Tri-County Parkway Location Study

HYDROLOGY AND HYDRAULICS TECHNICAL REPORT

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The Virginia Department of Transportation

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S.0 EXECUTIVE SUMMARY

Project History and Overview

The Tri-County Parkway Location Study evaluates a new north/south transportation link in northern Virginia that will connect the City of Manassas with Interstate 66 (I-66) and the Dulles corridor. The corridor begins in the north at the intersection of US 50 and Route 606 (Old Ox Road) and extends to the south at the interchange of VA 28/VA 234 Bypass. It is approximately 15 miles long and traverses portions of the counties of Prince William, Fairfax, and Loudoun along with the cities of Manassas and Manassas Park. The three counties that the Tri-County Parkway will traverse are among the top ten fastest growing counties in the Commonwealth of Virginia. The City of Manassas and the City of Manassas Park have also experienced substantial population growth over the last ten years. Much of the growth in Northern Virginia can be attributed to the emergence of high-tech industries near the Washington Dulles International Airport. A second rapid growth corridor within the region is the I-66 corridor. The primary problem the Tri-County Parkway is intended to address is the lack of adequate north-south transportation facilities linking the I-66 corridor with the Dulles area and VA 267. East of US 15 and west of the I-495 (Capital Beltway), only three principal urban arterials link the spokes together - VA 28 (Sully Road), Route 7100 (Fairfax County Parkway), and VA 123. These north-south facilities are heavily congested and will deteriorate further by the year 2025.

Purpose and Need

The study area presently lacks adequate north-south transportation facilities linking the I-66 corridor with the Dulles area and VA 267. The purpose and need for the Tri-County Parkway is comprised of four key elements, namely:

1. Improve transportation mobility and capacity and, by doing so, improve access and reduce congestion.
2. Enhance the linkage of communities and the transportation system that serves those communities.
3. Accommodate social demands, environmental goals, and economic development needs.
4. Improve safety and, by doing so, reduce the average crash, injury, and accident rates on the roadway network.

Each of the elements has equal value and importance in the overall transportation, environmental, economic, and quality of life objectives for the communities being served under the proposed action.

Alternatives

In accordance with NEPA requirements, alternatives initially considered for the Tri-County Location Study included the No-Build, Mass Transit, Transportation System Management (TSM), and Candidate Build Alternatives (CBAs). Each alternative was evaluated with respect to its potential impacts and its ability to address the project's purpose and need.

Alternatives Eliminated from Detailed Study

Assessments conducted as part of the Tri-County Parkway Location Study determined that the nature of the study area makes the identification of a mass transit alternative that can address the corridor's purpose and need problematic. No transit authority exists whose service area covers or would cover the entire study area, nor are there plans to establish such an authority. In addition, the development patterns and traffic patterns and volumes within the study corridor do not favor north-south through movement along the corridor. The majority of trips and greatest volumes are to points outside the study area or along only a portion of the corridor (i.e., from the Manassas and Centerville areas to I-66 and points east, from the South Riding area to the Dulles corridor). The through volumes are by far the weakest in the study area and would not attract sufficient transit riders to make such service viable; therefore, the mass transit alternative was eliminated from further consideration.

There are no practicable Transportation System Management (TSM) measures beyond those already proposed in the CLRP and VDOT Six Year Plan which could reasonably be implemented to satisfy the

purpose and need for the Tri-County Parkway. TSM-type improvements programmed into the aforementioned plans do not satisfy the project's purpose and need when considered as a stand-alone alternative; therefore, the TSM Alternative was eliminated from further consideration.

The No-Build Alternative

The No-Build Alternative includes currently programmed committed and funded roadway and transit projects in the Virginia Department of Transportation (VDOT) Six Year Plan and the CLRP developed by the MWCOG. The No-Build Alternative, while having no direct construction costs, would result in other economic, environmental, and quality of life impacts that can be expected from the continuation of roadway system deficiencies. While the No-Build alternative does not meet the project needs for traffic, safety, and roadway infrastructure improvements, it provides a baseline condition with which to compare the improvements and consequences associated with the Candidate Build Alternatives.

Candidate Build Alternatives (CBAs)

Three Candidate Build Alternatives (CBAs) have been identified for further evaluation in a Draft Environmental Impact Statement (EIS). These CBAs are referred to hereinafter as: (1) the "Comprehensive Plan" CBA, (2) the "West Two" CBA, and (3) the "West Four" CBA. Each of the CBAs is expected to be comprised of two or more facility types according to localized needs and goals. To assess environmental effects associated with a particular facility type along each CBA, three general design segments were developed. These general design segments and their relationship to each alternative assessed are described in the body of this Technical Report.

The Comprehensive Plan CBA

The Comprehensive Plan CBA would be located east of the Manassas National Battlefield. The Comprehensive Plan CBA would provide a new urban principal arterial roadway from the northern terminus at the intersection of US 50 and Route 606 (Old Ox Road) and the southern terminus at the Route 28 and Route 234 Bypass Interchange, and would consist of Segments F', F, and E. Segment F' between Route 50 and Route 620 would be comprised of improvements along an existing four-lane divided facility within an existing right-of-way on an existing alignment. Segment F' south of Route 620 would be a new four-lane divided facility within a new right-of-way on a new alignment. Three separate sections characterize segment E. The portion of Segment E between I-66 and the Fairfax/Prince William county line would be a new six-lane divided facility within a new right-of-way on a new alignment. The portion of segment E from the Fairfax/Prince William county line south to VA 234 would be a new six-lane divided facility within an existing right-of-way on an existing alignment. The portion of Segment E from VA 234 to the VA 234 Bypass would be comprised of improvements along an existing four-lane divided facility called Godwin Drive and would be widened to a six-lane divided facility within the existing right-of-way and on an existing alignment.

The West Two CBA

The West Two CBA is located west of the Manassas National Battlefield. The West Two CBA would provide a new urban principal arterial roadway from the northern terminus near the intersection of US 50 and Route 877 (Racefield Lane) and the southern terminus at the I-66 and Route 234 Interchange. The West Two CBA would be a new four-lane divided facility within a new right-of-way and on a new alignment, and would consist of Segments D and C.

The West Four CBA

The West Four CBA is also located west of the Manassas National Battlefield. The West Four CBA would provide a new urban principal arterial roadway from the northern terminus at the intersection of US 50 and Route 606 (Old Ox Road) and the southern terminus at the I-66 and Route 234 Interchange. The West Four CBA would consist of Segments F', G, and C. Segment F' between Route 50 and Route 620 (Braddock Road) would be comprised of improvements along an existing four-lane divided facility within an existing right-of-way on an existing alignment. Segment F' south of Route 620 would be comprised of a new four-lane divided facility within a new right-of-way on a new alignment.

Affected Environment

The Candidate Build Alternatives (CBAs) – The Comprehensive Plan CBA, The West Two CBA, and the West Four CBA - generally run in a north-south orientation, crossing the Bull Run watershed and three of its major tributaries Catharpin Run, Flat Branch, and Cub Run. The CBAs cross these streams, as well as several smaller tributaries and, in some cases, run parallel to the stream along the edge of the floodplain. Required stormwater facilities that have been defined as "Major Structures not in a floodplain" tend to be within smaller watersheds with flows above 500 cfs for the 100 year storm. Typically, these facility needs can be resolved by using a culvert or series of culverts. As far as possible, with existing data and topography, any area or location needing a roadway culvert for roadway or small watershed drainage was preliminarily assessed to determine if it will fit into the Minor Drainage or Major Drainage Facility. The Major Drainage Facilities were further separated by the floodplain criteria to identify the culvert or bridge structures type.

Environmental Consequences

Facilities are required to provide roadway drainage and to allow conveyance under the roadway of storm water runoff from smaller watershed to an adequate receiving water or channel. These facilities are most likely to be culverts. Stream crossings are generally major bridge structures crossing both the floodway and floodplain overbanks. The design must be sensitive to the impact of upstream water surface elevations. The installation of piers and approaches to the bridge can increase the upstream water surface elevations (causing increased flooding) and can increase velocities through the bridge opening (causing potential for damaging scour). The preliminary determination shows no significant impact on the water surface profiles due to the preliminary bridge cross-sections. Stormwater management can ultimately be achieved by a combination of best management practices (BMP) during future design phases and when a preferred alternative is selected. Candidate BMPs include, but are not limited to: grassed swales, vegetated buffers and filter strips, check dams, extended detention basins, water quality structures, retention basins, enhanced basins, forebays, bioretention facilities, and regional facilities. Impervious areas, water quality volumes, and estimated basin excavation volumes for all watersheds are identified.

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION AND HISTORY

The Tri-County Parkway Location Study evaluates a new north/south transportation link in northern Virginia that will connect the City of Manassas with Interstate 66 (I-66) and the Dulles corridor. The corridor begins in the north at the intersection of US 50 and Route 606 (Old Ox Road) and extends to the south at the interchange of VA 28/VA 234 Bypass. It is approximately 15 miles long and traverses portions of the counties of Prince William, Fairfax, and Loudoun along with the cities of Manassas and Manassas Park.

The Tri-County Parkway was first identified during the development of the transportation element of the comprehensive plans for Prince William, Fairfax, and Loudoun counties. The Tri-County Parkway has been the subject of many local studies and plans and has been known by many names throughout the years. In Prince William County, it has been referred to as the "Route 28 Bypass" and, in Loudoun County, the Tri-County Parkway has been known as the "Loudoun County Parkway". Several conceptual alignments were considered through Fairfax County even before it was first proposed in their comprehensive plan. The Tri-County Parkway has been incorporated in the three counties' comprehensive plans for over ten years. The Tri-County Parkway was adopted by the Metropolitan Washington Council of Governments (MWCOG) and included in their Constrained Long-Range Plan (CLRP) and Transportation Improvement Program (TIP) in the early to mid 1990s. Figure 1.1-1 illustrates the Tri-County Parkway project from a regional perspective, while Figure 1.1-2 depicts the study area within which Tri-County Parkway alternatives will be evaluated.

The three counties that the Tri-County Parkway will traverse are among the top ten fastest growing counties in the Commonwealth of Virginia. According to the 2000 Census, Loudoun County's population grew by 97 percent from 1990 to 2000. Prince William County's and Fairfax County's population grew by 30 percent and 19 percent, respectively, during those same years. The City of Manassas and the City of Manassas Park are also located within the Tri-County Parkway study area. Both of these cities have experienced substantial population growth over the last ten years. The City of Manassas had a population growth of 26 percent and the City of Manassas Park grew by 53 percent.

Much of the growth in Northern Virginia can be attributed to the emergence of high-tech industries near the Washington Dulles International Airport. By the year 2025, employment in the Dulles/Tysons corridor is expected to reach 280,000 jobs - 71 percent more than current conditions. The Dulles/Tysons corridor will become the second largest employer in the Washington Metropolitan region, second only to downtown Washington D.C. Prince William County and the City of Manassas have also experienced significant high-tech industry growth. The Dulles area consists of the Dulles Greenway, VA 7, VA 28, and US Route 50.

A second rapid growth corridor within the region is the I-66 corridor. Transportation improvements for the I-66 corridor from Interstate 495 (I-495) to the Gainesville area were evaluated in January 1999 as part of a comprehensive study entitled "The I-66 Corridor Major Investment Study (I-66 MIS)." Information from that study revealed that population in the I-66 corridor located within Fairfax, Prince William, and Loudoun counties is projected to increase from 269,000 persons in 1999 to 466,000 persons in 2020. This represents a 73 percent increase in population over the 22-year time frame. Employment is estimated to increase 83 percent in this same time period (from 162,000 jobs in 1999 to 296,000 jobs in 2020).

The primary problem the Tri-County Parkway is intended to address is the lack of adequate north-south transportation facilities linking the I-66 corridor with the Dulles area and VA 267. East of US 15 and west of the I-495 (Capital Beltway), only three principal urban arterials link the spokes together - VA 28 (Sully Road), Route 7100 (Fairfax County Parkway), and VA 123. These north-south facilities are heavily congested and will deteriorate further by the year 2025.

Level of service on VA 28 is currently deficient in the a.m. and p.m. peak periods. By 2025, most segments of VA Route 28 northbound in the a.m. and southbound in the p.m. are expected to operate at LOS F or G (a severely congested state). Traveling south in the p.m. between the Fairfax County line

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FIGURE 1.1-1
REGIONAL LOCATION MAP

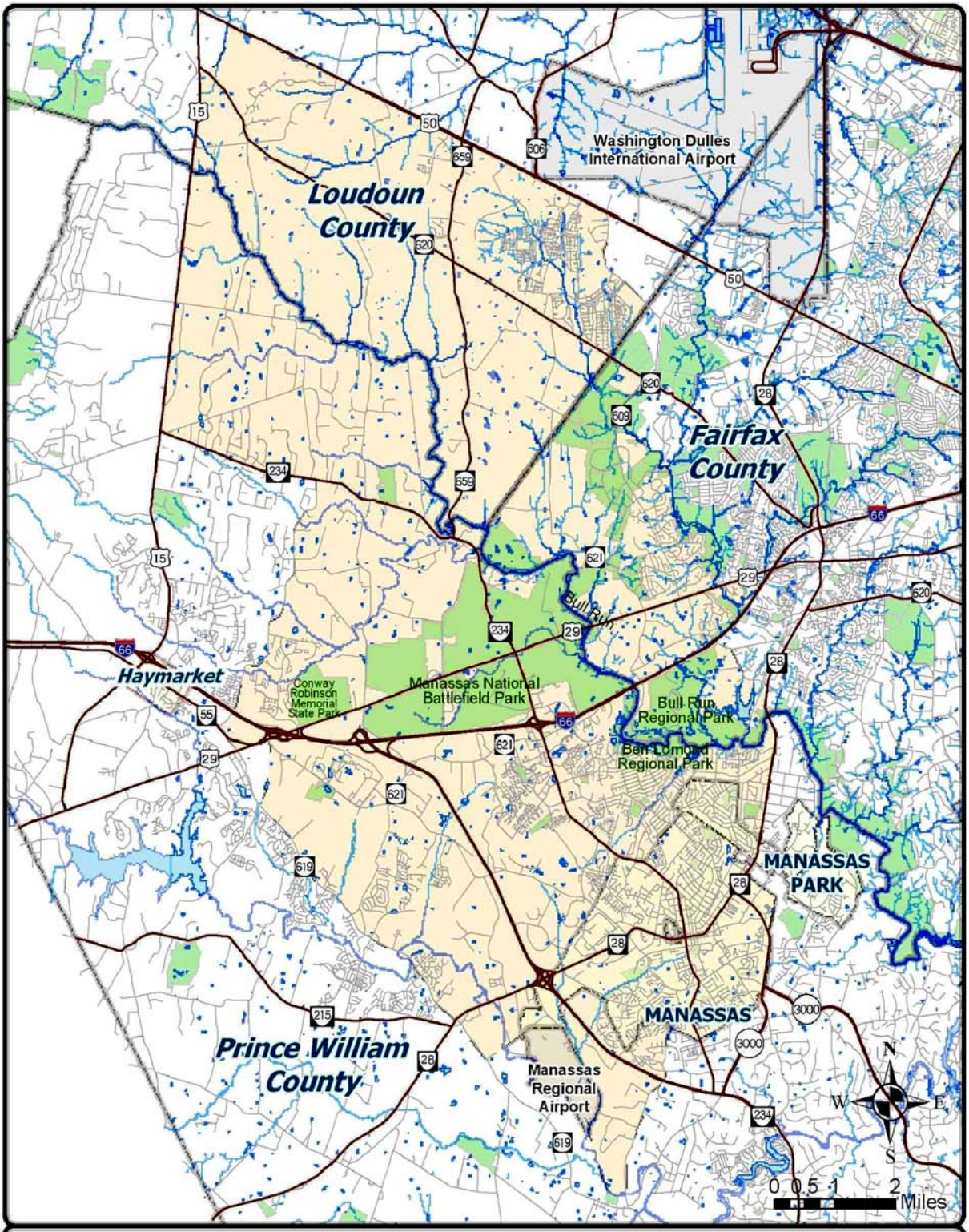

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FIGURE 1.1.2
STUDY AREA

and I-66, speeds are estimated to drop along VA 28 from an already slow 18 miles per hour (mph) to 13 mph between 2000 and 2025. The posted speed limit in this area is 45 mph. By 2025 the peak periods for a.m. and p.m. traffic on VA 28 could extend for over three hours each; however, improvements to VA 28 have been proposed under the Virginia Public-Private Transportation Act (VPPTA) of 1995 to convert the 14-mile stretch of VA 28 between I-66 and Route 7 to a limited access freeway. That project would involve widening VA 28 to an eight-lane section, as well as replacing up to ten signalized intersections with grade-separated interchanges. If the VA 28 improvements project is completed as planned, the added capacity should increase speeds and reduce congestion along VA 28 - in effect improving operating speeds in the a.m. and p.m. peak periods.

1.2 PURPOSE AND NEED

The study area presently lacks adequate north-south transportation facilities linking the I-66 corridor with the Dulles area and VA 267. The purpose and need for the Tri-County Parkway is comprised of four key elements. Each of the elements is a critical and salient factor to be addressed by the transportation alternatives. There is no attempt to weight one element over the others. Each of the elements has equal value and importance in the overall transportation, environmental, economic, and quality of life objectives for the communities being served under the proposed action. The four elements are listed below and are further elaborated in Sections 1.3 through 1.7 of the associated document titled Purpose and Need Statement (VDOT, 2003):

1. Improve transportation mobility and capacity and, by doing so, improve access and reduce congestion.
2. Enhance the linkage of communities and the transportation system that serves those communities.
3. Accommodate social demands, environmental goals, and economic development needs.
4. Improve safety and, by doing so, reduce the average crash, injury, and accident rates on the roadway network.

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2.0 ALTERNATIVES CONSIDERED

2.1 INTRODUCTION

In accordance with NEPA requirements, alternatives initially considered for the Tri-County Location Study included the No-Build, Mass Transit, Transportation System Management (TSM), and Candidate Build Alternatives (CBAs). Each alternative was evaluated with respect to its potential impacts and its ability to address the project's purpose and need.

2.2 ALTERNATIVES ELIMINATED FROM DETAILED STUDY

Assessments conducted as part of the Tri-County Parkway Location Study determined that the nature of the study area makes the identification of a mass transit alternative that can address the corridor's purpose and need problematic. No transit authority exists whose service area covers or would cover the entire study area, nor are there plans to establish such an authority. In addition, the development patterns and traffic patterns and volumes within the study corridor do not favor north-south through movement along the corridor. The majority of trips and greatest volumes are to points outside the study area or along only a portion of the corridor (i.e., from the Manassas and Centerville areas to I-66 and points east, from the South Riding area to the Dulles corridor). The through volumes are by far the weakest in the study area and would not attract sufficient transit riders to make such service viable; therefore, the mass transit alternative was eliminated from further consideration.

There are no practicable Transportation System Management (TSM) measures beyond those already proposed in the CLRP and VDOT Six Year Plan which could reasonably be implemented to satisfy the purpose and need for the Tri-County Parkway. TSM-type improvements programmed into the aforementioned plans do not satisfy the project's purpose and need when considered as a stand-alone alternative; therefore, the TSM Alternative was eliminated from further consideration.

2.3 THE NO-BUILD ALTERNATIVE

Consistent with the requirements of the NEPA and related FHWA guidelines, full consideration is given to the environmental consequences of taking no action to meet future travel demand (hereinafter referred to as the "No-Build Alternative"). The No-Build Alternative includes currently programmed committed and funded roadway and transit projects in the Virginia Department of Transportation (VDOT) Six Year Plan and the CLRP developed by the MWCOG. The No-Build Alternative, while having no direct construction costs, would result in other economic, environmental, and quality of life impacts that can be expected from the continuation of roadway system deficiencies. While the No-Build alternative does not meet the project needs for traffic, safety, and roadway infrastructure improvements, it provides a baseline condition with which to compare the improvements and consequences associated with the Candidate Build Alternatives. The following is a list of major projects identified in the CLRP which influence the Tri-County Parkway study area:

- Dulles/VA 7 Corridor
- VA 28 Corridor
- Prince William Parkway (VA 3000) Corridor
- Fairfax County Parkway (VA 7100) Corridor
- I-66/US 29/US 50 Corridor
- I-495 (Beltway) Corridor
- Manassas National Battlefield Park Bypass
- Western Transportation Corridor

2.4 CANDIDATE BUILD ALTERNATIVES

Three Candidate Build Alternatives (CBAs) have been identified for further evaluation in a Draft Environmental Impact Statement (EIS). These CBAs are referred to hereinafter as: (1) the

"Comprehensive Plan" CBA, (2) the "West Two" CBA, and (3) the "West Four" CBA. The process leading to the identification of these three CBAs is discussed in greater detail in the associated document tilted Alternatives Identification, Development, and Screening Technical Report (VDOT, 2004). The northern and southern termini for these CBAs have been selected in accordance with FHWA Technical Guidelines for termini development and are discussed in greater detail in the associated document titled Logical Termini Technical Memorandum (VDOT, 2003).

Each of the CBAs is expected to be comprised of two or more facility types according to localized needs and goals. To assess environmental effects associated with a particular facility type along each CBA, three general design concepts have been developed:

- General Design Segment 1 (hereinafter referred to as "Segment 1").
- General Design Segment 2 (hereinafter referred to as "Segment 2").
- General Design Segment 3 (hereinafter referred to as "Segment 3").

The process leading to the development of these general design segments is presented in the associated document tilted Study Location Report (VDOT, 2004). The three general design segments developed for purposes of this assessment are depicted in Figure 2.4-1 and are described as follows:

- *Segment 1*. *Segment 1* will provide a controlled access facility with four 12-foot lanes divided with a 42-foot graded grass median and 10-foot multi-use trail. The 42-foot wide median will allow for expanding to six lanes in the future. Segment 1 could either include (1) paved shoulders in areas where right-of-way is needed or (2) curb and gutter in areas where portions of the facility have been partially constructed and right-of-way exists. These design options are represented as Option 1 and Option 2, respectively. The median width will be transitioned to include additional width at all intersection approaches to allow for construction of dual left turn lanes, as necessary.

- *Segment 2*. *Segment 2* will provide a limited access facility with four 12-foot lanes divided with a 42-foot graded grass median, paved shoulders, and 10-foot multi-use trail. The median width will be transitioned to include additional width at all intersection approaches to allow for construction of dual left turn lanes, as necessary.

- *Segment 3*. *Segment 3* will provide a limited access facility with six lanes (four 12-foot outside lanes and two 13-foot inside lanes) divided with a 42-foot graded median, paved shoulders, and a 10-foot multi-use trail. The 13-foot inside lanes are adjacent to curbed median only.

2.4.1 The Comprehensive Plan CBA

The Comprehensive Plan CBA is so named because it incorporates certain alignments recognized in local Comprehensive Plans. The Comprehensive Plan CBA would be located east of the Manassas National Battlefield. The Comprehensive Plan CBA would provide a new urban principal arterial roadway from the northern terminus at the intersection of US 50 and Route 606 (Old Ox Road) and the southern terminus at the Route 28 and Route 234 Bypass Interchange, and would consist of Segments F', F, and E (see Figure 2.4-2). Segment F' between Route 50 and Route 620 would be comprised of improvements along an existing four-lane divided facility within an existing right-of-way on an existing alignment. Segment F' south of Route 620 would be a new four-lane divided facility within a new right-of-way on a new alignment. Three separate sections characterize segment E. The portion of Segment E between I-66 and the Fairfax/Prince William county line would be a new six-lane divided facility within a new right-of-way on a new alignment. The portion of segment E from the Fairfax/Prince William county line south to VA 234 would be a new six-lane divided facility within an existing right-of-way on an existing alignment. The portion of Segment E from VA 234 to the VA 234 Bypass would be comprised of improvements along an existing four-lane divided facility called Godwin Drive and would be widened to a six-lane divided facility within the existing right-of-way and on an existing alignment. The Comprehensive Plan CBA would consist of three of the aforementioned general design segments in the following areas:

- *Segment 1 (Options 1 and 2)* will extend from the intersection of US 50 and Route 606 (Old Ox Road) in Loudoun County to the Fairfax County Line.

- *Segment 2* will extend from the Fairfax County Line to I-66 (east of the Manassas National Battlefield).
- *Segment 3* will extend from I-66 in Fairfax County to Route 234 in Prince William County.

2.4.2 The West Two CBA

The West Two CBA is located west of the Manassas National Battlefield. The West Two CBA would provide a new urban principal arterial roadway from the northern terminus near the intersection of US 50 and Route 877 (Racefield Lane) and the southern terminus at the I-66 and Route 234 Interchange. The West Two CBA would be a new four-lane divided facility within a new right-of-way and on a new alignment, and would consist of Segments D and C (see Figure 2.4-2). The West Two CBA would consist of two of the aforementioned general design segments in the following areas:

- *Segment 1 (Option 1)* will extend from the intersection of US 50 and 877(Racefield Road) in Loudoun County to the Prince William County Line.
- *Segment 2* will extend from the Prince William County Line to the interchange of I-66 and Route 234 (west of the Manassas National Battlefield).

2.4.3 The West Four CBA

The West Four CBA is also located west of the Manassas National Battlefield. The West Four CBA would provide a new urban principal arterial roadway from the northern terminus at the intersection of US 50 and Route 606 (Old Ox Road) and the southern terminus at the I-66 and Route 234 Interchange. The West Four CBA would consist of Segments F', G, and C (Figure 2.4-2). Segment F' between Route 50 and Route 620 (Braddock Road) would be comprised of improvements along an existing four-lane divided facility within an existing right-of-way on an existing alignment. Segment F' south of Route 620 would be comprised of a new four-lane divided facility within a new right-of-way on a new alignment. The West Four CBA would consist of two of the aforementioned general design segments in the following areas:

- *Segment 1 (Option 1)* will extend from the intersection of US 50 and Route 606 (Old Ox Road) in Loudoun County to the Prince William County Line.
- *Segment 2* will extend from the Prince William County Line to the interchange of I-66 and Route 234 (west of the Manassas National Battlefield).

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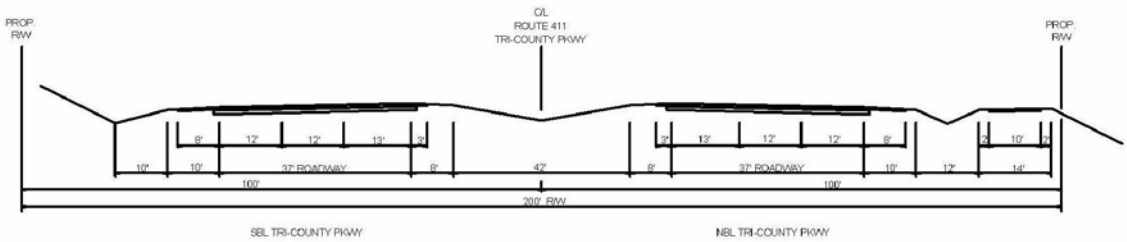
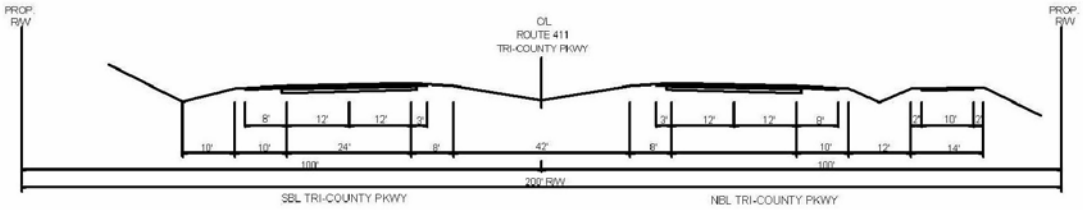
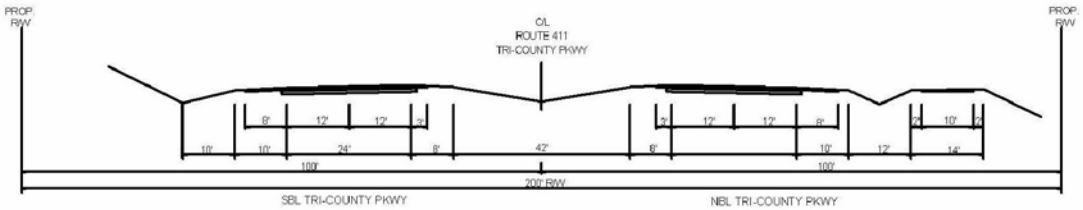


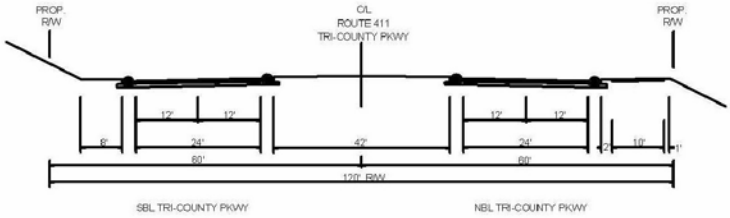
GENERAL DESIGN SEGMENT 3



GENERAL DESIGN SEGMENT 2



GENERAL DESIGN SEGMENT 1, OPTION 1



GENERAL DESIGN SEGMENT 1, OPTION 2

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FIGURE 2.4-1
GENERAL DESIGN SEGMENTS
TYPICAL SECTIONS

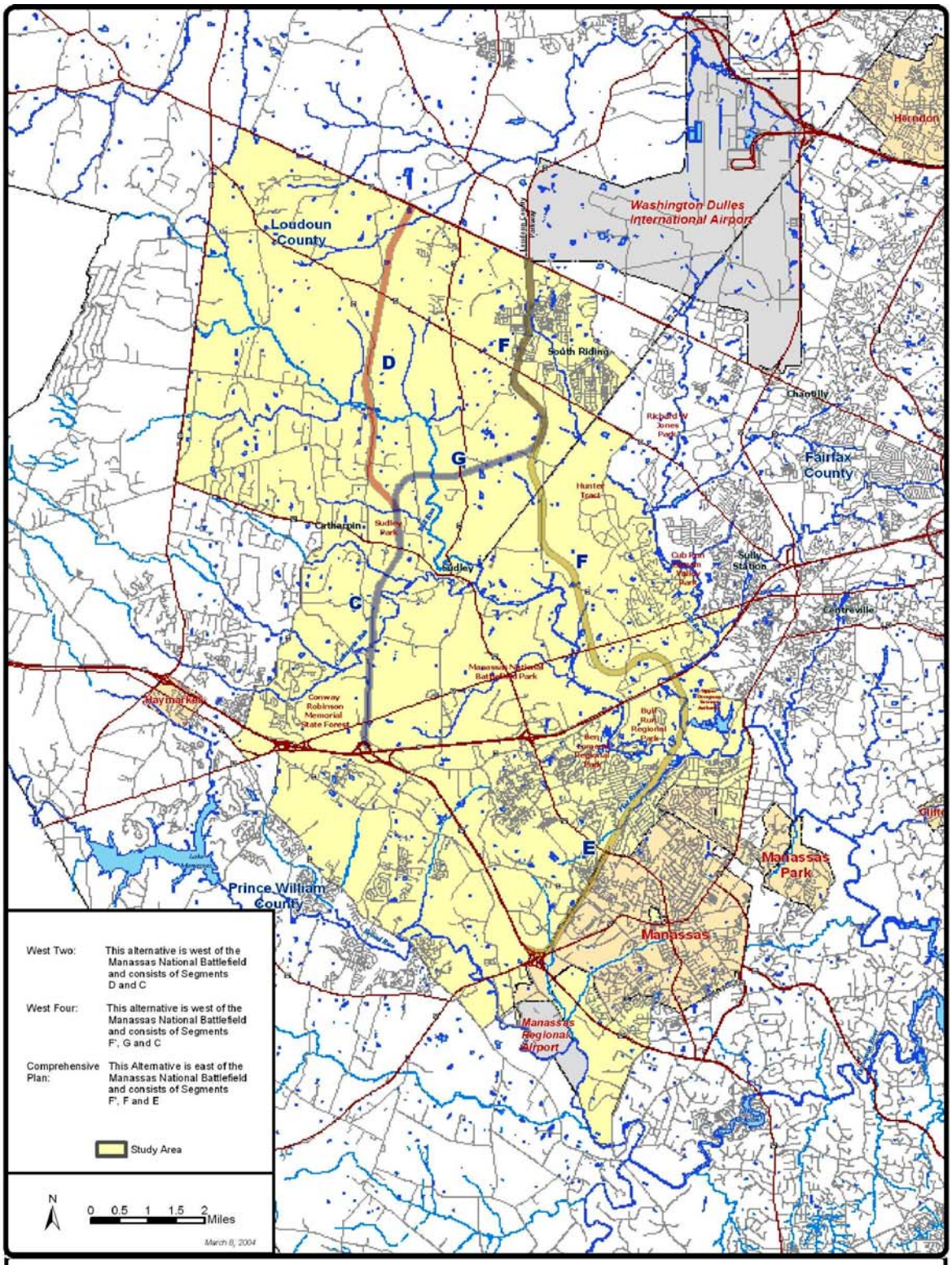

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FIGURE 2.4-2
CANDIDATE BUILD ALTERNATIVES

3.0 HYDROLOGIC & HYDRAULIC ANALYSIS

3.1 OVERVIEW

The Candidate Build Alternatives (CBAs) – The Comprehensive Plan CBA, The West Two CBA, and the West Four CBA - generally run in a north-south orientation, crossing the Bull Run watershed and three of its major tributaries Catharpin Run, Flat Branch, and Cub Run. The CBAs cross these streams, as well as several smaller tributaries and, in some cases, run parallel to the stream along the edge of the floodplain. The effects of these crossings and floodplain encroachments have been evaluated at a planning level.

Results of the hydrology and hydraulics analyses presented in this Technical Report provide data for comparison of alternatives and establish a preliminary structures requirement. The analyses are based on available data from USGS and county mapping, FEMA Flood Insurance Rate maps, and preliminary alignments set forth in the Location Study Report (VDOT, 2004). As the design process progresses, more accurate data will allow the design refinements necessary to produce preliminary and final design. Appendix 1 shows the study area, corridors for various alternatives, identified major bridges, and culvert crossings.

3.2 STREAM CROSSING AND ROADWAY DRAINAGE

The preliminary alternative alignments were located on USGS mapping and other available mapping. The stream crossings and drainage crossings necessary to convey water under the roads were identified on the maps, and the drainage areas were delineated for the three alternatives. These are listed in **Table 3.3-1**. The limited data and planning level nature of the analysis made it necessary to categorize the drainage facilities for the proposed crossings into these sets of facilities:

1. Minor Drainage Facilities – Generally a drainage area of less than 225 acres or less than 500 cubic feet per second (cfs) for the 100 year (1 percent clearance of occurrence) storm peak discharge from the watershed. These facilities would be designed in detail after additional data is obtained. The probable costs of construction for these facilities is considered incidental at the planning level and is included in the per linear foot of roadway cost.
2. Major Drainage Facilities but not in the floodplain – Generally a drainage area greater than 225 acres or more than 500 cfs up for the 100 year (one percent clearance of occurrence) storm peak discharge from the watershed. These facilities would be further refined as the design process moves toward preliminary and final design.
3. Major Drainage Facilities in flood plain areas. These are generally significant streams that have a definable floodplain. They would have a drainage area greater than 225 acres to over 20 square miles and have a peak discharge greater than 500 cfs up for the 100 year (one percent clearance of occurrence) storm peak discharge.

In some cases, these facilities are located parallel to the streams in the floodplain, and the bridge is provided to limit encroachment or to provide protection or mitigation of wetlands or other environmentally sensitive areas. The probable costs of construction for these is based on the required culvert or bridge developed by the planning level analysis and is included in the Major Drainage facilities line item.

3.3 STREAM CROSSINGS

Stream crossings are generally major bridge structures crossing both the floodway and floodplain overbanks. The design must be sensitive to the impact of upstream water surface elevations. The installation of piers and approaches to the bridge can increase the upstream water surface elevations (causing increased flooding) and can increase velocities through the bridge opening (causing potential for damaging scour). Table 3.3-2 lists the bridges or facilities that have been preliminarily determined to be necessary for each alternative.

Table 3.3-1
IDENTIFIED DRAINAGE FACILITIES

Number	Crossing Alphanumeric Code	Major w/Floodplain	Major	Minor < 500cfs
1	D-5	X		
2	D-3			X
3	D-2	X		
	D-2-A			X
4	D-1			X
5	C-6	X		
6	C-5	X		
7	C-5A			X
8	C-4			X
9	C-3		X	
10	C-2	X		
11	C-1			X
12	G-1			X
13	G-2	X		
14	G-6		X	
15	G-9	X		
16	F-20	X (existing structure)		
17	F-19	X (existing structure)		
18	F-18			X
19	F-17			Pond/quarry
20	F-16			X
21	F-15			X
22	F-14			X
23	F-13			X
24	F-12			X
25	F-10A	X		
26	F-10B		X	
27	F-9	X		
28	F-8			X
29	F-7			X
30	F-6		X	
31	F-5			X
32	F-4			X
33	F-4A			X
34	F-3			X
35	F-2			X
36	F-1A	X		
37	F-1B	X		
38	F-1C	X		
39	E-10A	X		
40	E-10B	X		
41	E-6A	X		
42	E-6B1	X		
43	E-6B2	X		
44	E-6B3	X		
45	E-2	X (existing structure)		

Table 3.3-2
MAJOR DRAINAGE FACILITES IN FLOODPLAINS
FLOODPLAIN AND BRIDGE DATA

Drainage Area ID	Stream/Flood Plain	100-Year Floodplain Width	100-Year FEMA Elev.	Main Channel Span Length (ft)	Begin Station	End Station	Total Length (ft)	Spans	Avg Span Length (ft)
C2	Little Bull Run/Catharpin Run	360	243	80	599+45	604+48	503	4	126
C5	Lick Branch (to Catharpin Run)	440	253	45	670+22	674+43	421	3	140
C6	Catamount Branch	300	Not Determined	50	738+42	741+06	264	2	132
D2	Bull Run	560	254	70	840+79	850+50	971	8	121
D5	South Fork (trib to Broad Run)	380	310	95	1029+31	1034+63	532	4	133
E2	Cannon Branch	200	195	EXISTING	-	-	-	-	-
E6A	Flat Branch	Encroach. Varies	Varies	Enc.	301+96	306+94	498	4	125
E6B1	Flat Branch	Encroach. Varies	Varies	40	257+63	288+60	3097	25	124
E6B2	Flat Branch	Encroach. Varies	Varies	Enc.				-	-
E6B3	Flat Branch	Encroach. Varies	Varies	35				25	124
E10A	Bull Run	80	164	150	344+55	380+97	3642	29	126
E10B	Bull Run	80	164	150	-	-	-	-	-
F10A	Bull Run Feeder Stream	200	Not Determined	100	596+08	597+08	100	1	100
F12	Elklick Run	No Data	Enc.	Enc.	799+28	802+62	334	3	111
F17	Elklick Run	370	Not Determined	EXISTING	853+00	856+00	300	-	-
F19	Elklick Run	370	280	EXISTING	EXISTING	-	-	-	-
F1A	Cub Run	3700	Not Determined	150	389+54	436+20	4666	37	126

Table 3.3.1
MAJOR DRAINAGE FACILITIES IN FLOODPLAINS
FLOODPLAIN AND BRIDGE DATA

Drainage Area ID	Stream/Flood Plain	100-Year Floodplain Width	100-Year FEMA Elev.	Main Channel Span Length (ft)	Begin Station	End Station	Total Length (ft)	Spans	Avg Span Length (ft)
F1B	Cub Run	3700	Not Determined	120					
F1C	Cub Run	3700	Not Determined	80					
F9	Bull Run Feeder Stream	350	Not Determined	30	631+50	634+85	335	3	112
G2	Bull Run	650	225	140	695+00	697+36	236		
G9	(intermittent stream from GIS)	450	Not Determined	150	775+62	778+08	246		

3.4 ROADWAY DRAINAGE

Facilities are required to provide roadway drainage and to allow conveyance under the roadway of storm water runoff from smaller watershed to an adequate receiving water or channel. These facilities are most likely to be culverts. Upstream and downstream erosion protection is often required and minor channel improvements or storm water best management practices are often necessary to protect the integrity of the proposed facility, the highway, and surrounding property owners. **Table 3.4-1** lists the major culverts necessary to carry 500 cfs or more that are not located in a floodplain.

Table 3.4-1
MAJOR DRAINAGE FACILITIES NOT IN THE FLOODPLAIN

Crossing	Peak Discharge (Q 25) (cubic feet per second)	Culvert Required	Box Culvert Length (LF)	Computed HW/D
C-3 --> Little Bull Run	694	Double 8'x6' Box	250	1.1
F-6	908	Double 8'x8' Box	250	1.0
F-10B	700	Double 8'x6' Box	250	1.1

3.5 AVAILABLE DATA

For this planning level of study, the data consisted of that which was available from common sources. No additional field work was performed.

3.6 CRITERIA

The criteria used for the analysis included:

- Virginia Stormwater Management Regulations
- Virginia Erosion and Sediment Control Regulations
- Chesapeake Bay Preservation Act
- VDOT Drainage Manual
- Virginia Erosion and Sediment Control Handbook
- Virginia Stormwater Management Handbook
- VDOT Road and Bridge Standards, Volume I and Volume II
- VDOT Road and Bridge Specifications
- VDOT Instructional & Informational Memorandum
- Pertinent county amendments to state criteria (Fairfax, Loudon, and Prince William)
- Where required, more stringent local criteria
- Where required, existing approved County Master Plans or studies.

3.7 TOPOGRAPHIC DATA

Topographic data sources included the USGS 1:24,000 scale quadrangles maps, FEMA Flood Insurance Rate Maps, and available County mapping. These maps were used for defining major features, defining watershed boundaries of major drainage facilities, and floodplain limits.

3.8 CROSS SECTION DATA

In order to develop water surface profiles, cross sections were needed and were taken from county GIS mapping. Cross-sections were taken 300 feet and 100 feet first upstream and downstream of the bridge centerline. The bridge profile and cross-section were used for the bridge itself. Unless otherwise shown,

the depth to low steel was assumed to be six feet from the top of roadway profile for planning purposes. The cross-sections were cut perpendicular to the direction of the flood flows and were extended to a point above the apparent edge of the floodplain elevation or the FEMA elevation for the 100 year storm, where that data was available.

3.9 STARTING ELEVATION

The computation of the water surface profile was started at the most downstream cross-section using the FEMA 100 year elevation, where available. If the FEMA elevations were not available, normal depth for the cross-section was determined using the cross-section data. The slope was the average stream bed slope as could be determined from either the streambed or the average floodplain elevation.

3.10 DISCHARGE DATA

The 100 year discharge was obtained from FEMA data or by computing the discharge using the VDOT regression analysis for major structures in the floodplain with drainage over 225 acres. For the structures not in the floodplain, the discharge was computed using TR55 and was limited to drainage areas less than 640 acres.

3.11 MINIMUM STRUCTURES REQUIREMENT

The analysis is to determine the minimum structure waterway opening and to provide a water surface elevation for the 100 year flood to assist in determining the low steel or lowest point of the bridge structure to avoid submergence during the 100 year flood. The water opening of the bridge was based on the end walls as shown on the preliminary alignment for the initial computation.

3.12 APPROACH AND LIMITS TO THE ANALYSIS

The approach to the determination of peak flows and water surface profile computations is suitable for the planning level and relative comparisons. The methods used have been derived for that level of accuracy. As the design progresses and more accurate data is available, the methodology will also change to produce more precise results.

3.13 HYDROLOGIC METHOD

Required stormwater facilities that have been defined as “Major Structures not in a floodplain” tend to be within smaller watersheds with flows above 500 cfs for the 100 year storm. Typically, these facility needs can be resolved by using a culvert or series of culverts. As far as possible, with existing data and topography, any area or location needing a roadway culvert for roadway or small watershed drainage was preliminarily assessed to determine if it will fit into the Minor Drainage or Major Drainage Facility. The Major Drainage Facilities were further separated by the floodplain criteria to identify the culvert or bridge structures type. For those determined to be candidates for Major Drainage Structure not in a floodplain, the discharge was computed using TR55 area and only those with a discharge greater then 500 cfs were listed. Those so determined are listed in Table 3.3.1, as previously noted.

For the remainder of the Major Drainage Facilities in flood plain areas which generally are significantly larger watersheds, the discharge was computed using the VDOT Regression Analysis. The discharges computed by the Regression Analysis were compared to the FEMA 100 year discharges data and the largest value was used for the computations of the water opening. **Table 3.13-1** shows these structures.

Table 3.13-1 MAJOR DRAINAGE FACILITIES IN FLOODPLAINS 100-YEAR DISCHARGE				
Drainage Area ID	**Stream/Floodplain**	**Drainage Area (acres)**	**Drainage Area (sq.mi.)**	**Q100 (cfs)**
Bridges Crossing Streams				
C-2	Little Bull Run/Catharpin Run	11800	18.44	6373
C-5	Lick Branch (to Catharpin Run)	2520	3.94	2369
C-6	Catamount Branch	2213	3.46	2180
D-2	Bull Run See Note 1			130000
D-5	South Fork (trib to Broad Run)	2306	3.60	2238
E-2	Cannon Branch See Note 2	1410	2.20	1633
E-10A	Bull Run See Note 1			20000
F-9	Bull Run Feeder Stream	1000	1.56	1310
F-19	Elklick Run See Note 2	740	1.16	1080
F-20	Elklick Run See Note 2	1490	2.33	1691
G-2	Bull Run See Note 1			13000
G-9	(intermittent stream from GIS)	260	0.41	552

Note 1 - Flows from FIS Studies

Note 2 - Existing Bridge

3.14 HYDRAULIC METHODS

Hydraulic analysis to determine the water surface profile and bridge impact was conducted only on those Major Drainage Facilities in floodplains. HECRAS was used for the reach at the bridge site. Cross-sections were taken 100 feet and 300 feet below and above the bridge, and the cross-sections shown by the bridge and road projects were used for the bridge cross-sections. Using the starting elevations at the most downstream cross-section, the water surface profile was run to determine the effect of the bridge embankment and piers on the upstream elevations. With the accuracy of the basic data, the relative changes in downstream and upstream water surface elevation were used to determine effect. The VDOT Drainage Manual criteria states:

12.3.2.4 ***Backwater/Increases Over Existing Conditions***
Designers shall conform to FEMA regulations for sites covered by the National Flood Insurance Program (NFIP). It is the Department's policy not to allow any increase in the level of the 1 percent flood for delineated floodplains established under the NFIP and for the increase to not exceed one foot during the passage of the 1 percent flood for sites not covered by NFIP.

12.3.2.5 ***Clearance***
Where practical a minimum clearance of one foot should be provided between the design approach water surface elevation and the low chord of the bridge for the design flood. Where this is not practicable, the bridge designer should establish the clearance based on the desired level of protection.

12.3.2.6 ***Flow Distribution***

The conveyance of the proposed stream crossing should be calculated to determine the flow distribution and to establish the location of bridge opening(s). The proposed facility should not cause any significant change in the existing flow distribution. Relief openings in the approach roadway embankment or other appropriate measures should be investigated if there is more than a 10 percent redistribution of flow.

3.14.1 Backwater/Increases Over Existing Conditions

Designers are required to conform to FEMA regulations for sites covered by the National Flood Insurance Program (NFIP). It is VDOT's policy not to allow any increase in the level of the one percent flood for delineated floodplains established under the NFIP and for the increase to not exceed one foot during the passage of the one percent flood for sites not covered by NFIP.

3.14.2 Clearance

Where practical, a minimum clearance of one foot should be provided between the design approach water surface elevation and the low chord of the bridge for the design flood. Where this is not practicable, the bridge designer should establish the clearance based on the desired level of protection.

3.14.3 Flow Distribution

The conveyance of the proposed stream crossing should be calculated to determine the flow distribution and to establish the location of bridge opening(s). The proposed facility should not cause any significant change in the existing flow distribution. Relief openings in the approach roadway embankment or other appropriate measures should be investigated if there is more than a ten percent redistribution of flow. In order to adhere to this criteria; it was determined procedurally that, if the upstream 100-foot cross-section location water surface elevation was computed to increase one foot or more with the bridge in place over the water surface profile without the bridge in place, it was considered significant and the bridge width between abutments would be increased in 25-foot increments and the water surface profile re-computed until the change in water surface elevation between upstream and downstream at the 100-foot upstream and downstream cross-section was reduced to 0.5 foot. If the increase was less than one foot at the upstream 100-foot cross-section and less than 0.5 foot at the 300-foot upstream cross-section, it was considered insignificant. If the increase was less than one foot at the upstream cross-section, but greater than 0.5 foot at the 300-foot cross-section, bridge width was adjusted in 25-foot increments until the 100-foot cross-section elevation did not increase more than 0.5 foot. When the bridge crosses a lake, the hydraulic analysis was not conducted, since the impact would be insignificant hydraulically. Where the bridge is located in a floodplain parallel to the stream, the hydraulic analysis was deferred to a future level of design to more definitively determine the pier type, location, and orientation. Table 3.15-1 shows the preliminary results of the analysis

3.15 PRELIMINARY DETERMINATIONS

The hydraulic analysis of each bridge is shown in **Table 3.15-1**. **Table 3.15-1** shows the bridge and the downstream and upstream water surface elevations with and without the bridge being in place. The plan, cross-sections, and profiles are available for each bridge in the appendix. **Table 3.15-1** also shows the bridge and the velocity through the bridge section.

The preliminary determination shows no significant impact on the water surface profiles due to the preliminary bridge cross-sections.

Table 3.15-1
BRIDGE AFFECT UPON WATER SURFACE AND VELOCITY

	Water Surface Elevation (ft.) From Center of Proposed Bridge					Velocity (ft/s)	
	Minimum Channel Elev. (ft)	300 Feet Upstream	100 Feet Upstream	100 Feet Downstream	300 Feet Downstream	100 Feet Upstream	100 Feet Downstream
CROSSING C2							
Elev. W. S. (ft.)-Bridge	240.00	250.83	250.34	249.36	245.82	4.97	6.78
Elev. W. S. (ft.)-Without Bridge	240.00	249.81	250.30	249.36	245.82	5.00	6.78
CROSSING C5							
Elev. W. S. (ft.)-Bridge	226.00	231.91	231.72	231.31	229.16	1.68	2.70
Elev. W. S. (ft.)-Without Bridge	226.00	231.90	231.70	231.31	229.16	1.69	2.70
CROSSING C6							
Elev. W. S. (ft.)-Bridge	240.00	248.13	247.90	246.93	243.71	3.01	5.48
Elev. W. S. (ft.)-Without Bridge	240.00	248.07	247.82	246.93	243.71	3.06	5.48
CROSSING D2							
Elev. W. S. (ft.)-Bridge	242.00	256.73	256.68	256.23	255.19	5.34	6.55
Elev. W. S. (ft.)-Without Bridge	242.00	256.71	256.66	256.23	255.19	5.35	6.55
CROSSING D5							
Elev. W. S. (ft.)-Bridge	298.00	304.74	303.63	301.86	297.59	5.63	6.82
Elev. W. S. (ft.)-Without Bridge	298.00	304.73	303.62	301.86	297.59	5.65	6.82
CROSSING E10-A							

Table 3.15-1
BRIDGE AFFECT UPON WATER SURFACE AND VELOCITY

	Water Surface Elevation (ft.) From Center of Proposed Bridge					Velocity (ft/s)	
	Minimum Channel Elev. (ft)	300 Feet Upstream	100 Feet Upstream	100 Feet Downstream	300 Feet Downstream	100 Feet Upstream	100 Feet Downstream
Elev. W. S. (ft.)-Bridge	146.00	152.14	152.13	152.12	152.10	0.73	0.69
Elev. W. S. (ft.)-Without Bridge	146.00	152.14	152.13	152.12	152.10	0.73	0.69
CROSSING F9							
Elev. W. S. (ft.)-Bridge	188.00	195.36	194.28	192.05	190.61	3.29	1.55
Elev. W. S. (ft.)-Without Bridge	188.00	195.35	194.26	192.05	190.61	3.31	1.55
CROSSING G2							
Elev. W. S. (ft.)-Bridge	214.00	219.53	219.37	218.75	217.11	1.82	2.17
Elev. W. S. (ft.)-Without Bridge	214.00	219.50	219.33	218.75	217.11	1.84	2.17
CROSSING G9							
Elev. W. S. (ft.)-Bridge	268.00	280.58	276.70	274.28	270.70	5.20	3.06
Elev. W. S. (ft.)-Without Bridge	268.00	280.75	276.44	274.28	270.70	6.36	3.06

3.16 STORMWATER MANAGEMENT

The objective of a stormwater management plan is to protect the aquatic environment by controlling the post-developed water quantity and quality, as nearly as practicable, equal to or better than predevelopment runoff characteristics. The stormwater management plan developed at a later phase of design for the Tri-County Parkway will be in conformance with the Virginia Stormwater Management Regulations (SWMR), Virginia Stormwater Management Handbook, Virginia Erosion and Sediment Control Regulations, Chesapeake Bay Protection Act (CBPA), and any necessary local amendments to these requirements.

Proposed impervious areas for each watershed within project limits were tabulated. Roadway and other linear-type development projects with impervious areas of less than one acre draining to any single outfall generally do not require water quality treatment. The proposed Tri-County Parkway lies within the water supply watershed of the Occoquan Reservoir, so stormwater management facilities will be provided for all areas. Stormwater management facilities will be placed adjacent to the proposed roadway right-of-way and will be positioned generally to treat just the roadway runoff to the maximum extent practical. Basin excavation volumes were determined by computing the Water Quality Volume (WQV) and multiplying the result by a factor of two (for extended detention basins) and then multiplied by a factor of four to provide stormwater quantity volume requirements to attenuate peak flow to predevelopment levels.

Stormwater management can ultimately be achieved by a combination of best management practices (BMP) during future design phases and when a preferred alternative is selected. Candidate BMPs include, but are not limited to: grassed swales, vegetated buffers and filter strips, check dams, extended detention basins, water quality structures, retention basins, enhanced basins, forebays, bioretention facilities, and regional facilities.

Impervious areas, water quality volumes, and estimated basin excavation volumes for all watersheds are identified in **Table 3.16-1**.

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Table 3.16-1
STORMWATER QUALITY VOLUME REQUIREMENTS

Road Alignment Segment	Roadway Length (ft.)	Roadway Impervious Area Width (ft)	Impervious Area (sq. ft.)	WQV (2 x1/2"x A) (cu. ft.)	Quantity Treatment Adjustment (x4) (cu. ft.)	Basin Excavation (cu. yd.)	Outfall
F/E	13,000	78	1,014,000	84,500	338,000	12,519	F-10
F/E	3,000	78	234,000	19,500	78,000	2,889	F-7
F/E	3,200	78	249,600	20,800	83,200	3,081	F-6
F/E	2,400	78	187,200	15,600	62,400	2,311	F-4A
F/E	4,000	78	312,000	26,000	104,000	3,852	F-4A
F/E	6,000	78	468,000	39,000	156,000	5,778	F-1
F/E	3,000	78	234,000	19,500	78,000	2,889	E-14
F/E	5,800	78	452,400	37,700	150,800	5,585	E-10
F/E	9,000	78	702,000	58,500	234,000	8,667	Flat Branch
F/E	10,500	78	819,000	68,250	273,000	10,111	Cannon Branch
F/E Subtotal				**389,350**		**57,681**	
F'	10,600	78	826,800	68,900	275,600	10,207	Elklick Run
F'	8,800	78	686,400	57,200	228,800	8,474	Elklick Run
F' Subtotal	**19,400**			**126,100**		**18,681**	
G	4,000	78	312,000	26,000	104,000	3,852	G-9
G	2,200	78	171,600	14,300	57,200	2,119	G-6
G	7,000	78	546,000	45,500	182,000	6,741	Bull Run
G	2,000	78	156,000	13,000	52,000	1,926	Lick Branch Feeder Stream
G Subtotal				**98,800**		**14,637**	
D	6,700	78	522,600	43,550	174,200	6,452	South Fork Broad Run
D	17,800	78	1,388,400	115,700	462,800	17,141	Bull Run

Table 3.16-1
STORMWATER QUALITY VOLUME REQUIREMENTS

Road Alignment Segment	Roadway Length (ft.)	Roadway Impervious Area Width (ft)	Impervious Area (sq. ft.)	WQV (2 x1/2"x A) (cu. ft.)	Quantity Treatment Adjustment (x4) (cu. ft.)	Basin Excavation (cu. yd.)	Outfall
D/C	10,200	78	795,600	66,300	265,200	9,822	Bull Run
C	4,500	78	351,000	29,250	117,000	4,333	Lick Branch
C	15,600	78	1,216,800	101,400	405,600	15,022	Little Bull Run
D/C Subtotal				**312,650**		**46,319**	

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Virginia Department of Environmental Quality. Virginia Ambient Water Quality Monitoring Report, Monitoring Year 1999 (DEQ Technical Bulletin WQA/1999-004). December 15, 1999.

Virginia Department of Environmental Quality. Virginia Ambient Water Quality Monitoring Report, Monitoring Year 1998 (DEQ Technical Bulletin WQA/1998-003). December 30, 1998.

Virginia Department of Environmental Quality. Virginia Department of Environmental Quality web page. http://www.deq.state.va.us/permits/homepage.html. July 2002.

Virginia State Water Control Board. Water Quality Standards 9 VAC 25-260-5 et. seq.

APPENDIX 1

TRI-COUNTY PARKWAY BRIDGE STUDY MAP

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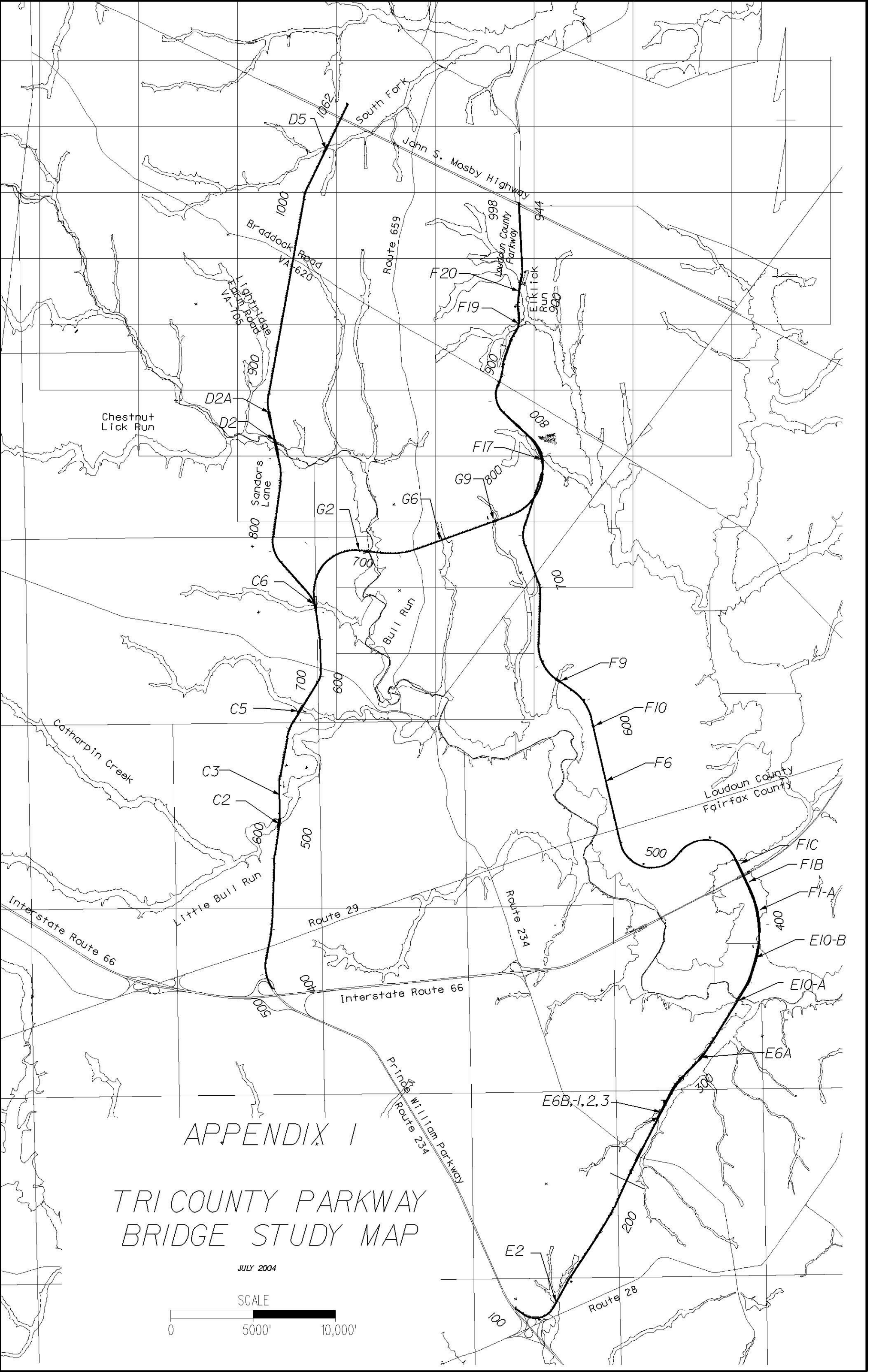
APPENDIX I
TRI COUNTY PARKWAY
BRIDGE STUDY MAP
JULY 2004
SCALE
0
5000'
10,000'
D5
D2A
D2
C6
C5
C3
C2
F20
F19
F17
G9
G6
G2
F9
F10
F6
F1C
F1B
F1-A
E10-B
E10-A
E6A
E6B,-1,2,3
E2
South Fork
John S. Mosby Highway
Braddock Road
VA-620
Route 659
Loudoun County Parkway
Elklick Run
Lightridge Farm Road
VA-705
Chestnut Lick Run
Sandors Lane
Bull Run
Catharpin Creek
Little Bull Run
Loudoun County
Fairfax County
Route 29
Route 234
Interstate Route 66
Prince William Parkway
Route 28

APPENDIX 2

TRI-COUNTY PARKWAY BRIDGE STUDY MAP

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING C2

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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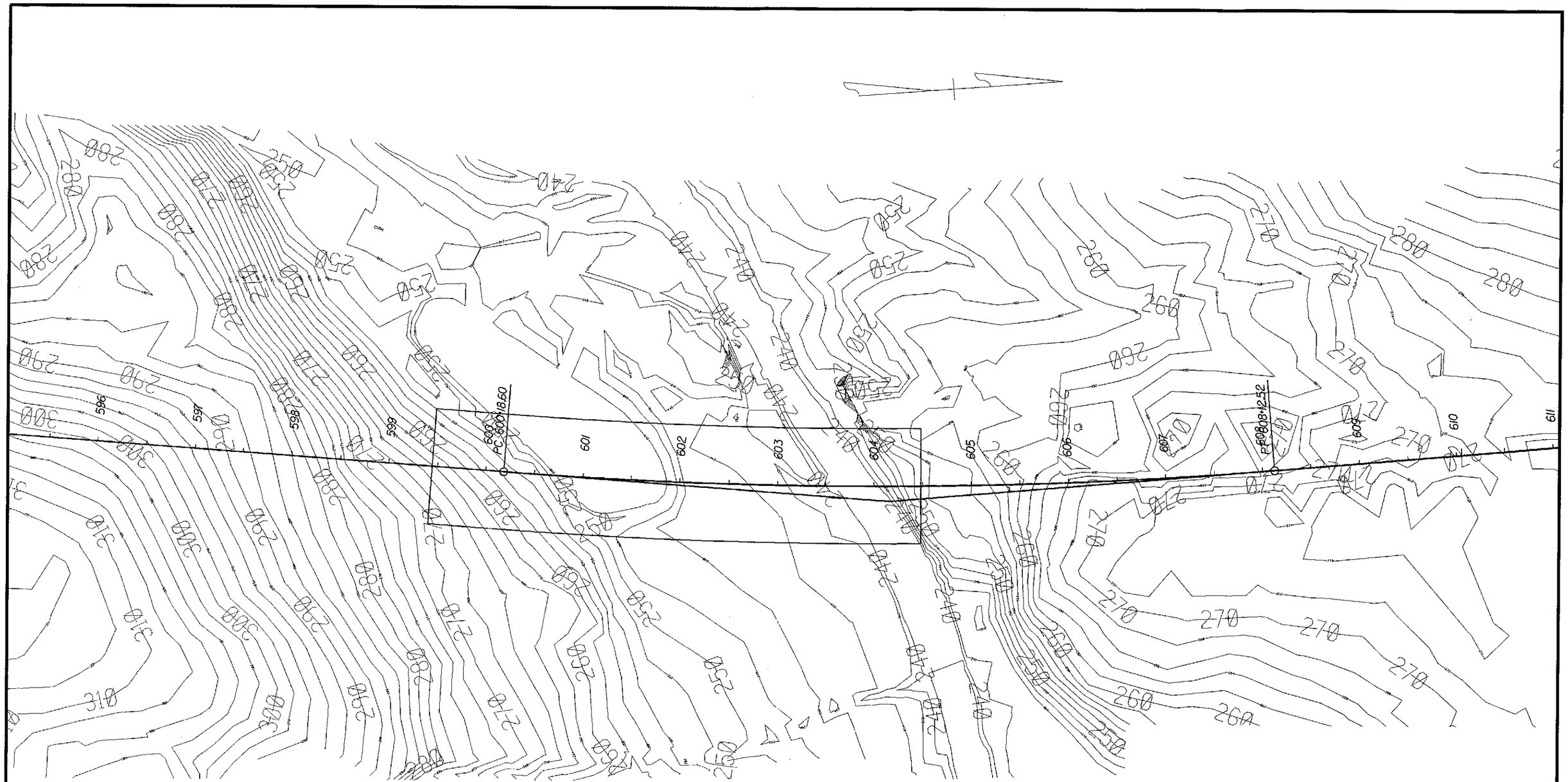


TRI COUNTY PARKWAY
Crossing C2

July 2004

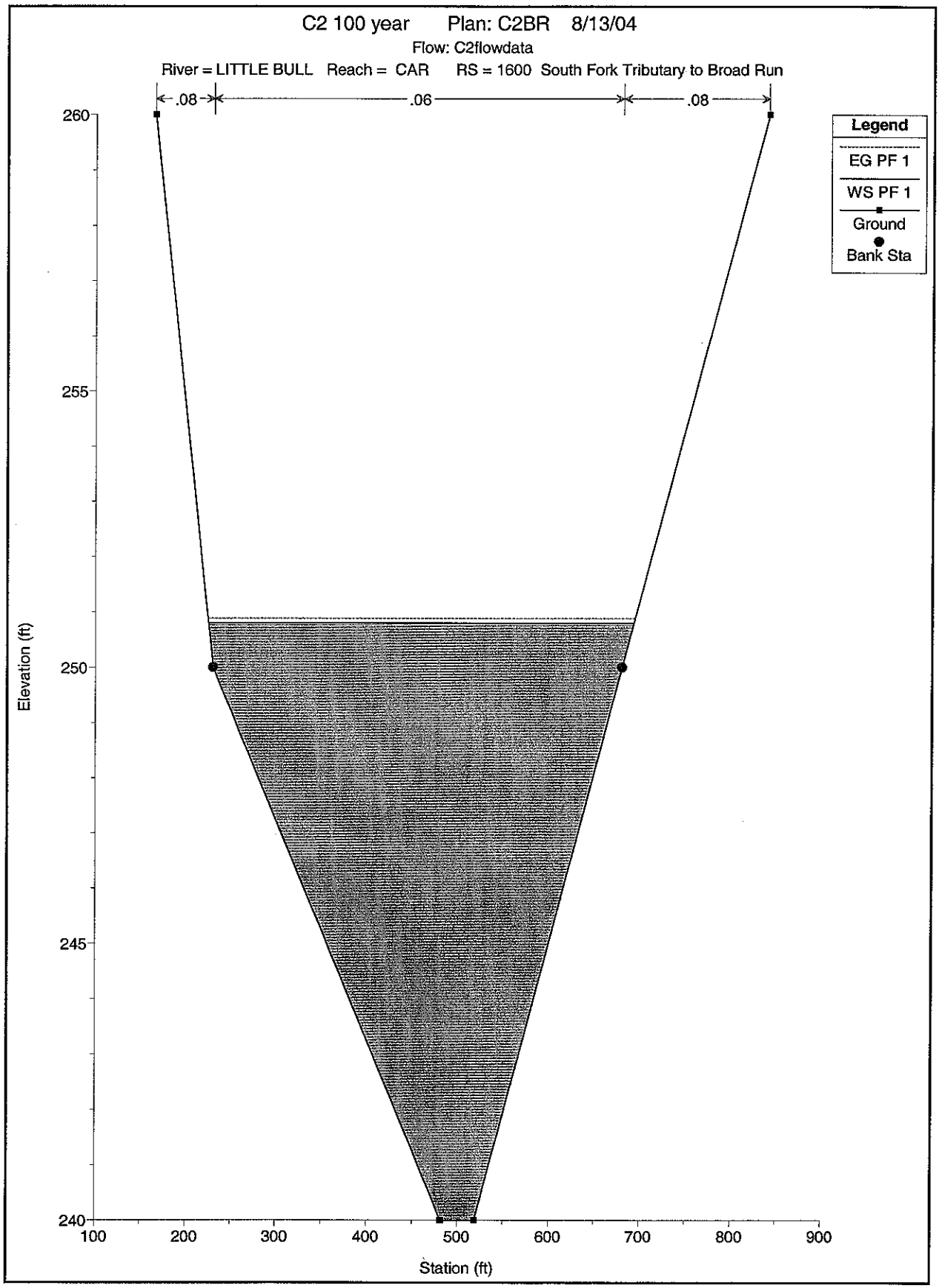
SCALE

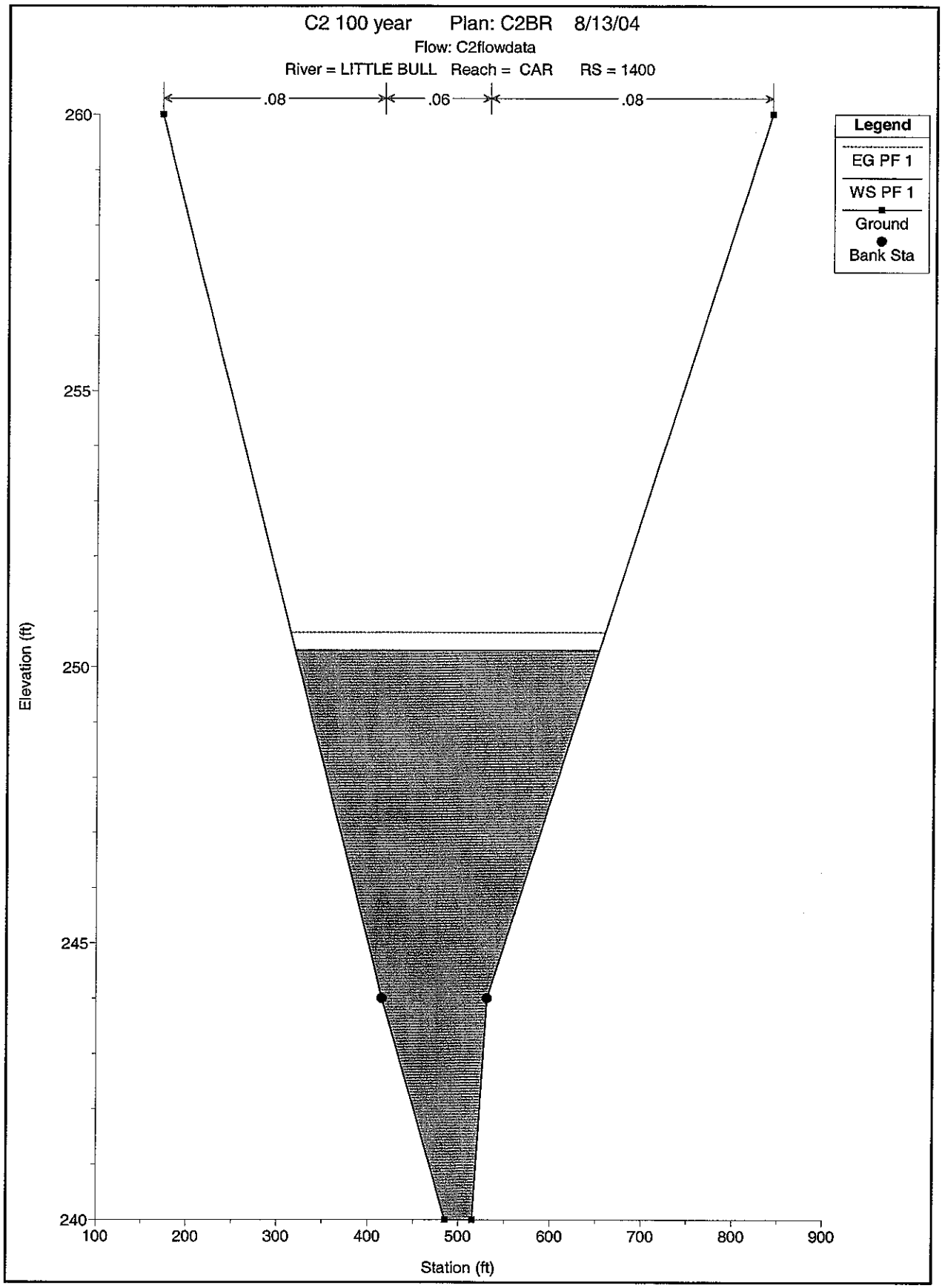
0 100' 200'

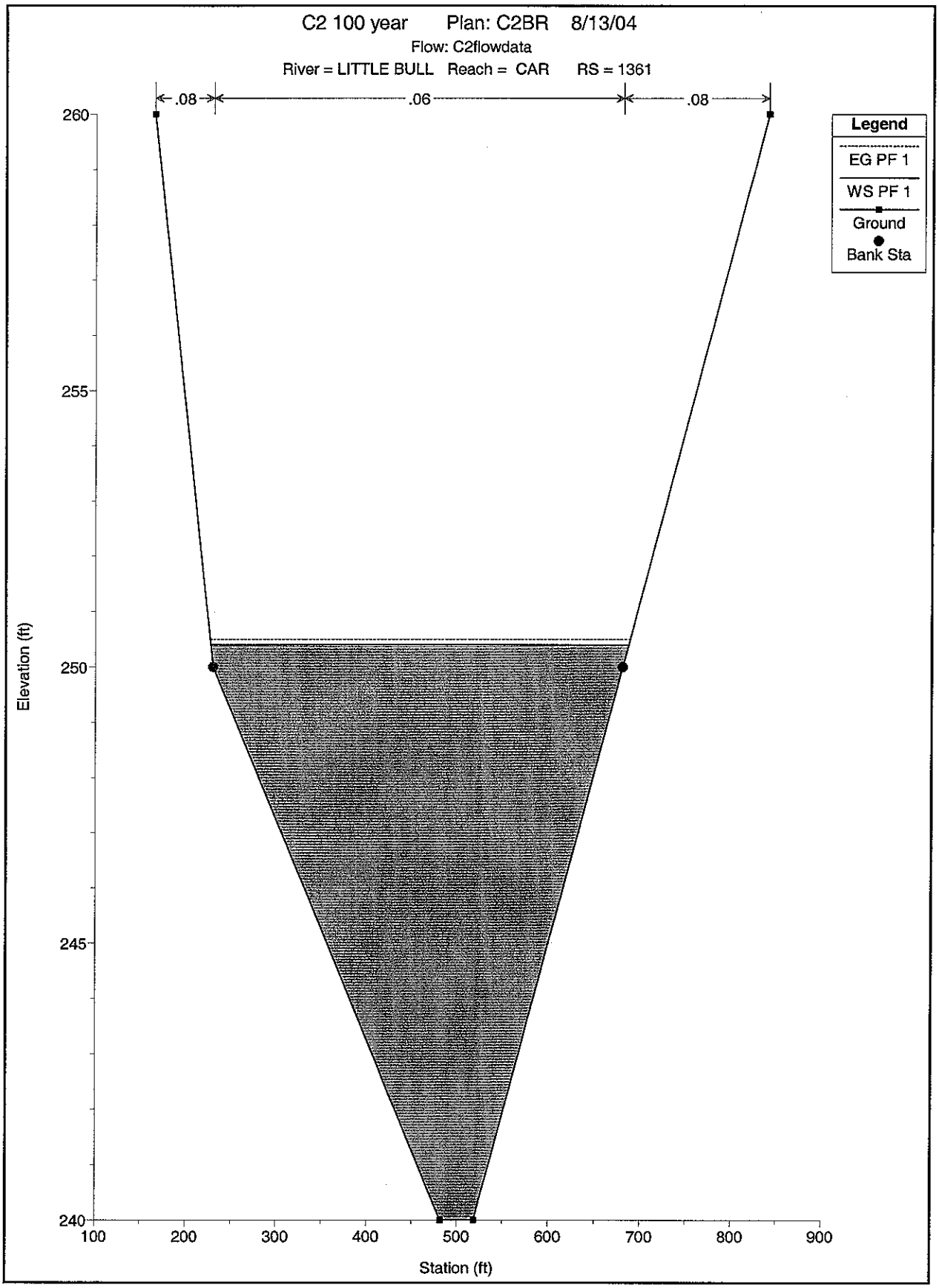
7/27/2004 9:02:27 AM Q:\PLOTTING\QUEUES\xes 8825.qpf M:\CD_C2.USF

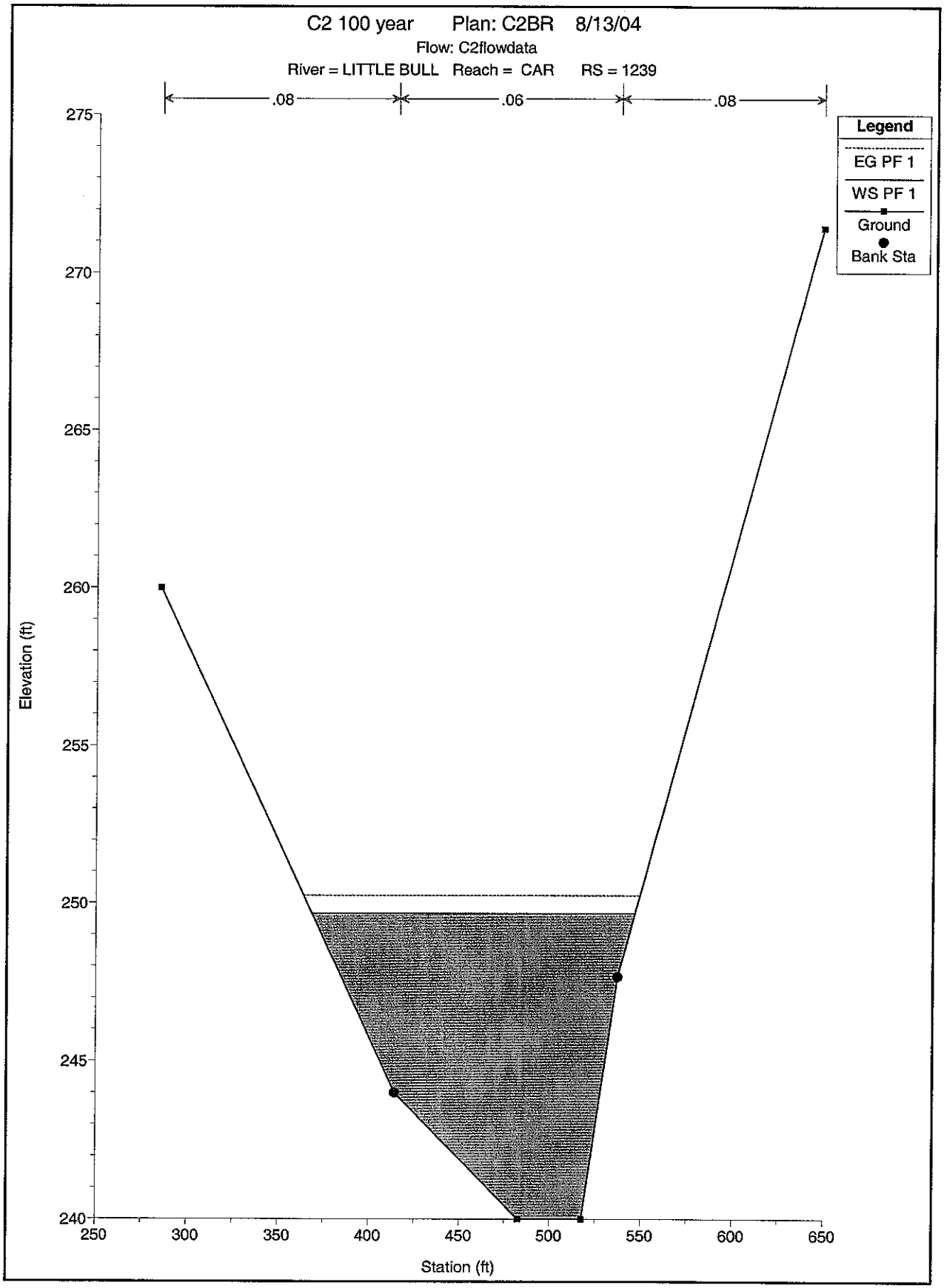
HEC-RAS Plan: C2BR2 River: LITTLE BULL Reach: CAR Profile: PF 1

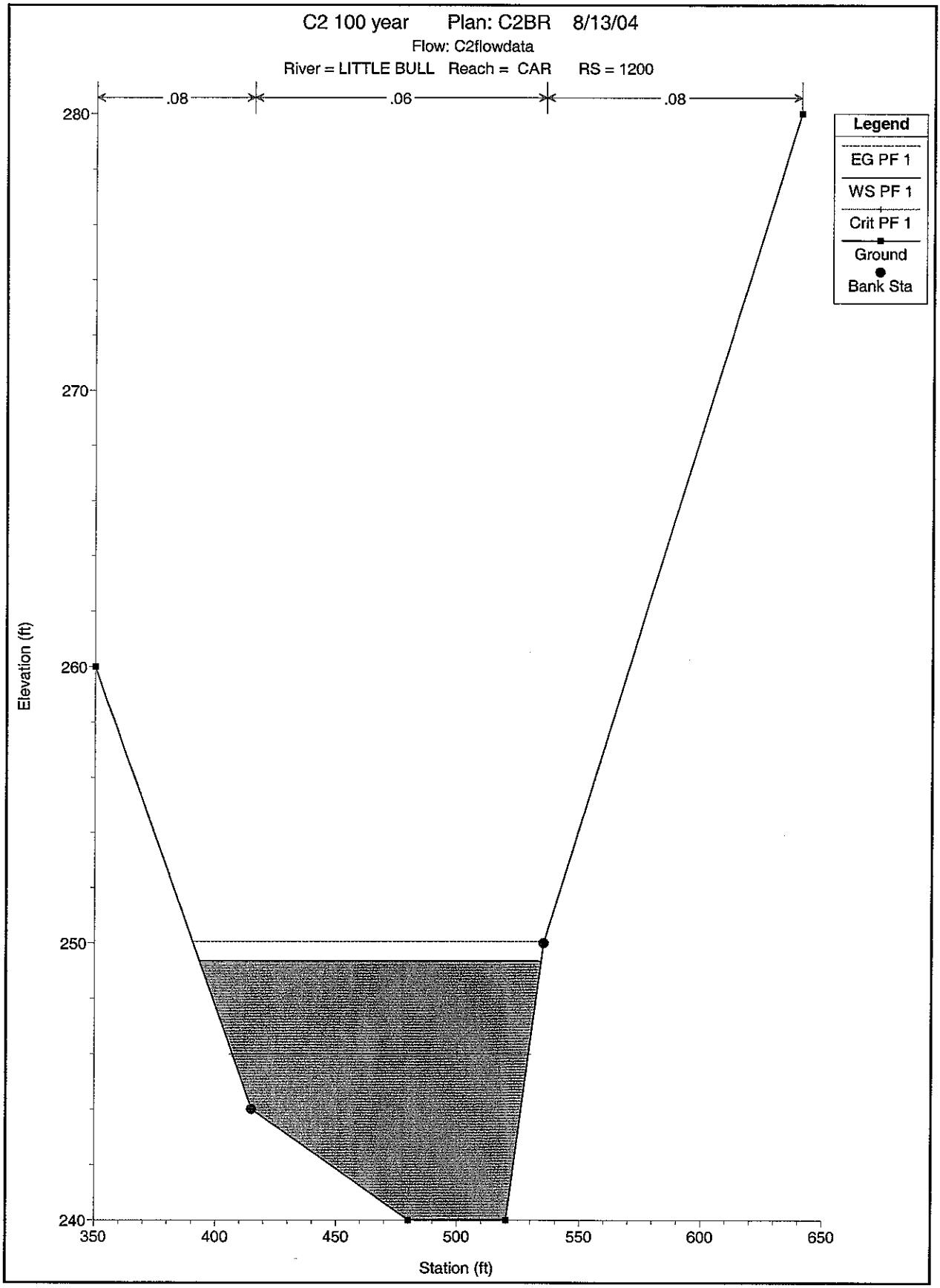
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CAR	1600	6373.00	240.00	250.81		250.89	0.000741	2.28	2804.62	468.12	0.16
CAR	1400	6373.00	240.00	250.30		250.62	0.002248	5.00	1703.81	333.63	0.30
CAR	1361	6373.00	240.00	250.41		250.50	0.000924	2.43	2620.15	459.16	0.18
CAR	1239	6373.00	240.00	249.68		250.25	0.004003	6.20	1117.23	178.03	0.39
CAR	1200	6373.00	240.00	249.36	245.99	250.06	0.005079	6.78	976.80	140.81	0.43
CAR	1000	6373.00	240.00	245.82	245.82	247.93	0.027787	11.75	573.79	155.75	0.94

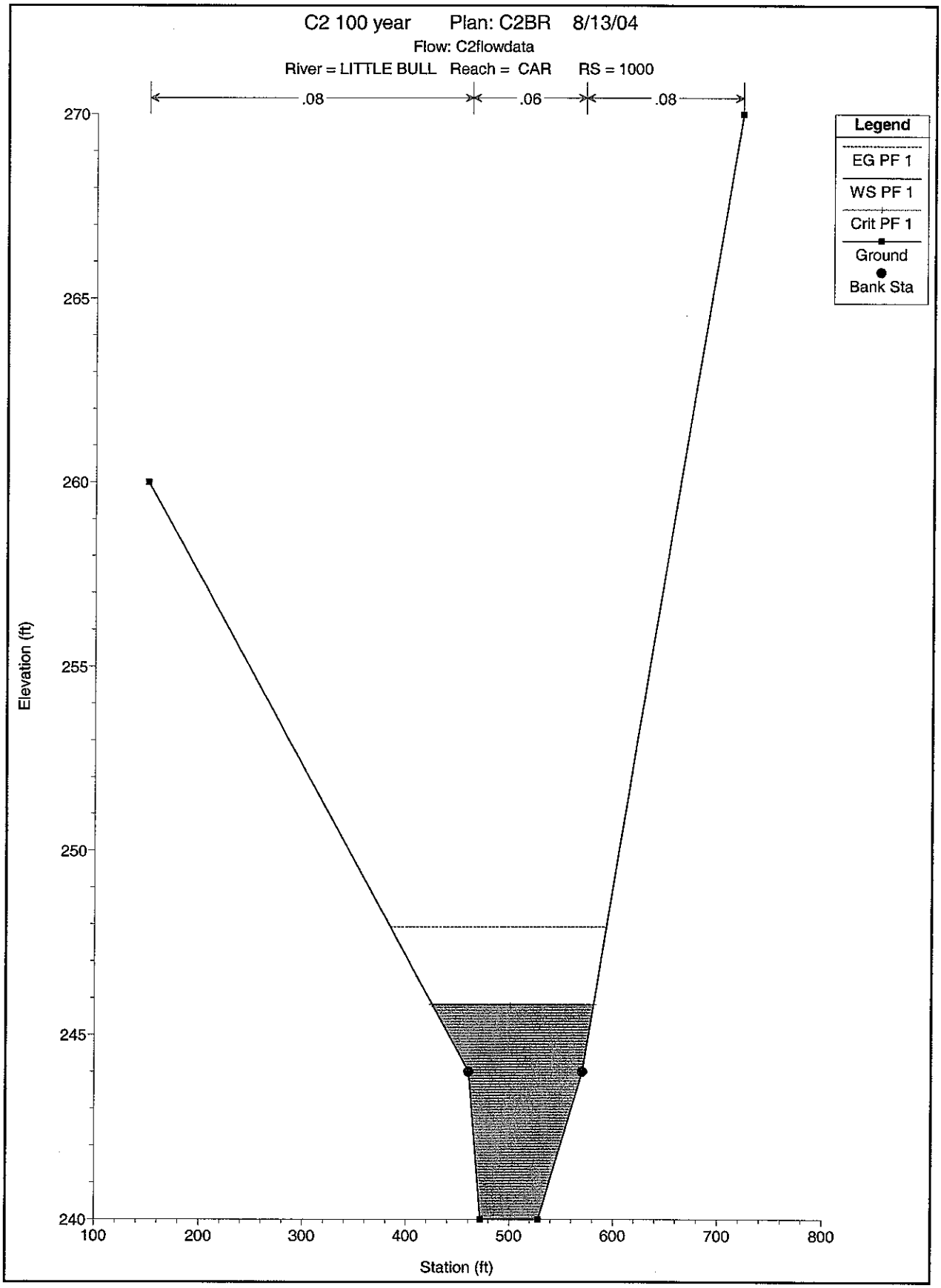

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1600 South Fork Tributary to Broad Run
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)

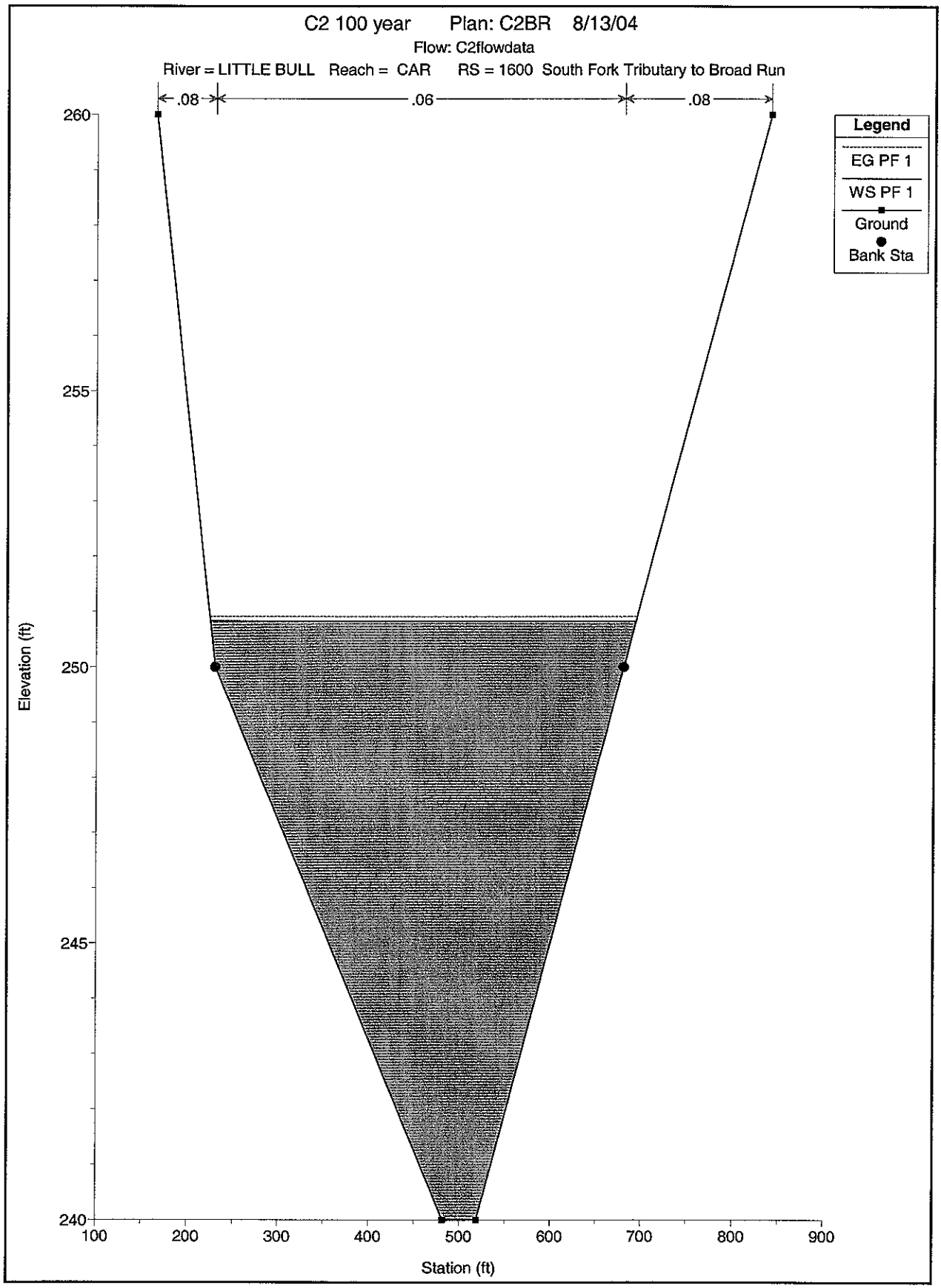

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
275
270
265
260
255
250
245
240
250
300
350
400
450
500
550
600
650
Station (ft)

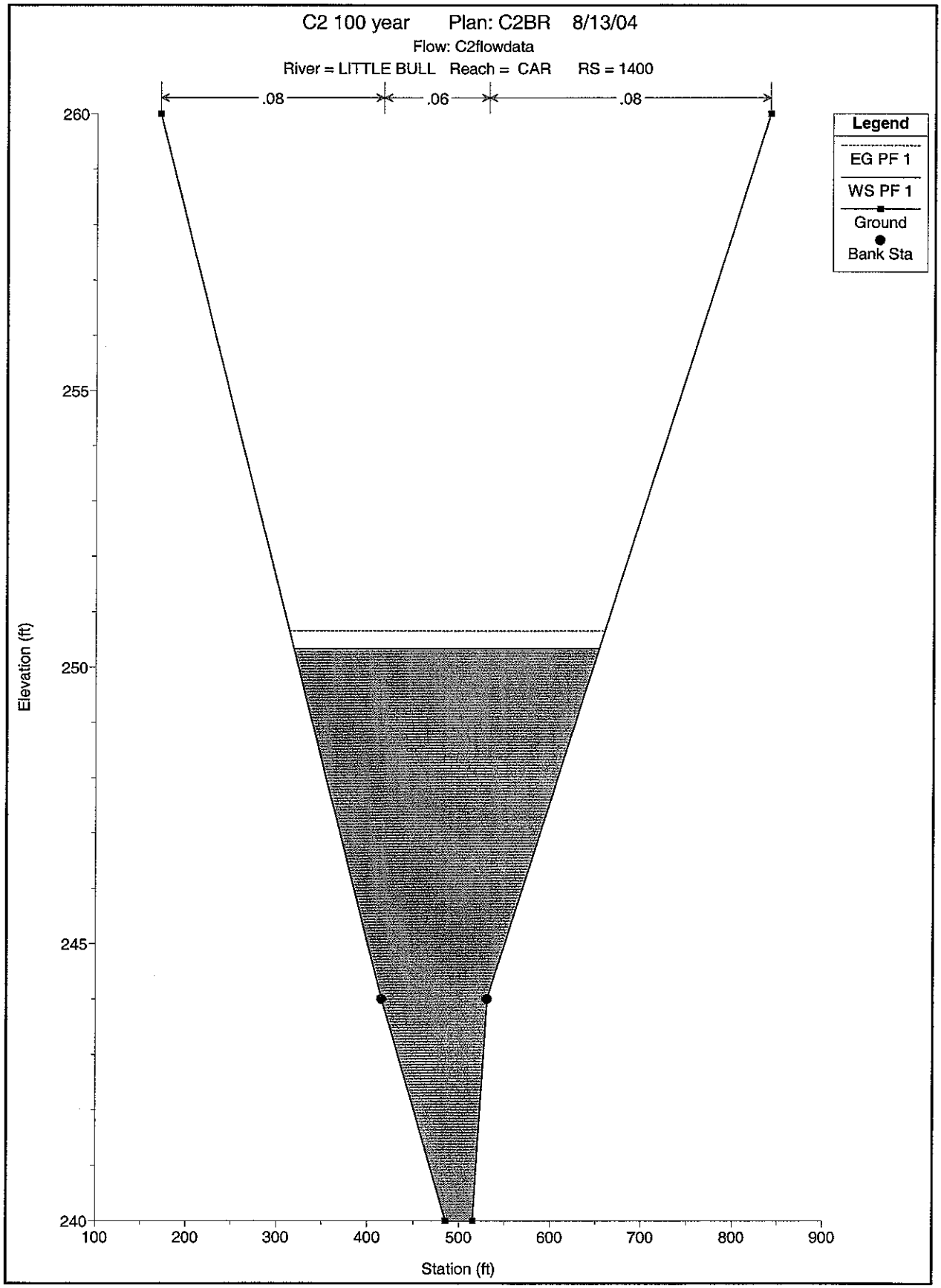

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
350
400
450
500
550
600
650
Station (ft)

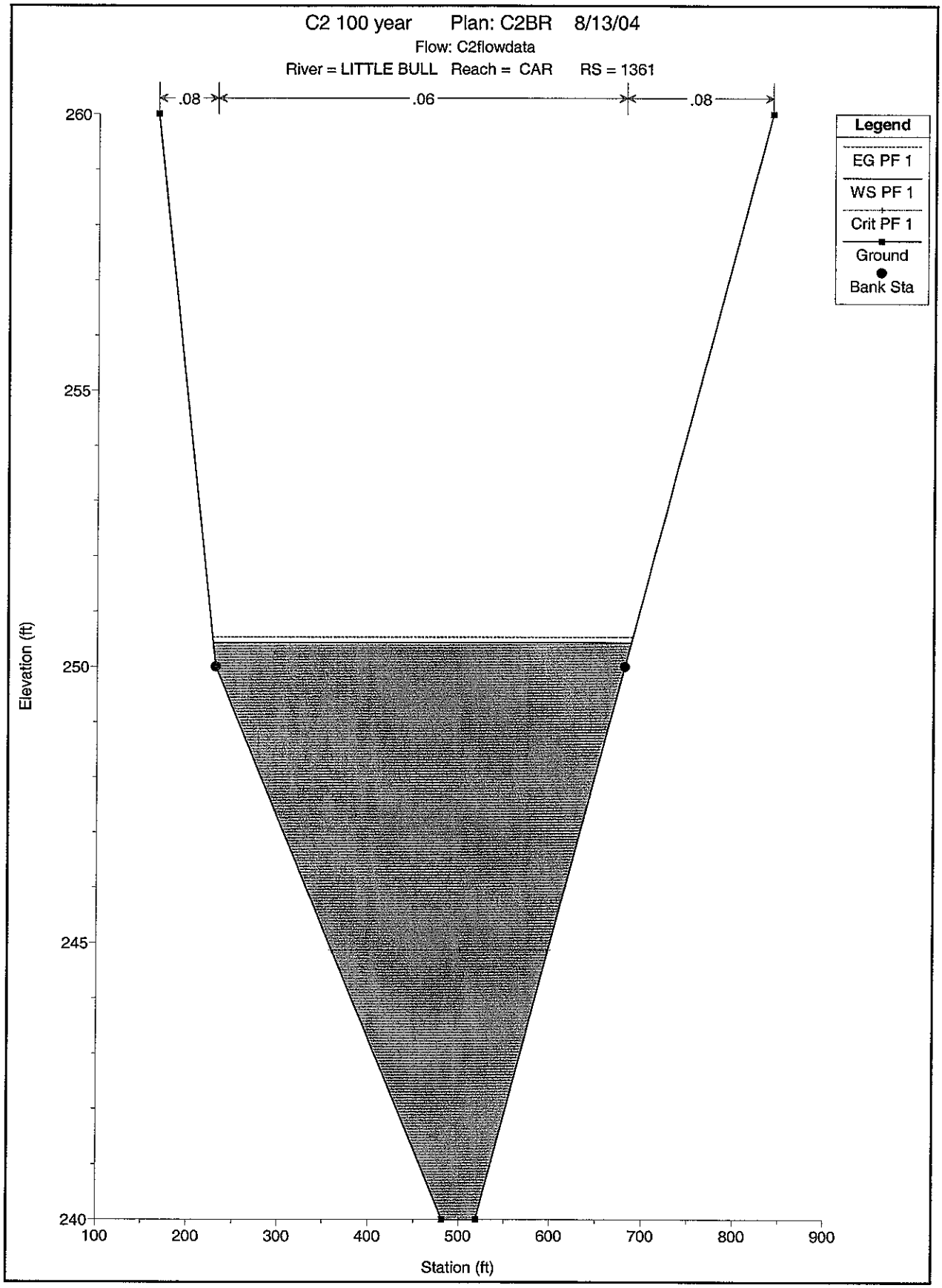

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
270
265
260
255
250
245
240
100
200
300
400
500
600
700
800
Station (ft)

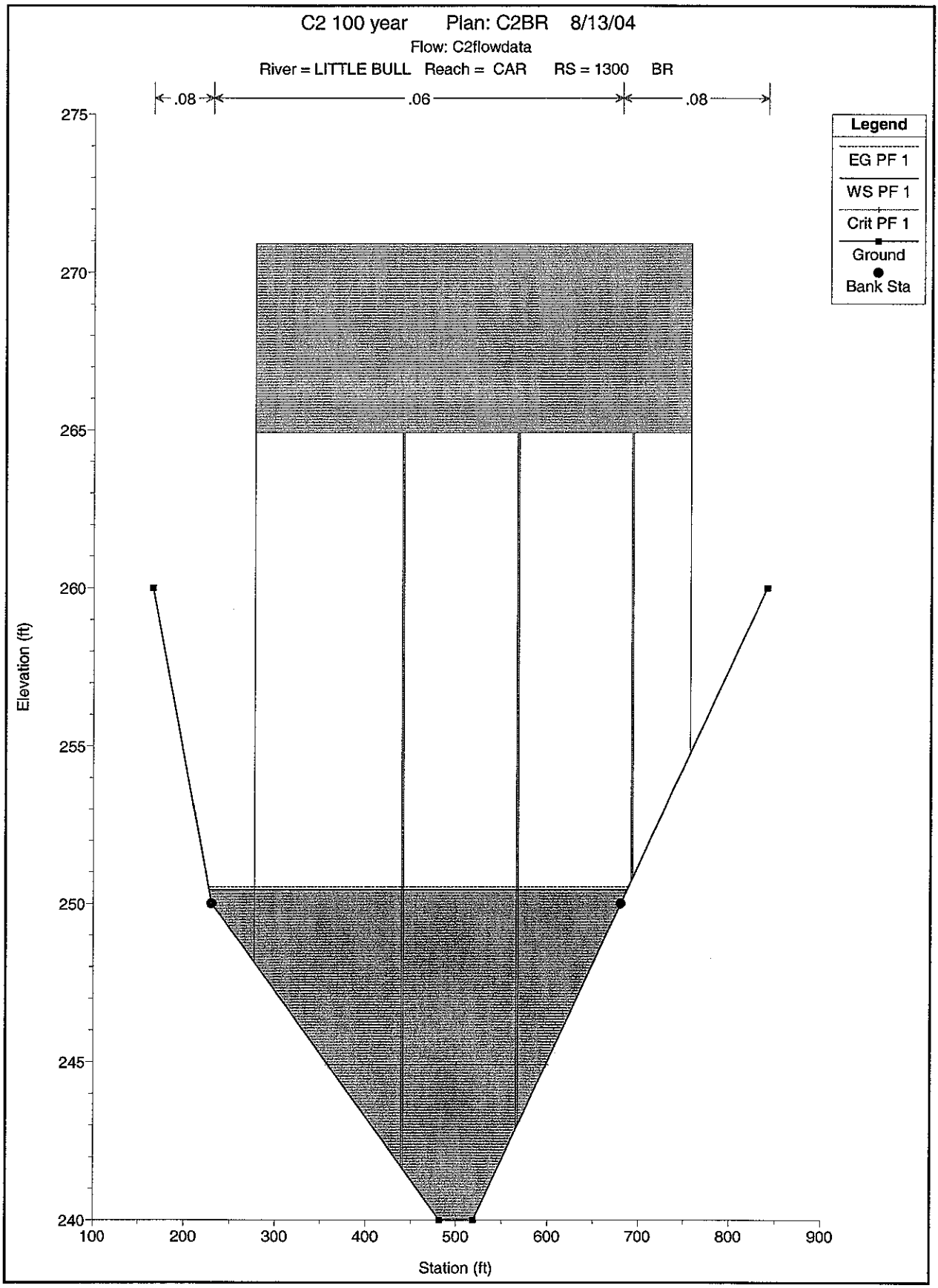
HEC-RAS Plan: C2BR2 River: LITTLE BULL Reach: CAR Profile: PF 1

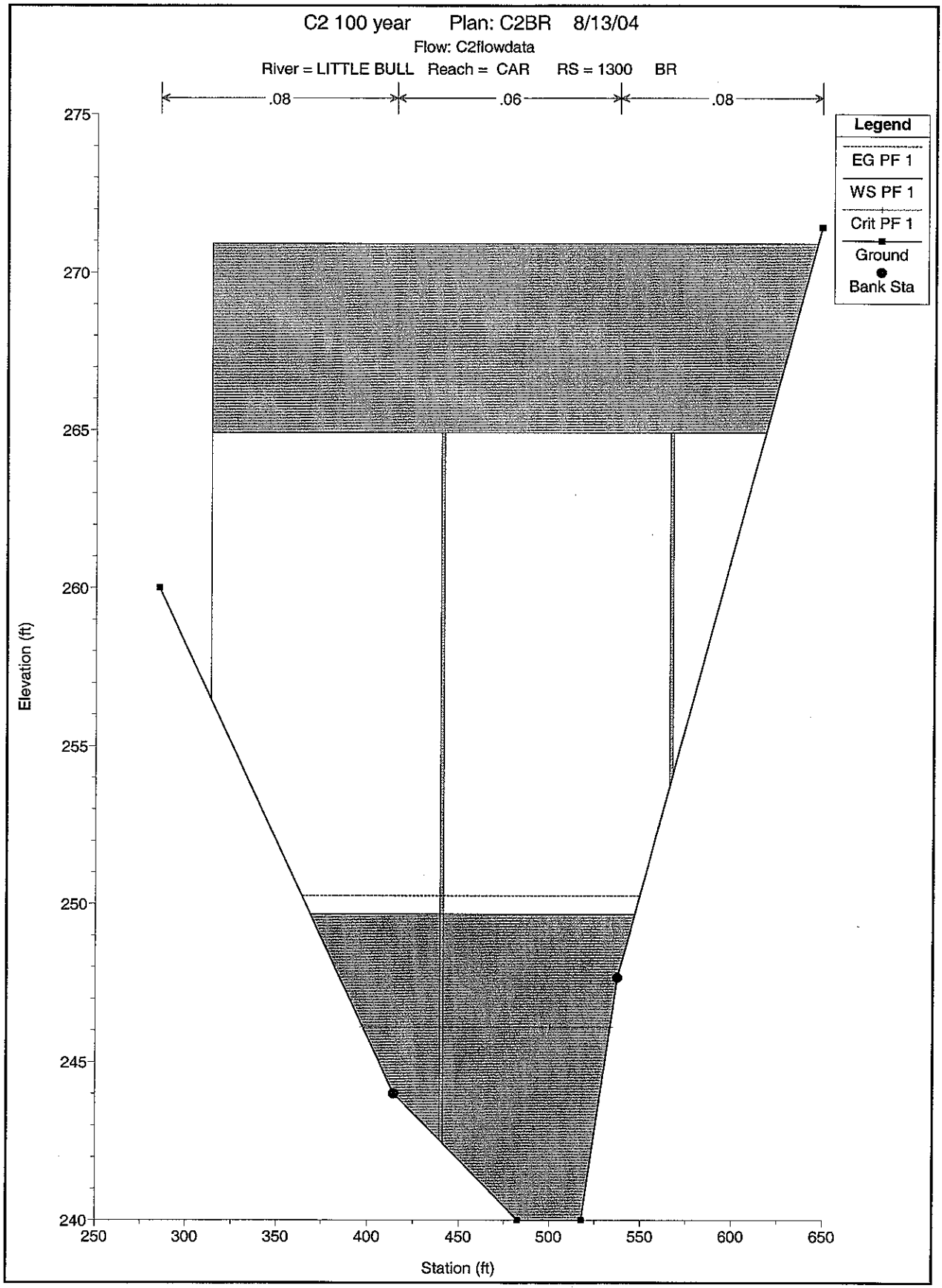
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CAR	1600	6373.00	240.00	250.83		250.91	0.000730	2.27	2818.04	468.76	0.16
CAR	1400	6373.00	240.00	250.34		250.65	0.002210	4.97	1715.90	334.88	0.29
CAR	1361	6373.00	240.00	250.44	244.87	250.53	0.000906	2.42	2636.27	459.95	0.18
CAR	1300	Bridge									
CAR	1239	6373.00	240.00	249.68		250.25	0.004003	6.20	1117.23	178.03	0.39
CAR	1200	6373.00	240.00	249.36	245.99	250.06	0.005079	6.78	976.80	140.81	0.43
CAR	1000	6373.00	240.00	245.82	245.82	247.93	0.027787	11.75	573.79	155.75	0.94

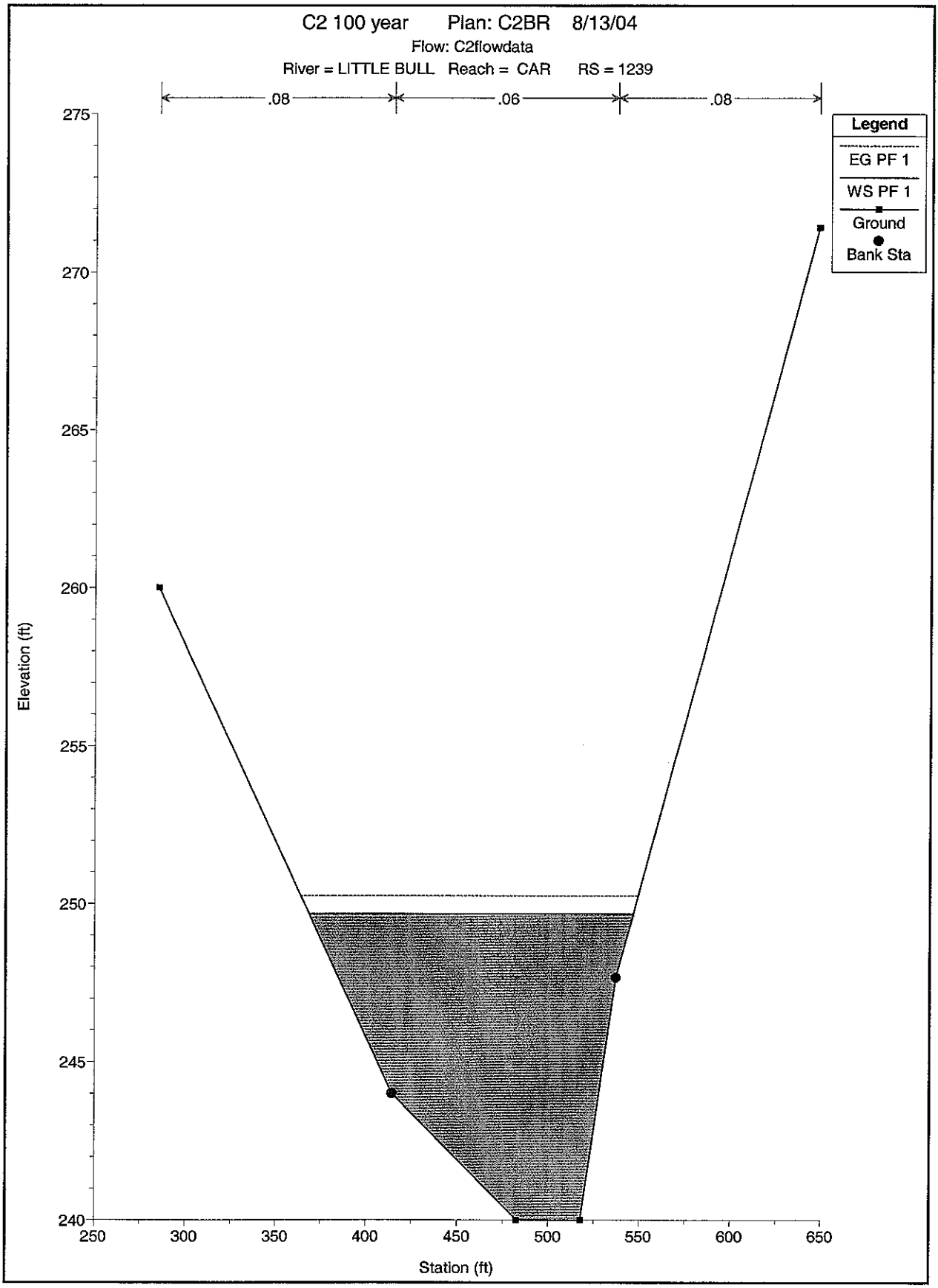

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1600 South Fork Tributary to Broad Run
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)

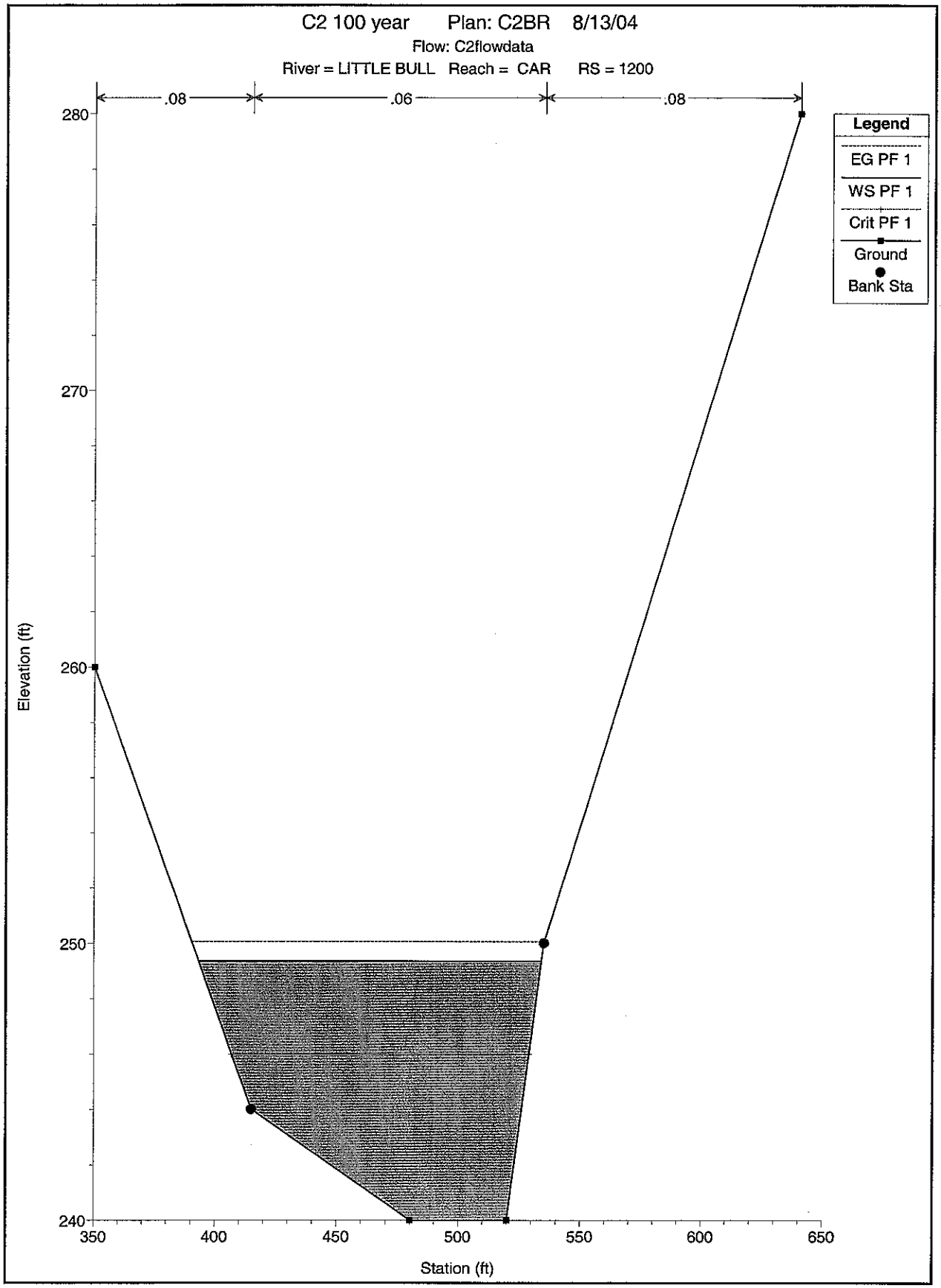

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)

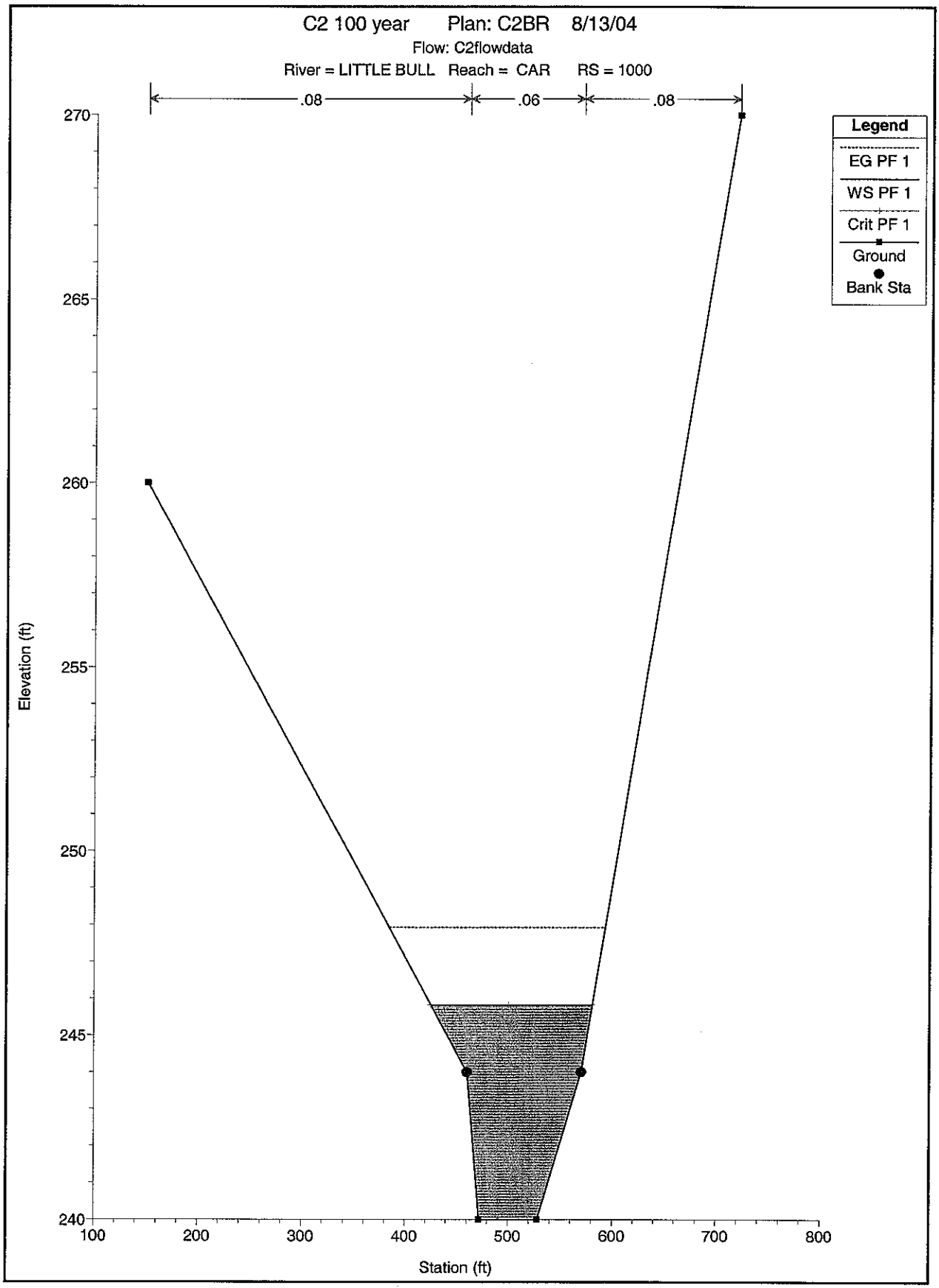

C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
275
270
265
260
255
250
245
240
100
200
300
400
500
600
700
800
900
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
275
270
265
260
255
250
245
240
250
300
350
400
450
500
550
600
650
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
275
270
265
260
255
250
245
240
250
300
350
400
450
500
550
600
650
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
350
400
450
500
550
600
650
Station (ft)


C2 100 year Plan: C2BR 8/13/04
Flow: C2flowdata
River = LITTLE BULL Reach = CAR RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
270
265
260
255
250
245
240
100
200
300
400
500
600
700
800
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING C3

PART 1: Plan Sheet

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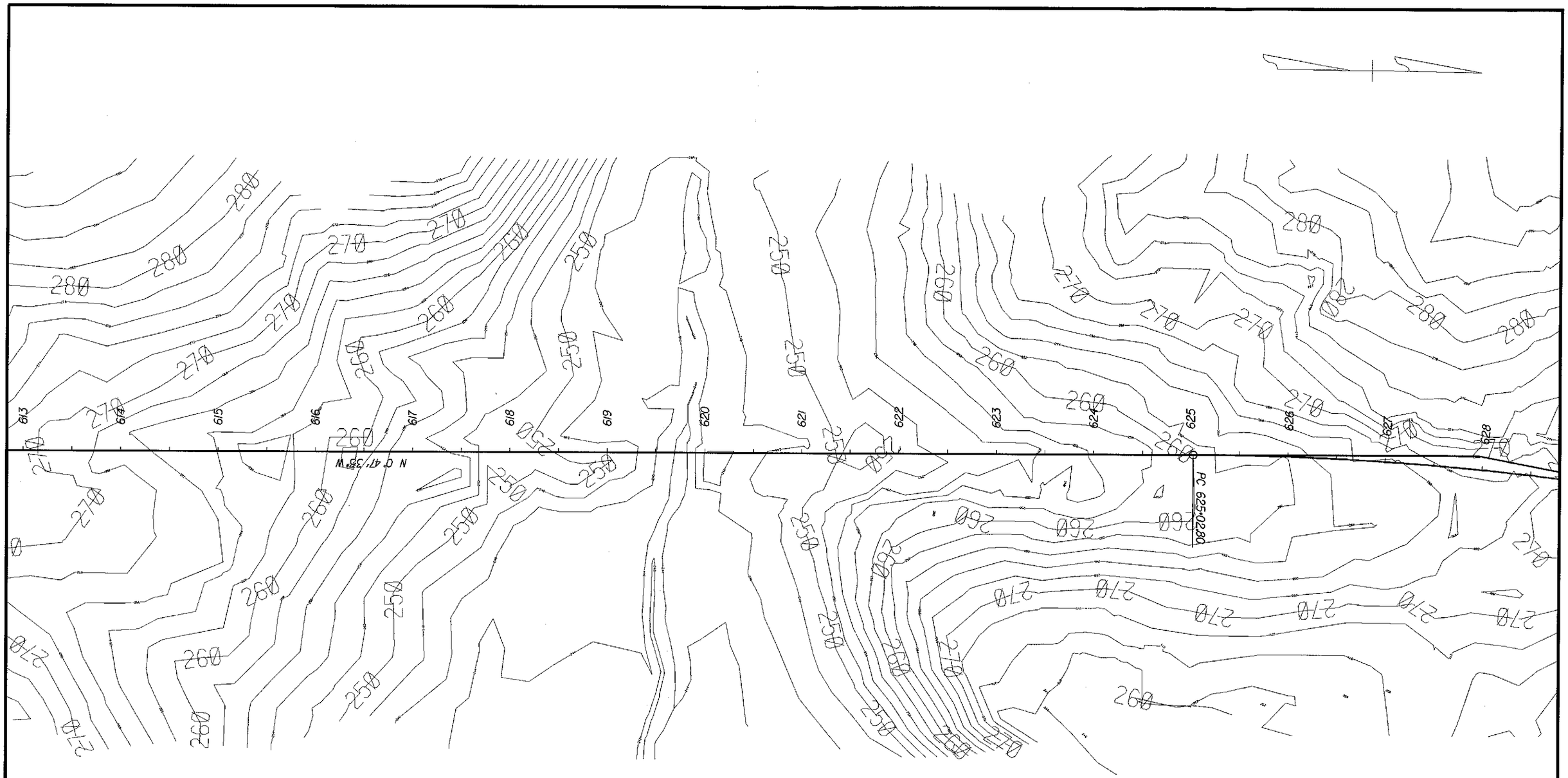

TRI COUNTY PARKWAY
Crossing C3

July 2004

SCALE

0 100' 200'

7/27/2004 9:02:57 AM O:\PLOTTING\QUEUES\xes 8825.qcf M:\CD_C2.USF

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING C5

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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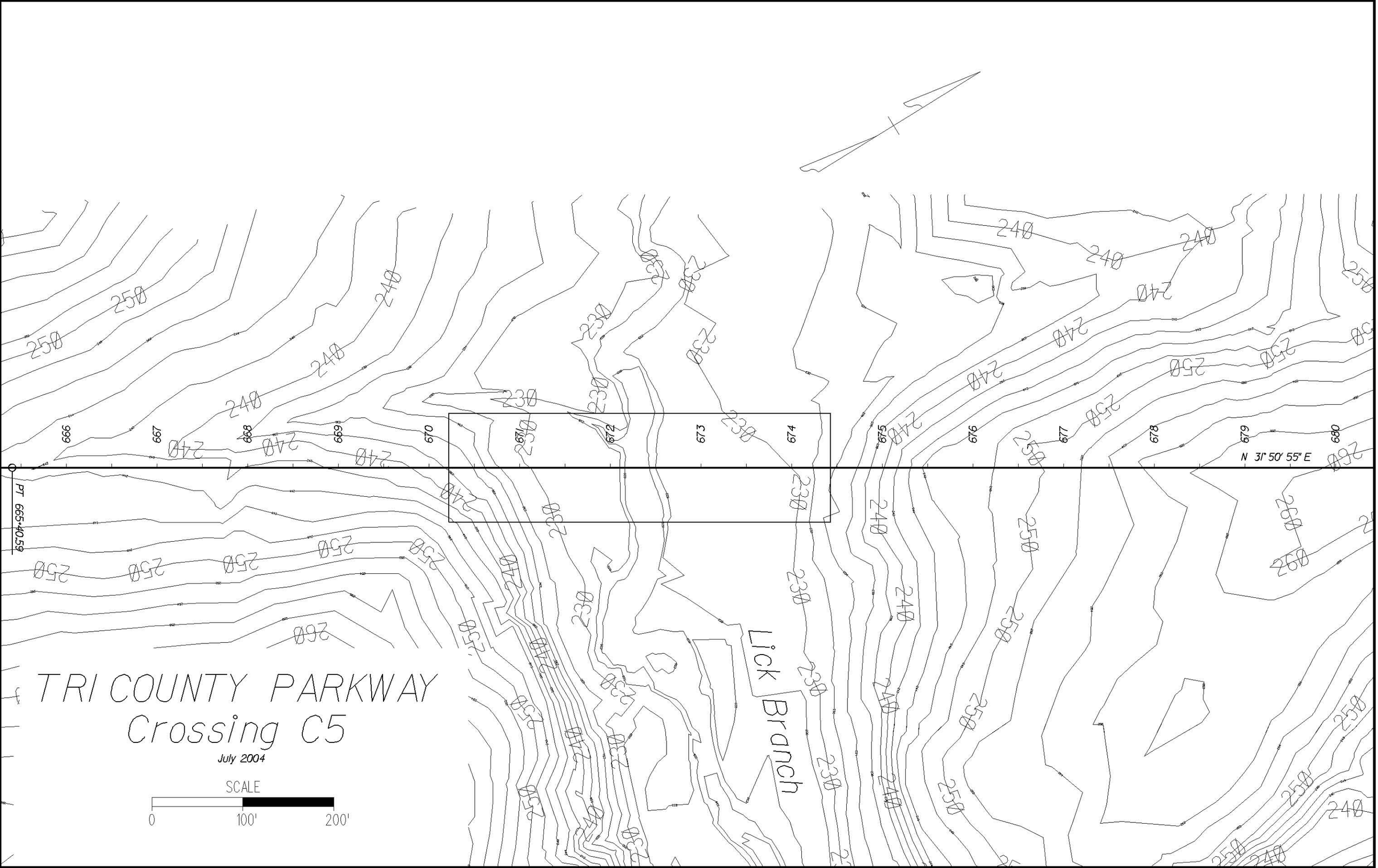
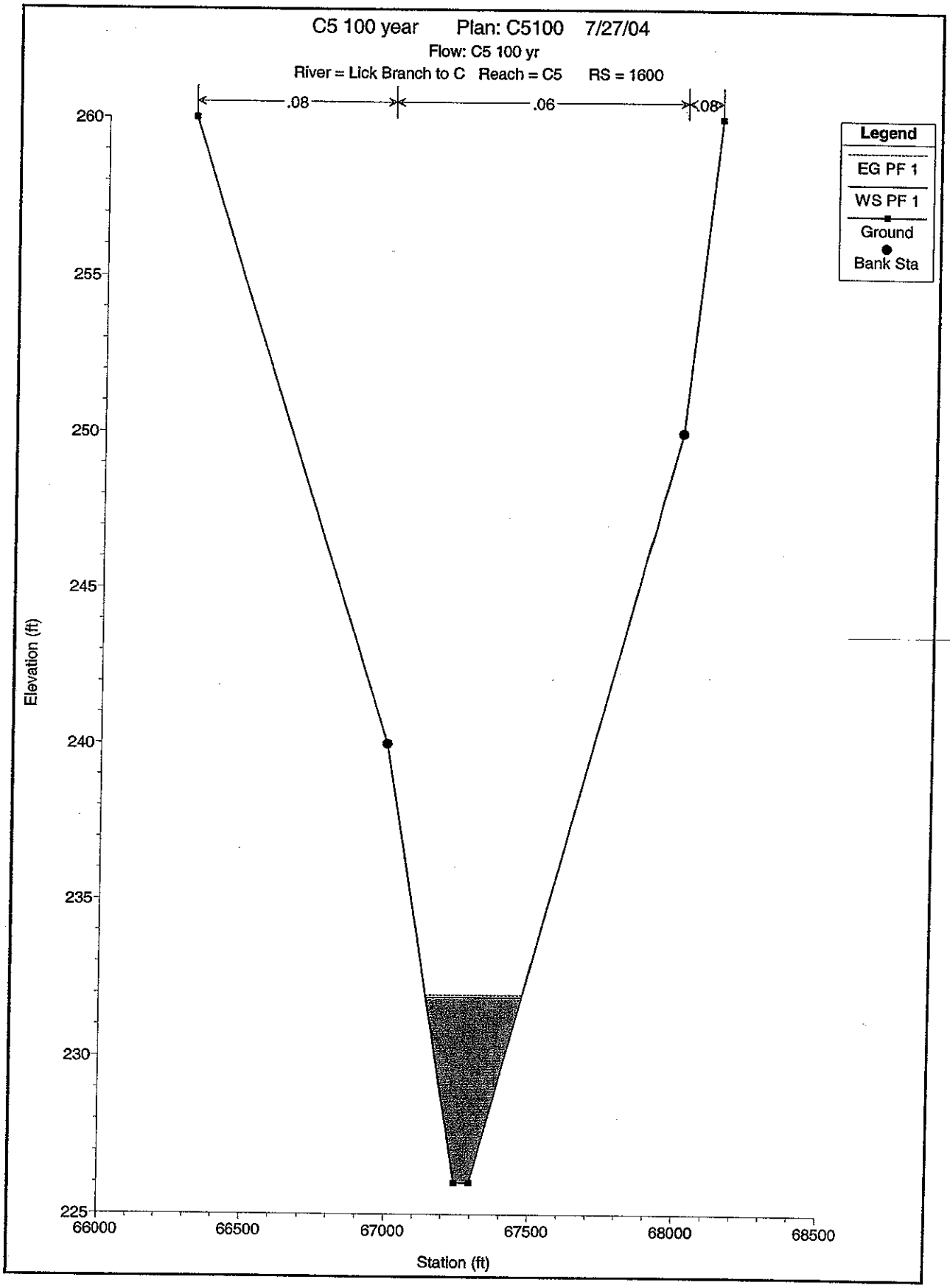
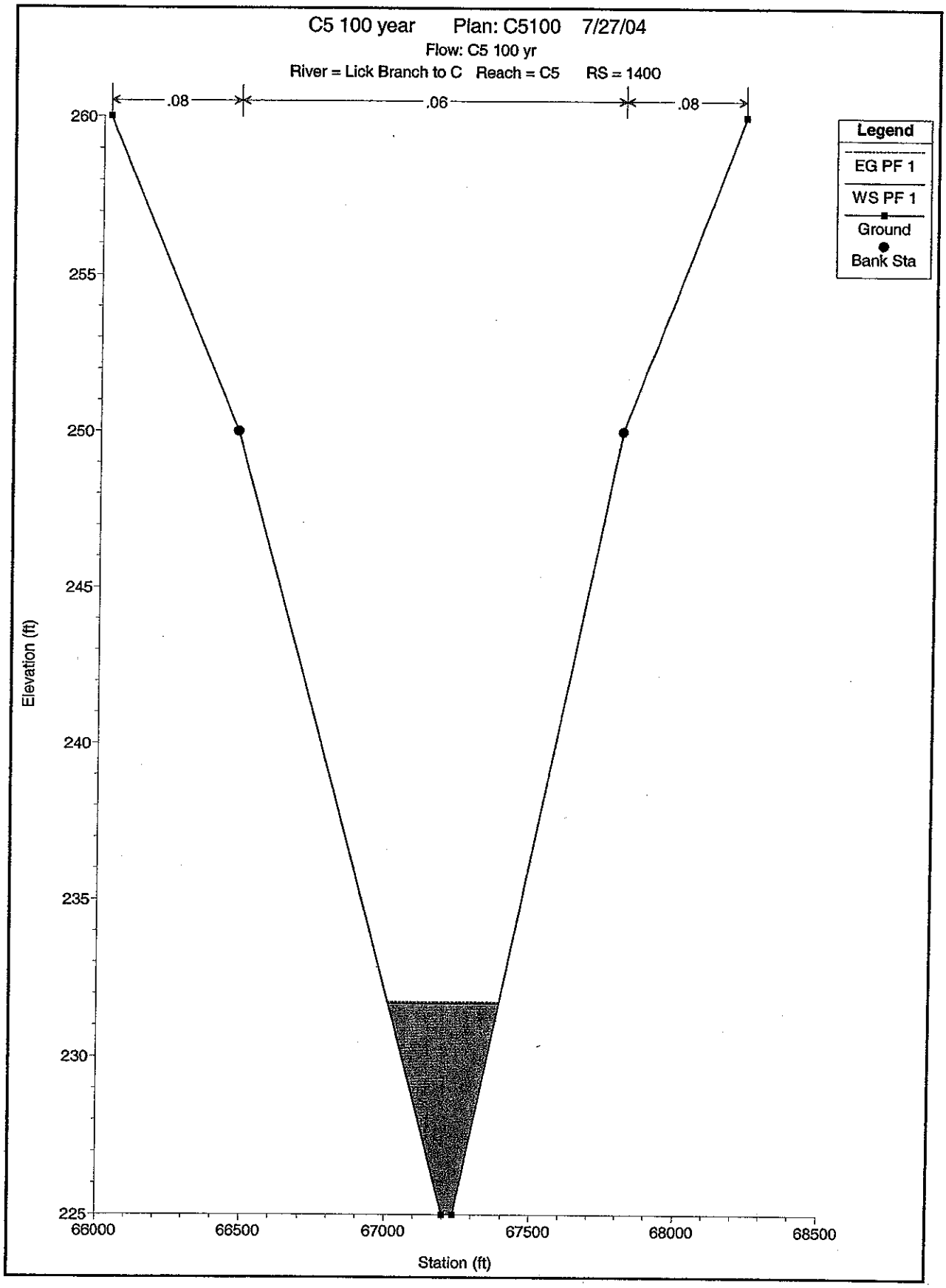
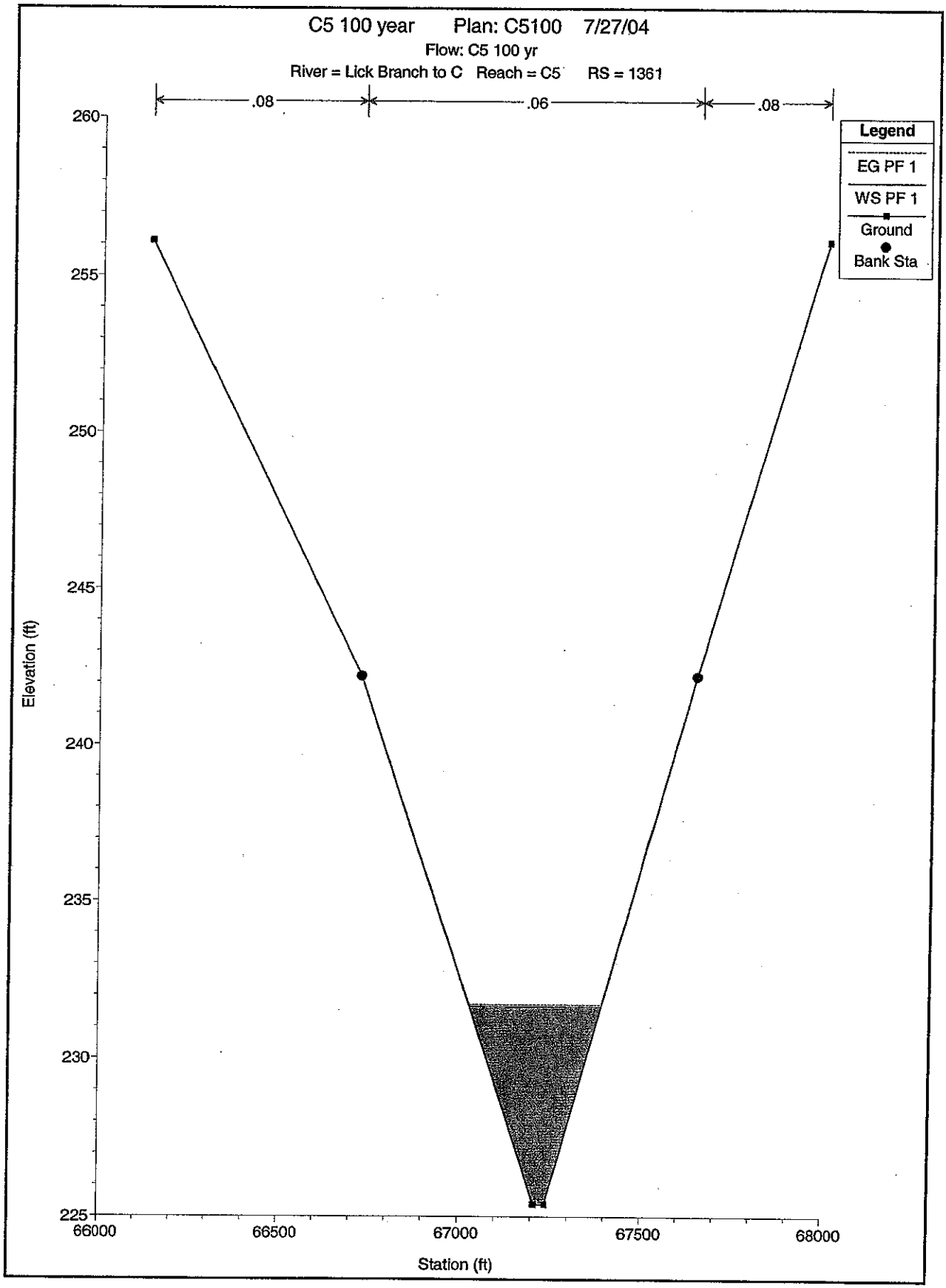

TRI COUNTY PARKWAY
Crossing C5
July 2004
SCALE
0
100'
200'
Lick Branch
N 31° 50' 55" E
PT 665+40.59
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680

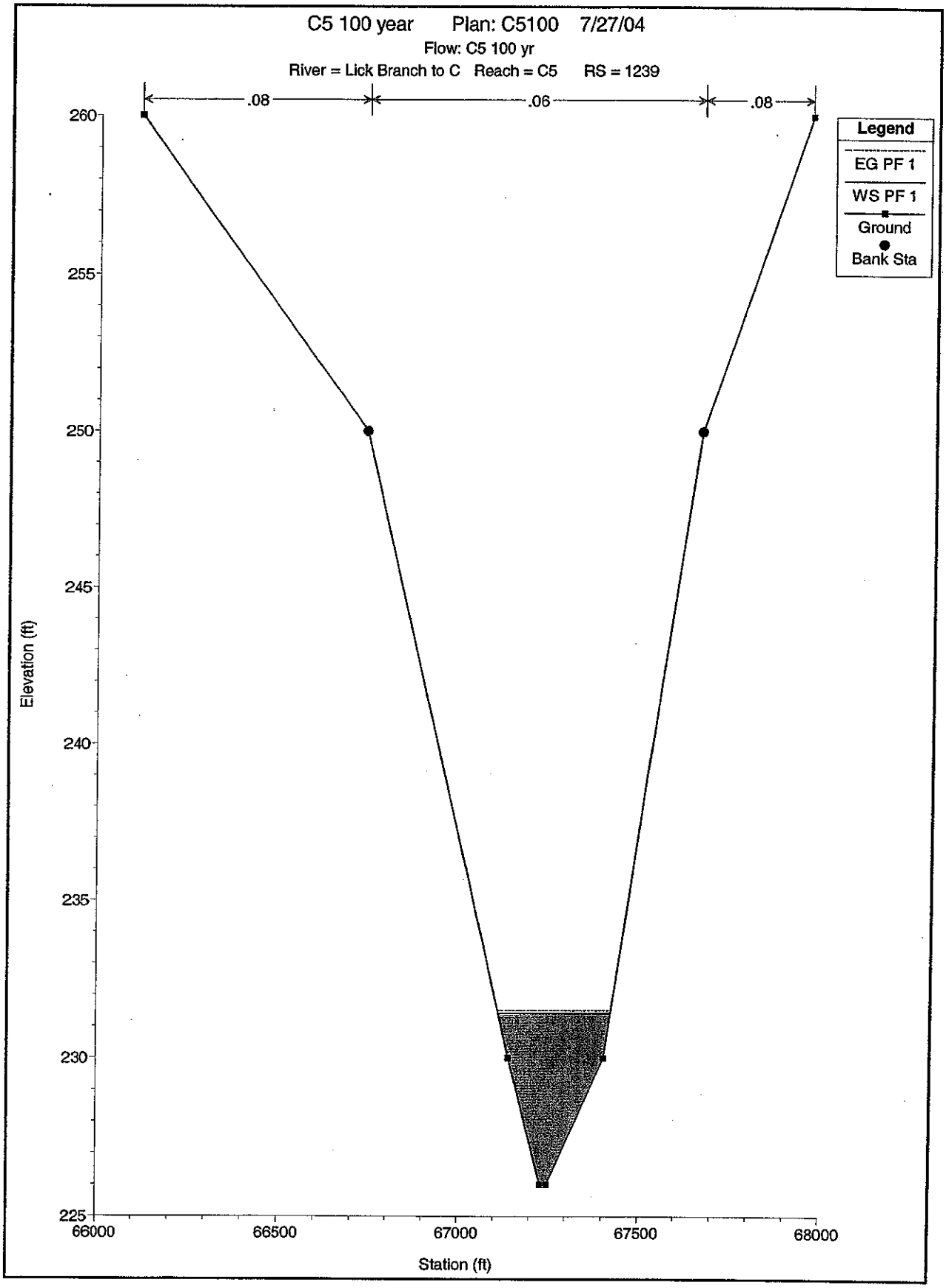
HEC-RAS Plan: C5 River: Lick Branch to C Reach: C5 Profile: PF 1

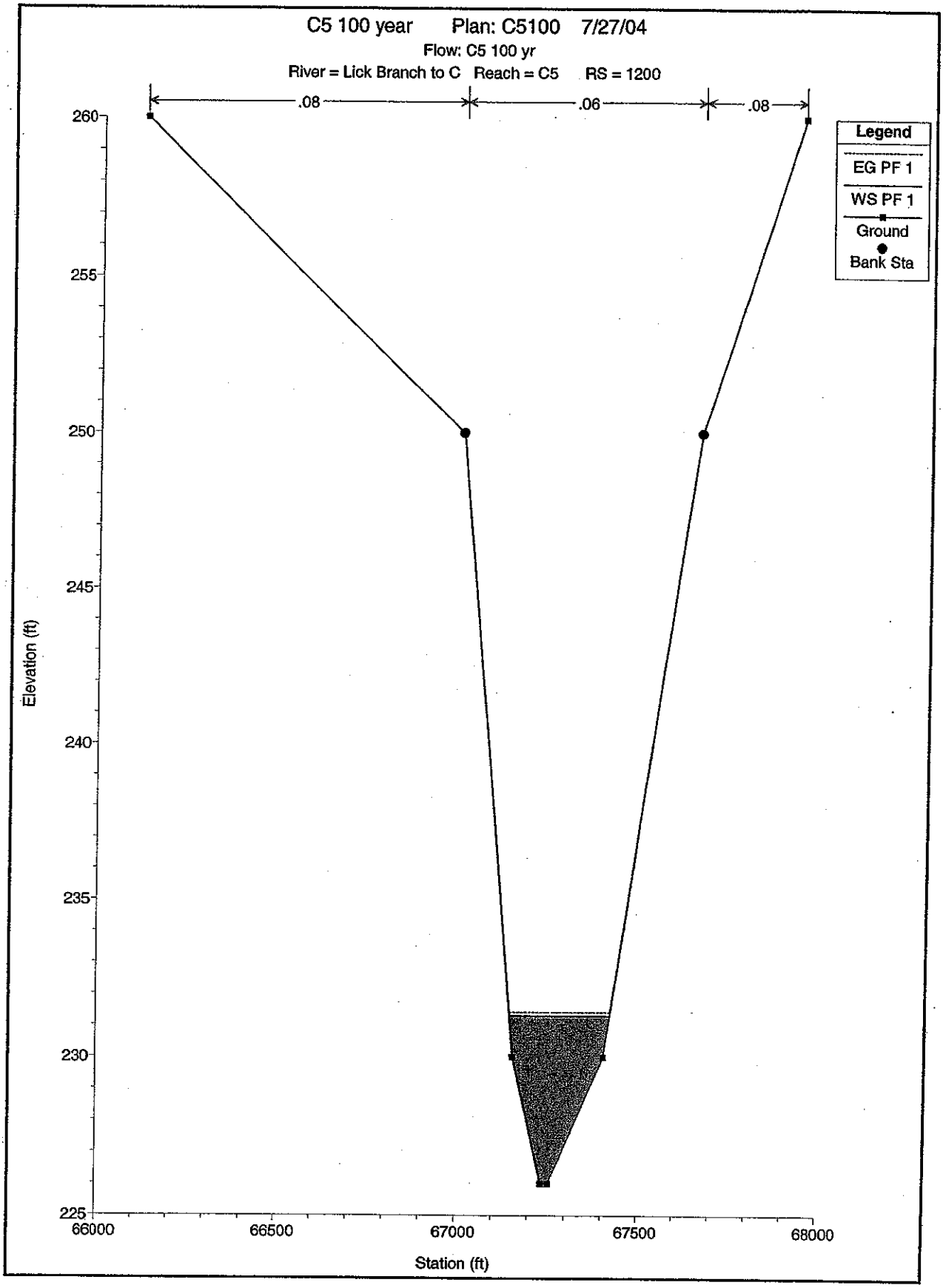
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
C5	1600	2369.00	226.00	231.90		231.96	0.001407	2.10	1127.94	331.49	0.20
C5	1400	2369.00	225.00	231.70		231.75	0.000817	1.69	1405.85	382.38	0.15
C5	1361	2369.00	225.39	231.65		231.71	0.001194	1.93	1226.83	361.75	0.18
C5	1239	2369.00	226.00	231.42		231.51	0.002099	2.43	975.42	311.24	0.24
C5	1200	2369.00	226.00	231.31		231.42	0.002533	2.70	877.90	275.30	0.27
C5	1000	2369.00	226.00	229.16	229.16	230.03	0.044766	7.48	316.59	185.40	1.01

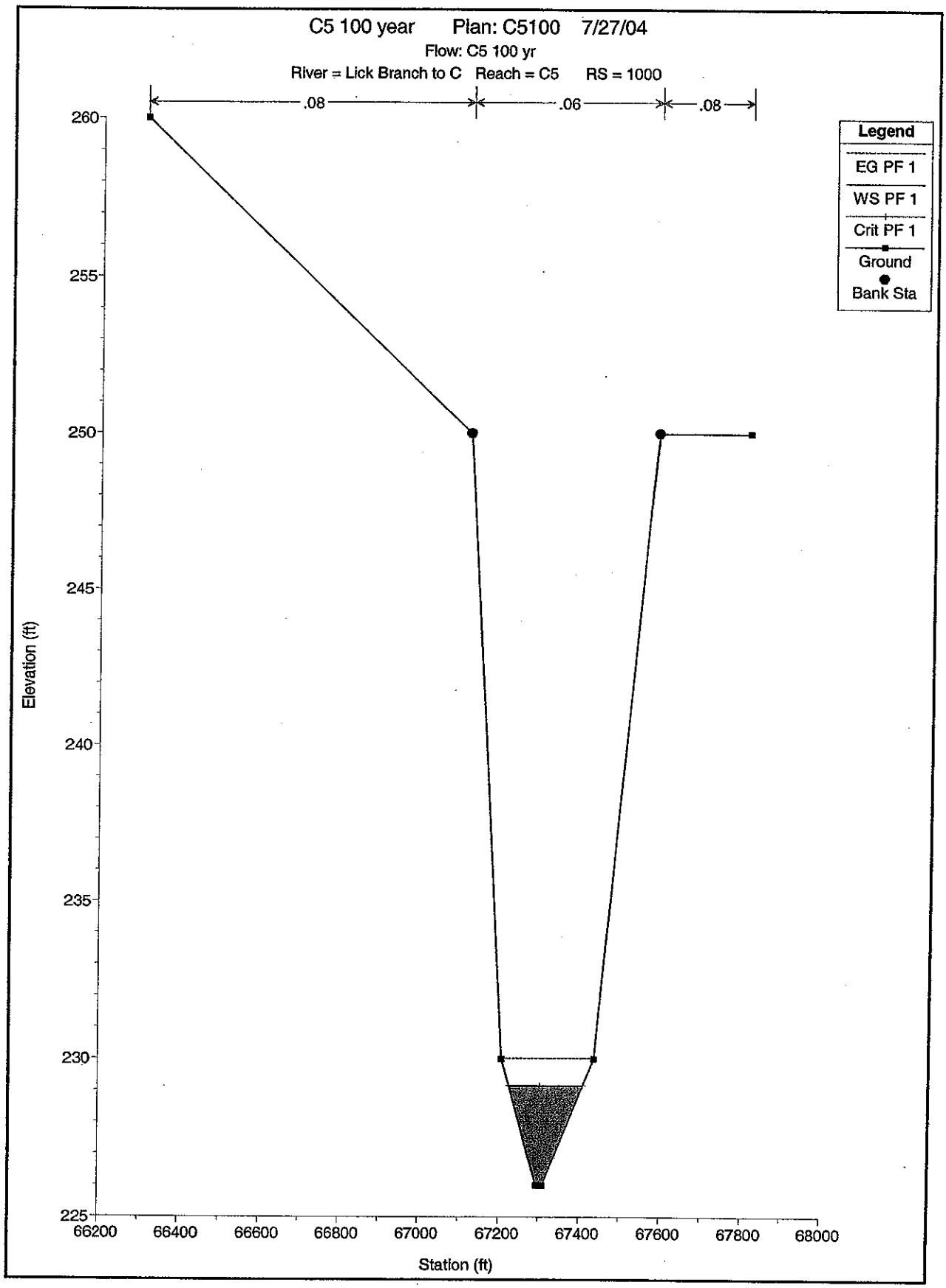

C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
68500
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
68500
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)

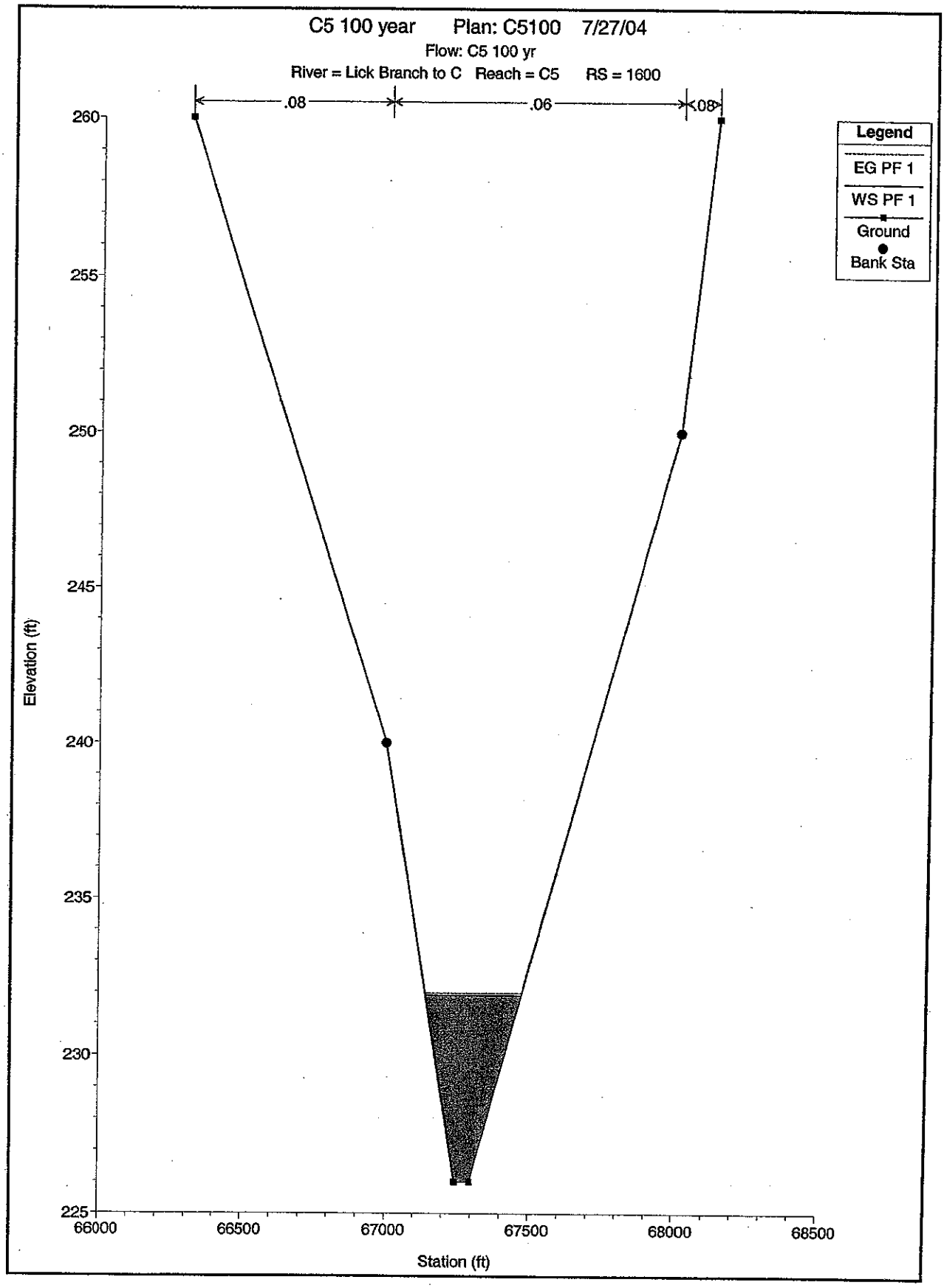

C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)

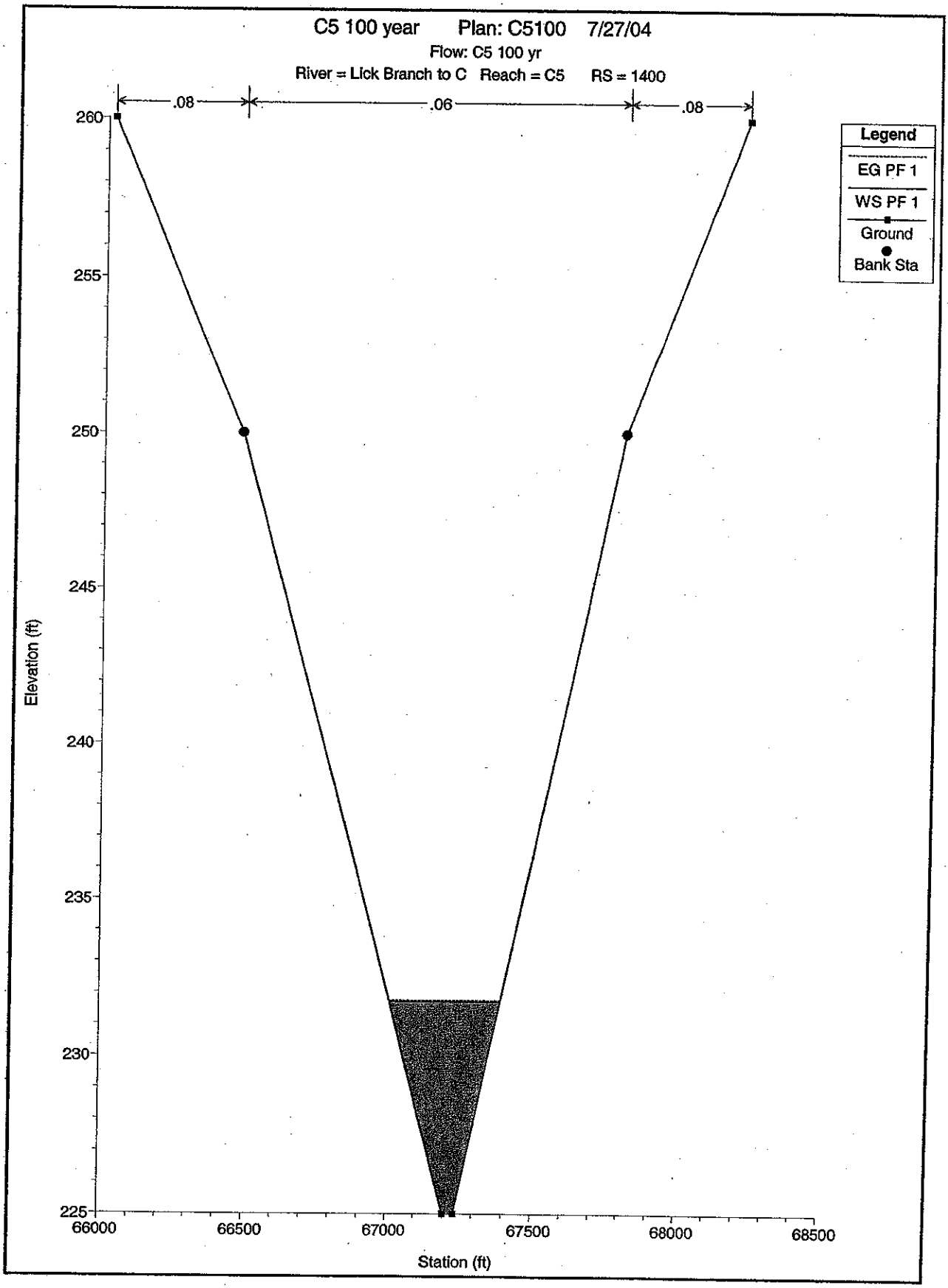

C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)

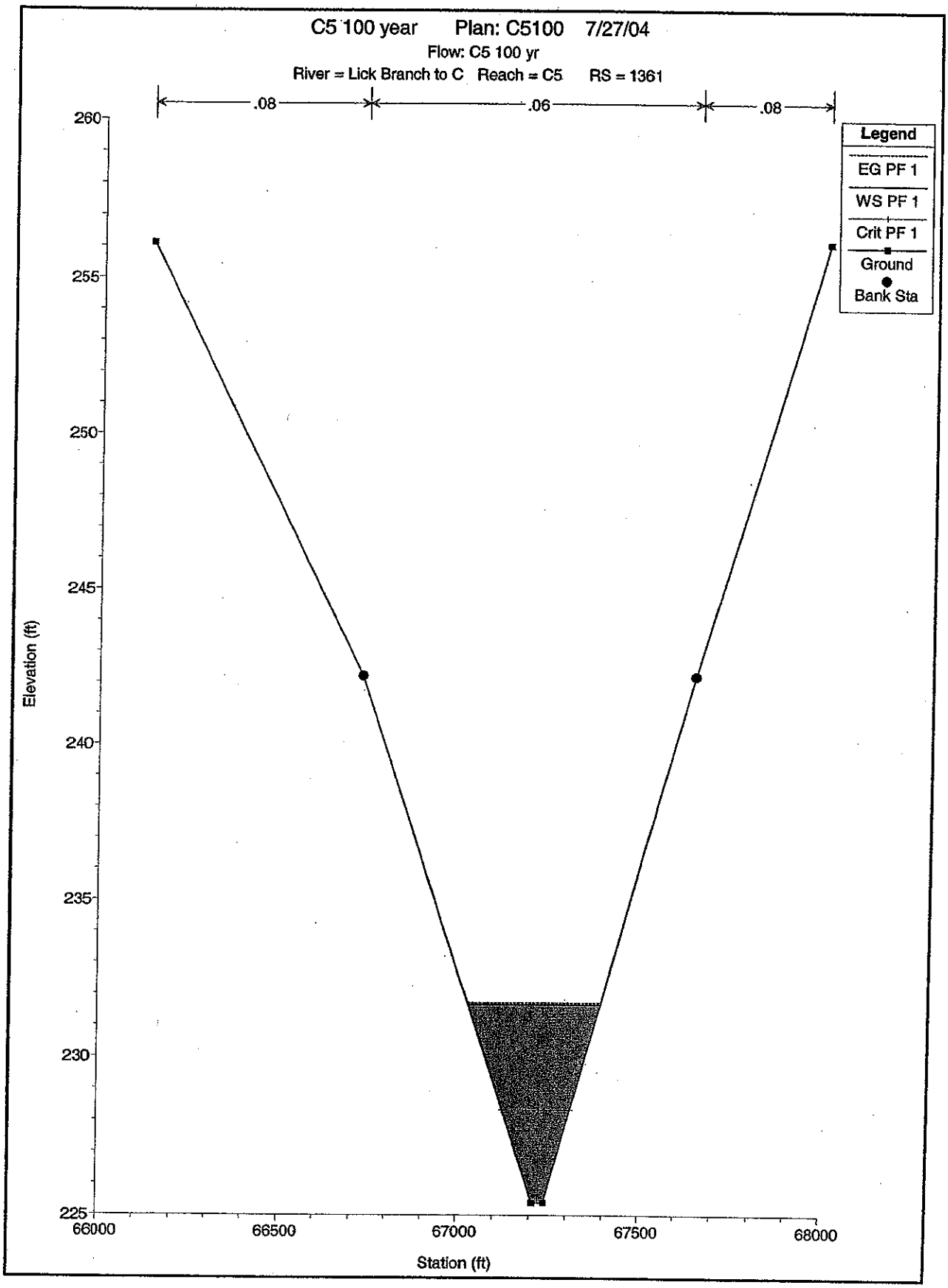

C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66200
66400
66600
66800
67000
67200
67400
67600
67800
68000
Station (ft)

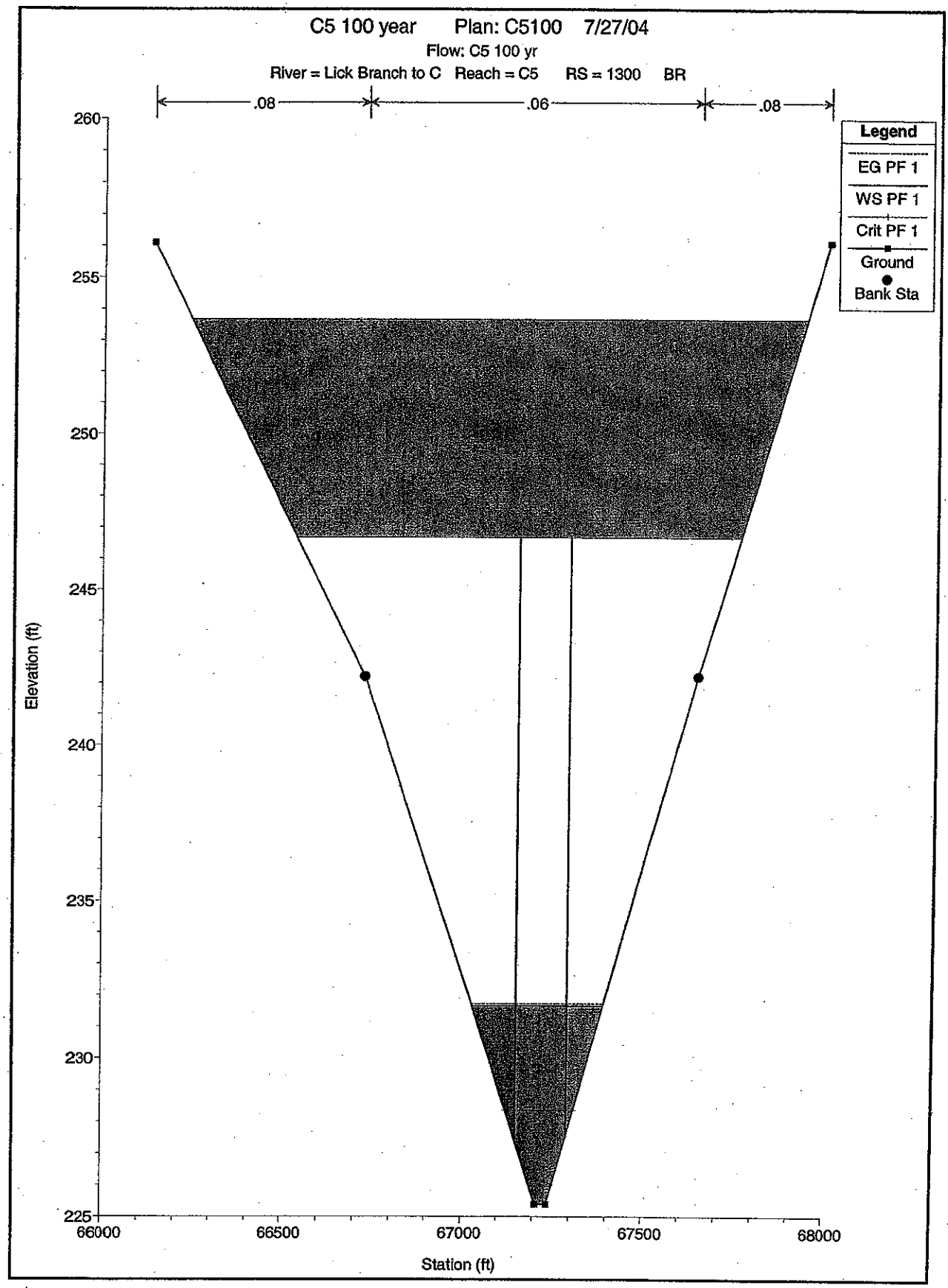
HEC-RAS Plan: C5 River: Lick Branch to C Reach: C5 Profile: PF 1

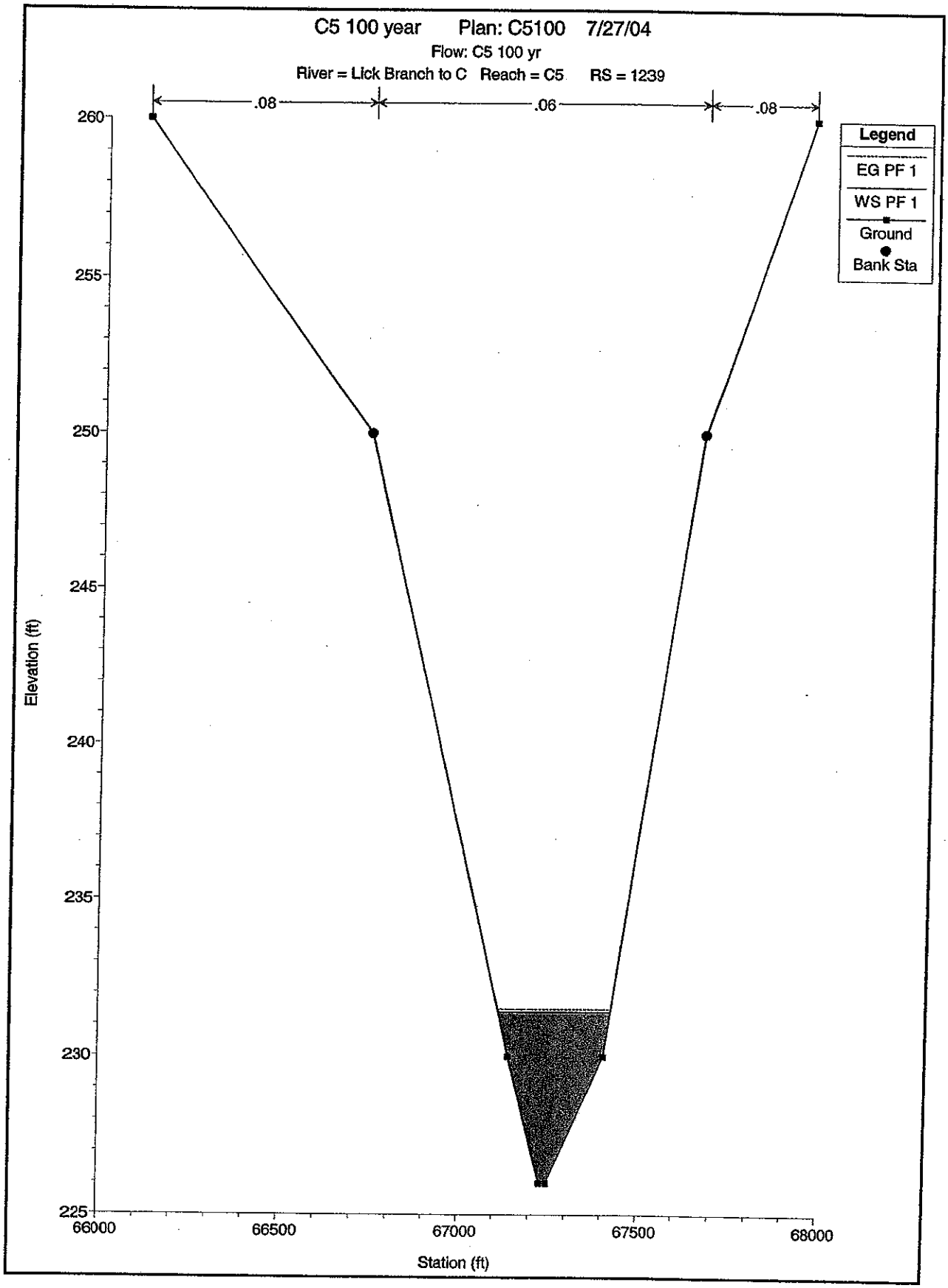
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
C5	1600	2369.00	226.00	231.91		231.98	0.001391	2.09	1132.59	332.16	0.20
C5	1400	2369.00	225.00	231.72		231.76	0.000807	1.68	1412.09	383.23	0.15
C5	1361	2369.00	225.39	231.67	228.32	231.72	0.001178	1.92	1233.04	362.66	0.18
C5	1300	Bridge									
C5	1239	2369.00	226.00	231.42		231.51	0.002099	2.43	975.42	311.24	0.24
C5	1200	2369.00	226.00	231.31		231.42	0.002533	2.70	877.90	275.30	0.27
C5	1000	2369.00	226.00	229.16	229.16	230.03	0.044766	7.48	316.59	185.40	1.01

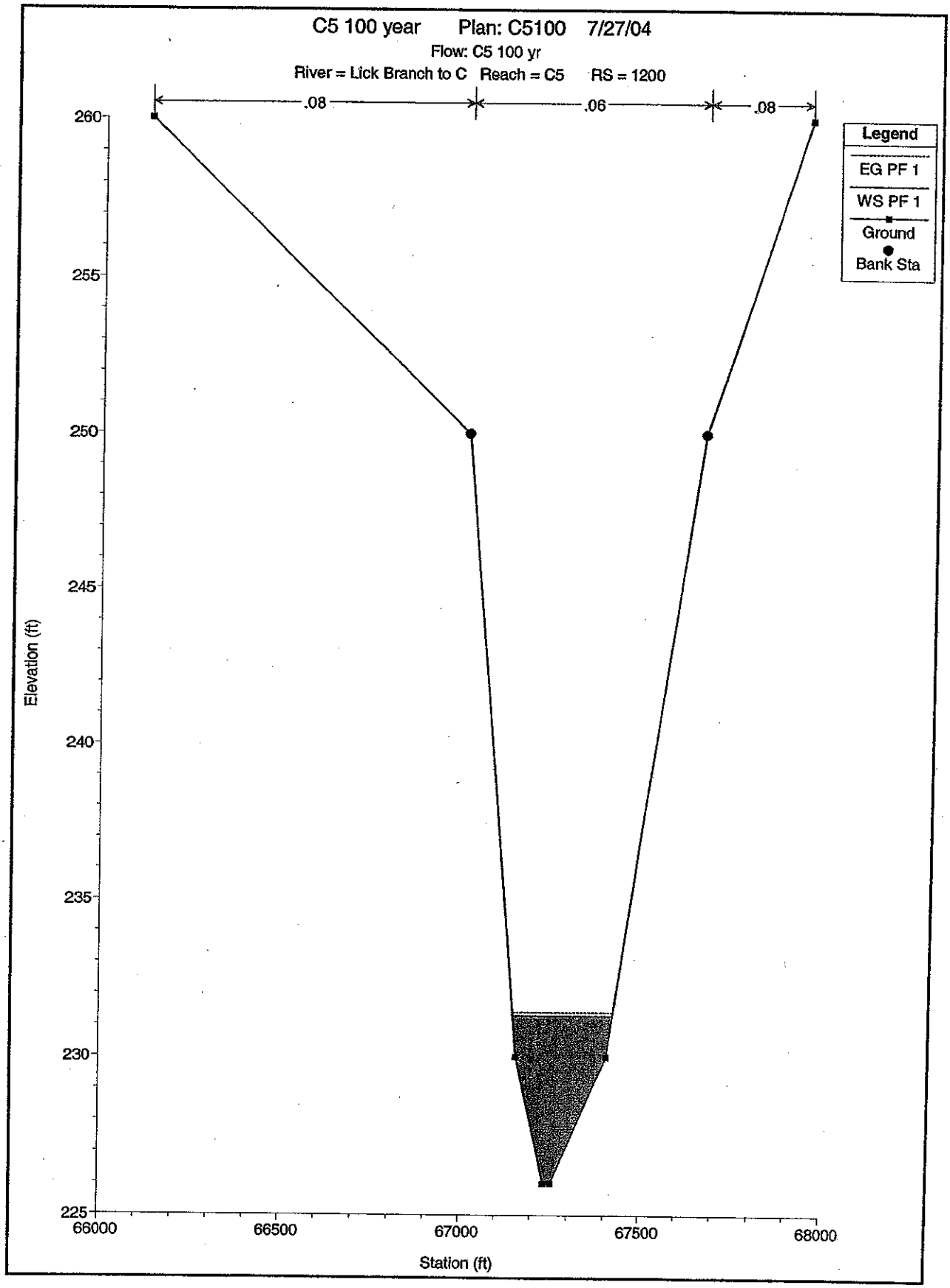

C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
68500
Station (ft)

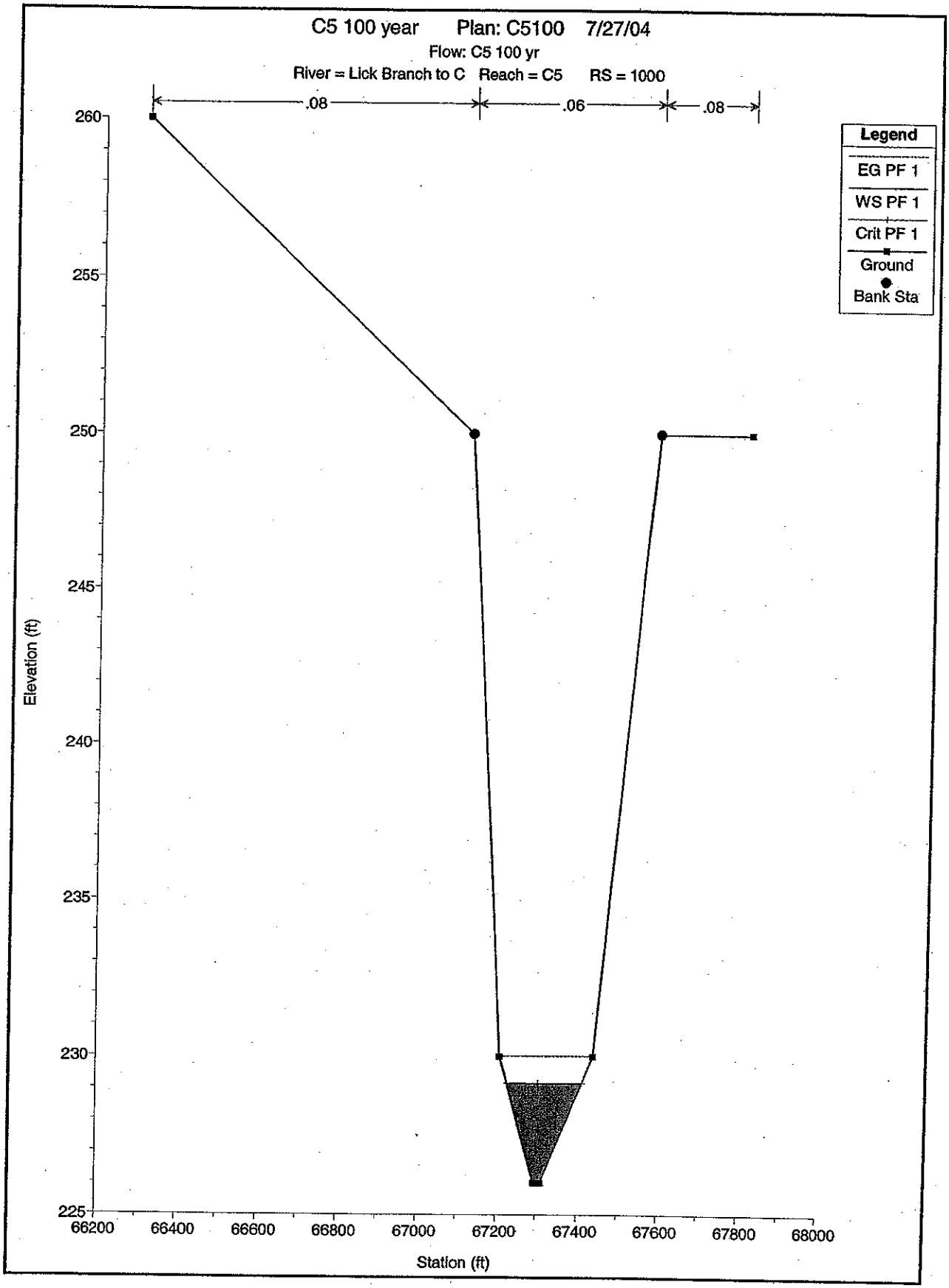

C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
68500
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66000
66500
67000
67500
68000
Station (ft)


C5 100 year Plan: C5100 7/27/04
Flow: C5 100 yr
River = Lick Branch to C Reach = C5 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
235
230
225
66200
66400
66600
66800
67000
67200
67400
67600
67800
68000
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING C6

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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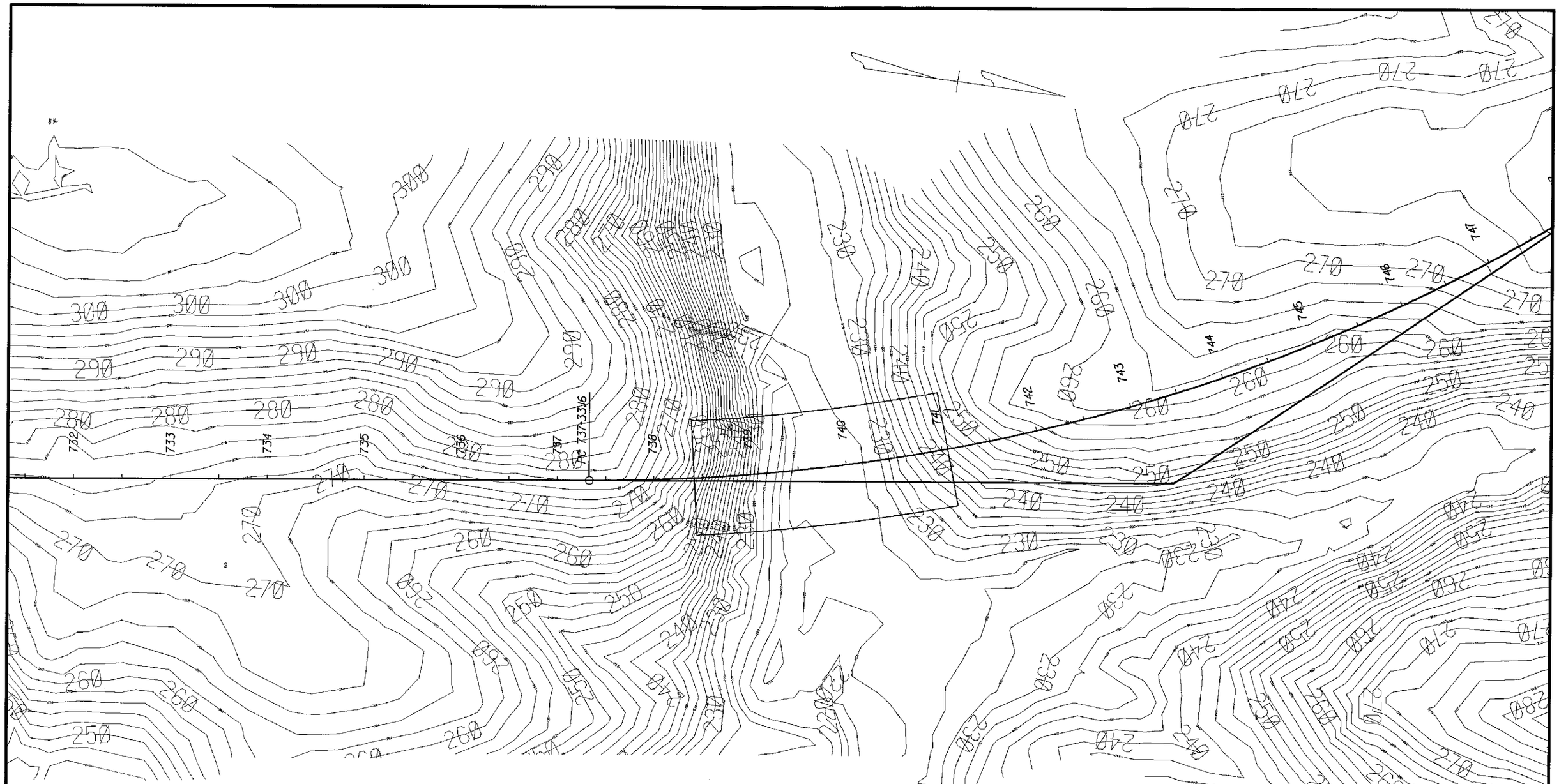


TRI COUNTY PARKWAY
Crossing C6

July 2004

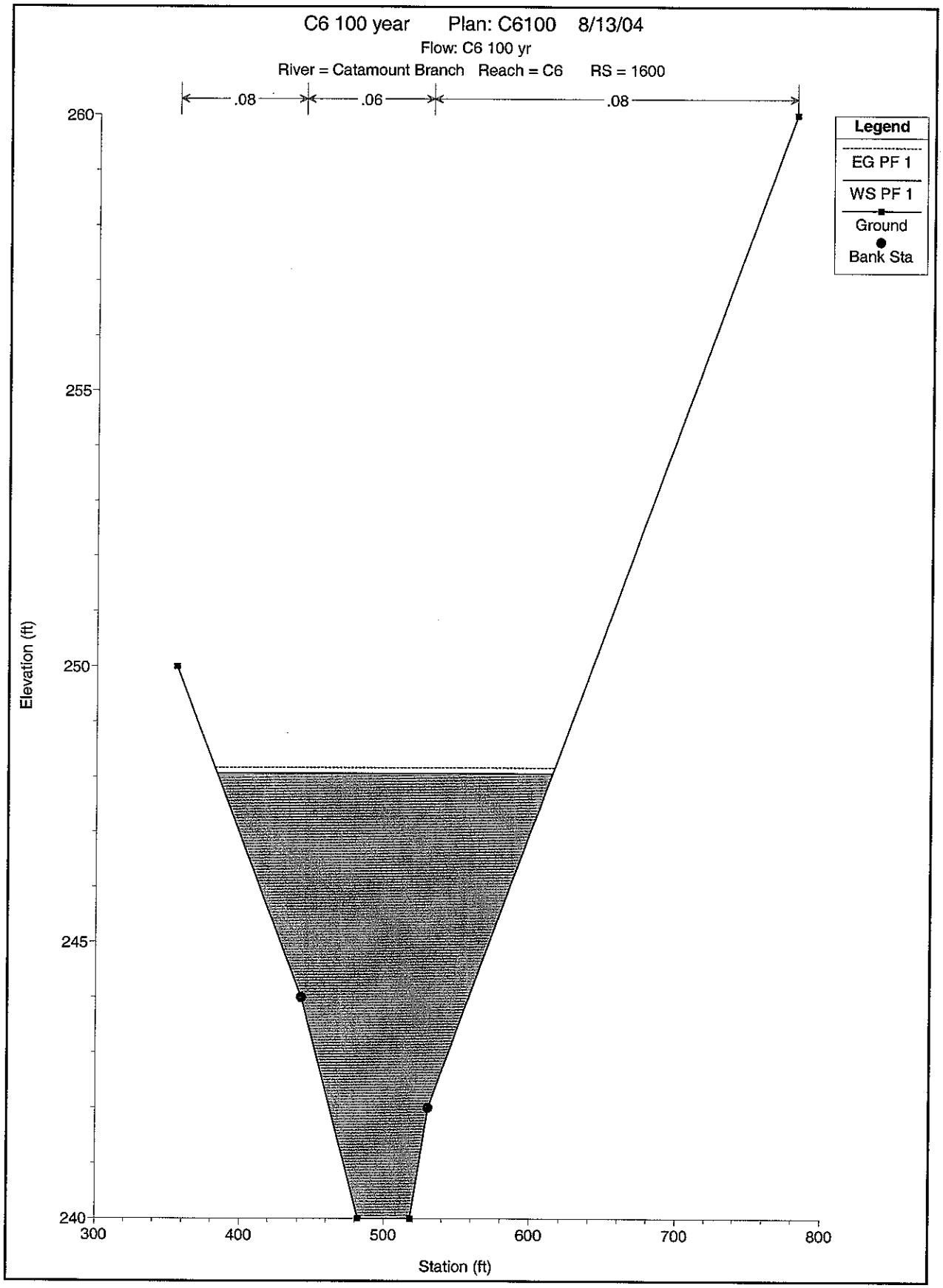
SCALE

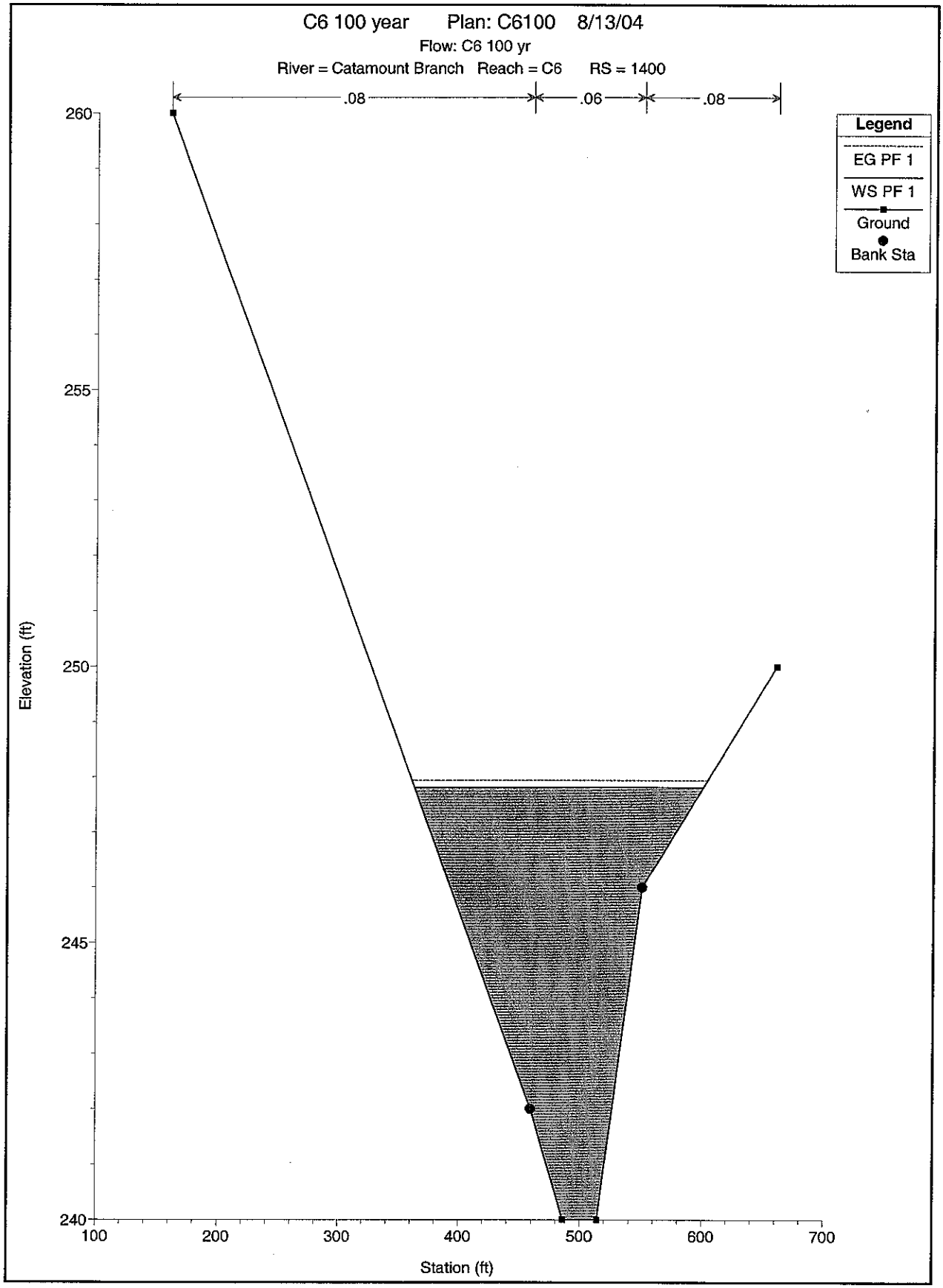
0 100' 200'

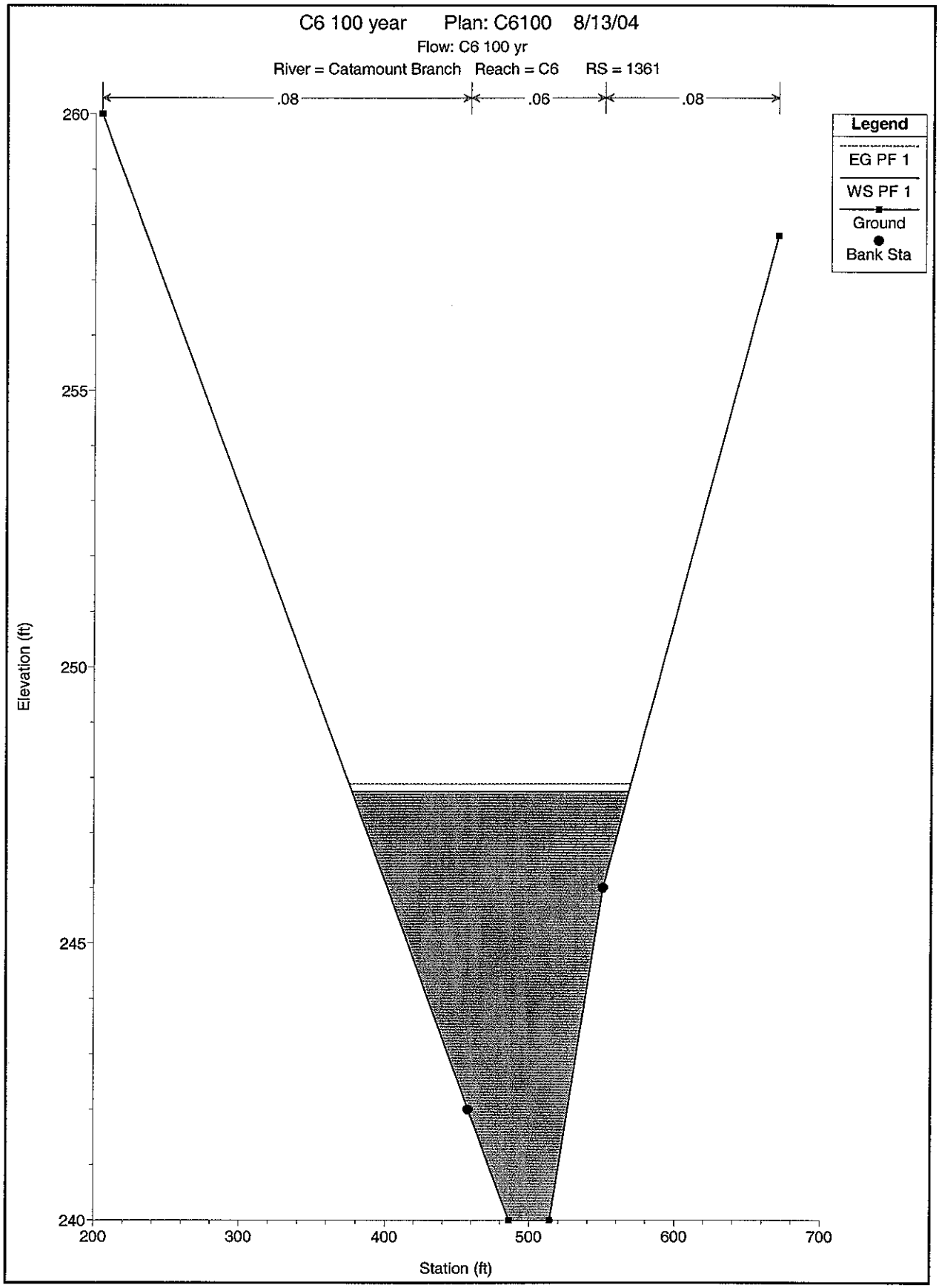
7/27/2004 9:05:12 AM G:\PLOTTING\QUEUES\xes 8825.qcf M:\CD_C6.USF

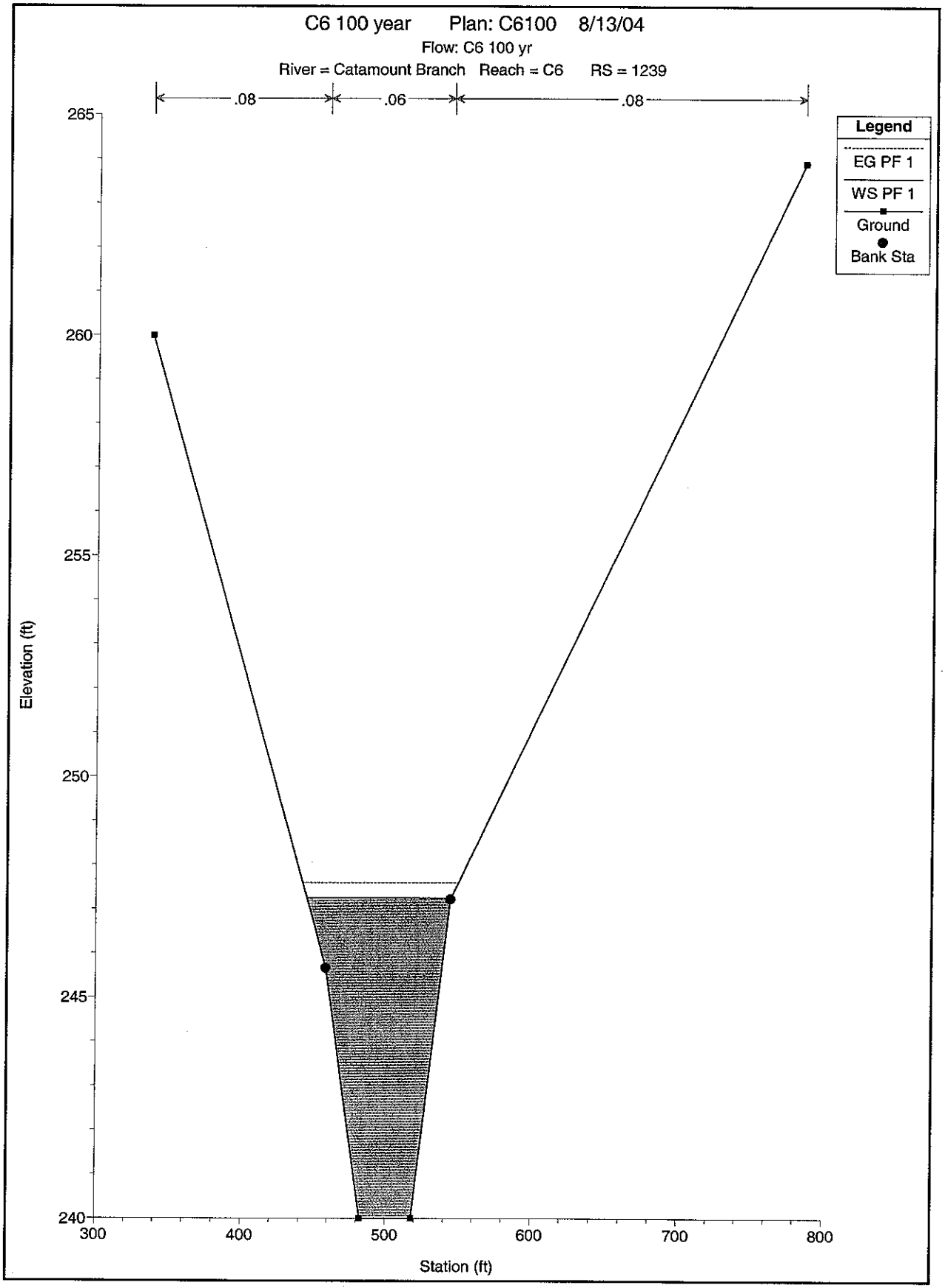
HEC-RAS Plan: C6 River: Catamount Branch Reach: C6 Profile: PF 1

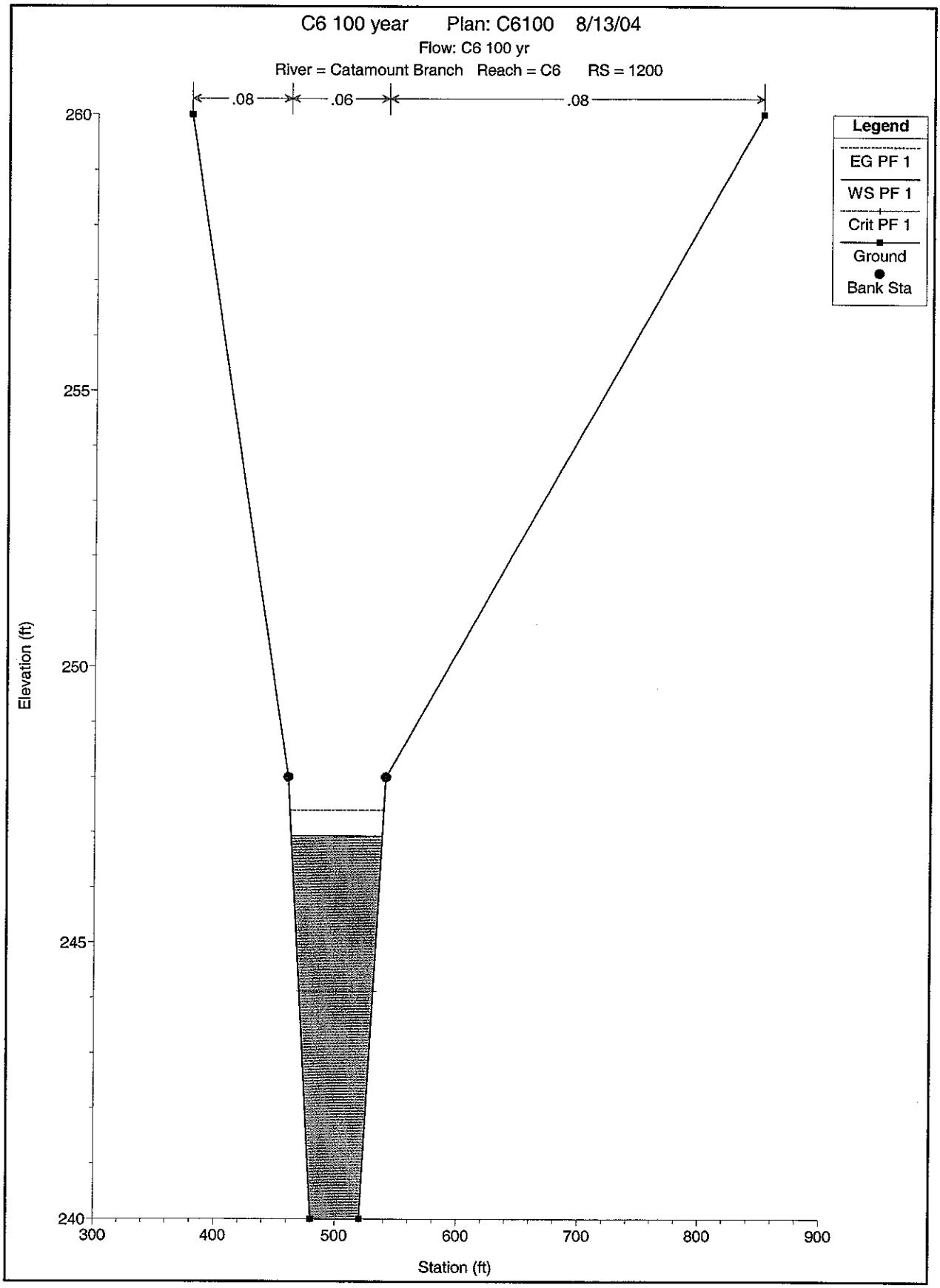
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
C6	1600	2180.00	240.00	248.07		248.17	0.000986	2.84	993.26	231.21	0.19
C6	1400	2180.00	240.00	247.82		247.94	0.001314	3.06	903.52	237.73	0.21
C6	1361	2180.00	240.00	247.75		247.89	0.001425	3.17	829.35	191.25	0.22
C6	1239	2180.00	240.00	247.25		247.59	0.003997	4.73	469.56	99.69	0.36
C6	1200	2180.00	240.00	246.93	244.12	247.40	0.005528	5.48	397.52	74.67	0.42
C6	1000	2180.00	240.00	243.71	243.71	244.98	0.039385	9.05	240.86	95.92	1.01

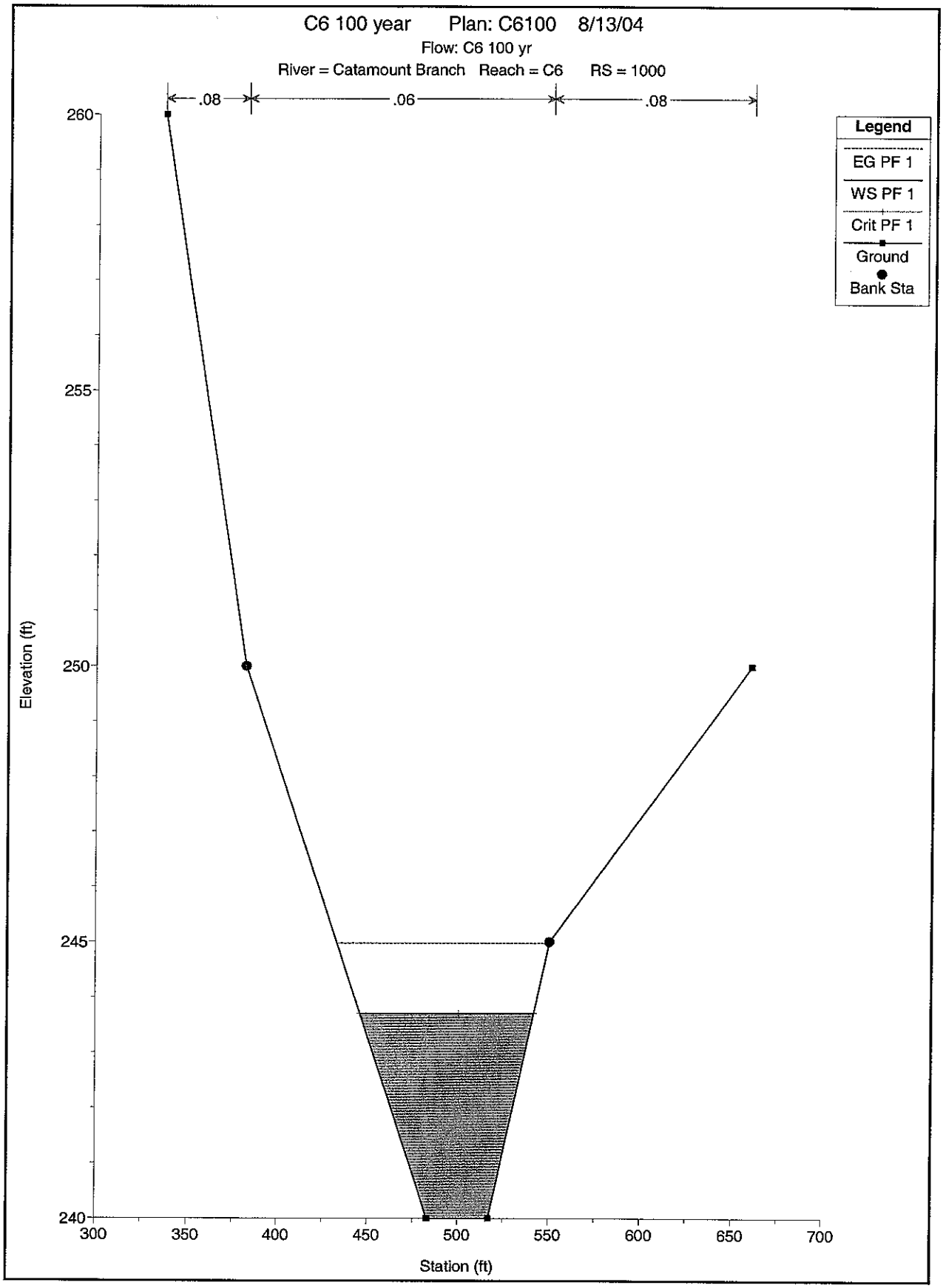

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
300
400
500
600
700
800
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
200
300
400
500
600
700
Station (ft)

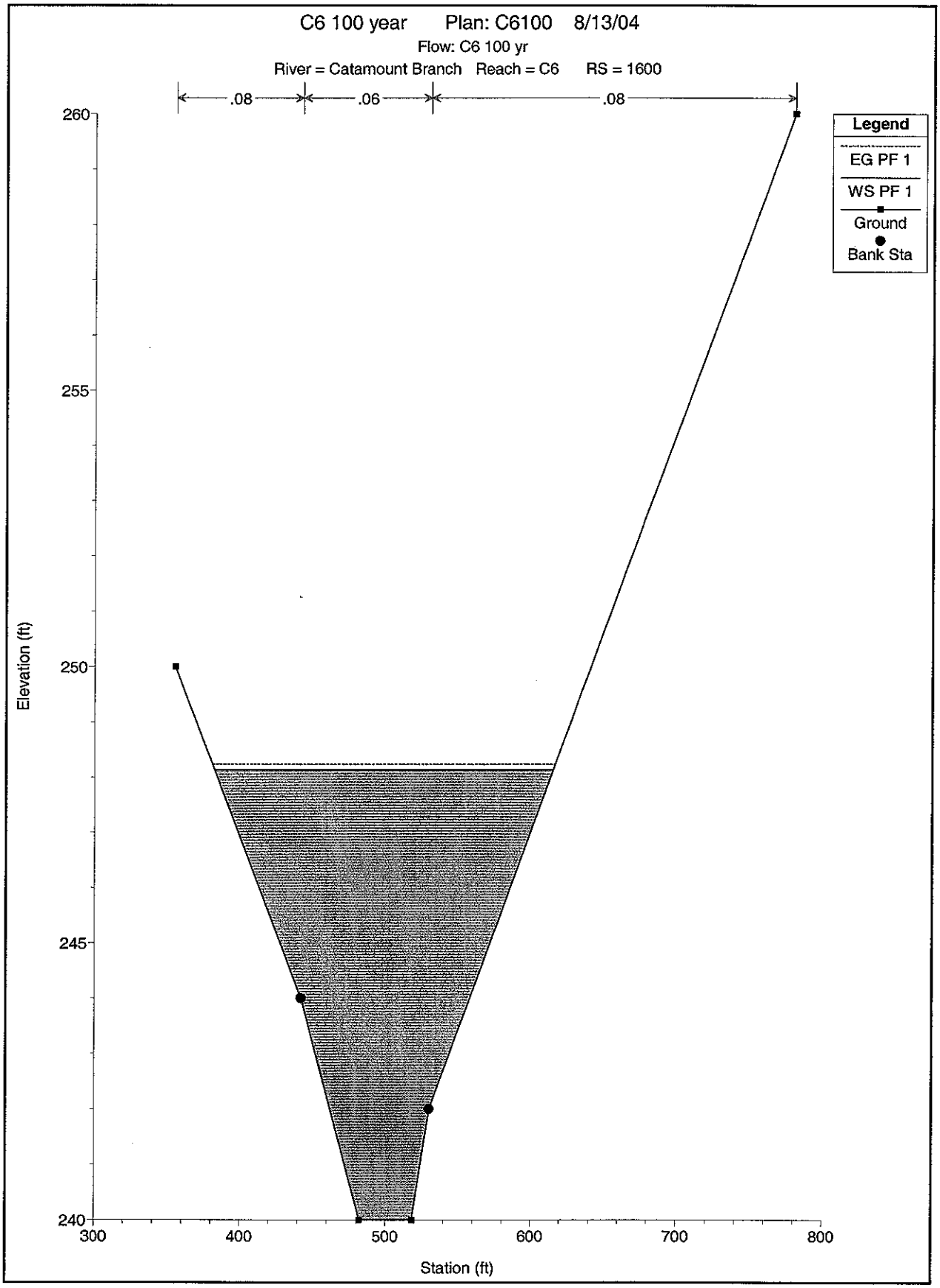

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
265
260
255
250
245
240
300
400
500
600
700
800
Station (ft)

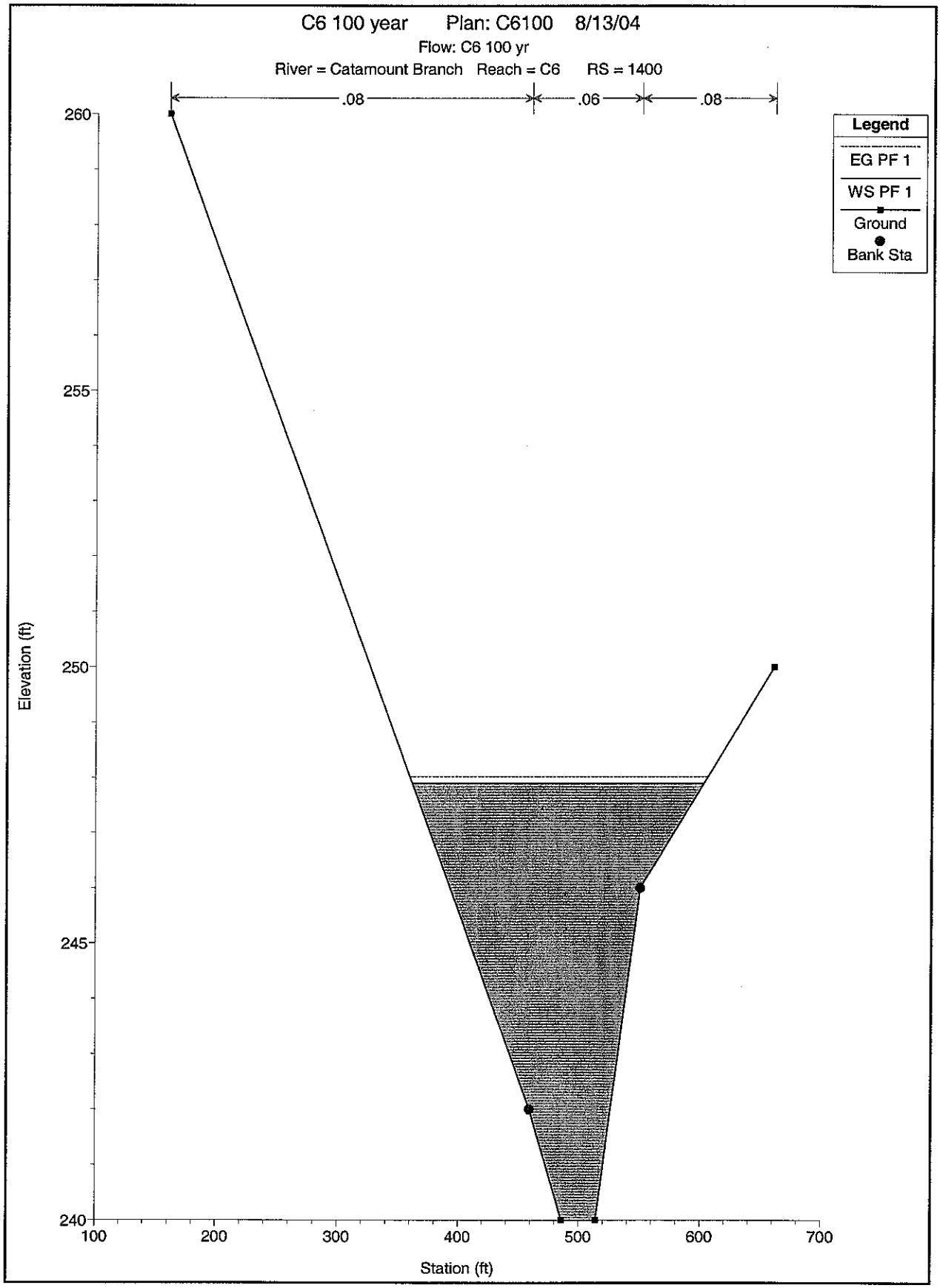

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
300
400
500
600
700
800
900
Station (ft)

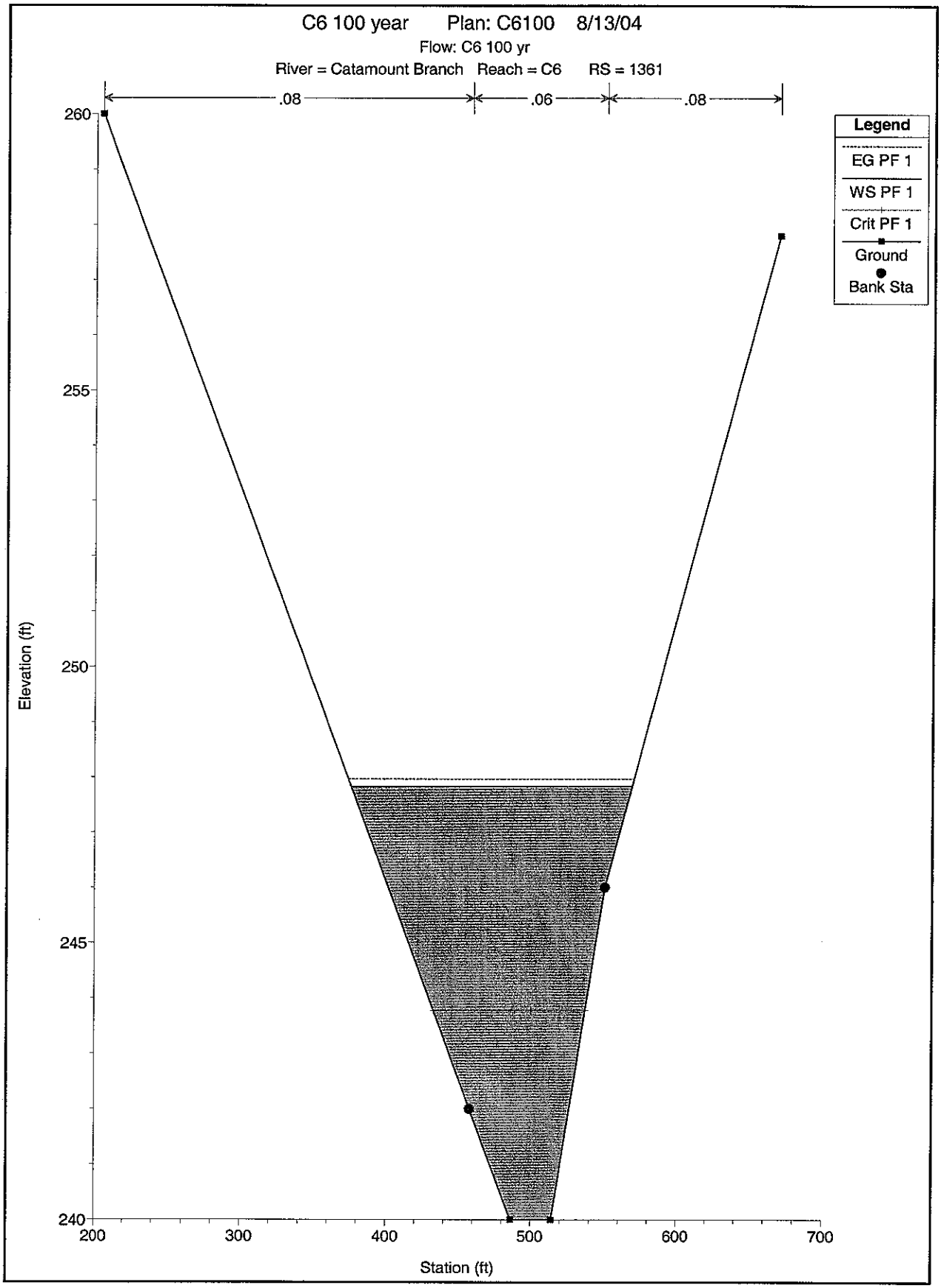

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
300
350
400
450
500
550
600
650
700
Station (ft)

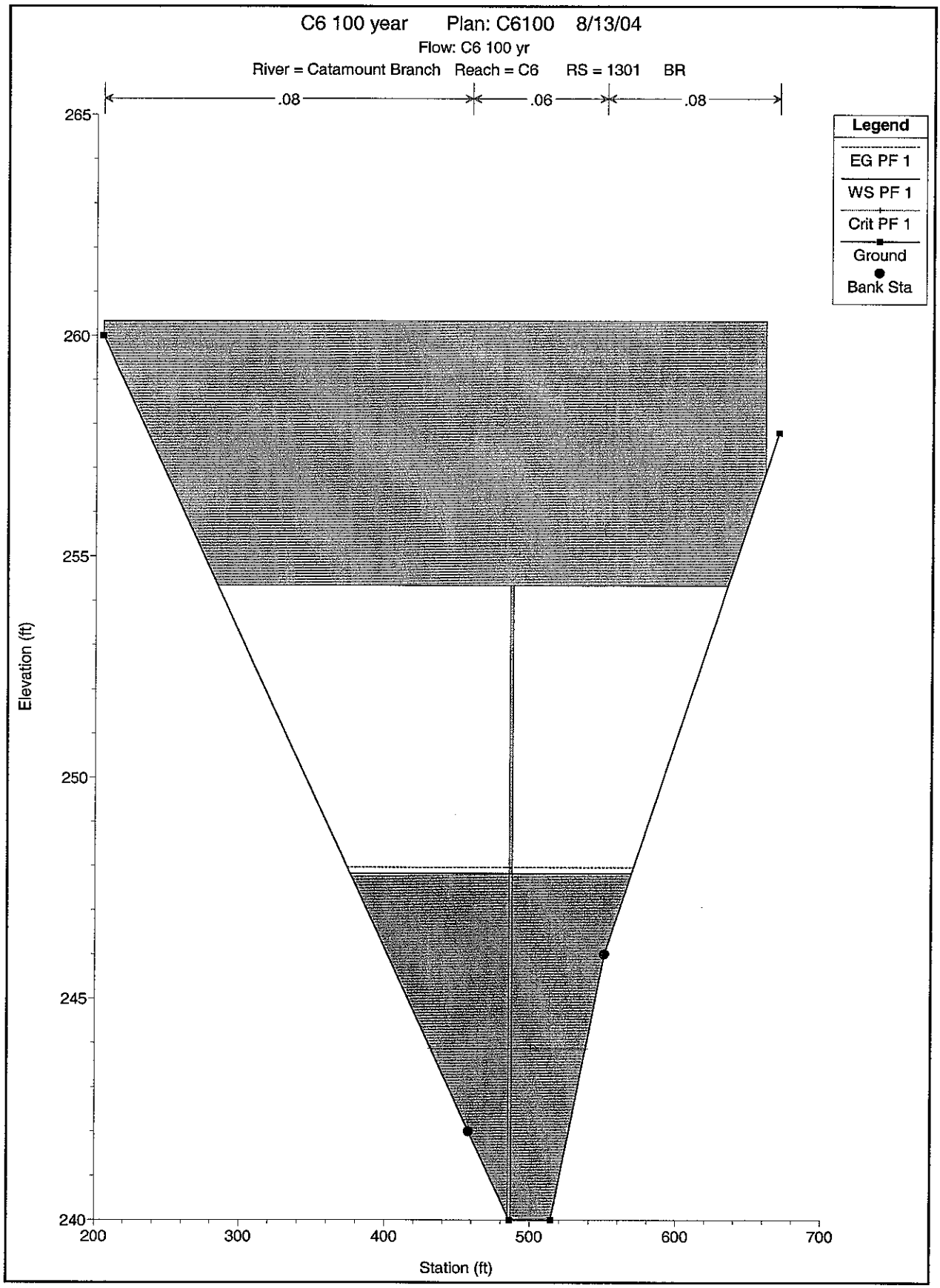
HEC-RAS Plan: C6 River: Catamount Branch Reach: C6 Profile: PF 1

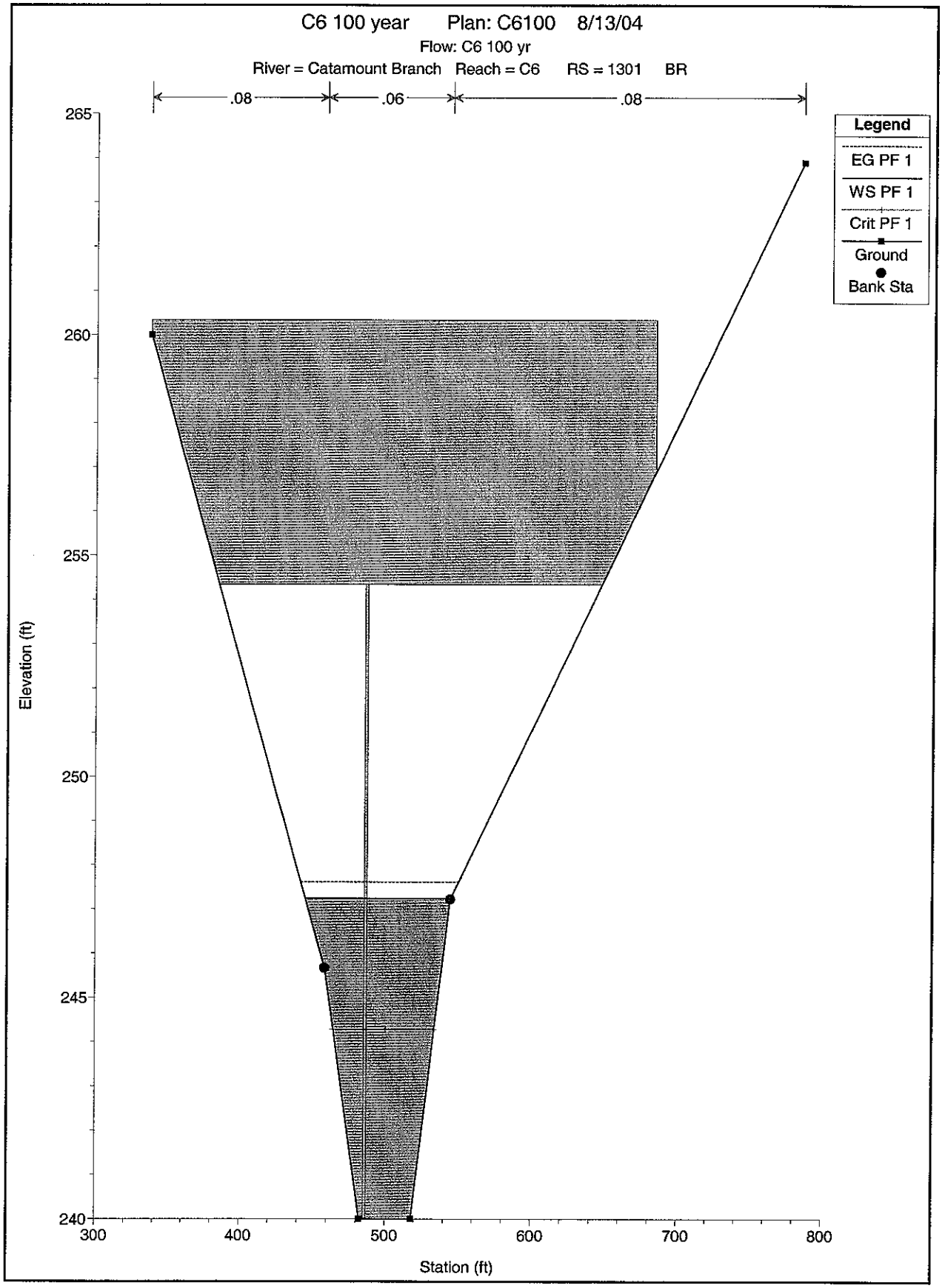
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
C6	1600	2180.00	240.00	248.13		248.24	0.000948	2.81	1009.04	233.14	0.19
C6	1400	2180.00	240.00	247.90		248.02	0.001251	3.01	922.48	241.22	0.21
C6	1361	2180.00	240.00	247.83	243.78	247.97	0.001356	3.12	845.22	193.24	0.22
C6	1301	Bridge									
C6	1239	2180.00	240.00	247.25		247.59	0.003997	4.73	469.56	99.69	0.36
C6	1200	2180.00	240.00	246.93	244.12	247.40	0.005528	5.48	397.52	74.67	0.42
C6	1000	2180.00	240.00	243.71	243.71	244.98	0.039385	9.05	240.86	95.92	1.01

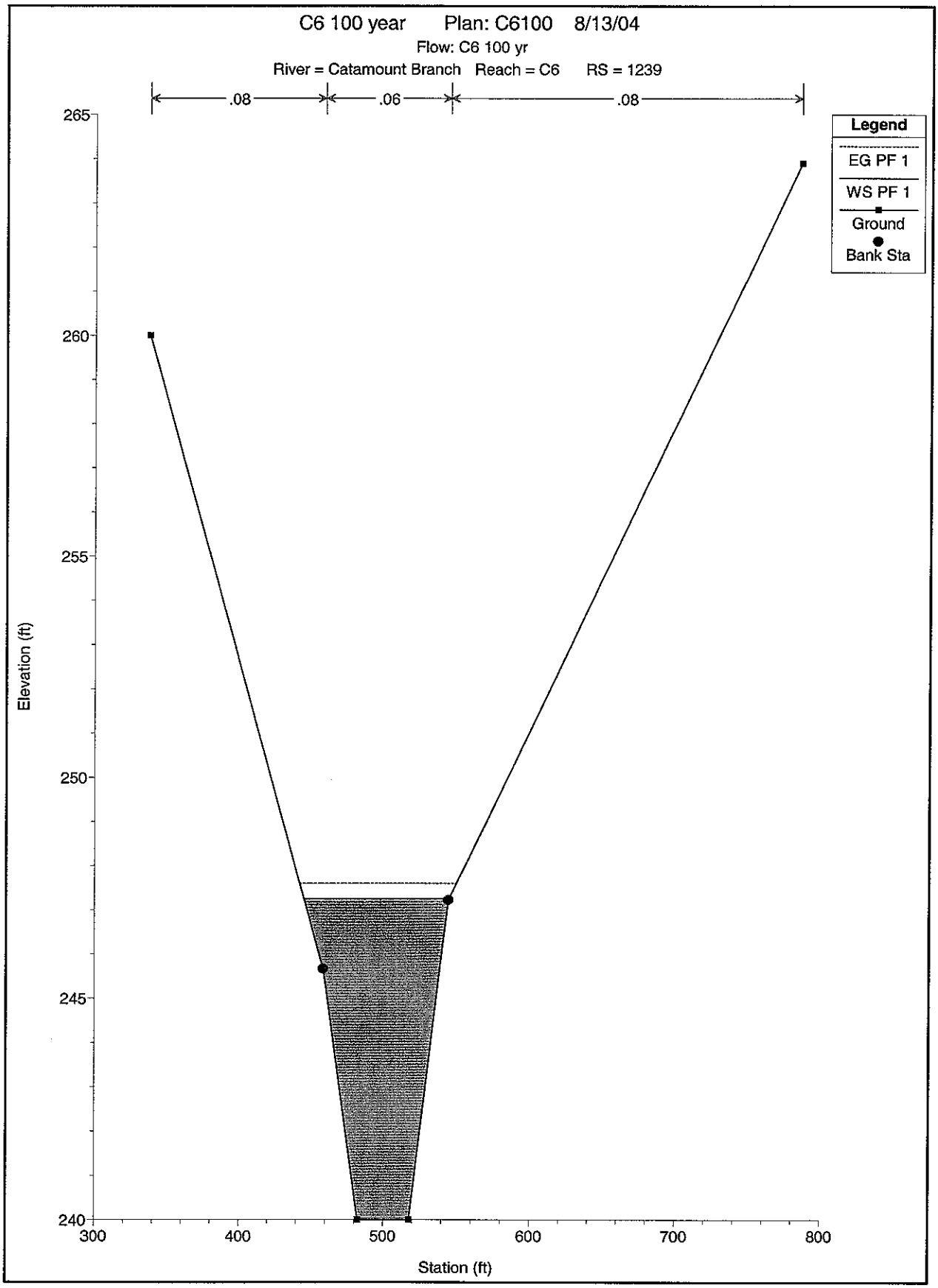

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
300
400
500
600
700
800
Station (ft)

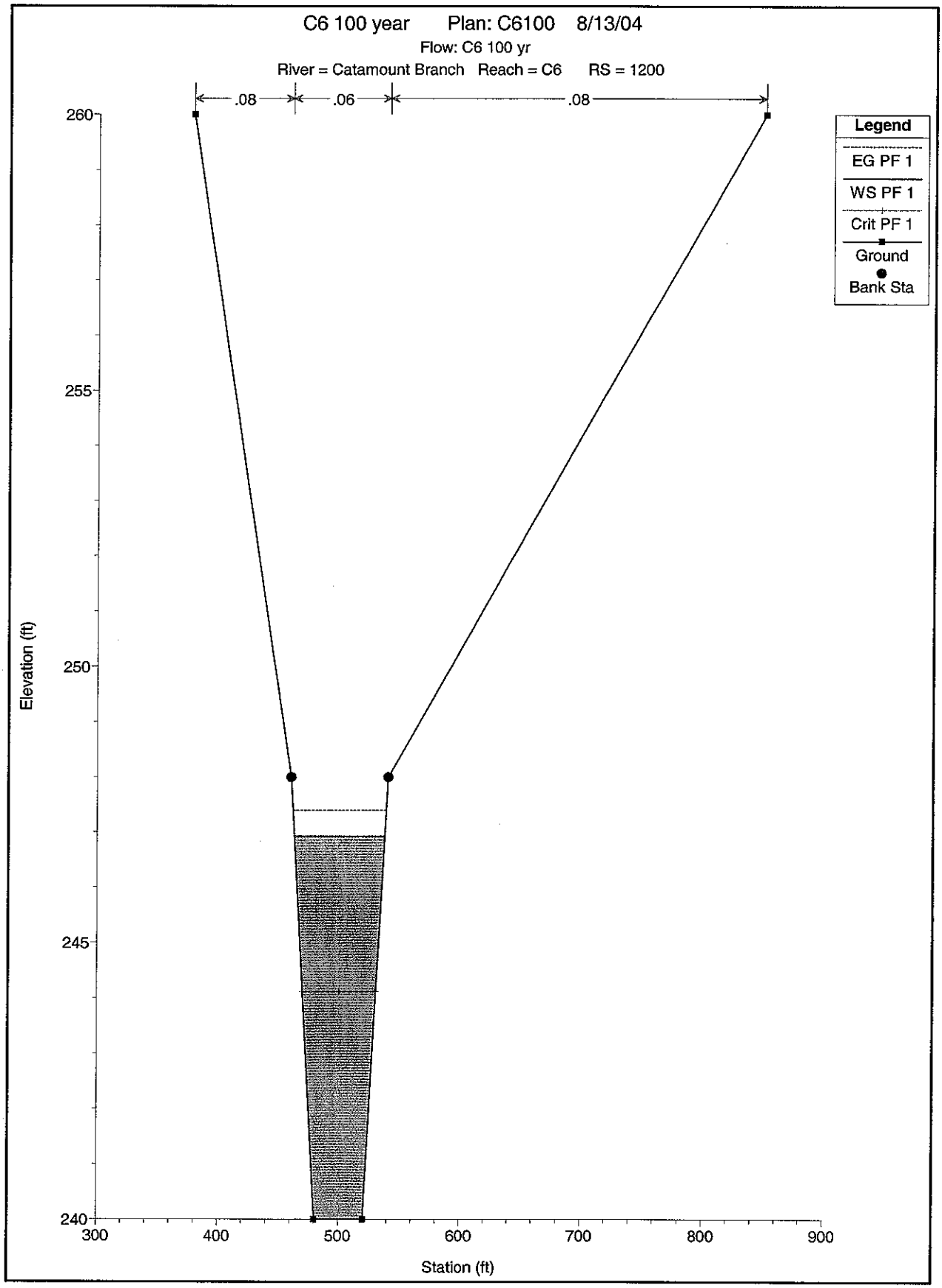

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
100
200
300
400
500
600
700
Station (ft)

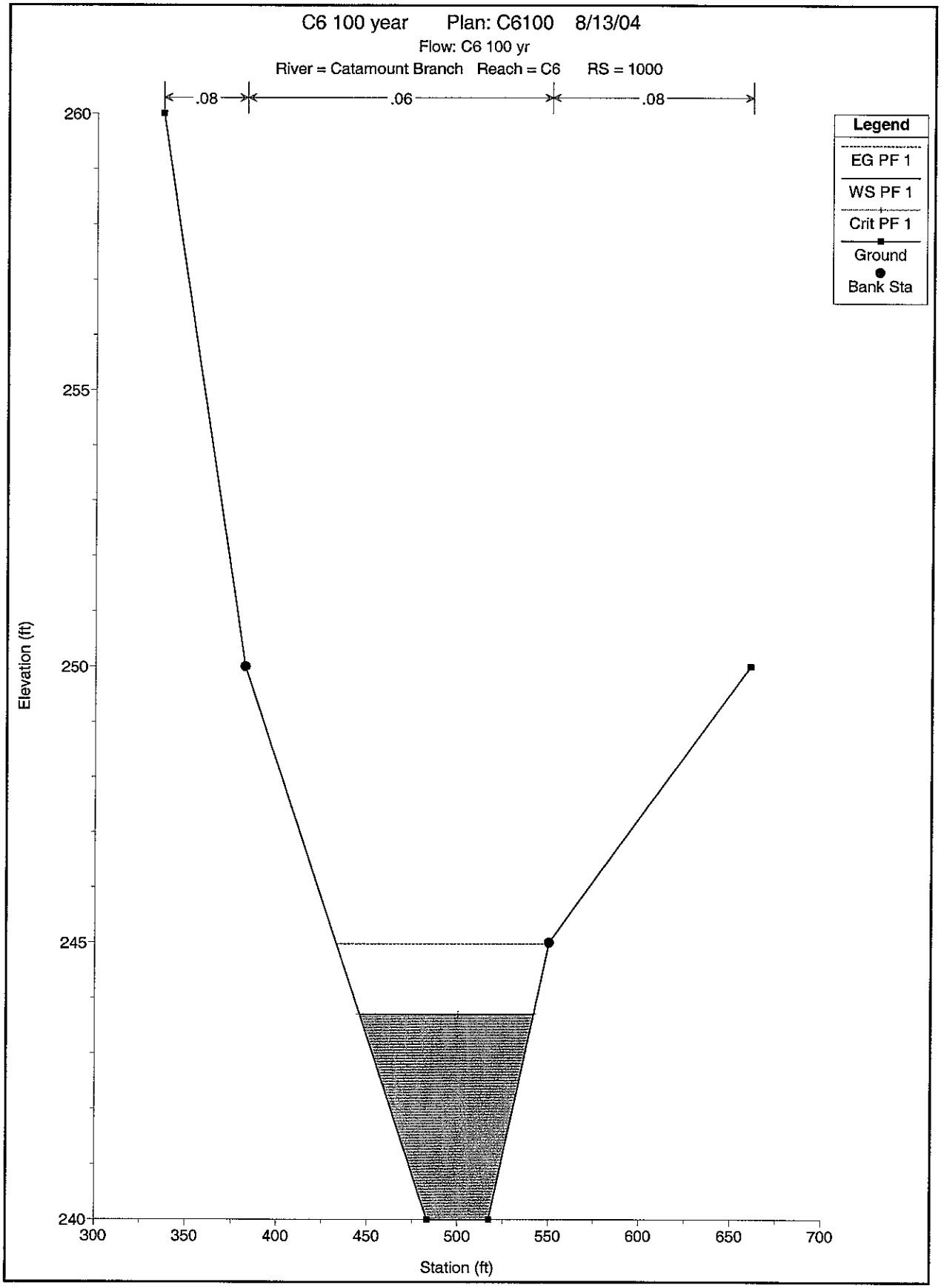

C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
200
300
400
500
600
700
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1301 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
265
260
255
250
245
240
Elevation (ft)
200
300
400
500
600
700
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1301 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
265
260
255
250
245
240
300
400
500
600
700
800
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
265
260
255
250
245
240
300
400
500
600
700
800
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
300
400
500
600
700
800
900
Station (ft)


C6 100 year Plan: C6100 8/13/04
Flow: C6 100 yr
River = Catamount Branch Reach = C6 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
260
255
250
245
240
300
350
400
450
500
550
600
650
700
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING D2

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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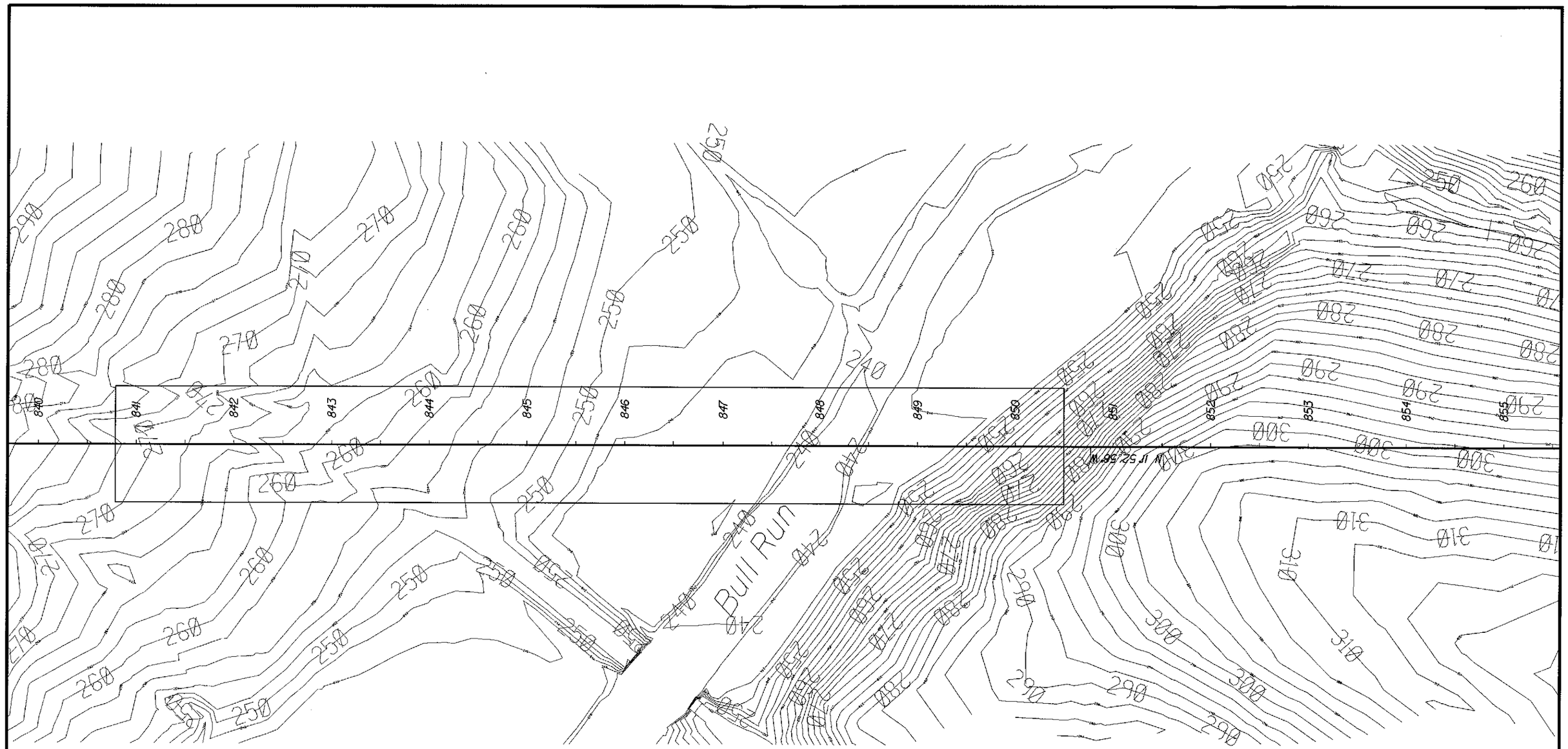


TRI COUNTY PARKWAY
Crossing D2

July 2004

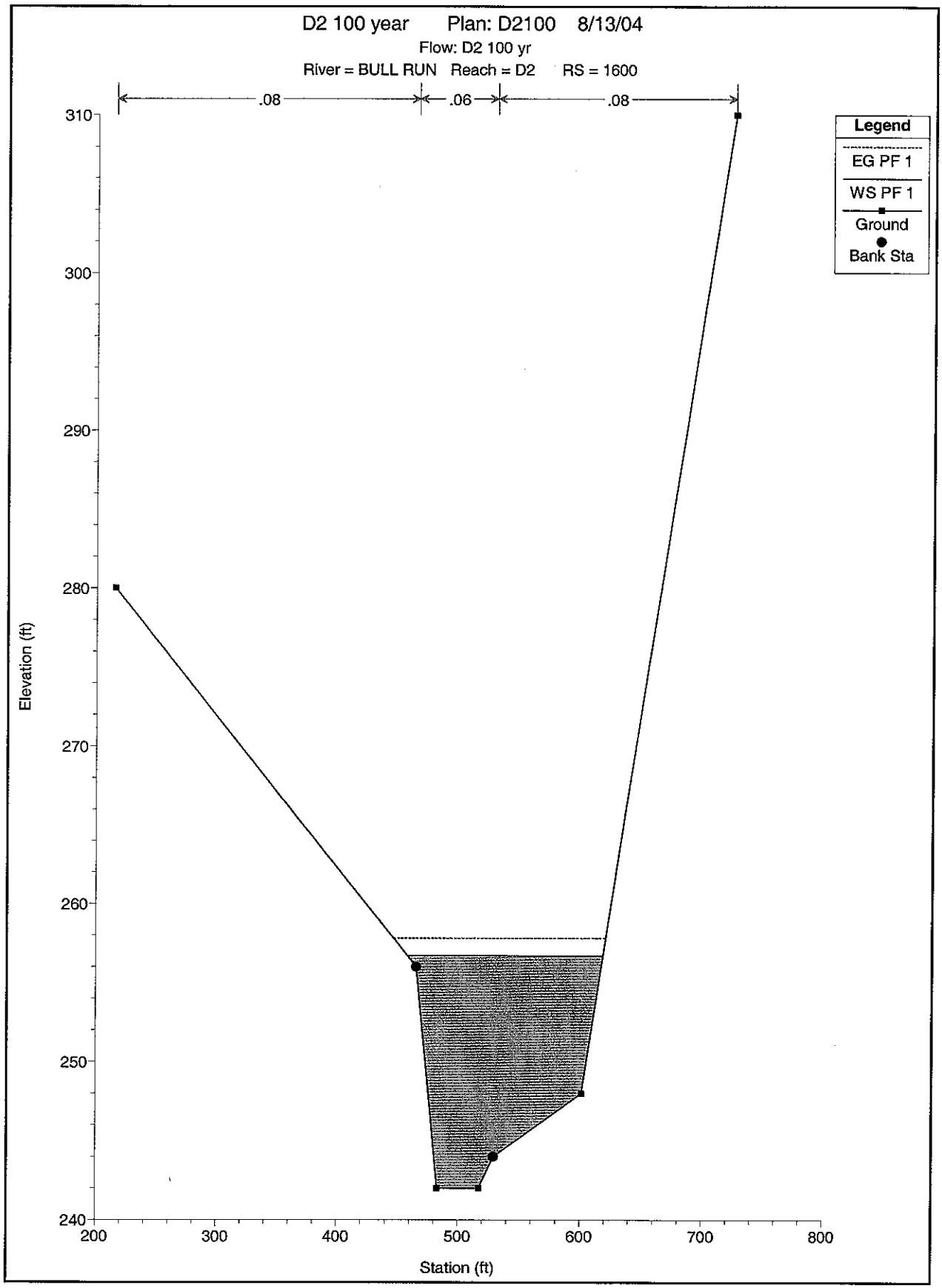
SCALE

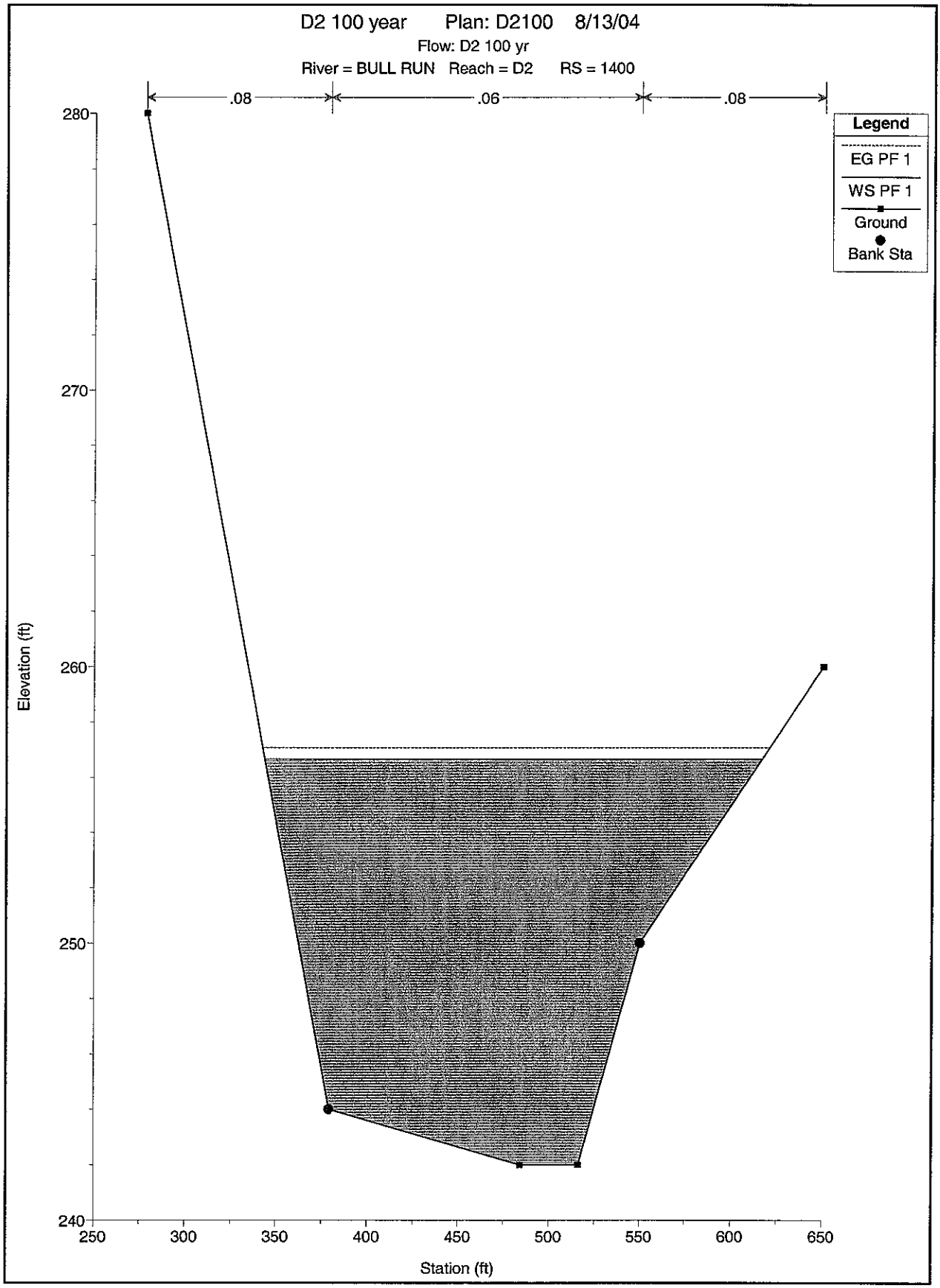
0 100' 200'

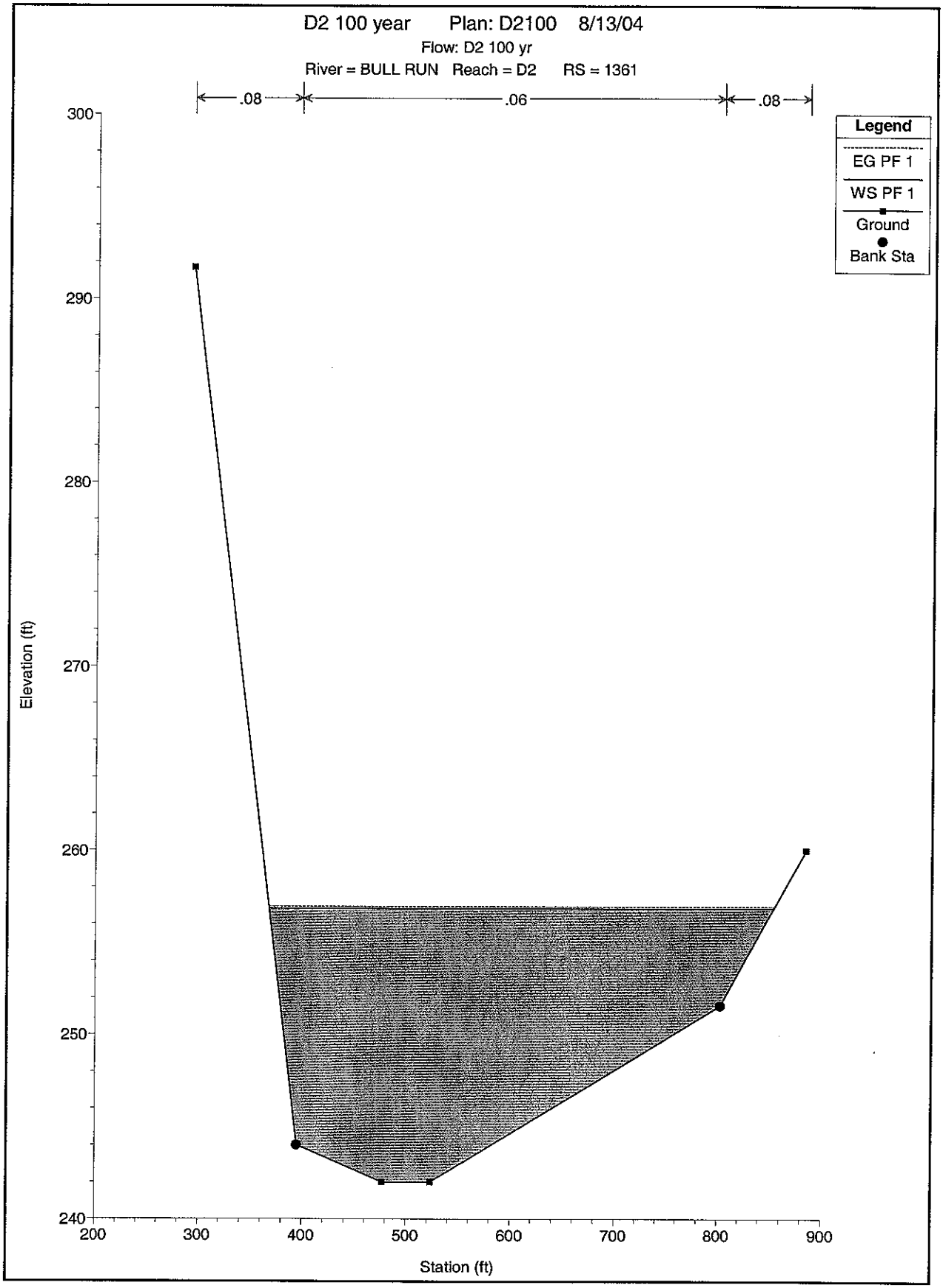
7/27/2004 9:09:18 AM O:\PLOTTING\QUEUES\xes 8825.qef M:\CD_D2.USF

HEC-RAS Plan: D2 River: BULL RUN Reach: D2 Profile: PF 1

Reach	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)	
D2	1600	13000.00	242.00	256.71		257.81	0.005746	9.65	1652.47	160.77	0.48
D2	1400	13000.00	242.00	256.66		257.08	0.001497	5.35	2712.49	273.12	0.26
D2	1361	13000.00	242.00	256.84		256.96	0.000477	2.73	4943.77	486.42	0.14
D2	1239	13000.00	242.00	256.65		256.87	0.000838	3.95	3860.14	423.88	0.19
D2	1200	13000.00	242.00	256.23		256.79	0.002113	6.55	2505.26	264.47	0.31
D2	1000	13000.00	242.00	255.19	250.33	256.18	0.004006	8.61	1874.03	209.18	0.42


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
310
300
290
280
270
260
250
240
200
300
400
500
600
700
800
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
250
300
350
400
450
500
550
600
650
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
300
290
280
270
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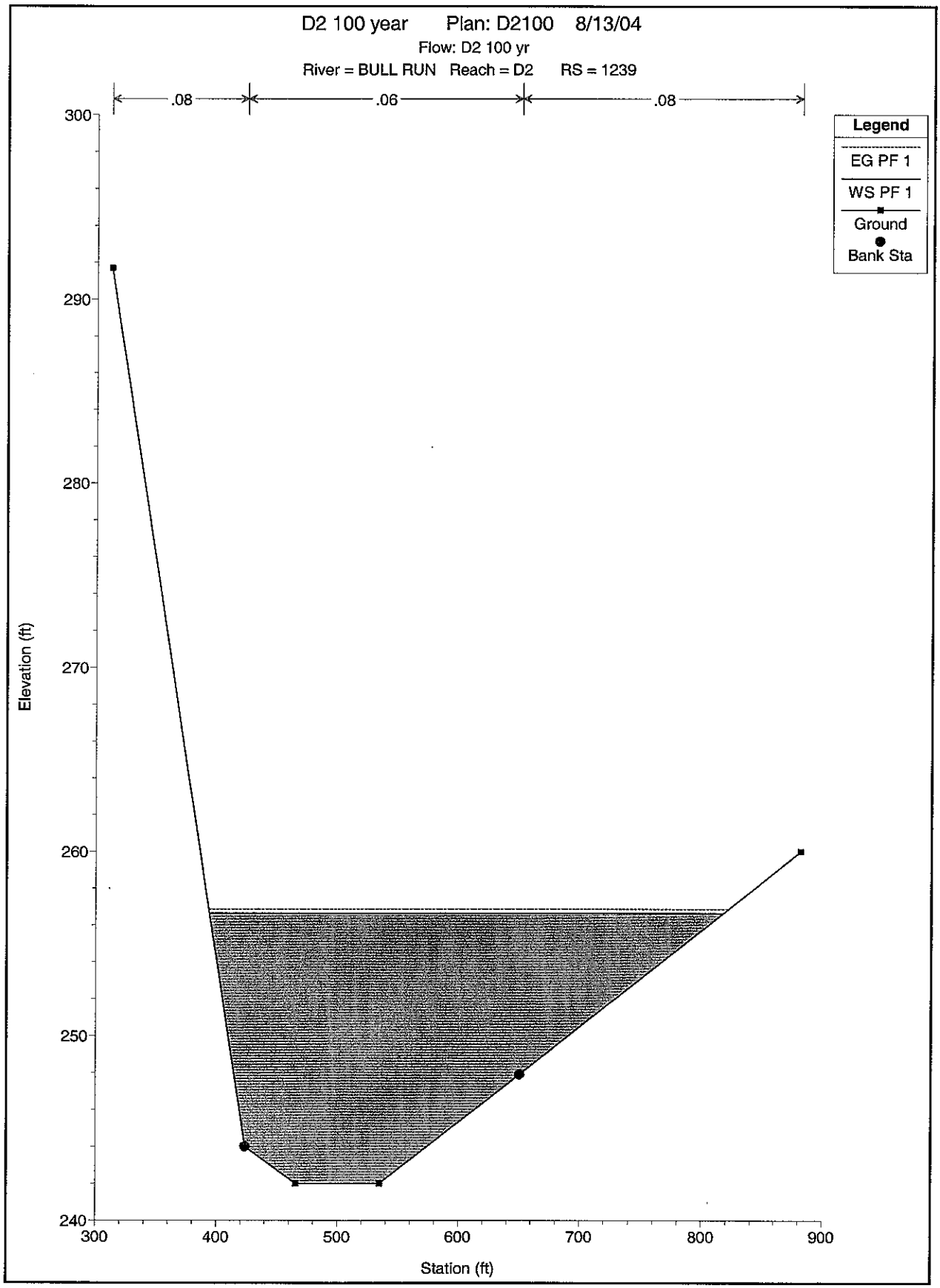
200
300
400
500
600
700
800
900
Station (ft)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Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1239
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.06
.08
Legend
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WS PF 1
Ground
Bank Sta
Elevation (ft)
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290
280
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700
800
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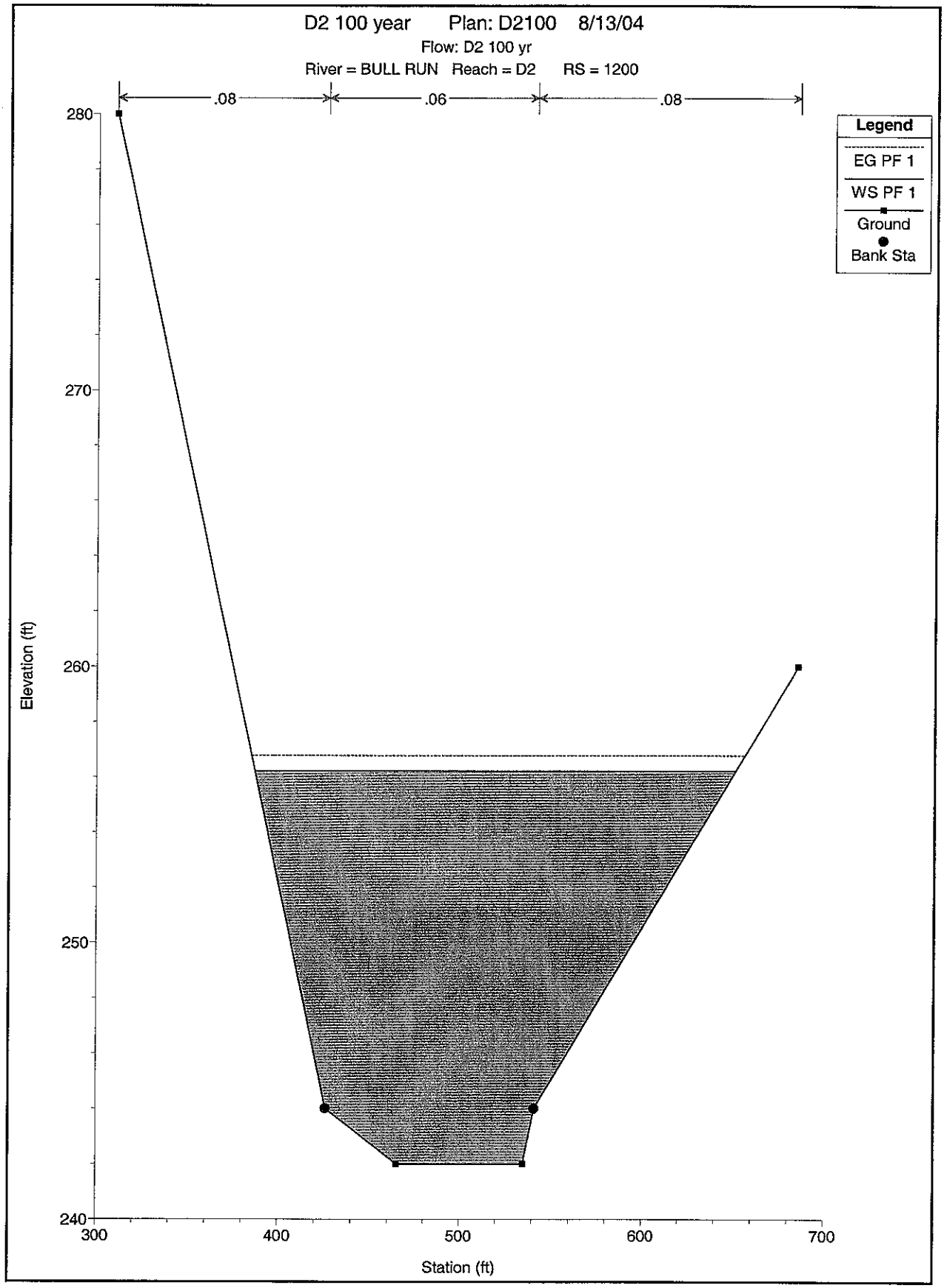
Station (ft)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Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1200
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.06
.08
Legend
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WS PF 1
Ground
Bank Sta
Elevation (ft)
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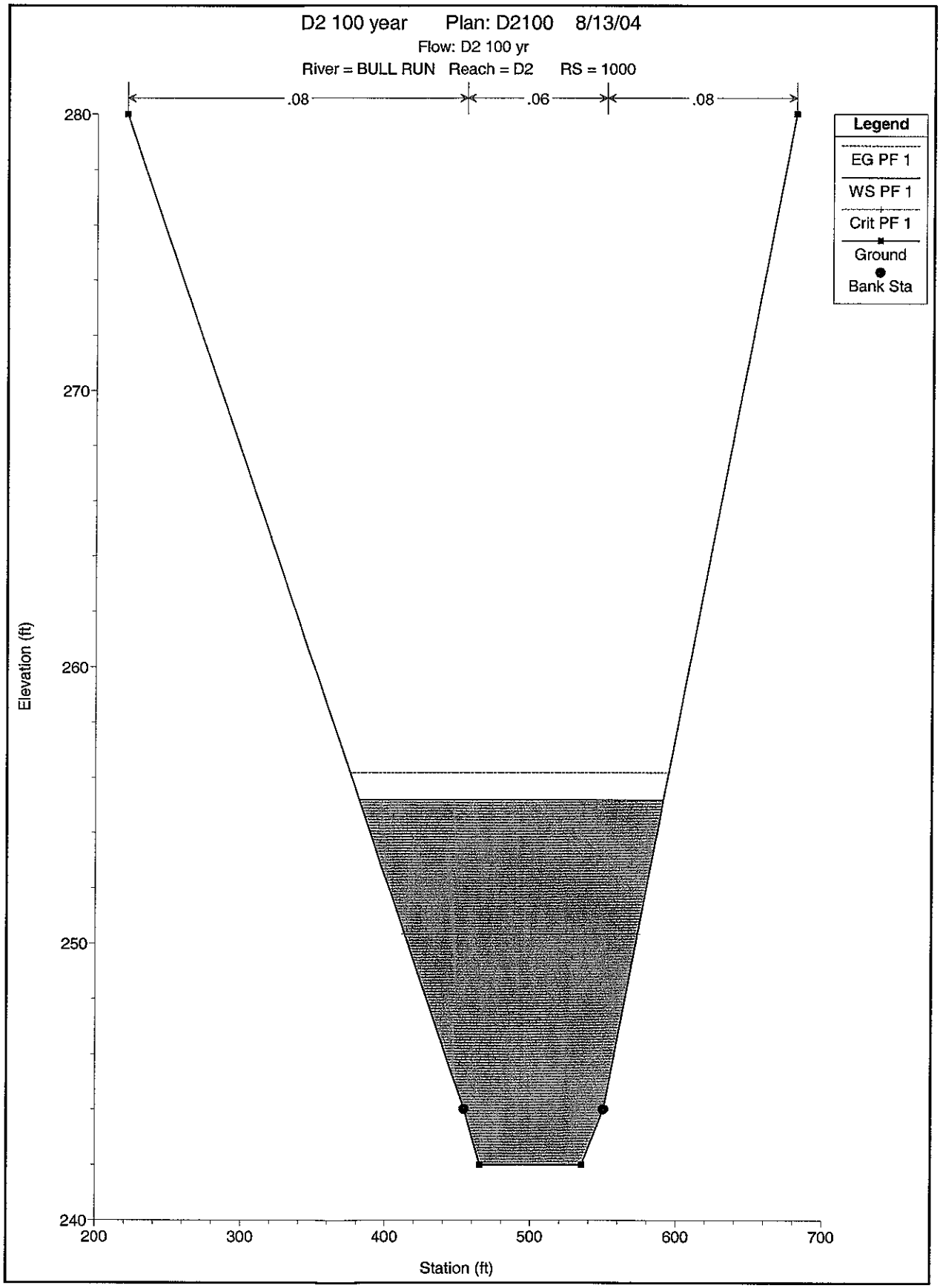
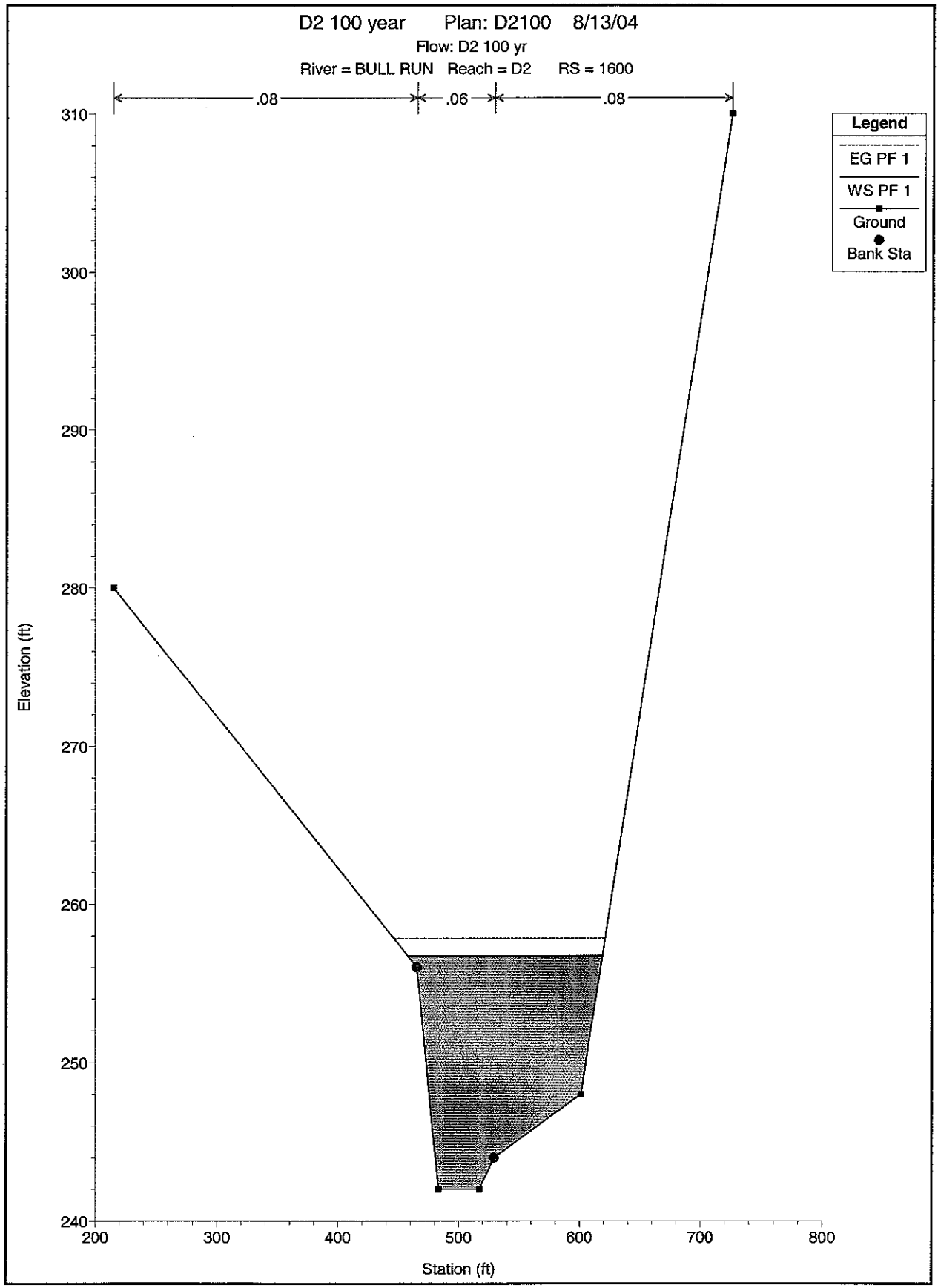
270
260
250
240
300
400
500
600
700
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
200
300
400
500
600
700
Station (ft)

HEC-RAS Plan: D2 River: BULL RUN Reach: D2 Profile: PF 1

Reach	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)	
D2	1600	13000.00	242.00	256.73		257.83	0.005708	9.62	1656.19	161.06	0.48
D2	1400	13000.00	242.00	256.68		257.10	0.001487	5.34	2719.22	273.43	0.26
D2	1361	13000.00	242.00	256.87	247.82	256.98	0.000474	2.73	4955.39	486.70	0.14
D2	1300	Bridge									
D2	1239	13000.00	242.00	256.65		256.87	0.000838	3.95	3860.14	423.88	0.19
D2	1200	13000.00	242.00	256.23		256.79	0.002113	6.55	2505.26	264.47	0.31
D2	1000	13000.00	242.00	255.19	250.33	256.18	0.004006	8.61	1874.03	209.18	0.42


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1600
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.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
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300
290
280
270
260
250
240
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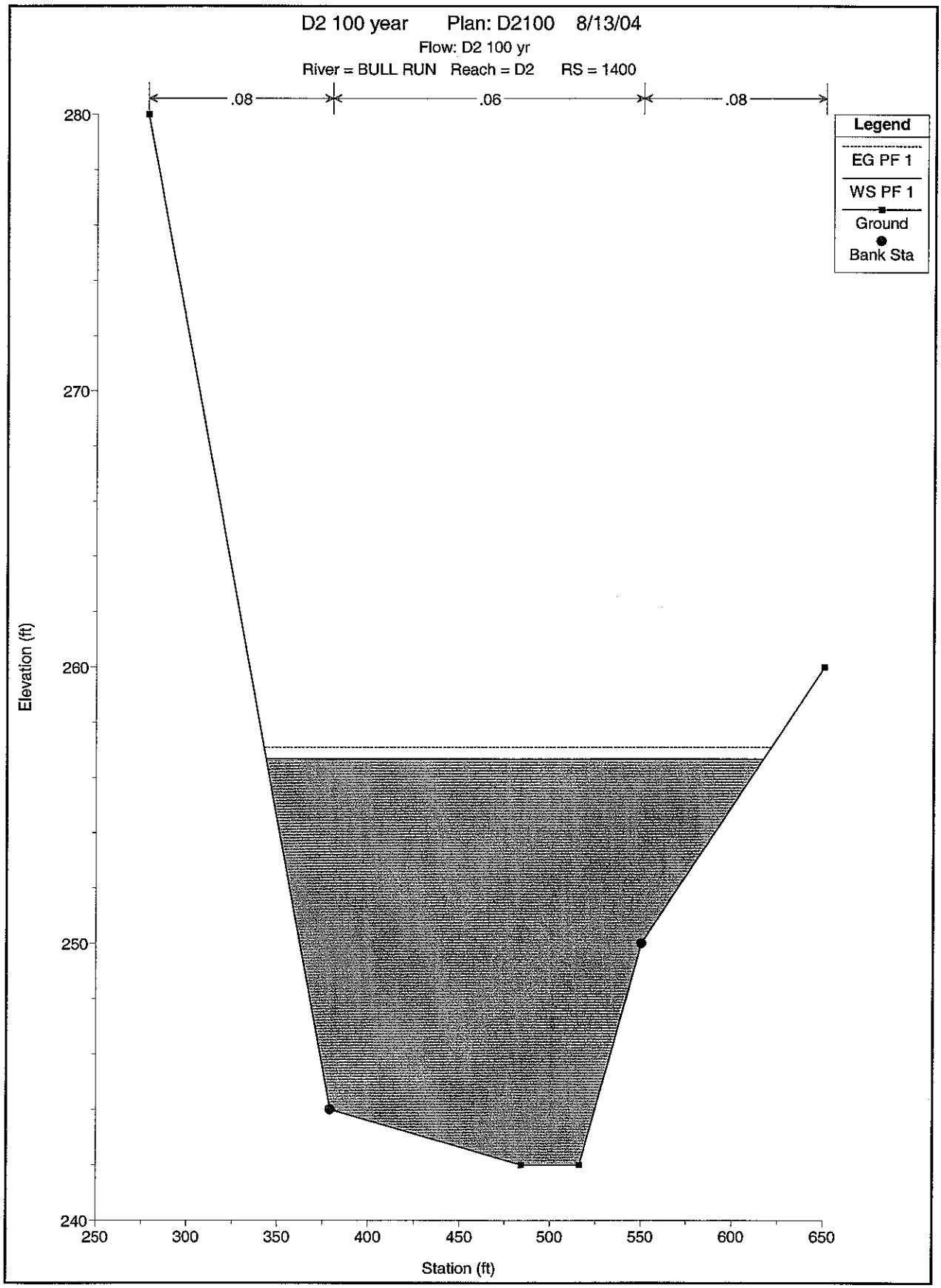
300
400
500
600
700
800
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
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240
250
300
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400
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600
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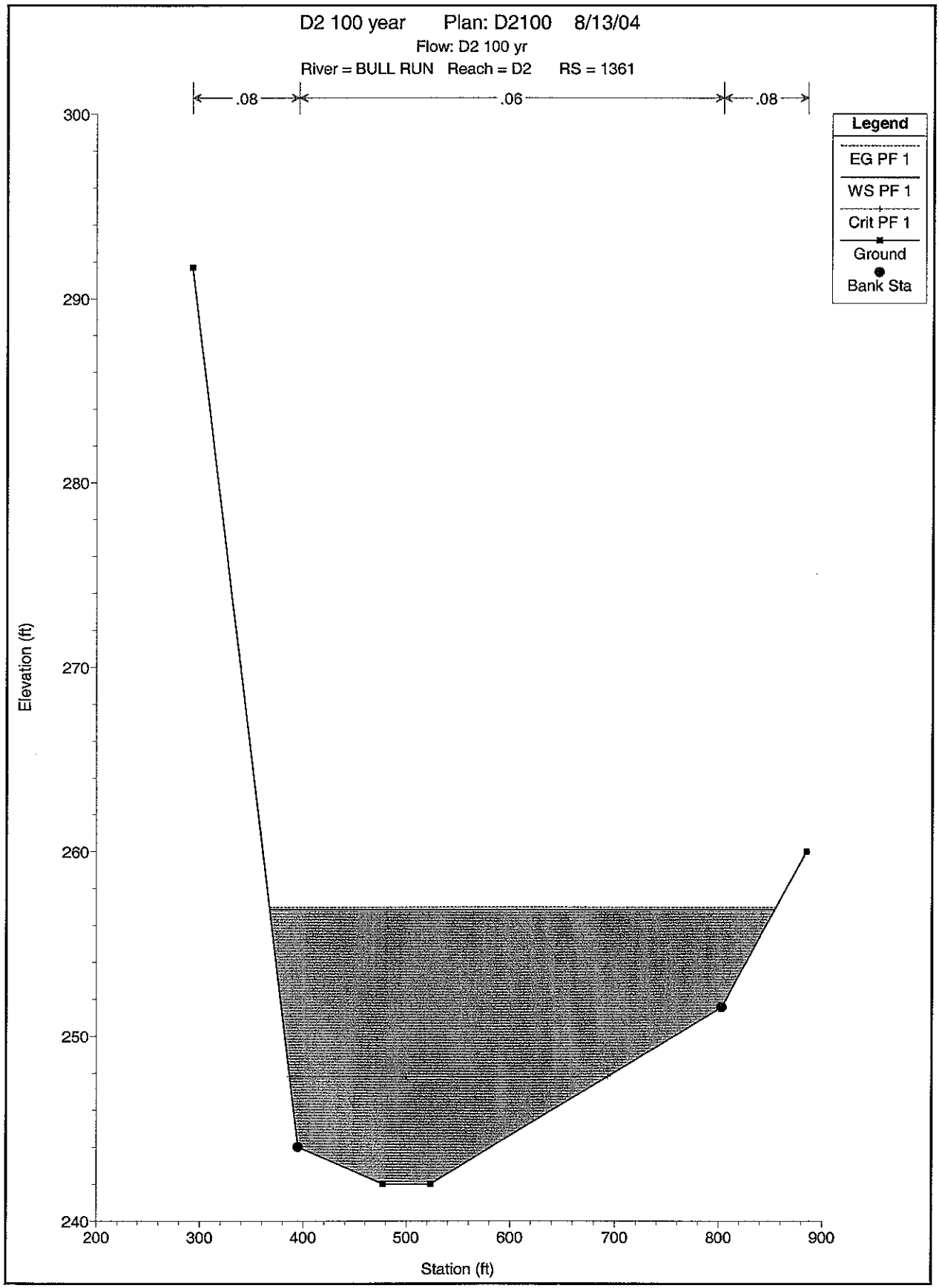
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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400
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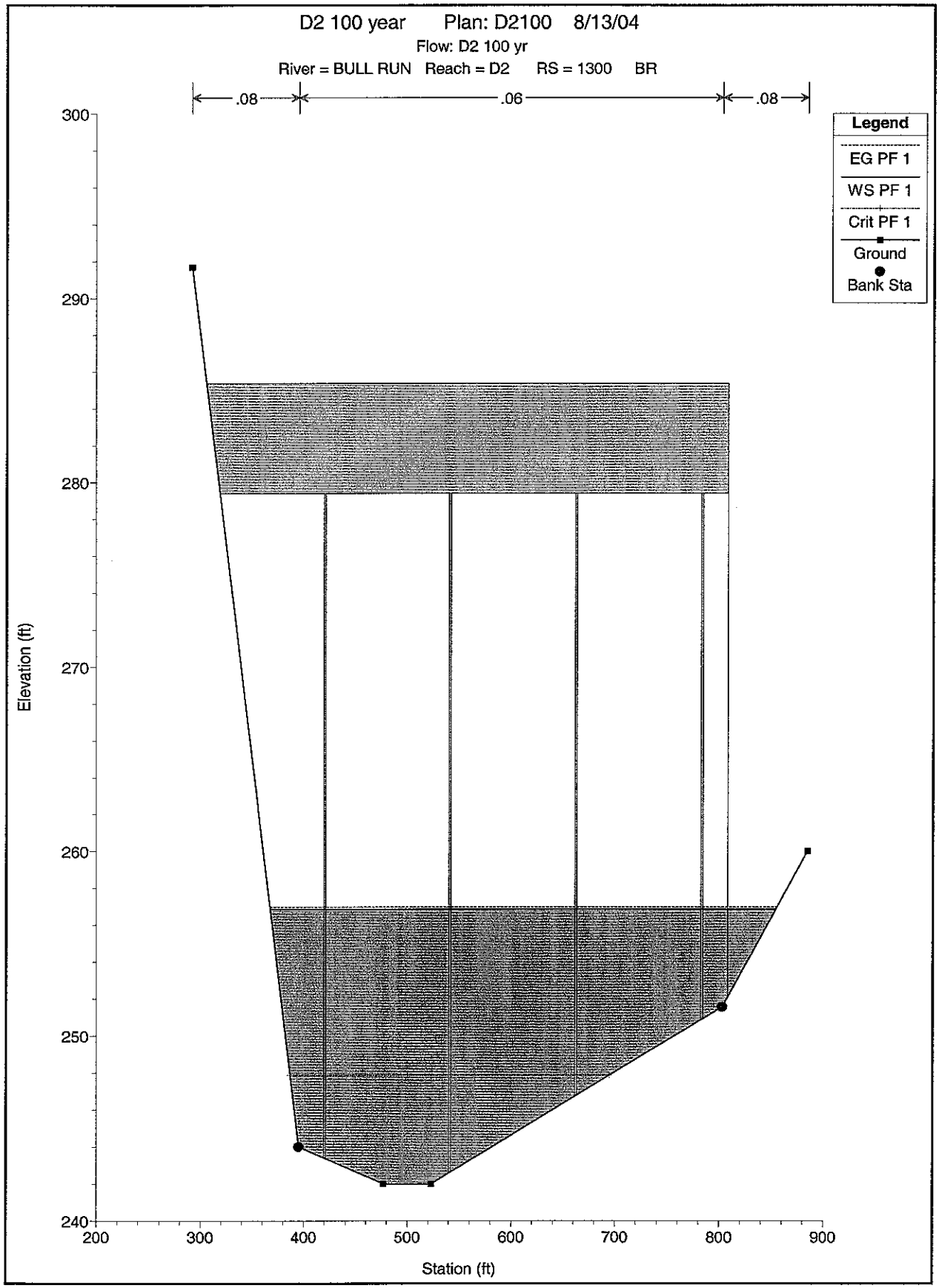
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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290
280
270
260
250
240
200
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400
500
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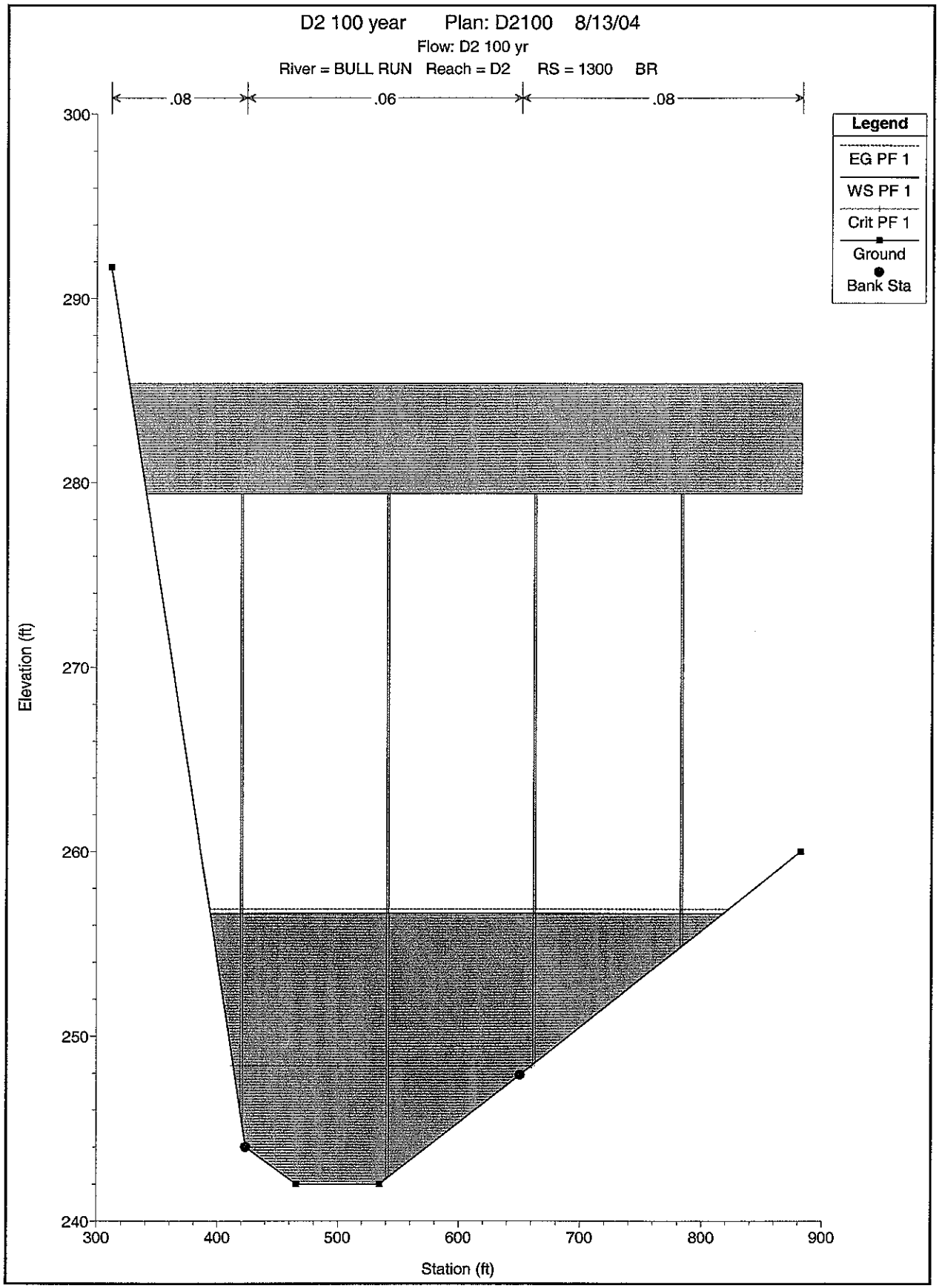
700
800
900
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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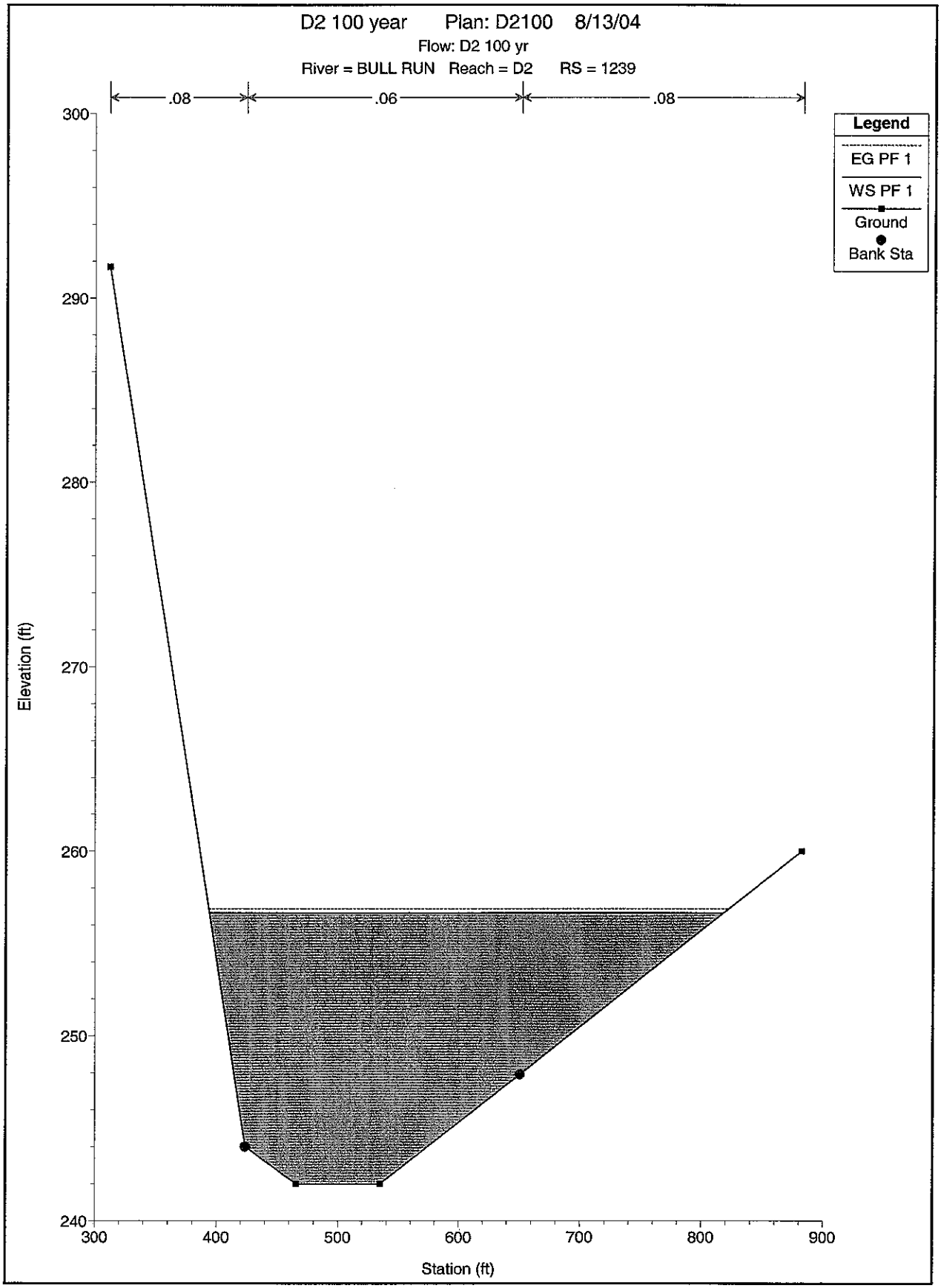
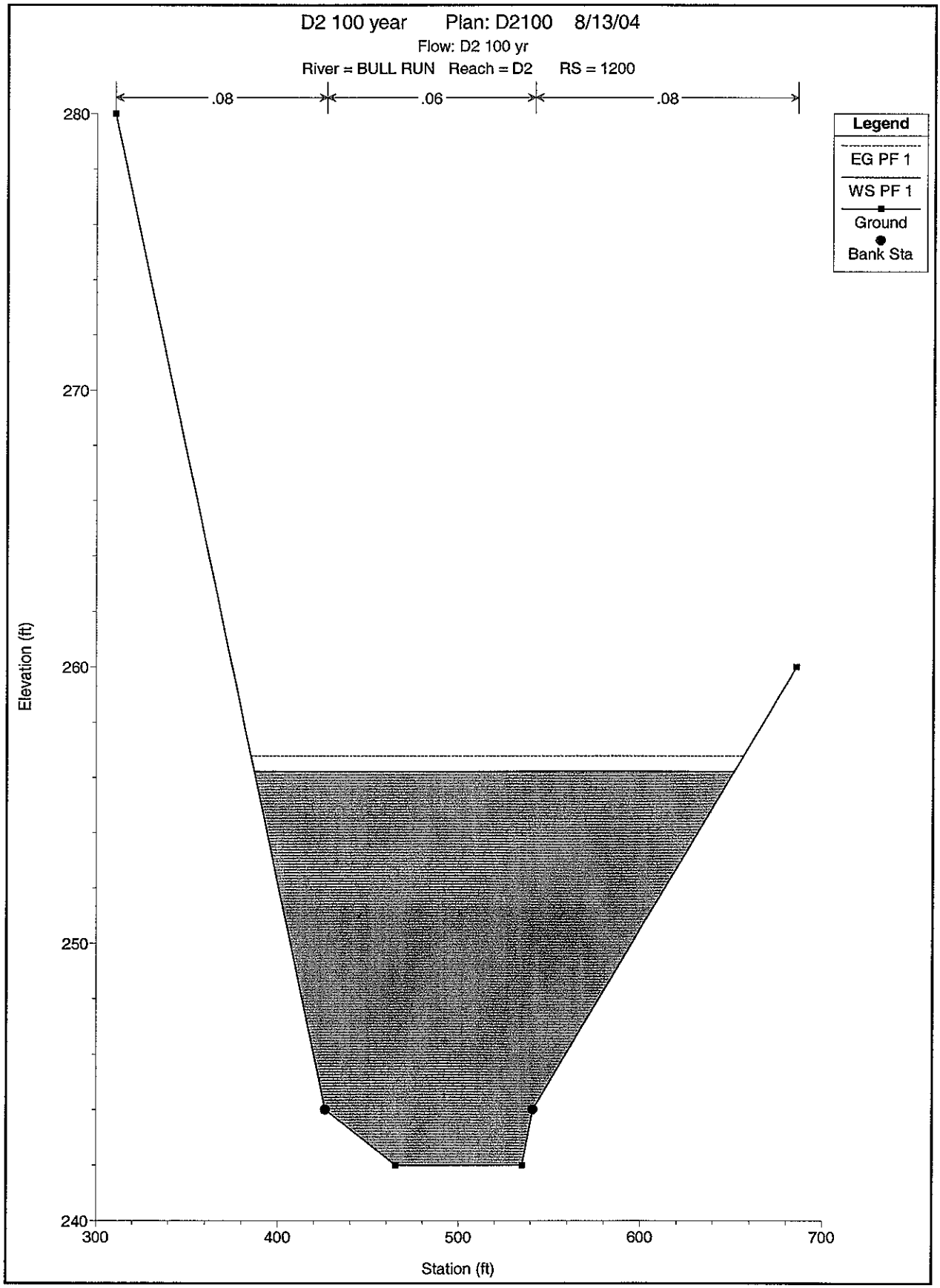
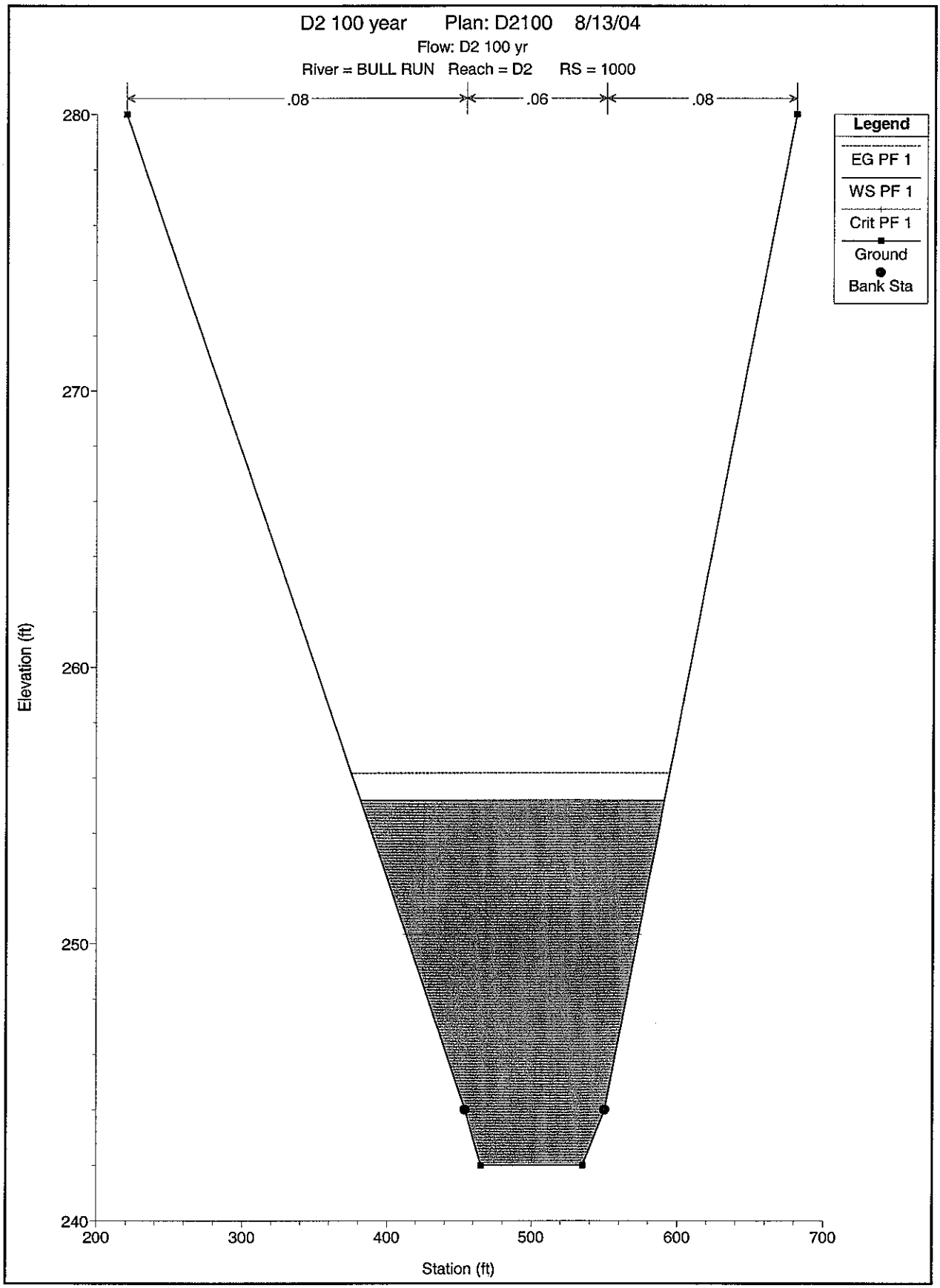
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
300
290
280
270
260
250
240
300
400
500
600
700
800
900
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
300
400
500
600
700
Station (ft)


D2 100 year Plan: D2100 8/13/04
Flow: D2 100 yr
River = BULL RUN Reach = D2 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
200
300
400
500
600
700
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING D2A

PART 1: Plan Sheet

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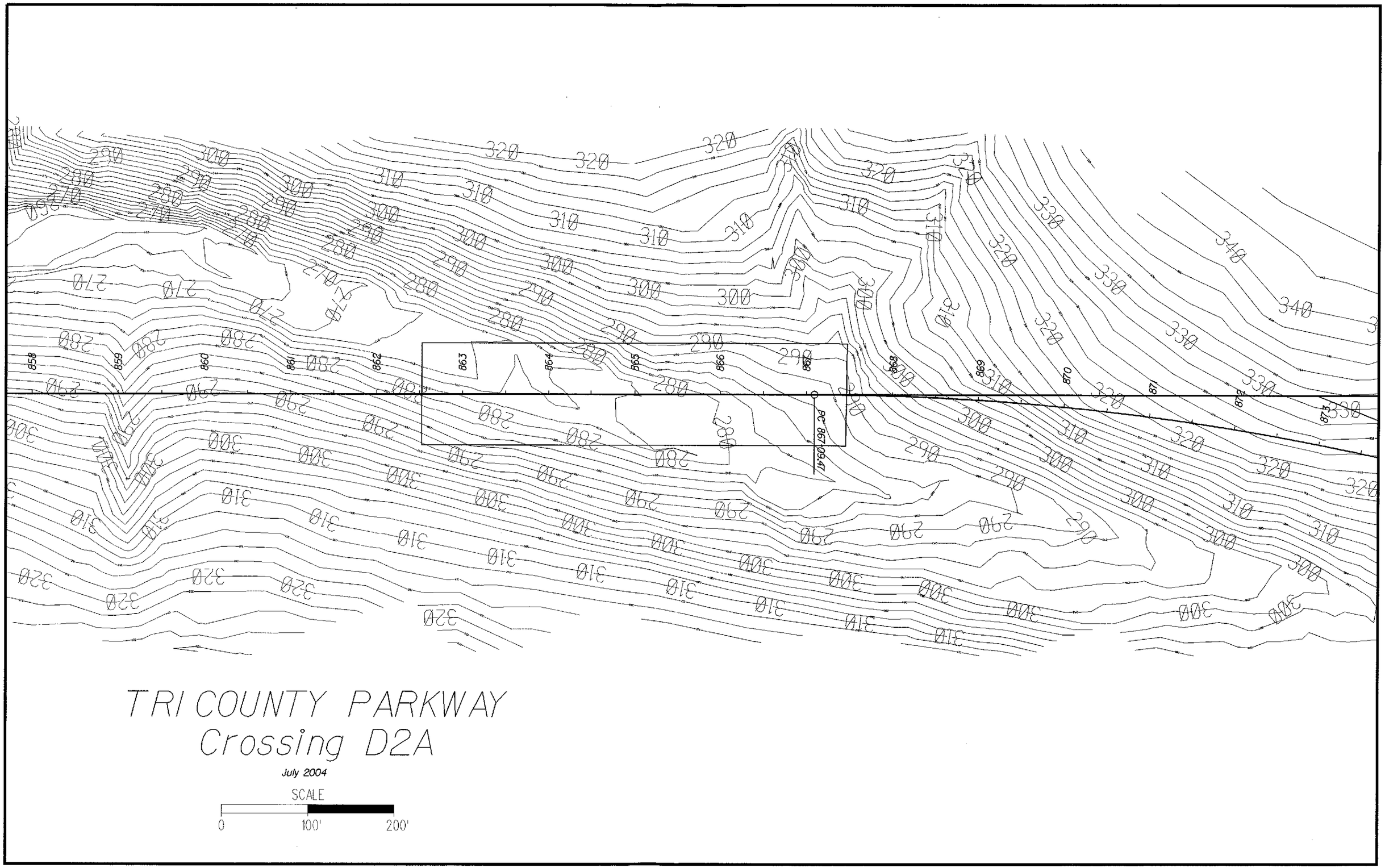

TRI COUNTY PARKWAY
Crossing D2A

July 2004

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING D5

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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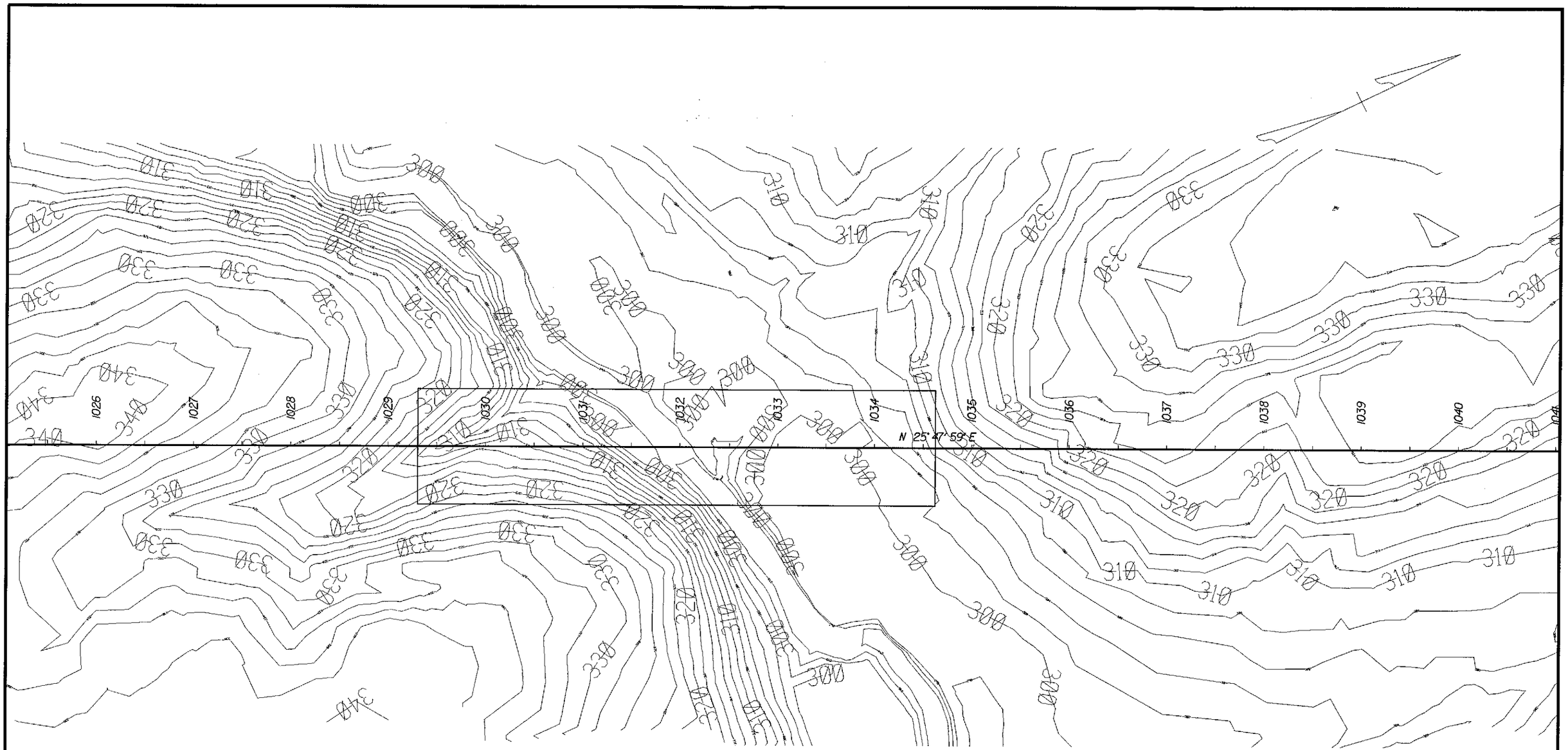

TRI COUNTY PARKWAY
Crossing D5

July 2004

SCALE

0 100' 200'

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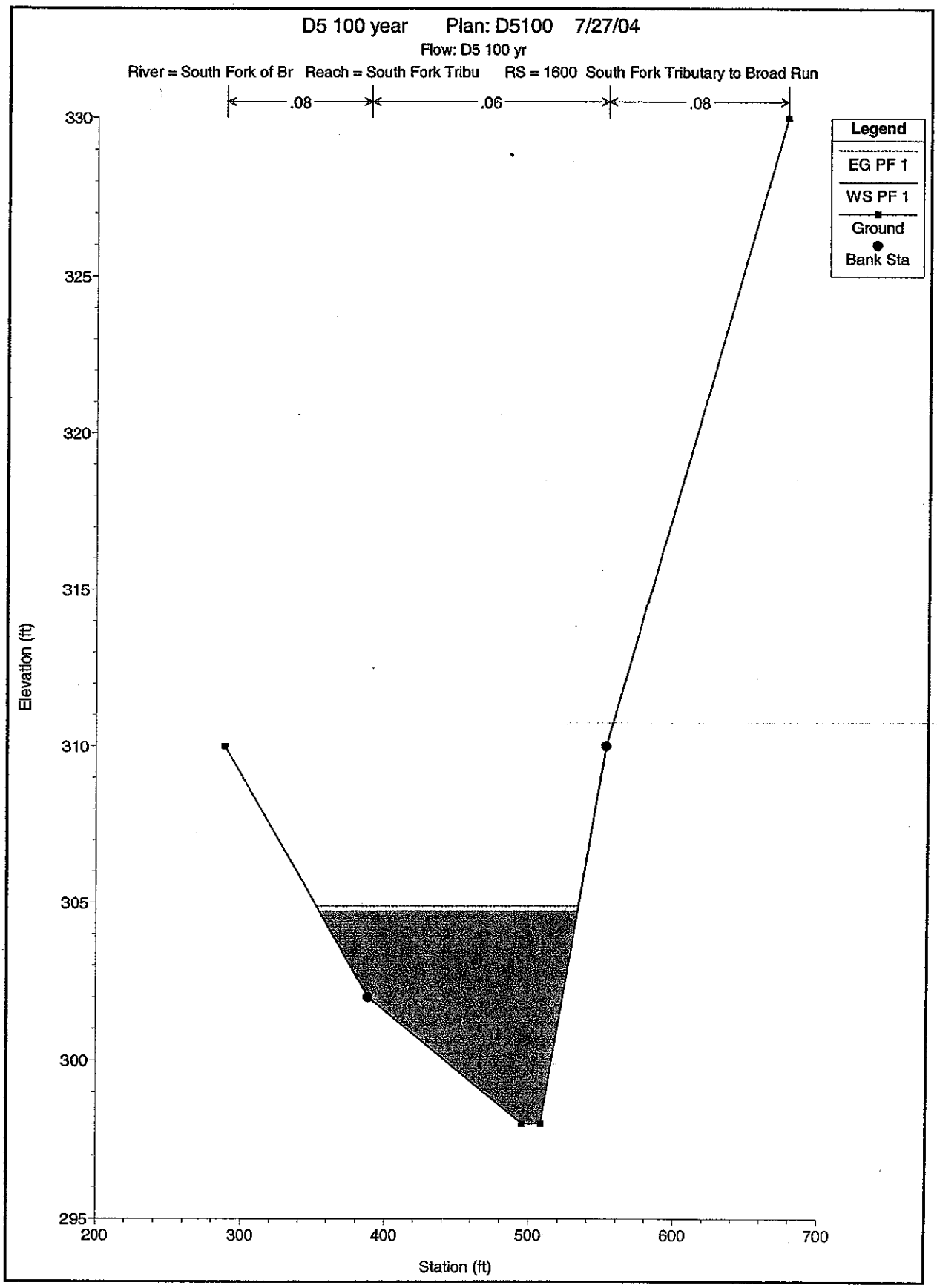
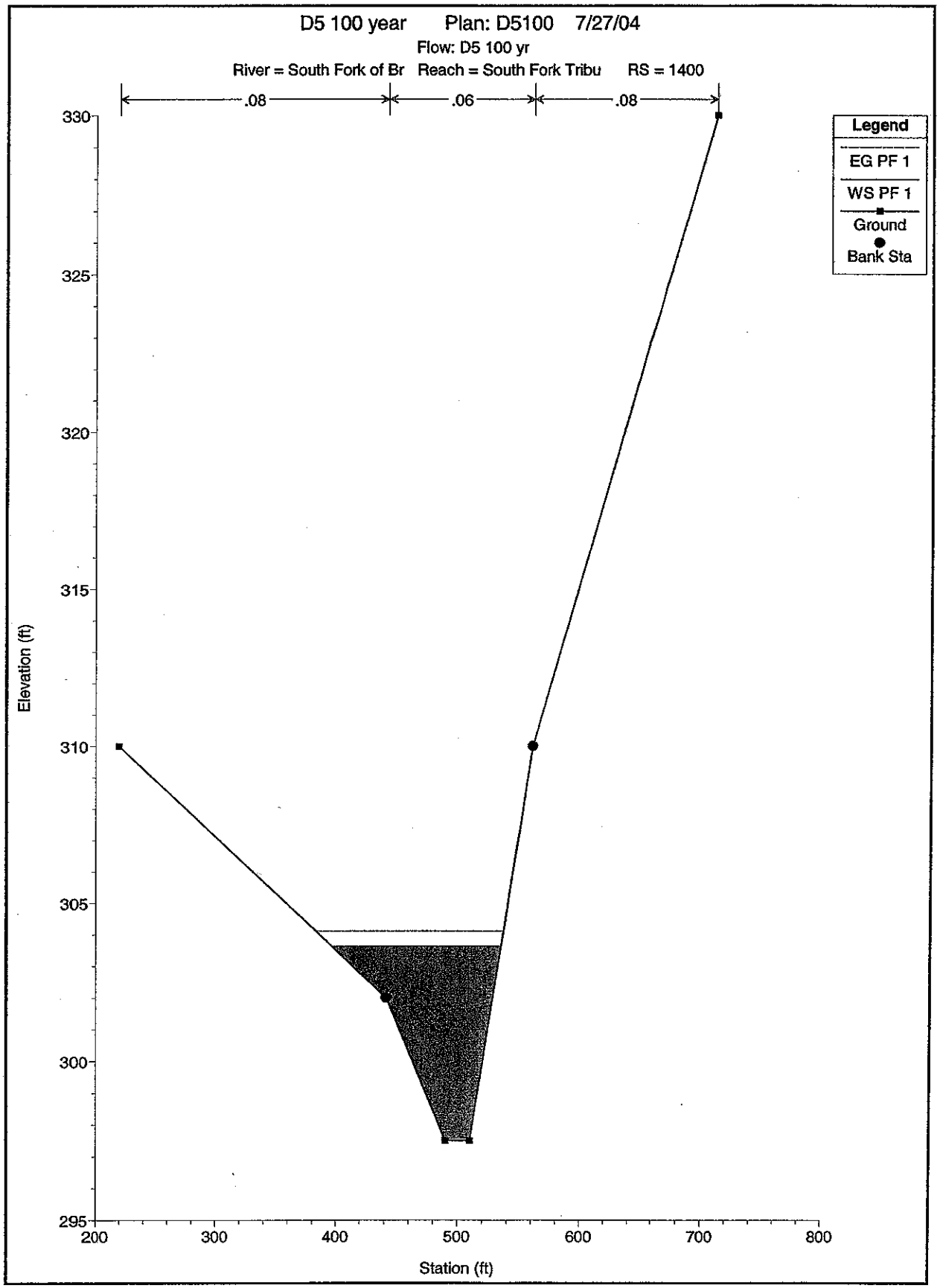
HEC-RAS Plan: D5A River: South Fork of Br Reach: South Fork Tribu Profile: PF 1

Reach	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)	
South Fork Tribu	1600	2238.00	298.00	304.73		304.89	0.002195	3.23	723.80	178.85	0.26
South Fork Tribu	1400	2238.00	297.50	303.62		304.11	0.007926	5.65	423.54	138.48	0.49
South Fork Tribu	1361	2238.00	297.70	303.40		303.79	0.006782	5.15	479.69	162.84	0.45
South Fork Tribu	1239	2238.00	296.78	302.50		302.94	0.007196	5.45	457.73	148.44	0.47
South Fork Tribu	1200	2238.00	296.00	301.86	300.61	302.56	0.011351	6.82	352.60	111.74	0.58
South Fork Tribu	1000	2238.00	294.00	297.59	297.59	298.58	0.043009	7.99	280.11	144.11	1.01


D5 100 year Plan: D5100 7/27/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1600 South Fork Tributary to Broad Run
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
330
325
320
315
310
305
300
295
200
300
400
500
600
700
Station (ft)


D5 100 year Plan: D5100 7/27/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
330
325
320
315
310
305
300
295
200
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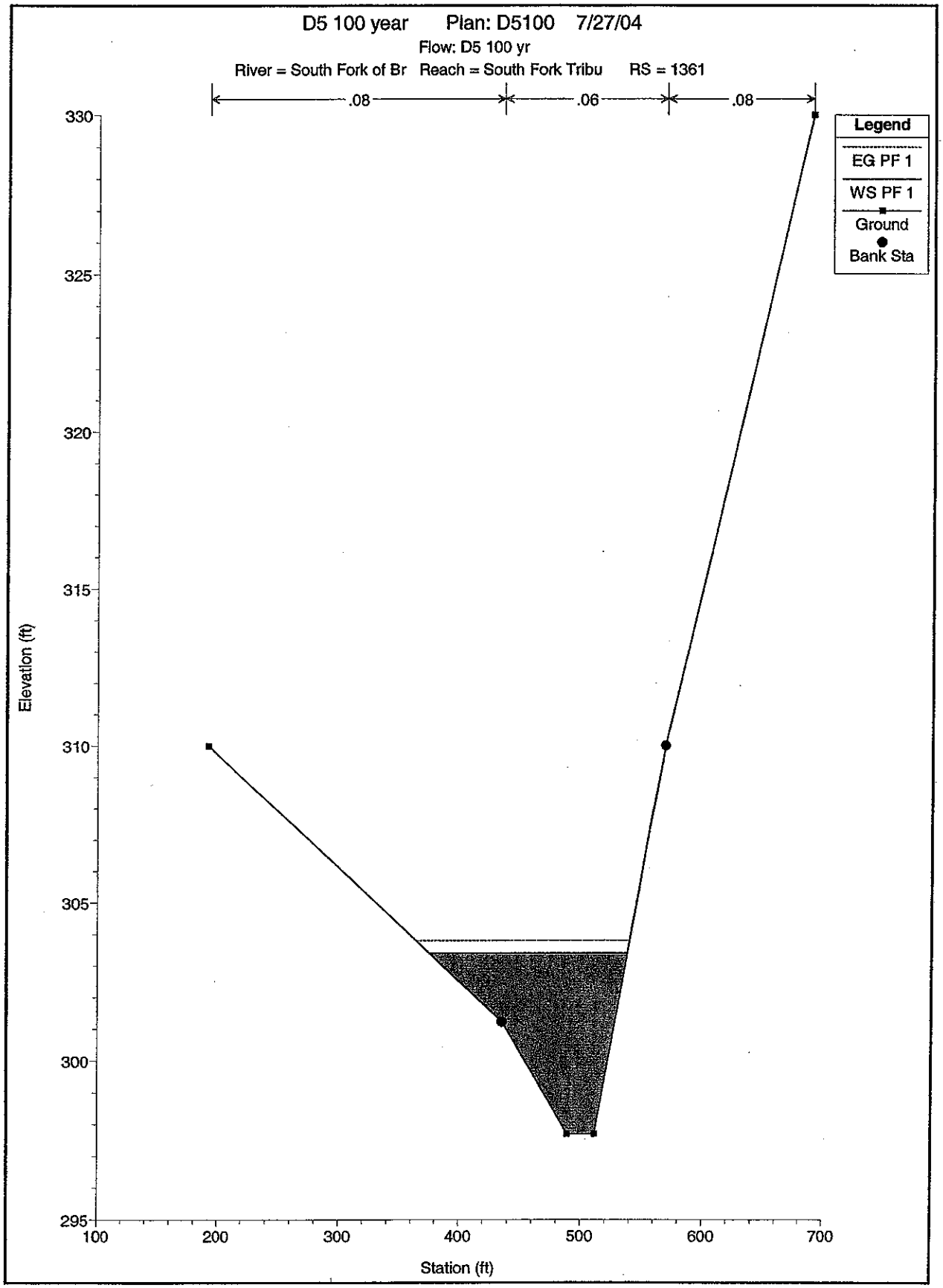
700
800
Station (ft)


D5 100 year Plan: D5100 7/27/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
330
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315
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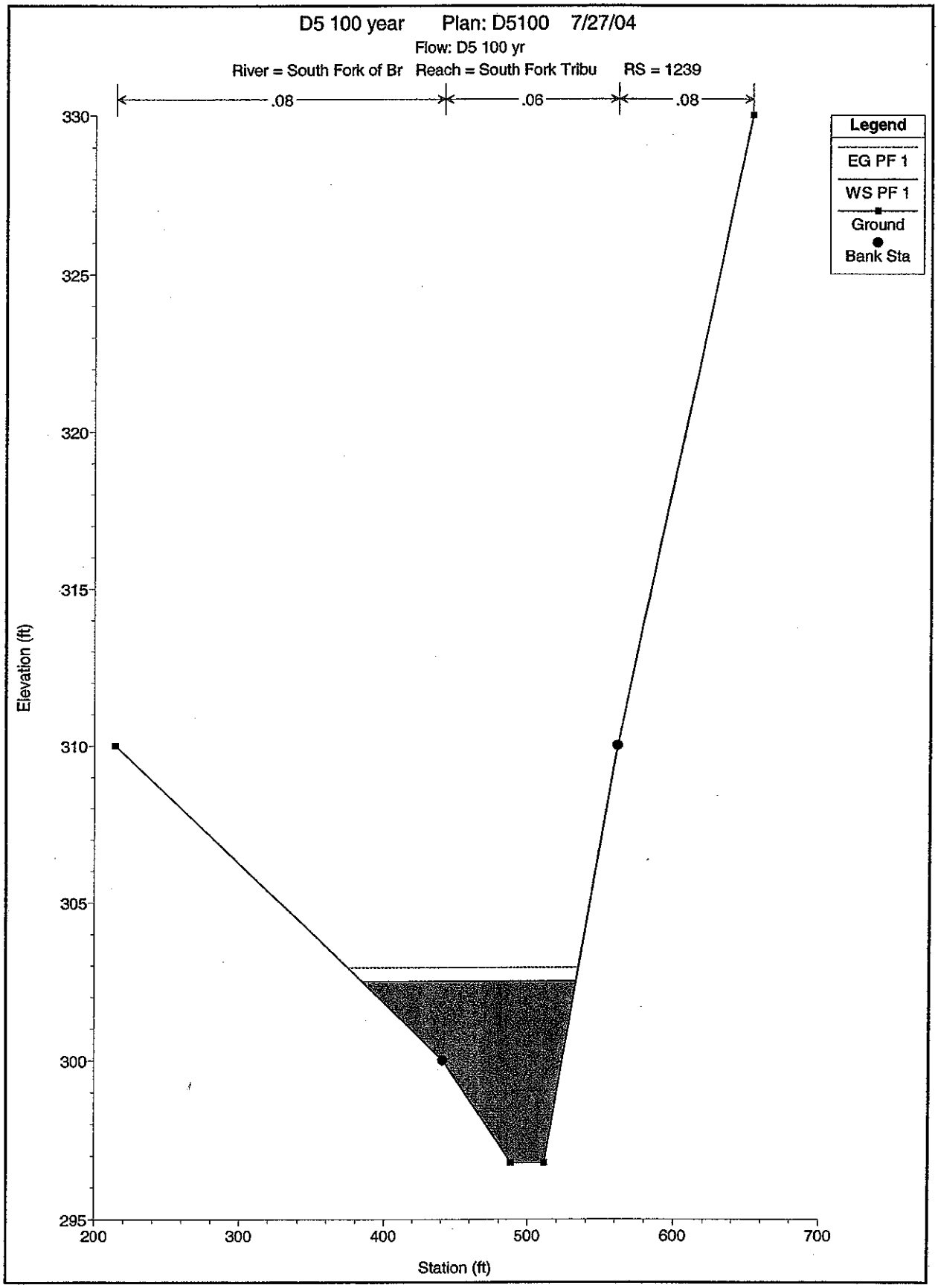
305
300
295
100
200
300
400
500
600
700
Station (ft)


D5 100 year Plan: D5100 7/27/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1239
.08
.06
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Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
330
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310
305
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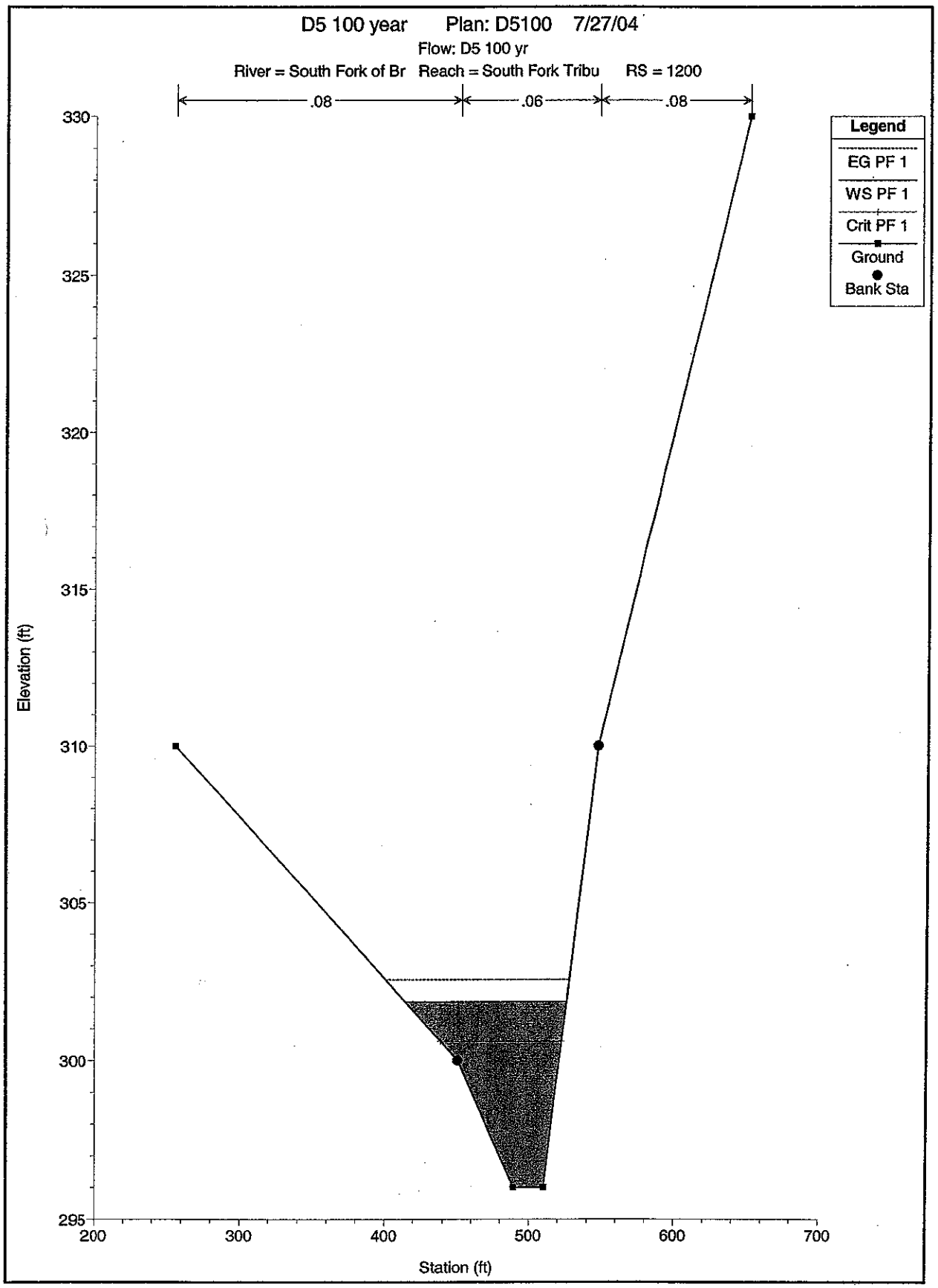
200
300
400
500
600
700
Station (ft)


D5 100 year Plan: D5100 7/27/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1200
.08
.06
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Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
330
325
320
315
310
305
300
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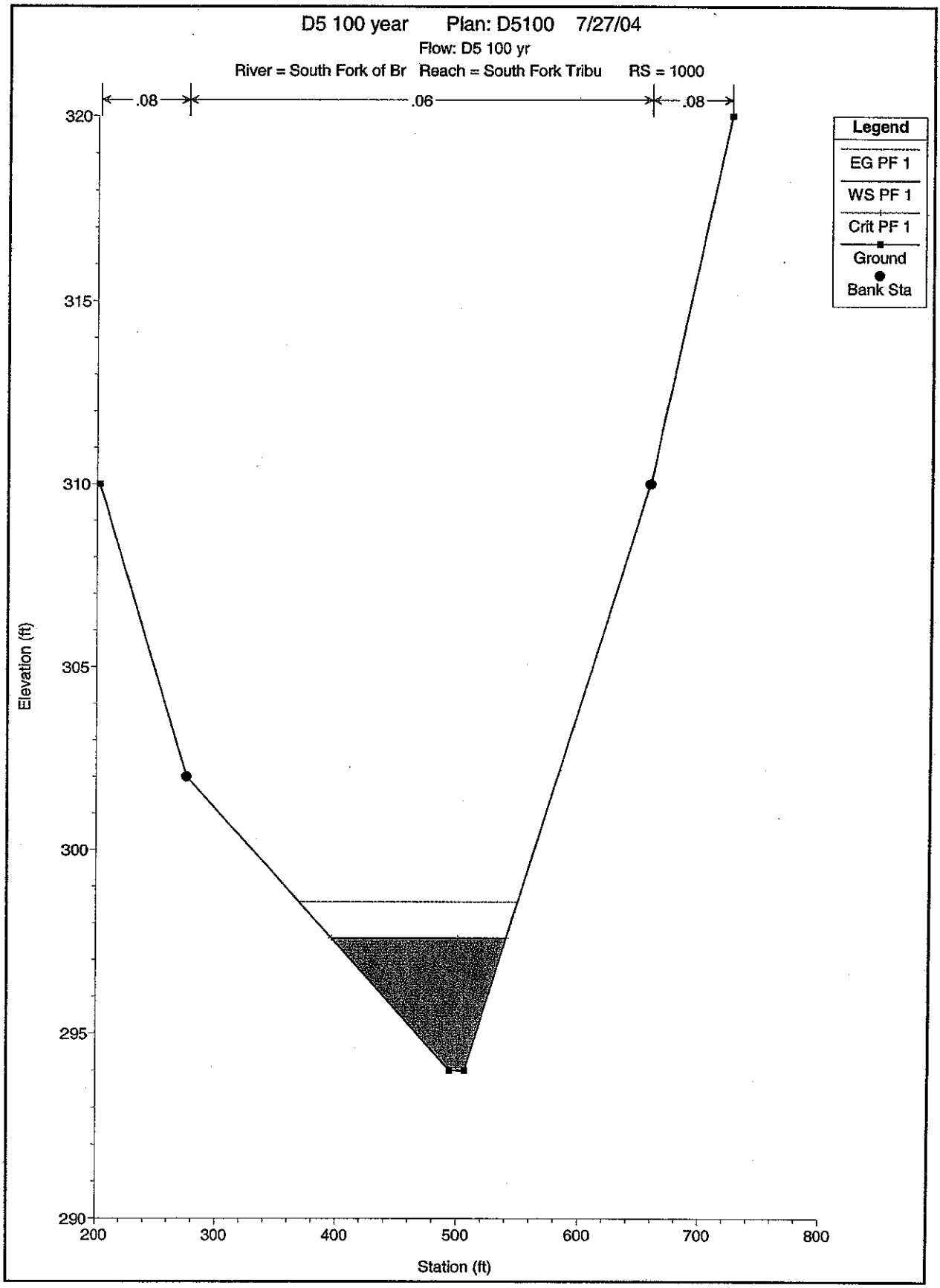
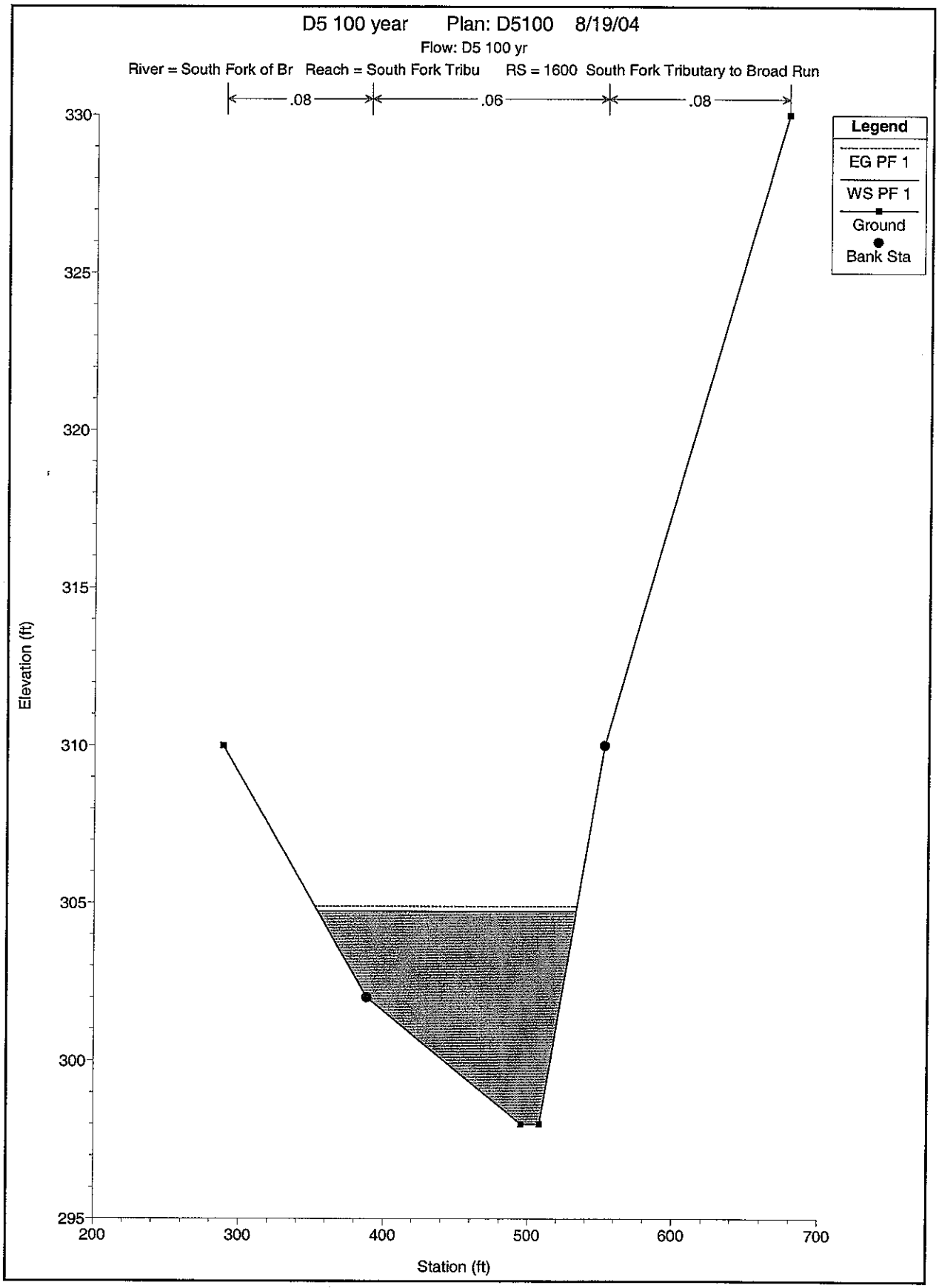
200
300
400
500
600
700
Station (ft)


D5 100 year Plan: D5100 7/27/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
320
315
310
305
300
295
290
200
300
400
500
600
700
800
Station (ft)

HEC-RAS Plan: D5A River: South Fork of Br Reach: South Fork Tribu Profile: PF 1

Reach	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)	
South Fork Tribu	1600	2238.00	298.00	304.74		304.90	0.002188	3.23	724.60	178.93	0.26
South Fork Tribu	1400	2238.00	297.50	303.63		304.11	0.007853	5.63	425.15	138.85	0.49
South Fork Tribu	1361	2238.00	297.70	303.41	301.71	303.80	0.006696	5.13	482.15	163.33	0.45
South Fork Tribu	1300	Bridge									
South Fork Tribu	1239	2238.00	296.78	302.50		302.94	0.007196	5.45	457.73	148.44	0.47
South Fork Tribu	1200	2238.00	296.00	301.86	300.61	302.56	0.011351	6.82	352.60	111.74	0.58
South Fork Tribu	1000	2238.00	294.00	297.59	297.59	298.58	0.043009	7.99	280.11	144.11	1.01


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1600 South Fork Tributary to Broad Run
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
330
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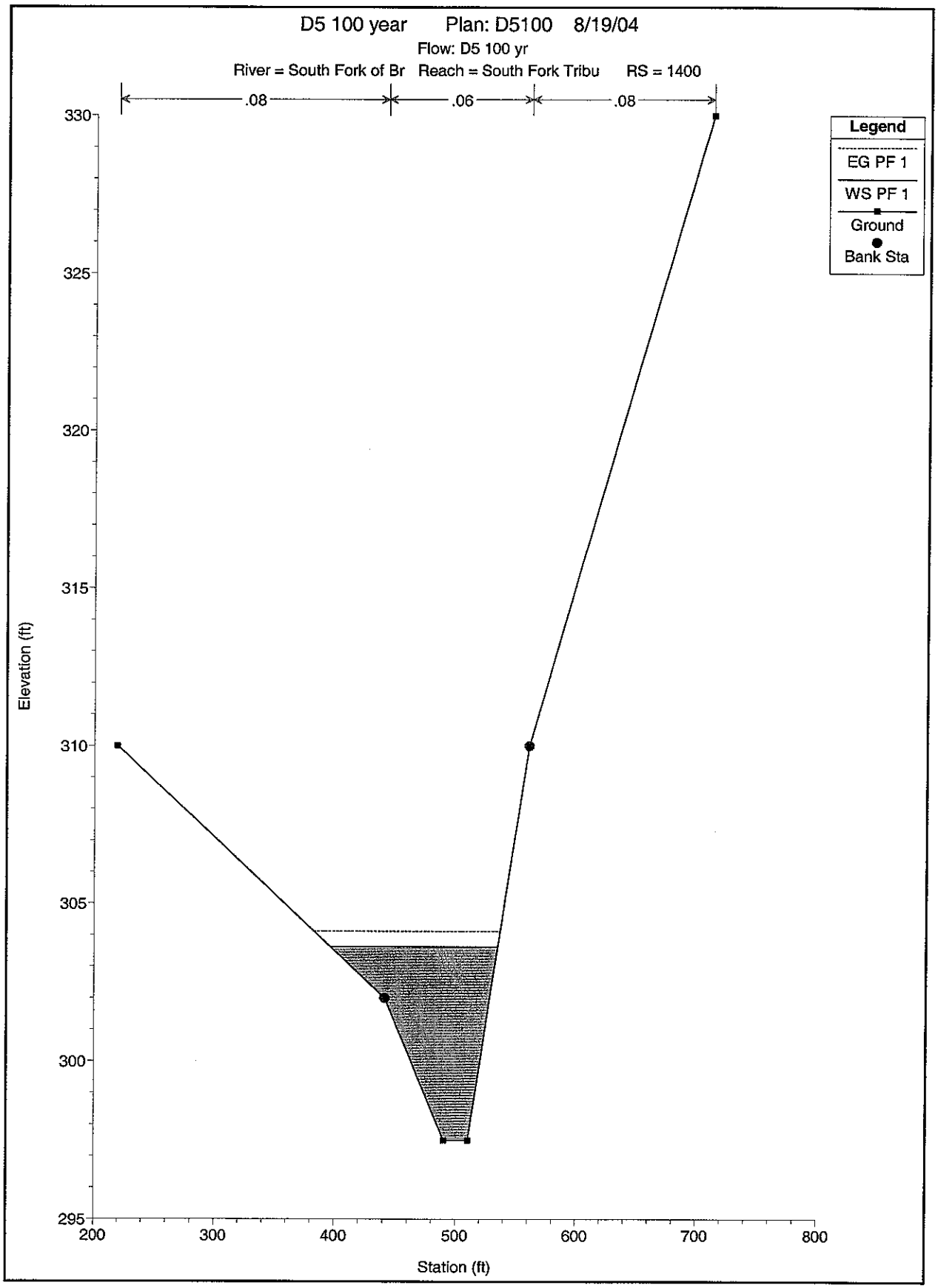
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1400
.08
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Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
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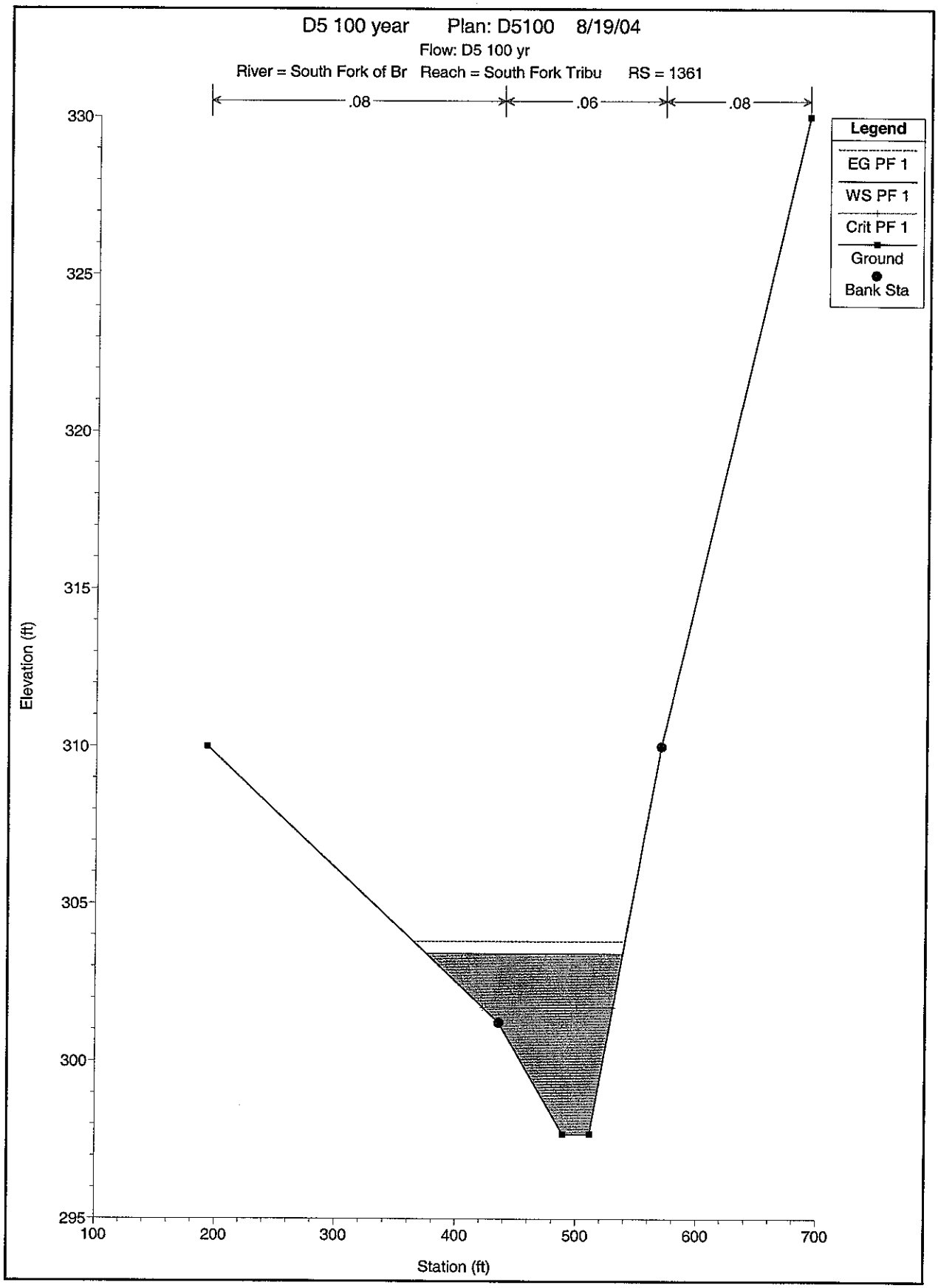
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1361
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Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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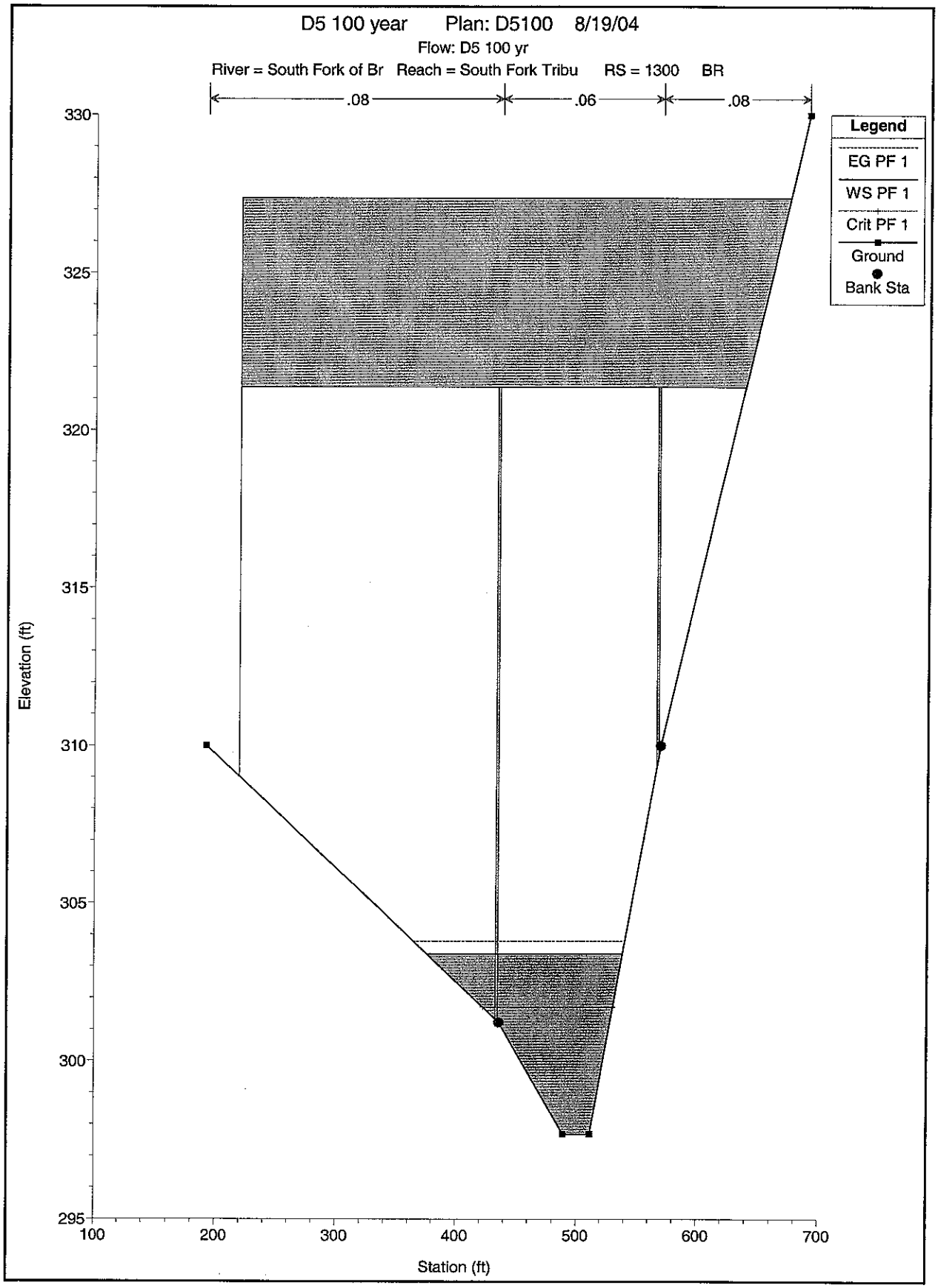
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
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Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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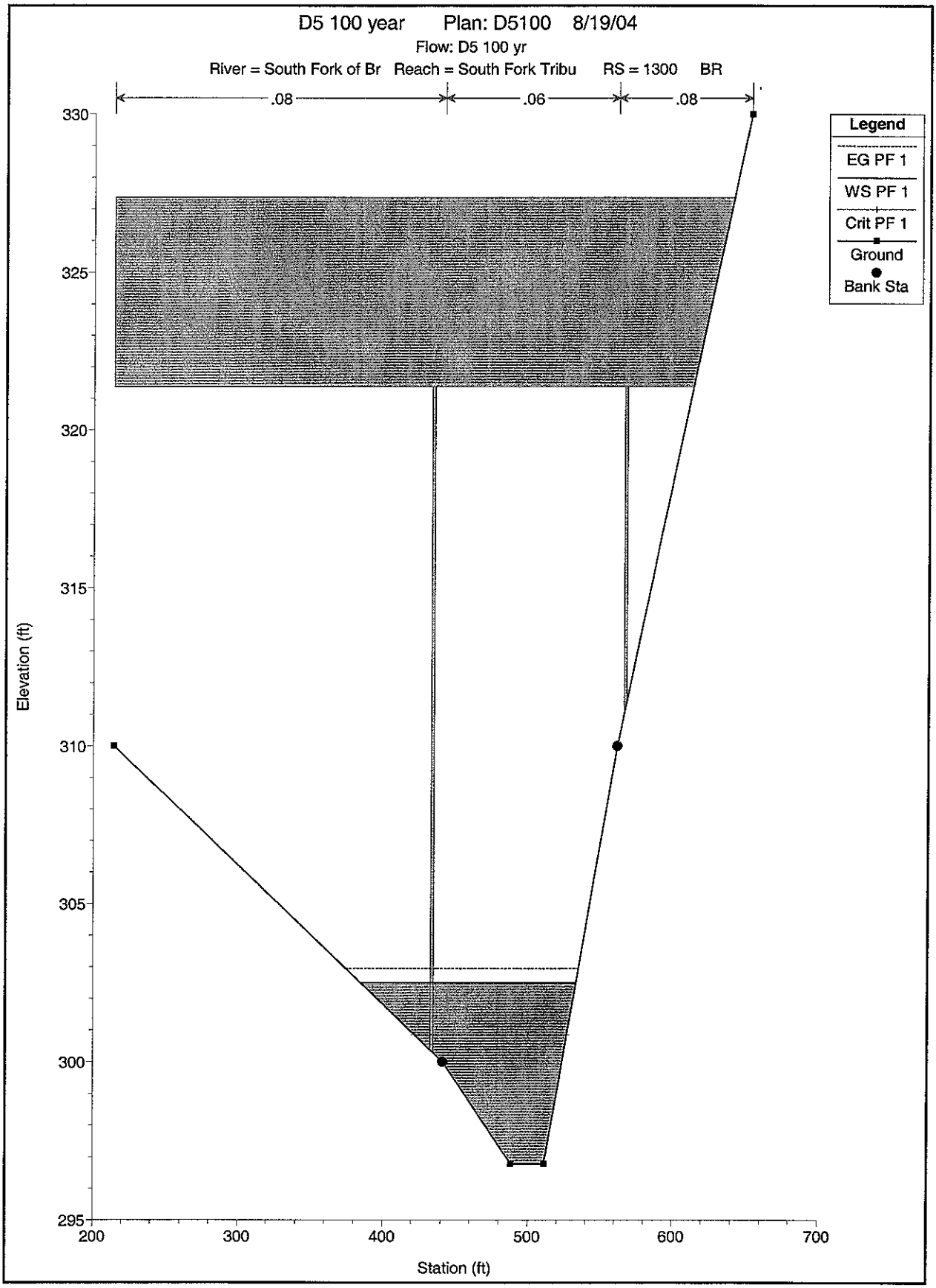
600
700
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
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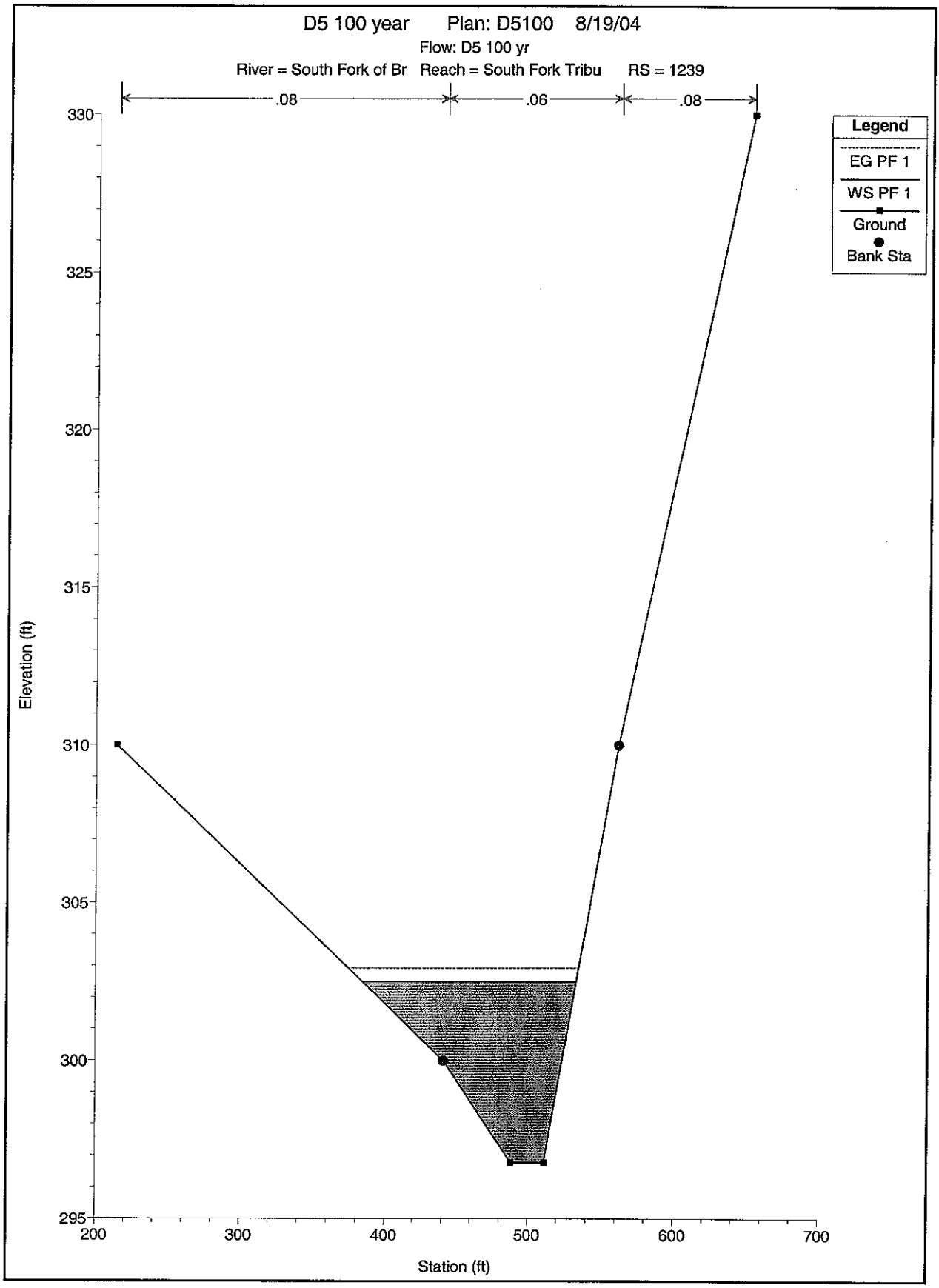
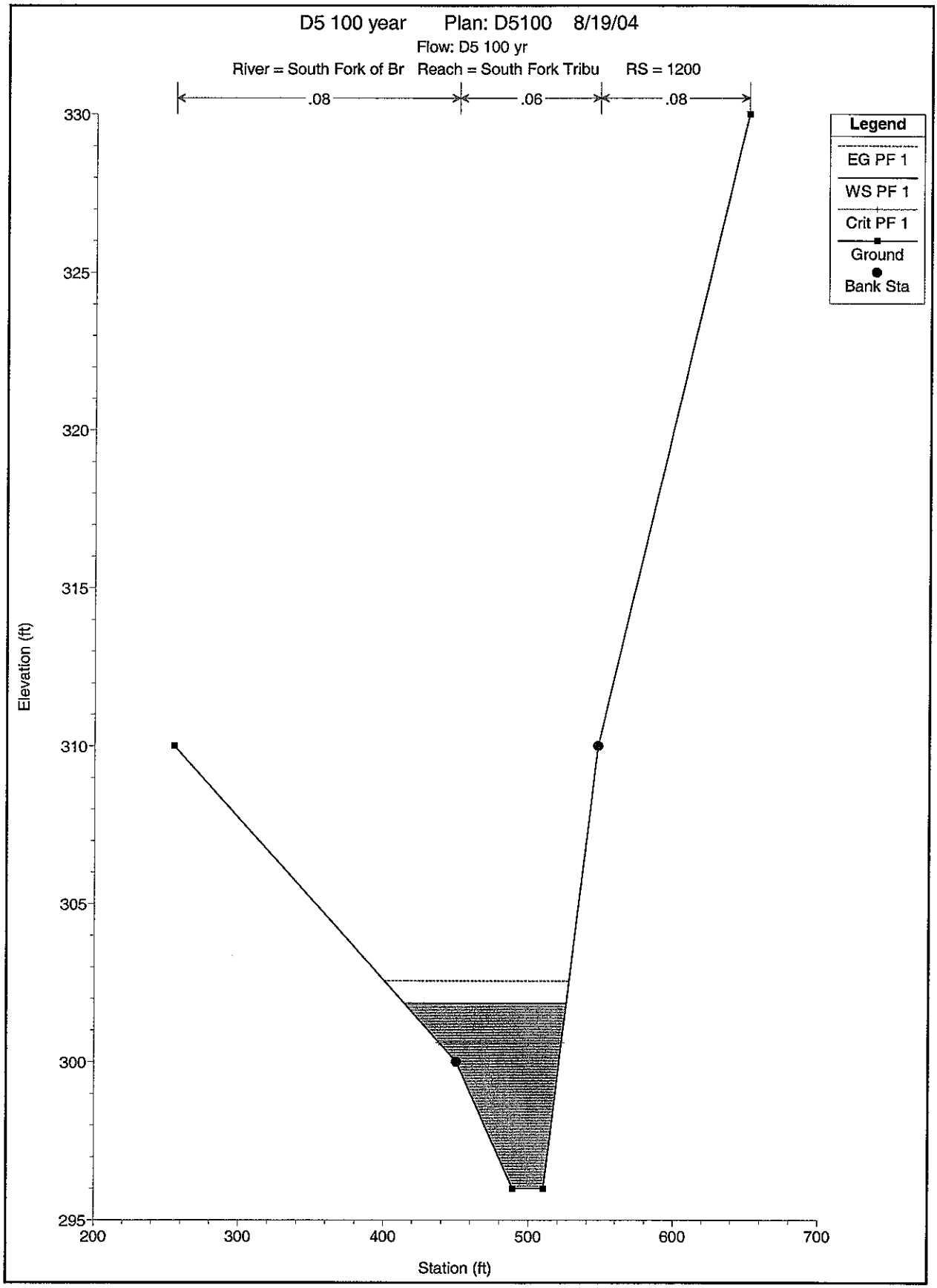
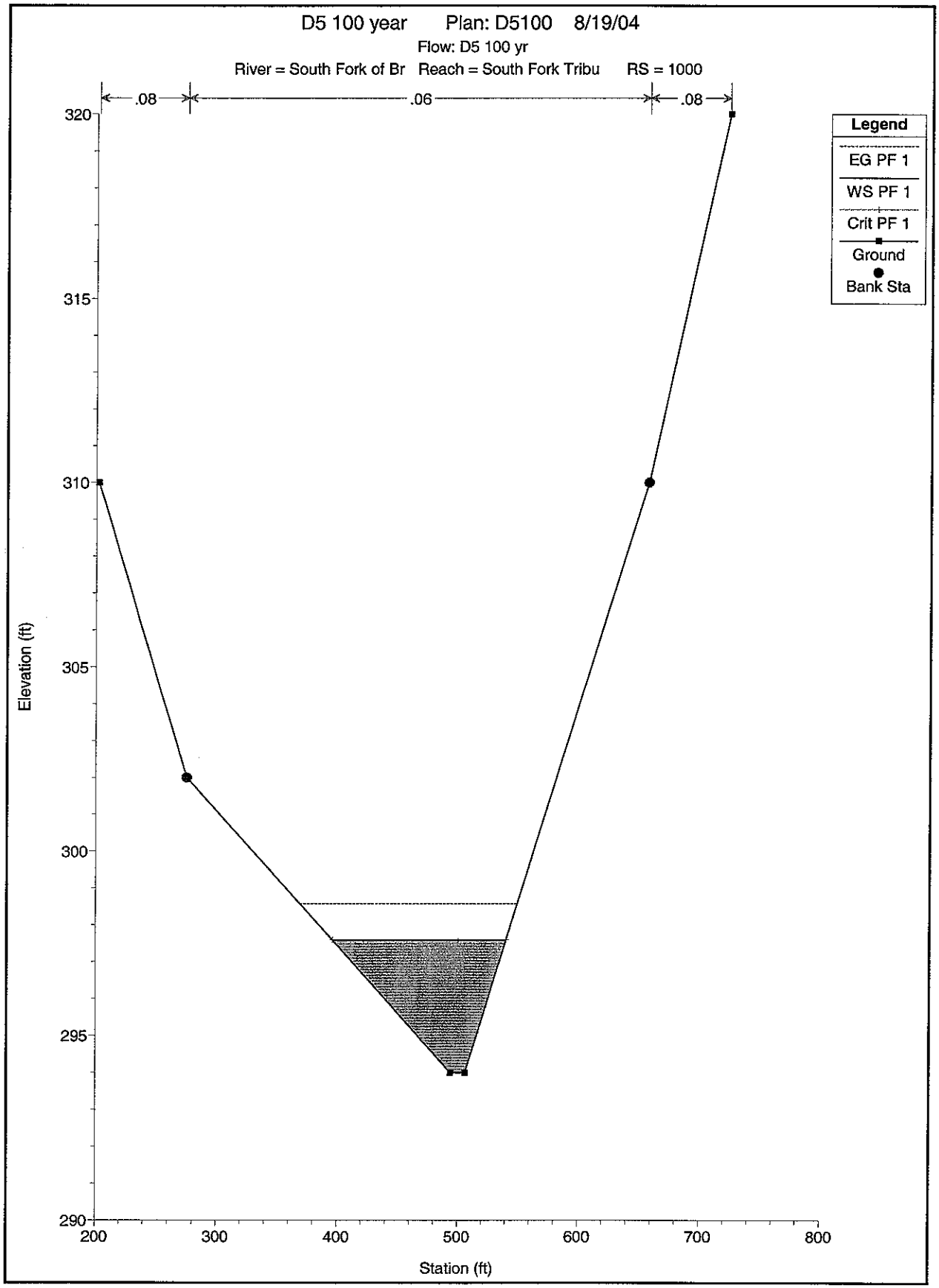
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
330
325
320
315
310
305
300
295
200
300
400
500
600
700
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
330
325
320
315
310
305
300
295
200
300
400
500
600
700
Station (ft)


D5 100 year Plan: D5100 8/19/04
Flow: D5 100 yr
River = South Fork of Br Reach = South Fork Tribu RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
320
315
310
305
300
295
290
200
300
400
500
600
700
800
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING E2

PART 1: Plan Sheet

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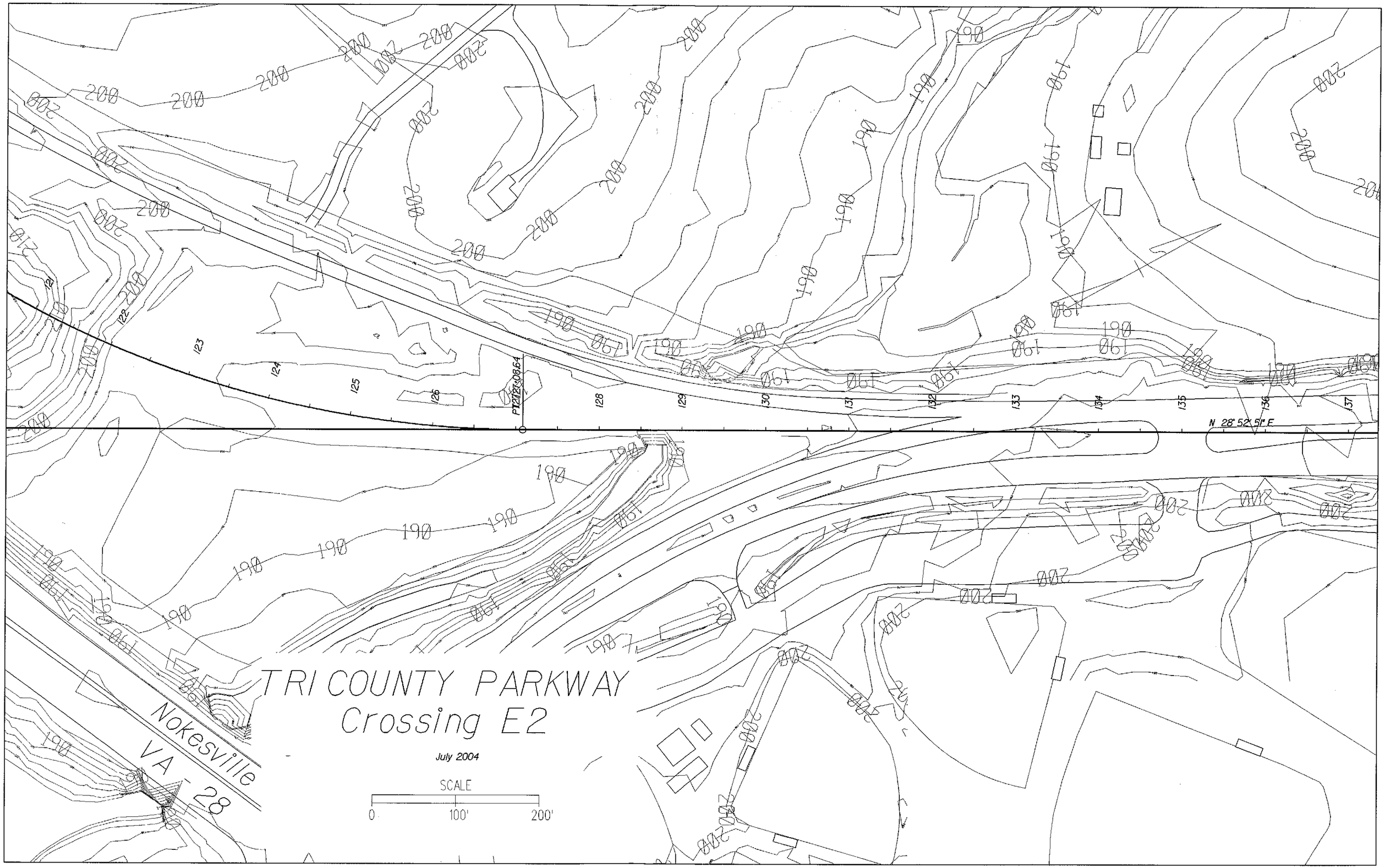

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING E6A

PART 1: Plan Sheet

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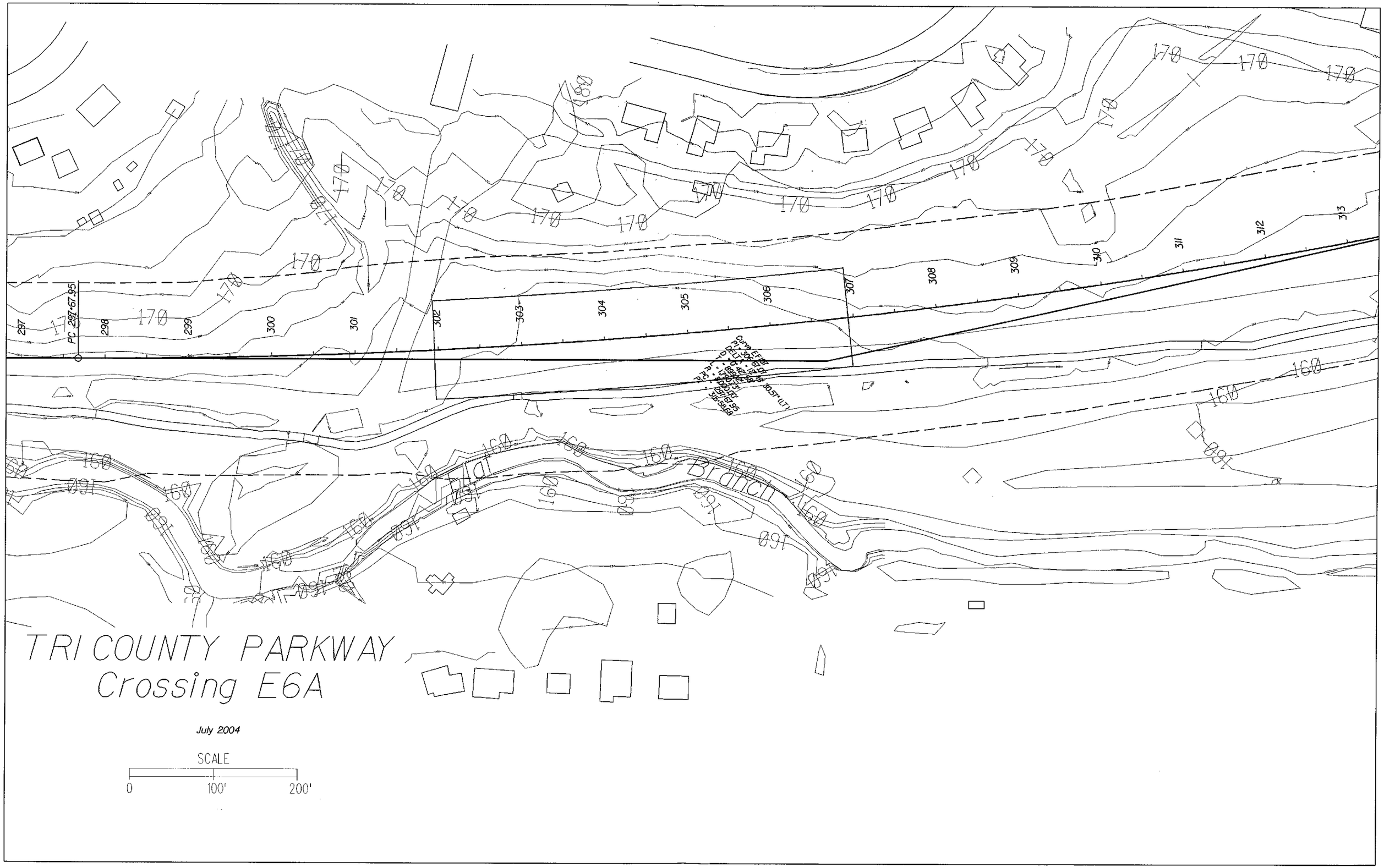

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING E6B-1,2,3

PART 1: Plan Sheet

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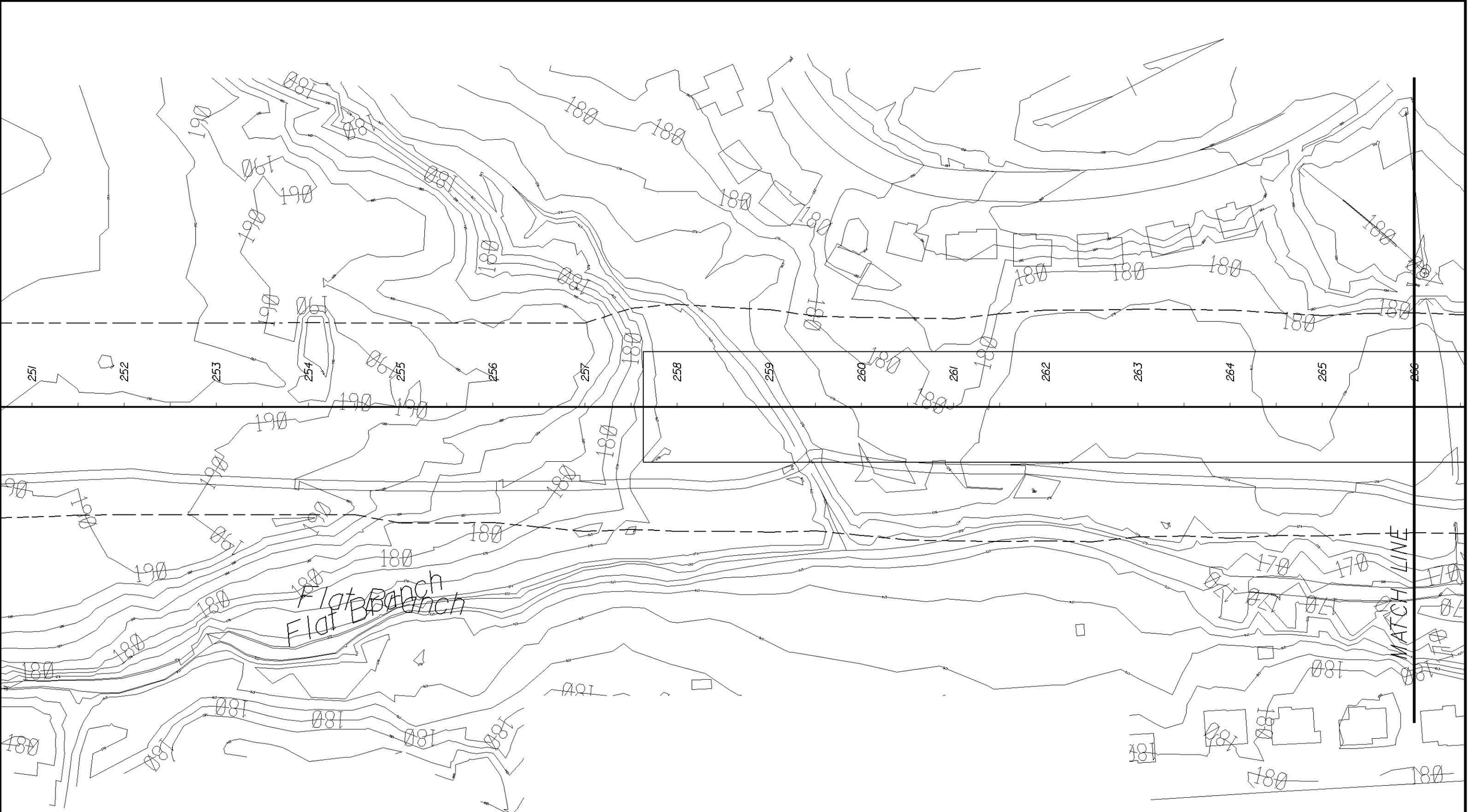
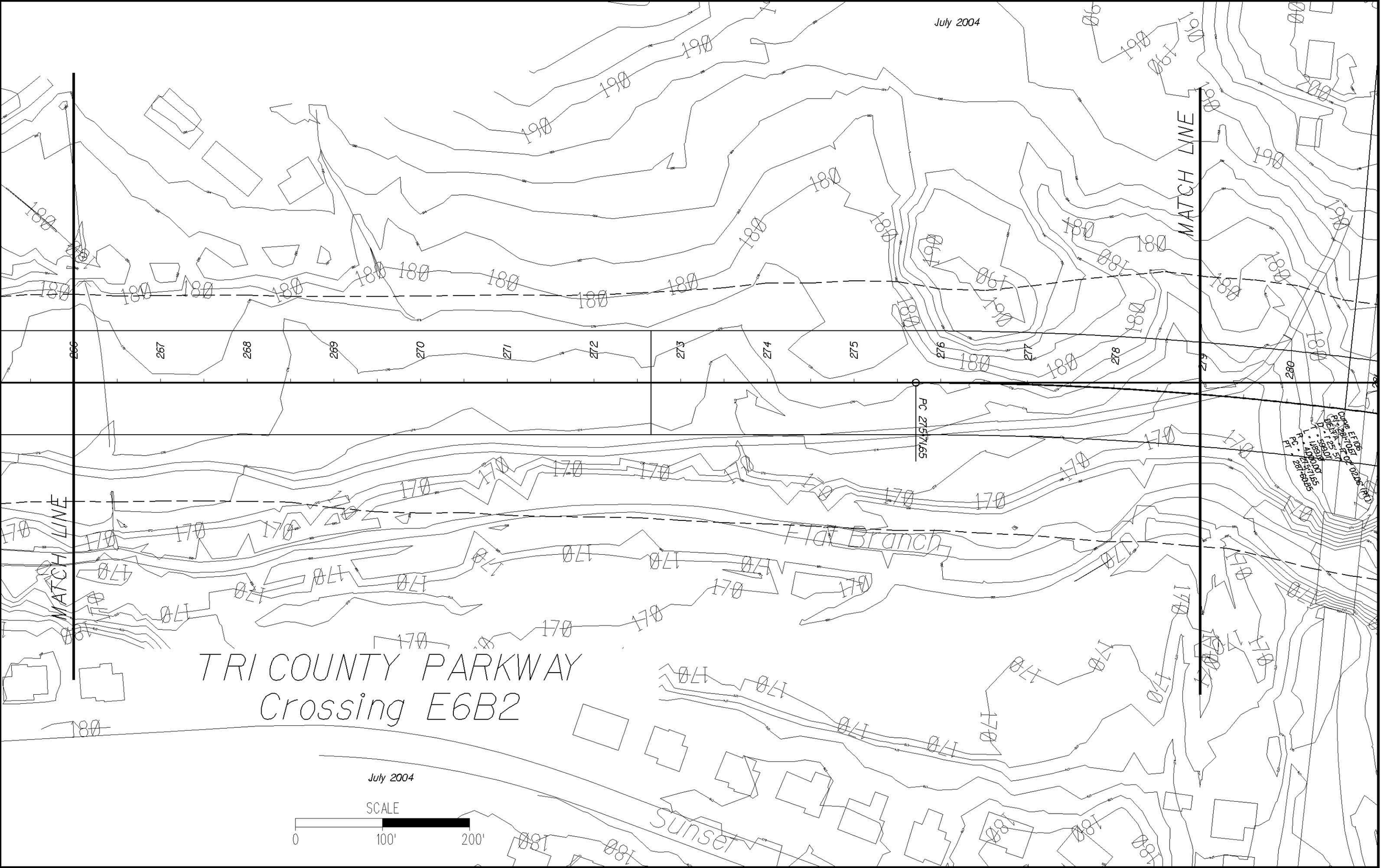


TRI COUNTY PARKWAY
Crossing E6BI

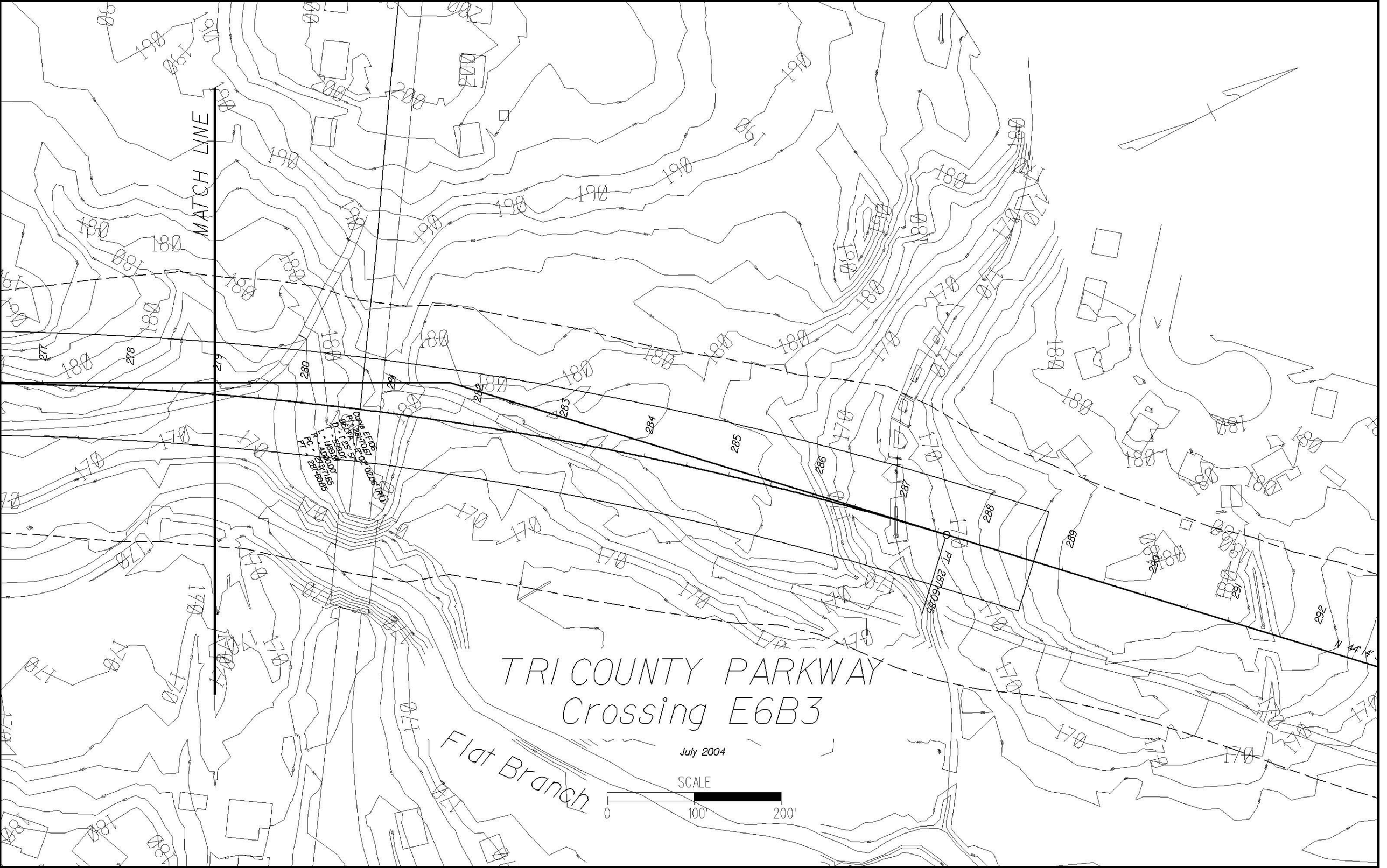
July 2004

SCALE

0 100' 200'



July 2004
MATCH LINE
MATCH LINE
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
PC 275+71.65
Flat Branch
Sunset
TRI COUNTY PARKWAY
Crossing E6B2
July 2004
SCALE
0
100'
200'


MATCH LINE
TRI COUNTY PARKWAY
Crossing E6B3
July 2004
Flat Branch
SCALE
0
100'
200'
N 44°14'
PT 287+60.85
Curve EF106
PI = 281+70.67
DELTA = 17° 02' 02.06" (RT)
D = 1° 25' 57"
T = 599.01'
L = 1,189.18'
R = 4,000.00'
PC = 275+71.65
PT = 287+60.85

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING E-10A

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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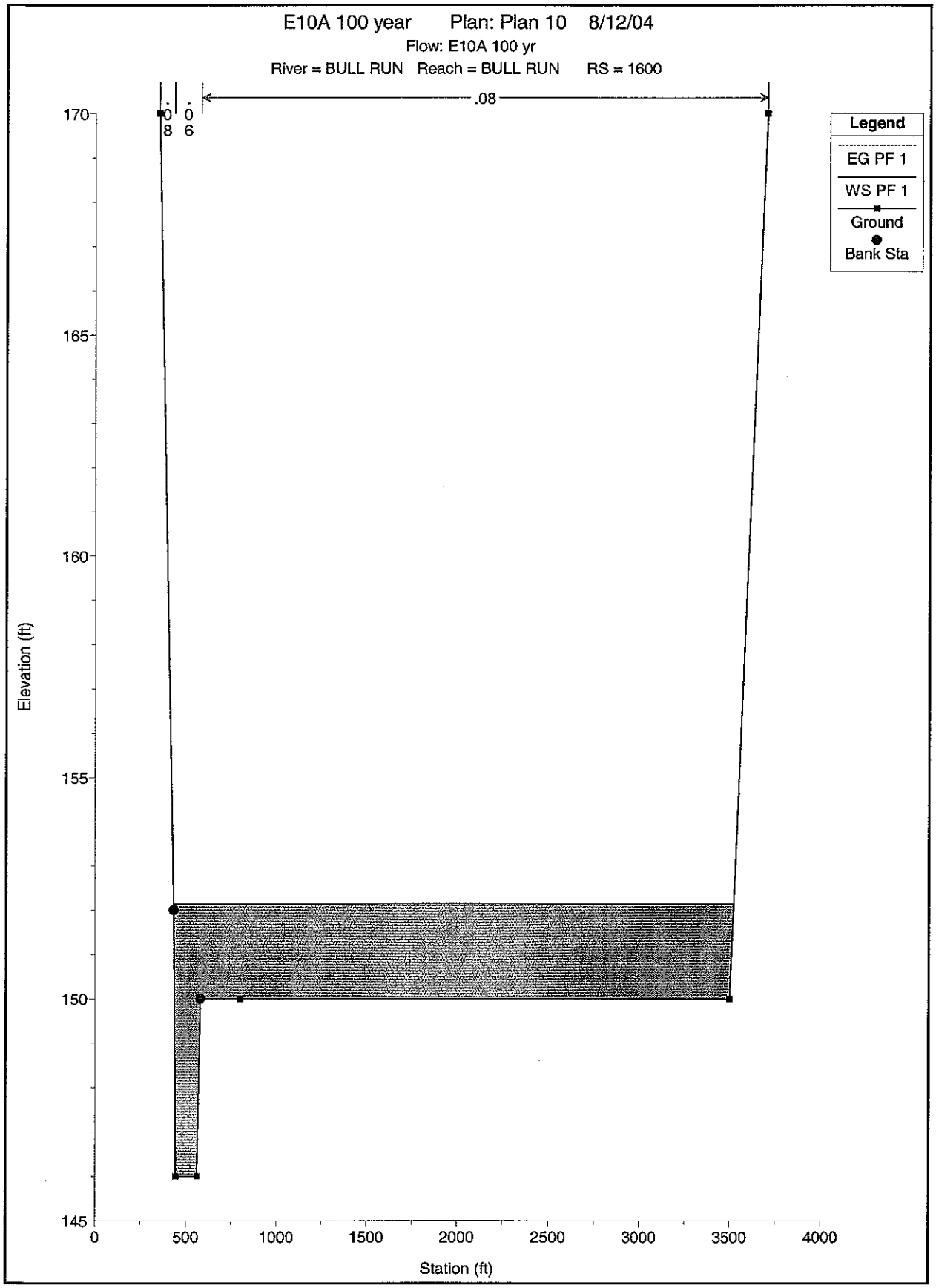
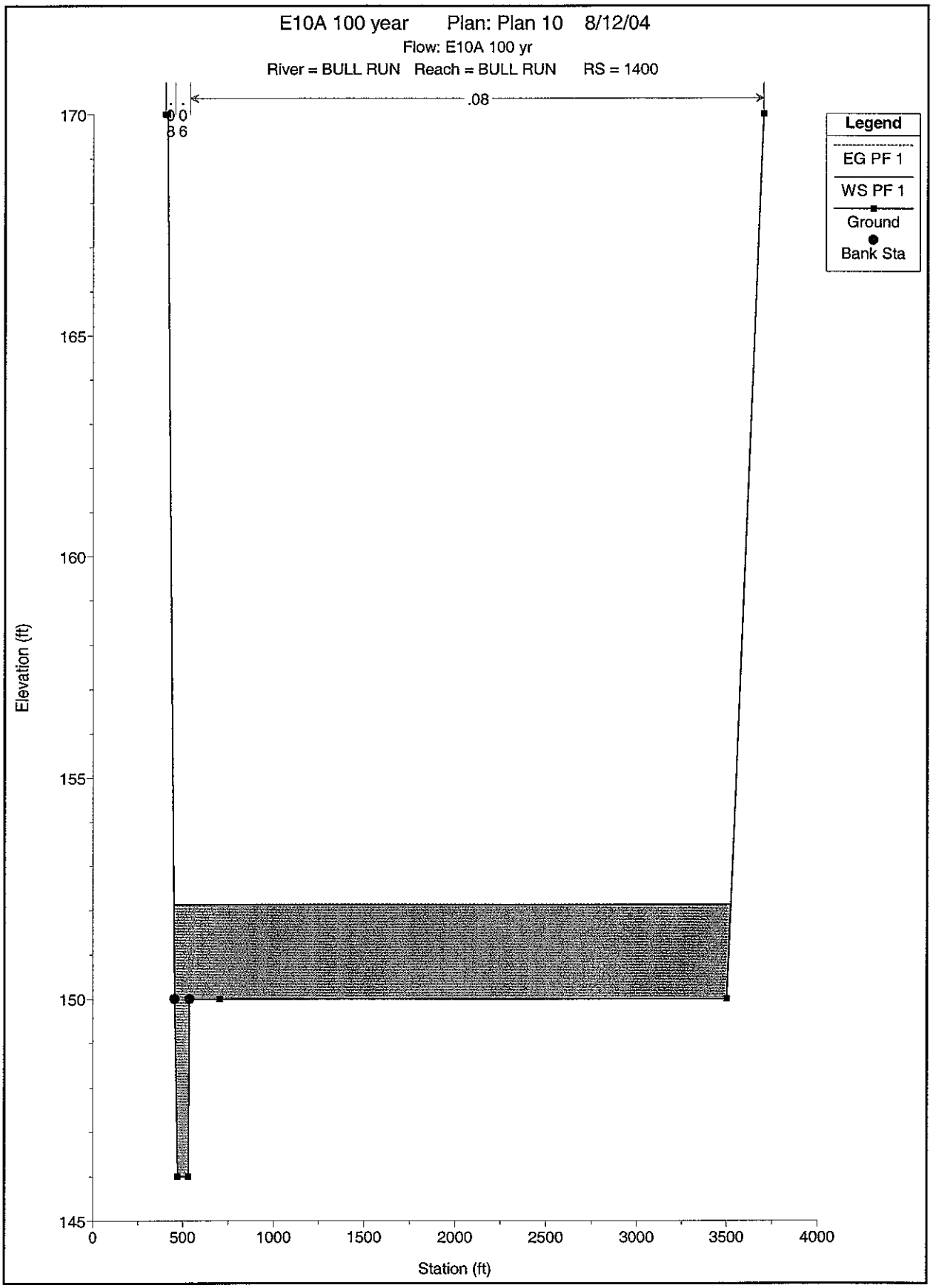
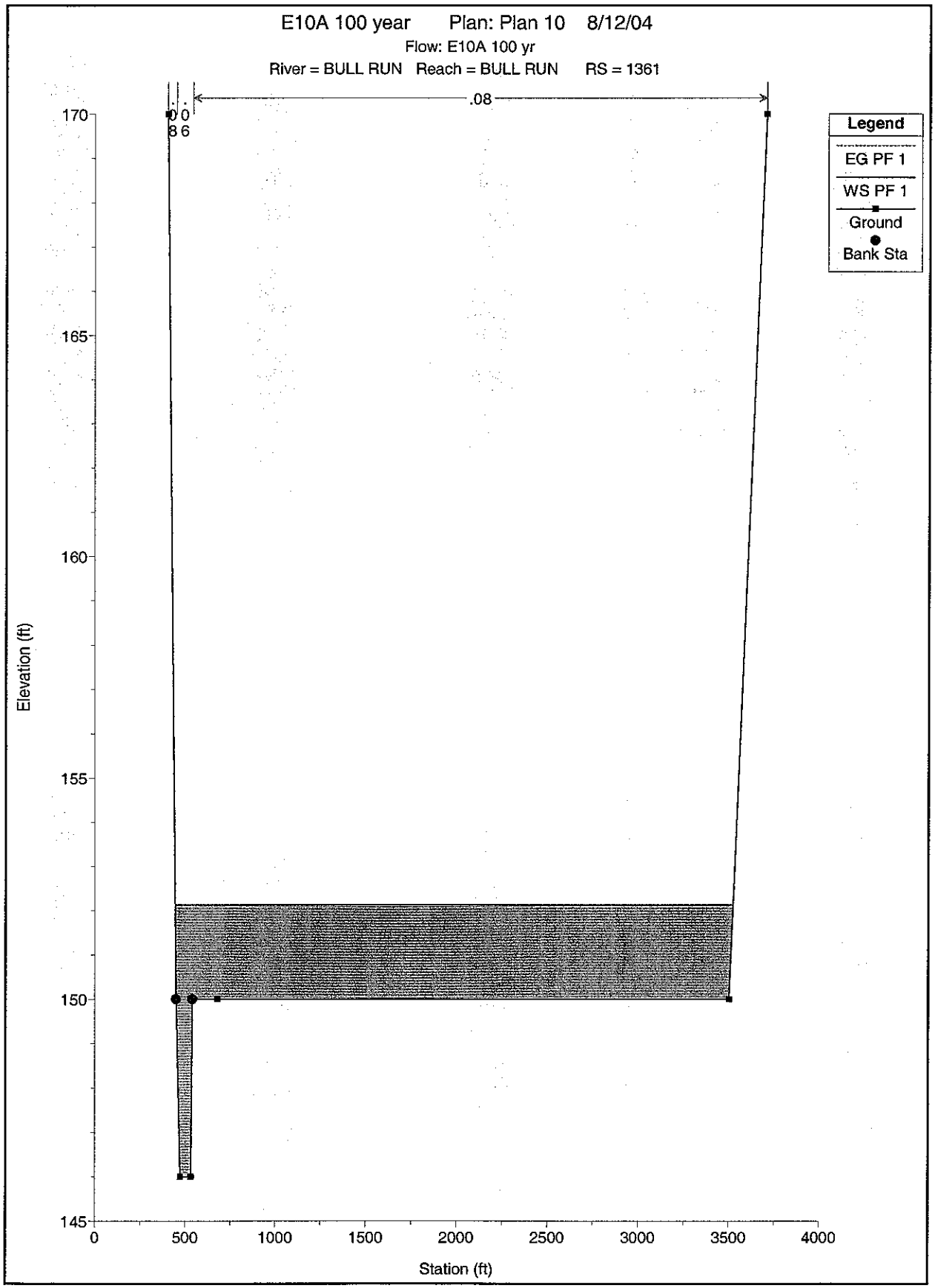
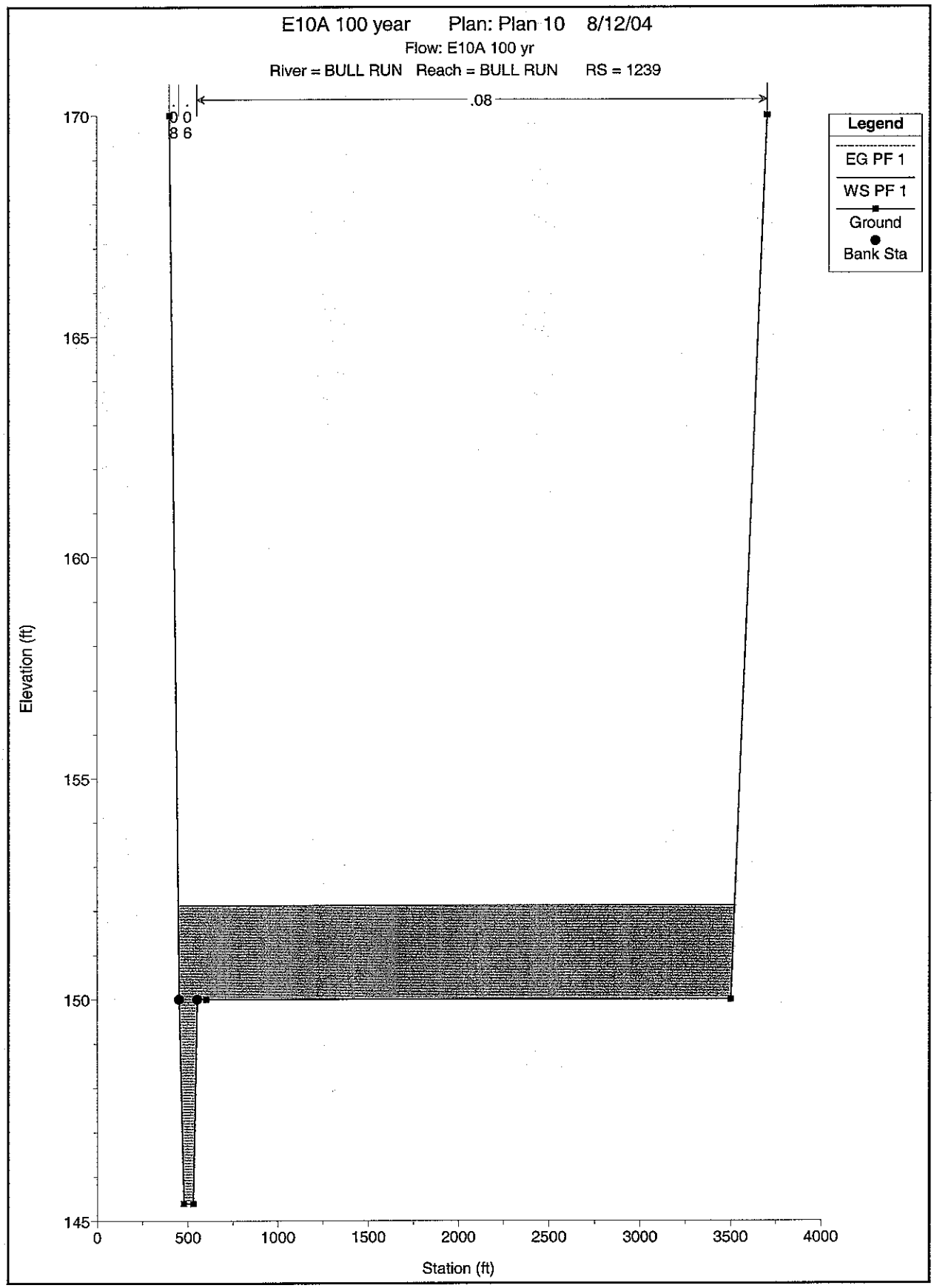
HEC-RAS Plan: Plan 10 River: BULL RUN Reach: BULL RUN Profile: PF 1

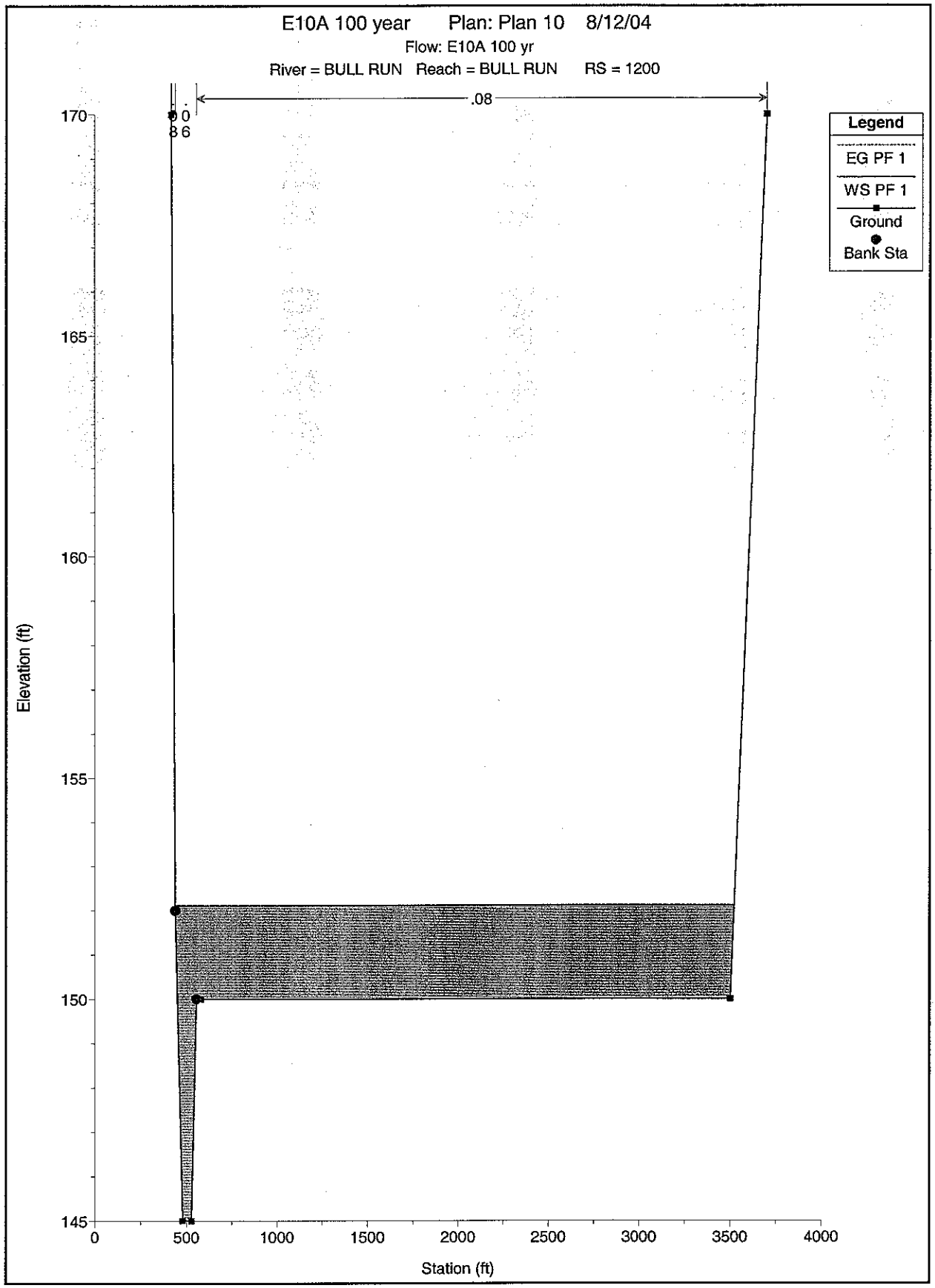
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BULL RUN	1600	2180.00	146.00	152.14		152.15	0.000071	0.66	7119.29	3091.07	0.05
BULL RUN	1400	2180.00	146.00	152.13		152.14	0.000089	0.73	6817.89	3072.94	0.05
BULL RUN	1361	2180.00	146.00	152.13		152.13	0.000088	0.71	6835.84	3079.19	0.05
BULL RUN	1239	2180.00	145.39	152.12		152.12	0.000085	0.72	6846.30	3076.51	0.05
BULL RUN	1200	2180.00	145.00	152.12		152.12	0.000084	0.69	6874.13	3082.31	0.05
BULL RUN	1000	2180.00	144.00	152.10	147.66	152.10	0.000085	0.80	6768.01	3052.30	0.05

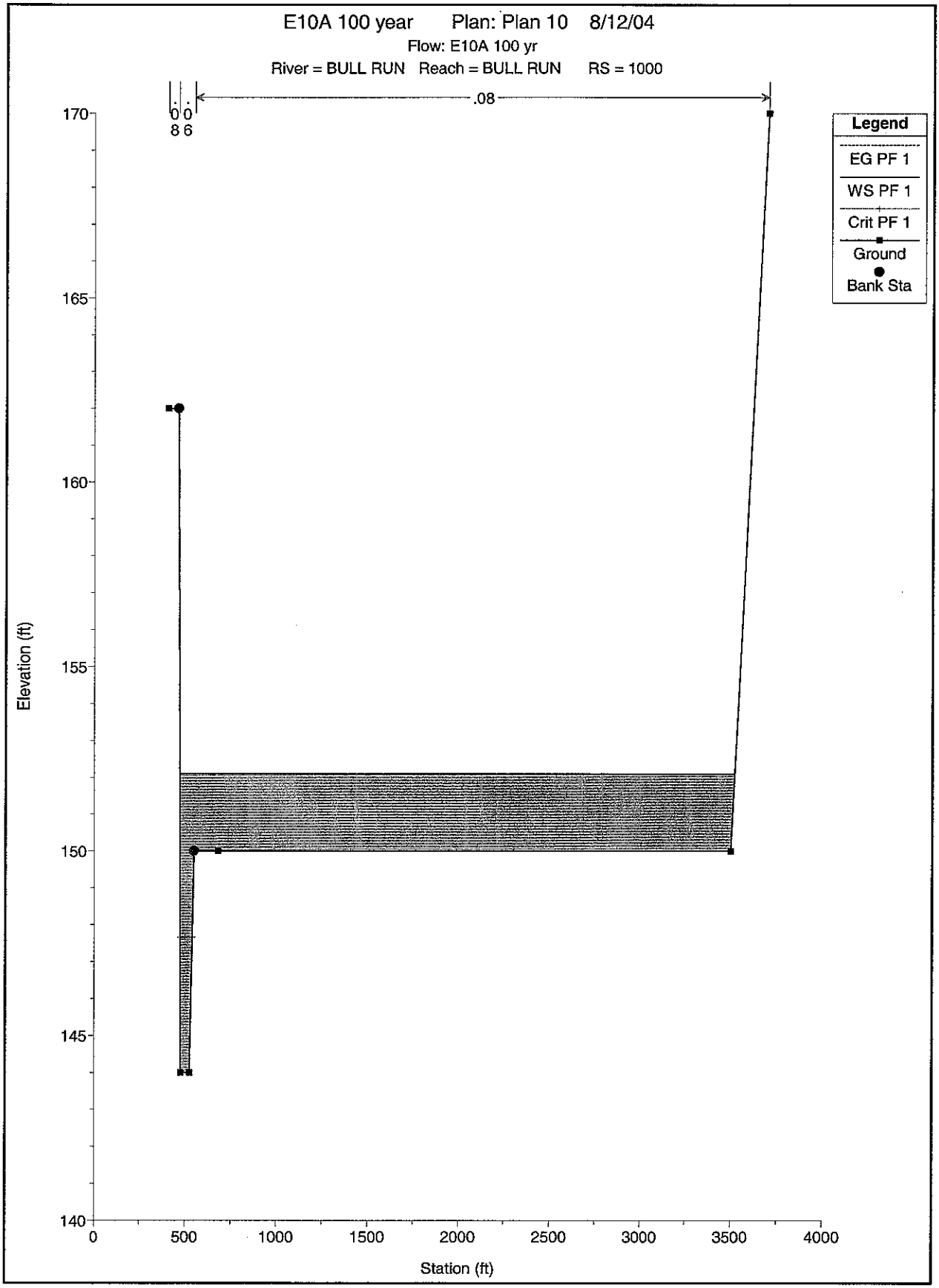

E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1600
.08
.08
.06
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1400
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1361
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000

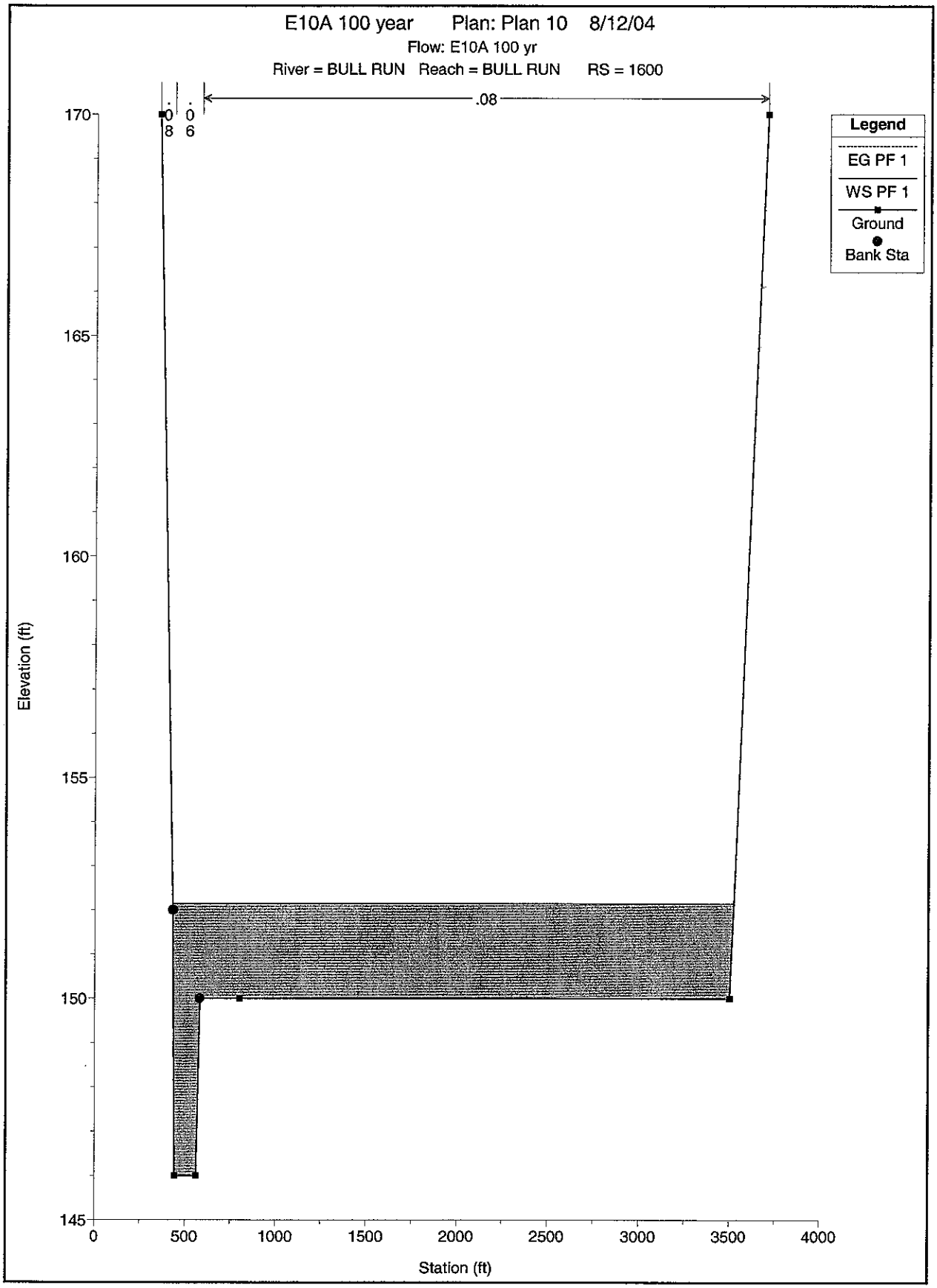

E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1239
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000

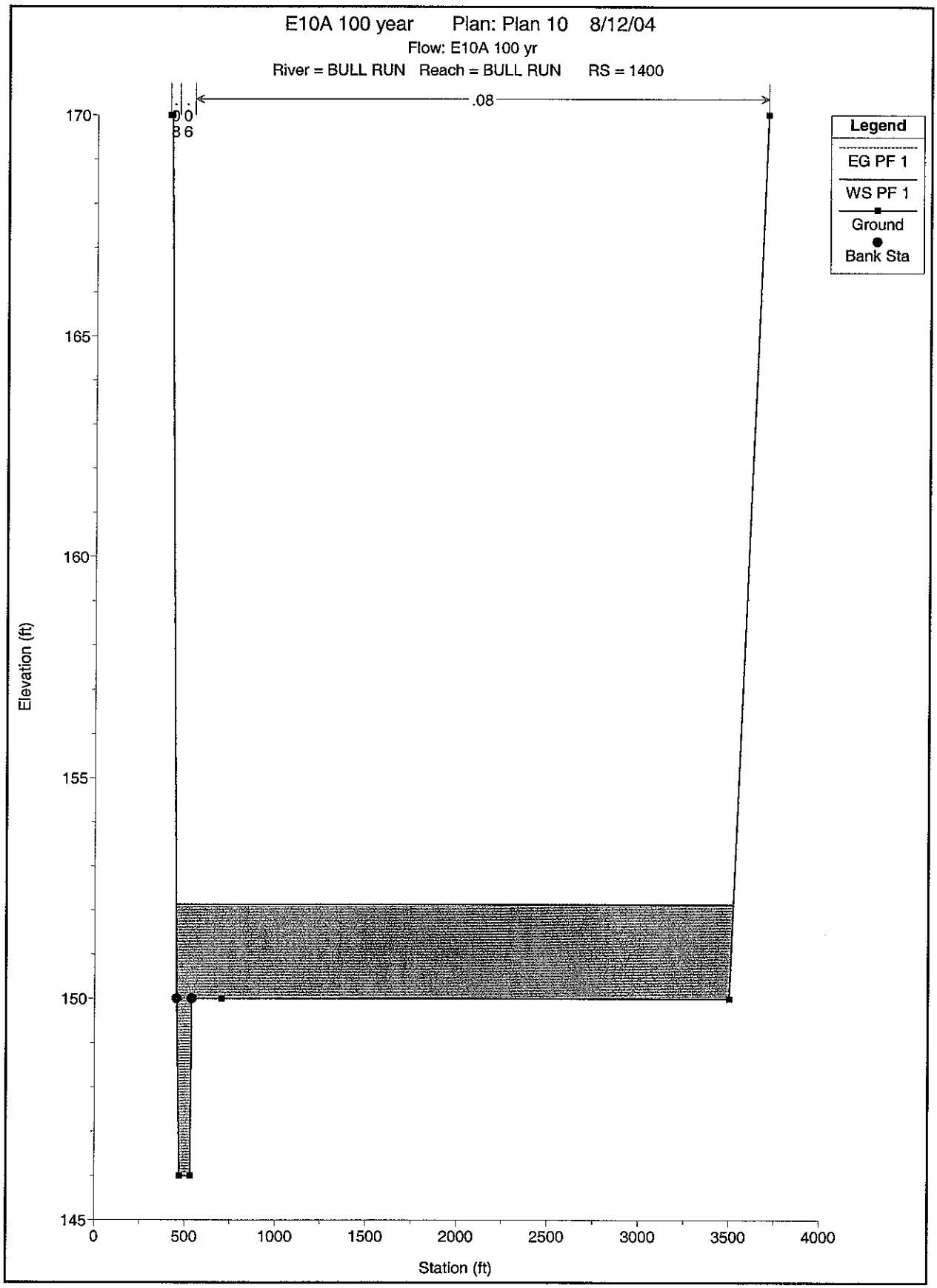

E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1200
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000

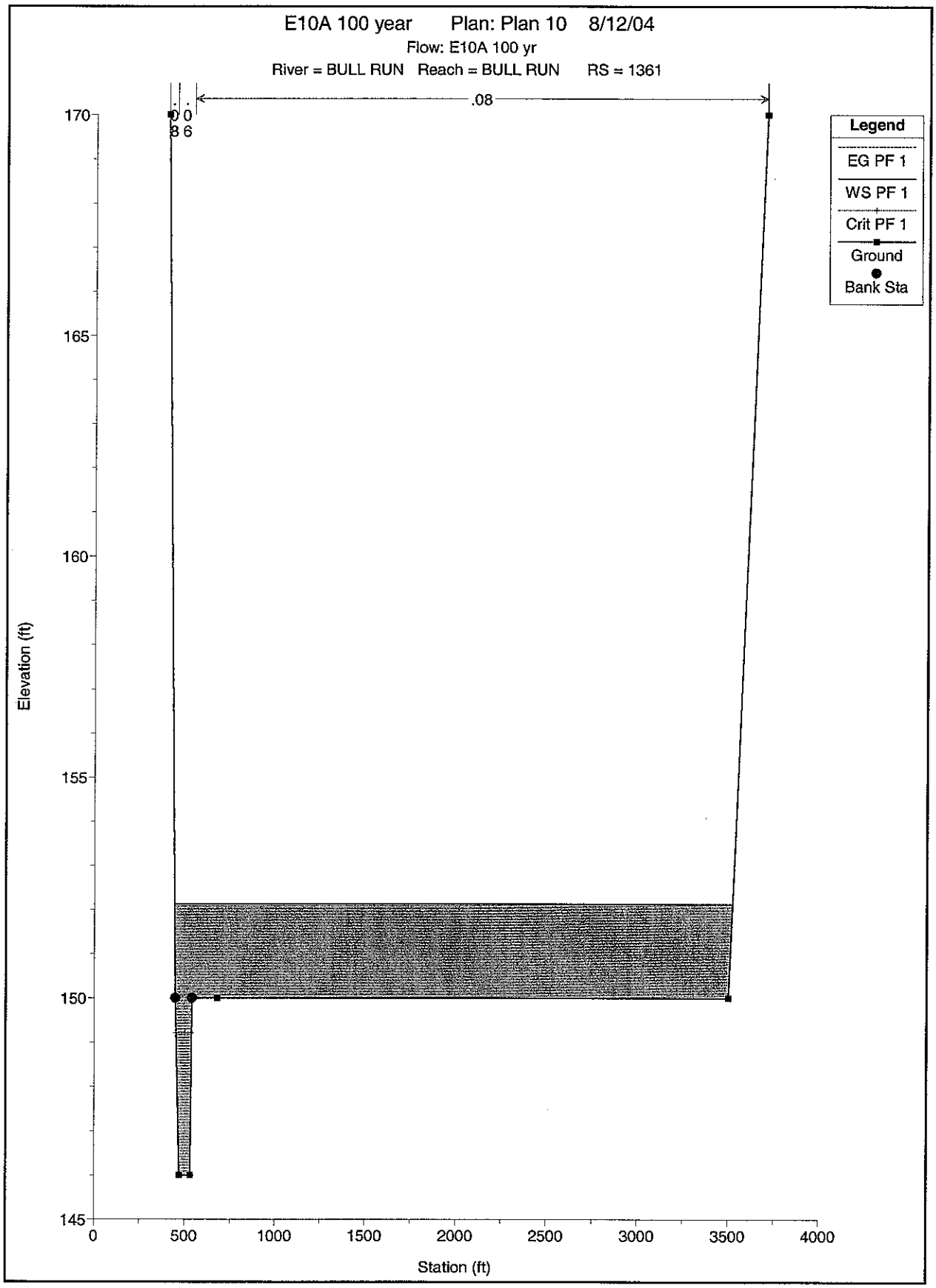

E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1000
.08
.06
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
140
0
500
1000
1500
2000
2500
3000
3500
4000

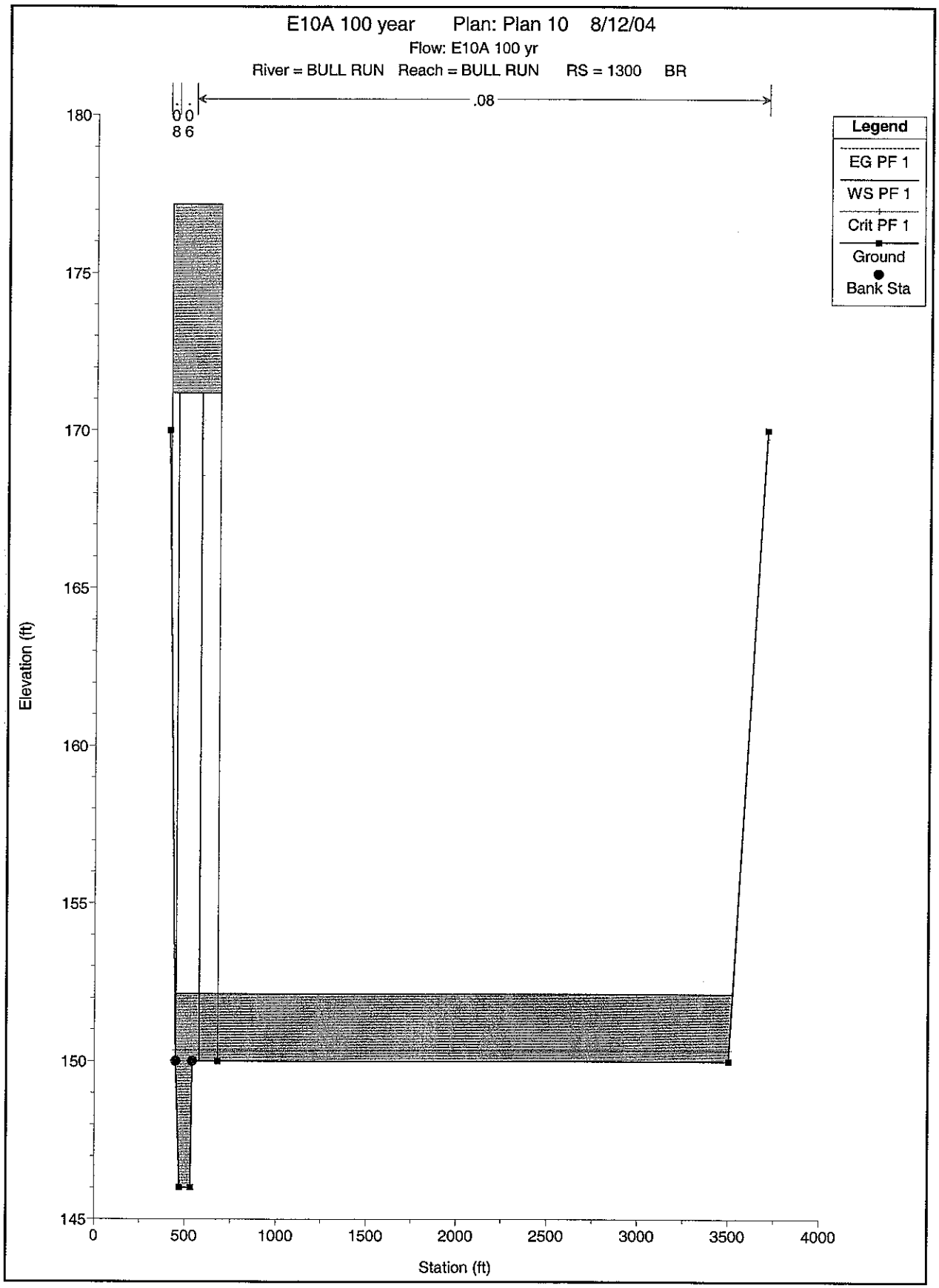
HEC-RAS Plan: Plan 10 River: BULL RUN Reach: BULL RUN Profile: PF 1

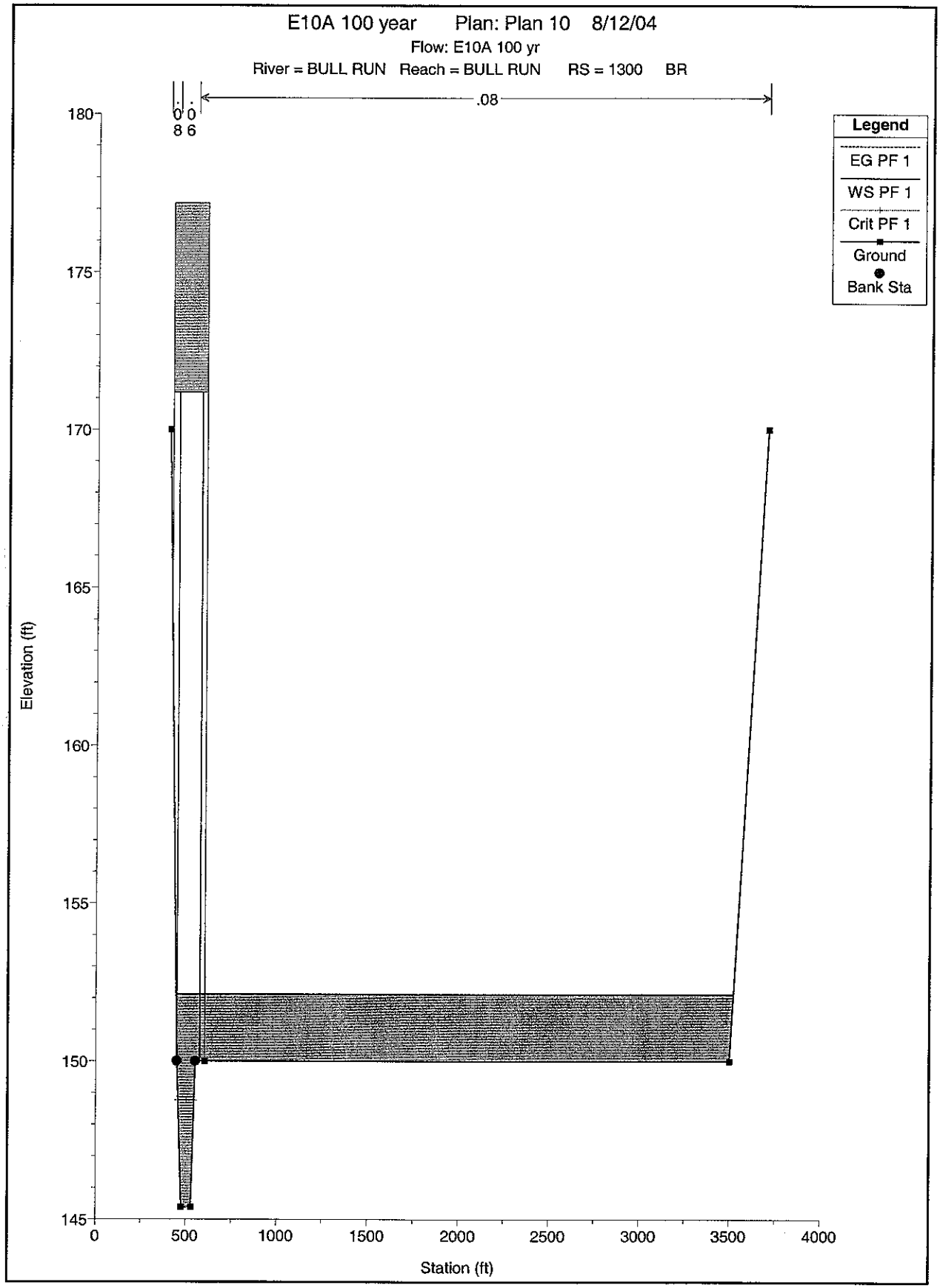
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BULL RUN	1600	2180.00	146.00	152.14		152.15	0.000071	0.66	7119.81	3091.08	0.05
BULL RUN	1400	2180.00	146.00	152.13		152.14	0.000089	0.73	6818.41	3072.94	0.05
BULL RUN	1361	2180.00	146.00	152.13	149.21	152.13	0.000088	0.71	6836.35	3079.19	0.05
BULL RUN	1300	Bridge									
BULL RUN	1239	2180.00	145.39	152.12		152.12	0.000085	0.72	6846.30	3076.51	0.05
BULL RUN	1200	2180.00	145.00	152.12		152.12	0.000084	0.69	6874.13	3082.31	0.05
BULL RUN	1000	2180.00	144.00	152.10	147.66	152.10	0.000085	0.80	6768.01	3052.30	0.05

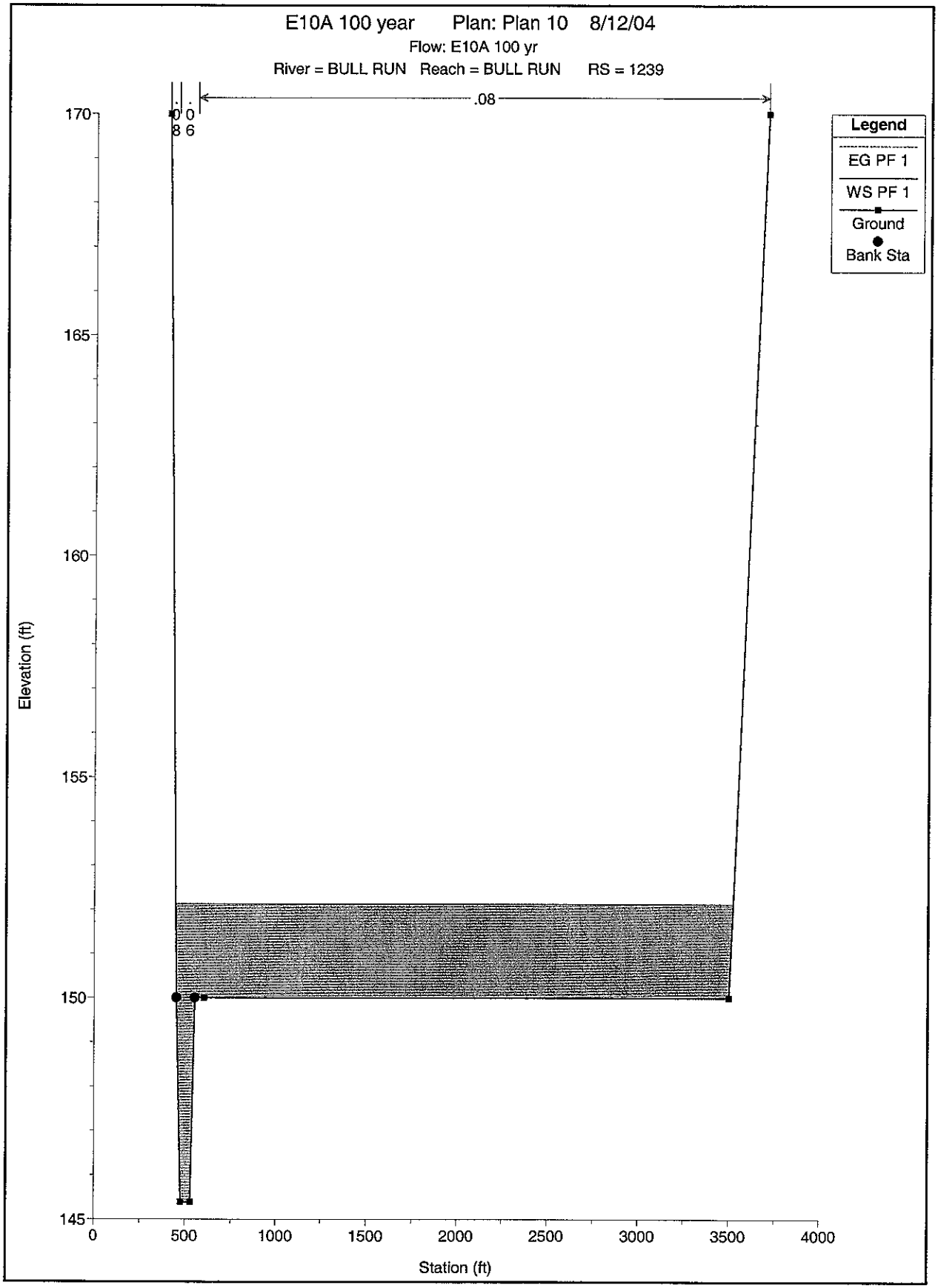

E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1600
.08
.08
.06
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)

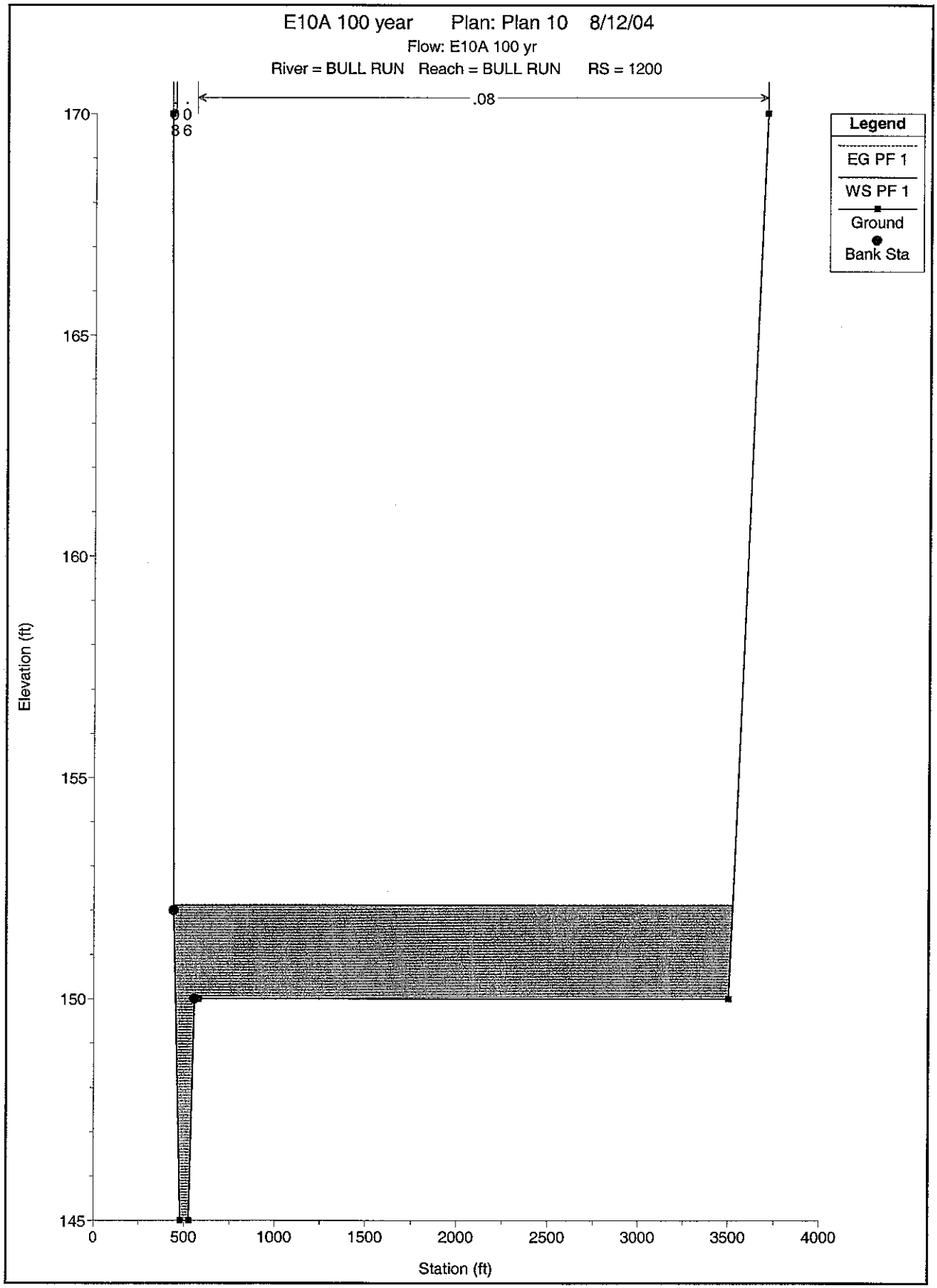

E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1400
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1361
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1300 BR
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
180
175
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1300 BR
.08
.06
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
180
175
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1239
.08
.06
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)


E10A 100 year Plan: Plan 10 8/12/04
Flow: E10A 100 yr
River = BULL RUN Reach = BULL RUN RS = 1200
.08
.0
86
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
170
165
160
155
150
145
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING E10B

PART 1: Plan Sheet

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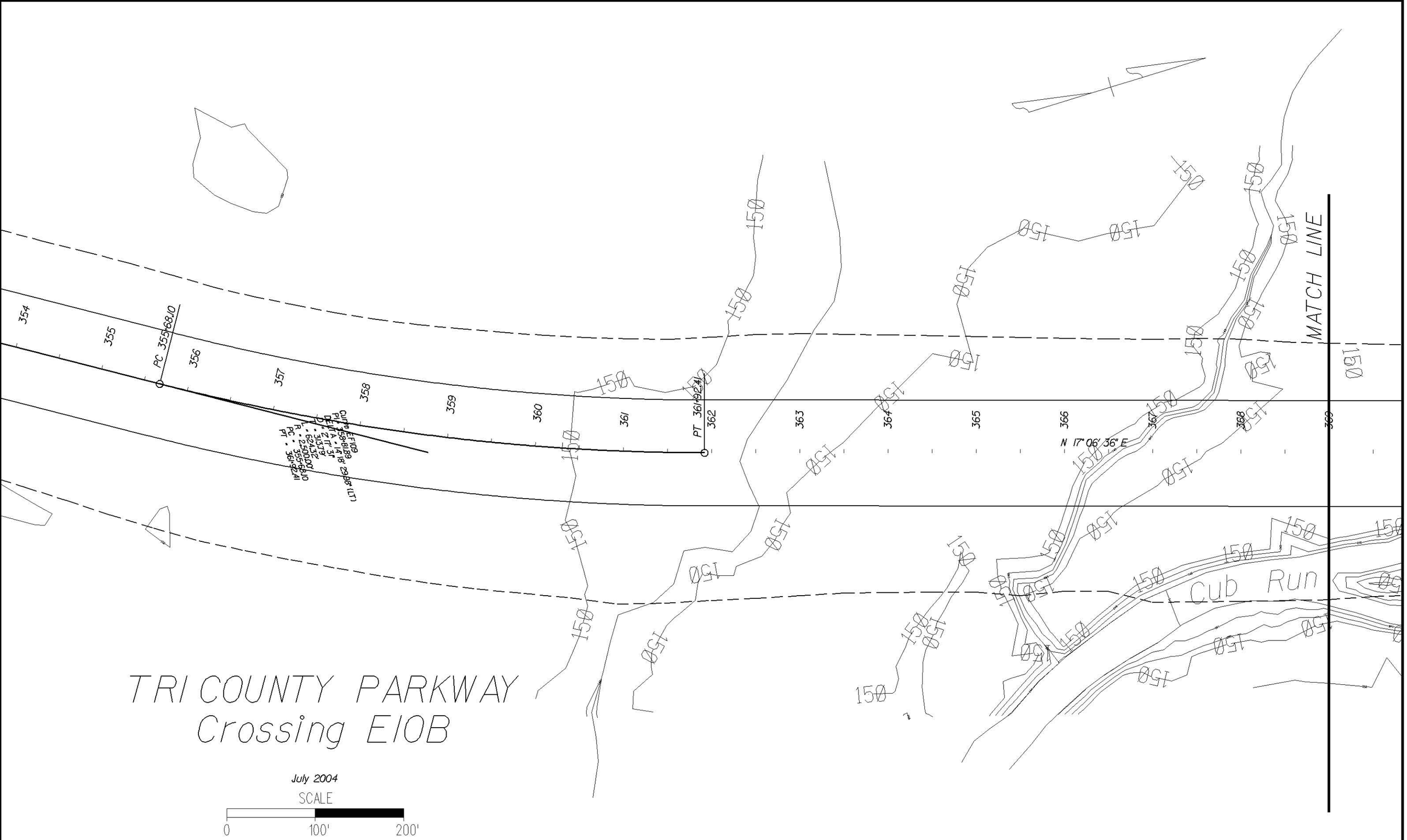


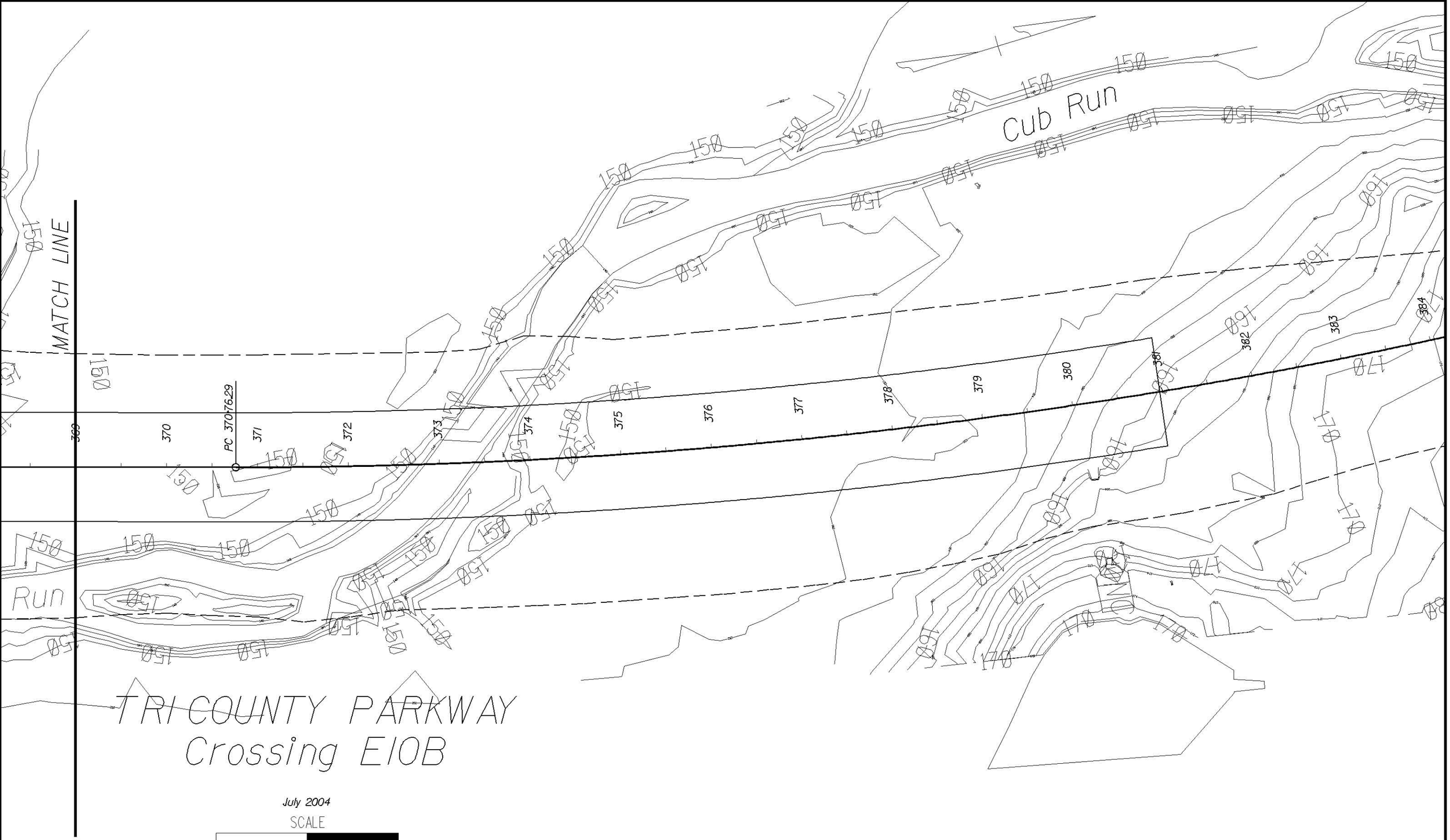
TRI COUNTY PARKWAY
Crossing E10B

July 2004

SCALE

0 100' 200'

Sheet 1 of 2


MATCH LINE
Cub Run
Run
PC 37+76.29
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
150
160
170
TRI COUNTY PARKWAY
Crossing E10B
July 2004
SCALE
0
100'
200'
Sheet 2 of 2

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F1-A

PART 1: Plan Sheet

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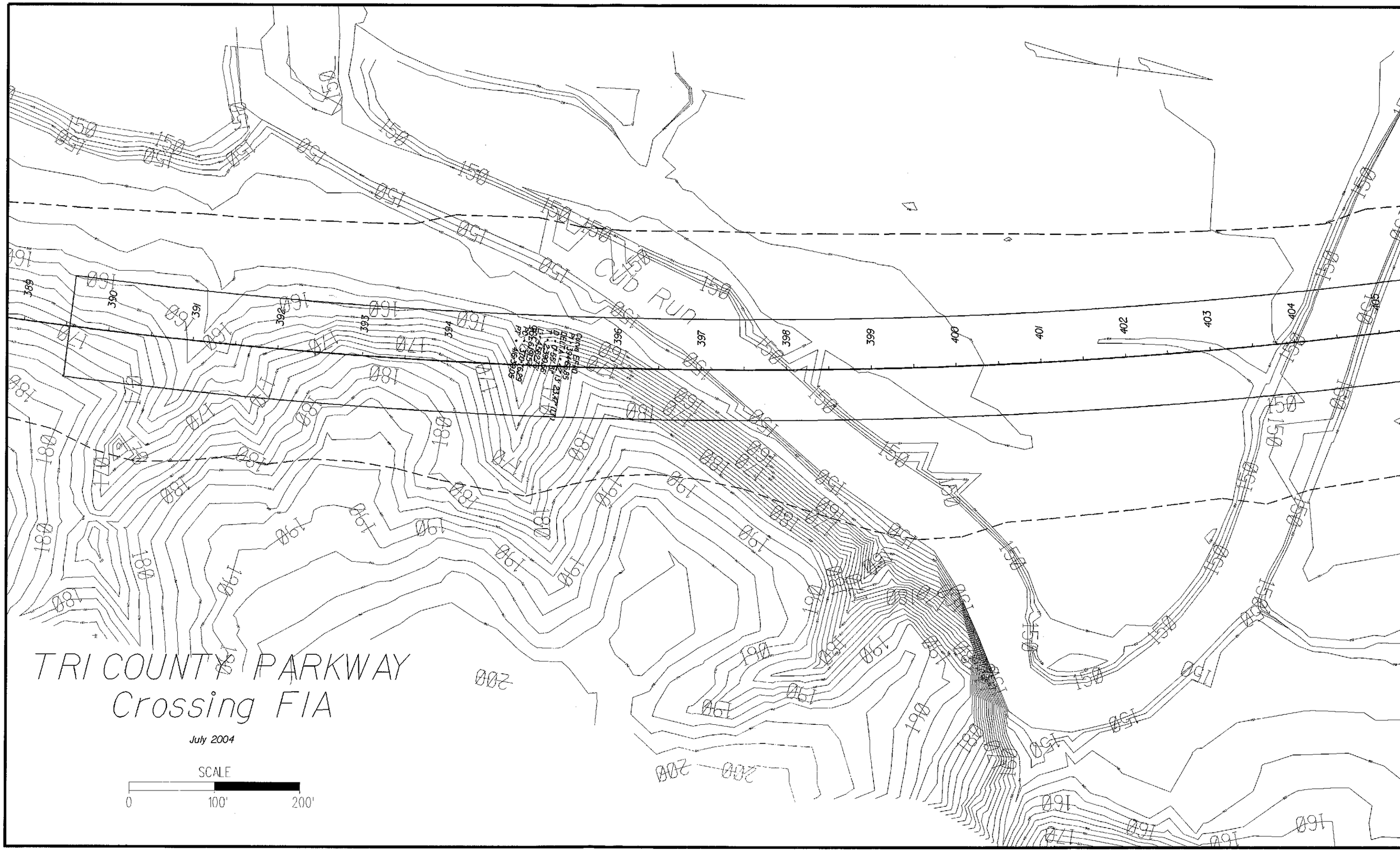

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F1B,C

PART 1: Plan Sheet

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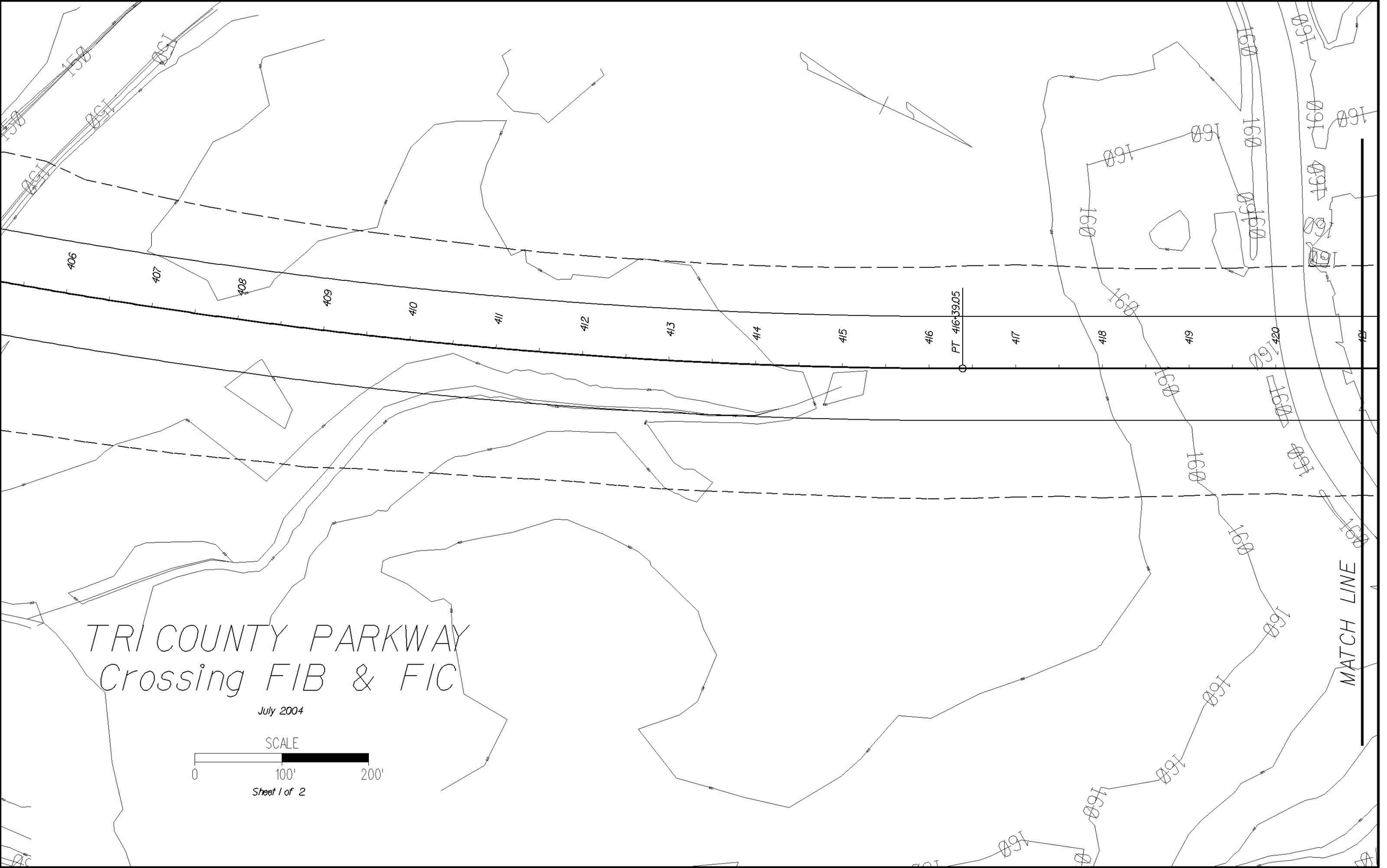
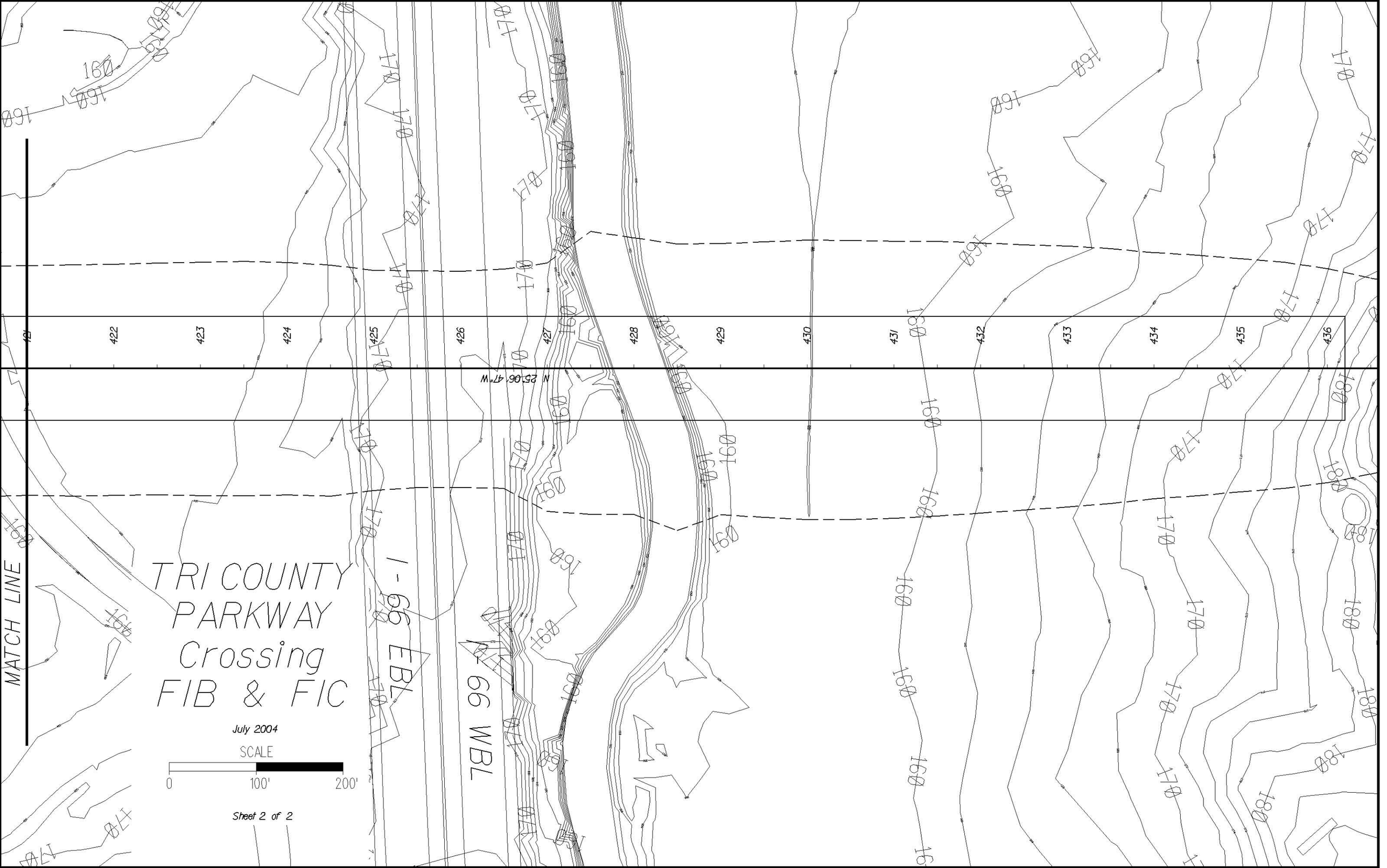

TRI COUNTY PARKWAY
Crossing FIB & FIC
July 2004
SCALE
0
100'
200'
Sheet 1 of 2
MATCH LINE
PT 416+39.05
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
160
158


TRI COUNTY
PARKWAY
Crossing
FIB & FIC
July 2004
SCALE
0
100'
200'
Sheet 2 of 2
MATCH LINE
I-66 EBL
I-66 WBL
N 25°06' 47"W
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
160
170
180

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F6

PART 1: Plan Sheet

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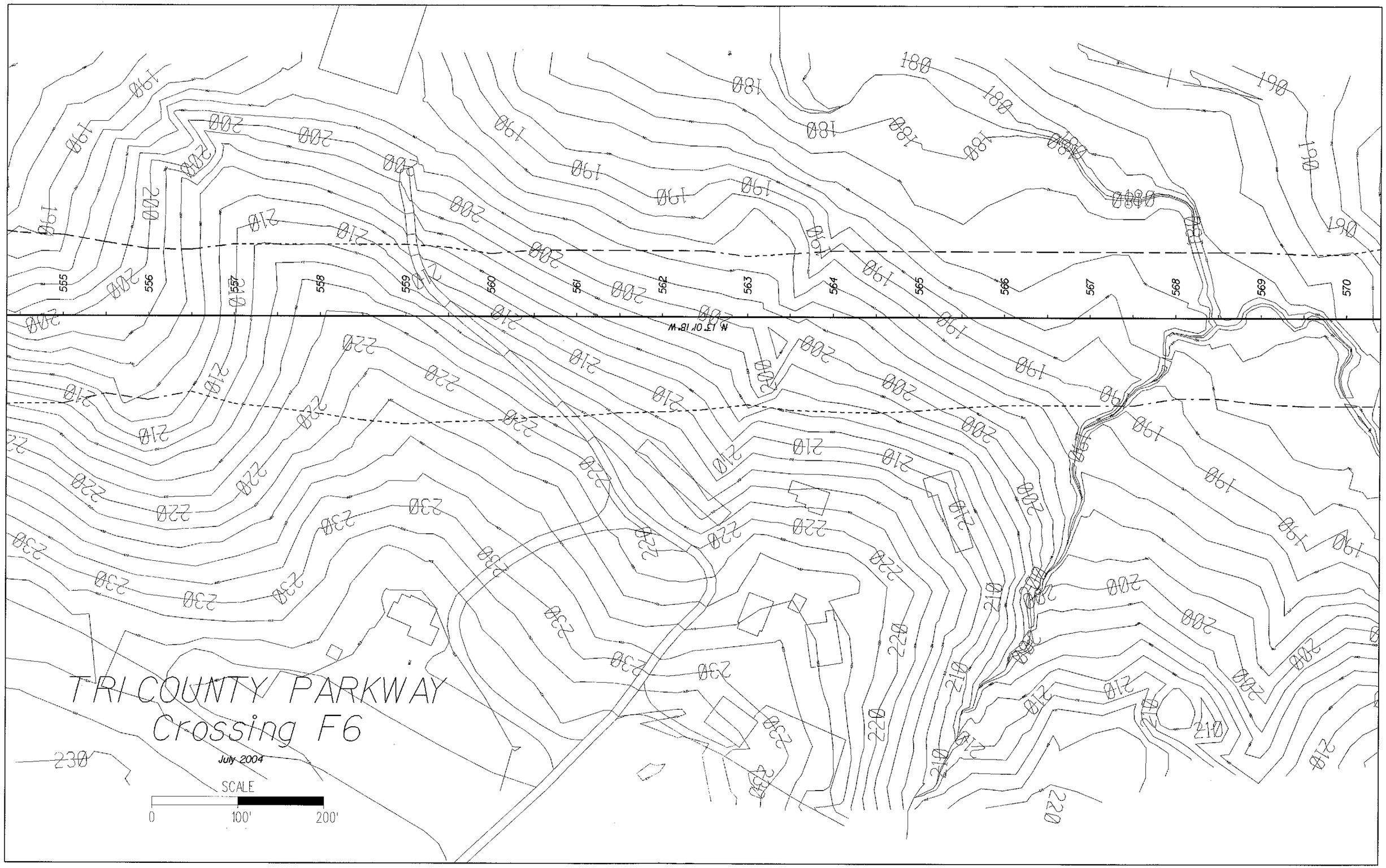

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F9

PART 1: Plan Sheet

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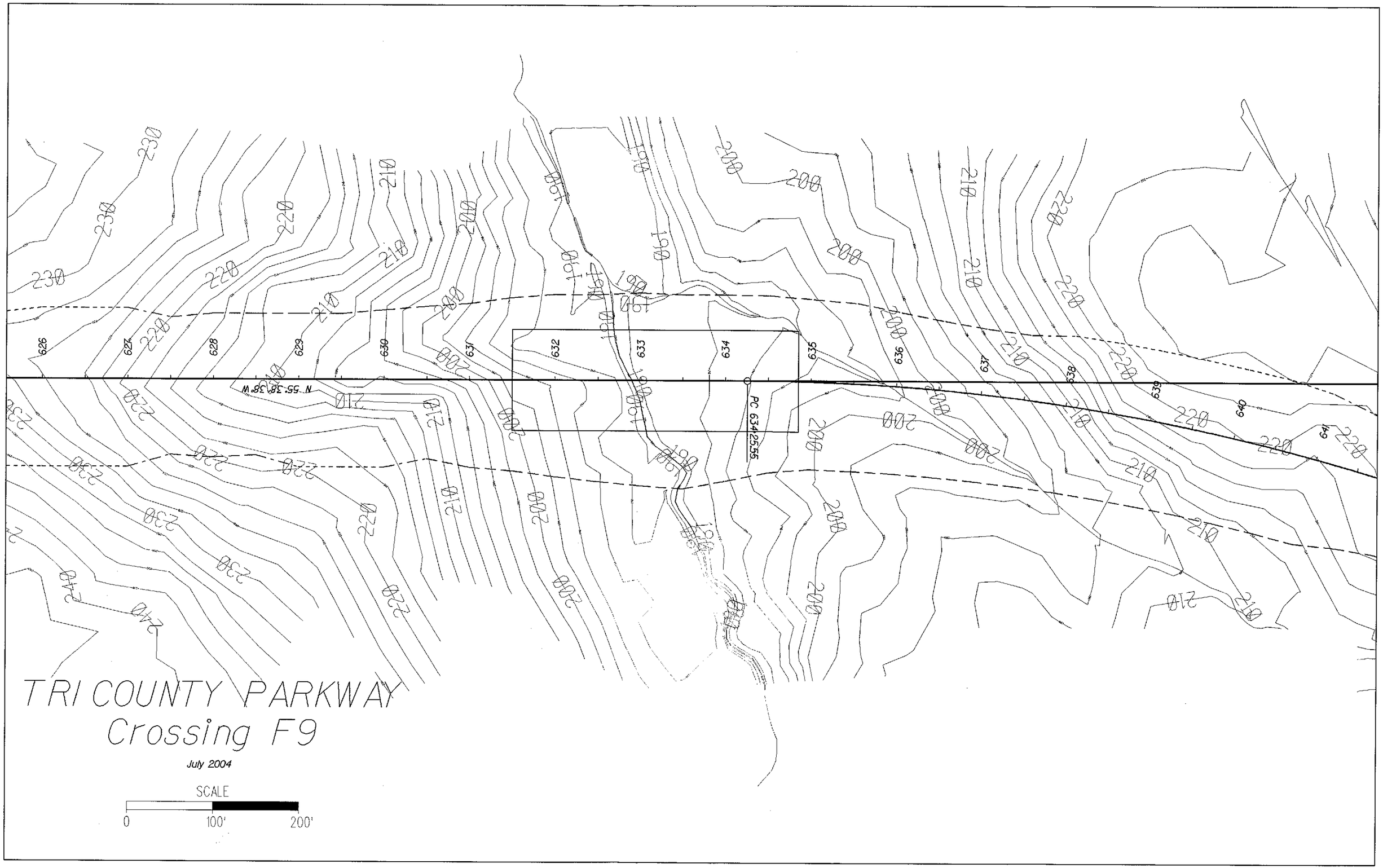

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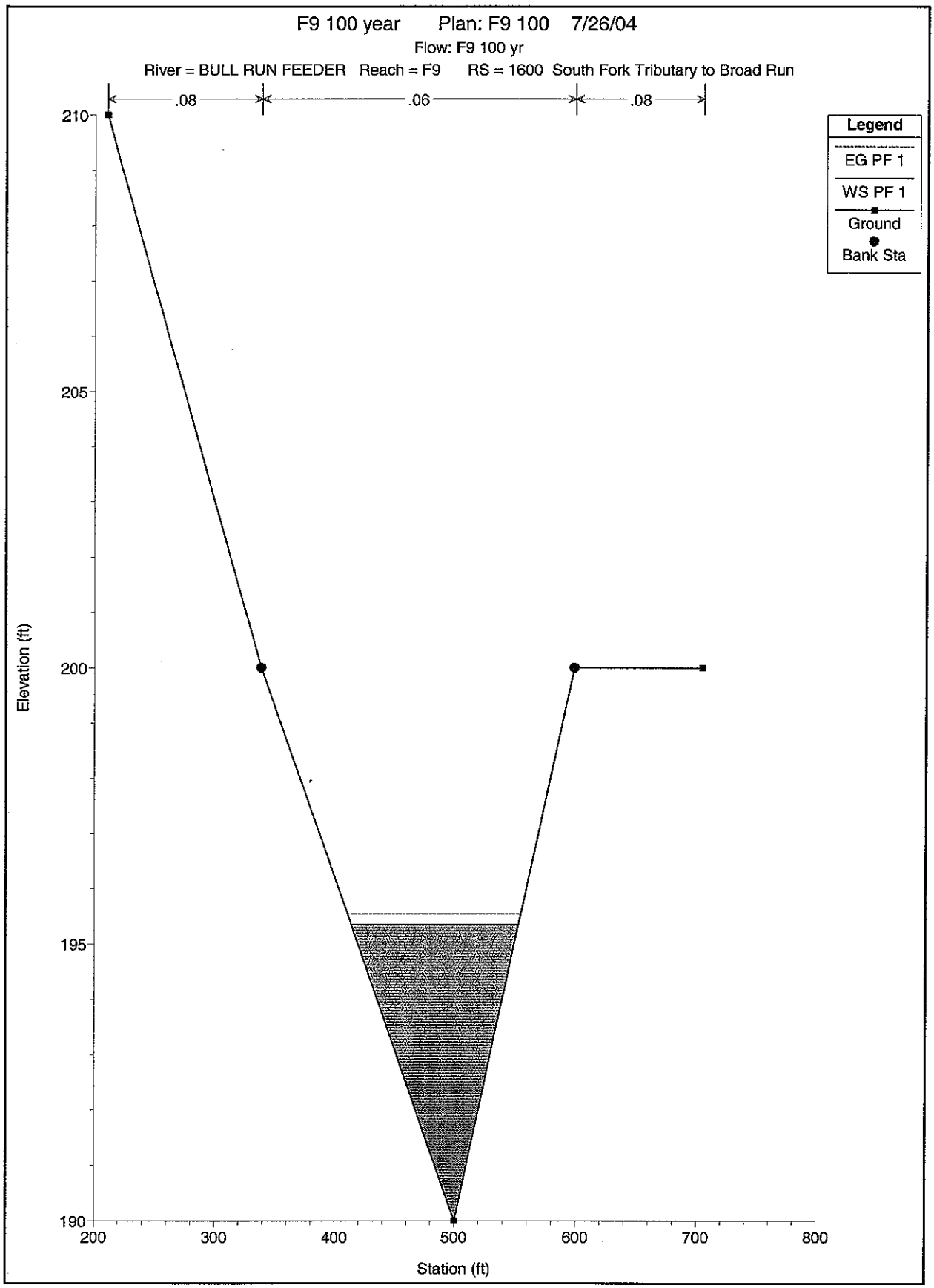
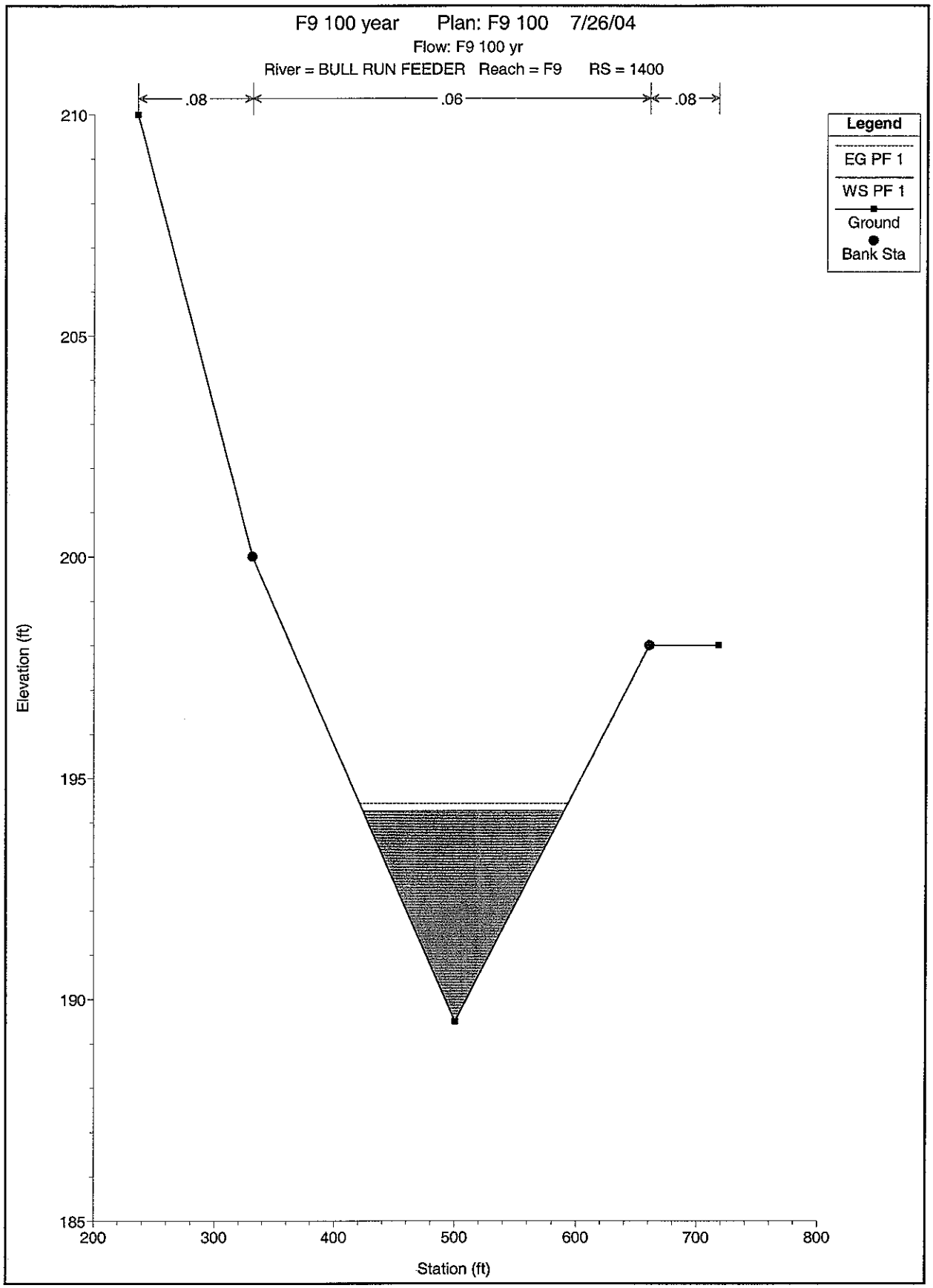
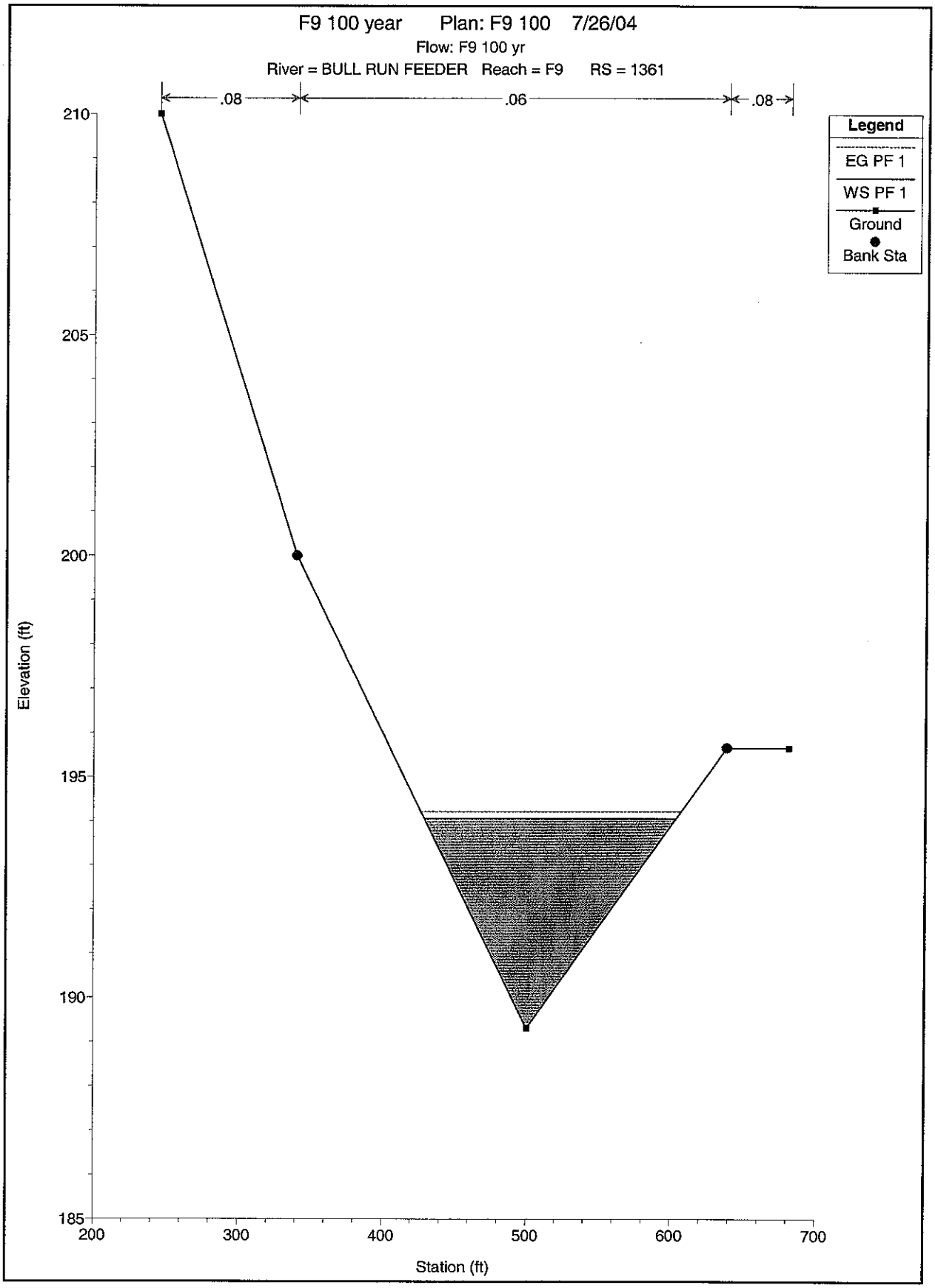
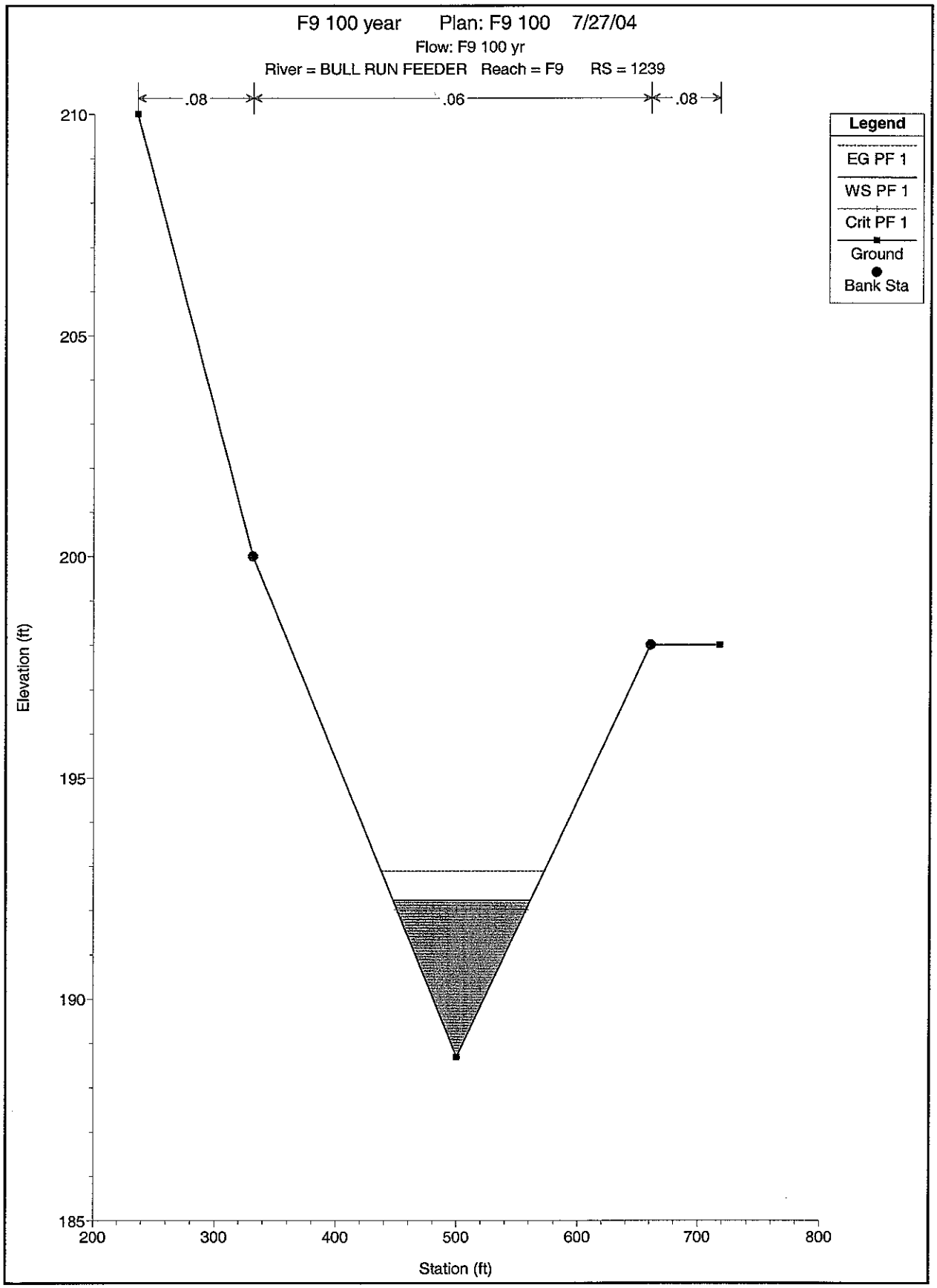
HEC-RAS Plan: F9 River: BULL RUN FEEDER Reach: F9 Profile: PF 1

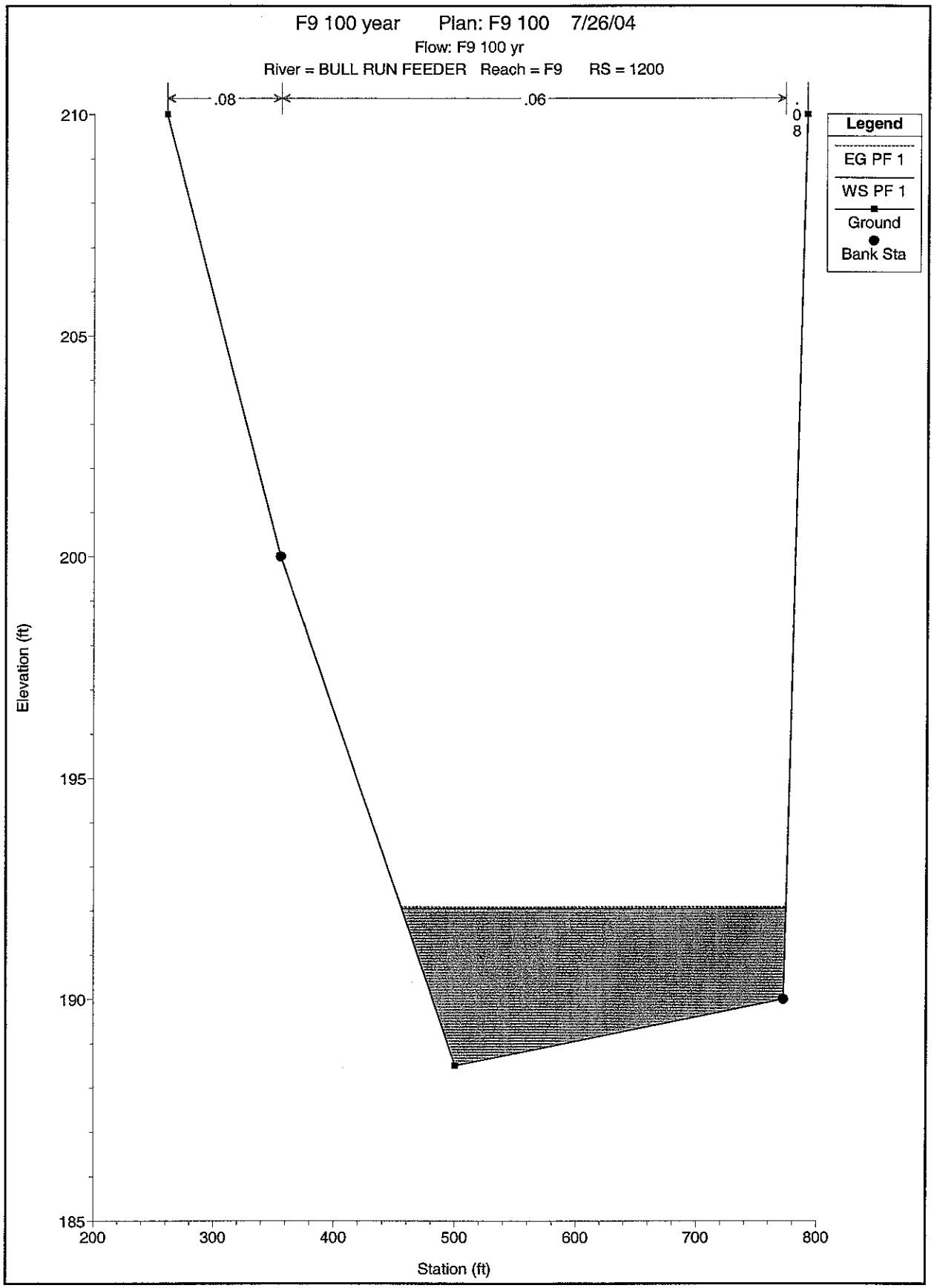
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
F9	1600	1310.00	190.00	195.35		195.55	0.005446	3.52	372.58	139.19	0.38
F9	1400	1310.00	189.50	194.26		194.43	0.005625	3.31	395.96	166.29	0.38
F9	1361	1310.00	189.31	194.06		194.22	0.005116	3.15	415.35	174.55	0.36
F9	1239	1310.00	188.70	192.23	192.01	192.89	0.032412	6.51	201.14	113.72	0.86
F9	1200	1310.00	188.50	192.05		192.09	0.001071	1.55	843.99	318.65	0.17
F9	1000	1310.00	188.00	190.61	190.61	191.38	0.044714	7.03	187.64	125.15	0.99

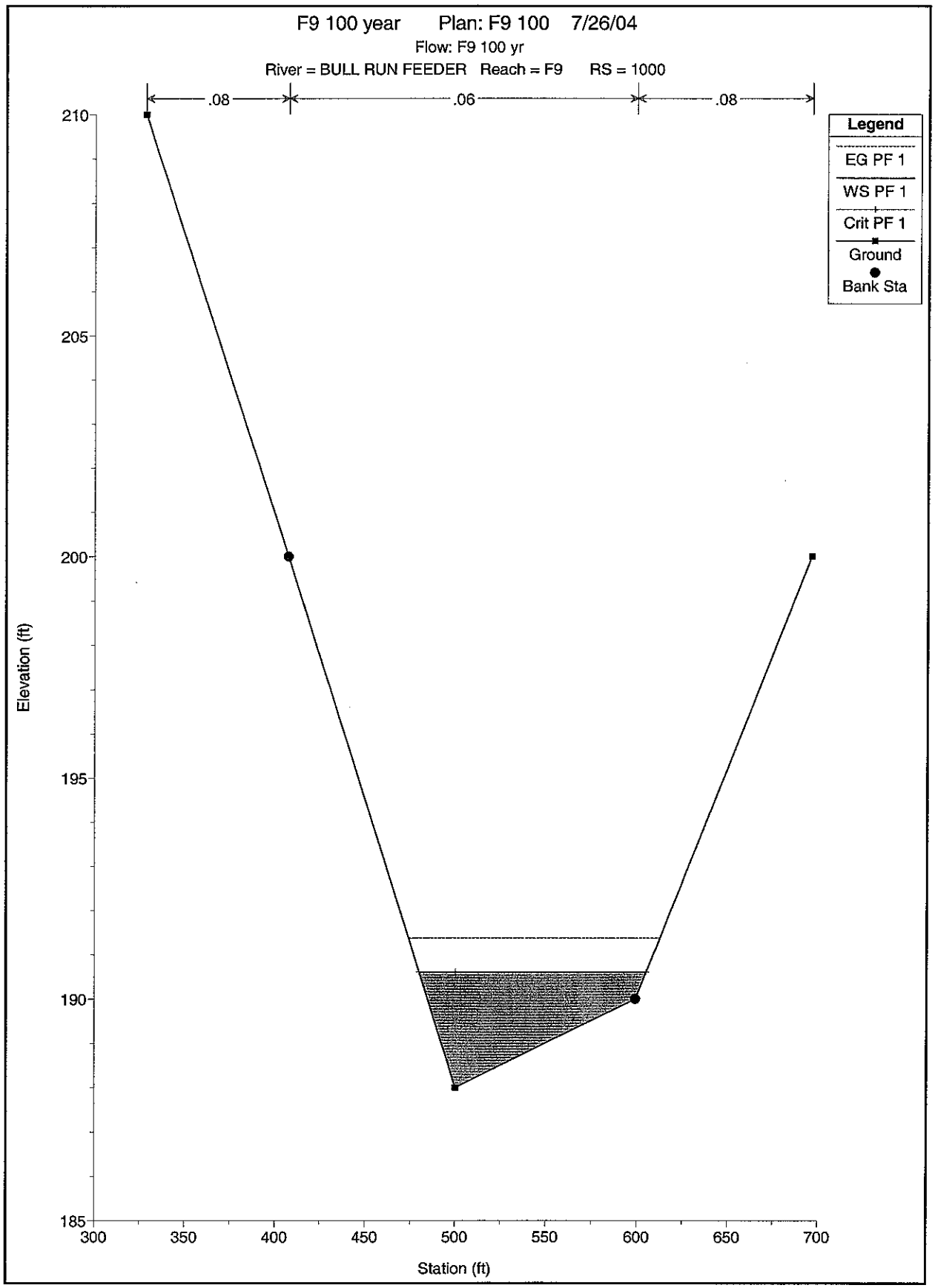

F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1600 South Fork Tributary to Broad Run
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
200
300
400
500
600
700
800
Station (ft)


F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)


F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
Station (ft)

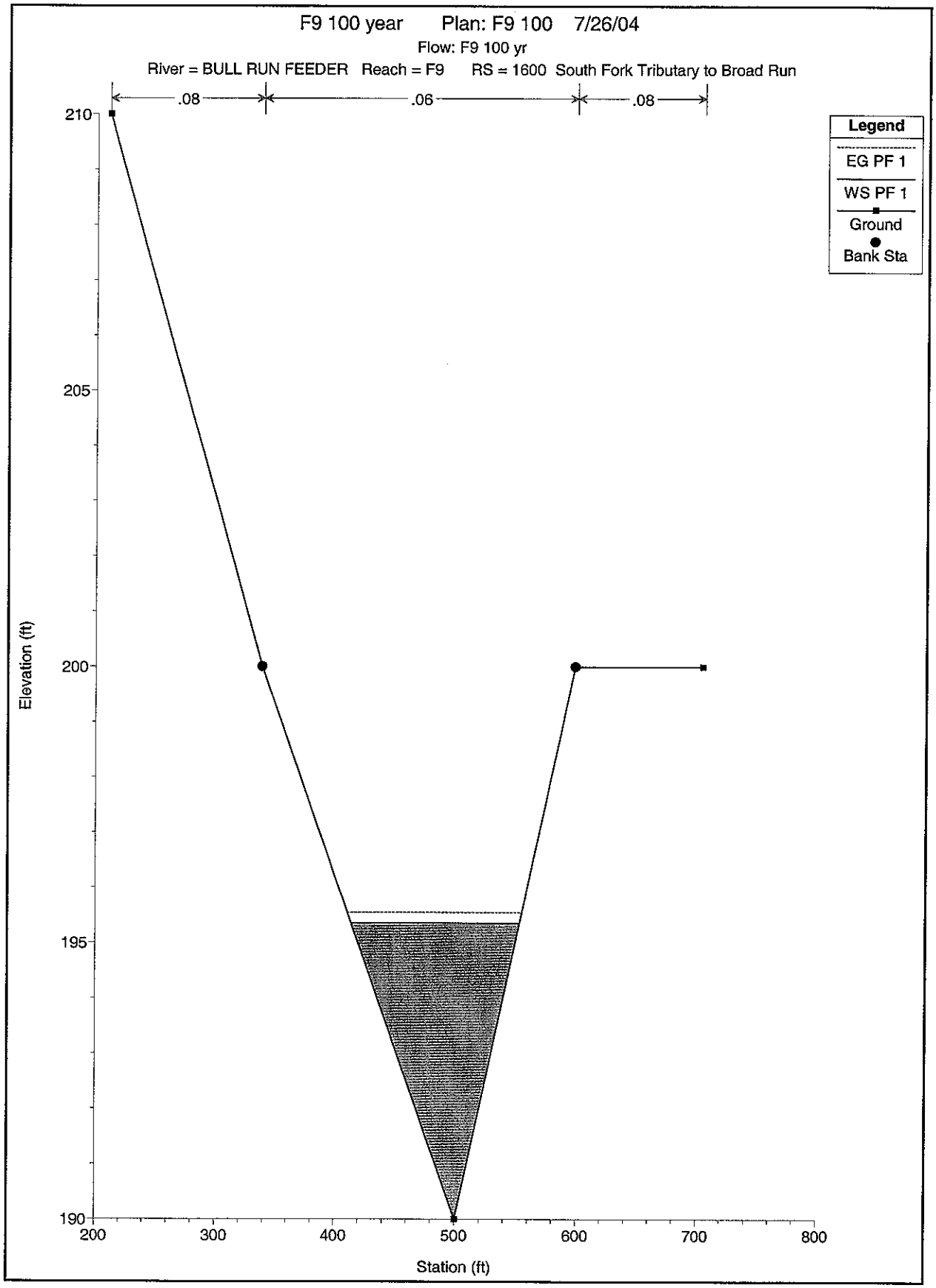

F9 100 year Plan: F9 100 7/27/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)

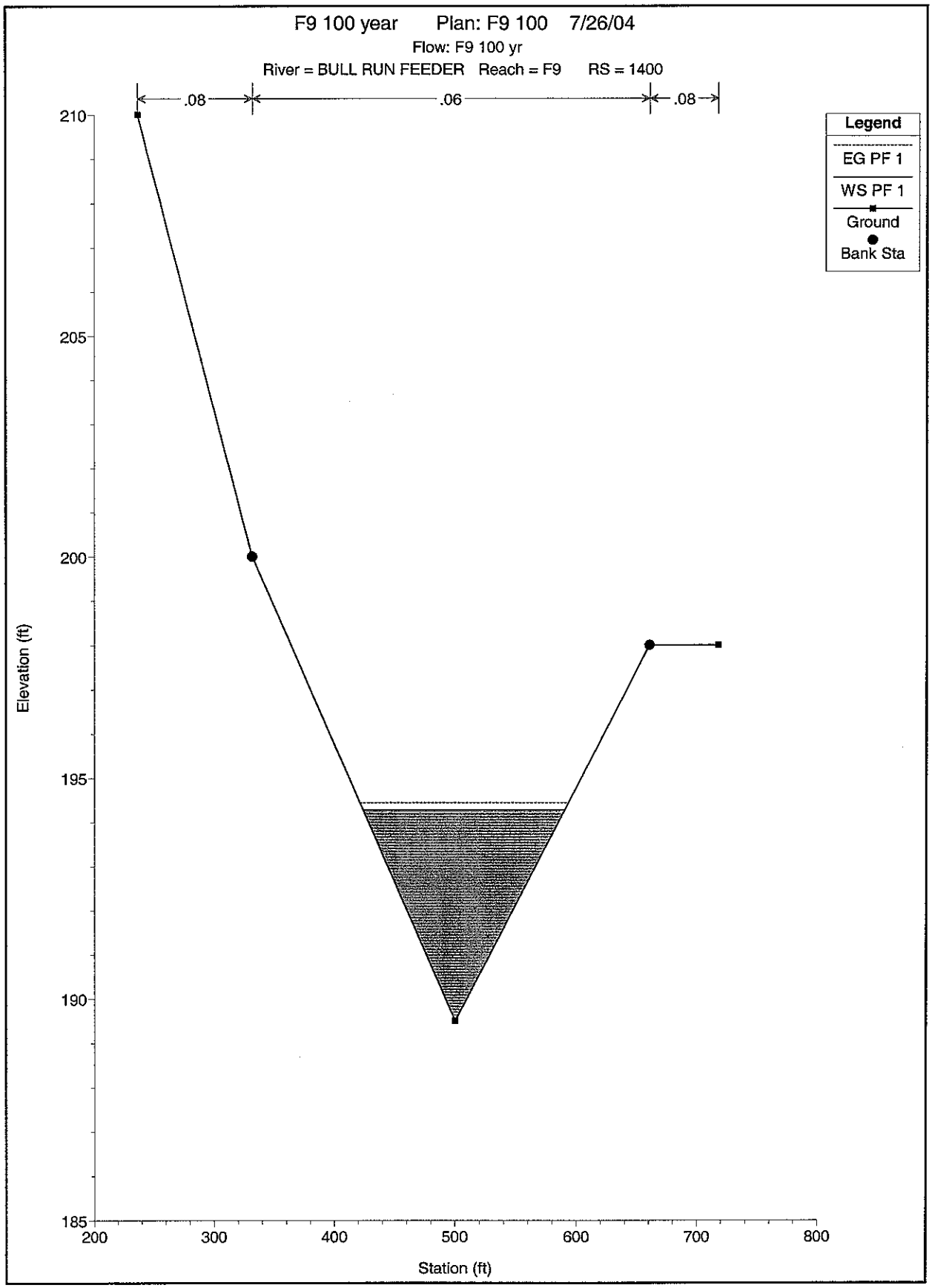

F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)

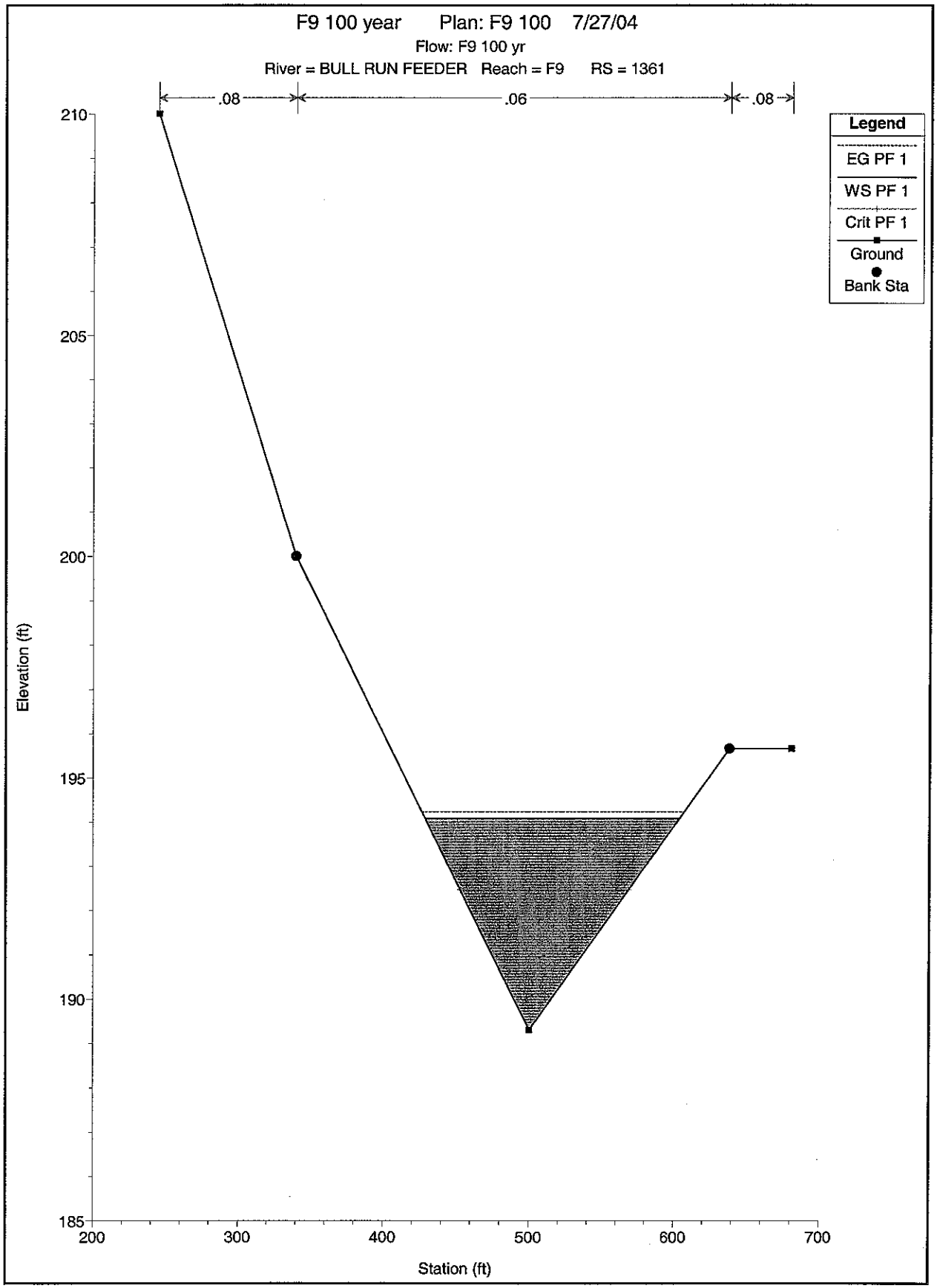

F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
300
350
400
450
500
550
600
650
700
Station (ft)

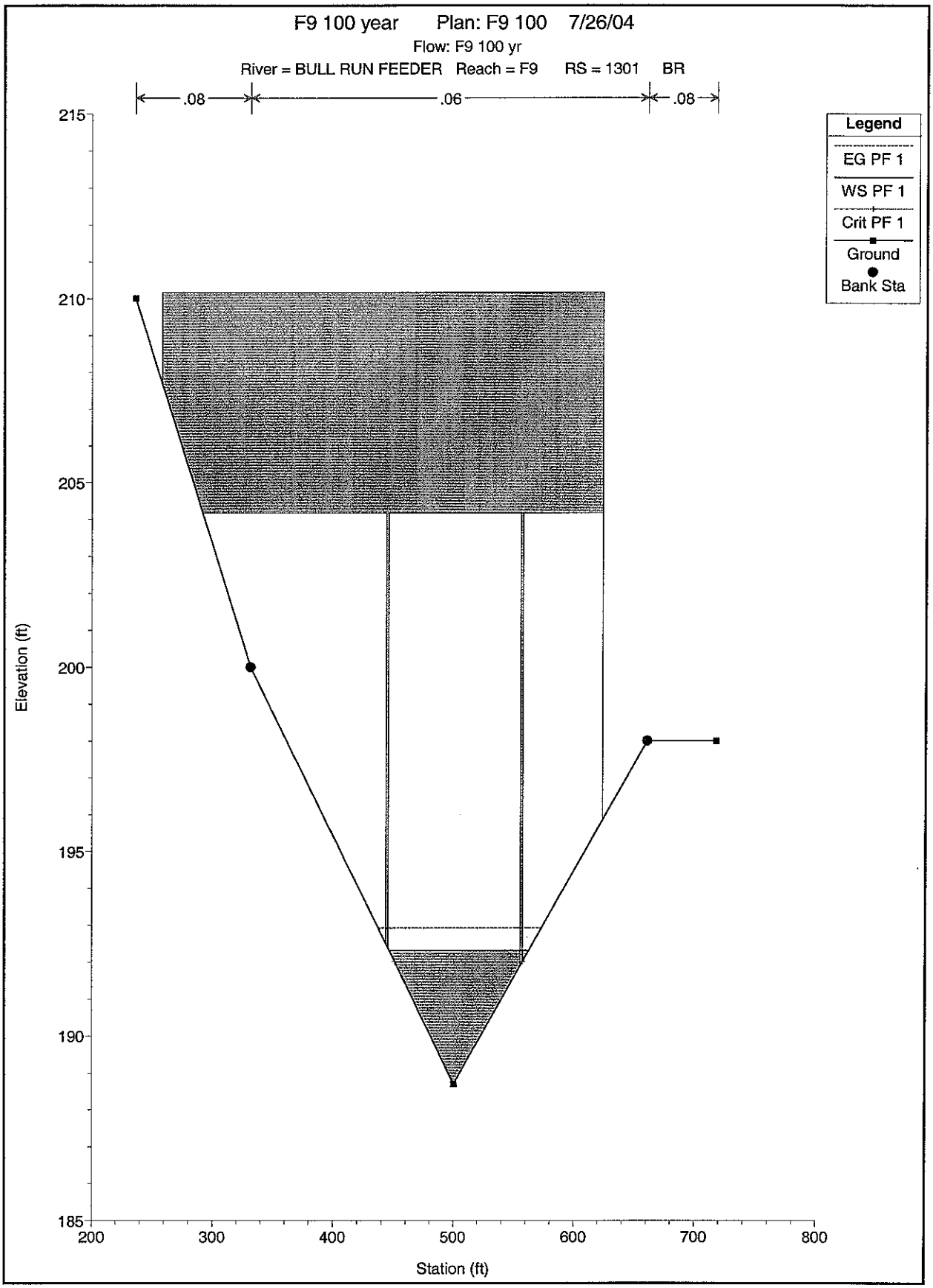
HEC-RAS Plan: F9 River: BULL RUN FEEDER Reach: F9 Profile: PF 1

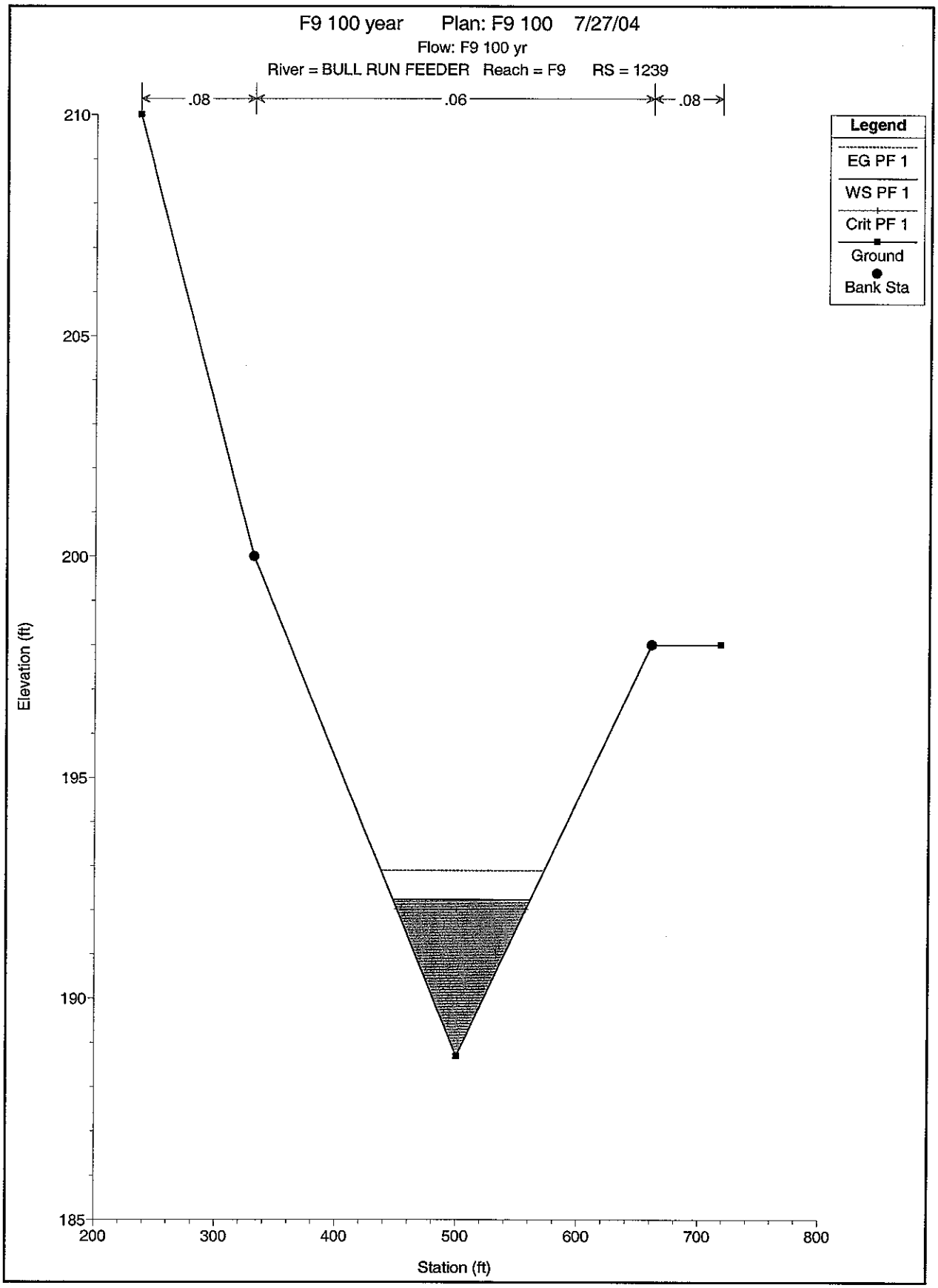
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
F9	1600	1310.00	190.00	195.36		195.55	0.005431	3.51	372.96	139.26	0.38
F9	1400	1310.00	189.50	194.28		194.44	0.005538	3.29	398.28	166.78	0.38
F9	1361	1310.00	189.31	194.08	192.47	194.23	0.005014	3.13	418.50	175.21	0.36
F9	1301	Bridge									
F9	1239	1310.00	188.70	192.23	192.01	192.89	0.032412	6.51	201.14	113.72	0.85
F9	1200	1310.00	188.50	192.05		192.09	0.001071	1.55	843.99	318.65	0.17
F9	1000	1310.00	188.00	190.61	190.61	191.38	0.044714	7.03	187.64	125.15	0.99

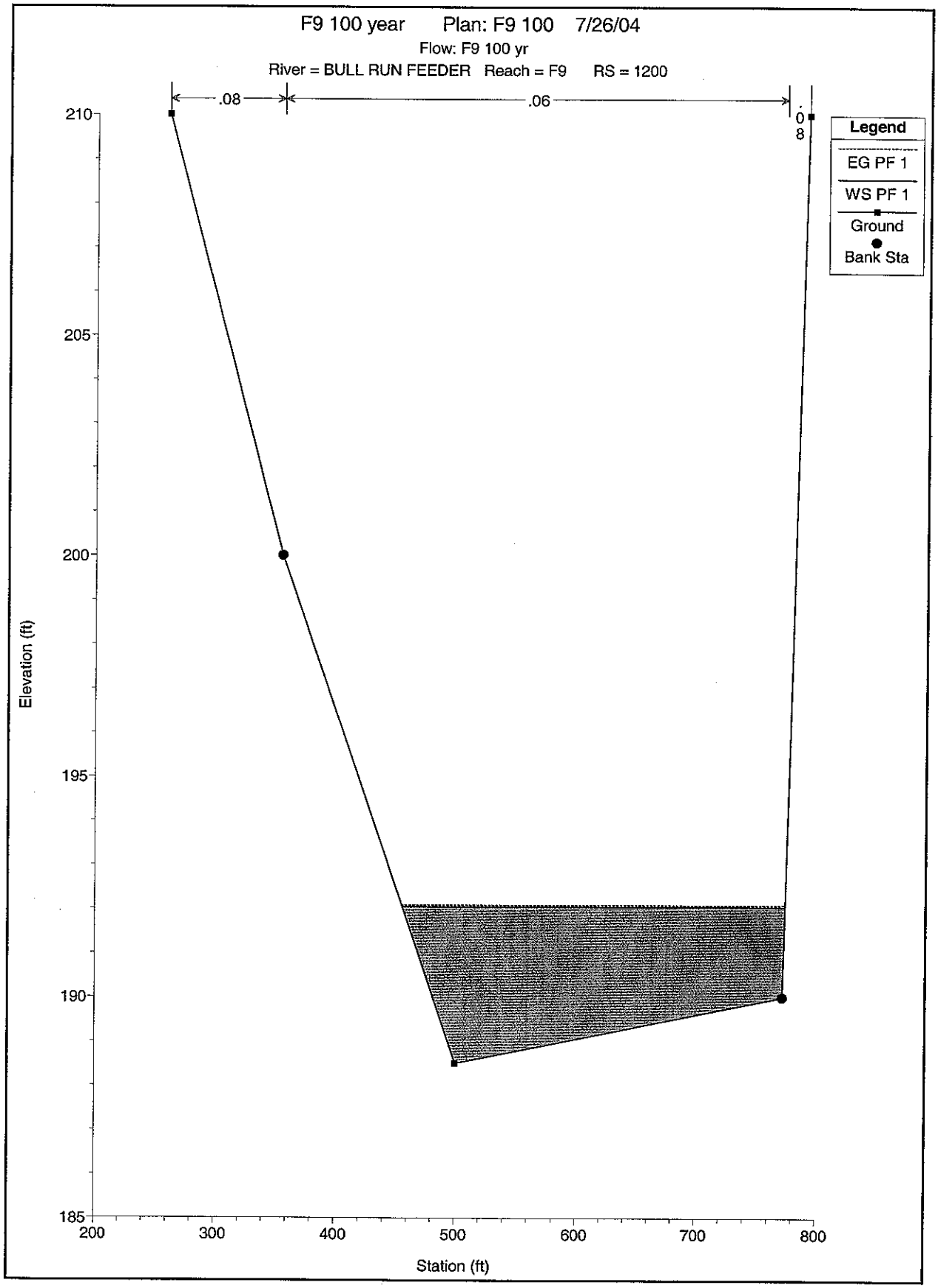

F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1600 South Fork Tributary to Broad Run
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
200
300
400
500
600
700
800
Station (ft)

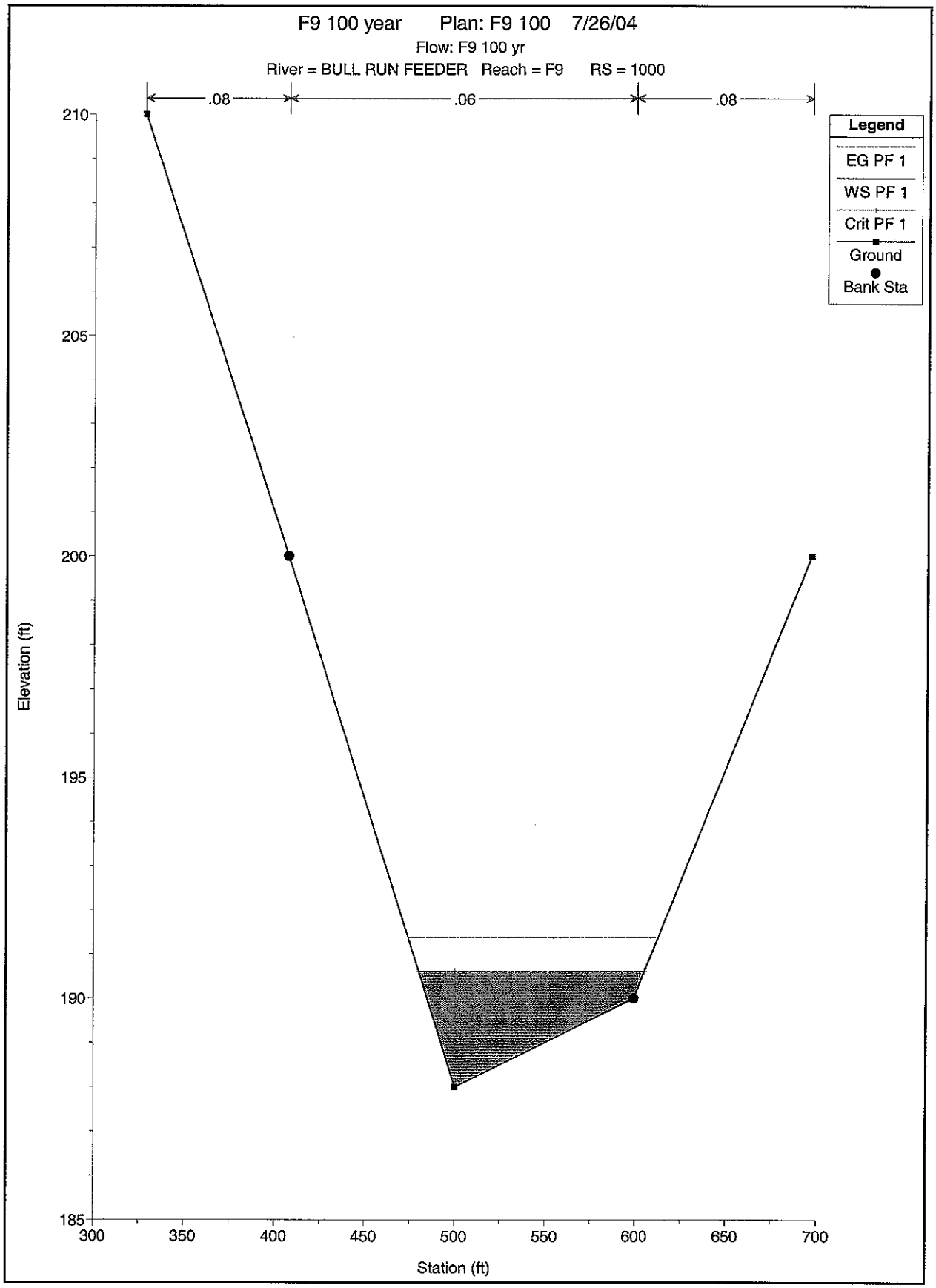

F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)


F9 100 year Plan: F9 100 7/27/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
Station (ft)


F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1301 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
215
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)


F9 100 year Plan: F9 100 7/27/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)


F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
200
300
400
500
600
700
800
Station (ft)


F9 100 year Plan: F9 100 7/26/04
Flow: F9 100 yr
River = BULL RUN FEEDER Reach = F9 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
210
205
200
195
190
185
300
350
400
450
500
550
600
650
700
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F10

PART 1: Plan Sheet

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TRI COUNTY PARKWAY
Crossing F10

July 2004

SCALE

0 100' 200'

7/27/2004 11:20:09 AM Q:\PLOTTING\QUEUES\xes 8825.qof M:\EF_F10.USF

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F17

PART 1: Plan Sheet

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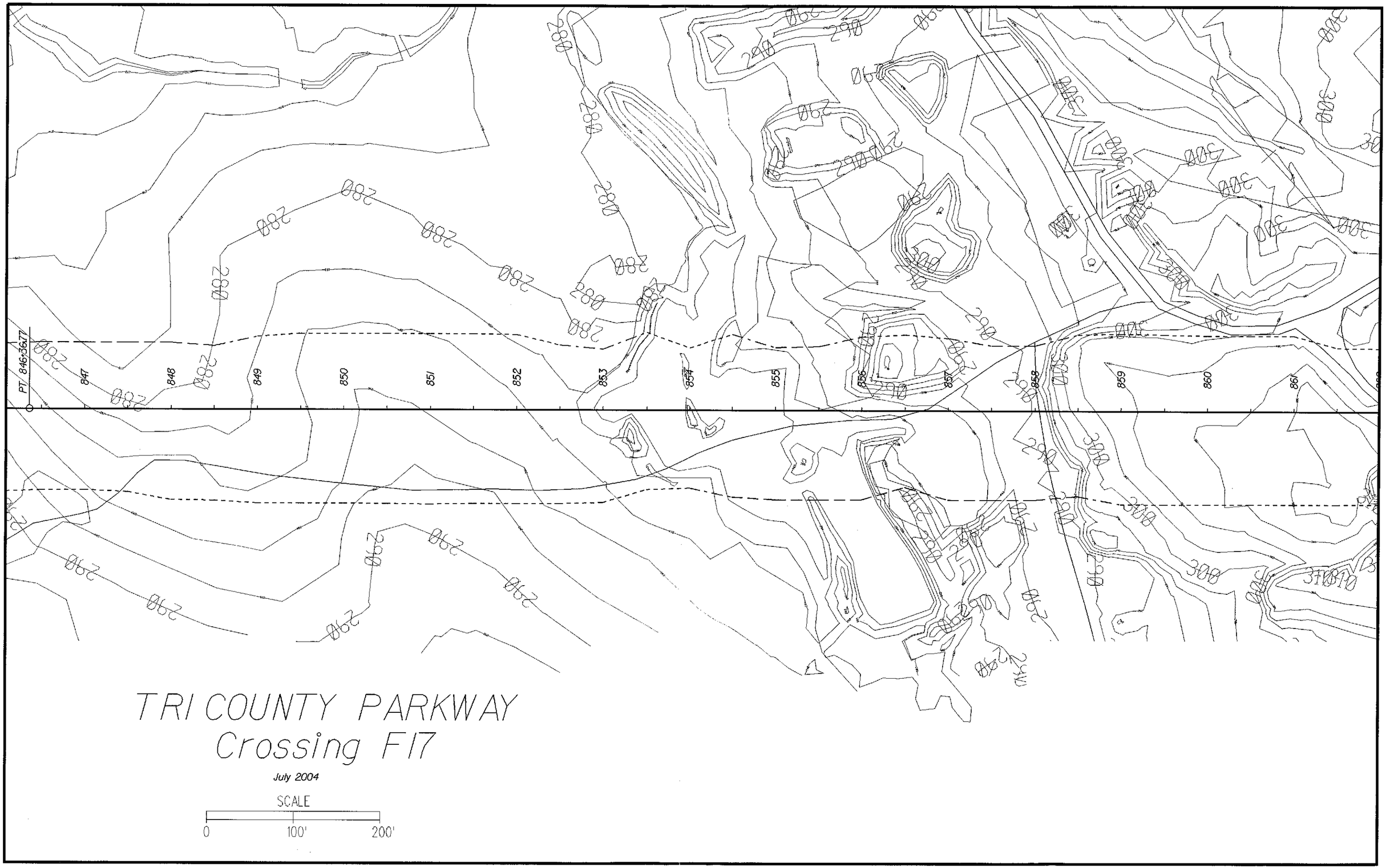

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F19

PART 1: Plan Sheet

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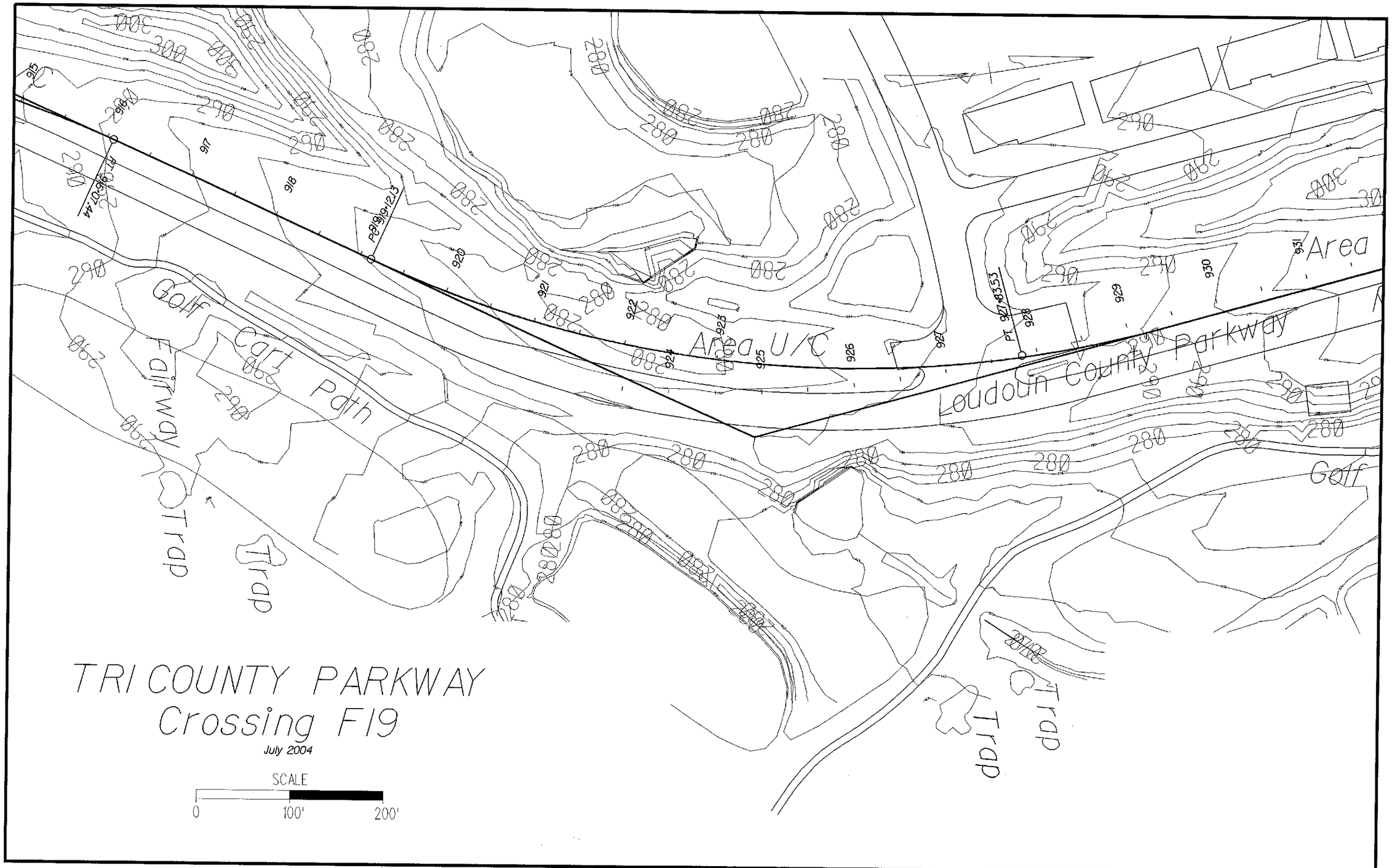

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING F20

PART 1: Plan Sheet

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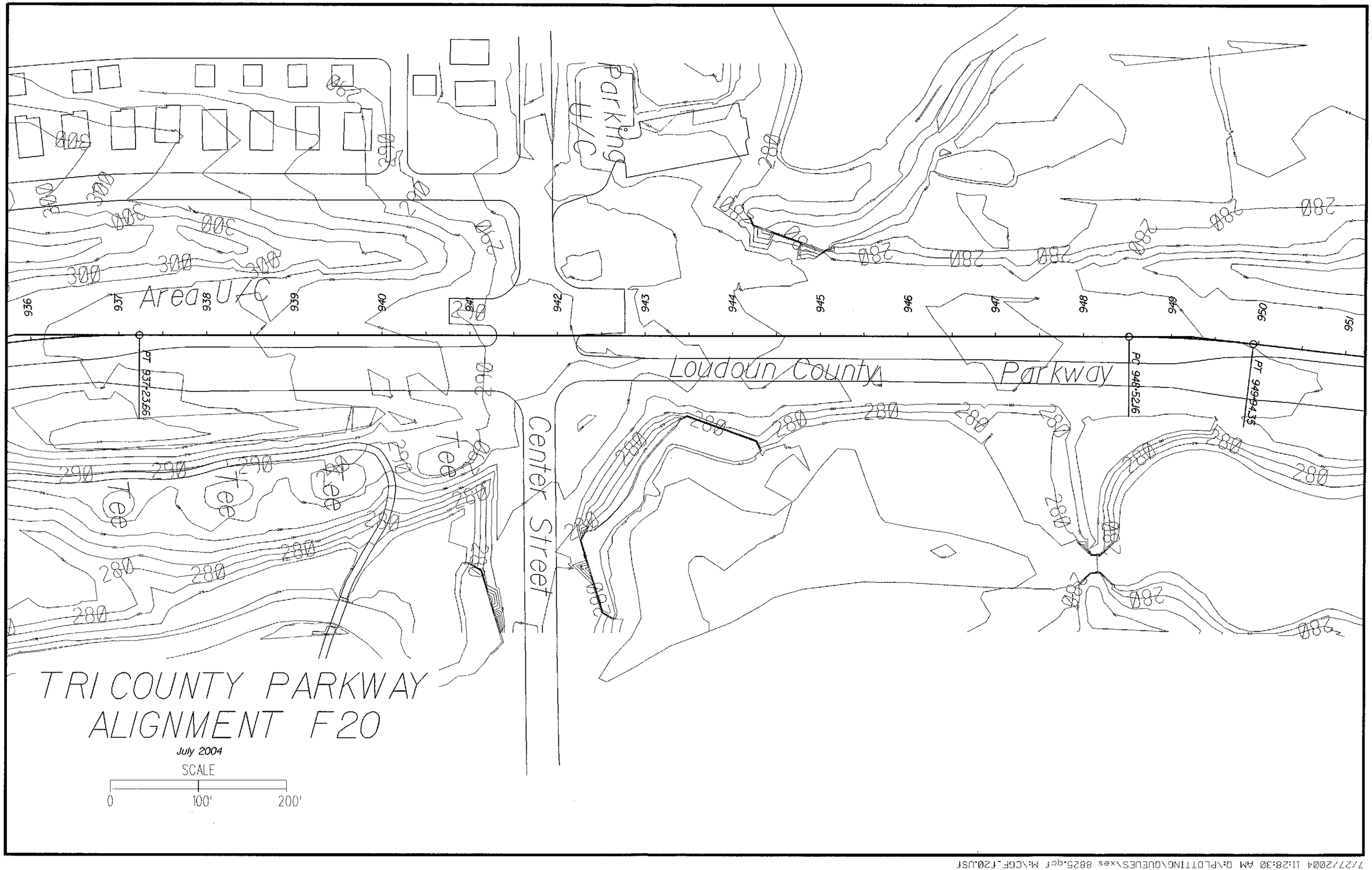

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING G2

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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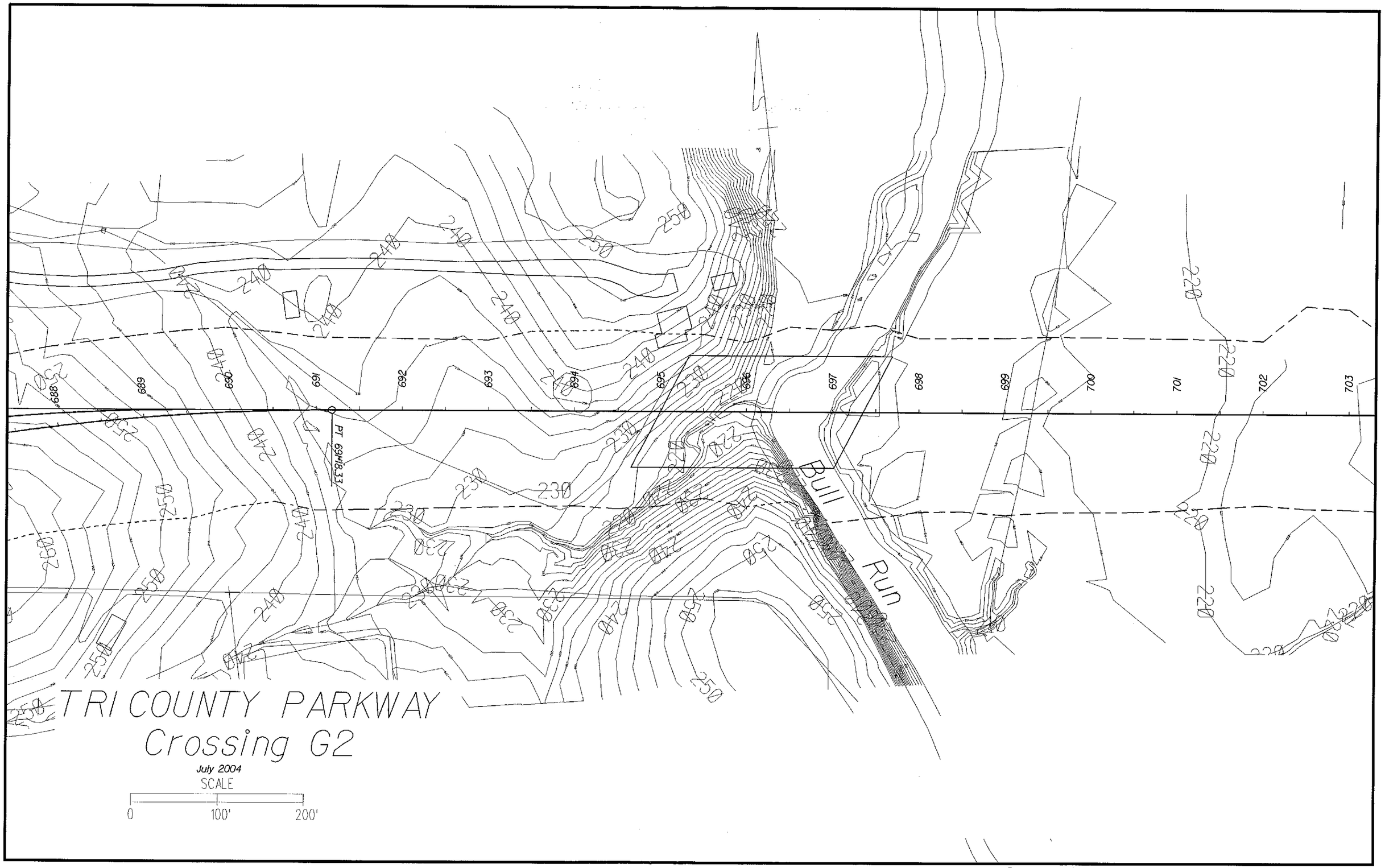

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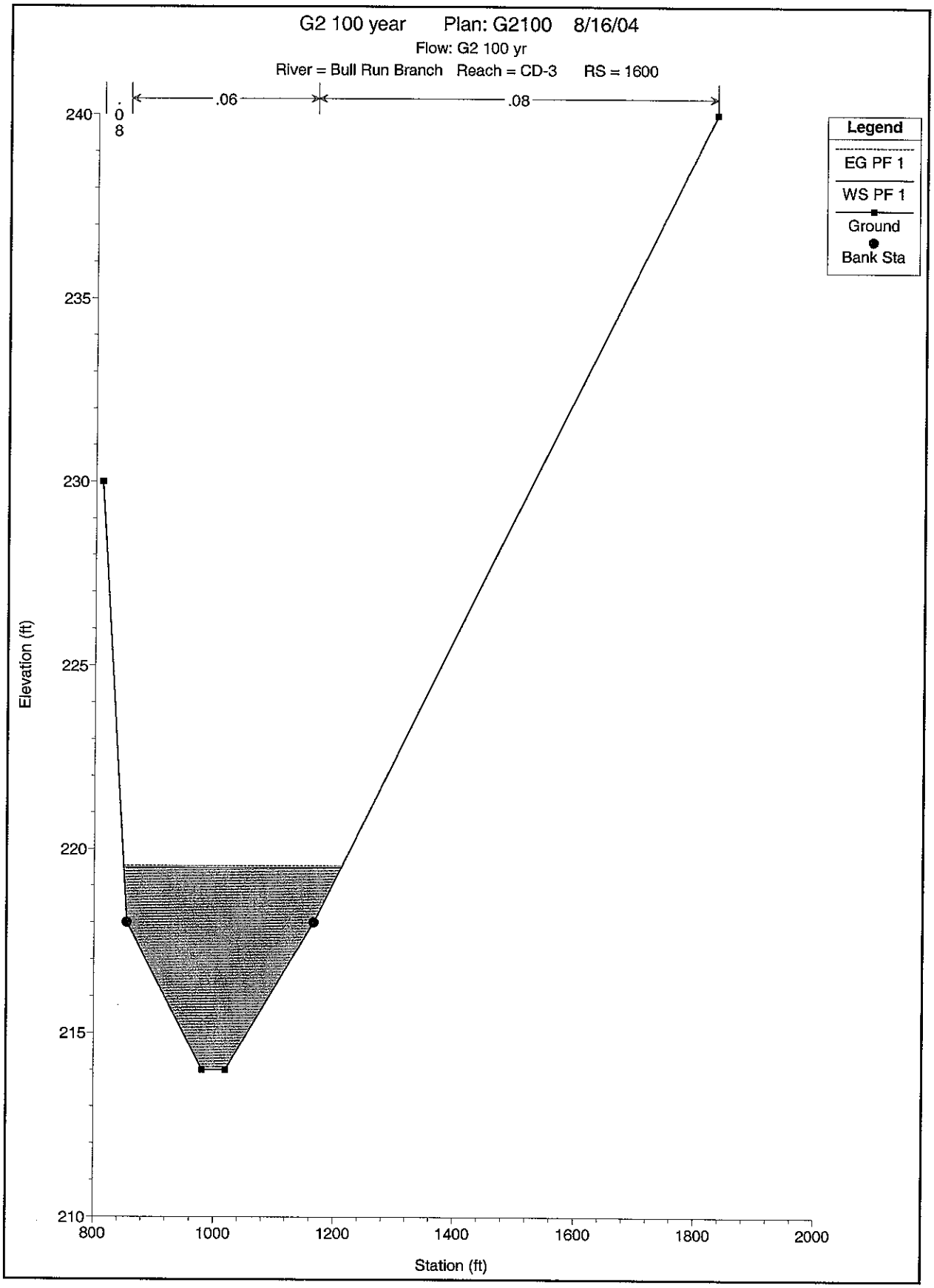
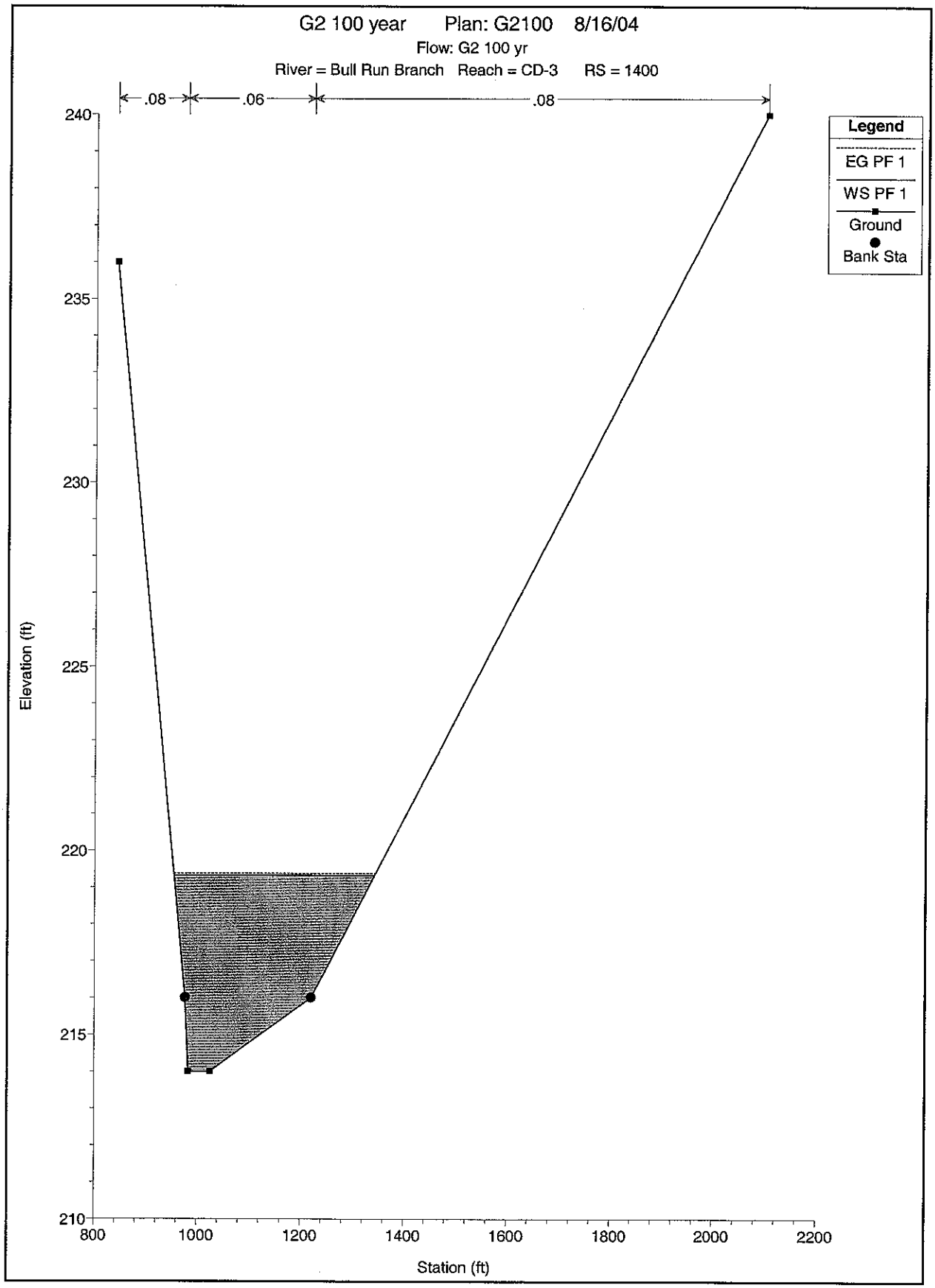
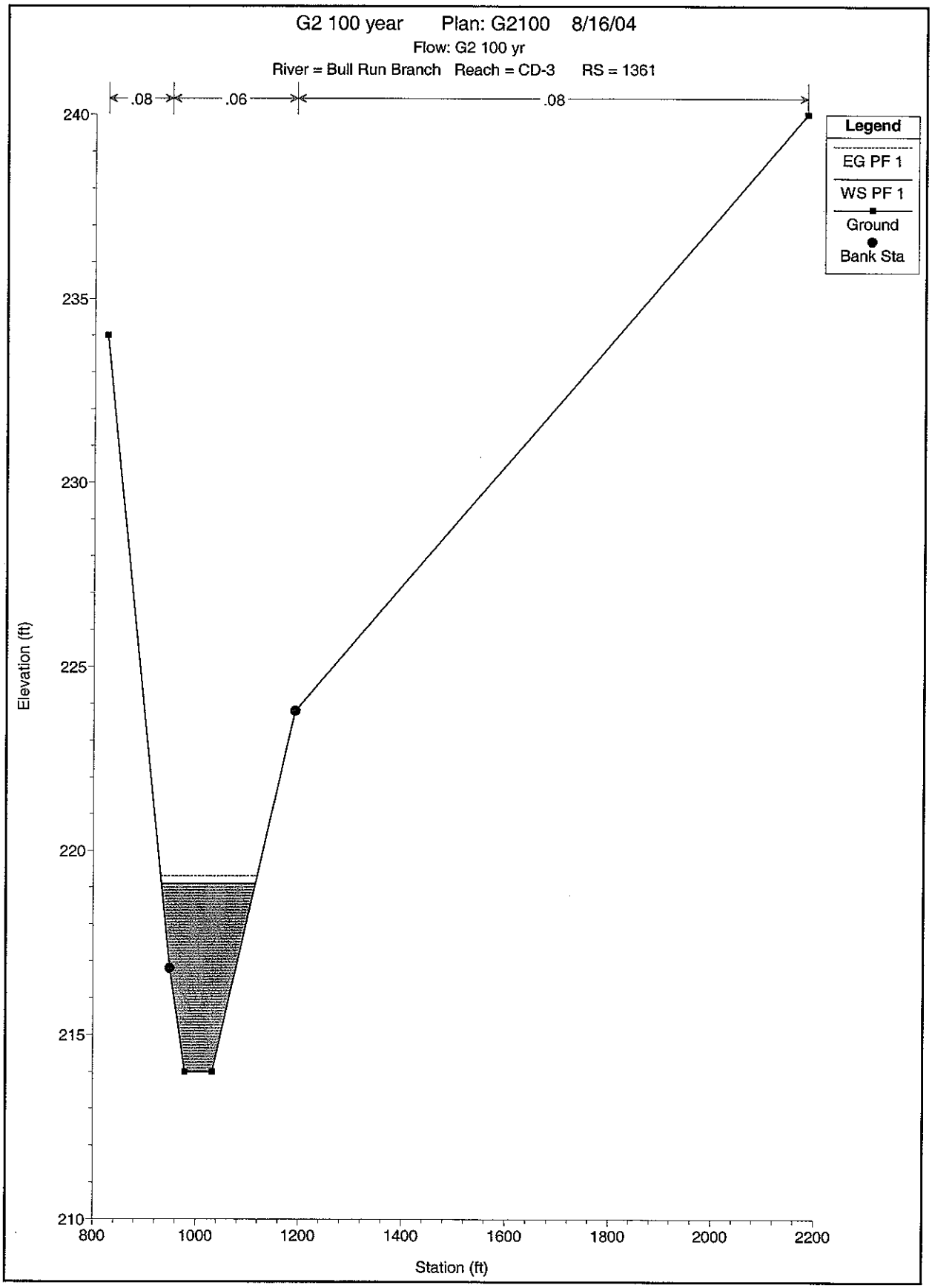
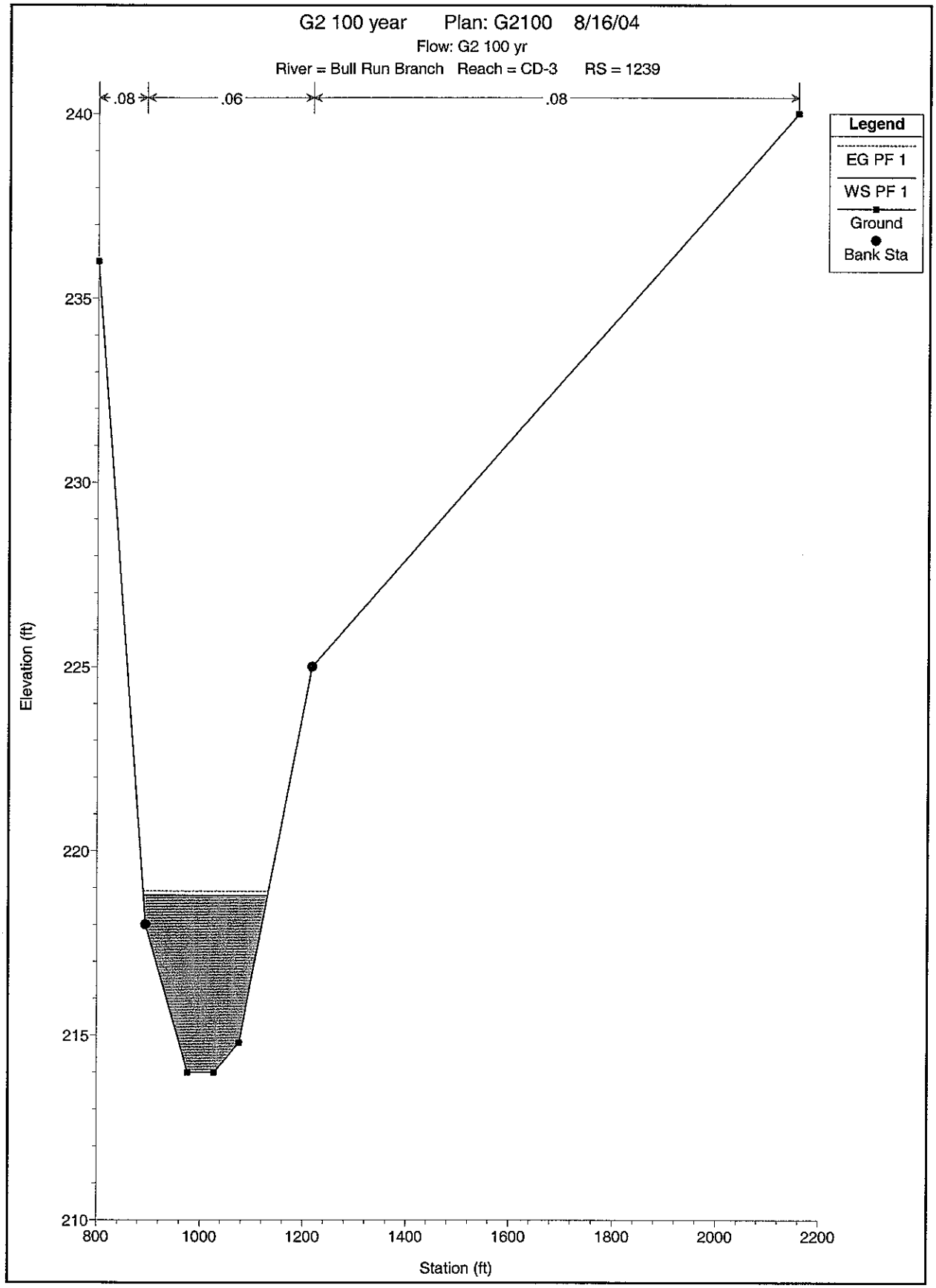
HEC-RAS Plan: G2 River: Bull Run Branch Reach: CD-3 Profile: PF 1

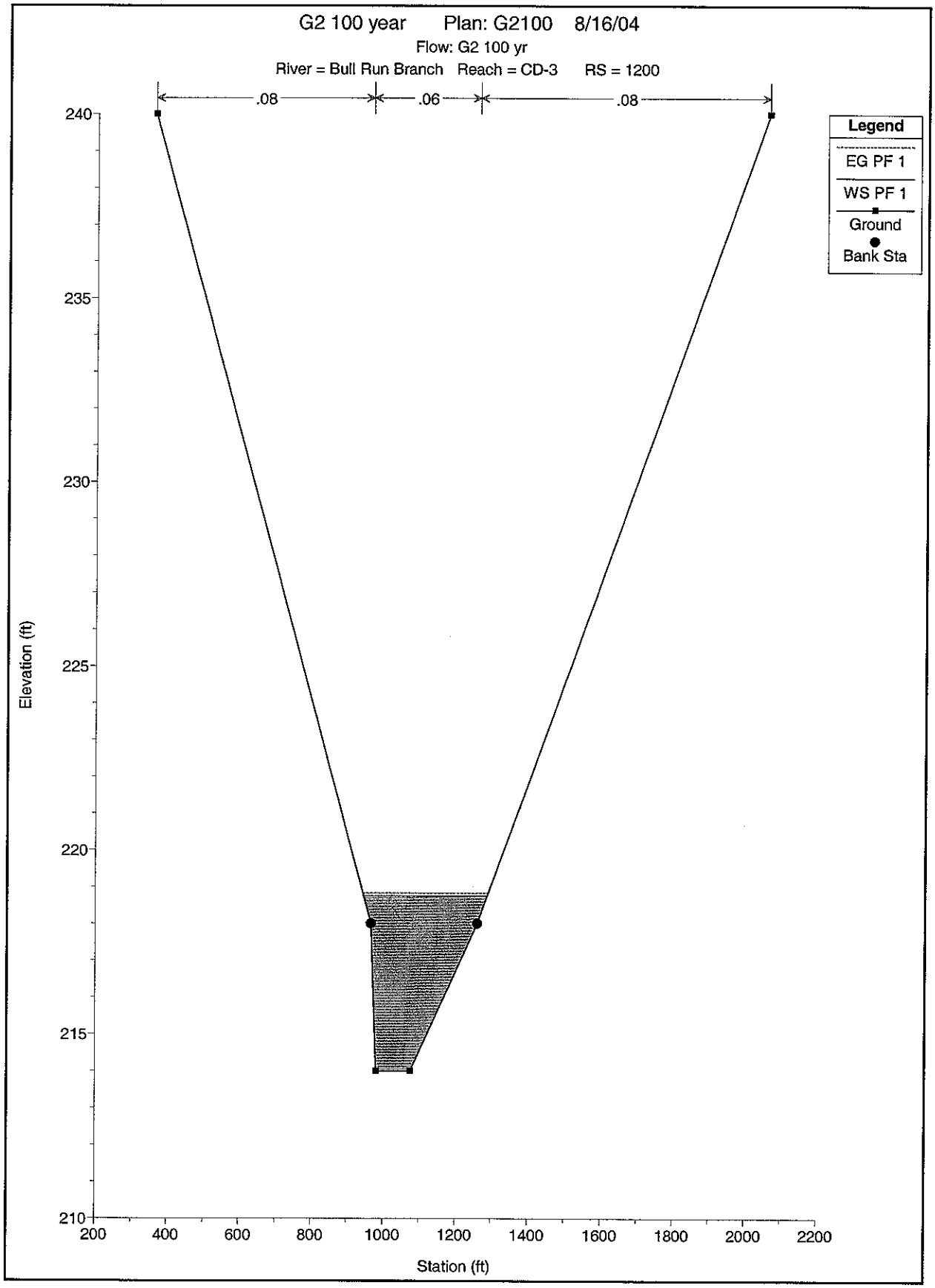
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CD-3	1600	2180.00	214.00	219.50		219.55	0.000965	1.86	1203.21	361.71	0.17
CD-3	1400	2180.00	214.00	219.33		219.38	0.000740	1.84	1335.76	387.94	0.15
CD-3	1361	2180.00	214.00	219.10		219.31	0.003940	3.63	612.43	182.40	0.34
CD-3	1239	2180.00	214.00	218.80		218.91	0.002400	2.73	800.70	241.02	0.26
CD-3	1200	2180.00	214.00	218.75		218.83	0.001505	2.17	1020.42	343.12	0.21
CD-3	1000	2180.00	214.00	217.11	217.11	217.89	0.045428	7.09	307.55	197.50	1.00

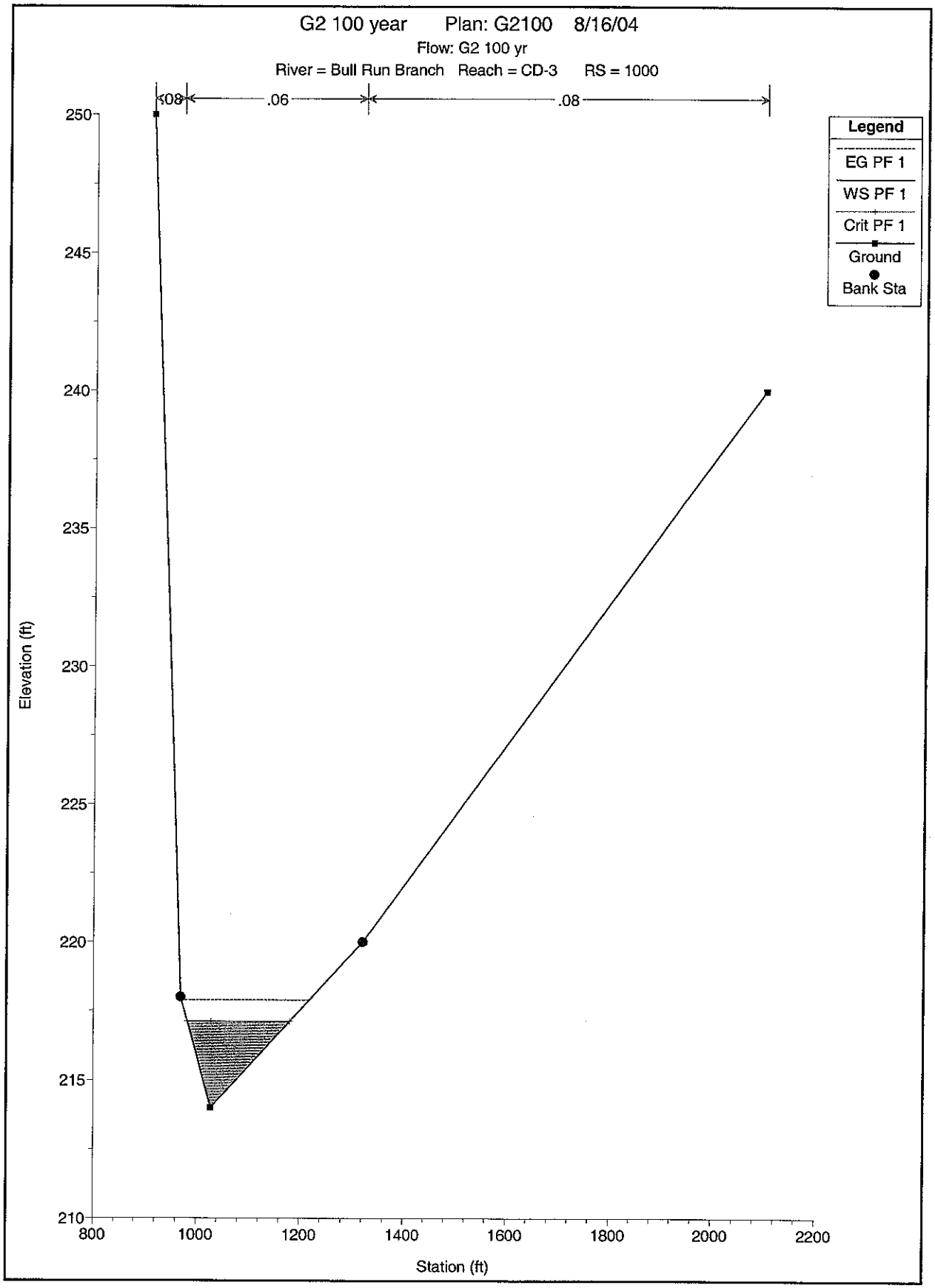

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)

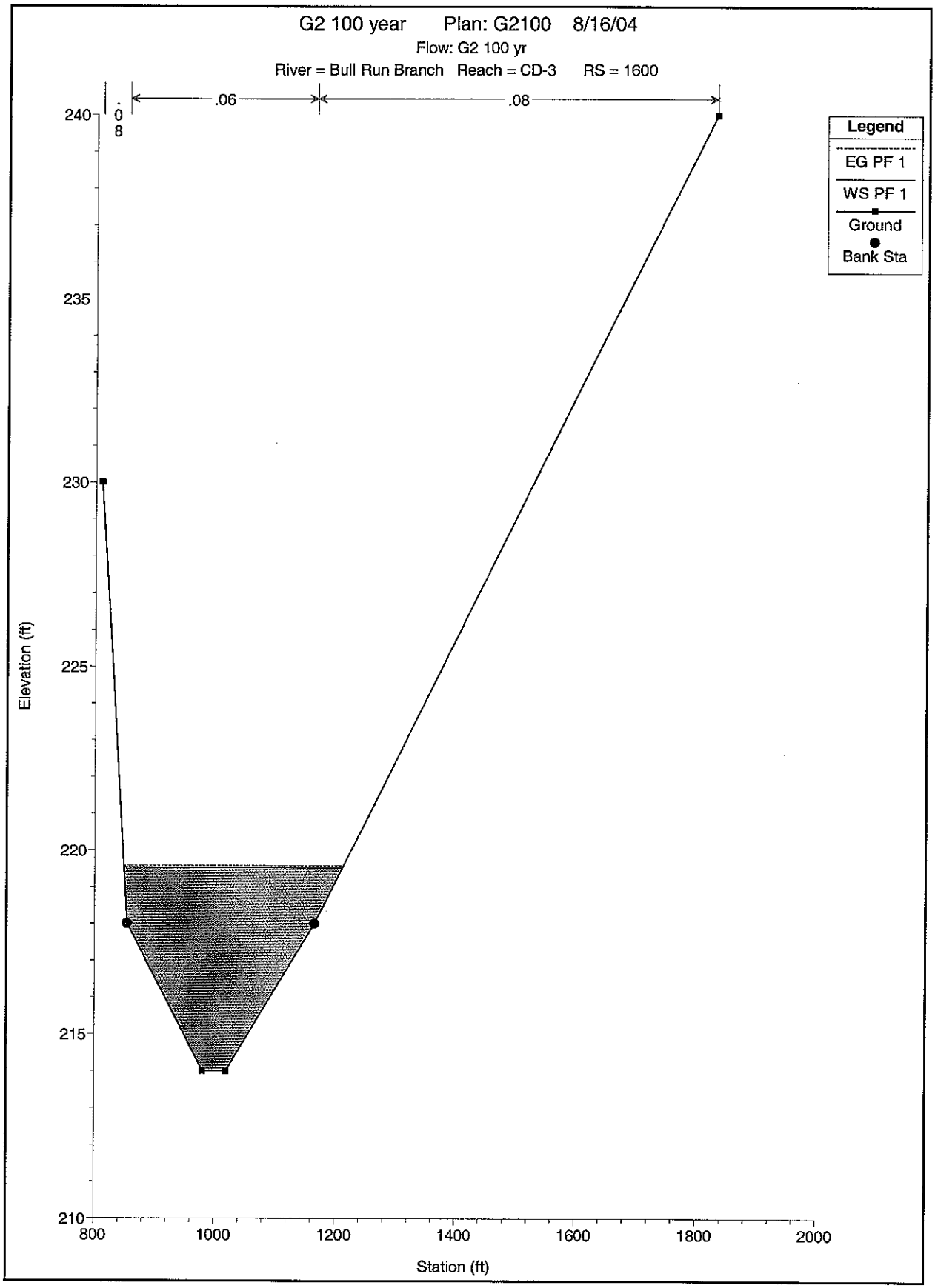

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)

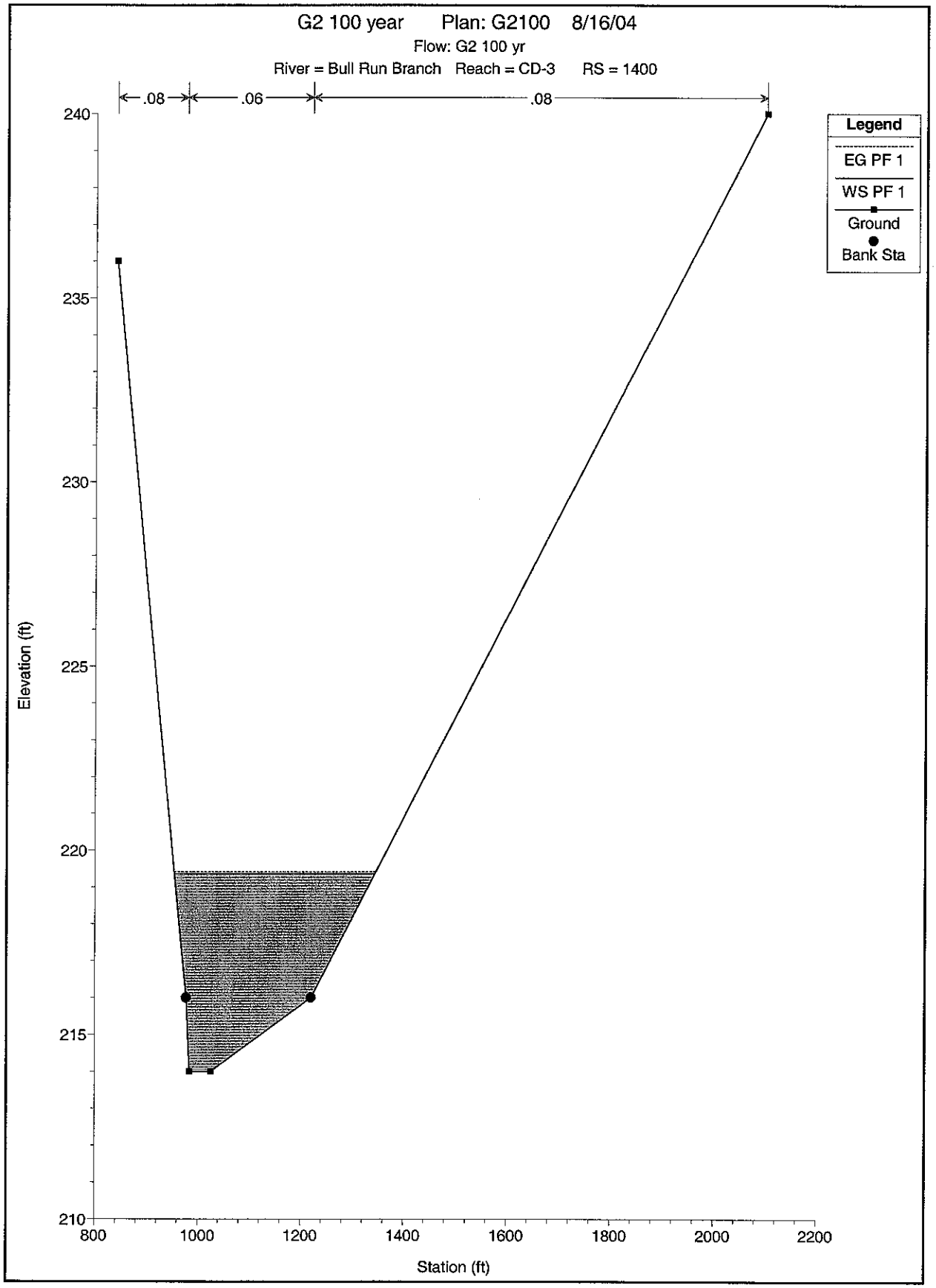

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)

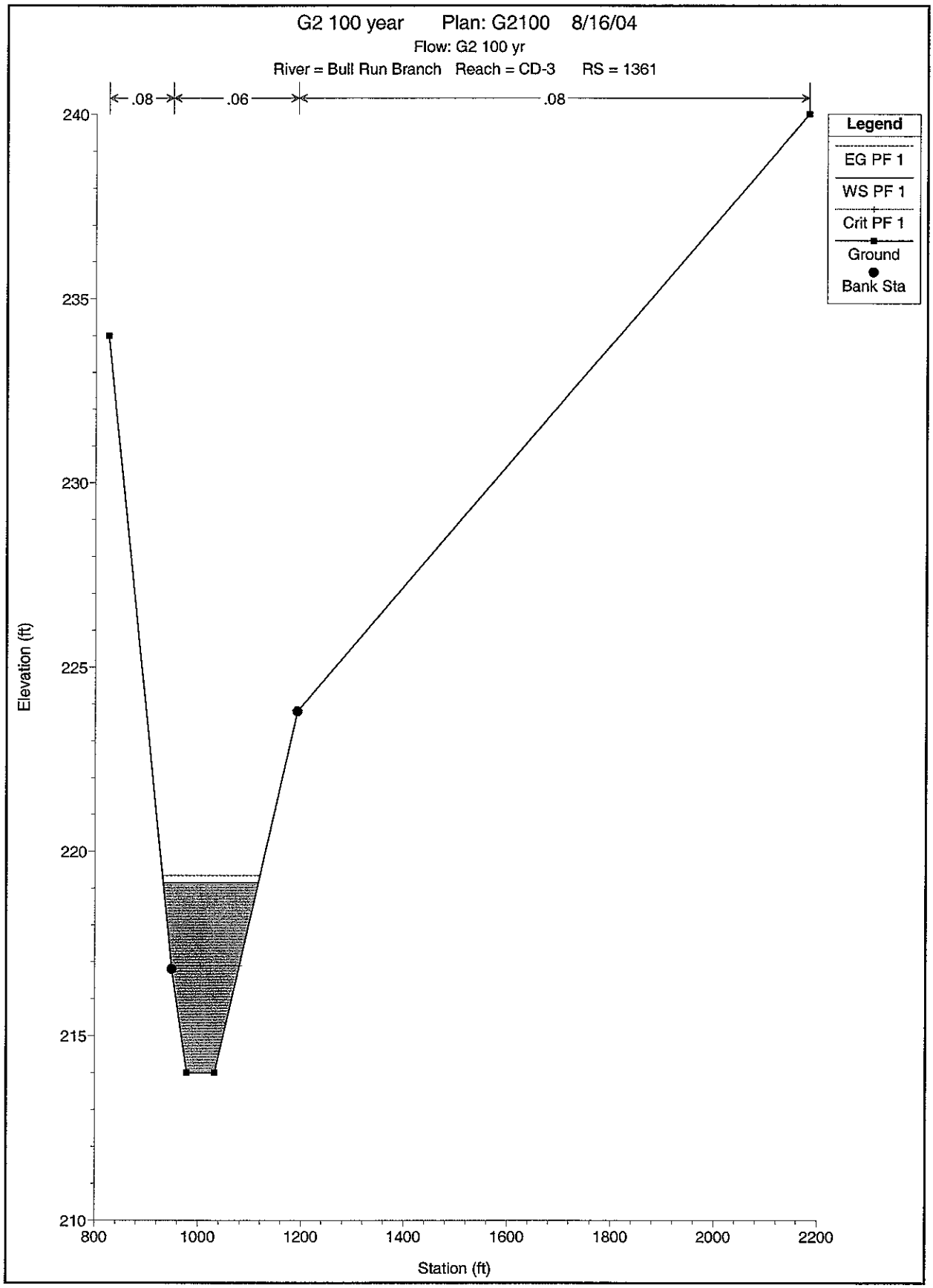

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
250
245
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)

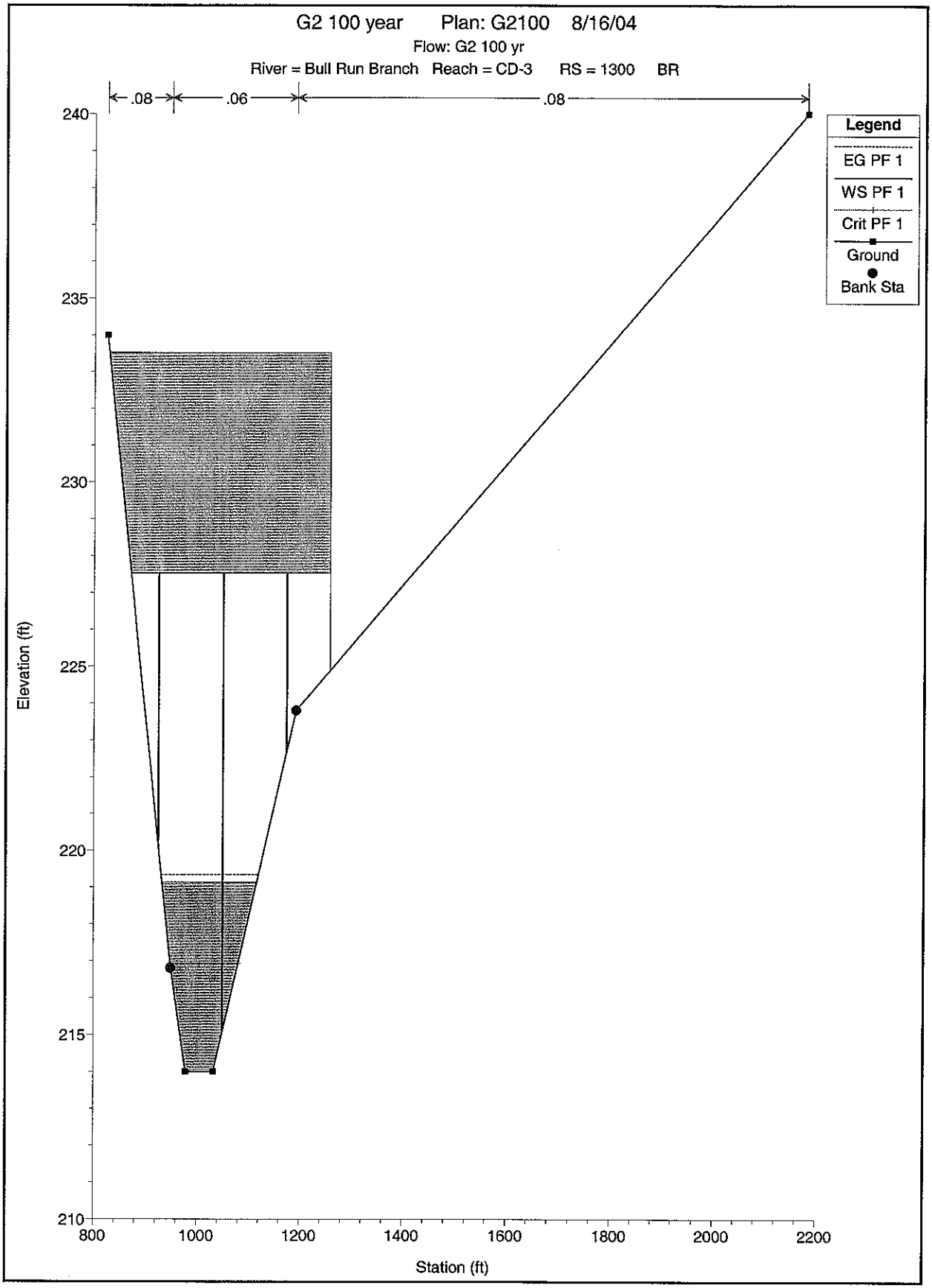
HEC-RAS Plan: G2 River: Bull Run Branch Reach: CD-3 Profile: PF 1

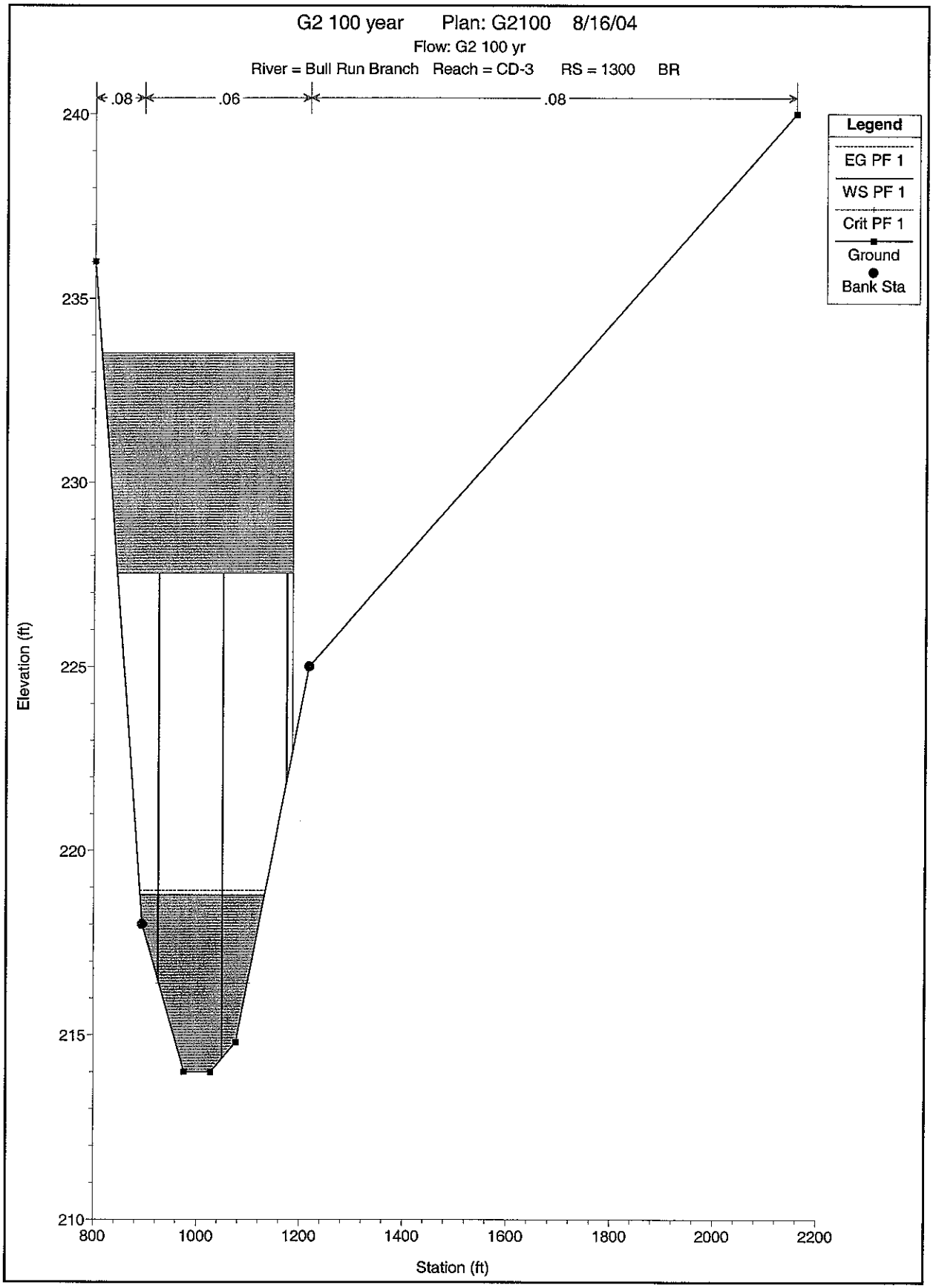
Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CD-3	1600	2180.00	214.00	219.53		219.58	0.000938	1.84	1214.35	362.75	0.17
CD-3	1400	2180.00	214.00	219.37		219.41	0.000719	1.82	1349.54	389.49	0.15
CD-3	1361	2180.00	214.00	219.15	216.89	219.34	0.003809	3.59	620.00	183.37	0.33
CD-3	1300	Bridge									
CD-3	1239	2180.00	214.00	218.80		218.91	0.002400	2.73	800.70	241.02	0.26
CD-3	1200	2180.00	214.00	218.75		218.83	0.001505	2.17	1020.42	343.12	0.21
CD-3	1000	2180.00	214.00	217.11	217.11	217.89	0.045428	7.09	307.55	197.50	1.00

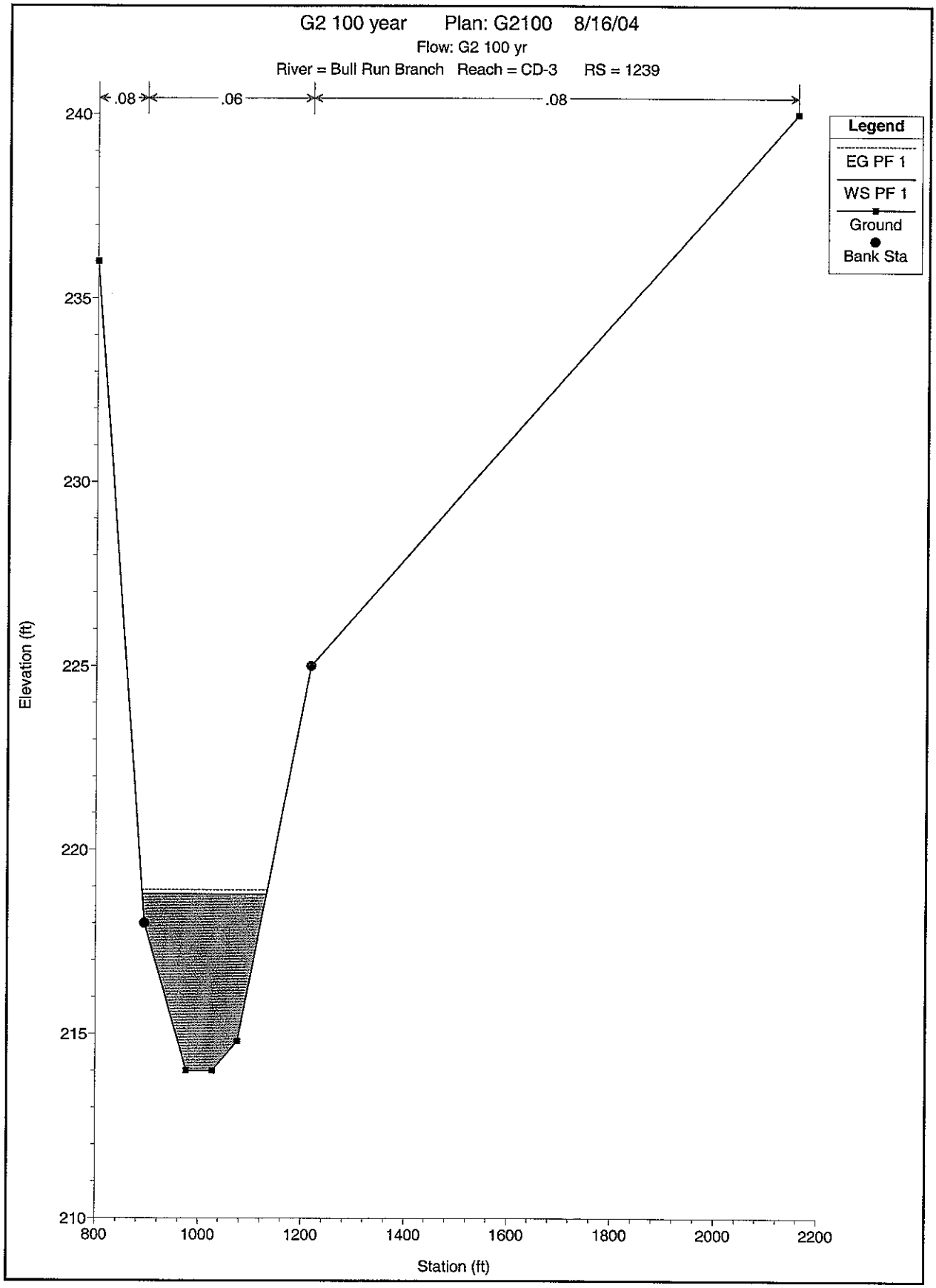

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
Station (ft)

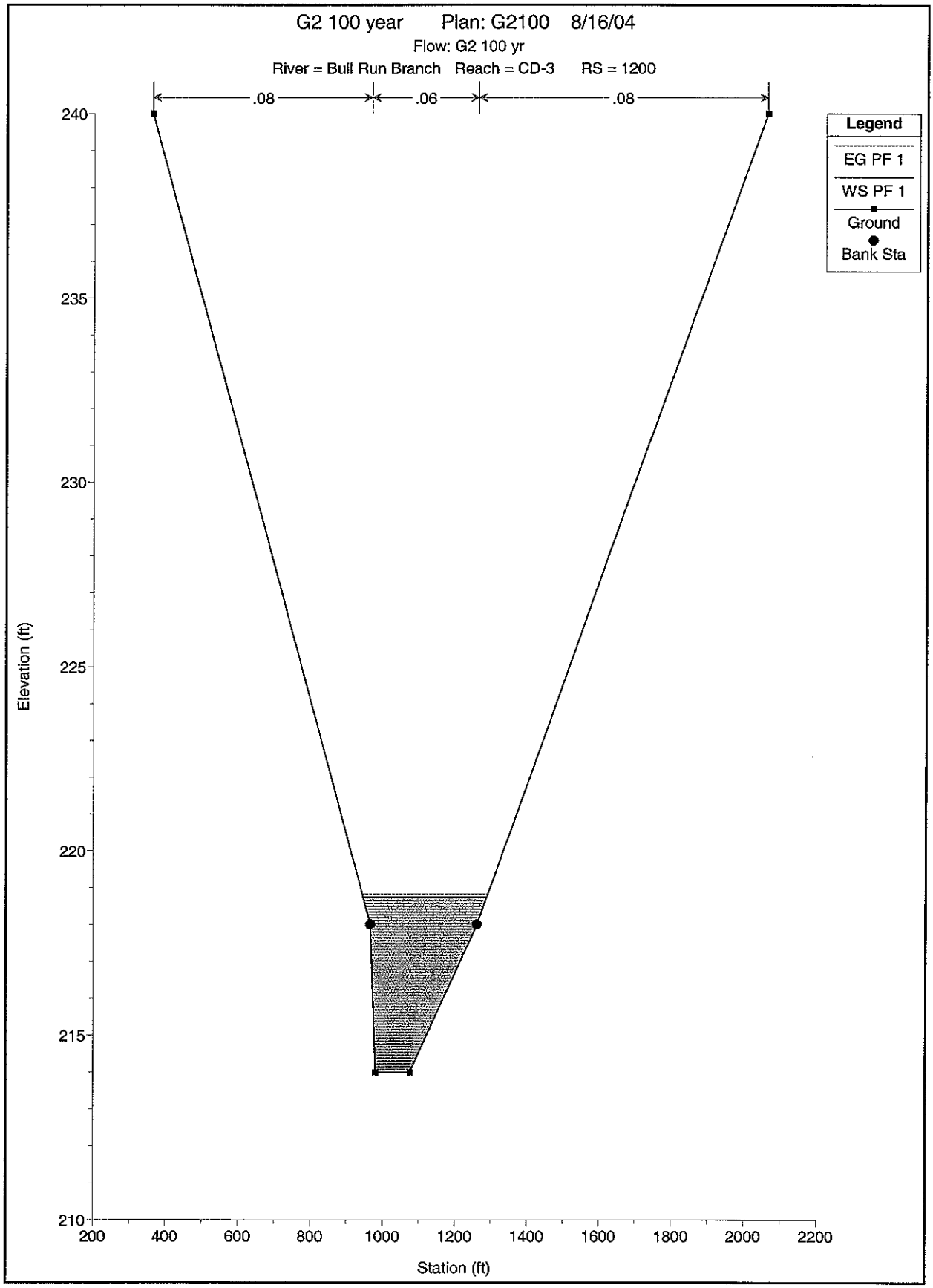

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1400
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)

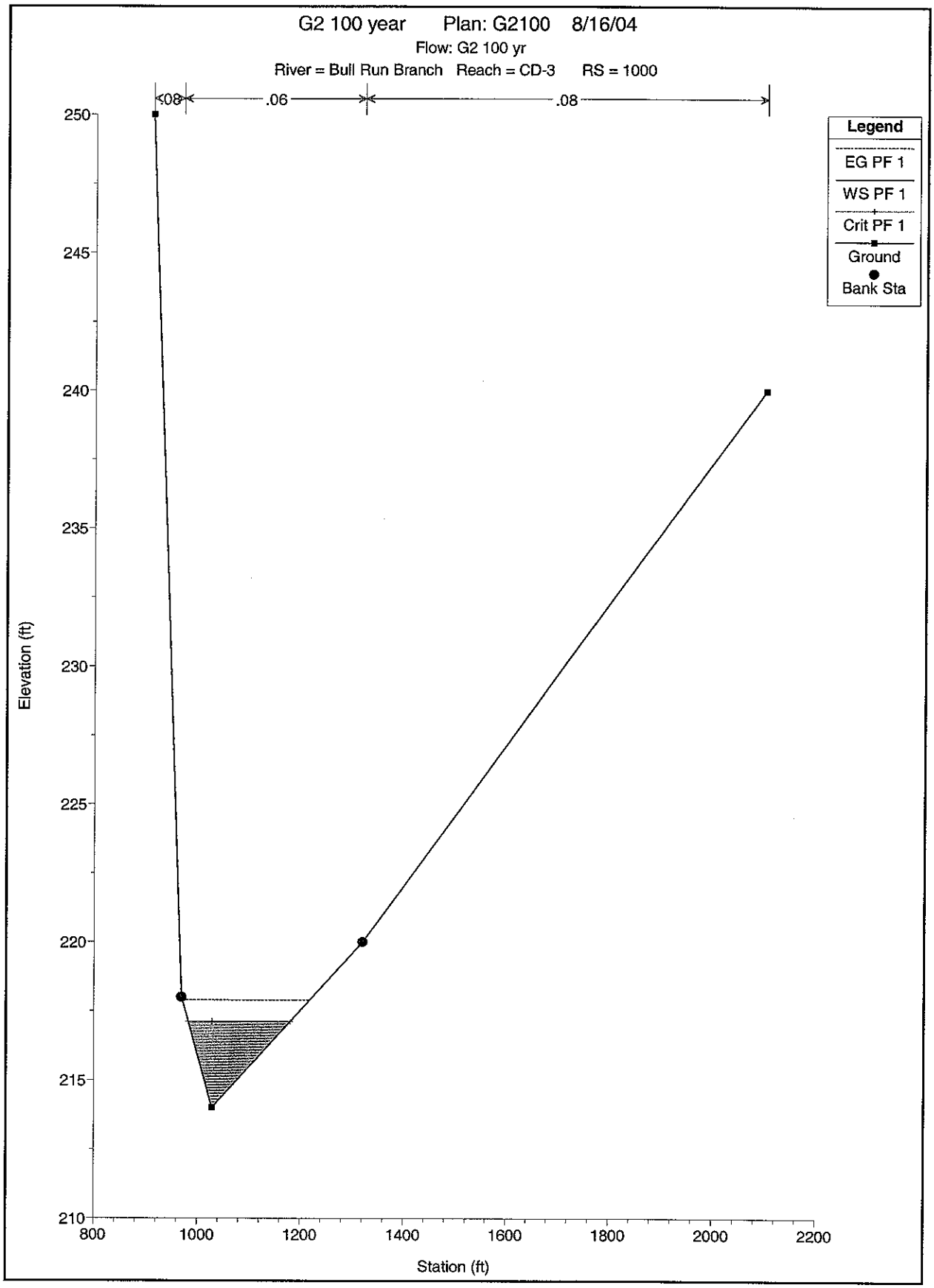

G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1300 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1200
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)


G2 100 year Plan: G2100 8/16/04
Flow: G2 100 yr
River = Bull Run Branch Reach = CD-3 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
250
245
240
235
230
225
220
215
210
800
1000
1200
1400
1600
1800
2000
2200
Station (ft)

Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING G6

PART 1: Plan Sheet

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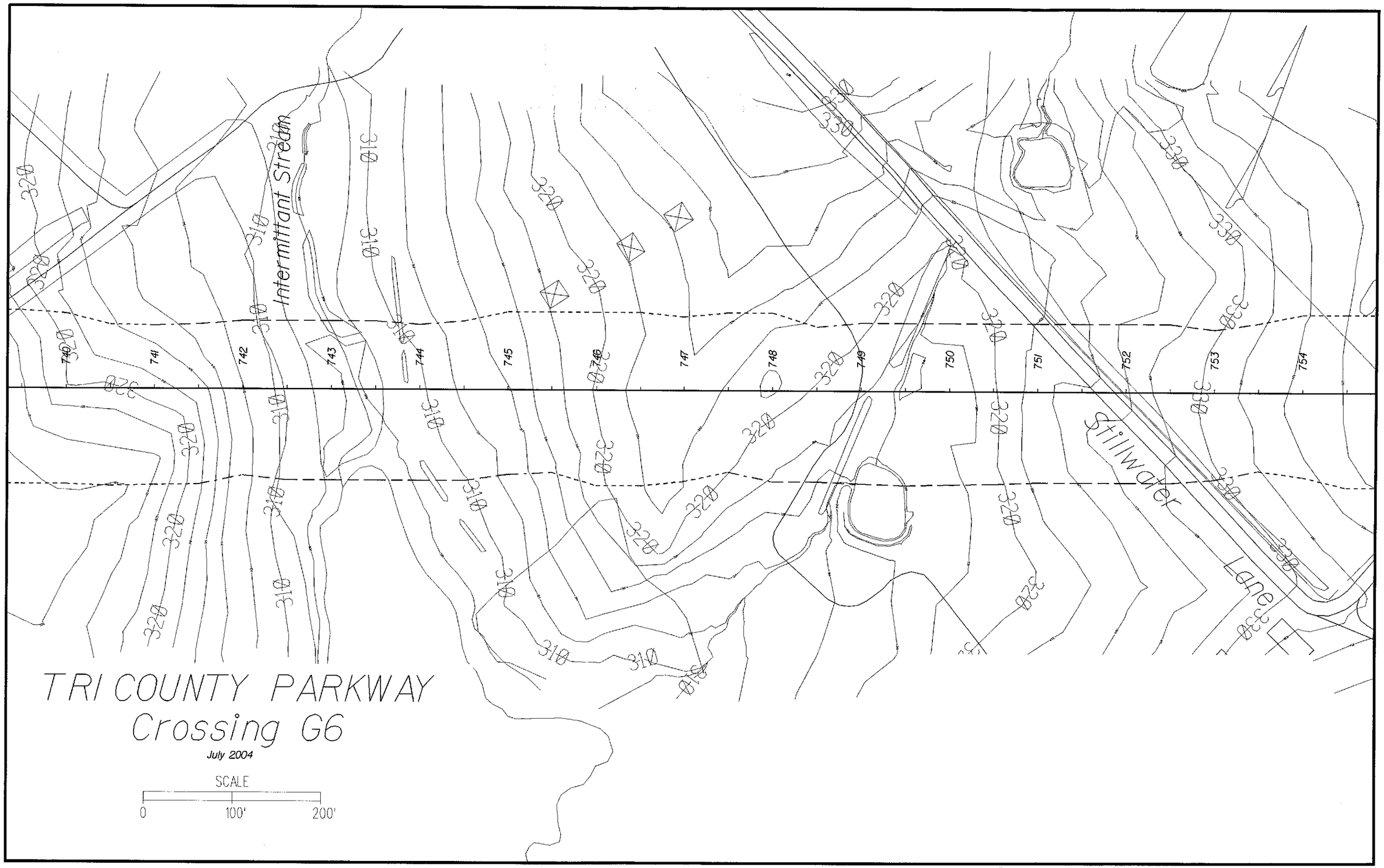

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Tri-County PARKWAY Location Study

TRI-COUNTY PARKWAY

BRIDGE CROSSING ANALYSIS

CROSSING G9

PART 1: Plan Sheet
PART 2: HEC RAS Output of Existing Conditions
PART 3: HEC RAS Cross Sections, Existing Conditions
PART 4: HEC RAS Output, Proposed Bridge
PART 5: HEC RAS Cross Sections, Proposed Bridge

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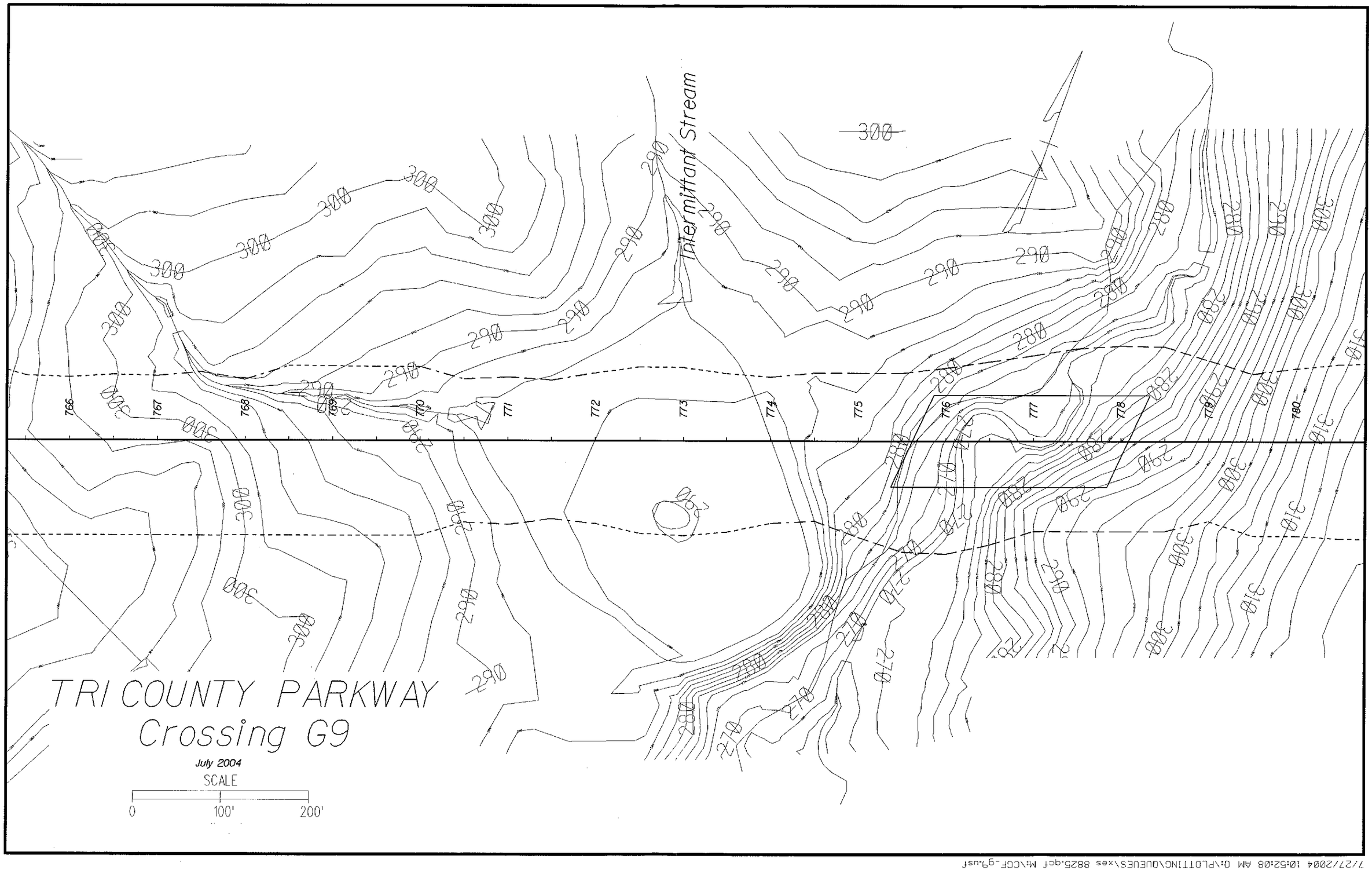

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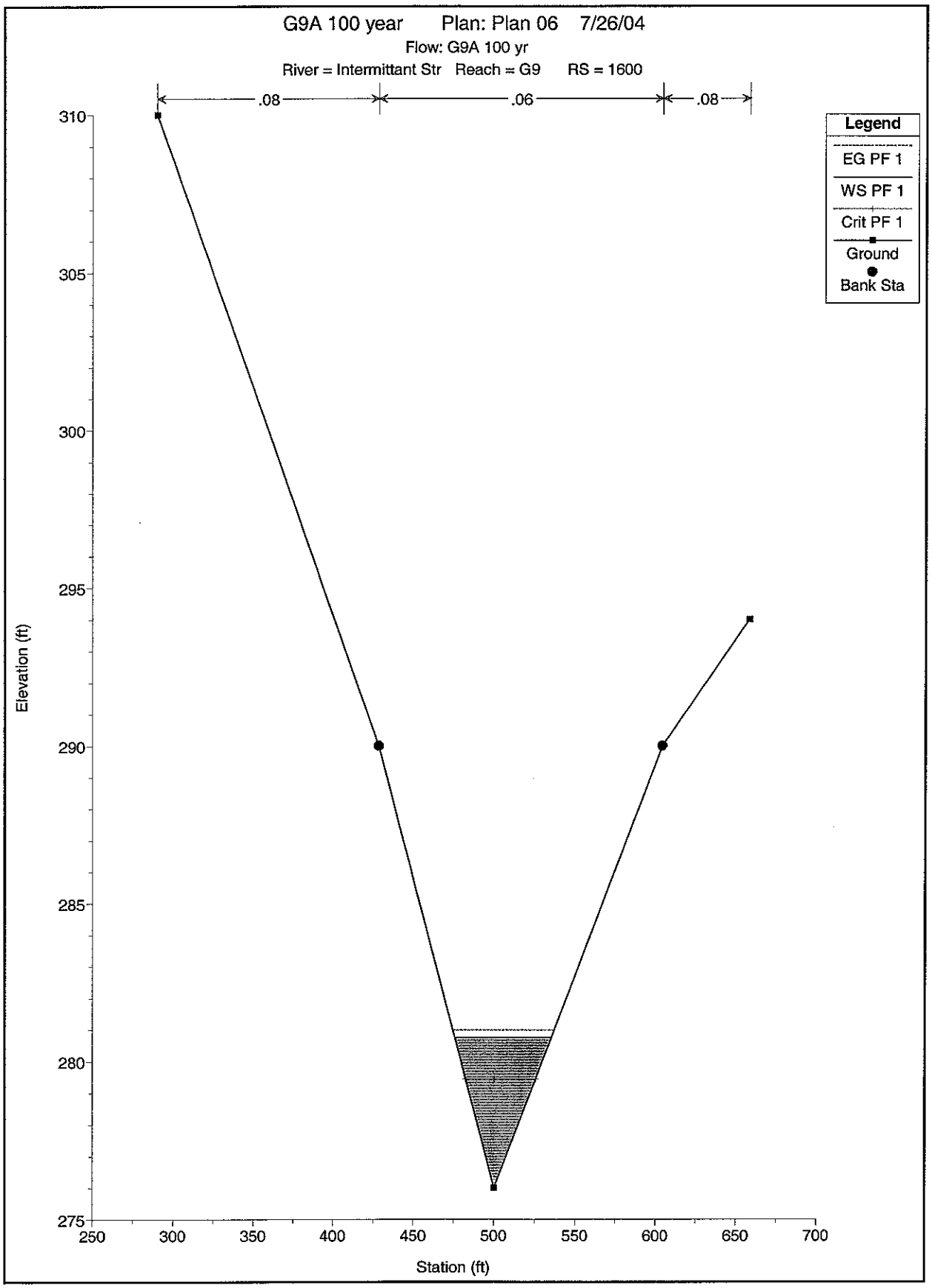
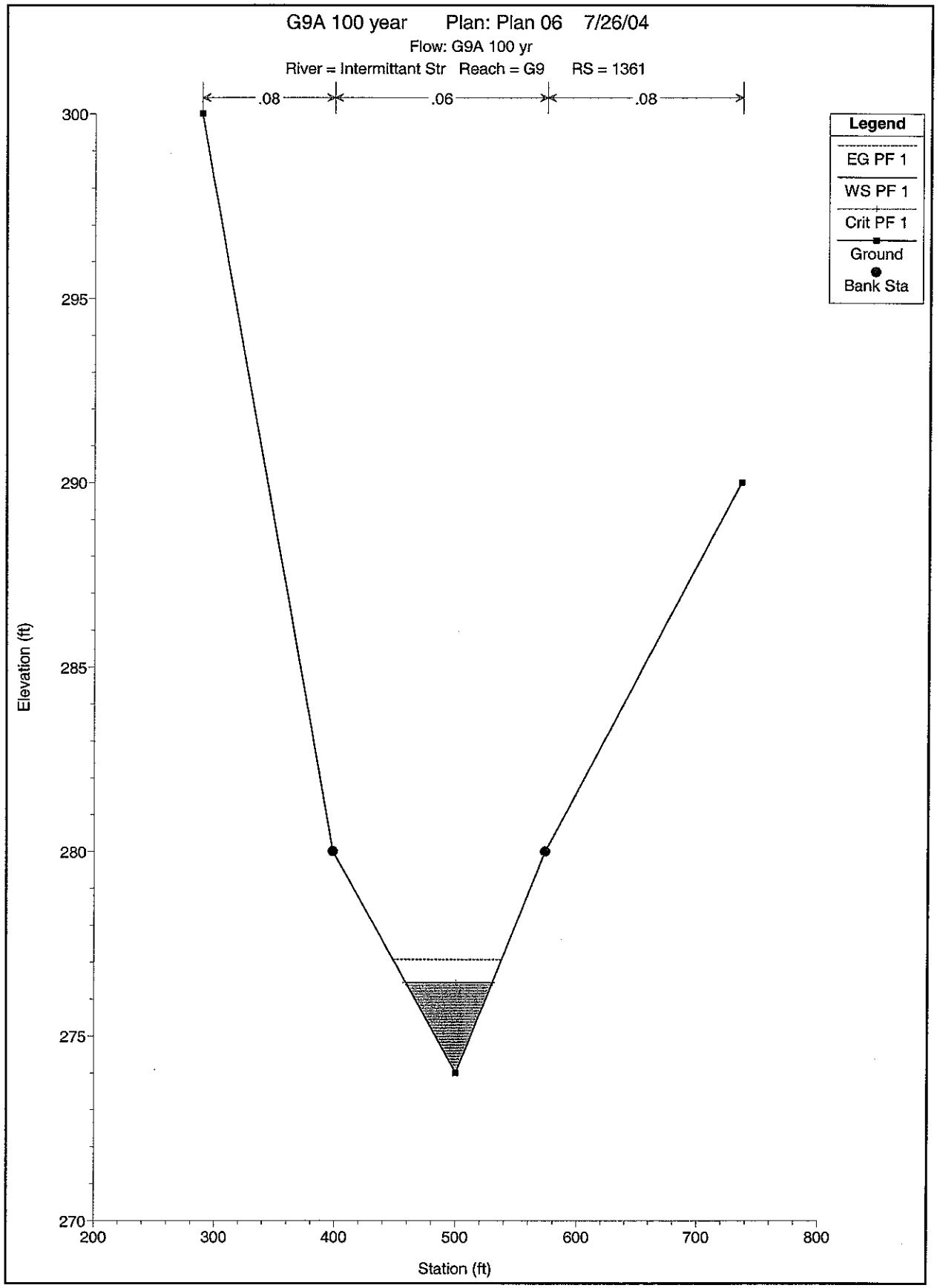
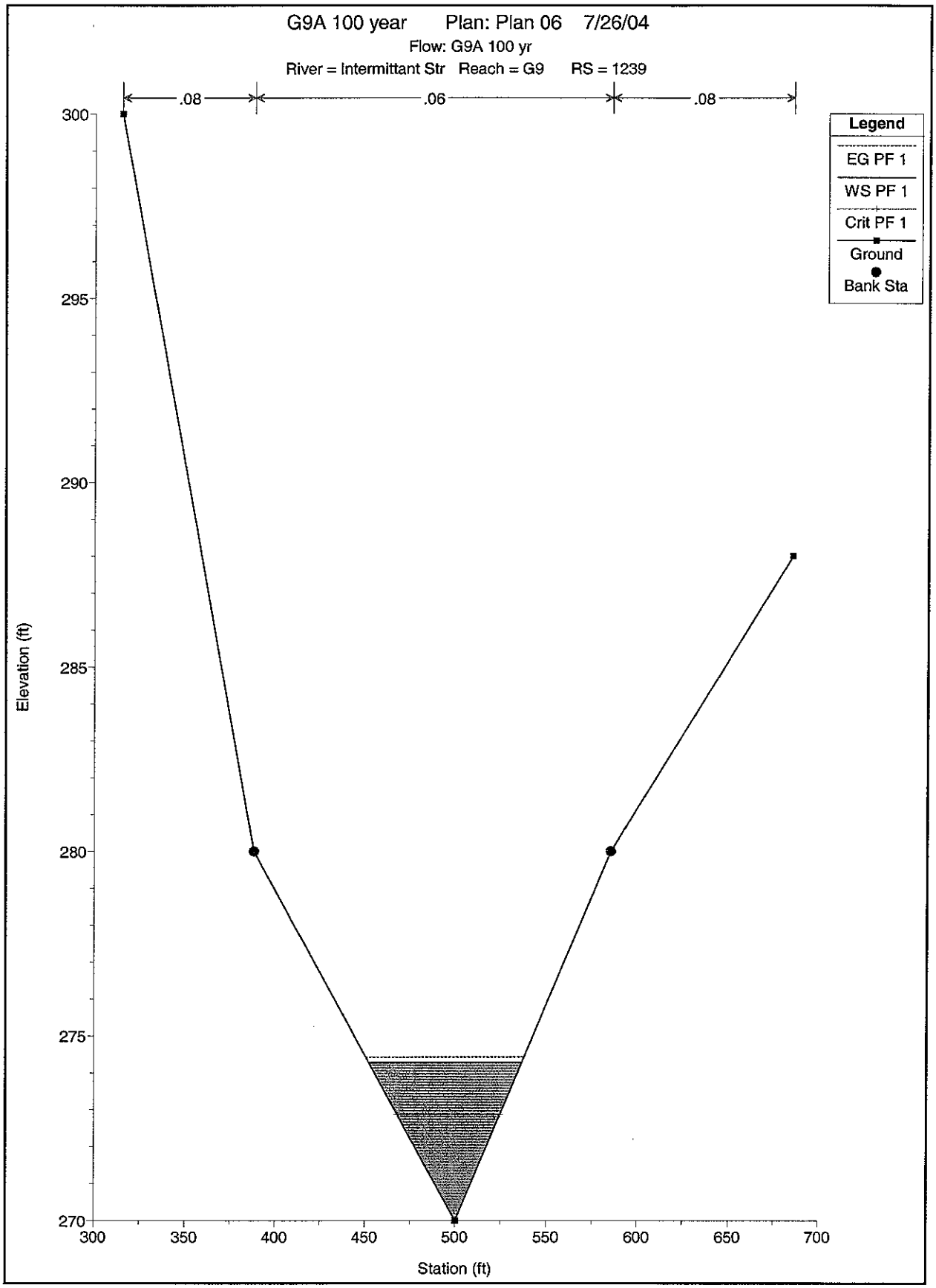
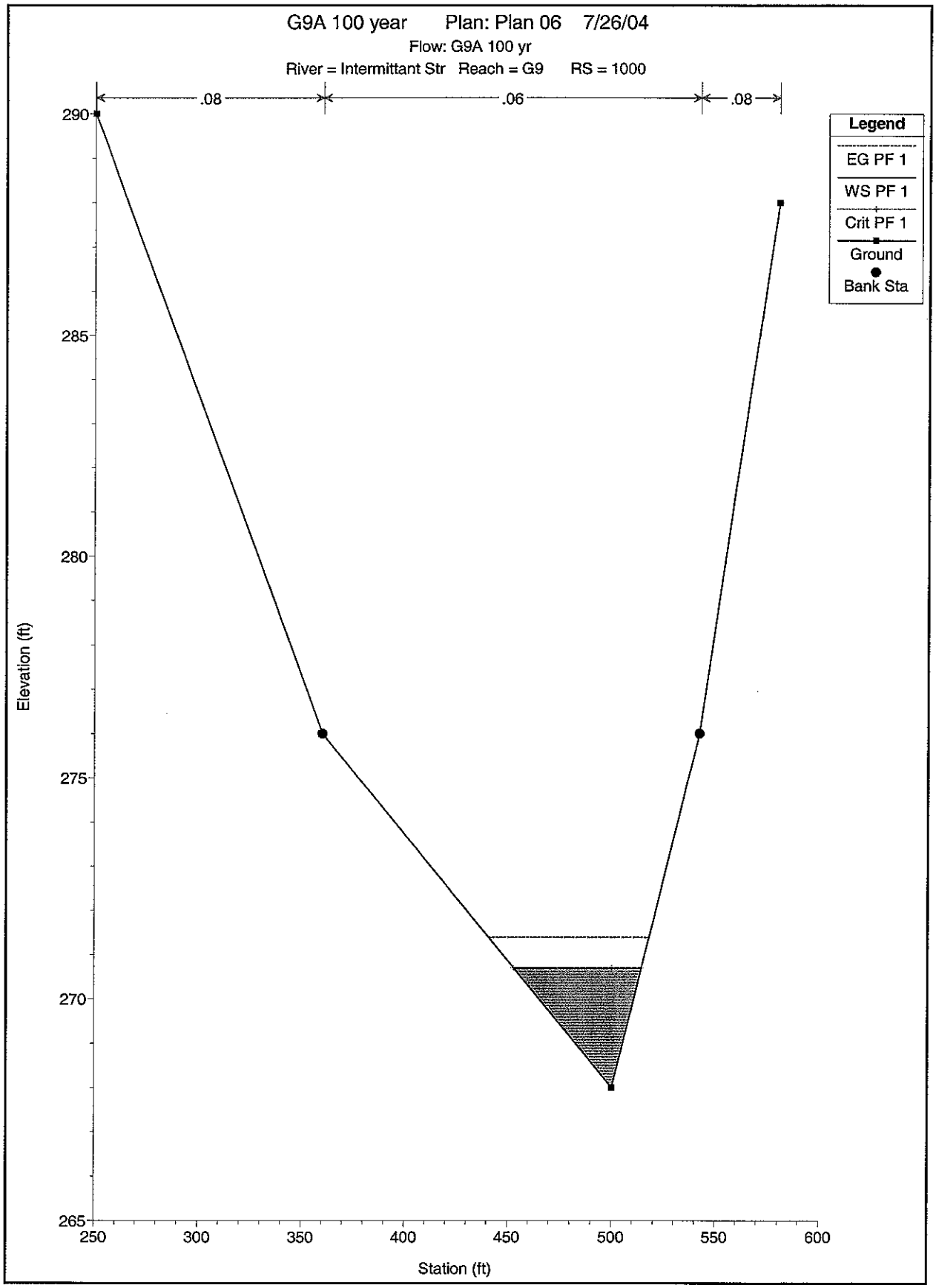
HEC-RAS Plan: Plan 06 River: Intermittant Str Reach: G9 Profile: PF 1

Reach	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)	
G9	1600	552.00	276.00	280.75	279.43	280.99	0.007895	3.89	142.06	59.76	0.44
G9	1361	552.00	274.00	276.44	276.44	277.07	0.050754	6.36	86.80	71.15	1.01
G9	1239	552.00	270.00	274.28	272.87	274.42	0.005581	3.06	180.32	84.29	0.37
G9	1000	552.00	268.00	270.70	270.70	271.39	0.048970	6.67	82.80	61.38	1.01


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
310
305
300
295
290
285
280
275
250
300
350
400
450
500
550
600
650
700
Station (ft)

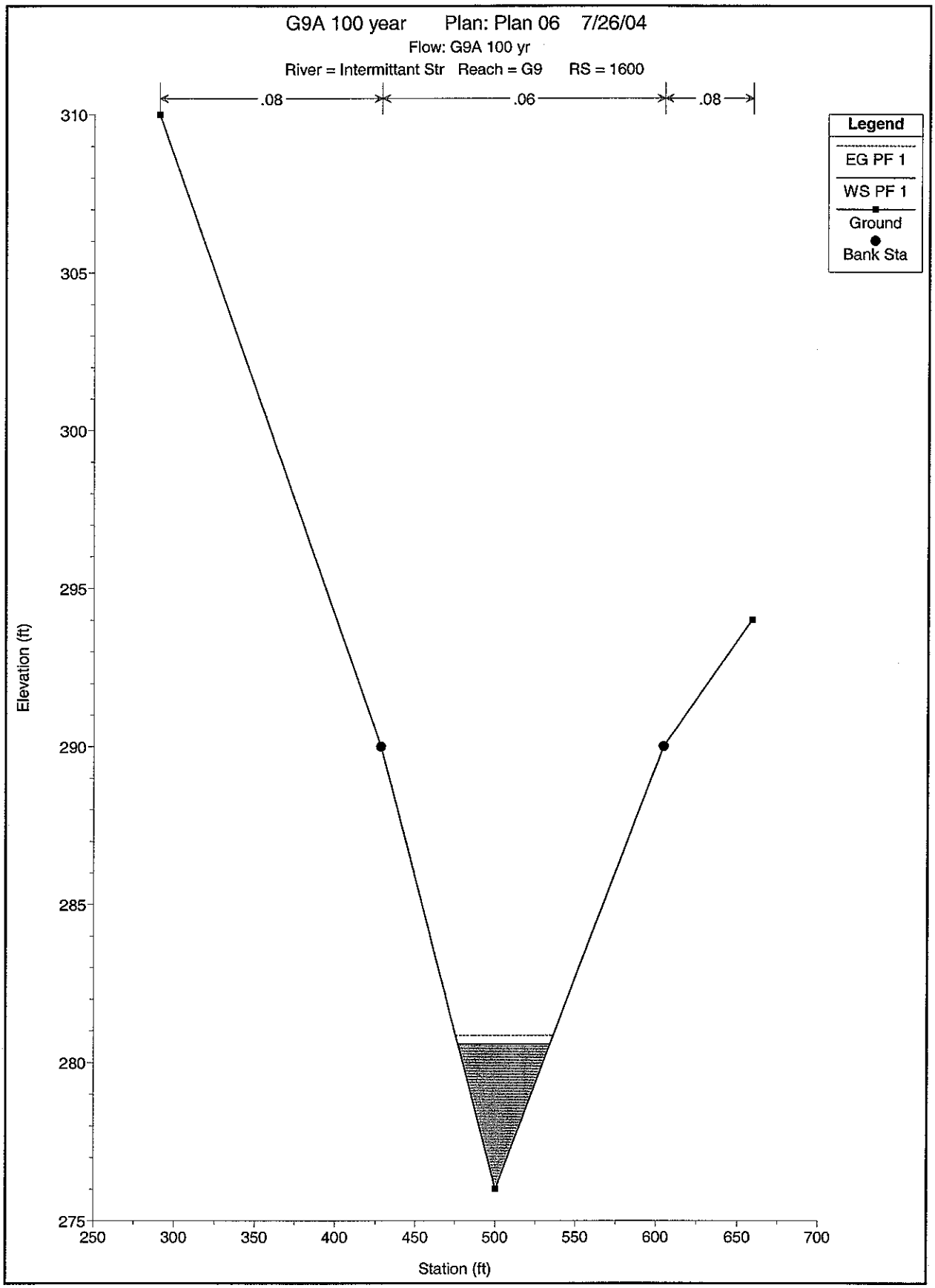

G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
300
295
290
285
280
275
270
200
300
400
500
600
700
800
Station (ft)

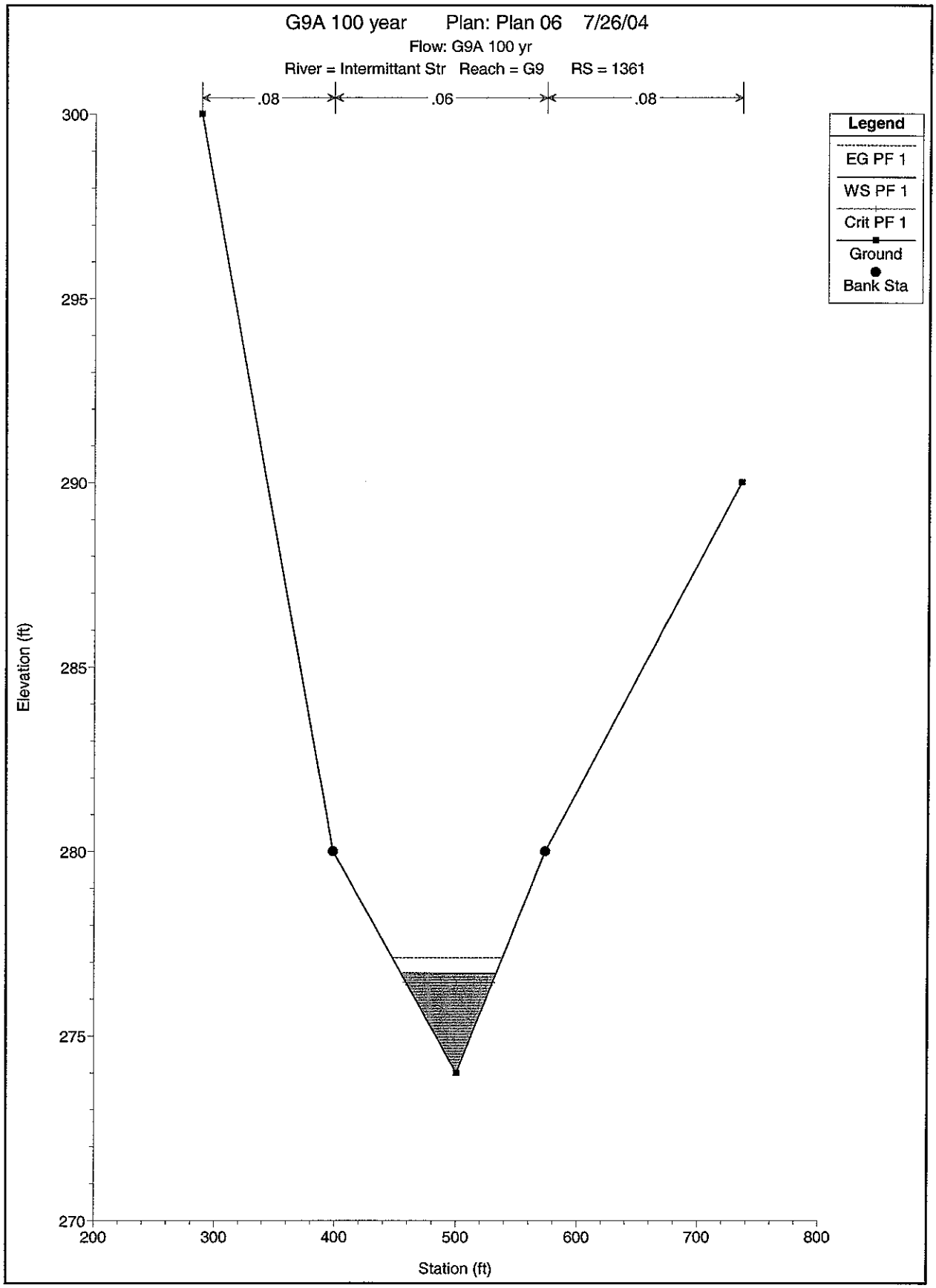

G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
300
295
290
285
280
275
270
300
350
400
450
500
550
600
650
700
Station (ft)


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
290
285
280
275
270
265
250
300
350
400
450
500
550
600
Station (ft)

HEC-RAS Plan: Plan 06 River: Intermittant Str Reach: G9 Profile: PF 1

Reach	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)	
G9	1600	552.00	276.00	280.58		280.85	0.009588	4.18	132.07	57.62	0.49
G9	1361	552.00	274.00	276.70	276.44	277.12	0.029660	5.20	106.17	78.70	0.79
G9	1301	Bridge									
G9	1239	552.00	270.00	274.28	272.87	274.42	0.005581	3.06	180.32	84.29	0.37
G9	1000	552.00	268.00	270.70	270.70	271.39	0.048970	6.67	82.80	61.38	1.01


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1600
.08
.06
.08
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
310
305
300
295
290
285
280
275
250
300
350
400
450
500
550
600
650
700
Station (ft)


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1361
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
300
295
290
285
280
275
270
200
300
400
500
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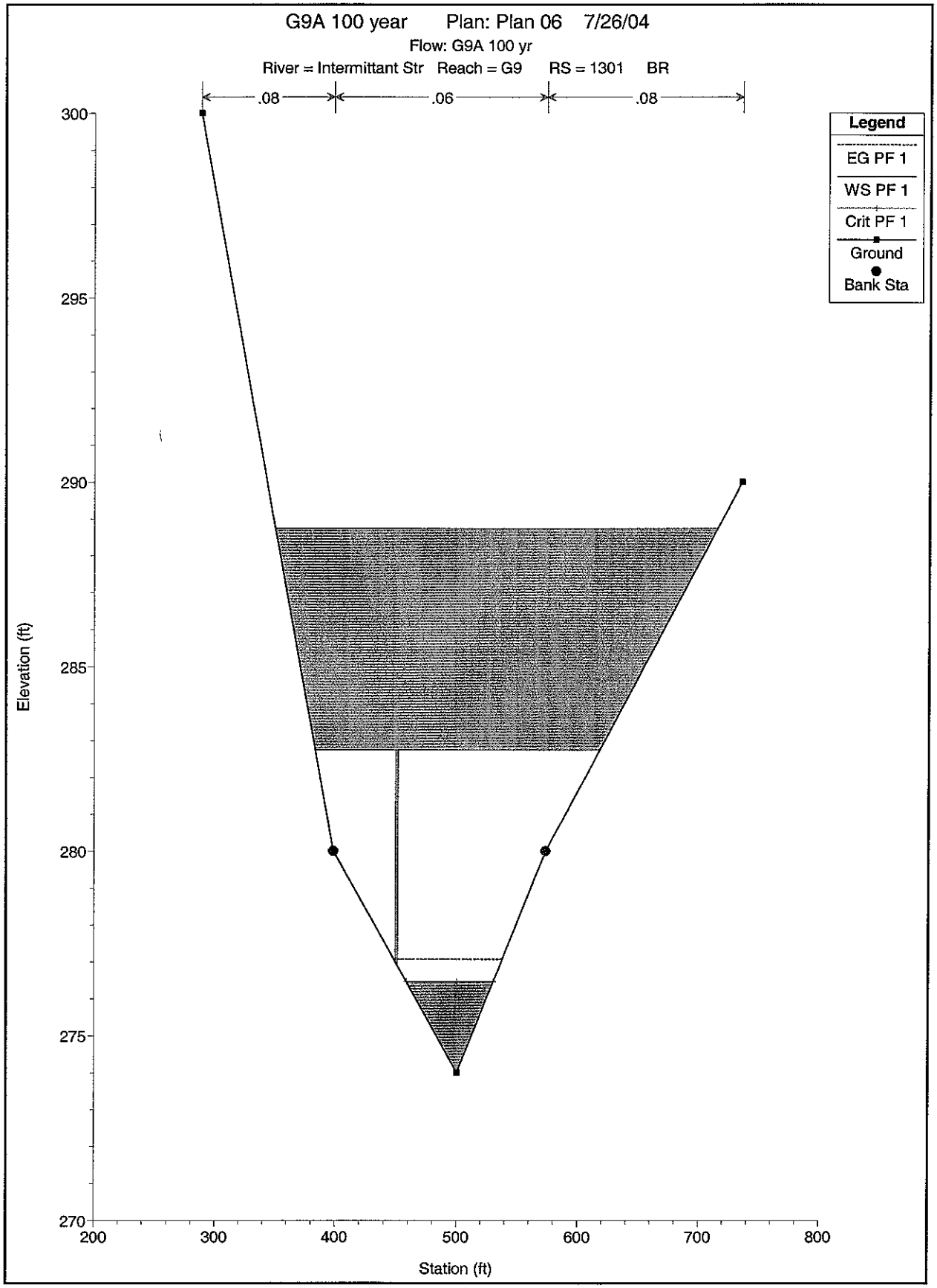
700
800
Station (ft)


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1301 BR
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
300
295
290
285
280
275
270
200
300
400
500
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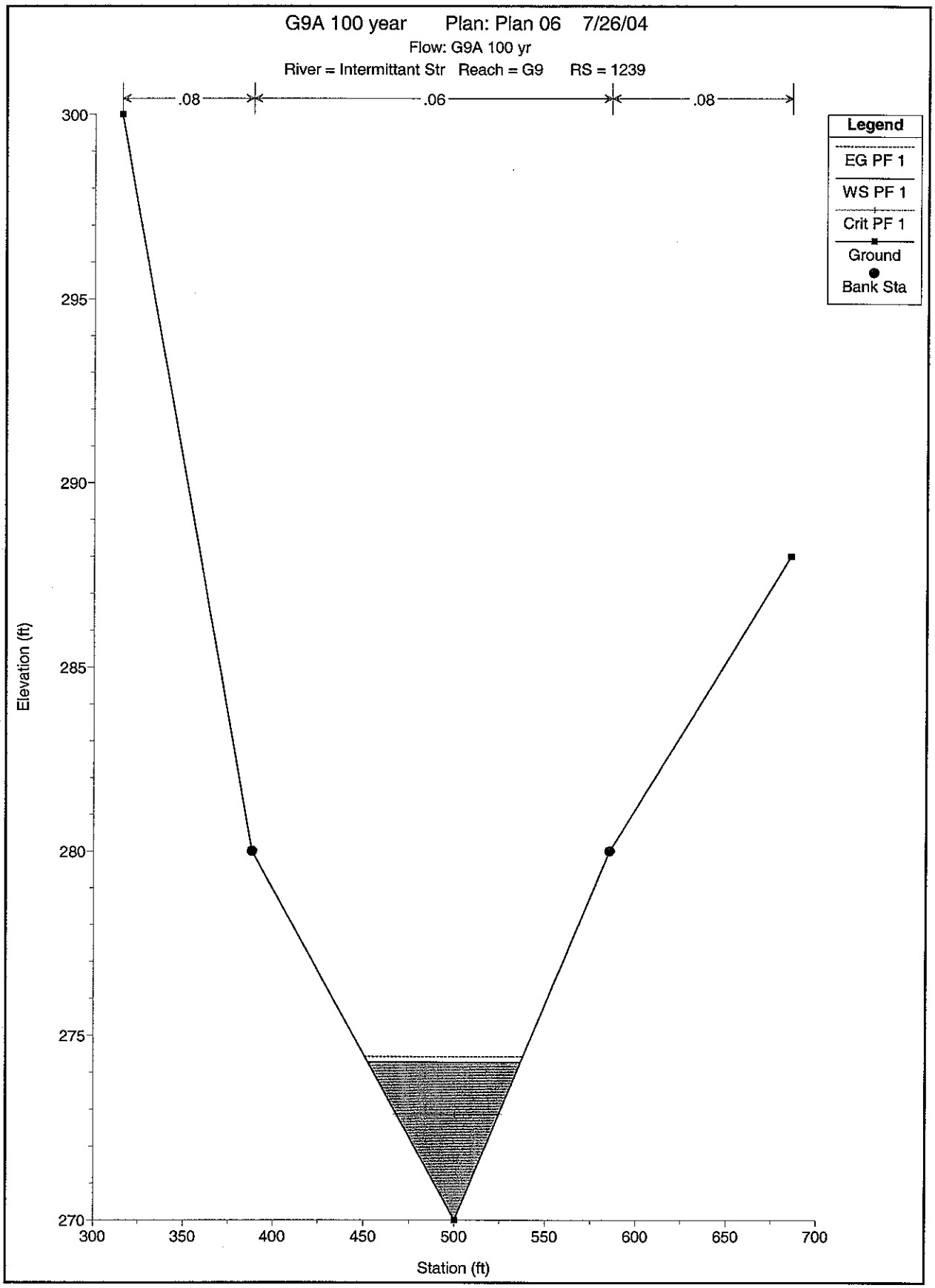
700
800
Station (ft)


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1239
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
300
295
290
285
280
275
270
300
350
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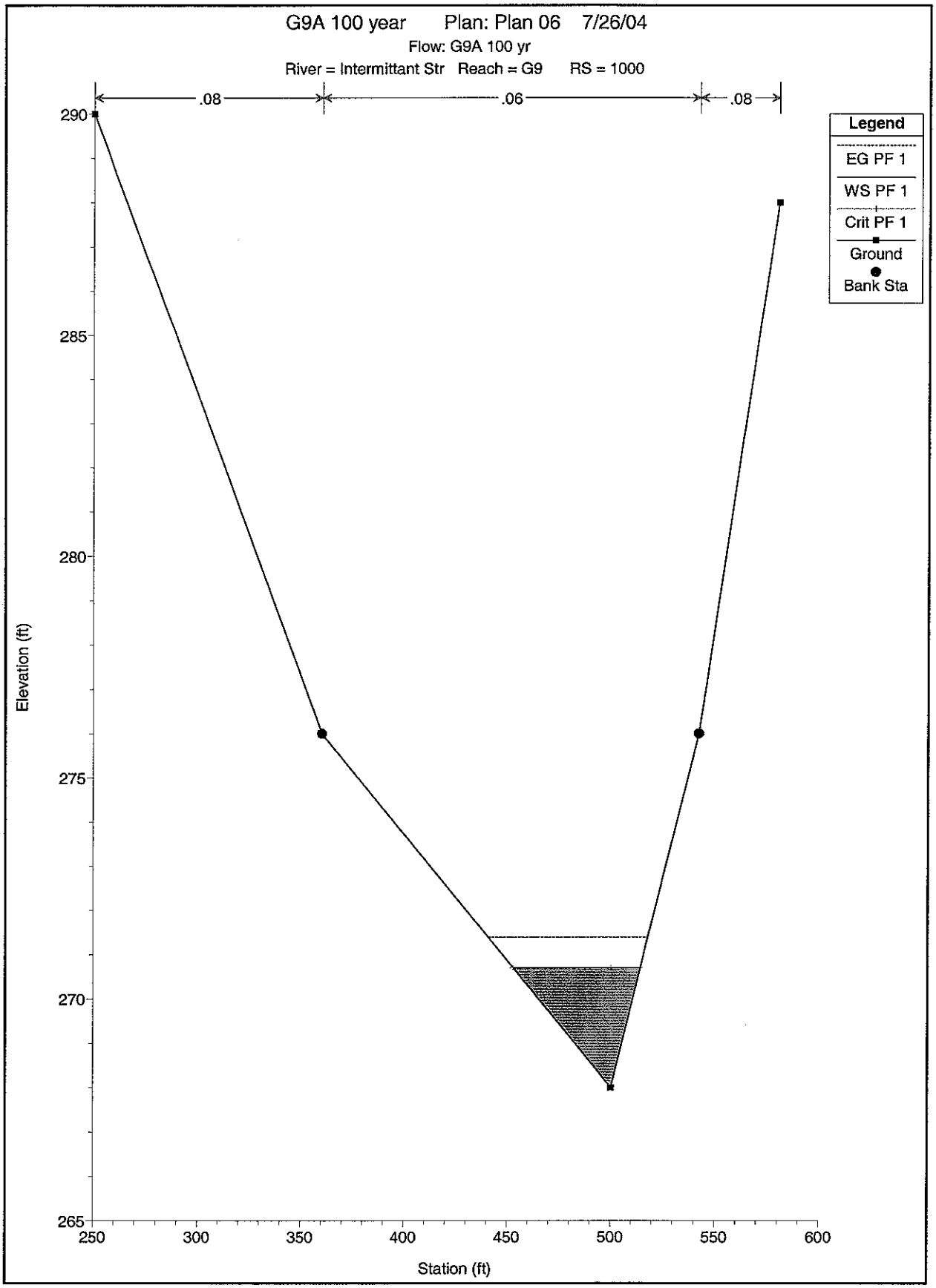
450
500
550
600
650
700
Station (ft)


G9A 100 year Plan: Plan 06 7/26/04
Flow: G9A 100 yr
River = Intermittant Str Reach = G9 RS = 1000
.08
.06
.08
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
290
285
280
275
270
265
250
300
350
400
450
500
550
600
Station (ft)