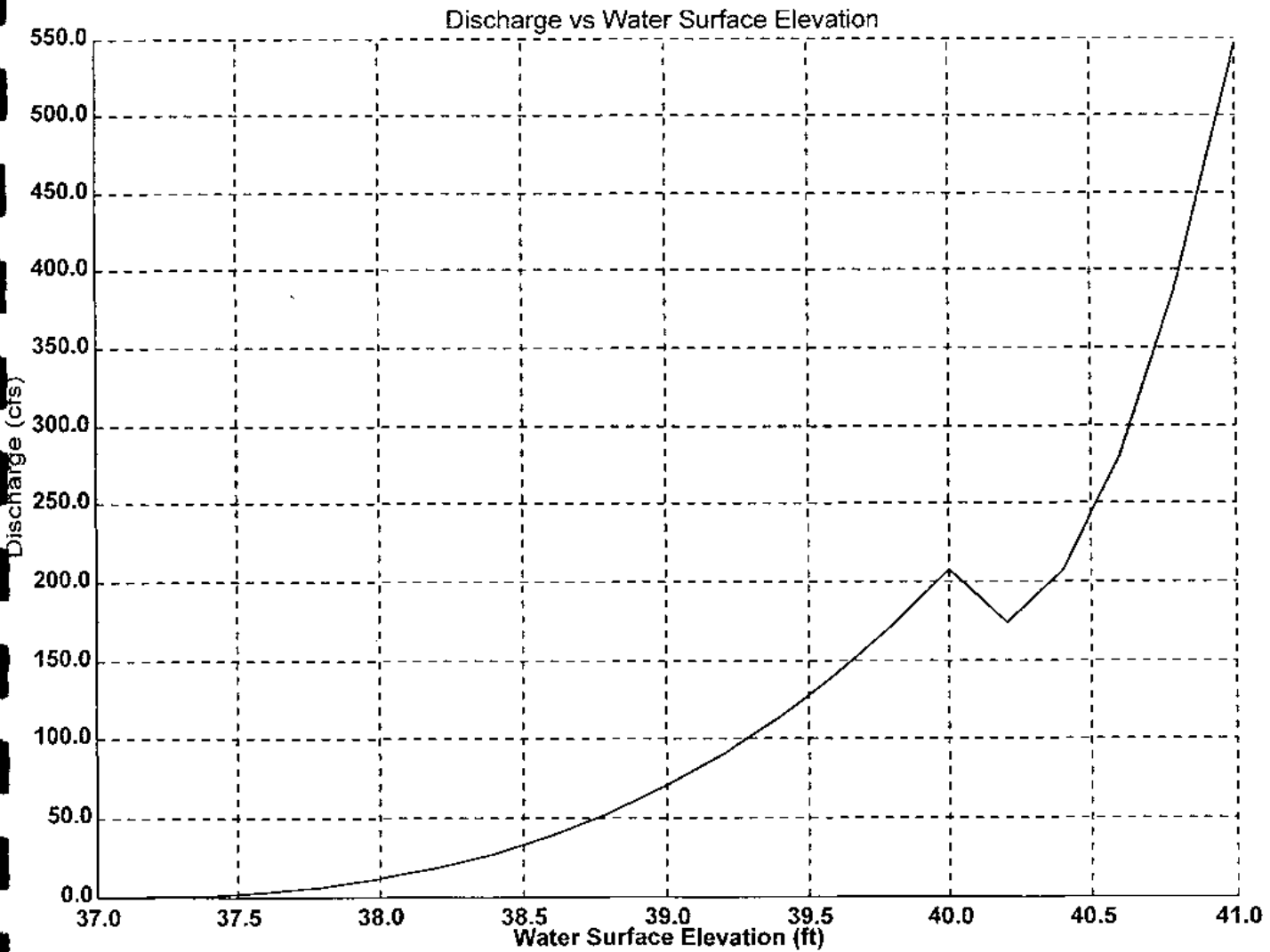


Curve
Plotted Curves for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 25 - Capacity on S side of Road
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.066000 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	37.00	41.00	0.20 ft



Section 26 - S. Road Shldr Capacity
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 26 - S. Road Shoulder Cap
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.066000	ft/ft
Water Surface Elevation	47.00	ft

Elevation range: 45.70 ft to 47.00 ft.

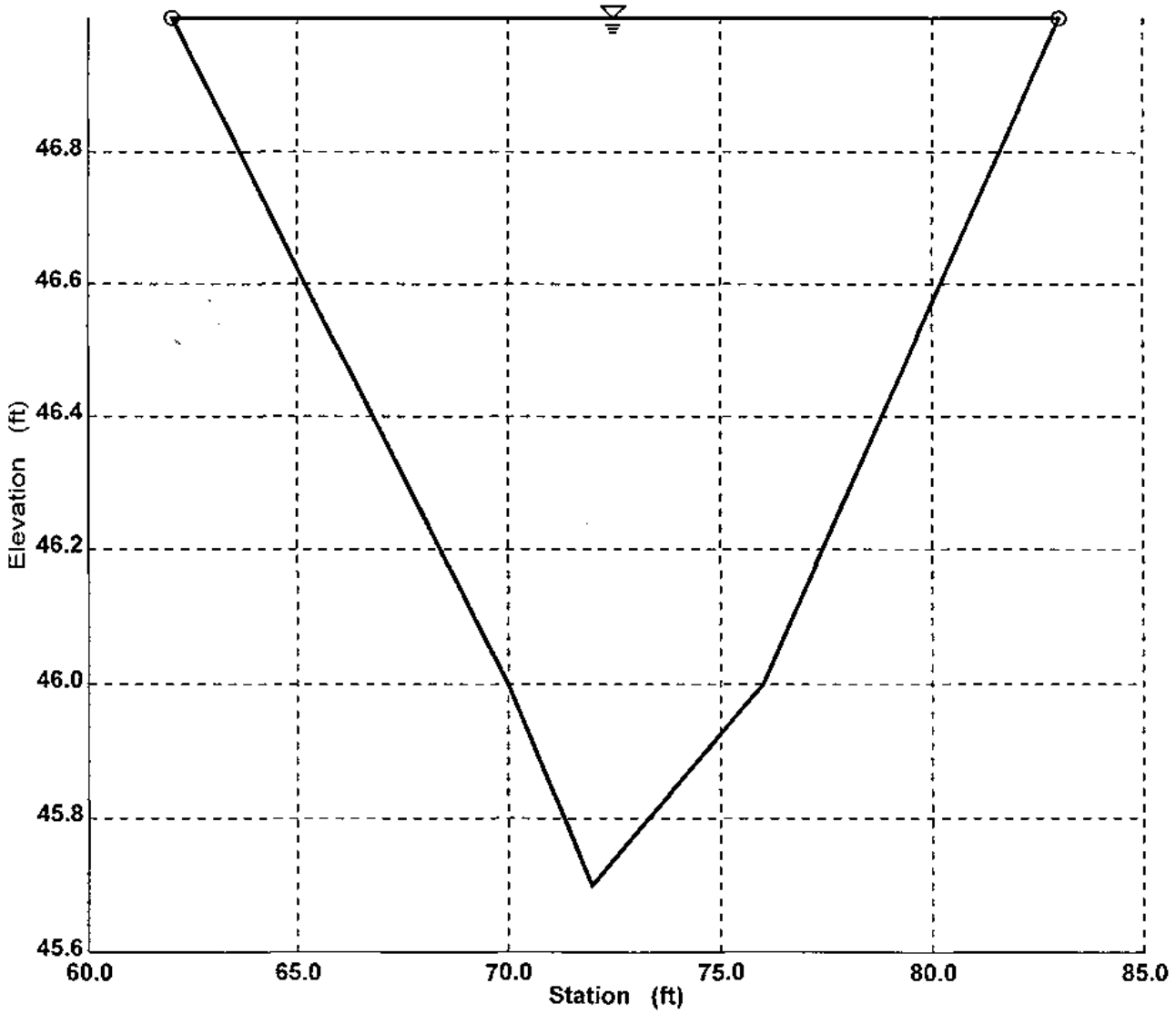
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
62.00	47.00	62.00	83.00	0.035
70.00	46.00			
72.00	45.70			
76.00	46.00			
83.00	47.00			

Results		
Wtd. Mannings Coefficient	0.035	
Discharge	121.49	cfs
Flow Area	14.40	ft²
Wetted Perimeter	21.17	ft
Top Width	21.00	ft
Height	1.30	ft
Critical Depth	47.33	ft
Critical Slope	0.018706	ft/ft
Velocity	8.44	ft/s
Velocity Head	1.11	ft
Specific Energy	48.11	ft
Froude Number	1.80	
Flow is supercritical.		

Section 26 - S. Road Shoulder Capacity
Cross Section for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 26 - S. Road Shoulder Cap
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Wtd. Mannings Coefficient	0.035	
Channel Slope	0.066000	ft/ft
Water Surface Elevation	47.00	ft
Discharge	121.49	cfs



Section 26 Overflow Capacity
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 26 Overflow Capacity
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.066000	ft/ft
Water Surface Elevation	47.22	ft

Elevation range: 45.70 ft to 47.00 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	47.00	0.00	30.00	0.040
30.00	46.10	30.00	40.00	0.035
40.00	46.00	40.00	50.00	0.040
50.00	47.00	50.00	62.00	0.020
62.00	47.00	62.00	70.00	0.040
70.00	46.00	70.00	76.00	0.035
72.00	45.70	76.00	79.00	0.040
76.00	46.00			
79.00	47.00			

Results		
Wtd. Mannings Coefficient	0.034	
Discharge	530.58	cfs
Flow Area	57.78	ft^2
Wetted Perimeter	79.76	ft
Top Width	79.00	ft
Height	1.52	ft
Critical Depth	47.61	ft
Critical Slope	0.017265	ft/ft
Velocity	9.18	ft/s
Velocity Head	1.31	ft
Specific Energy	48.53	ft
Froude Number	1.89	

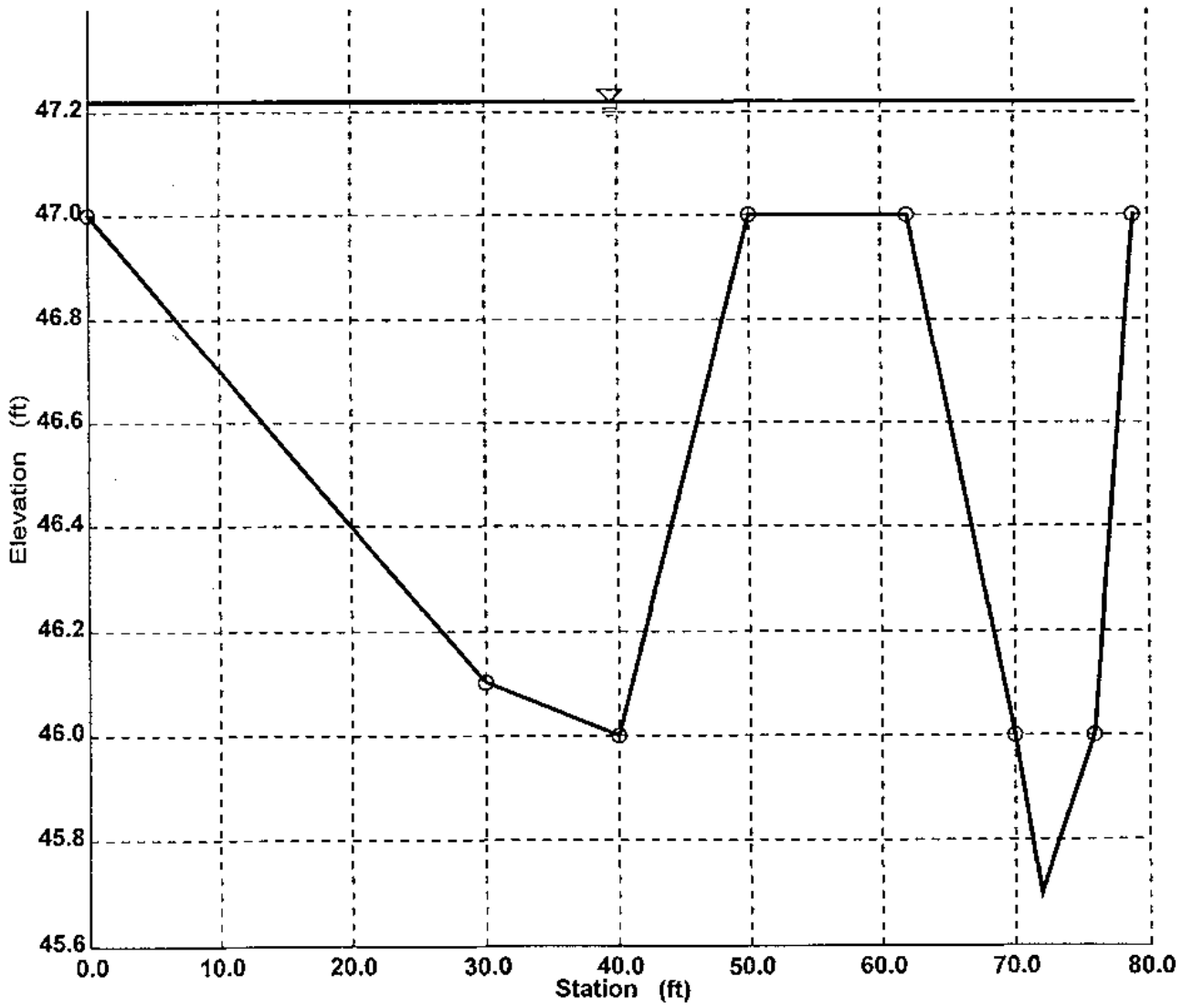
Flow is supercritical.

Water elevation exceeds lowest end station by 0.22 ft.

Branch 2 - Section 26 Right End
Cross Section for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 26 Overflow Capacity
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Wtd. Mannings Coefficient	0.034	
Channel Slope	0.066000	ft/ft
Water Surface Elevation	47.22	ft
Discharge	530.58	cfs

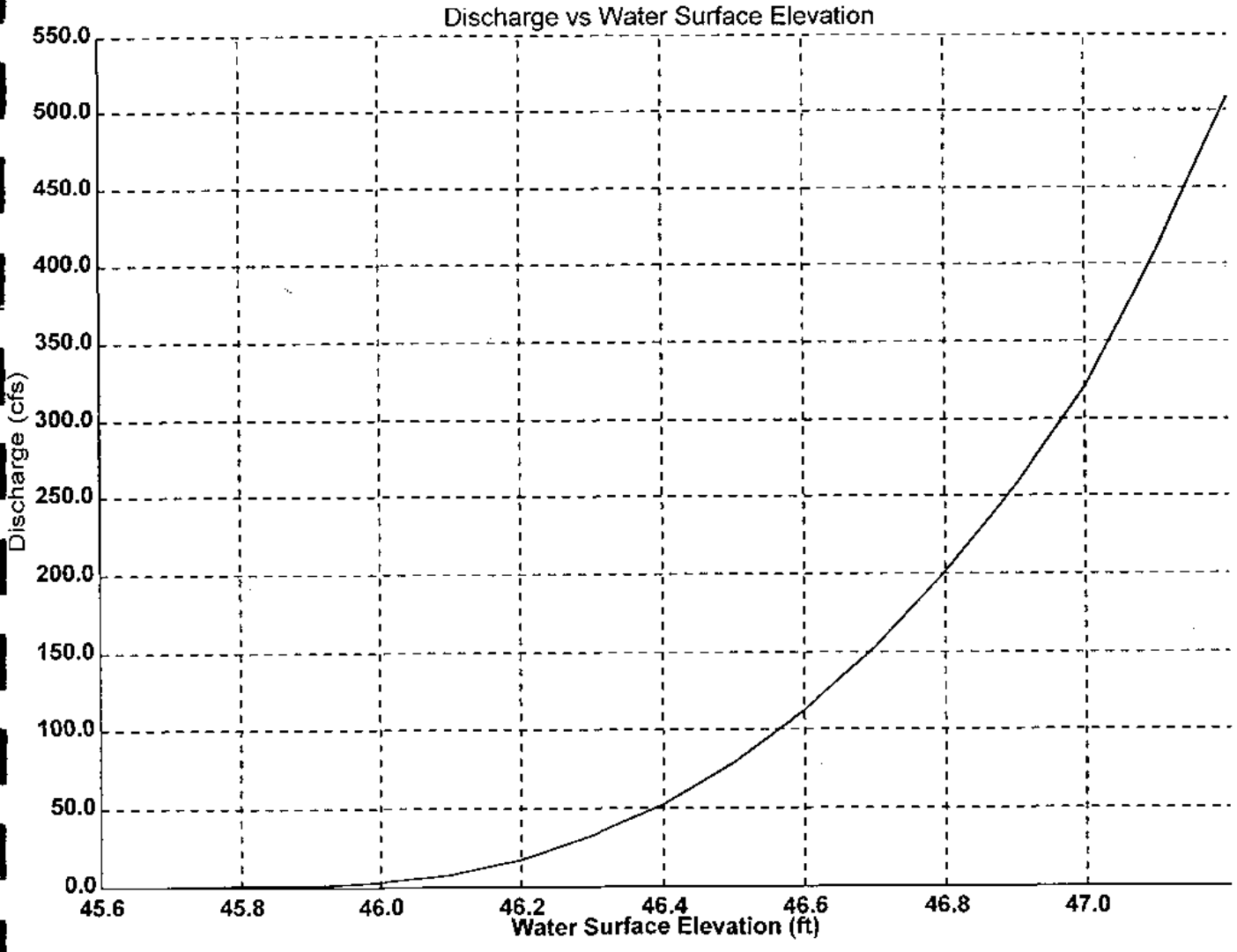


Section 26 Overflow
Plotted Curves for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sad23.fm2
Worksheet	Section 26 Overflow Capacity
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.066000 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	45.70	47.22	0.10 ft



Harding Lawson Associates
Engineering
and
Environmental Services

SHEET 1 OF 2
JOB NO. 37957
DATE 8/22/97
COMPUTED BY MEF
CHECKED BY

PROJECT SAD #23
SUBJECT RIP RAP SIZING

WHITES CREEK BRANCH 1 - 3000 cfs

FLOW DISTRIBUTION AT ACCESS CULVERT PARKWAY:

BRIDGE		519
CULVERT 1	(2) 8x10	1488
CULVERT 2	(2) 60" RCPs	493
CULVERT 3	(2) 60" RCPs	500

CULVERT #1

Q = 1488 cfs (744 cfs / CULVERT)

OUTLET V = 12.5 fe/s

DEPTH D/S OF OUTLET = 6'

RIP-RAP SIZING BASED ON WC HCDDM SECTION 807

FOR $y = D_o$:

$$d_{50} = \frac{0.082 (Q)^{4/3}}{TW (D_o)}$$

$$= \frac{0.0882 (744)^{4/3}}{6(10)}$$

$$= 0.92'$$

FOR $y = \frac{1}{2} D_o$:

$$d_{50} = \frac{0.01245 (Q)^{4/3}}{TW (D_o)}$$

$$= \frac{0.01245 (700)^{4/3}}{60}$$

$$= 1.40'$$

CULVERT # 2+3

$Q = 500$ cfs

OUTLET $V = 12.7$ fps

D/S DEPTH ~ 6'

FOR $Y = D_o$:

$$d_{50} = \frac{0.0082 (250)^{1/3}}{30}$$

$= 0.43'$

FOR $Y = \frac{1}{2} D_o$:

$$d_{50} = \frac{0.01245 (Q)^{1/3}}{30}$$

$= 0.65'$

WHITES CREEK BRANCH 2 - $Q = 3000$ cfs - (3) 8'x10' RCB

$Q = 2591$ cfs (864 cfs / CULVERT)

OUTLET $V = 14.1$ fps

DEPTH D/S OF OUTLET ~5'

FOR $Y = \frac{1}{2} D_o$:

$$d_{50} = \frac{0.01245 (8.64)^{1/3}}{(5)(10)}$$

$= 2.05'$

COE HYDRAULIC DESIGN OF FLOOD CONTROL CHANNELS - PLATES 29+30

FOR: $V = 15$ fps

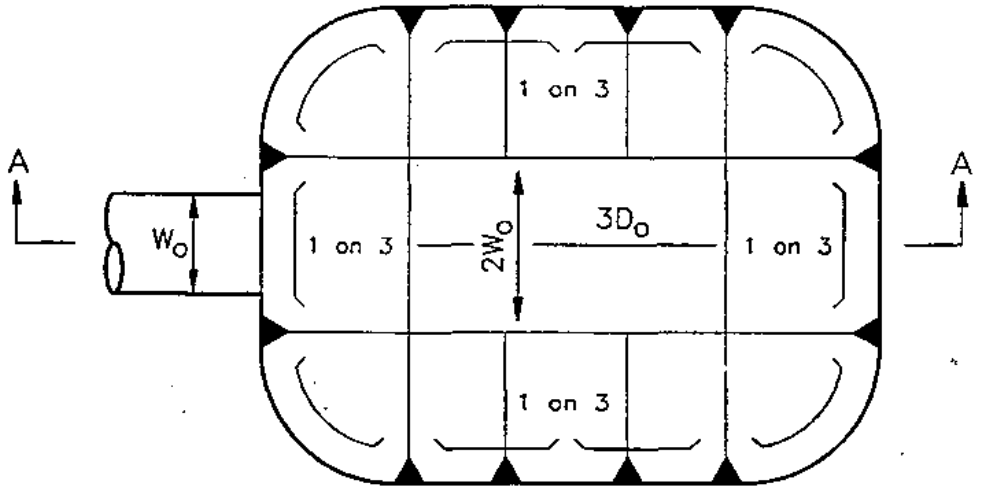
STONE WEIGHT (W_{50}) =

(IBASH) 300 lbs $\Rightarrow D_{50} = 1.5'$

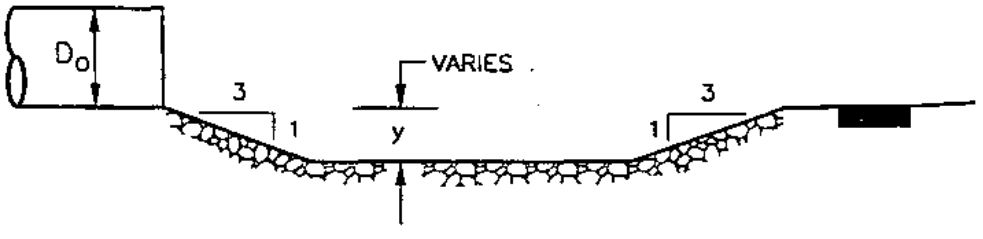
(USBR) 1800 lbs $\Rightarrow D_{50} = 2.6'$

$\therefore$ 24" RIP-RAP SHOULD BE SUFFICIENT

PREFORMED SCOUR HOLE



PLAN VIEW

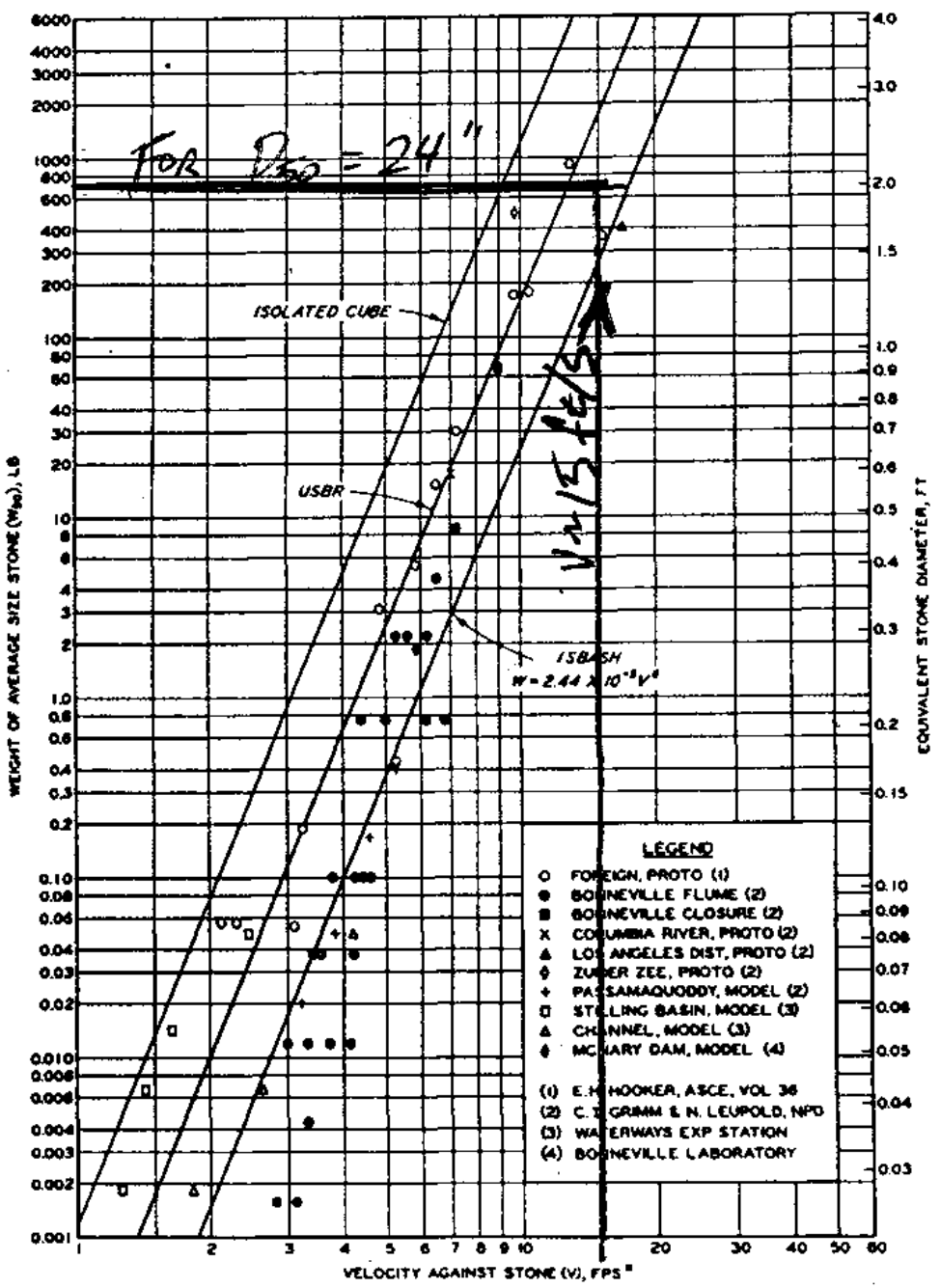


SECTION VIEW

CLASSIFICATION AND GRADATION OF LOOSE RIPRAP

RIPRAP DESIGNATION	%SMALLER THAN GIVEN SIZE BY WEIGHT	INTERMEDIATE ROCK DIMENSION (Inches)	d_{50}* (Inches)
Type VL	70-100	12	
	50-70	9	
	35-50	6	6**
	2-10	2	
Type L	70-100	15	
	50-70	12	
	35-50	9	9**
	2-10	3	
Type M	70-100	21	
	50-70	18	
	35-50	12	12
	2-10	4	
Type H	100	30	
	50-70	24	
	35-50	18	18
	2-10	6	
Type VH	100	42	
	50-70	33	
	35-50	24	24
	2-10	9	

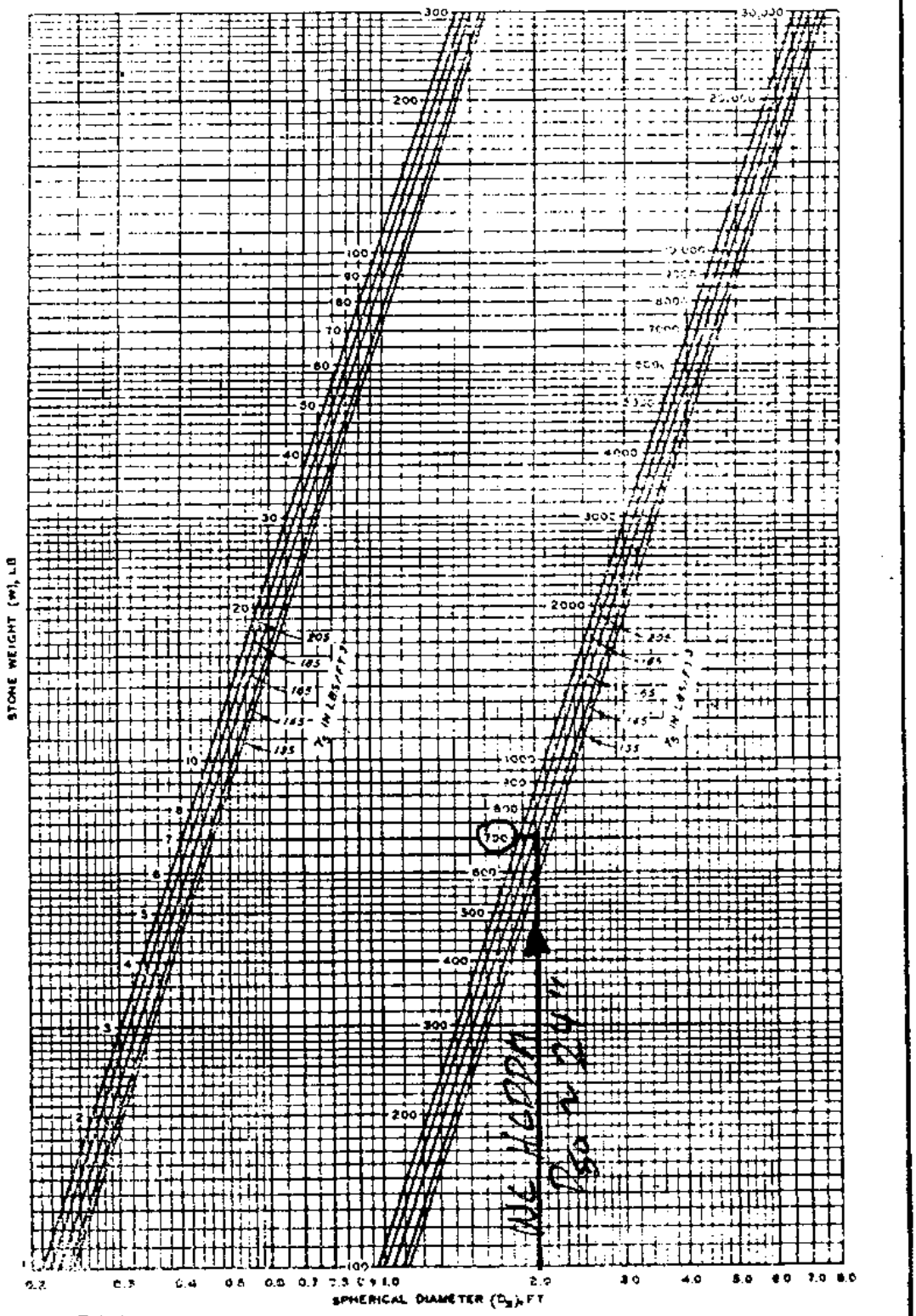
* d_{50} = mean particle size
** Bury types VL and L with native top soil and re-vegetate to protect from vandalism.



NOTE: SPECIFIC WEIGHT OF ROCK = 165 LB/CU FT.
*FOR STONE PROTECTION BELOW ENERGY DISSIPATORS USE AS AVERAGE VELOCITY ACROSS END SILL.

VELOCITY VS STONE WEIGHT

SEE TEXT PAGE 36



SEE TEXT PAGE 39

Plate 30

Arrow Creek Parkway - Whites Creek Branch 1, C-Span Arch Bridge

Scour Analysis

Based on HEC -18, April 1993

Scour Estimates:

Live Bed Contraction Scour:

$y2/y1 = (Q2/Q1)^{0.857} * (W1/W2)^{k1}$ (Eq. 16)

		1000 cfs	
Where:	y1 =	3.84	ft
	Q1 =	350	cfs
	Q2 =	682	cfs
	W1 =	55	ft
	W2 =	42	ft
	k1 =	0.59	
	R=	3.00	ft
	t=	3.9	lb/ft^2
	V/w =	0.71	
	V =	1.422	ft/s
	w =	2	ft/s
	g =	32.2	ft/s^2
	S1 =	0.02094	ft/ft
	y2/y1=	2.08	
	y2=	7.97	
	Scour =	**4.1**	

Abutment Scour Estimate:

K1	0.8200
K2	1
L	80.00
Ae	120.0
Fr	0.4
Ve	2.9
Qe	200
Ya	2.5
Ys	**4.4**

Rip Rap Sizing:

	100-yr
$Fr = V/(gy)^{.5}$ =	0.4316658

$D50 = y(k/(Ss-1))(V^2/gy)$ (Eq. 93, HEC-18, Pg. 118)

		3000 cfs	
Where:	V =	6	ft/s
	g =	32.2	ft/s^2
	y =	6	ft
	Ss =	2.65	
	k =	1.02	(Vertical wall abutment)
Results:	**D50 =**	**0.7**	**ft**

Hydraulic data was estimated using HEC-RAS.

Prepared by: MEF
Date: June 11, 1997
SCOUR.XLS

HEC-RAS Plan: Imported Pla Reach: 1 Riv Sta: 7 Profile: 1

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
-19.49	-12.10	0.22	2.57	6.85	39.8	0.38	2.56
-12.10	12.04	5.75	33.70	24.21	1040.6	1.40	5.12
12.04	299.24	93.15	384.69	219.63	16849.2	1.76	7.26

HEC-RAS Plan: Imported Pla Reach: 1 Riv Sta: 6 Profile: 1

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
-35.17	-27.45	0.01	0.32	3.00	2.2	0.11	0.96
-27.45	-19.74	0.38	4.09	7.74	79.4	0.53	2.77
-19.74	-12.03	1.60	9.73	7.75	336.5	1.26	4.93
-12.03	12.03	8.34	41.55	24.17	1476.8	1.73	6.02
12.03	312.27	89.52	354.93	195.76	15855.7	1.82	7.57

HEC-RAS Plan: Imported Pla Reach: 1 Riv Sta: 7 Profile: 1

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
-272.18	-260.35	0.05	5.79	11.85	106.8	0.49	0.27
-260.35	-248.53	0.19	12.64	11.83	392.4	1.07	0.45
-248.53	-236.71	0.37	18.92	11.84	768.7	1.60	0.59
-236.71	-224.89	0.65	26.61	11.84	1356.8	2.25	0.74
-224.89	-213.07	0.89	32.03	11.83	1849.8	2.71	0.83
-213.07	-201.25	1.05	35.47	11.83	2192.6	3.00	0.89
-201.25	-189.42	1.28	39.78	11.83	2652.6	3.36	0.96
-189.42	-177.60	1.59	45.41	11.83	3308.7	3.84	1.05
-177.60	-165.78	1.38	41.62	11.85	2858.7	3.52	0.99
-165.78	-153.96	0.90	32.23	11.85	1866.3	2.73	0.84
-153.96	-142.14	0.63	26.11	11.83	1315.9	2.21	0.73
-142.14	-130.32	0.59	25.07	11.82	1229.8	2.12	0.71
-130.32	-118.49	0.63	26.03	11.82	1309.3	2.20	0.73
-118.49	-106.67	0.66	26.82	11.82	1376.4	2.27	0.74
-106.67	-94.85	0.66	26.80	11.82	1374.5	2.27	0.74
-94.85	-83.03	0.61	25.65	11.82	1277.8	2.17	0.72
-83.03	-71.21	0.59	24.93	11.82	1218.5	2.11	0.71
-71.21	-59.39	0.59	24.92	11.82	1217.6	2.11	0.71
-59.39	-47.56	0.65	26.61	11.82	1357.7	2.25	0.74
-47.56	-35.74	0.83	30.66	11.84	1718.5	2.59	0.81
-35.74	-23.92	1.29	40.17	11.87	2690.7	3.40	0.97
-23.92	-12.10	2.14	54.32	11.89	4444.2	4.59	1.18
-12.10	12.04	5.90	142.16	24.21	11458.6	5.89	1.24
12.04	299.24	75.88	1558.66	274.46	147441.3	5.70	1.46