

**HYDROLOGY
AND HYDRAULIC REPORT
BENTON BURN SITE
ESCONDIDO, CALIFORNIA**

Prepared for

California Integrated Waste Management Board
101 I Street
Sacramento, CA 95814

URS Project No. 17326074.10002

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List of Acronyms and Abbreviations

| | |
|-------|--|
| CCR | California Code of Regulations |
| CIWMB | California Integrated Waste Management Board |
| cfs | cubic feet per second |
| DU | dwelling unit |
| fps | feet per second |
| ft | feet |
| LEA | Local Enforcement Agency |
| RAP | Remedial Action Plan |
| RCP | Reinforced Concrete Pipe |
| SMS | State Minimum Standards |

SECTION 1 INTRODUCTION

This drainage report presents the results of the hydrologic and hydraulic analyses associated with the Remedial Action Plan (RAP) for the Benton Burn Site, SWIS No. 37-CR-0008 (project). The project site is partly located within the limits of the City of Escondido (city) and unincorporated areas or the County of San Diego (County), California. The project site, at its southwesterly terminus, is surrounded by single-family dwellings along Still Water Glen, David Glen, and Larkhaven Glen roads; while at its northeasterly terminus the project site is bound by Sleepy Hill Lane. See Figure 1, Site Vicinity Map.

Based on reports provided by the California Integrated Waste Management Board (CIWMB) the project site was operated as a burn site from about 1948 through 1953. Municipal and commercial refuse was accepted at the facility where it was burned and placed in a canyon. The San Diego County Local Enforcement Agency (LEA) has been inspecting the site for compliance with applicable regulatory state minimum standards (SMS) in accordance with California Code of Regulations (CCR), Title 27, Division 2, Chapter 3, Subchapter 4, Articles 1 and 6, et. seq. Inspections of the burn dump revealed the presence of conditions that were cited as violations of the SMS. These violations included site security, *drainage and erosion control*, grading of fill surfaces, and site maintenance. In 2006, the LEA requested the CIWMB to conduct an investigation of the site to assess its conditions with respect to SMS.

At the request of CIWMB, URS has prepared a Remedial Action Plan (RAP) to meet the SMS and address the violations cited per the LEA investigations. As part of the RAP for the project, the hydrologic and hydraulic evaluations included herein have enabled URS to develop the RAP.

In general, the analyses presented herein provide the following:

- Existing and proposed conditions hydrologic analyses for the 2-, 10-, 50-, and 100-year storm events;
- Existing and proposed conditions hydraulic HEC-RAS analyses for the 2-, 10-, 50-, and 100-year storm events;
- A comparative analysis of existing versus proposed flow velocities and water surface profiles.

1.1 HYDROLOGIC SETTING

The project site encompasses portions of an ephemeral stream near the base of granitic hills. The topography of the project site footprint generally slopes from northeast to southwest with elevations of approximately 860 at its northeasterly end, and 820 at its southwesterly end. The average stream slope along the lower end of the project site varies from approximately 2 to 7%, while the slopes along the upper end of the project site vary from approximately 5% to 30%.

From a regional perspective, the watershed tributary to the project site encompasses approximately 60 acres. It stretches from David Glen at its southwesterly end to the Merriam Mountains at its northerly end. The watershed land uses within the County side consist of low density and multiple rural uses, while the watershed areas within the city are designated as biological open space and are part of the city's draft

Multiple Habitat Conservation Subarea Plan Reserve. The hydrologic soil group types consist of B, C and D, with the C hydrologic soil type being the most prevalent.

The storm runoff conveyed by the ephemeral stream enters into a 42-inch reinforced concrete pipe (RCP) that is located under David Glen. The entrance to the 42-inch RCP culvert is located on the easterly side of David Glen. Storm runoff is then conveyed to the west.

SECTION 2 HYDROLOGIC CRITERIA AND METHODOLOGY

This section of the report summarizes the hydrology criteria and methodology that were used in the hydrologic analyses.

2.1 HYDROLOGIC CRITERIA

The Rational Method outlined in the San Diego County Hydrology Manual (June 2003) was used in the 2-, 10-, 50-, and 100-year/6-hour storm event hydrologic analyses. Table 1 summarizes the San Diego County hydrologic parameters used for the project.

Appendix A includes the Land Use Map, Runoff Coefficients for Urban Areas (Table 3-1), Hydrologic Soil Group map, and the 2-, 10-, 50- and 100-yr Isopluvials. The Land Use Map was obtained from the County of San Diego GIS database; and the Runoff Coefficients for Urban Areas, Hydrologic Soil Group map, and the isopluvials were extracted from the San Diego County Hydrology Manual.

2.2 HYDROLOGIC METHODOLOGY

The project watershed and drainage subareas were delineated using a two-foot contour topographic map that was specifically developed for the project by Ninyo & Moore, which was then augmented with 2-foot aerial topography obtained from the City of Escondido.

It is important to note that only one set of hydrology calculations was prepared for both the existing and proposed conditions. The underlying premise is that the proposed project remedial alternatives included in the RAP maintain the existing conditions such as land use/impermeability and grading.

CIVILCADD/CIVILDESIGN Engineering Software was used to model and compute the 2-, 10-, 50-, and 100-year storm runoff quantities. CIVILCADD/CIVILDESIGN is a computer-aided design program where the user develops a node link model of the watershed. The program allows for the modeling of processes such as initial areas, street flow, pipe flow, channel flow, confluences, user specified hydrology data, etc. The program has the capability of estimating conduit sizes to convey design storm runoffs, or the user may input specific conduit sizes and open channels. The watershed hydrologic parameters such as hydrologic soil group types, land use, and rainfall intensity distribution can be based on the County of San Diego Hydrology Manual, 1984 or 2003 editions. The program uses node numbers to identify the location of each process. Developing independent node link models for each interior watershed and linking these sub-models together at confluence points creates the node link model. Stream entries must be made sequentially until all are entered. The node numbers used for the hydrology analysis are shown on Figure 2, Hydrology Map. Appendix A also includes the existing/developed project hydrology Rational Method computer output.

SECTION 3 HYDRAULIC METHODOLOGY

This section describes the methodology used in the hydraulic analyses associated with the existing conditions and remedial alternatives proposed in the RAP for the project.

In general, mathematical models such as HEC-2 or HEC-RAS provide an approximation of a river's rigid-boundary response to parameters such as discharge, geometry, and roughness. For this project the HEC-RAS model was used. The hydrology analyses results (peak 2-, 10-, 50-, and 100-year flows) for the various storm events were used in the HEC-RAS model to determine existing floodplain widths, water surface profiles, and velocities associated with the project.

From a hydraulic perspective, the purpose of the HEC-RAS analyses was to verify that existing condition hydraulic parameters such as topwidths, water surface profiles and channel velocities for remedial alternatives presented in the RAP are reasonably maintained and do not adversely impact neighboring properties along the project footprint, as well as upstream and downstream from the project.

3.1 EXISTING CONDITION HYDRAULIC MODEL DEVELOPMENT

Cross Section Development: The cross section elevation data used to develop the first five HEC-RAS cross sections, from cross section 30 through cross section 125 was determined using the City's 2-foot contour map. Data for the development of cross sections 150 through 215 was extracted from the 2-foot contour map by Ninyo & Moore. The cross sections extend upstream and downstream of the site so that potential impacts due to the RAP can be evaluated. The cross section locations are shown on Figures 3 and 4.

Loss Coefficients: The loss coefficients along the creek are based on a visual inspection of the site. The vegetation density along the creek varies widely from clean, straight bare soil to very weedy reaches with heavy stands of brush. Therefore, the Manning's roughness coefficients (n-values) along the main channel and overbanks vary from 0.025 to 0.070. Contraction and expansion coefficients of 0.1 and 0.3 were used, respectively, in areas away from the entrance to the existing 42-inch RCP culvert, while of 0.3 and 0.5 were used near the culvert.

Starting Water Surface Elevations: The HEC-RAS analyses were initialized at the entrance of the existing 42-inch RCP culvert located immediately on the easterly side of David Glen. The invert elevation at the entrance of the culvert, and cross sections 30 through 125 were approximated using the city's 2-foot contour map. To verify these approximations, a sensitivity analysis was performed. The purpose of the sensitivity analysis was to verify that the 42-inch RCP invert elevation and cross section approximations do not create a backwater condition that could potentially affect the calculated water surface profiles along the project footprint, as well as downstream and upstream from the project. The sensitivity analysis consisted of calculating two water surface profiles for each storm event (2-, 10-, 50, and 100-year). The headwater calculations for the starting water surface elevations at the entrance of the 42-inch RCP were done assuming an inlet control condition for each profile, and for each storm event, one headwater calculation was done assuming a "Square Edge with Headwall" entrance, while the second one was done assuming a "Groove End with Headwall".

It is important to note that only the most conservative HEC-RAS computer output results of the sensitivity analyses were included herein.

Explanation of HEC-RAS Model: The HEC-RAS program calculates water surface profiles for steady or unsteady gradually varied flow in natural or man made channels, and can be used to calculate both subcritical and supercritical flow profiles. The computational procedure solves the energy equation by using the standard step method, with energy loss due to friction (Manning's equation). The program can model the effects of channel improvements and physical obstructions such as bridges, culverts, weirs and levees. Input data such as channel geometry, discharge, roughness coefficient and stage/discharge relationship for the river is entered manually, and can be in either English or metric units.

3.2 PROPOSED RAP HYDRAULIC ANALYSIS

The proposed grading alternative included in the RAP consists of 2 feet of clean fill over the existing burn area, with filter fabric covered by rock within the 100-year floodplain limits. The revised grading was modeled in HEC-RAS by adding 2 feet of fill to the existing cross section. The rock fill within the floodplain was modeled by adjusting the Manning's roughness coefficient ('n' value) to 0.04 to reflect the increased hydraulic roughness associated with the rock.

SECTION 4 RESULTS**4.1 HYDROLOGY RESULTS**

Table 2 summarizes the results for the 2-, 10-, 50- and 100-year hydrologic analyses for the project. Figure 2, Hydrology Map shows the surface watershed boundaries, and Appendix A contains the hydrology model output files.

Note that the results shown in Table 2 above represent the results for the existing and proposed conditions at the downstream end of the site. Because the existing runoff coefficients/land use and grades will be maintained, it is anticipated that storm runoff for both conditions will be maintained. As a result, only one set of calculations was prepared for both conditions.

4.2 HYDRAULIC ANALYSIS RESULTS

Hydraulic analysis results for the existing condition indicate that there will be no backwater effect from the 42-inch culvert at David Glen downstream of the site for a range of culvert entrance condition assumptions. The HEC-RAS model output is included in Appendix B. Figures 3 and 4, Hydraulic Maps show the cross section locations, along with the 100-year floodplain limits. A summary of existing condition 100-year hydraulic parameters is provided below.

- 100-year floodplain topwidths of 8 to 44 feet.
- 100-year flow depths of 1 to 2 feet.
- 100-year flow velocities of 4 to 19 feet per second (fps).

The 100-year floodplain topwidths and flow depths are relatively small in comparison to the canyon topwidth and depth as shown in Figures 3 and 4. Flow velocities are relatively high in the narrow, steep portions of the site which is the cause of existing localized channel erosion in these areas. Design sizing of the proposed rock fill within channel bottom will utilize shear stress, in lieu of velocity, as the criterion for erosion through the site.

Hydraulic modeling of the proposed fill within the burn area indicates that there will be areas of increased 100-year flood elevations that mirror the 2 feet of proposed fill; however, as shown in Table 3 and by the HEC-RAS cross section plots in Appendix B, the water surface elevations will be well below the canyon top of bank (and house pad elevations) through the proposed fill areas.

SECTION 5 CONCLUSION AND RECOMMENDATIONS

Implementation of the proposed RAP will result in the placement of approximately 2 feet of fill over those areas where burn ash containing waste is within 2 feet of the ground surface at the site. Within the areas of the 100-year floodplain included in the area to be capped, filter fabric will be placed and covered with 2 feet of rock designed to withstand 100-year flood hydraulic shear stresses to prevent mobilization of the rock during flood events. The recommended minimum rock diameter is 1 to 2 inches. Larger rock (a minimum of 12-inch diameter) is recommended for the steeper area of the drainage near the center of the burn site footprint.

While implementation of the RAP will result in local increases in water surface elevations due to rock fill placement within the 100-year floodplain, the water surface elevations will be well below the existing top of bank and house pad elevations and will not result in increased flooding, erosion, or sedimentation upstream or downstream of the site.

Table 1 Hydrology Criteria

| | |
|-------------------------------------|--|
| Design Storm Event | 2-, 10-, 50-, and 100-year/6-hour |
| Land Use (Existing and Proposed) | <u>County:</u> Multiple Rural Use: 1DU/4,8,20 Ac (undisturbed natural terrain), Residential Use: 1DU/1,2,4 Ac (low density residential) <u>City:</u> Biological Open Space (undisturbed natural terrain) |
| Hydrologic Group Soil Type | B, C, and D |
| Runoff Coefficients | Varies from C = 0.25 to C = 0.36 (weighted C values) |
| Precipitation | 2-year: 1.6in 10-year: 2.4in 50-year: 3.0in 100-year: 3.5in |

Table 2 Hydrology Analysis Results

| Storm Event | Peak Flow (cfs) |
|-----------------|-----------------|
| 2-year/6-hour | 44 |
| 10-year/6-hour | 69 |
| 50-year/6-hour | 88 |
| 100-year/6-hour | 104 |

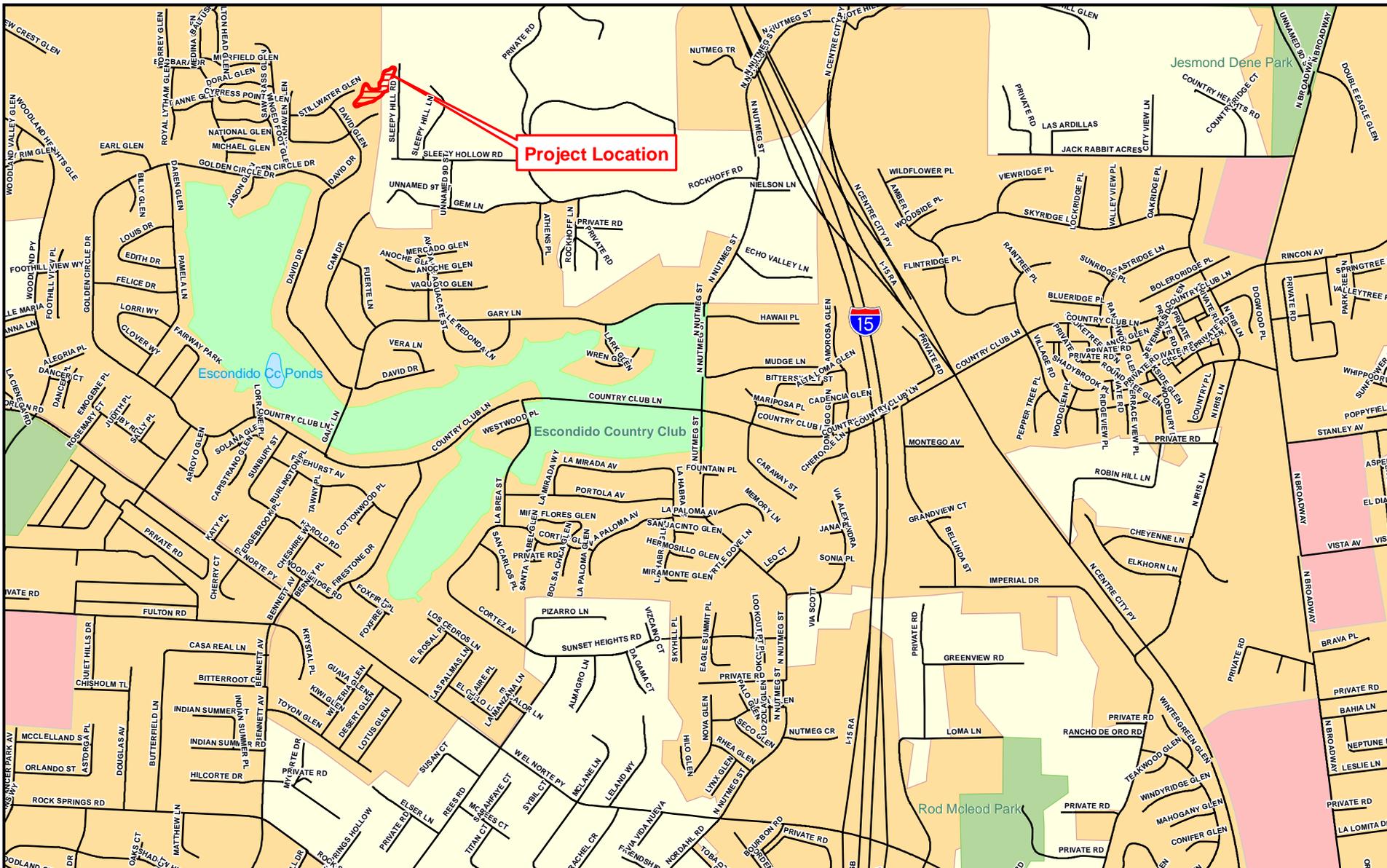
Table 3 Hydraulic Analysis Results

| Cross Section | Existing Channel Invert Elevation (ft) | Proposed Channel Invert Elevation (ft) | Existing 100-year WSEL (ft) | Proposed 100-year WSEL (ft) | Elevation of Top of Left Bank (ft) | Elevation of Top of Right Bank (ft) | Existing 100-year Velocity (fps) | Proposed 100-year Velocity (fps) |
|---------------|--|--|-----------------------------|-----------------------------|------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| 30 | 817 | 817 | 823.90 | 823.90 | 822-824 ¹ | 830 ¹ | 1.88 | 1.88 |
| 40 | 817.5 | 817.5 | 823.96 | 823.96 | 822-824 ¹ | 832 ¹ | 1.00 | 1.00 |
| 50 | 819.5 | 819.5 | 823.96 | 823.96 | 824 ¹ | 832 ¹ | 1.28 | 1.28 |
| 100 | 819.7 | 819.7 | 823.96 | 823.96 | 828 ¹ | 832 | 1.54 | 1.54 |
| 125 | 819.8 | 819.8 | 823.96 | 823.96 | 830 ¹ | 834 | 1.57 | 1.57 |
| 150 | 822 | 822.0 | 823.61 | 823.92 | 835 ¹ | 832 | 11.11 | 6.14 |
| 155 | 826 | 827.5 | 827.94 | 828.53 | 842 | 834 | 4.56 | 4.30 |
| 160 | 828 | 829.2 | 829.07 | 830.26 | 840 | 842 | 7.64 | 7.79 |
| 165 | 830.1 | 832.1 | 831.48 | 833.63 | 843 | 844 | 7.32 | 6.06 |
| 170 | 834 | 836.0 | 835.07 | 837.11 | 856 | 855 | 10.11 | 9.43 |
| 175 | 836.6 | 838.6 | 838.52 | 840.70 | 860 | 860 | 7.88 | 6.64 |
| 180 | 838.1 | 840.1 | 839.63 | 841.63 | 862 | 862 | 12.06 | 11.99 |
| 185 | 840 | 842.0 | 841.43 | 843.45 | 864 | 866 | 18.69 | 18.36 |
| 190 | 850 | 852.0 | 851.19 | 853.59 | 864 | 870 | 17.47 | 9.81 |
| 195 | 860 | 862.0 | 861.13 | 863.04 | 873 | 875 | 9.44 | 11.20 |
| 200 | 866 | 868 | 867.82 | 870.27 | 889 | 874.5 | 9.60 | 6.30 |

Notes:

¹ Top of bank elevations for these sections are estimated based upon City of Escondido 2 foot contour mapping (no spot elevations for estimating pad elevations as with the more detailed Ninjo & Moore project site topography).

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Project Location

SOURCES: ESRI (Base Layers 2008).

VICINITY MAP BENTON BURN DUMP



625 0 625 1250 Feet
 SCALE: 1" = 1250 Feet (1:15,000)
 SCALE CORRECT WHEN PRINTED AT 8.5X11

CREATED BY: CL

DATE: 2-18-09

FIG. NO:

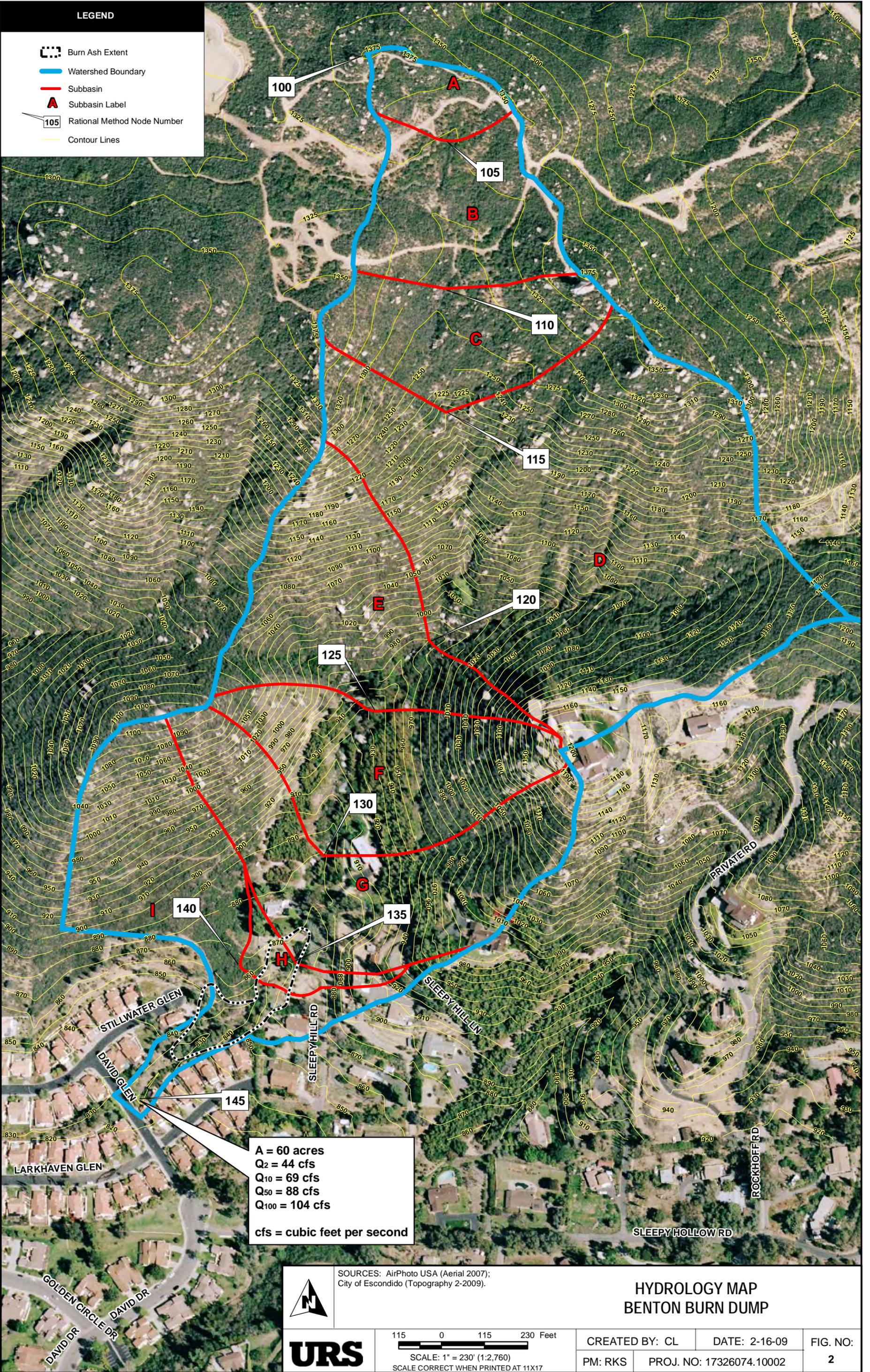
PM: RKS

PROJ. NO: 17326074.10002

1

LEGEND

-  Burn Ash Extent
-  Watershed Boundary
-  Subbasin
-  Subbasin Label
-  Rational Method Node Number
-  Contour Lines



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SOURCES: AirPhoto USA (Aerial 2007);
City of Escondido (Topography 2-2009).



115 0 115 230 Feet
SCALE: 1" = 230' (1:2,760)
SCALE CORRECT WHEN PRINTED AT 11X17

**HYDROLOGY MAP
BENTON BURN DUMP**

| | | |
|----------------|--------------------------|----------|
| CREATED BY: CL | DATE: 2-16-09 | FIG. NO: |
| PM: RKS | PROJ. NO: 17326074.10002 | 2 |

LEGEND

-  Burn Ash Extent
-  100 Year Floodplain
-  HEC-RAS Section Location



100 YEAR FLOODPLAIN

STILLWATER GLEN

DAVID GLEN

LARKHAVEN GLEN

SLEEPY HILL RD



SOURCES: AirPhoto USA (Aerial 2007).



40 0 40 80 Feet

SCALE: 1" = 80' (1:960)

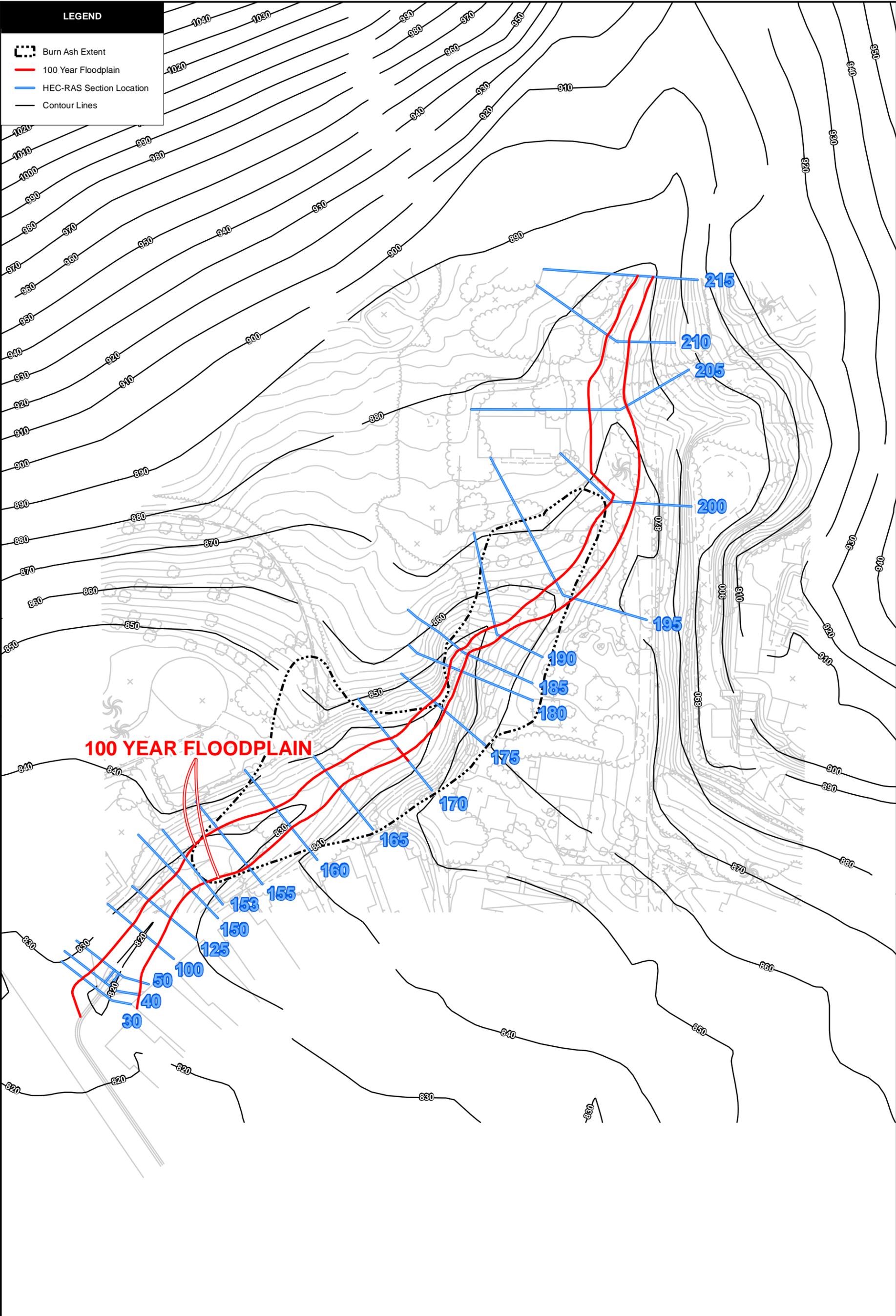
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**HYDRAULIC MAP
BENTON BURN DUMP**

| | | |
|----------------|--------------------------|----------|
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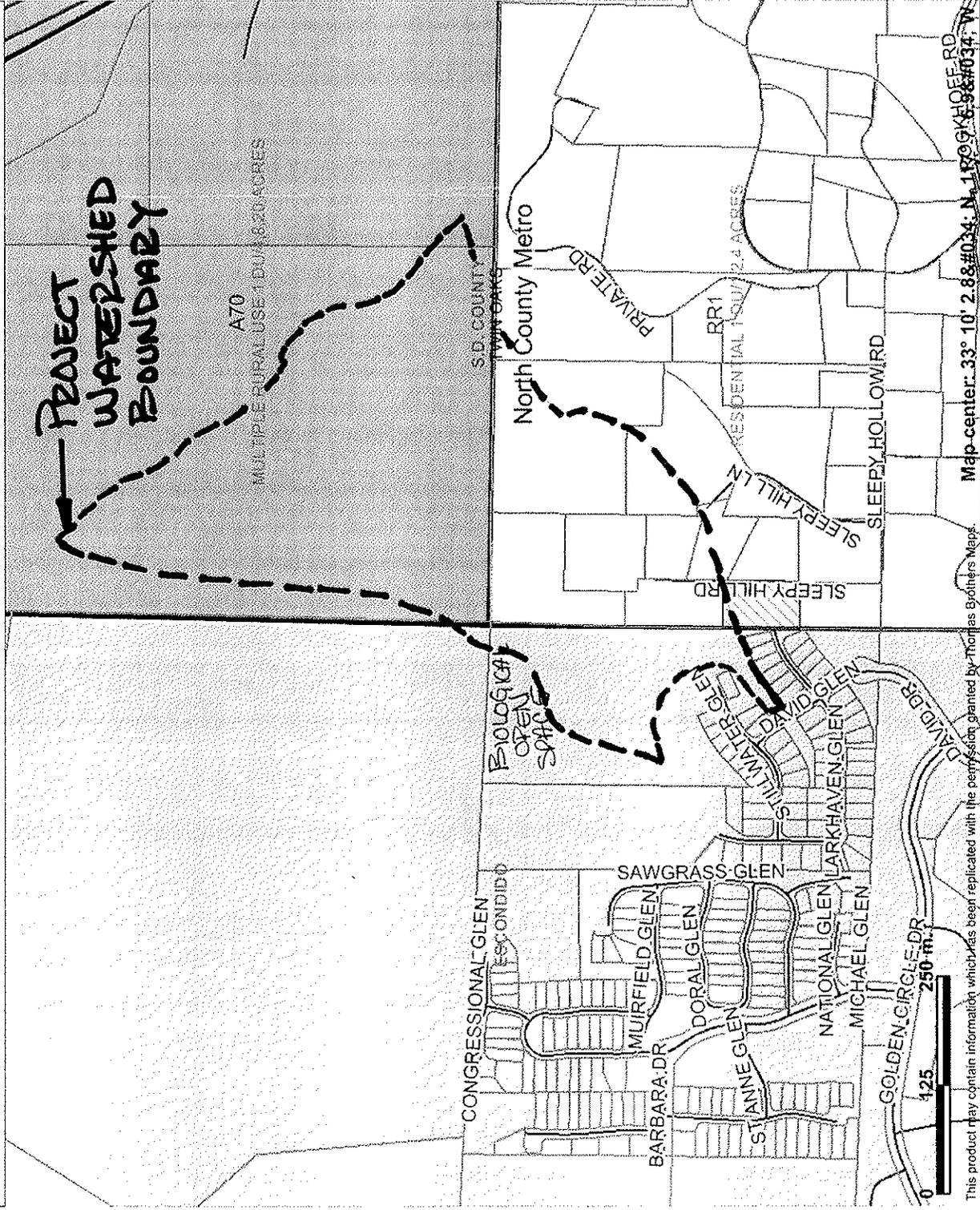
LEGEND

- Burn Ash Extent
- 100 Year Floodplain
- HEC-RAS Section Location
- Contour Lines

100 YEAR FLOODPLAIN

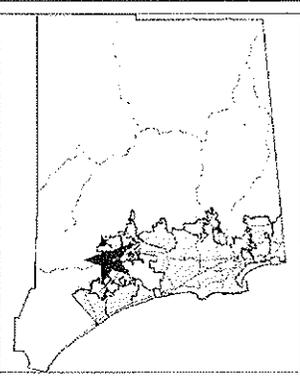
| | | | | |
|--|---|--|--|---|
| | SOURCES: AirPhoto USA (Aerial 2007); City of Escondido (Topography 2-2009) | | HYDRAULIC MAP WITH TOPOGRAPHY BENTON BURN DUMP | |
| | | SCALE: 1" = 80' (1:960) SCALE CORRECT WHEN PRINTED AT 11X17 | CREATED BY: CL PM: RKS | DATE: 2-19-09 PROJ. NO: 17326074.10002 |

LAND USE/ZONING



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Legend

- Parcels
- Highways
- Freeways
- Streets
- Water Bodies
- Water Bodies
- General Plan (Existing)
- Residential 1 DU/1.24 Acres
- Residential 1 DU/1.24 Acres
- Residential 2 DU/1.24 Acres
- Residential 2.8 DU/1.24 Acres
- Residential 4.3 DU/1.24 Acres
- Residential 7.3 DU/1.24 Acres
- Residential 10.9 DU/1.24 Acres
- Residential 14.5 DU/1.24 Acres
- Residential 24 DU/1.24 Acres
- Residential 43 DU/1.24 Acres
- Office Professional
- Neighborhood Professional
- General Commercial
- Service Commercial
- Visitor Serving Commercial
- Limited Impact Industrial
- Fallbrook Village Mixed Use
- General Impact Industrial
- Estate Residential 1 DU/2.4 Acres
- Multiple Rural Use 1 DU/4.8, 20 Acres
- Intensive Ag. 1 DU/1.24, 4.8 Acres
- General Agriculture
- Specific Plan Area
- Public/Semi-Public Lands
- National Forest and State Parks
- Impact Sensitive 1 DU/20 Acres
- Extractive
- Telecommunications
- Indian Reservation

Scale: 1:6,966

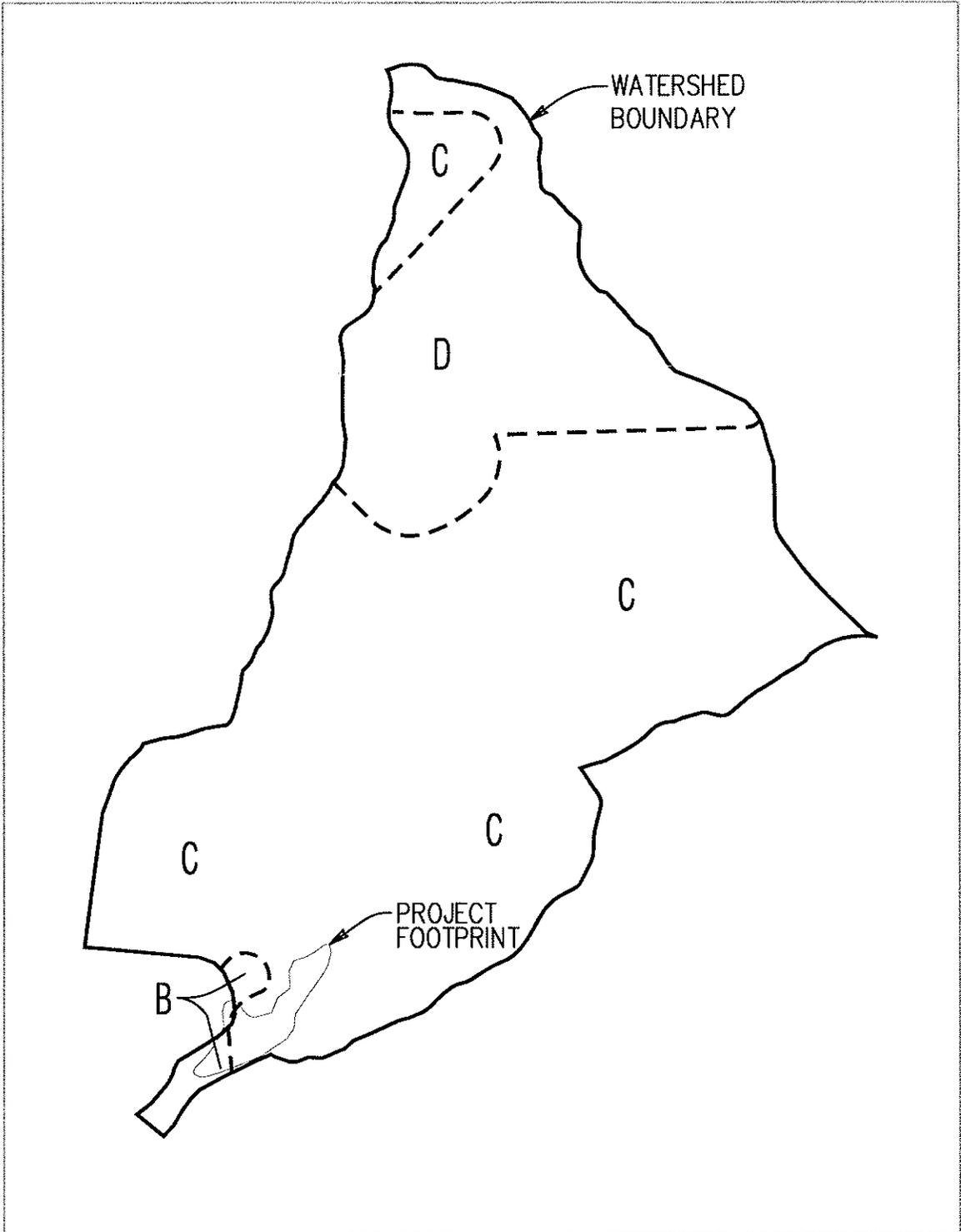
**Table 3-1
 RUNOFF COEFFICIENTS FOR URBAN AREAS**

| Land Use | | Runoff Coefficient "C" | | | | |
|---------------------------------------|--------------------------------|------------------------|-----------|------|------|------|
| NRCS Elements | County Elements | % IMPER. | Soil Type | | | |
| | | | A | B | C | D |
| Undisturbed Natural Terrain (Natural) | Permanent Open Space | 0* | 0.20 | 0.25 | 0.30 | 0.35 |
| Low Density Residential (LDR) | Residential, 1.0 DU/A or less | 10 | 0.27 | 0.32 | 0.36 | 0.41 |
| Low Density Residential (LDR) | Residential, 2.0 DU/A or less | 20 | 0.34 | 0.38 | 0.42 | 0.46 |
| Low Density Residential (LDR) | Residential, 2.9 DU/A or less | 25 | 0.38 | 0.41 | 0.45 | 0.49 |
| Medium Density Residential (MDR) | Residential, 4.3 DU/A or less | 30 | 0.41 | 0.45 | 0.48 | 0.52 |
| Medium Density Residential (MDR) | Residential, 7.3 DU/A or less | 40 | 0.48 | 0.51 | 0.54 | 0.57 |
| Medium Density Residential (MDR) | Residential, 10.9 DU/A or less | 45 | 0.52 | 0.54 | 0.57 | 0.60 |
| Medium Density Residential (MDR) | Residential, 14.5 DU/A or less | 50 | 0.55 | 0.58 | 0.60 | 0.63 |
| High Density Residential (HDR) | Residential, 24.0 DU/A or less | 65 | 0.66 | 0.67 | 0.69 | 0.71 |
| High Density Residential (HDR) | Residential, 43.0 DU/A or less | 80 | 0.76 | 0.77 | 0.78 | 0.79 |
| Commercial/Industrial (N. Com) | Neighborhood Commercial | 80 | 0.76 | 0.77 | 0.78 | 0.79 |
| Commercial/Industrial (G. Com) | General Commercial | 85 | 0.80 | 0.80 | 0.81 | 0.82 |
| Commercial/Industrial (O.P. Com) | Office Professional/Commercial | 90 | 0.83 | 0.84 | 0.84 | 0.85 |
| Commercial/Industrial (Limited I.) | Limited Industrial | 90 | 0.83 | 0.84 | 0.84 | 0.85 |
| Commercial/Industrial (General I.) | General Industrial | 95 | 0.87 | 0.87 | 0.87 | 0.87 |

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).

DU/A = dwelling units per acre

NRCS = National Resources Conservation Service



HYDROLOGIC SOILS GROUP MAP

NTS

(EXCERPT FROM APPENDIX A, HYDROLOGIC SOIL GROUPS MAP, OF THE COUNTY OF SAN DIEGO HYDROLOGY MANUAL)

County of San Diego Hydrology Manual



Rainfall Isopleths

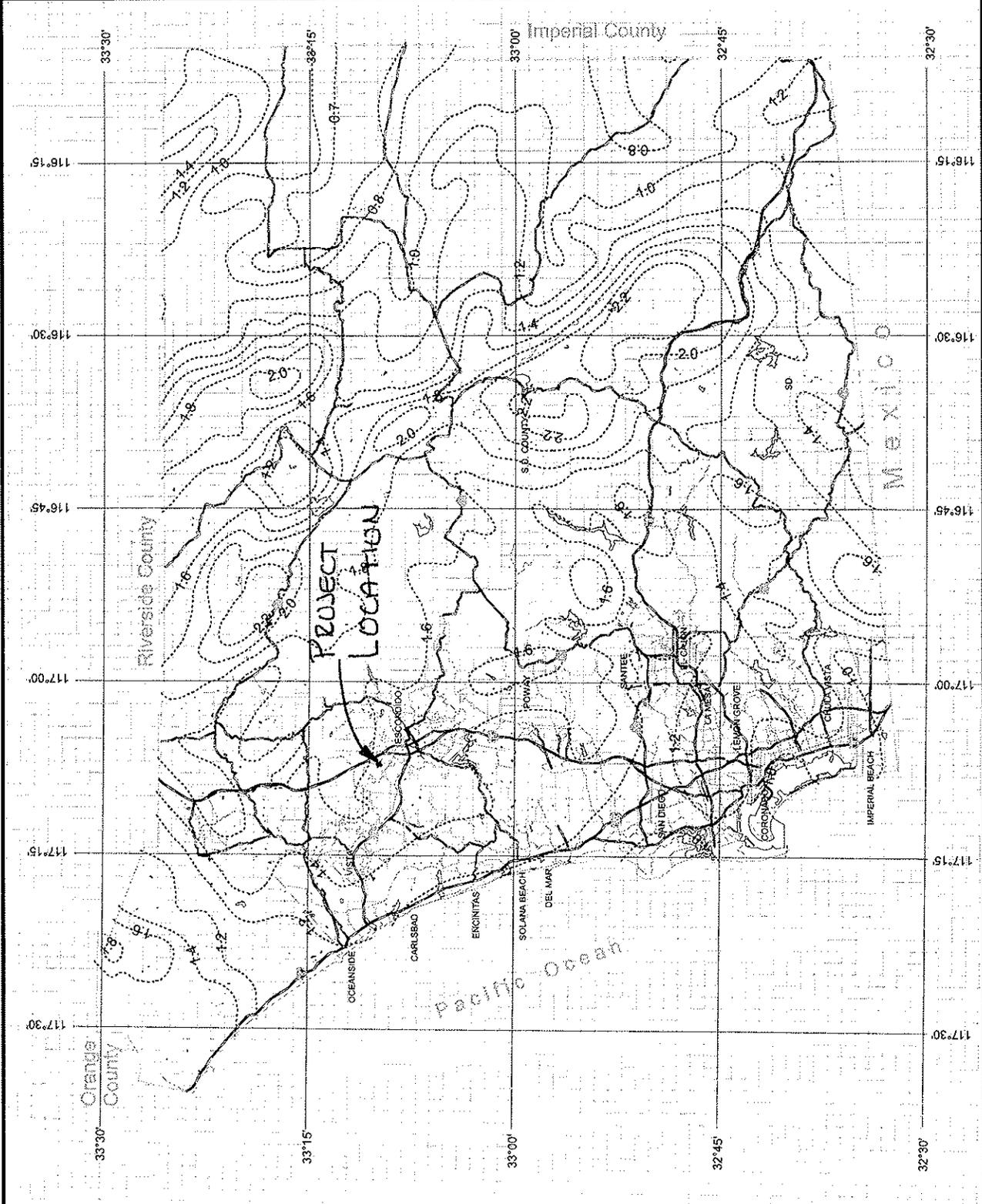
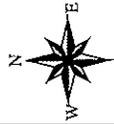
2 Year Rainfall Event - 6 Hours



$I_2 = 1.6$



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County of San Diego Hydrology Manual



Rainfall Isopleths

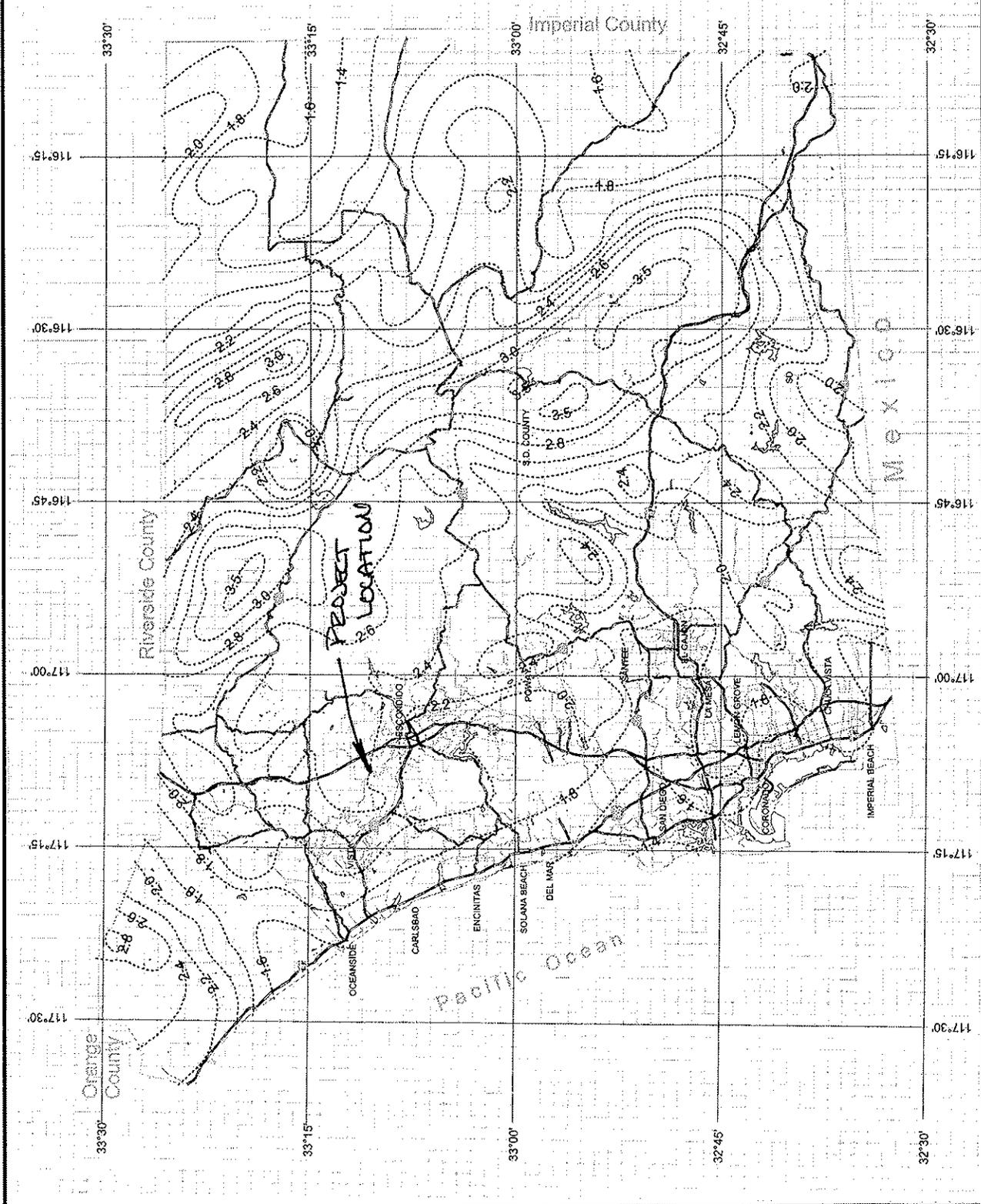
10 Year Rainfall Event - 6 Hours

..... Isopleth (inches)

$$I_{10} = 2.4$$



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County of San Diego Hydrology Manual



Rainfall Isopleths

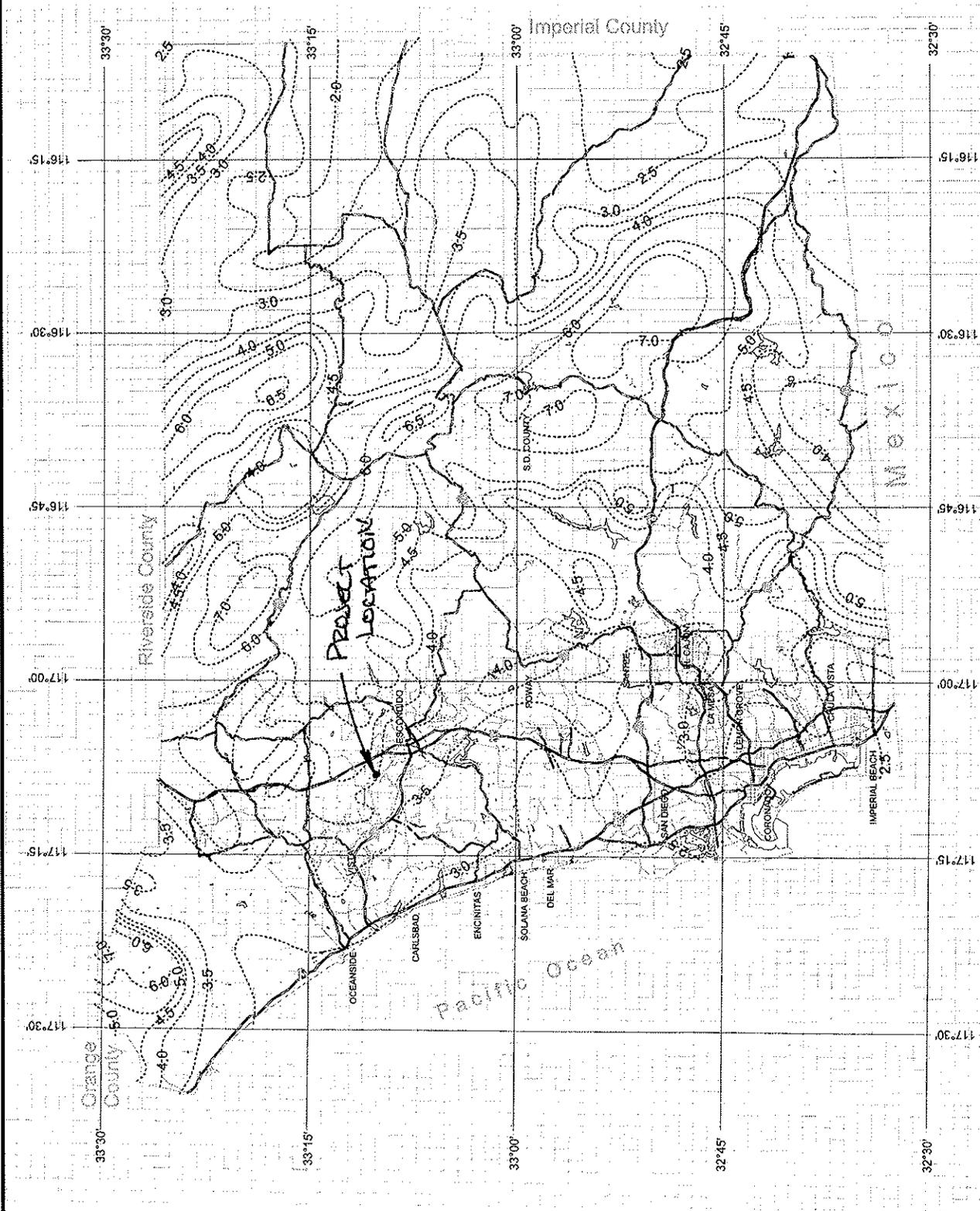
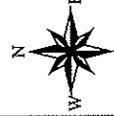
10 Year Rainfall Event - 24 Hours



$$I_{10} = 4.0$$



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County of San Diego Hydrology Manual



Rainfall Isopleths

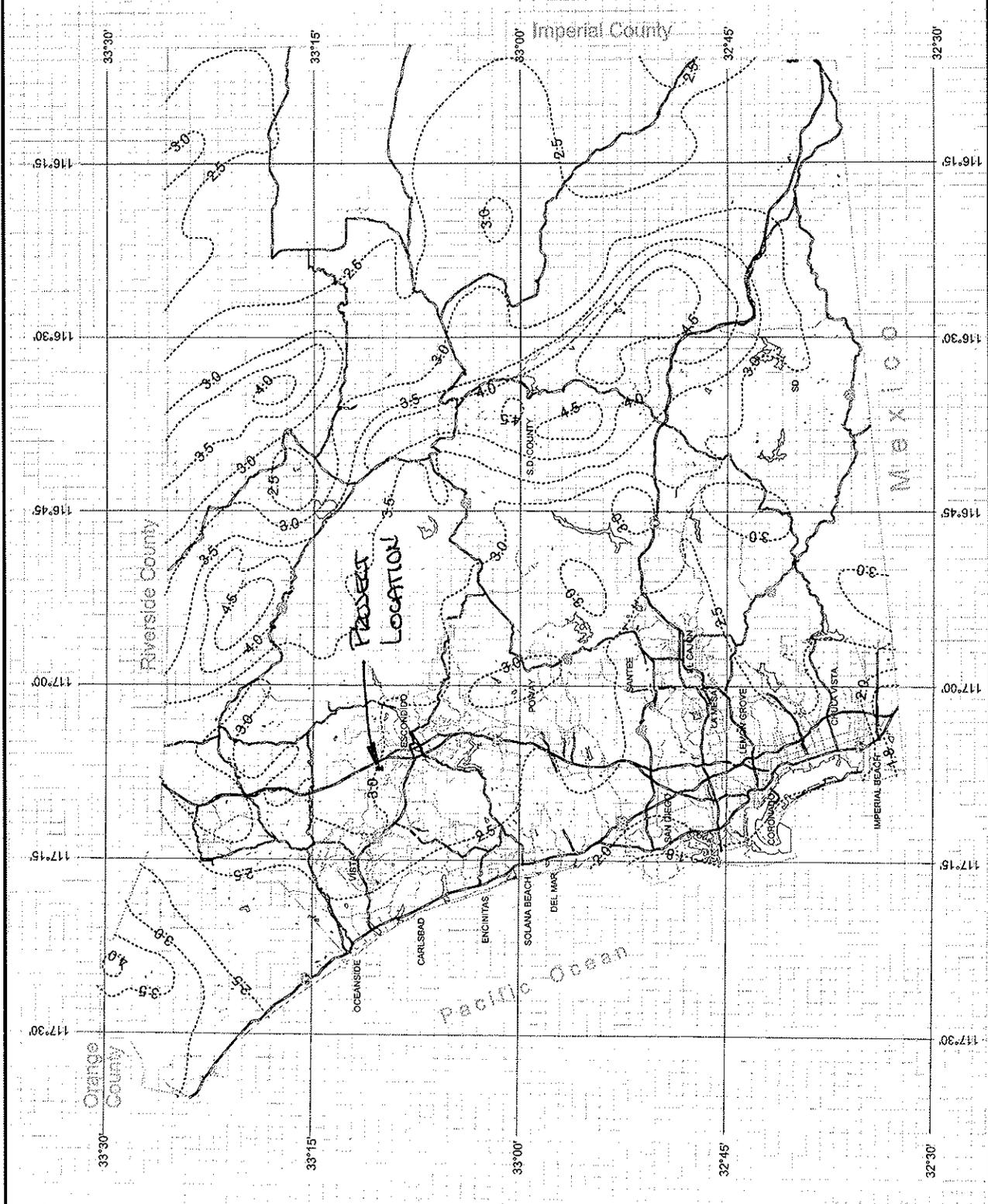
50 Year Rainfall Event - 6 Hours

..... Isopleth (inches)

$I_{50} = 3.0$



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County of San Diego Hydrology Manual



Rainfall Isoplethals

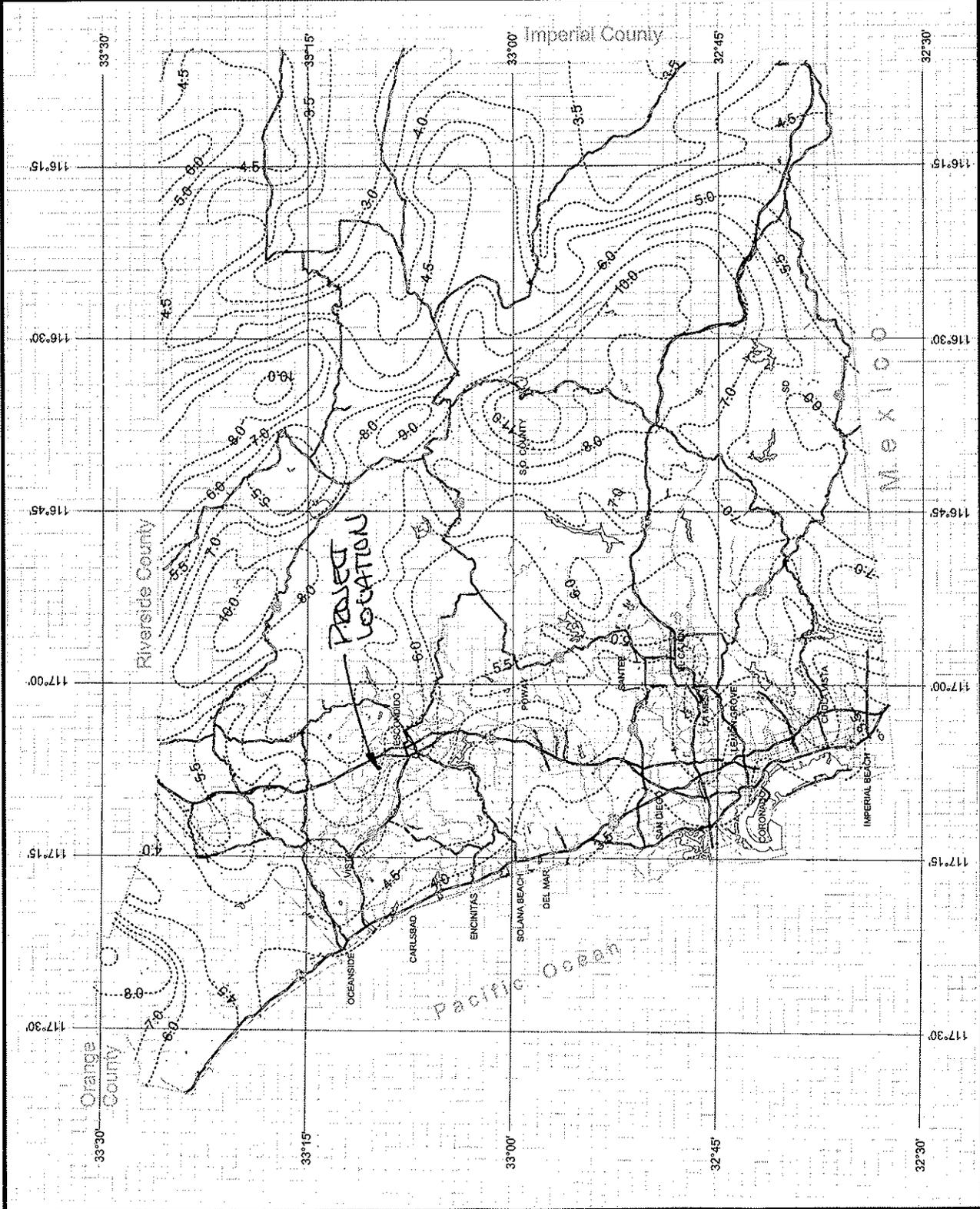
50 Year Rainfall Event - 24 Hours



$I_{50} = 6.0$



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County of San Diego Hydrology Manual



Rainfall Isoplethals

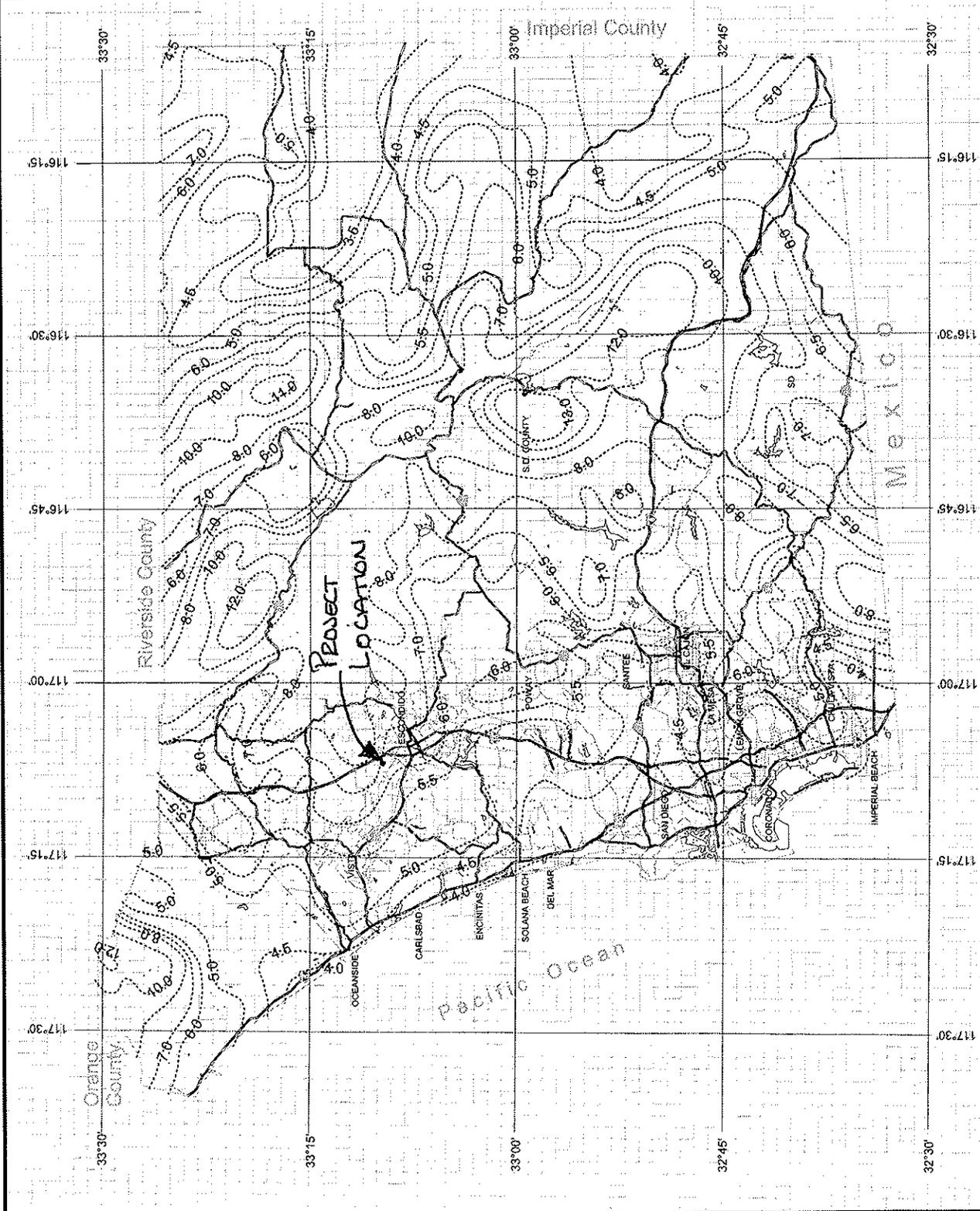
100 Year Rainfall Event - 24 Hours



$I_{100} = 7.0$



DPW GIS
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San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software, (c)1991-2006 Version 7.7

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 01/21/09

BENTON DUMP - CITY OF ESCONDIDO - EXISTING CONDITIONS HYDROLOGIC
ANALYSIS-USE n = 0.025 THRU n = 0.035 FOR CHANNEL FLOW PROCESSES
2-YR, 6-HOUR STORM EVENT
CIVILD FILE: EX2.RD3

***** Hydrology Study Control Information *****

Program License Serial Number 6219

Rational hydrology study storm event year is 2.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 1.600
24 hour precipitation(inches) = 2.500
P6/P24 = 64.0%
San Diego hydrology manual 'C' values used

+-----+
Process from Point/Station 100.000 to Point/Station 105.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.350
Decimal fraction soil group D = 0.650
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.332
Initial subarea total flow distance = 341.800(Ft.)
Highest elevation = 1377.500(Ft.)
Lowest elevation = 1320.000(Ft.)
Elevation difference = 57.500(Ft.) Slope = 16.823 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of 16.82 %, in a development type of
Permanent Open Space
In Accordance With Figure 3-3
Initial Area Time of Concentration = 5.39 minutes
TC = [1.8*(1.1-C)*distance(Ft.)^{.5}/(% slope^(1/3))]
TC = [1.8*(1.1-0.3325)*(100.000^{.5})/(16.823^(1/3))] = 5.39
The initial area total distance of 341.80 (Ft.) entered leaves a
remaining distance of 241.80 (Ft.)
Using Figure 3-4, the travel time for this distance is 1.06 minutes
for a distance of 241.80 (Ft.) and a slope of 16.82 %
with an elevation difference of 40.68(Ft.) from the end of the top area
Tt = [11.9*length(Mi)³/(elevation change(Ft.))]^{.385} *60(min/hr)
= 1.061 Minutes
Tt=[(11.9*0.0458³)/(40.68)]^{.385}= 1.06
Total initial area Ti = 5.39 minutes from Figure 3-3 formula plus
1.06 minutes from the Figure 3-4 formula = 6.45 minutes
Rainfall intensity (I) = 3.576(In/Hr) for a 2.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.332

Subarea runoff = 1.730 (CFS)
Total initial stream area = 1.455 (Ac.)

Process from Point/Station 105.000 to Point/Station 110.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 3.936 (CFS)
Depth of flow = 0.369 (Ft.), Average velocity = 3.899 (Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 12.90
2 12.30 11.90
3 16.90 9.90
4 21.30 7.90
5 34.20 3.90
6 43.40 1.90
7 60.50 0.00
8 71.50 1.90
9 77.30 3.90
10 91.60 9.90
11 97.00 11.90

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 3.936 (CFS)
' ' flow top width = 5.464 (Ft.)
' ' velocity = 3.899 (Ft/s)
' ' area = 1.009 (Sq. Ft)
' ' Froude number = 1.599

Upstream point elevation = 1320.000 (Ft.)
Downstream point elevation = 1285.000 (Ft.)
Flow length = 431.000 (Ft.)
Travel time = 1.84 min.
Time of concentration = 8.30 min.
Depth of flow = 0.369 (Ft.)
Average velocity = 3.899 (Ft/s)
Total irregular channel flow = 3.936 (CFS)
Irregular channel normal depth above invert elev. = 0.369 (Ft.)
Average velocity of channel (s) = 3.899 (Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 3.041 (In/Hr) for a 2.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.210
Decimal fraction soil group D = 0.790
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 3.041 (In/Hr) for a 2.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.338 CA = 1.998
Subarea runoff = 4.346 (CFS) for 4.460 (Ac.)
Total runoff = 6.076 (CFS) Total area = 5.915 (Ac.)
Depth of flow = 0.435 (Ft.), Average velocity = 4.347 (Ft/s)

Process from Point/Station 110.000 to Point/Station 115.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 8.109 (CFS)
Depth of flow = 0.341 (Ft.), Average velocity = 6.430 (Ft/s)
***** Irregular Channel Data *****

```

-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00              8.20
    2              5.60              6.00
    3             11.60              4.00
    4             20.30              2.00
    5             40.20              0.00
    6             63.80              2.00
    7             74.30              4.00
    8             80.40              6.00
    9             95.10             14.00
Manning's 'N' friction factor = 0.035
-----

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```

Sub-Channel flow = 8.109(CFS)
'   '   flow top width = 7.407(Ft.)
'   '   velocity = 6.430(Ft/s)
'   '   area = 1.261(Sq.Ft)
'   '   Froude number = 2.746

```

```

Upstream point elevation = 1285.000(Ft.)
Downstream point elevation = 1200.000(Ft.)
Flow length = 347.800(Ft.)
Travel time = 0.90 min.
Time of concentration = 9.20 min.
Depth of flow = 0.341(Ft.)
Average velocity = 6.430(Ft/s)
Total irregular channel flow = 8.109(CFS)
Irregular channel normal depth above invert elev. = 0.341(Ft.)
Average velocity of channel(s) = 6.430(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 2.845(In/Hr) for a 2.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[UNDISTURBED NATURAL TERRAIN ]
(Permanent Open Space )
Impervious value, Ai = 0.000
Sub-Area C Value = 0.350
Rainfall intensity = 2.845(In/Hr) for a 2.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.343 CA = 3.541
Subarea runoff = 3.999(CFS) for 4.408(Ac.)
Total runoff = 10.075(CFS) Total area = 10.323(Ac.)
Depth of flow = 0.369(Ft.), Average velocity = 6.788(Ft/s)

```

```

+++++
Process from Point/Station 115.000 to Point/Station 120.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

```

```

-----
Estimated mean flow rate at midpoint of channel = 19.252(CFS)
Depth of flow = 0.539(Ft.), Average velocity = 10.388(Ft/s)
***** Irregular Channel Data *****
-----

```

```

Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00              13.00
    2             12.30             12.00
    3             16.90             10.00
    4             21.30              8.00
    5             34.20              4.00
    6             43.40              2.00
    7             60.50              0.00
    8             77.30              4.00
    9             91.60             10.00
   10            97.00             12.00

```

11 101.00 14.00
Manning's 'N' friction factor = 0.035

Sub-Channel flow = 19.252(CFS)
' ' flow top width = 6.875(Ft.)
' ' velocity= 10.388(Ft/s)
' ' area = 1.853(Sq.Ft)
' ' Froude number = 3.526

Upstream point elevation = 1200.000(Ft.)
Downstream point elevation = 970.000(Ft.)
Flow length = 657.000(Ft.)
Travel time = 1.05 min.
Time of concentration = 10.25 min.
Depth of flow = 0.539(Ft.)
Average velocity = 10.388(Ft/s)
Total irregular channel flow = 19.252(CFS)
Irregular channel normal depth above invert elev. = 0.539(Ft.)
Average velocity of channel(s) = 10.388(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 2.653(In/Hr) for a 2.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.220
Decimal fraction soil group D = 0.780
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 2.653(In/Hr) for a 2.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.340 CA = 10.687
Subarea runoff = 18.279(CFS) for 21.081(Ac.)
Total runoff = 28.354(CFS) Total area = 31.404(Ac.)
Depth of flow = 0.623(Ft.), Average velocity = 11.444(Ft/s)

Process from Point/Station 120.000 to Point/Station 125.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 31.002(CFS)
Depth of flow = 0.757(Ft.), Average velocity = 8.488(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 13.00
2 12.30 12.00
3 16.90 10.00
4 21.30 8.00
5 34.20 4.00
6 43.40 2.00
7 60.50 0.00
8 77.30 4.00
9 91.60 10.00
10 97.00 12.00
11 101.00 14.00
Manning's 'N' friction factor = 0.035

Sub-Channel flow = 31.002(CFS)
' ' flow top width = 9.651(Ft.)
' ' velocity= 8.488(Ft/s)
' ' area = 3.652(Sq.Ft)
' ' Froude number = 2.432

Upstream point elevation = 970.000(Ft.)
Downstream point elevation = 930.000(Ft.)

Flow length = 269.000(Ft.)
 Travel time = 0.53 min.
 Time of concentration = 10.78 min.
 Depth of flow = 0.757(Ft.)
 Average velocity = 8.488(Ft/s)
 Total irregular channel flow = 31.002(CFS)
 Irregular channel normal depth above invert elev. = 0.757(Ft.)
 Average velocity of channel(s) = 8.488(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 2.569(In/Hr) for a 2.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 0.970
 Decimal fraction soil group D = 0.030
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.361
 Rainfall intensity = 2.569(In/Hr) for a 2.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.344 CA = 13.065
 Subarea runoff = 5.203(CFS) for 6.577(Ac.)
 Total runoff = 33.557(CFS) Total area = 37.981(Ac.)
 Depth of flow = 0.780(Ft.), Average velocity = 8.658(Ft/s)

++++++
 Process from Point/Station 125.000 to Point/Station 130.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 35.409(CFS)
 Depth of flow = 0.774(Ft.), Average velocity = 7.999(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 12.90 |
| 2 | 12.30 | 11.90 |
| 3 | 16.90 | 9.90 |
| 4 | 21.30 | 7.90 |
| 5 | 34.20 | 3.90 |
| 6 | 43.40 | 1.90 |
| 7 | 60.50 | 0.00 |
| 8 | 71.50 | 1.90 |
| 9 | 77.30 | 3.90 |
| 10 | 91.60 | 9.90 |
| 11 | 97.00 | 11.90 |

Manning's 'N' friction factor = 0.035

 Sub-Channel flow = 35.409(CFS)
 ' ' flow top width = 11.443(Ft.)
 ' ' velocity = 7.999(Ft/s)
 ' ' area = 4.427(Sq.Ft)
 ' ' Froude number = 2.266

Upstream point elevation = 930.000(Ft.)
 Downstream point elevation = 876.000(Ft.)
 Flow length = 423.500(Ft.)
 Travel time = 0.88 min.
 Time of concentration = 11.66 min.
 Depth of flow = 0.774(Ft.)
 Average velocity = 7.999(Ft/s)
 Total irregular channel flow = 35.409(CFS)
 Irregular channel normal depth above invert elev. = 0.774(Ft.)
 Average velocity of channel(s) = 7.999(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 2.441(In/Hr) for a 2.0 year storm
 Decimal fraction soil group A = 0.000

Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 2.441(In/Hr) for a 2.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.346 CA = 15.240
 Subarea runoff = 3.650(CFS) for 6.042(Ac.)
 Total runoff = 37.207(CFS) Total area = 44.023(Ac.)
 Depth of flow = 0.788(Ft.), Average velocity = 8.098(Ft/s)

++++++
 Process from Point/Station 130.000 to Point/Station 135.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 39.551(CFS)
 Depth of flow = 0.887(Ft.), Average velocity = 5.568(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 20.00 |
| 2 | 18.60 | 8.00 |
| 3 | 23.20 | 6.00 |
| 4 | 27.70 | 4.00 |
| 5 | 33.80 | 2.00 |
| 6 | 48.30 | 0.00 |
| 7 | 69.90 | 2.00 |
| 8 | 75.90 | 4.00 |
| 9 | 82.30 | 6.00 |
| 10 | 98.70 | 14.00 |
| 11 | 105.40 | 16.00 |

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 39.552(CFS)
 ' ' flow top width = 16.013(Ft.)
 ' ' velocity = 5.568(Ft/s)
 ' ' area = 7.103(Sq.Ft)
 ' ' Froude number = 1.473

Upstream point elevation = 876.000(Ft.)
 Downstream point elevation = 860.000(Ft.)
 Flow length = 312.000(Ft.)
 Travel time = 0.93 min.
 Time of concentration = 12.60 min.
 Depth of flow = 0.887(Ft.)
 Average velocity = 5.568(Ft/s)
 Total irregular channel flow = 39.551(CFS)
 Irregular channel normal depth above invert elev. = 0.887(Ft.)
 Average velocity of channel(s) = 5.568(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 2.323(In/Hr) for a 2.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 2.323(In/Hr) for a 2.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.348 CA = 18.009
 Subarea runoff = 4.629(CFS) for 7.692(Ac.)

Total runoff = 41.836(CFS) Total area = 51.715(Ac.)
Depth of flow = 0.906(Ft.), Average velocity = 5.647(Ft/s)

Process from Point/Station 135.000 to Point/Station 140.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 41.929(CFS)
Depth of flow = 0.590(Ft.), Average velocity = 9.020(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 13.00 |
| 2 | 3.80 | 12.00 |
| 3 | 14.00 | 6.00 |
| 4 | 19.00 | 4.00 |
| 5 | 26.70 | 2.00 |
| 6 | 47.70 | 0.00 |
| 7 | 49.70 | 0.00 |
| 8 | 68.60 | 2.00 |
| 9 | 75.00 | 4.00 |
| 10 | 94.20 | 12.00 |
| 11 | 99.40 | 14.00 |

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 41.930(CFS)
' ' flow top width = 13.765(Ft.)
' ' velocity = 9.020(Ft/s)
' ' area = 4.648(Sq.Ft)
' ' Froude number = 2.736

Upstream point elevation = 860.000(Ft.)
Downstream point elevation = 840.000(Ft.)
Flow length = 103.600(Ft.)
Travel time = 0.19 min.
Time of concentration = 12.79 min.
Depth of flow = 0.590(Ft.)
Average velocity = 9.020(Ft/s)
Total irregular channel flow = 41.929(CFS)
Irregular channel normal depth above invert elev. = 0.590(Ft.)
Average velocity of channel(s) = 9.020(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 2.301(In/Hr) for a 2.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 2.301(In/Hr) for a 2.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.347 CA = 18.239
Subarea runoff = 0.124(CFS) for 0.775(Ac.)
Total runoff = 41.960(CFS) Total area = 52.490(Ac.)
Depth of flow = 0.590(Ft.), Average velocity = 9.022(Ft/s)

Process from Point/Station 140.000 to Point/Station 145.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 43.159(CFS)
Depth of flow = 0.714(Ft.), Average velocity = 6.626(Ft/s)
***** Irregular Channel Data *****

```

-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00              13.00
    2              3.80              12.00
    3              14.00             6.00
    4              19.00             4.00
    5              26.70             2.00
    6              47.70             0.00
    7              49.70             0.00
    8              68.60             2.00
    9              75.00             4.00
   10              94.20            12.00
   11              99.40            14.00
Manning's 'N' friction factor = 0.025
-----

```

```

Sub-Channel flow = 43.159(CFS)
'   '   flow top width = 16.244(Ft.)
'   '   velocity= 6.626(Ft/s)
'   '   area = 6.513(Sq.Ft)
'   '   Froude number = 1.844

```

```

Upstream point elevation = 840.000(Ft.)
Downstream point elevation = 820.000(Ft.)
Flow length = 473.000(Ft.)
Travel time = 1.19 min.
Time of concentration = 13.98 min.
Depth of flow = 0.714(Ft.)
Average velocity = 6.626(Ft/s)
Total irregular channel flow = 43.159(CFS)
Irregular channel normal depth above invert elev. = 0.714(Ft.)
Average velocity of channel(s) = 6.626(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 2.172(In/Hr) for a 2.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN ]
(Permanent Open Space )
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 2.172(In/Hr) for a 2.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.341 CA = 20.394
Subarea runoff = 2.342(CFS) for 7.269(Ac.)
Total runoff = 44.302(CFS) Total area = 59.759(Ac.)
Depth of flow = 0.722(Ft.), Average velocity = 6.670(Ft/s)
End of computations, total study area = 59.759 (Ac.)

```


San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software, (c)1991-2006 Version 7.7

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 01/21/09

BENTON DUMP - CITY OF ESCONDIDO - EXISTING CONDITIONS HYDROLOGIC
ANALYSIS-USE n = 0.025 THRU n = 0.035 FOR CHANNEL FLOW PROCESSES
10-YR, 6-HOUR STORM EVENT
CIVILD FILE: EX10.RD3

***** Hydrology Study Control Information *****

Program License Serial Number 6219

Rational hydrology study storm event year is 10.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 2.400
24 hour precipitation(inches) = 4.000
P6/P24 = 60.0%
San Diego hydrology manual 'C' values used

Process from Point/Station 100.000 to Point/Station 105.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.350
Decimal fraction soil group D = 0.650
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.332
Initial subarea total flow distance = 341.800(Ft.)
Highest elevation = 1377.500(Ft.)
Lowest elevation = 1320.000(Ft.)
Elevation difference = 57.500(Ft.) Slope = 16.823 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of 16.82 %, in a development type of
Permanent Open Space
In Accordance With Figure 3-3
Initial Area Time of Concentration = 5.39 minutes
TC = [1.8*(1.1-C)*distance(Ft.)^0.5]/(% slope^(1/3))
TC = [1.8*(1.1-0.3325)*(100.000^0.5)/(16.823^(1/3))]= 5.39
The initial area total distance of 341.80 (Ft.) entered leaves a
remaining distance of 241.80 (Ft.)
Using Figure 3-4, the travel time for this distance is 1.06 minutes
for a distance of 241.80 (Ft.) and a slope of 16.82 %
with an elevation difference of 40.68(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3/(elevation change(Ft.))]^0.385 *60(min/hr)
= 1.061 Minutes
Tt=[(11.9*0.0458^3)/(40.68)]^0.385= 1.06
Total initial area Ti = 5.39 minutes from Figure 3-3 formula plus
1.06 minutes from the Figure 3-4 formula = 6.45 minutes
Rainfall intensity (I) = 5.364(In/Hr) for a 10.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.332

Subarea runoff = 2.595(CFS)
Total initial stream area = 1.455(Ac.)

Process from Point/Station 105.000 to Point/Station 110.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 5.964(CFS)
Depth of flow = 0.432(Ft.), Average velocity = 4.327(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 12.90
2 12.30 11.90
3 16.90 9.90
4 21.30 7.90
5 34.20 3.90
6 43.40 1.90
7 60.50 0.00
8 71.50 1.90
9 77.30 3.90
10 91.60 9.90
11 97.00 11.90

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 5.964(CFS)
' ' flow top width = 6.386(Ft.)
' ' velocity = 4.327(Ft/s)
' ' area = 1.379(Sq.Ft)
' ' Froude number = 1.641

Upstream point elevation = 1320.000(Ft.)
Downstream point elevation = 1285.000(Ft.)
Flow length = 431.000(Ft.)
Travel time = 1.66 min.
Time of concentration = 8.11 min.
Depth of flow = 0.432(Ft.)
Average velocity = 4.327(Ft/s)
Total irregular channel flow = 5.964(CFS)
Irregular channel normal depth above invert elev. = 0.432(Ft.)
Average velocity of channel(s) = 4.327(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 4.628(In/Hr) for a 10.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.210
Decimal fraction soil group D = 0.790
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 4.628(In/Hr) for a 10.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.338 CA = 1.998
Subarea runoff = 6.651(CFS) for 4.460(Ac.)
Total runoff = 9.246(CFS) Total area = 5.915(Ac.)
Depth of flow = 0.509(Ft.), Average velocity = 4.828(Ft/s)

Process from Point/Station 110.000 to Point/Station 115.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 12.373(CFS)
Depth of flow = 0.399(Ft.), Average velocity = 7.146(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 8.20 |
| 2 | 5.60 | 6.00 |
| 3 | 11.60 | 4.00 |
| 4 | 20.30 | 2.00 |
| 5 | 40.20 | 0.00 |
| 6 | 63.80 | 2.00 |
| 7 | 74.30 | 4.00 |
| 8 | 80.40 | 6.00 |
| 9 | 95.10 | 14.00 |

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 12.373 (CFS)
' ' flow top width = 8.679 (Ft.)
' ' velocity = 7.146 (Ft/s)
' ' area = 1.731 (Sq.Ft)
' ' Froude number = 2.819

Upstream point elevation = 1285.000 (Ft.)
Downstream point elevation = 1200.000 (Ft.)
Flow length = 347.800 (Ft.)
Travel time = 0.81 min.
Time of concentration = 8.92 min.
Depth of flow = 0.399 (Ft.)
Average velocity = 7.146 (Ft/s)
Total irregular channel flow = 12.373 (CFS)
Irregular channel normal depth above invert elev. = 0.399 (Ft.)
Average velocity of channel(s) = 7.146 (Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 4.352 (In/Hr) for a 10.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.350
Rainfall intensity = 4.352 (In/Hr) for a 10.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.343 CA = 3.541
Subarea runoff = 6.163 (CFS) for 4.408 (Ac.)
Total runoff = 15.408 (CFS) Total area = 10.323 (Ac.)
Depth of flow = 0.433 (Ft.), Average velocity = 7.549 (Ft/s)

Process from Point/Station 115.000 to Point/Station 120.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 29.520 (CFS)
Depth of flow = 0.633 (Ft.), Average velocity = 11.560 (Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 13.00 |
| 2 | 12.30 | 12.00 |
| 3 | 16.90 | 10.00 |
| 4 | 21.30 | 8.00 |
| 5 | 34.20 | 4.00 |
| 6 | 43.40 | 2.00 |
| 7 | 60.50 | 0.00 |
| 8 | 77.30 | 4.00 |
| 9 | 91.60 | 10.00 |
| 10 | 97.00 | 12.00 |

11 101.00 14.00
Manning's 'N' friction factor = 0.035

Sub-Channel flow = 29.520(CFS)
' ' flow top width = 8.070(Ft.)
' ' velocity= 11.560(Ft/s)
' ' area = 2.554(Sq.Ft)
' ' Froude number = 3.621

Upstream point elevation = 1200.000(Ft.)
Downstream point elevation = 970.000(Ft.)
Flow length = 657.000(Ft.)
Travel time = 0.95 min.
Time of concentration = 9.87 min.
Depth of flow = 0.633(Ft.)
Average velocity = 11.560(Ft/s)
Total irregular channel flow = 29.520(CFS)
Irregular channel normal depth above invert elev. = 0.633(Ft.)
Average velocity of channel(s) = 11.560(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 4.078(In/Hr) for a 10.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.220
Decimal fraction soil group D = 0.780
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 4.078(In/Hr) for a 10.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.340 CA = 10.687
Subarea runoff = 28.170(CFS) for 21.081(Ac.)
Total runoff = 43.578(CFS) Total area = 31.404(Ac.)
Depth of flow = 0.732(Ft.), Average velocity = 12.742(Ft/s)

Process from Point/Station 120.000 to Point/Station 125.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 47.663(CFS)
Depth of flow = 0.889(Ft.), Average velocity = 9.452(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 13.00
2 12.30 12.00
3 16.90 10.00
4 21.30 8.00
5 34.20 4.00
6 43.40 2.00
7 60.50 0.00
8 77.30 4.00
9 91.60 10.00
10 97.00 12.00
11 101.00 14.00

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 47.663(CFS)
' ' flow top width = 11.340(Ft.)
' ' velocity= 9.452(Ft/s)
' ' area = 5.043(Sq.Ft)
' ' Froude number = 2.498

Upstream point elevation = 970.000(Ft.)
Downstream point elevation = 930.000(Ft.)

Flow length = 269.000(Ft.)
 Travel time = 0.47 min.
 Time of concentration = 10.35 min.
 Depth of flow = 0.889(Ft.)
 Average velocity = 9.452(Ft/s)
 Total irregular channel flow = 47.663(CFS)
 Irregular channel normal depth above invert elev. = 0.889(Ft.)
 Average velocity of channel(s) = 9.452(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 3.956(In/Hr) for a 10.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 0.970
 Decimal fraction soil group D = 0.030
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.361
 Rainfall intensity = 3.956(In/Hr) for a 10.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.344 CA = 13.065
 Subarea runoff = 8.106(CFS) for 6.577(Ac.)
 Total runoff = 51.684(CFS) Total area = 37.981(Ac.)
 Depth of flow = 0.917(Ft.), Average velocity = 9.645(Ft/s)

++++++
 Process from Point/Station 125.000 to Point/Station 130.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 54.625(CFS)
 Depth of flow = 0.910(Ft.), Average velocity = 8.914(Ft/s)
 ***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 12.90 |
| 2 | 12.30 | 11.90 |
| 3 | 16.90 | 9.90 |
| 4 | 21.30 | 7.90 |
| 5 | 34.20 | 3.90 |
| 6 | 43.40 | 1.90 |
| 7 | 60.50 | 0.00 |
| 8 | 71.50 | 1.90 |
| 9 | 77.30 | 3.90 |
| 10 | 91.60 | 9.90 |
| 11 | 97.00 | 11.90 |

 Manning's 'N' friction factor = 0.035

Sub-Channel flow = 54.625(CFS)
 ' ' flow top width = 13.463(Ft.)
 ' ' velocity = 8.914(Ft/s)
 ' ' area = 6.128(Sq.Ft)
 ' ' Froude number = 2.328

Upstream point elevation = 930.000(Ft.)
 Downstream point elevation = 876.000(Ft.)
 Flow length = 423.500(Ft.)
 Travel time = 0.79 min.
 Time of concentration = 11.14 min.
 Depth of flow = 0.910(Ft.)
 Average velocity = 8.914(Ft/s)
 Total irregular channel flow = 54.625(CFS)
 Irregular channel normal depth above invert elev. = 0.910(Ft.)
 Average velocity of channel(s) = 8.914(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 3.772(In/Hr) for a 10.0 year storm
 Decimal fraction soil group A = 0.000

Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 3.772(In/Hr) for a 10.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.346 CA = 15.240
 Subarea runoff = 5.804(CFS) for 6.042(Ac.)
 Total runoff = 57.488(CFS) Total area = 44.023(Ac.)
 Depth of flow = 0.928(Ft.), Average velocity = 9.029(Ft/s)

++++++
 Process from Point/Station 130.000 to Point/Station 135.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 61.203(CFS)
 Depth of flow = 1.045(Ft.), Average velocity = 6.211(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 20.00 |
| 2 | 18.60 | 8.00 |
| 3 | 23.20 | 6.00 |
| 4 | 27.70 | 4.00 |
| 5 | 33.80 | 2.00 |
| 6 | 48.30 | 0.00 |
| 7 | 69.90 | 2.00 |
| 8 | 75.90 | 4.00 |
| 9 | 82.30 | 6.00 |
| 10 | 98.70 | 14.00 |
| 11 | 105.40 | 16.00 |

Manning's 'N' friction factor = 0.035

 Sub-Channel flow = 61.203(CFS)
 ' ' flow top width = 18.861(Ft.)
 ' ' velocity = 6.211(Ft/s)
 ' ' area = 9.854(Sq.Ft)
 ' ' Froude number = 1.514

Upstream point elevation = 876.000(Ft.)
 Downstream point elevation = 860.000(Ft.)
 Flow length = 312.000(Ft.)
 Travel time = 0.84 min.
 Time of concentration = 11.98 min.
 Depth of flow = 1.045(Ft.)
 Average velocity = 6.211(Ft/s)
 Total irregular channel flow = 61.203(CFS)
 Irregular channel normal depth above invert elev. = 1.045(Ft.)
 Average velocity of channel(s) = 6.211(Ft/s)

Adding area flow to channel
 Rainfall intensity (I) = 3.600(In/Hr) for a 10.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 3.600(In/Hr) for a 10.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.348 CA = 18.009
 Subarea runoff = 7.343(CFS) for 7.692(Ac.)

Total runoff = 64.831(CFS) Total area = 51.715(Ac.)
Depth of flow = 1.068(Ft.), Average velocity = 6.301(Ft/s)

Process from Point/Station 135.000 to Point/Station 140.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 64.992(CFS)
Depth of flow = 0.710(Ft.), Average velocity = 10.079(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 13.00
2 3.80 12.00
3 14.00 6.00
4 19.00 4.00
5 26.70 2.00
6 47.70 0.00
7 49.70 0.00
8 68.60 2.00
9 75.00 4.00
10 94.20 12.00
11 99.40 14.00

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 64.992(CFS)
' ' flow top width = 16.164(Ft.)
' ' velocity = 10.079(Ft/s)
' ' area = 6.448(Sq.Ft)
' ' Froude number = 2.812

Upstream point elevation = 860.000(Ft.)
Downstream point elevation = 840.000(Ft.)
Flow length = 103.600(Ft.)
Travel time = 0.17 min.
Time of concentration = 12.15 min.
Depth of flow = 0.710(Ft.)
Average velocity = 10.079(Ft/s)
Total irregular channel flow = 64.992(CFS)
Irregular channel normal depth above invert elev. = 0.710(Ft.)
Average velocity of channel(s) = 10.079(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 3.567(In/Hr) for a 10.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 3.567(In/Hr) for a 10.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.347 CA = 18.239
Subarea runoff = 0.228(CFS) for 0.775(Ac.)
Total runoff = 65.060(CFS) Total area = 52.490(Ac.)
Depth of flow = 0.710(Ft.), Average velocity = 10.082(Ft/s)

Process from Point/Station 140.000 to Point/Station 145.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 67.027(CFS)
Depth of flow = 0.858(Ft.), Average velocity = 7.405(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 13.00 |
| 2 | 3.80 | 12.00 |
| 3 | 14.00 | 6.00 |
| 4 | 19.00 | 4.00 |
| 5 | 26.70 | 2.00 |
| 6 | 47.70 | 0.00 |
| 7 | 49.70 | 0.00 |
| 8 | 68.60 | 2.00 |
| 9 | 75.00 | 4.00 |
| 10 | 94.20 | 12.00 |
| 11 | 99.40 | 14.00 |

Manning's 'N' friction factor = 0.025

Sub-Channel flow = 67.027(CFS)
' ' flow top width = 19.109(Ft.)
' ' velocity = 7.405(Ft/s)
' ' area = 9.052(Sq.Ft)
' ' Froude number = 1.896

Upstream point elevation = 840.000(Ft.)
Downstream point elevation = 820.000(Ft.)
Flow length = 473.000(Ft.)
Travel time = 1.06 min.
Time of concentration = 13.21 min.
Depth of flow = 0.858(Ft.)
Average velocity = 7.405(Ft/s)
Total irregular channel flow = 67.027(CFS)
Irregular channel normal depth above invert elev. = 0.858(Ft.)
Average velocity of channel(s) = 7.405(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 3.379(In/Hr) for a 10.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 3.379(In/Hr) for a 10.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.341 CA = 20.394
Subarea runoff = 3.851(CFS) for 7.269(Ac.)
Total runoff = 68.910(CFS) Total area = 59.759(Ac.)
Depth of flow = 0.867(Ft.), Average velocity = 7.457(Ft/s)
End of computations, total study area = 59.759 (Ac.)

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software, (c)1991-2006 Version 7.7

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 01/21/09

BENTON DUMP - CITY OF ESCONDIDO - EXISTING CONDITIONS HYDROLOGIC
ANALYSIS-USE n = 0.025 THRU n = 0.035 FOR CHANNEL FLOW PROCESSES
50-YR, 6-HOUR STORM EVENT
CIVILD FILE: EX50.RD3

***** Hydrology Study Control Information *****

Program License Serial Number 6219

Rational hydrology study storm event year is 50.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 3.000
24 hour precipitation(inches) = 6.000
P6/P24 = 50.0%
San Diego hydrology manual 'C' values used

Process from Point/Station 100.000 to Point/Station 105.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.350
Decimal fraction soil group D = 0.650
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.332
Initial subarea total flow distance = 341.800(Ft.)
Highest elevation = 1377.500(Ft.)
Lowest elevation = 1320.000(Ft.)
Elevation difference = 57.500(Ft.) Slope = 16.823 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of 16.82 %, in a development type of
Permanent Open Space
In Accordance With Figure 3-3
Initial Area Time of Concentration = 5.39 minutes
TC = [1.8*(1.1-C)*distance(Ft.)^0.5]/(% slope^(1/3))
TC = [1.8*(1.1-0.3325)*(100.000^0.5)/(16.823^(1/3))]= 5.39
The initial area total distance of 341.80 (Ft.) entered leaves a
remaining distance of 241.80 (Ft.)
Using Figure 3-4, the travel time for this distance is 1.06 minutes
for a distance of 241.80 (Ft.) and a slope of 16.82 %
with an elevation difference of 40.68(Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3]/(elevation change(Ft.))]^0.385 *60(min/hr)
= 1.061 Minutes
Tt=[(11.9*0.0458^3)/(40.68)]^0.385= 1.06
Total initial area Ti = 5.39 minutes from Figure 3-3 formula plus
1.06 minutes from the Figure 3-4 formula = 6.45 minutes
Rainfall intensity (I) = 6.705(In/Hr) for a 50.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.332

Subarea runoff = 3.244(CFS)
Total initial stream area = 1.455(Ac.)

Process from Point/Station 105.000 to Point/Station 110.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 7.469(CFS)
Depth of flow = 0.470(Ft.), Average velocity = 4.577(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 12.90
2 12.30 11.90
3 16.90 9.90
4 21.30 7.90
5 34.20 3.90
6 43.40 1.90
7 60.50 0.00
8 71.50 1.90
9 77.30 3.90
10 91.60 9.90
11 97.00 11.90

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 7.469(CFS)
' ' flow top width = 6.948(Ft.)
' ' velocity = 4.577(Ft/s)
' ' area = 1.632(Sq.Ft)
' ' Froude number = 1.664

Upstream point elevation = 1320.000(Ft.)
Downstream point elevation = 1285.000(Ft.)
Flow length = 431.000(Ft.)
Travel time = 1.57 min.
Time of concentration = 8.02 min.
Depth of flow = 0.470(Ft.)
Average velocity = 4.577(Ft/s)
Total irregular channel flow = 7.469(CFS)
Irregular channel normal depth above invert elev. = 0.470(Ft.)
Average velocity of channel(s) = 4.577(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 5.827(In/Hr) for a 50.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.210
Decimal fraction soil group D = 0.790
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 5.827(In/Hr) for a 50.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.338 CA = 1.998
Subarea runoff = 8.398(CFS) for 4.460(Ac.)
Total runoff = 11.641(CFS) Total area = 5.915(Ac.)
Depth of flow = 0.555(Ft.), Average velocity = 5.114(Ft/s)

Process from Point/Station 110.000 to Point/Station 115.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 15.575(CFS)
Depth of flow = 0.435(Ft.), Average velocity = 7.569(Ft/s)
***** Irregular Channel Data *****

```

-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00              8.20
    2              5.60              6.00
    3             11.60              4.00
    4             20.30              2.00
    5             40.20              0.00
    6             63.80              2.00
    7             74.30              4.00
    8             80.40              6.00
    9             95.10             14.00
Manning's 'N' friction factor = 0.035
-----

```

```

Sub-Channel flow = 15.575 (CFS)
'   '   flow top width = 9.461 (Ft.)
'   '   velocity = 7.569 (Ft/s)
'   '   area = 2.058 (Sq.Ft)
'   '   Froude number = 2.860

```

```

Upstream point elevation = 1285.000 (Ft.)
Downstream point elevation = 1200.000 (Ft.)
Flow length = 347.800 (Ft.)
Travel time = 0.77 min.
Time of concentration = 8.79 min.
Depth of flow = 0.435 (Ft.)
Average velocity = 7.569 (Ft/s)
Total irregular channel flow = 15.575 (CFS)
Irregular channel normal depth above invert elev. = 0.435 (Ft.)
Average velocity of channel(s) = 7.569 (Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 5.494 (In/Hr) for a 50.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[UNDISTURBED NATURAL TERRAIN ]
(Permanent Open Space )
Impervious value, Ai = 0.000
Sub-Area C Value = 0.350
Rainfall intensity = 5.494 (In/Hr) for a 50.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.343 CA = 3.541
Subarea runoff = 7.811 (CFS) for 4.408 (Ac.)
Total runoff = 19.452 (CFS) Total area = 10.323 (Ac.)
Depth of flow = 0.473 (Ft.), Average velocity = 8.002 (Ft/s)

```

```

*****
Process from Point/Station 115.000 to Point/Station 120.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

```

```

-----
Estimated mean flow rate at midpoint of channel = 37.339 (CFS)
Depth of flow = 0.691 (Ft.), Average velocity = 12.259 (Ft/s)
***** Irregular Channel Data *****

```

```

-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00             13.00
    2             12.30             12.00
    3             16.90             10.00
    4             21.30              8.00
    5             34.20              4.00
    6             43.40              2.00
    7             60.50              0.00
    8             77.30              4.00
    9             91.60             10.00
   10            97.00             12.00

```

11 101.00 14.00
Manning's 'N' friction factor = 0.035

Sub-Channel flow = 37.340 (CFS)
' ' flow top width = 8.813 (Ft.)
' ' velocity = 12.259 (Ft/s)
' ' area = 3.046 (Sq.Ft)
' ' Froude number = 3.675

Upstream point elevation = 1200.000 (Ft.)
Downstream point elevation = 970.000 (Ft.)
Flow length = 657.000 (Ft.)
Travel time = 0.89 min.
Time of concentration = 9.68 min.
Depth of flow = 0.691 (Ft.)
Average velocity = 12.259 (Ft/s)
Total irregular channel flow = 37.339 (CFS)
Irregular channel normal depth above invert elev. = 0.691 (Ft.)
Average velocity of channel(s) = 12.259 (Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 5.161 (In/Hr) for a 50.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.220
Decimal fraction soil group D = 0.780
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 5.161 (In/Hr) for a 50.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.340 CA = 10.687
Subarea runoff = 35.708 (CFS) for 21.081 (Ac.)
Total runoff = 55.160 (CFS) Total area = 31.404 (Ac.)
Depth of flow = 0.800 (Ft.), Average velocity = 13.515 (Ft/s)

+++++
Process from Point/Station 120.000 to Point/Station 125.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 60.367 (CFS)
Depth of flow = 0.972 (Ft.), Average velocity = 10.027 (Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 13.00
2 12.30 12.00
3 16.90 10.00
4 21.30 8.00
5 34.20 4.00
6 43.40 2.00
7 60.50 0.00
8 77.30 4.00
9 91.60 10.00
10 97.00 12.00
11 101.00 14.00

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 60.367 (CFS)
' ' flow top width = 12.390 (Ft.)
' ' velocity = 10.027 (Ft/s)
' ' area = 6.020 (Sq.Ft)
' ' Froude number = 2.535

Upstream point elevation = 970.000 (Ft.)
Downstream point elevation = 930.000 (Ft.)

Flow length = 269.000(Ft.)
 Travel time = 0.45 min.
 Time of concentration = 10.13 min.
 Depth of flow = 0.972(Ft.)
 Average velocity = 10.027(Ft/s)
 Total irregular channel flow = 60.367(CFS)
 Irregular channel normal depth above invert elev. = 0.972(Ft.)
 Average velocity of channel(s) = 10.027(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 5.013(In/Hr) for a 50.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 0.970
 Decimal fraction soil group D = 0.030
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.361
 Rainfall intensity = 5.013(In/Hr) for a 50.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.344 CA = 13.065
 Subarea runoff = 10.336(CFS) for 6.577(Ac.)
 Total runoff = 65.496(CFS) Total area = 37.981(Ac.)
 Depth of flow = 1.002(Ft.), Average velocity = 10.234(Ft/s)

++++++
 Process from Point/Station 125.000 to Point/Station 130.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 69.284(CFS)
 Depth of flow = 0.995(Ft.), Average velocity = 9.460(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 12.90 |
| 2 | 12.30 | 11.90 |
| 3 | 16.90 | 9.90 |
| 4 | 21.30 | 7.90 |
| 5 | 34.20 | 3.90 |
| 6 | 43.40 | 1.90 |
| 7 | 60.50 | 0.00 |
| 8 | 71.50 | 1.90 |
| 9 | 77.30 | 3.90 |
| 10 | 91.60 | 9.90 |
| 11 | 97.00 | 11.90 |

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 69.284(CFS)
 ' ' flow top width = 14.718(Ft.)
 ' ' velocity = 9.460(Ft/s)
 ' ' area = 7.324(Sq.Ft)
 ' ' Froude number = 2.363

Upstream point elevation = 930.000(Ft.)
 Downstream point elevation = 876.000(Ft.)
 Flow length = 423.500(Ft.)
 Travel time = 0.75 min.
 Time of concentration = 10.87 min.
 Depth of flow = 0.995(Ft.)
 Average velocity = 9.460(Ft/s)
 Total irregular channel flow = 69.284(CFS)
 Irregular channel normal depth above invert elev. = 0.995(Ft.)
 Average velocity of channel(s) = 9.460(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 4.789(In/Hr) for a 50.0 year storm
 Decimal fraction soil group A = 0.000

Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 4.789(In/Hr) for a 50.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.346 CA = 15.240
 Subarea runoff = 7.481(CFS) for 6.042(Ac.)
 Total runoff = 72.977(CFS) Total area = 44.023(Ac.)
 Depth of flow = 1.015(Ft.), Average velocity = 9.584(Ft/s)

++++++
 Process from Point/Station 130.000 to Point/Station 135.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 77.730(CFS)
 Depth of flow = 1.143(Ft.), Average velocity = 6.593(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 20.00 |
| 2 | 18.60 | 8.00 |
| 3 | 23.20 | 6.00 |
| 4 | 27.70 | 4.00 |
| 5 | 33.80 | 2.00 |
| 6 | 48.30 | 0.00 |
| 7 | 69.90 | 2.00 |
| 8 | 75.90 | 4.00 |
| 9 | 82.30 | 6.00 |
| 10 | 98.70 | 14.00 |
| 11 | 105.40 | 16.00 |

Manning's 'N' friction factor = 0.035

 Sub-Channel flow = 77.730(CFS)
 ' ' flow top width = 20.630(Ft.)
 ' ' velocity = 6.593(Ft/s)
 ' ' area = 11.789(Sq.Ft)
 ' ' Froude number = 1.537

Upstream point elevation = 876.000(Ft.)
 Downstream point elevation = 860.000(Ft.)
 Flow length = 312.000(Ft.)
 Travel time = 0.79 min.
 Time of concentration = 11.66 min.
 Depth of flow = 1.143(Ft.)
 Average velocity = 6.593(Ft/s)
 Total irregular channel flow = 77.730(CFS)
 Irregular channel normal depth above invert elev. = 1.143(Ft.)
 Average velocity of channel(s) = 6.593(Ft/s)

Adding area flow to channel
 Rainfall intensity (I) = 4.577(In/Hr) for a 50.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 4.577(In/Hr) for a 50.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.348 CA = 18.009
 Subarea runoff = 9.452(CFS) for 7.692(Ac.)

Total runoff = 82.429(CFS) Total area = 51.715(Ac.)
Depth of flow = 1.168(Ft.), Average velocity = 6.691(Ft/s)

Process from Point/Station 135.000 to Point/Station 140.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 82.616(CFS)
Depth of flow = 0.785(Ft.), Average velocity = 10.709(Ft/s)

***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 13.00 |
| 2 | 3.80 | 12.00 |
| 3 | 14.00 | 6.00 |
| 4 | 19.00 | 4.00 |
| 5 | 26.70 | 2.00 |
| 6 | 47.70 | 0.00 |
| 7 | 49.70 | 0.00 |
| 8 | 68.60 | 2.00 |
| 9 | 75.00 | 4.00 |
| 10 | 94.20 | 12.00 |
| 11 | 99.40 | 14.00 |

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 82.616(CFS)
' ' flow top width = 17.658(Ft.)
' ' velocity = 10.709(Ft/s)
' ' area = 7.715(Sq.Ft)
' ' Froude number = 2.855

Upstream point elevation = 860.000(Ft.)
Downstream point elevation = 840.000(Ft.)
Flow length = 103.600(Ft.)
Travel time = 0.16 min.
Time of concentration = 11.82 min.
Depth of flow = 0.785(Ft.)
Average velocity = 10.709(Ft/s)
Total irregular channel flow = 82.616(CFS)
Irregular channel normal depth above invert elev. = 0.785(Ft.)
Average velocity of channel(s) = 10.709(Ft/s)

Adding area flow to channel

Rainfall intensity (I) = 4.537(In/Hr) for a 50.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000

[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)

Impervious value, Ai = 0.000

Sub-Area C Value = 0.297

Rainfall intensity = 4.537(In/Hr) for a 50.0 year storm

Effective runoff coefficient used for total area

(Q=KCIA) is C = 0.347 CA = 18.239

Subarea runoff = 0.316(CFS) for 0.775(Ac.)

Total runoff = 82.745(CFS) Total area = 52.490(Ac.)

Depth of flow = 0.785(Ft.), Average velocity = 10.713(Ft/s)

Process from Point/Station 140.000 to Point/Station 145.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 85.296(CFS)
Depth of flow = 0.947(Ft.), Average velocity = 7.868(Ft/s)

***** Irregular Channel Data *****

Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 13.00 |
| 2 | 3.80 | 12.00 |
| 3 | 14.00 | 6.00 |
| 4 | 19.00 | 4.00 |
| 5 | 26.70 | 2.00 |
| 6 | 47.70 | 0.00 |
| 7 | 49.70 | 0.00 |
| 8 | 68.60 | 2.00 |
| 9 | 75.00 | 4.00 |
| 10 | 94.20 | 12.00 |
| 11 | 99.40 | 14.00 |

Manning's 'N' friction factor = 0.025

Sub-Channel flow = 85.296 (CFS)
' ' flow top width = 20.893 (Ft.)
' ' velocity = 7.868 (Ft/s)
' ' area = 10.841 (Sq.Ft)
' ' Froude number = 1.925

Upstream point elevation = 840.000 (Ft.)
Downstream point elevation = 820.000 (Ft.)
Flow length = 473.000 (Ft.)
Travel time = 1.00 min.
Time of concentration = 12.83 min.
Depth of flow = 0.947 (Ft.)
Average velocity = 7.868 (Ft/s)
Total irregular channel flow = 85.296 (CFS)
Irregular channel normal depth above invert elev. = 0.947 (Ft.)
Average velocity of channel (s) = 7.868 (Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 4.305 (In/Hr) for a 50.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 4.305 (In/Hr) for a 50.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.341 CA = 20.394
Subarea runoff = 5.049 (CFS) for 7.269 (Ac.)
Total runoff = 87.794 (CFS) Total area = 59.759 (Ac.)
Depth of flow = 0.958 (Ft.), Average velocity = 7.926 (Ft/s)
End of computations, total study area = 59.759 (Ac.)

San Diego County Rational Hydrology Program

CIVILCADD/CIVILDESIGN Engineering Software, (c)1991-2006 Version 7.7

Rational method hydrology program based on
San Diego County Flood Control Division 2003 hydrology manual
Rational Hydrology Study Date: 01/21/09

BENTON DUMP - CITY OF ESCONDIDO - EXISTING CONDITIONS HYDROLOGIC
ANALYSIS-USE n = 0.025 THRU n = 0.035 FOR CHANNEL FLOW PROCESSES
100-YR, 6-HOUR STORM EVENT
CIVILD FILE: EX100.RD3

***** Hydrology Study Control Information *****

Program License Serial Number 6219

Rational hydrology study storm event year is 100.0
English (in-lb) input data Units used

Map data precipitation entered:
6 hour, precipitation(inches) = 3.500
24 hour precipitation(inches) = 7.000
P6/P24 = 50.0%
San Diego hydrology manual 'C' values used

Process from Point/Station 100.000 to Point/Station 105.000
**** INITIAL AREA EVALUATION ****

Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.350
Decimal fraction soil group D = 0.650
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.332
Initial subarea total flow distance = 341.800 (Ft.)
Highest elevation = 1377.500 (Ft.)
Lowest elevation = 1320.000 (Ft.)
Elevation difference = 57.500 (Ft.) Slope = 16.823 %
INITIAL AREA TIME OF CONCENTRATION CALCULATIONS:
The maximum overland flow distance is 100.00 (Ft)
for the top area slope value of 16.82 %, in a development type of
Permanent Open Space
In Accordance With Figure 3-3
Initial Area Time of Concentration = 5.39 minutes
TC = [1.8*(1.1-C)*distance(Ft.)^0.5]/(% slope^(1/3))
TC = [1.8*(1.1-0.3325)*(100.000^0.5)]/(16.823^(1/3))= 5.39
The initial area total distance of 341.80 (Ft.) entered leaves a
remaining distance of 241.80 (Ft.)
Using Figure 3-4, the travel time for this distance is 1.06 minutes
for a distance of 241.80 (Ft.) and a slope of 16.82 %
with an elevation difference of 40.68 (Ft.) from the end of the top area
Tt = [11.9*length(Mi)^3]/(elevation change(Ft.))^0.385 *60 (min/hr)
= 1.061 Minutes
Tt=[(11.9*0.0458^3)/(40.68)]^0.385= 1.06
Total initial area Ti = 5.39 minutes from Figure 3-3 formula plus
1.06 minutes from the Figure 3-4 formula = 6.45 minutes
Rainfall intensity (I) = 7.822 (In/Hr) for a 100.0 year storm
Effective runoff coefficient used for area (Q=KCIA) is C = 0.332

Subarea runoff = 3.784(CFS)
Total initial stream area = 1.455(Ac.)

Process from Point/Station 105.000 to Point/Station 110.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 8.746(CFS)
Depth of flow = 0.498(Ft.), Average velocity = 4.761(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 12.90
2 12.30 11.90
3 16.90 9.90
4 21.30 7.90
5 34.20 3.90
6 43.40 1.90
7 60.50 0.00
8 71.50 1.90
9 77.30 3.90
10 91.60 9.90
11 97.00 11.90

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 8.746(CFS)
' ' flow top width = 7.371(Ft.)
' ' velocity = 4.761(Ft/s)
' ' area = 1.837(Sq.Ft)
' ' Froude number = 1.681

Upstream point elevation = 1320.000(Ft.)
Downstream point elevation = 1285.000(Ft.)
Flow length = 431.000(Ft.)
Travel time = 1.51 min.
Time of concentration = 7.96 min.
Depth of flow = 0.498(Ft.)
Average velocity = 4.761(Ft/s)
Total irregular channel flow = 8.746(CFS)
Irregular channel normal depth above invert elev. = 0.498(Ft.)
Average velocity of channel(s) = 4.761(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 6.831(In/Hr) for a 100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.210
Decimal fraction soil group D = 0.790
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 6.831(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.338 CA = 1.998
Subarea runoff = 9.864(CFS) for 4.460(Ac.)
Total runoff = 13.648(CFS) Total area = 5.915(Ac.)
Depth of flow = 0.589(Ft.), Average velocity = 5.321(Ft/s)

Process from Point/Station 110.000 to Point/Station 115.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 18.279(CFS)
Depth of flow = 0.462(Ft.), Average velocity = 7.878(Ft/s)
***** Irregular Channel Data *****

```

-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00              8.20
    2              5.60              6.00
    3             11.60              4.00
    4             20.30              2.00
    5             40.20              0.00
    6             63.80              2.00
    7             74.30              4.00
    8             80.40              6.00
    9             95.10             14.00
Manning's 'N' friction factor = 0.035
-----

```

```

-----
Sub-Channel flow = 18.279(CFS)
'   '   flow top width = 10.046(Ft.)
'   '   velocity = 7.878(Ft/s)
'   '   area = 2.320(Sq.Ft)
'   '   Froude number = 2.889
-----

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```

Upstream point elevation = 1285.000(Ft.)
Downstream point elevation = 1200.000(Ft.)
Flow length = 347.800(Ft.)
Travel time = 0.74 min.
Time of concentration = 8.70 min.
Depth of flow = 0.462(Ft.)
Average velocity = 7.878(Ft/s)
Total irregular channel flow = 18.279(CFS)
Irregular channel normal depth above invert elev. = 0.462(Ft.)
Average velocity of channel(s) = 7.878(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 6.453(In/Hr) for a 100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.000
Decimal fraction soil group D = 1.000
[UNDISTURBED NATURAL TERRAIN ]
(Permanent Open Space )
Impervious value, Ai = 0.000
Sub-Area C Value = 0.350
Rainfall intensity = 6.453(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.343 CA = 3.541
Subarea runoff = 9.199(CFS) for 4.408(Ac.)
Total runoff = 22.847(CFS) Total area = 10.323(Ac.)
Depth of flow = 0.502(Ft.), Average velocity = 8.330(Ft/s)
-----

```

```

*****
Process from Point/Station 115.000 to Point/Station 120.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****
-----

```

```

-----
Estimated mean flow rate at midpoint of channel = 43.912(CFS)
Depth of flow = 0.735(Ft.), Average velocity = 12.766(Ft/s)
***** Irregular Channel Data *****
-----

```

```

-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00             13.00
    2             12.30             12.00
    3             16.90             10.00
    4             21.30              8.00
    5             34.20              4.00
    6             43.40              2.00
    7             60.50              0.00
    8             77.30              4.00
    9             91.60             10.00
   10            97.00             12.00
-----

```

11 101.00 14.00
Manning's 'N' friction factor = 0.035

Sub-Channel flow = 43.912(CFS)
' ' flow top width = 9.365(Ft.)
' ' velocity= 12.766(Ft/s)
' ' area = 3.440(Sq.Ft)
' ' Froude number = 3.712

Upstream point elevation = 1200.000(Ft.)
Downstream point elevation = 970.000(Ft.)
Flow length = 657.000(Ft.)
Travel time = 0.86 min.
Time of concentration = 9.56 min.
Depth of flow = 0.735(Ft.)
Average velocity = 12.766(Ft/s)
Total irregular channel flow = 43.912(CFS)
Irregular channel normal depth above invert elev. = 0.735(Ft.)
Average velocity of channel(s) = 12.766(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 6.073(In/Hr) for a 100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.000
Decimal fraction soil group C = 0.220
Decimal fraction soil group D = 0.780
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.339
Rainfall intensity = 6.073(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.340 CA = 10.687
Subarea runoff = 42.054(CFS) for 21.081(Ac.)
Total runoff = 64.901(CFS) Total area = 31.404(Ac.)
Depth of flow = 0.850(Ft.), Average velocity = 14.076(Ft/s)

Process from Point/Station 120.000 to Point/Station 125.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 71.055(CFS)
Depth of flow = 1.033(Ft.), Average velocity = 10.444(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 13.00
2 12.30 12.00
3 16.90 10.00
4 21.30 8.00
5 34.20 4.00
6 43.40 2.00
7 60.50 0.00
8 77.30 4.00
9 91.60 10.00
10 97.00 12.00
11 101.00 14.00

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 71.055(CFS)
' ' flow top width = 13.171(Ft.)
' ' velocity= 10.444(Ft/s)
' ' area = 6.803(Sq.Ft)
' ' Froude number = 2.561

Upstream point elevation = 970.000(Ft.)
Downstream point elevation = 930.000(Ft.)

Flow length = 269.000(Ft.)
 Travel time = 0.43 min.
 Time of concentration = 9.98 min.
 Depth of flow = 1.033(Ft.)
 Average velocity = 10.444(Ft/s)
 Total irregular channel flow = 71.055(CFS)
 Irregular channel normal depth above invert elev. = 1.033(Ft.)
 Average velocity of channel(s) = 10.444(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 5.903(In/Hr) for a 100.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 0.970
 Decimal fraction soil group D = 0.030
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.361
 Rainfall intensity = 5.903(In/Hr) for a 100.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.344 CA = 13.065
 Subarea runoff = 12.221(CFS) for 6.577(Ac.)
 Total runoff = 77.122(CFS) Total area = 37.981(Ac.)
 Depth of flow = 1.065(Ft.), Average velocity = 10.660(Ft/s)

++++++
 Process from Point/Station 125.000 to Point/Station 130.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 81.603(CFS)
 Depth of flow = 1.058(Ft.), Average velocity = 9.855(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 12.90 |
| 2 | 12.30 | 11.90 |
| 3 | 16.90 | 9.90 |
| 4 | 21.30 | 7.90 |
| 5 | 34.20 | 3.90 |
| 6 | 43.40 | 1.90 |
| 7 | 60.50 | 0.00 |
| 8 | 71.50 | 1.90 |
| 9 | 77.30 | 3.90 |
| 10 | 91.60 | 9.90 |
| 11 | 97.00 | 11.90 |

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 81.603(CFS)
 ' ' flow top width = 15.650(Ft.)
 ' ' velocity = 9.855(Ft/s)
 ' ' area = 8.280(Sq.Ft)
 ' ' Froude number = 2.388

Upstream point elevation = 930.000(Ft.)
 Downstream point elevation = 876.000(Ft.)
 Flow length = 423.500(Ft.)
 Travel time = 0.72 min.
 Time of concentration = 10.70 min.
 Depth of flow = 1.058(Ft.)
 Average velocity = 9.855(Ft/s)
 Total irregular channel flow = 81.603(CFS)
 Irregular channel normal depth above invert elev. = 1.058(Ft.)
 Average velocity of channel(s) = 9.855(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 5.645(In/Hr) for a 100.0 year storm
 Decimal fraction soil group A = 0.000

Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 5.645(In/Hr) for a 100.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.346 CA = 15.240
 Subarea runoff = 8.908(CFS) for 6.042(Ac.)
 Total runoff = 86.030(CFS) Total area = 44.023(Ac.)
 Depth of flow = 1.079(Ft.), Average velocity = 9.986(Ft/s)

++++++
 Process from Point/Station 130.000 to Point/Station 135.000
 **** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

 Estimated mean flow rate at midpoint of channel = 91.685(CFS)
 Depth of flow = 1.216(Ft.), Average velocity = 6.871(Ft/s)
 ***** Irregular Channel Data *****

 Information entered for subchannel number 1 :

| Point number | 'X' coordinate | 'Y' coordinate |
|--------------|----------------|----------------|
| 1 | 0.00 | 20.00 |
| 2 | 18.60 | 8.00 |
| 3 | 23.20 | 6.00 |
| 4 | 27.70 | 4.00 |
| 5 | 33.80 | 2.00 |
| 6 | 48.30 | 0.00 |
| 7 | 69.90 | 2.00 |
| 8 | 75.90 | 4.00 |
| 9 | 82.30 | 6.00 |
| 10 | 98.70 | 14.00 |
| 11 | 105.40 | 16.00 |

Manning's 'N' friction factor = 0.035

 Sub-Channel flow = 91.685(CFS)
 ' ' flow top width = 21.948(Ft.)
 ' ' velocity = 6.871(Ft/s)
 ' ' area = 13.344(Sq.Ft)
 ' ' Froude number = 1.553

Upstream point elevation = 876.000(Ft.)
 Downstream point elevation = 860.000(Ft.)
 Flow length = 312.000(Ft.)
 Travel time = 0.76 min.
 Time of concentration = 11.46 min.
 Depth of flow = 1.216(Ft.)
 Average velocity = 6.871(Ft/s)
 Total irregular channel flow = 91.685(CFS)
 Irregular channel normal depth above invert elev. = 1.216(Ft.)
 Average velocity of channel(s) = 6.871(Ft/s)
 Adding area flow to channel
 Rainfall intensity (I) = 5.402(In/Hr) for a 100.0 year storm
 Decimal fraction soil group A = 0.000
 Decimal fraction soil group B = 0.000
 Decimal fraction soil group C = 1.000
 Decimal fraction soil group D = 0.000
 [LOW DENSITY RESIDENTIAL]
 (1.0 DU/A or Less)
 Impervious value, Ai = 0.100
 Sub-Area C Value = 0.360
 Rainfall intensity = 5.402(In/Hr) for a 100.0 year storm
 Effective runoff coefficient used for total area
 (Q=KCIA) is C = 0.348 CA = 18.009
 Subarea runoff = 11.248(CFS) for 7.692(Ac.)

Total runoff = 97.279(CFS) Total area = 51.715(Ac.)
Depth of flow = 1.243(Ft.), Average velocity = 6.973(Ft/s)

Process from Point/Station 135.000 to Point/Station 140.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 97.509(CFS)
Depth of flow = 0.841(Ft.), Average velocity = 11.166(Ft/s)
***** Irregular Channel Data *****

Information entered for subchannel number 1 :
Point number 'X' coordinate 'Y' coordinate
1 0.00 13.00
2 3.80 12.00
3 14.00 6.00
4 19.00 4.00
5 26.70 2.00
6 47.70 0.00
7 49.70 0.00
8 68.60 2.00
9 75.00 4.00
10 94.20 12.00
11 99.40 14.00

Manning's 'N' friction factor = 0.035

Sub-Channel flow = 97.509(CFS)
' ' flow top width = 18.773(Ft.)
' ' velocity = 11.166(Ft/s)
' ' area = 8.733(Sq.Ft)
' ' Froude number = 2.885

Upstream point elevation = 860.000(Ft.)
Downstream point elevation = 840.000(Ft.)
Flow length = 103.600(Ft.)
Travel time = 0.15 min.
Time of concentration = 11.61 min.
Depth of flow = 0.841(Ft.)
Average velocity = 11.166(Ft/s)
Total irregular channel flow = 97.509(CFS)
Irregular channel normal depth above invert elev. = 0.841(Ft.)
Average velocity of channel(s) = 11.166(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 5.355(In/Hr) for a 100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN]
(Permanent Open Space)
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 5.355(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.347 CA = 18.239
Subarea runoff = 0.393(CFS) for 0.775(Ac.)
Total runoff = 97.672(CFS) Total area = 52.490(Ac.)
Depth of flow = 0.841(Ft.), Average velocity = 11.171(Ft/s)

Process from Point/Station 140.000 to Point/Station 145.000
**** IRREGULAR CHANNEL FLOW TRAVEL TIME ****

Estimated mean flow rate at midpoint of channel = 100.743(CFS)
Depth of flow = 1.014(Ft.), Average velocity = 8.205(Ft/s)
***** Irregular Channel Data *****

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-----
Information entered for subchannel number 1 :
Point number      'X' coordinate      'Y' coordinate
    1              0.00              13.00
    2              3.80              12.00
    3             14.00              6.00
    4             19.00              4.00
    5             26.70              2.00
    6             47.70              0.00
    7             49.70              0.00
    8             68.60              2.00
    9             75.00              4.00
   10             94.20             12.00
   11            99.40             14.00
Manning's 'N' friction factor = 0.025
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Sub-Channel flow = 100.743(CFS)
'   '   flow top width = 22.224(Ft.)
'   '   velocity= 8.205(Ft/s)
'   '   area = 12.279(Sq.Ft)
'   '   Froude number = 1.945

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Upstream point elevation = 840.000(Ft.)
Downstream point elevation = 820.000(Ft.)
Flow length = 473.000(Ft.)
Travel time = 0.96 min.
Time of concentration = 12.57 min.
Depth of flow = 1.014(Ft.)
Average velocity = 8.205(Ft/s)
Total irregular channel flow = 100.743(CFS)
Irregular channel normal depth above invert elev. = 1.014(Ft.)
Average velocity of channel(s) = 8.205(Ft/s)
Adding area flow to channel
Rainfall intensity (I) = 5.087(In/Hr) for a 100.0 year storm
Decimal fraction soil group A = 0.000
Decimal fraction soil group B = 0.070
Decimal fraction soil group C = 0.930
Decimal fraction soil group D = 0.000
[UNDISTURBED NATURAL TERRAIN ]
(Permanent Open Space )
Impervious value, Ai = 0.000
Sub-Area C Value = 0.297
Rainfall intensity = 5.087(In/Hr) for a 100.0 year storm
Effective runoff coefficient used for total area
(Q=KCIA) is C = 0.341 CA = 20.394
Subarea runoff = 6.083(CFS) for 7.269(Ac.)
Total runoff = 103.754(CFS) Total area = 59.759(Ac.)
Depth of flow = 1.026(Ft.), Average velocity = 8.266(Ft/s)
End of computations, total study area = 59.759 (Ac.)

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HEC-RAS Plan: 2-yr Exist River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|--------|-----------|---------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| BENTON | 215 | PF 1 | 44.30 | 873.50 | 874.54 | 874.74 | 875.21 | 0.060031 | 6.55 | 6.76 | 10.84 | 1.46 |
| BENTON | 210 | PF 1 | 44.30 | 870.80 | 872.75 | 872.10 | 872.83 | 0.003325 | 2.25 | 19.65 | 17.74 | 0.38 |
| BENTON | 205 | PF 1 | 44.30 | 871.30 | 872.12 | 872.12 | 872.35 | 0.030134 | 3.85 | 11.56 | 26.41 | 1.00 |
| BENTON | 200 | PF 1 | 44.30 | 866.00 | 867.35 | 867.62 | 868.23 | 0.085501 | 7.53 | 5.88 | 8.75 | 1.62 |
| BENTON | 195 | PF 1 | 44.30 | 860.00 | 860.82 | 861.10 | 861.73 | 0.054557 | 7.63 | 5.80 | 14.13 | 2.10 |
| BENTON | 190 | PF 1 | 44.30 | 850.00 | 850.82 | 851.47 | 854.60 | 0.234641 | 15.60 | 2.84 | 6.90 | 4.28 |
| BENTON | 185 | PF 1 | 44.30 | 840.00 | 841.06 | 841.75 | 844.36 | 0.390683 | 14.57 | 3.04 | 5.73 | 3.53 |
| BENTON | 180 | PF 1 | 44.30 | 838.10 | 839.27 | 839.64 | 840.47 | 0.120072 | 8.79 | 5.04 | 8.62 | 2.03 |
| BENTON | 175 | PF 1 | 44.30 | 836.60 | 838.03 | 838.17 | 838.60 | 0.024245 | 6.03 | 7.35 | 10.24 | 1.25 |
| BENTON | 170 | PF 1 | 44.30 | 834.00 | 834.75 | 835.08 | 835.91 | 0.152200 | 8.61 | 5.14 | 13.63 | 2.47 |
| BENTON | 165 | PF 1 | 44.30 | 830.10 | 831.12 | 831.27 | 831.63 | 0.033300 | 5.74 | 7.72 | 15.11 | 1.42 |
| BENTON | 160 | PF 1 | 44.30 | 828.00 | 828.75 | 828.94 | 829.36 | 0.051198 | 6.25 | 7.09 | 16.93 | 1.70 |
| BENTON | 155 | PF 1 | 44.30 | 826.00 | 827.63 | 827.63 | 827.84 | 0.018149 | 3.64 | 12.18 | 28.43 | 0.98 |
| BENTON | 150 | PF 1 | 44.30 | 822.00 | 823.27 | 823.69 | 825.06 | 0.268450 | 10.72 | 4.13 | 10.31 | 2.99 |
| BENTON | 125 | PF 1 | 44.30 | 819.80 | 820.67 | 820.96 | 821.59 | 0.050297 | 8.01 | 5.85 | 10.00 | 1.60 |
| BENTON | 100 | PF 1 | 44.30 | 819.70 | 820.99 | 820.68 | 821.16 | 0.002800 | 3.43 | 14.19 | 15.67 | 0.57 |
| BENTON | 50 | PF 1 | 44.30 | 819.50 | 820.51 | 820.51 | 820.88 | 0.021065 | 4.99 | 9.39 | 13.18 | 0.93 |
| BENTON | 40 | PF 1 | 44.30 | 817.50 | 820.10 | 818.71 | 820.16 | 0.001043 | 2.27 | 23.55 | 13.68 | 0.25 |
| BENTON | 30 | PF 1 | 44.30 | 817.00 | 820.10 | 817.99 | 820.15 | 0.000366 | 1.79 | 24.80 | 17.20 | 0.18 |

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- Square Edge with Headwall
- Groove End with Headwall
- Groove End Projecting

2.075

Critical Depth (ft)

7.458

Critical Velocity (ft/s)

44.3

Q = Discharge (cfs) \longrightarrow 2-YR FLOW

.02

Culvert Barrel Slope (ft/ft)

3.5

Culvert diameter (ft)

3.111

Headwater (ft)

Calc

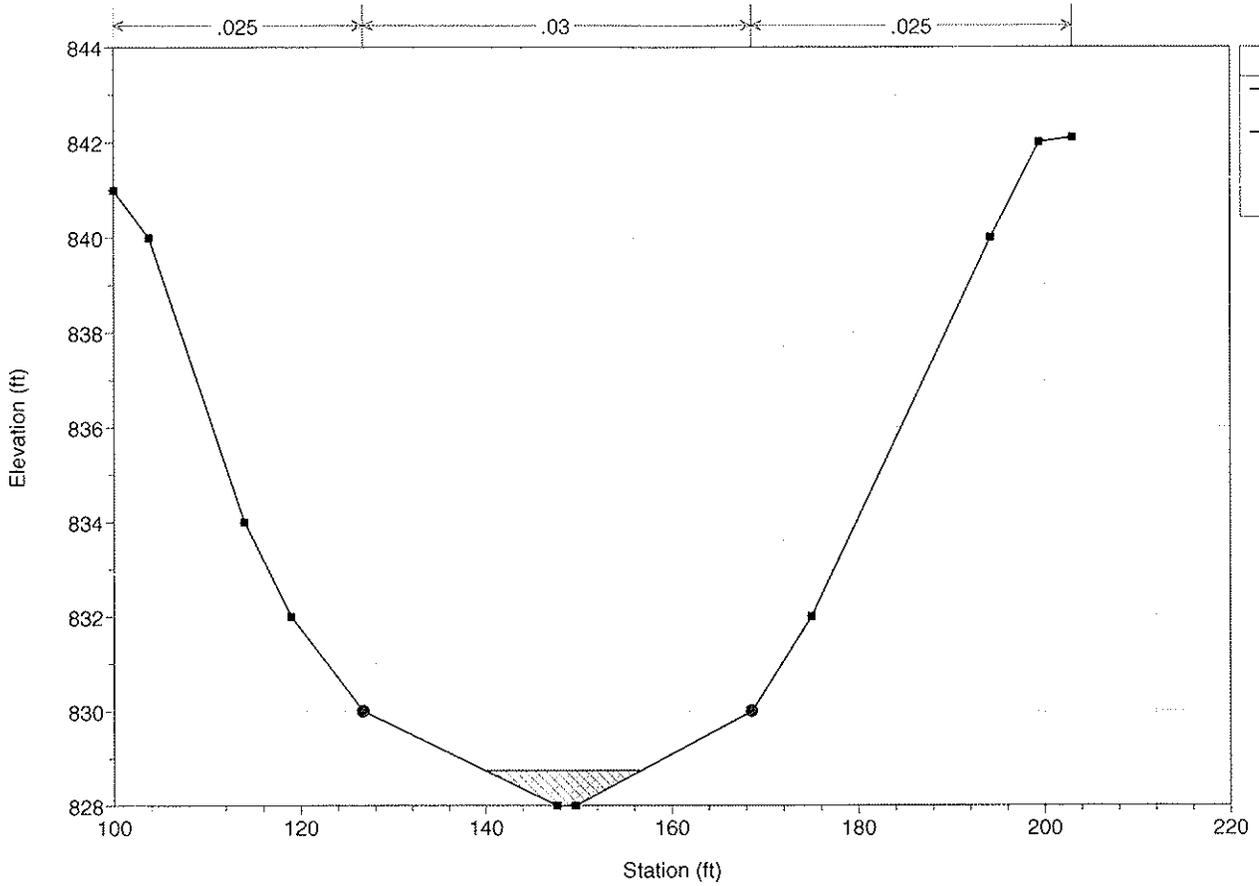
Units

English

Metric

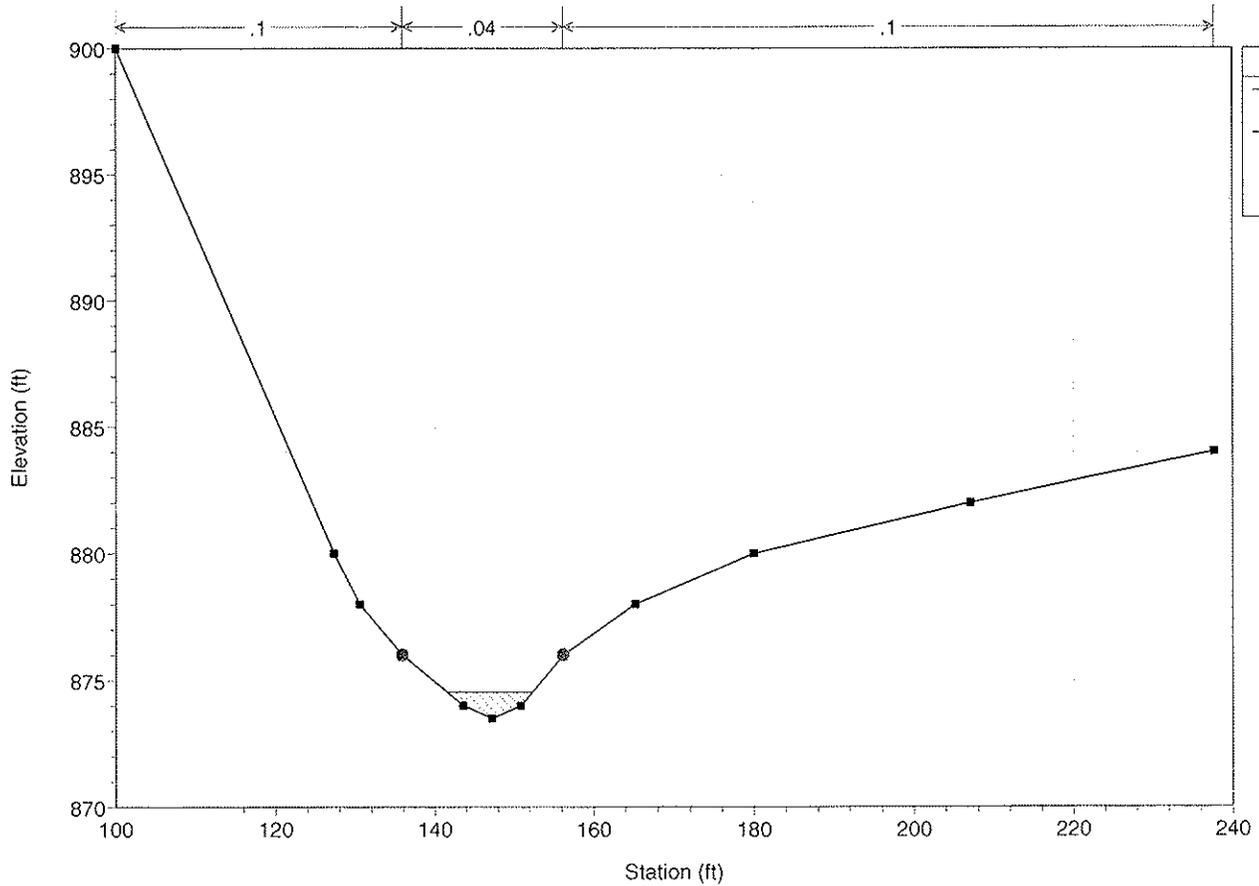
BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 160

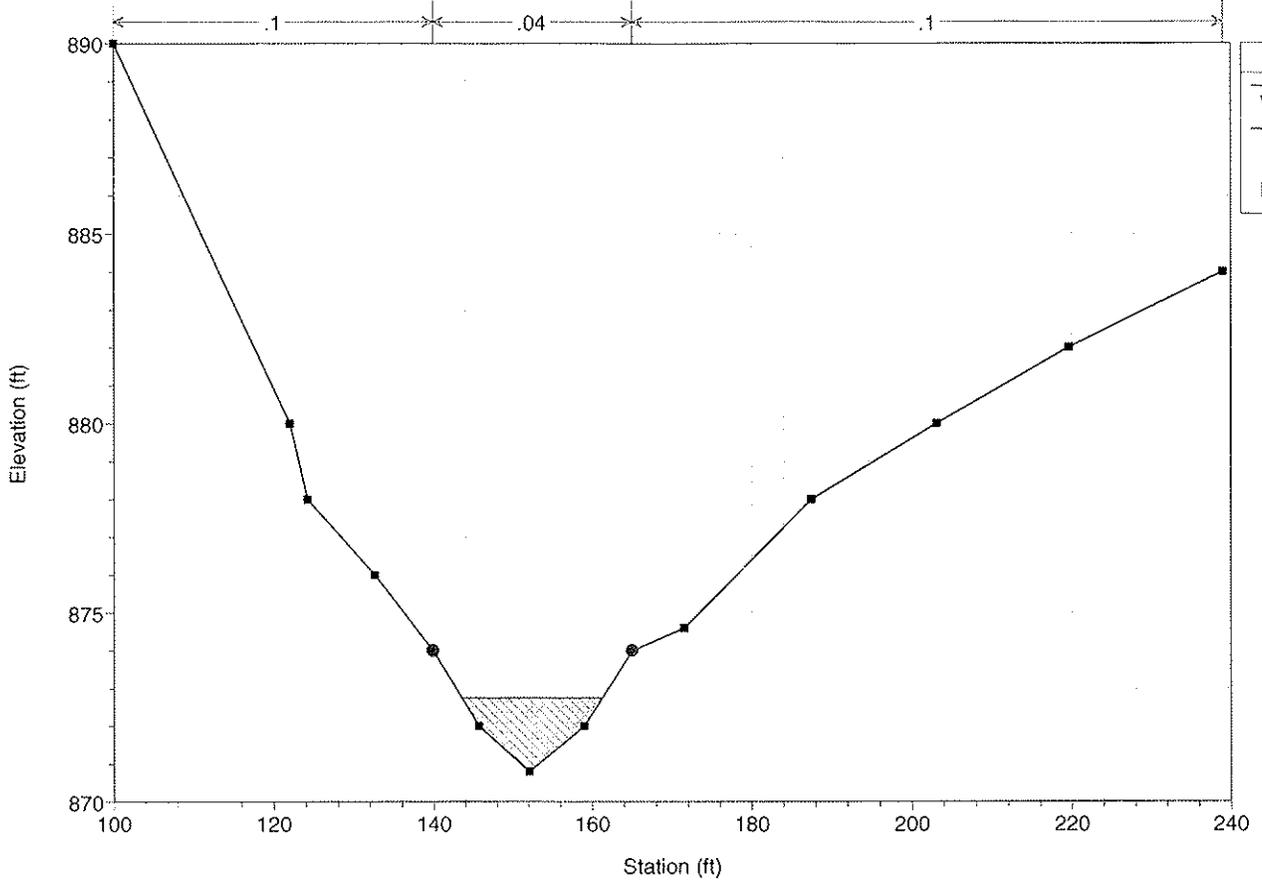


BENTON Plan: 2-yr Exist 2/19/2009

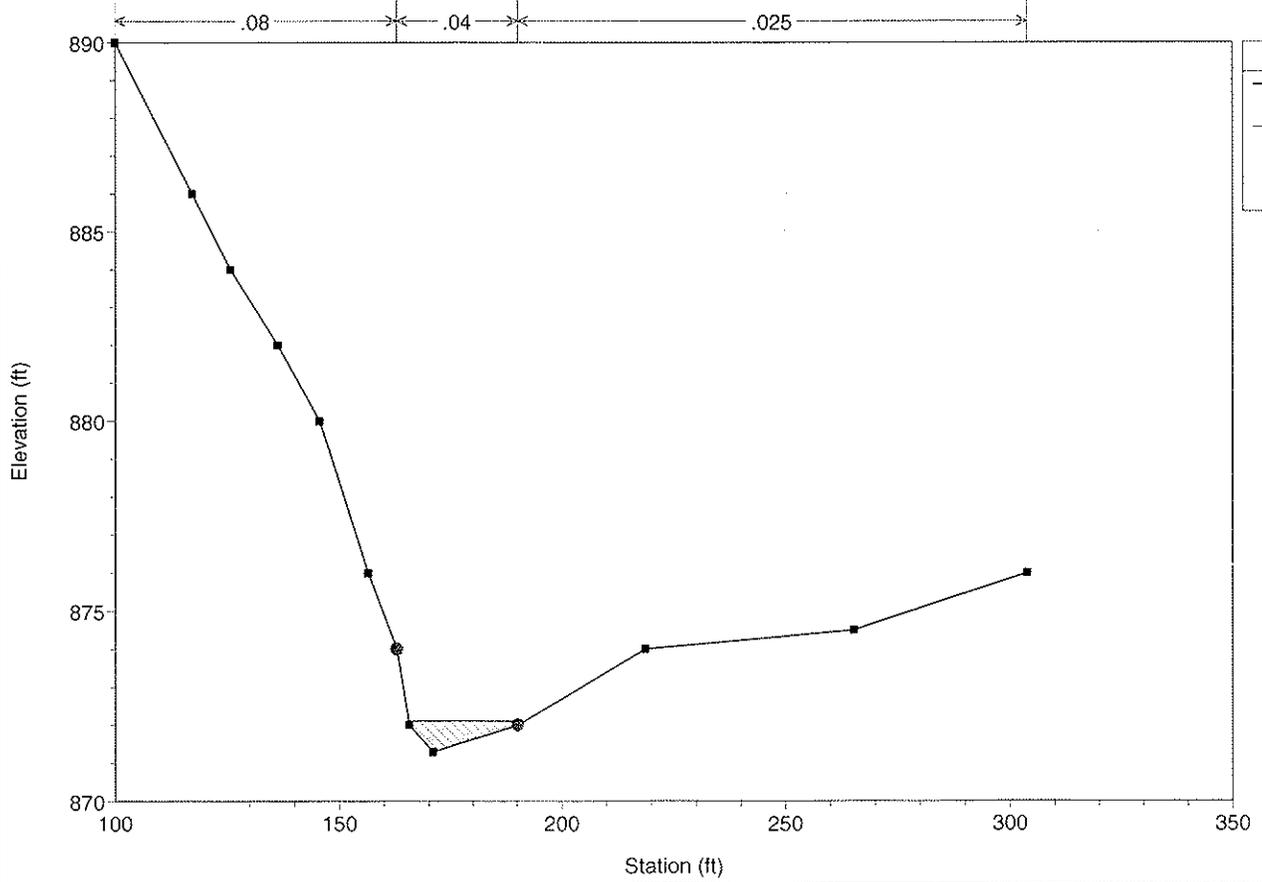
River = BENTON Reach = BENTON RS = 215



BENTON Plan: 2-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 210

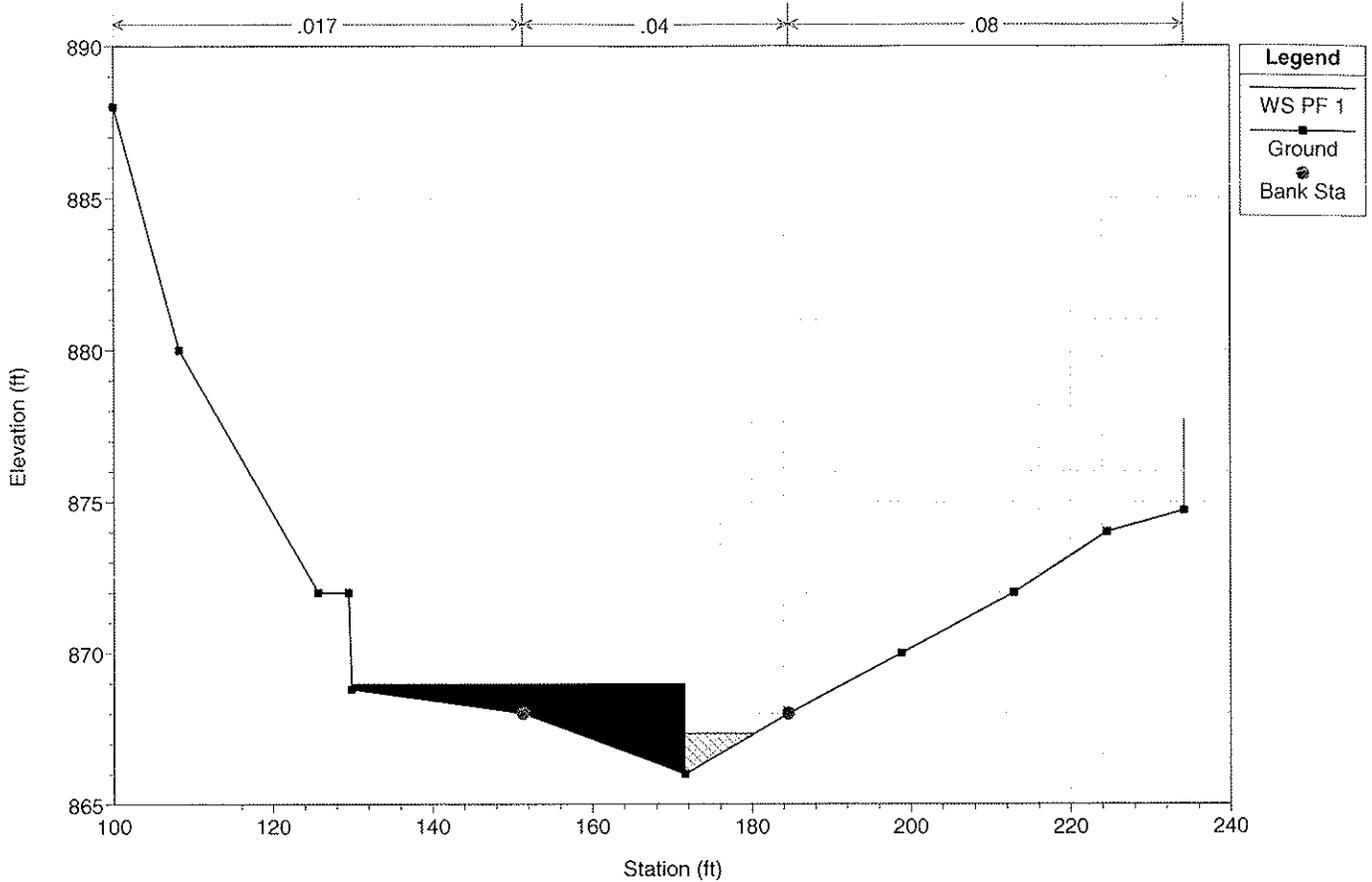


BENTON Plan: 2-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 205



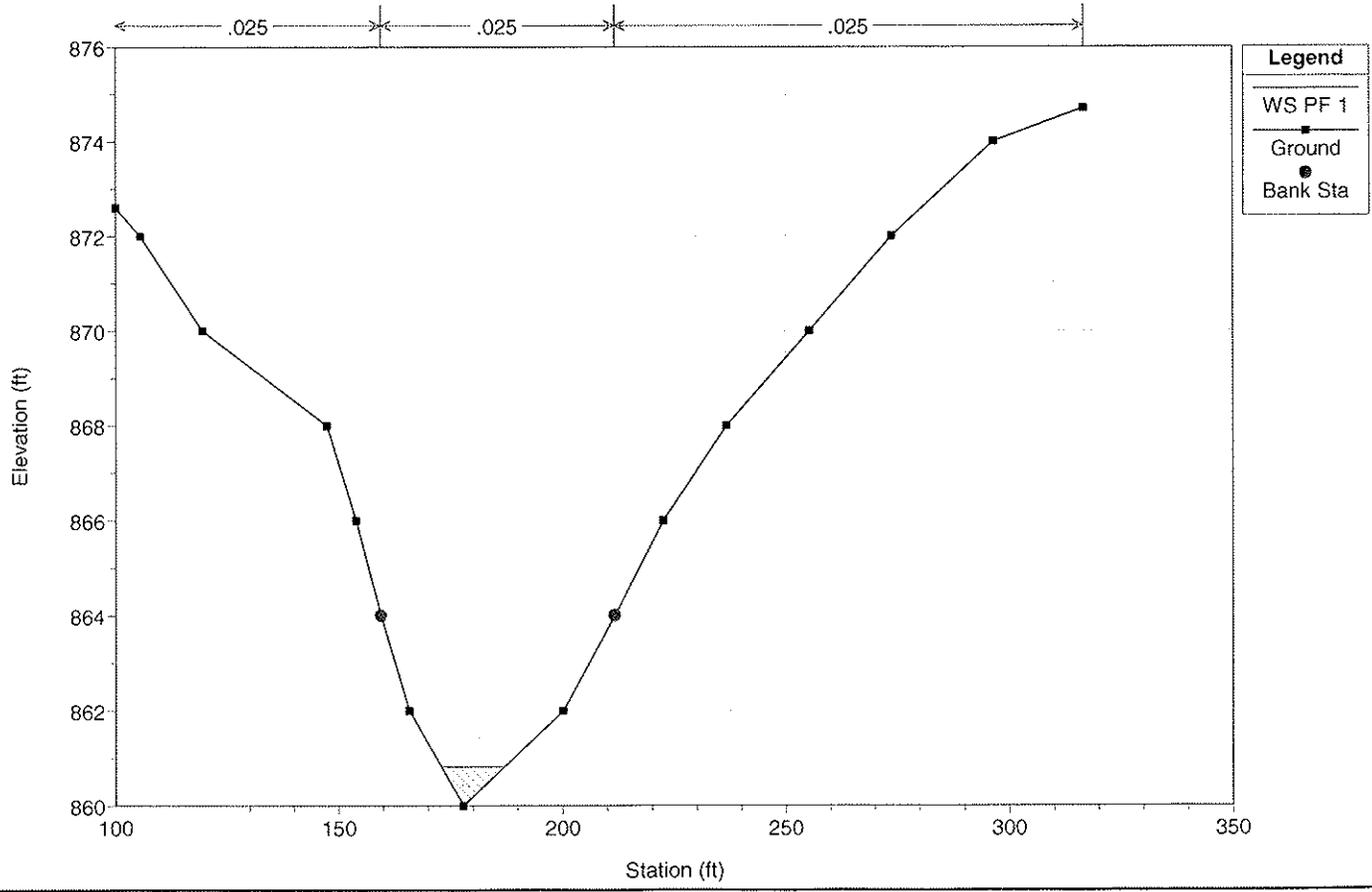
BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 200



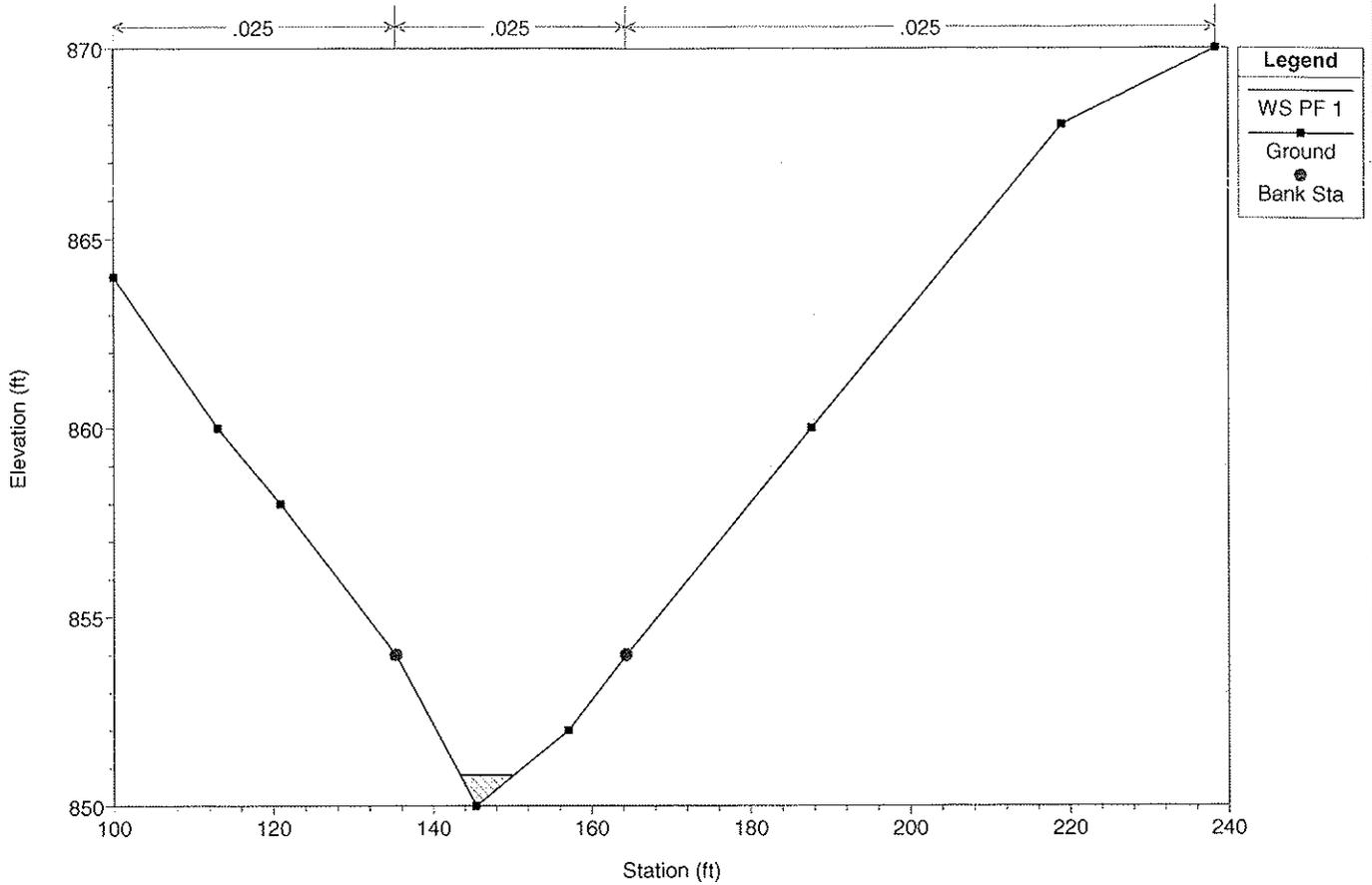
BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 195



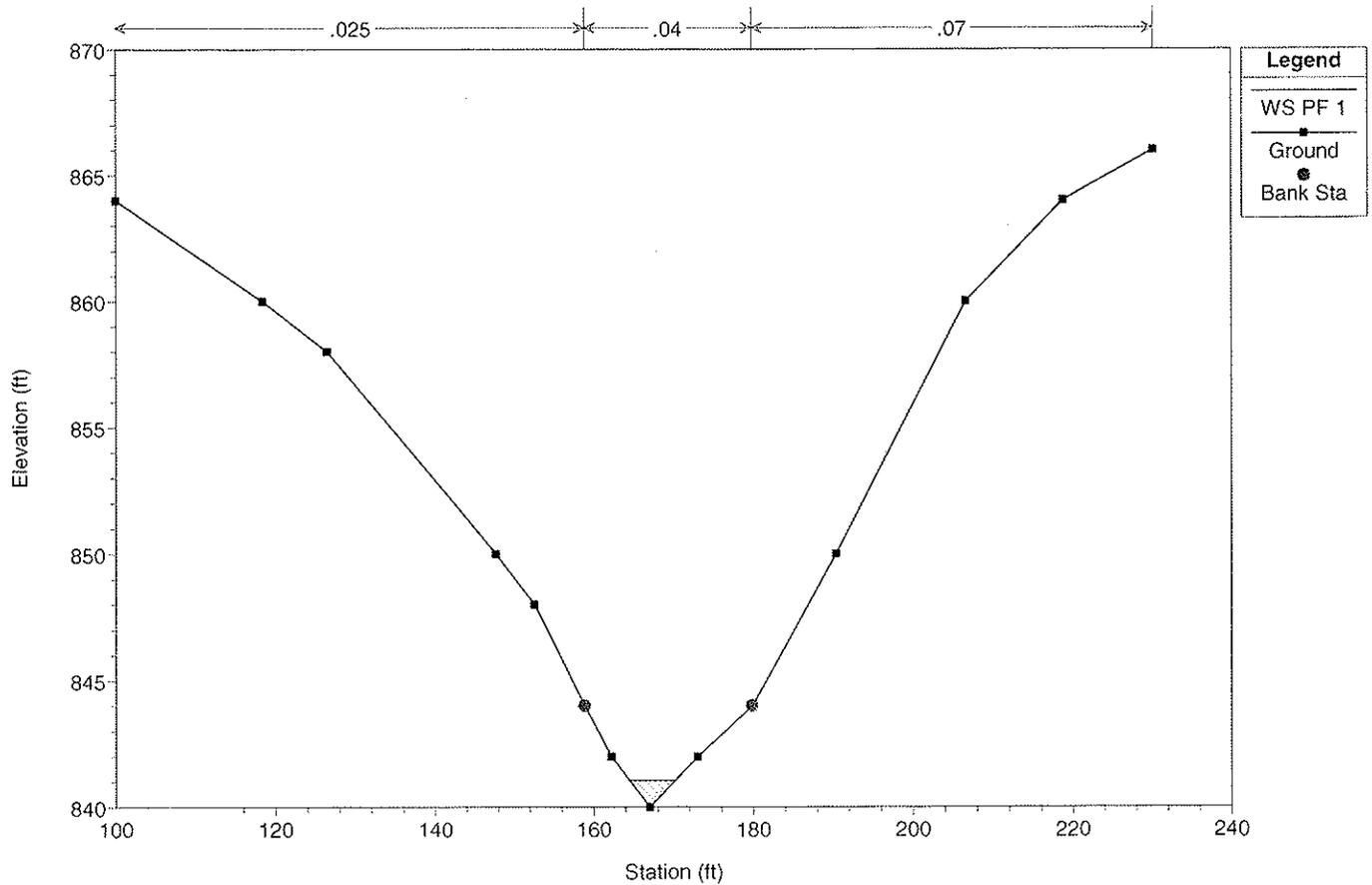
BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 190



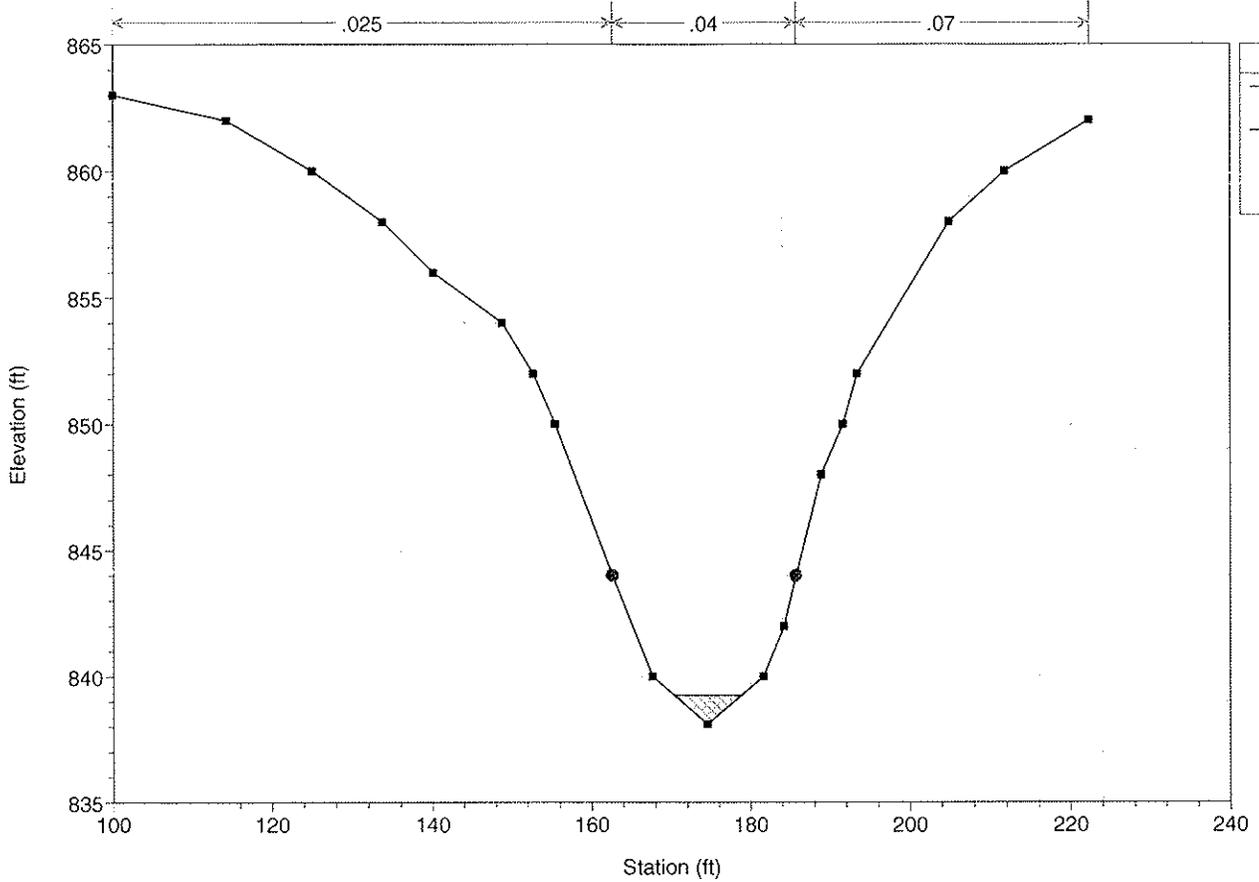
BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 185



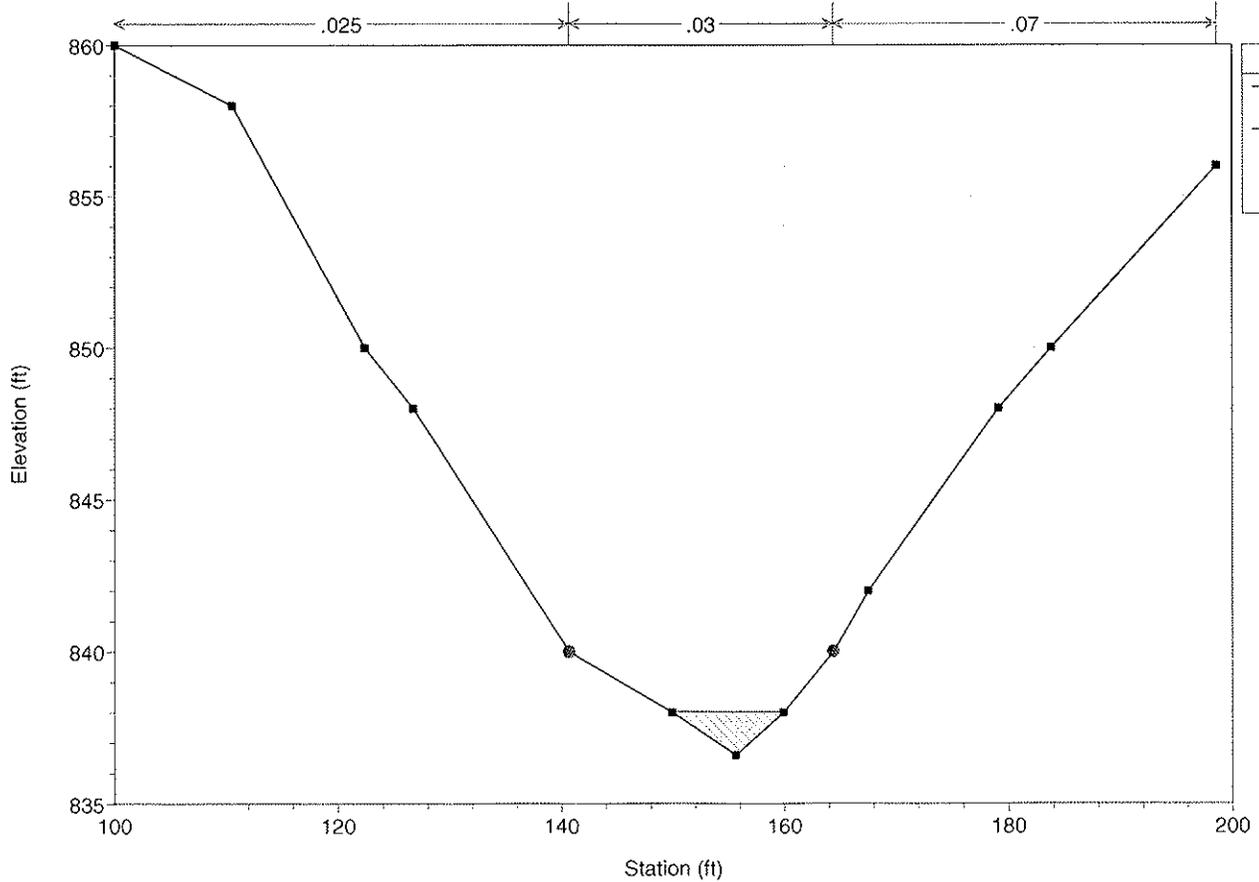
BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 180

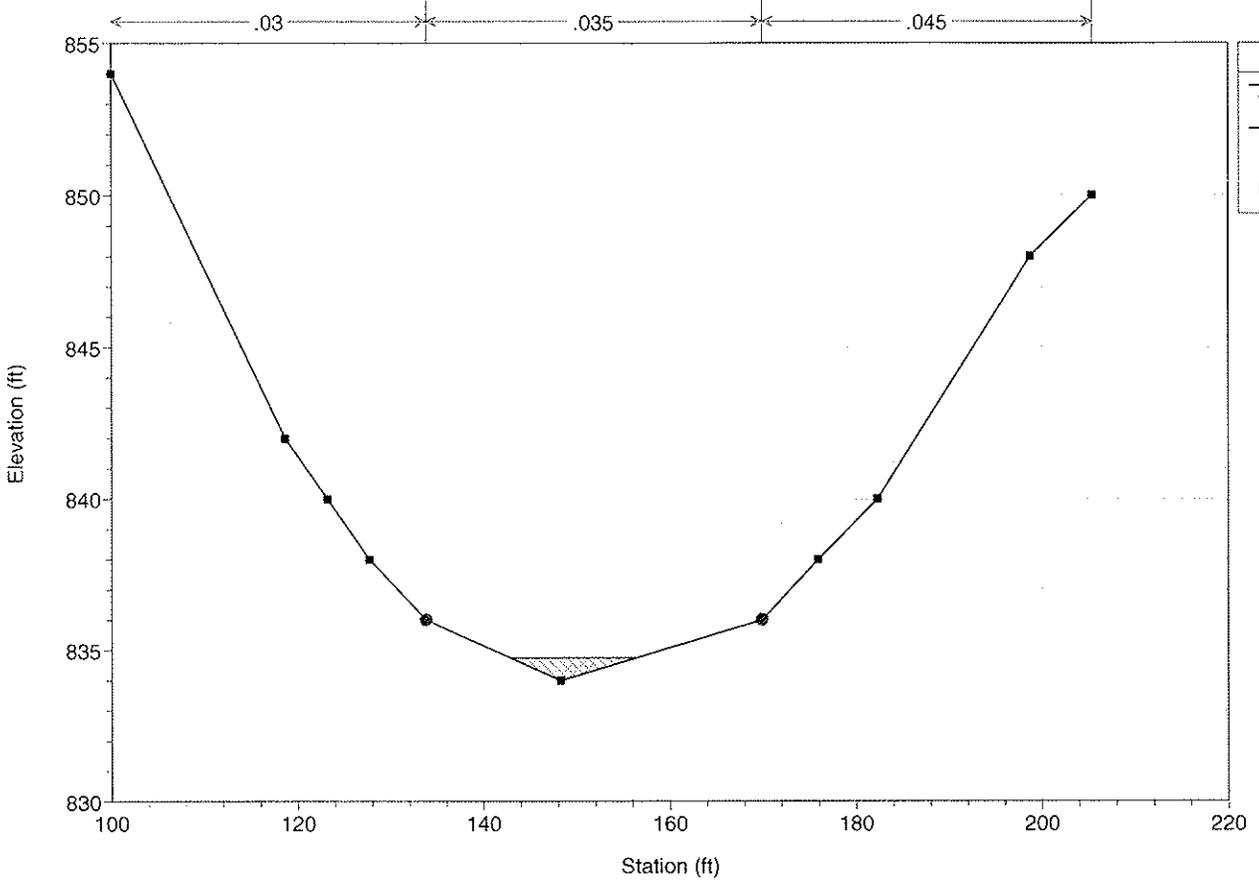


BENTON Plan: 2-yr Exist 2/19/2009

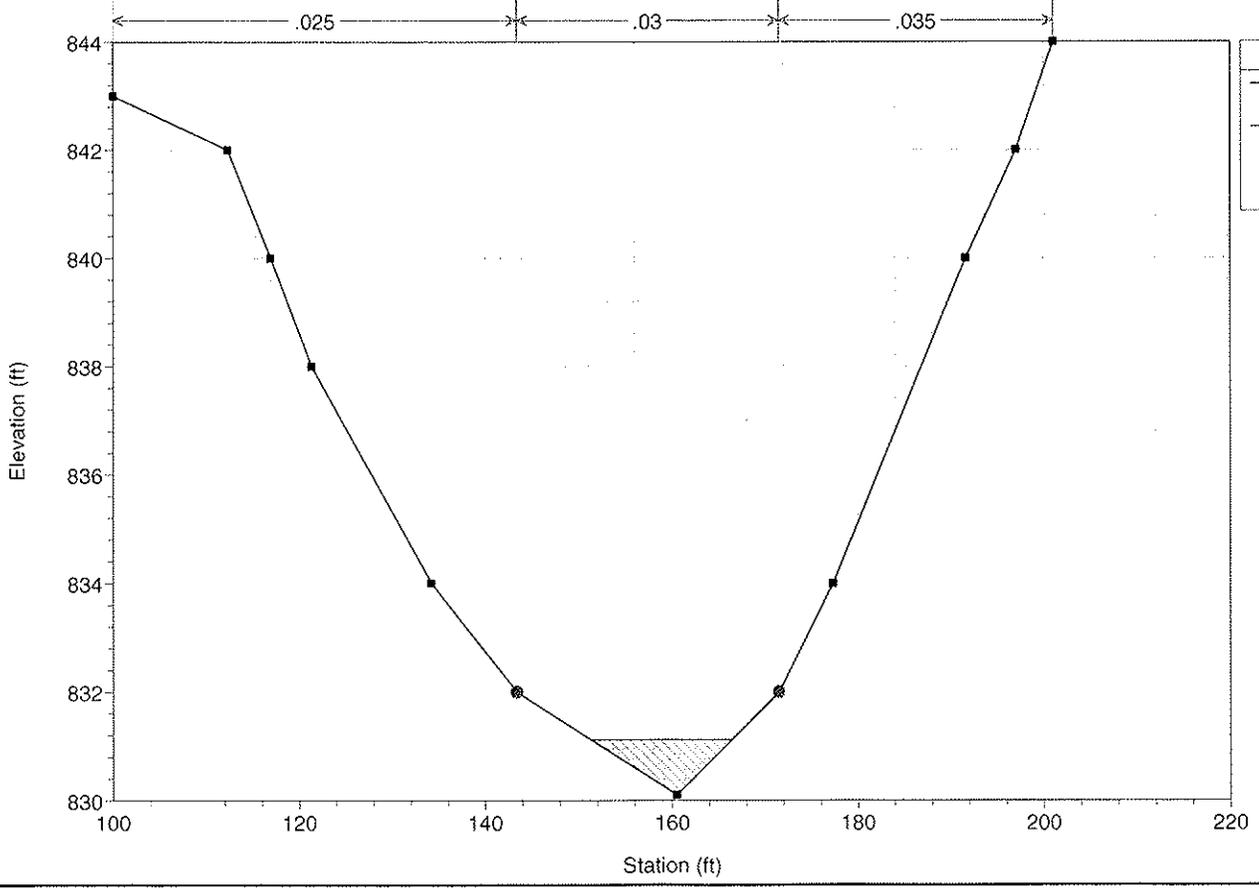
River = BENTON Reach = BENTON RS = 175



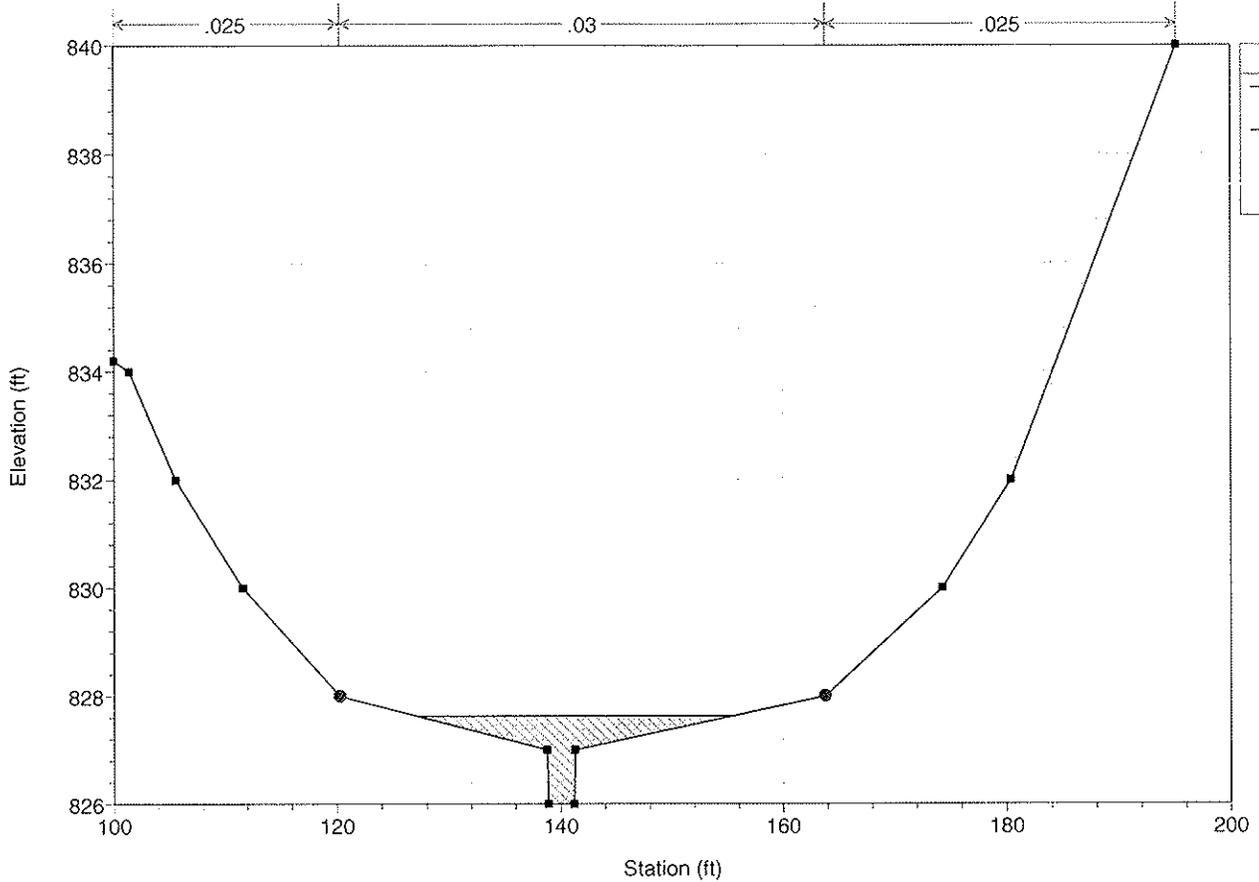
BENTON Plan: 2-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 170



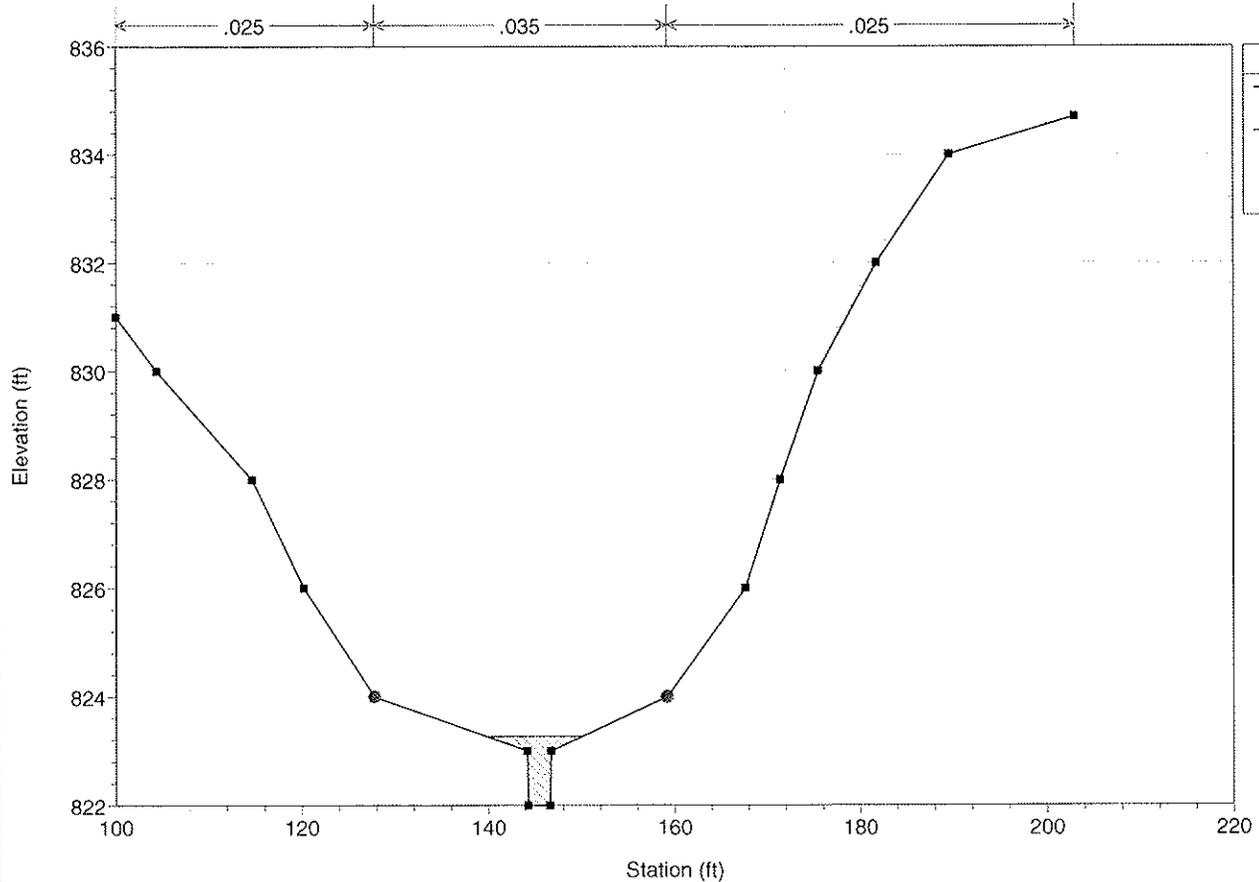
BENTON Plan: 2-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 165



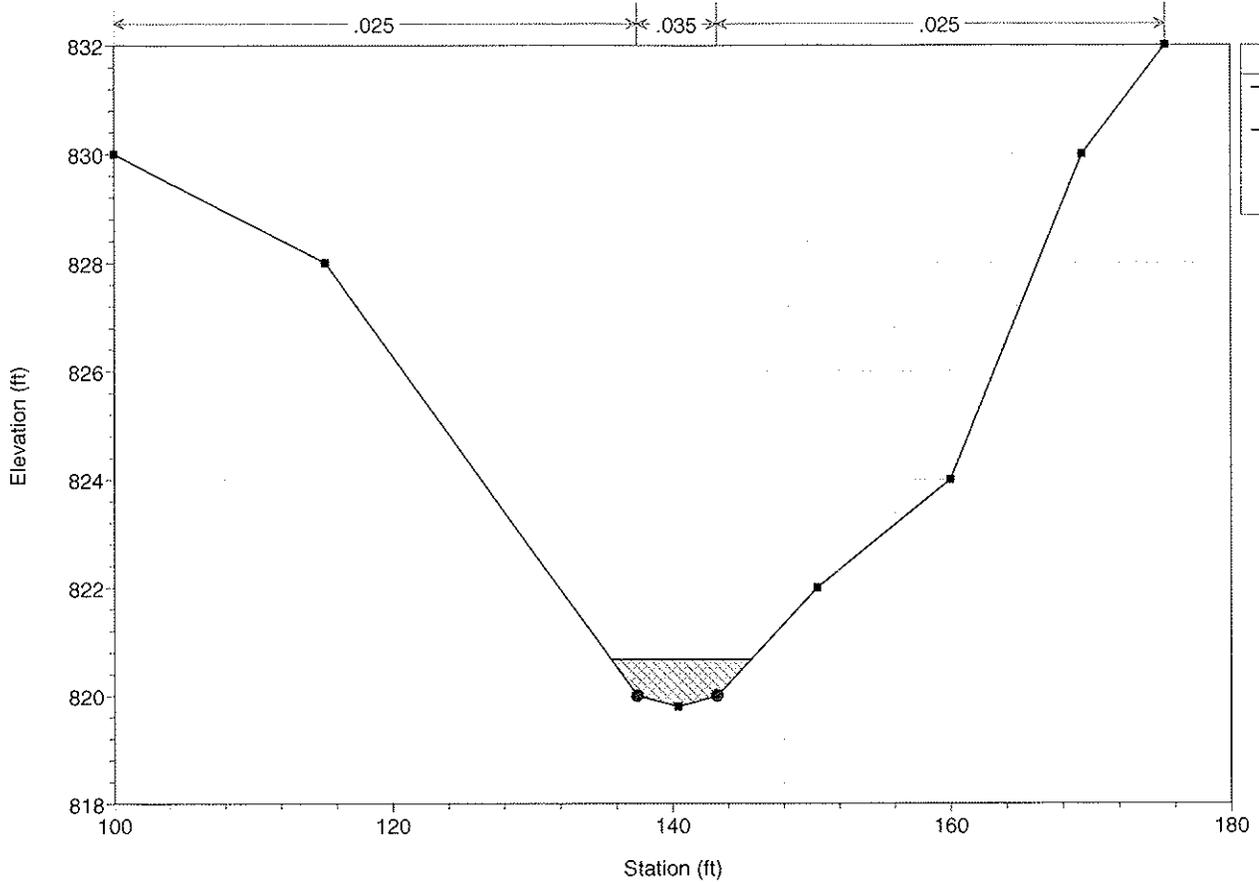
BENTON Plan: 2-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 155



BENTON Plan: 2-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 150

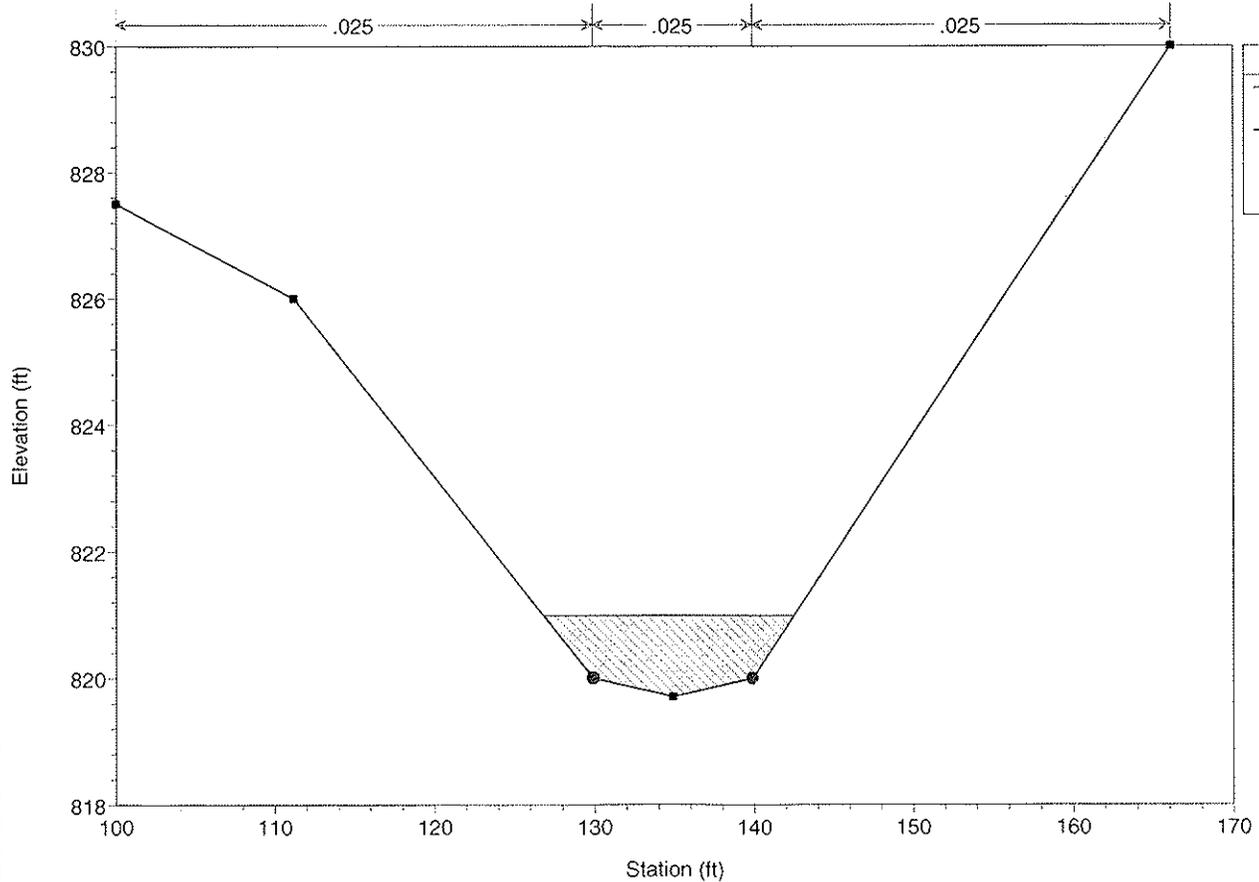


BENTON Plan: 2-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 125



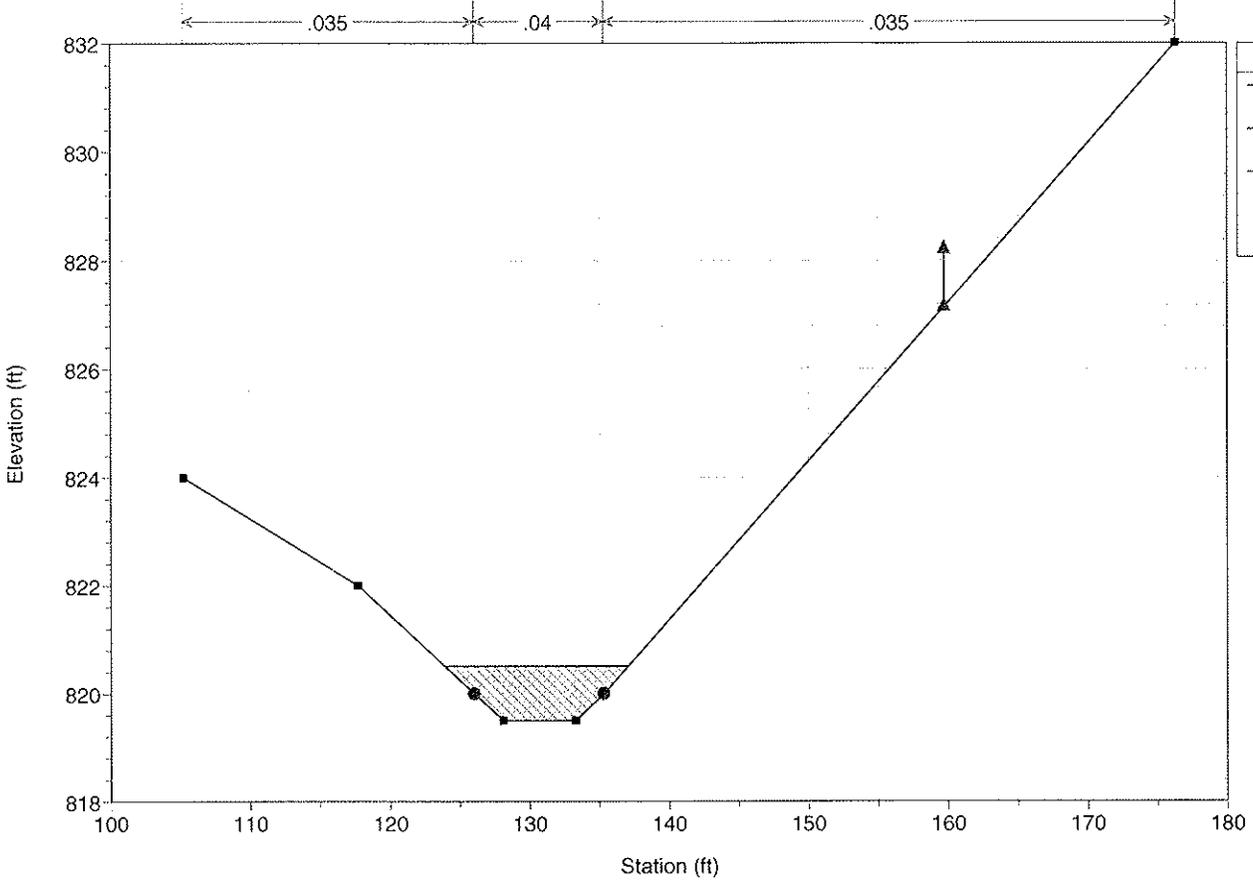
Legend
WS PF 1
Ground
Bank Sta

BENTON Plan: 2-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 100

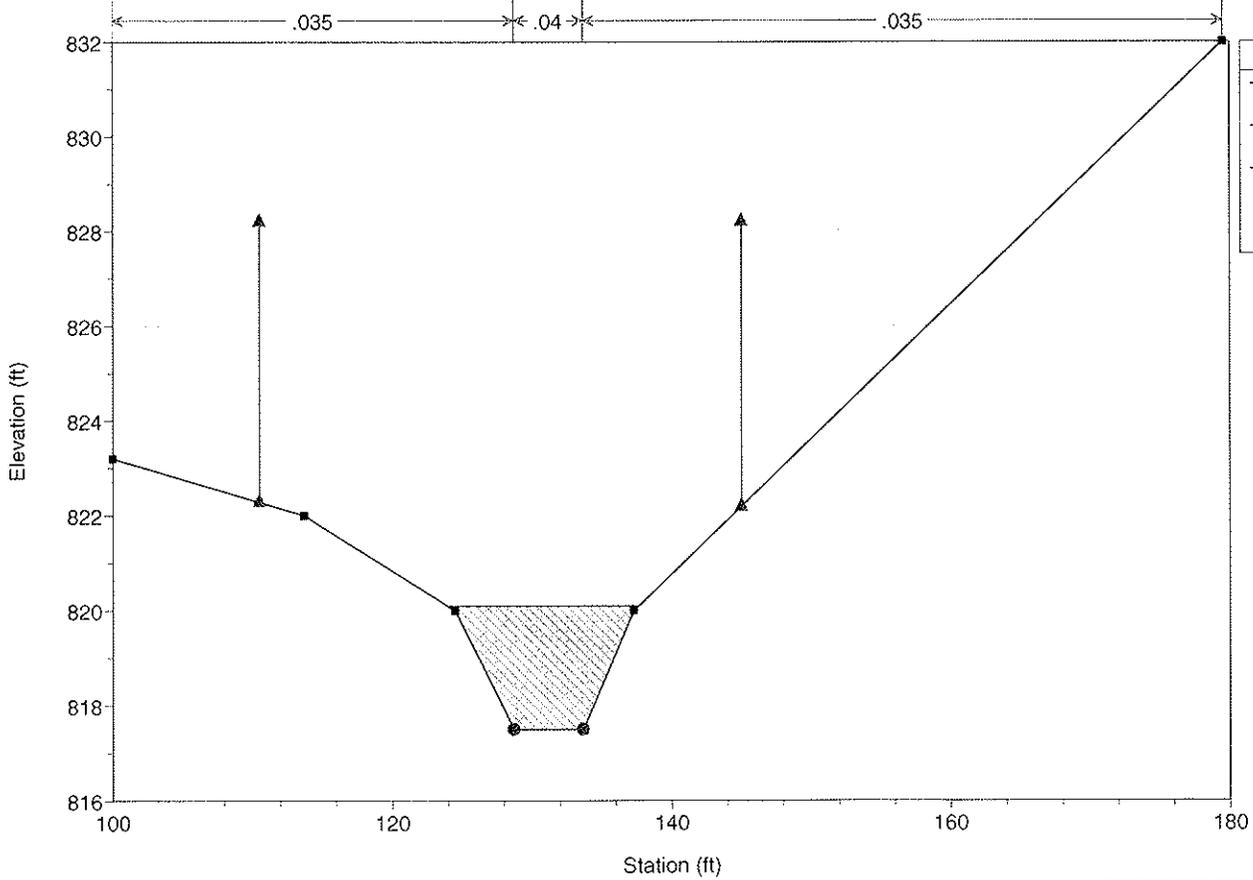


Legend
WS PF 1
Ground
Bank Sta

BENTON Plan: 2-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 50

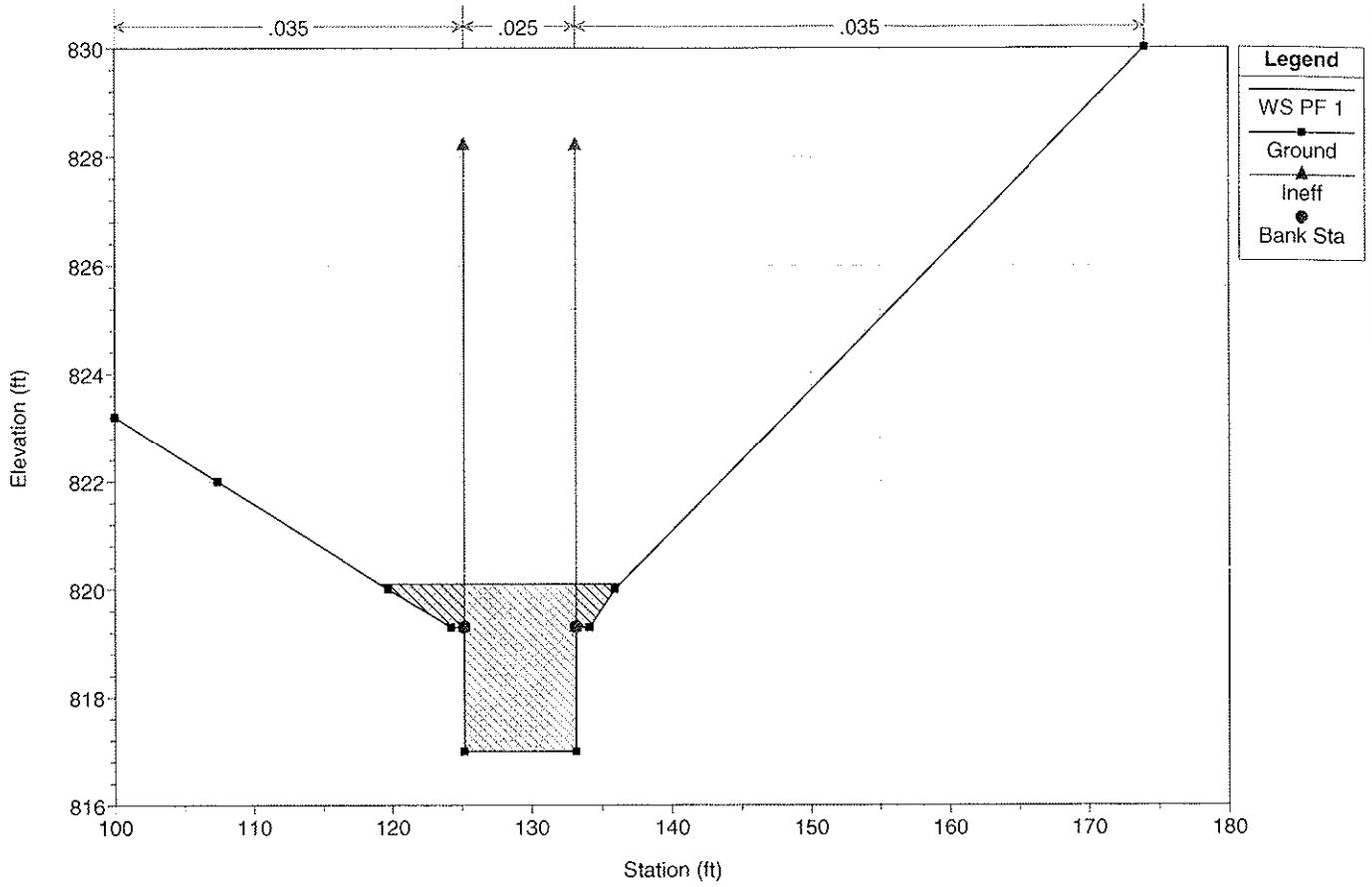


BENTON Plan: 2-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 40



BENTON Plan: 2-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 30



HEC-RAS Plan: 10-yr Exist River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 215 | PF 1 | 68.90 | 873.50 | 874.76 | 875.02 | 875.62 | 0.060045 | 7.44 | 9.27 | 12.25 | 1.51 | |
| BENTON | 210 | PF 1 | 68.90 | 870.80 | 873.01 | 872.35 | 873.13 | 0.004367 | 2.82 | 24.41 | 19.26 | 0.44 | |
| BENTON | 205 | PF 1 | 68.90 | 871.30 | 872.28 | 872.28 | 872.57 | 0.025782 | 4.33 | 16.13 | 28.99 | 0.97 | |
| BENTON | 200 | PF 1 | 68.90 | 866.00 | 867.57 | 867.94 | 868.72 | 0.091295 | 8.62 | 7.99 | 10.19 | 1.72 | |
| BENTON | 195 | PF 1 | 68.90 | 860.00 | 860.97 | 861.31 | 862.09 | 0.053585 | 8.47 | 8.14 | 16.73 | 2.14 | |
| BENTON | 190 | PF 1 | 68.90 | 850.00 | 850.99 | 851.75 | 855.29 | 0.207297 | 16.63 | 4.14 | 8.33 | 4.15 | |
| BENTON | 185 | PF 1 | 68.90 | 840.00 | 841.24 | 842.08 | 845.58 | 0.420457 | 16.73 | 4.12 | 6.67 | 3.75 | |
| BENTON | 180 | PF 1 | 68.90 | 838.10 | 839.44 | 839.94 | 841.11 | 0.138477 | 10.36 | 6.65 | 9.90 | 2.23 | |
| BENTON | 175 | PF 1 | 68.90 | 836.60 | 838.28 | 838.47 | 839.01 | 0.025557 | 6.88 | 10.02 | 11.89 | 1.32 | |
| BENTON | 170 | PF 1 | 68.90 | 834.00 | 834.90 | 835.29 | 836.27 | 0.142769 | 9.39 | 7.34 | 16.27 | 2.46 | |
| BENTON | 165 | PF 1 | 68.90 | 830.10 | 831.30 | 831.49 | 831.95 | 0.034580 | 6.50 | 10.60 | 17.71 | 1.48 | |
| BENTON | 160 | PF 1 | 68.90 | 828.00 | 828.90 | 829.14 | 829.65 | 0.050297 | 6.94 | 9.93 | 20.00 | 1.74 | |
| BENTON | 155 | PF 1 | 68.90 | 826.00 | 827.76 | 827.79 | 828.04 | 0.021319 | 4.27 | 16.12 | 33.64 | 1.09 | |
| BENTON | 150 | PF 1 | 68.90 | 822.00 | 823.46 | 823.89 | 825.14 | 0.221984 | 10.40 | 6.62 | 15.82 | 2.83 | |
| BENTON | 125 | PF 1 | 68.90 | 819.80 | 820.88 | 821.25 | 822.06 | 0.048175 | 9.16 | 8.02 | 11.30 | 1.63 | |
| BENTON | 100 | PF 1 | 68.90 | 819.70 | 821.48 | 820.93 | 821.64 | 0.001773 | 3.46 | 22.60 | 18.50 | 0.48 | |
| BENTON | 50 | PF 1 | 68.90 | 819.50 | 821.39 | 820.79 | 821.54 | 0.003686 | 3.29 | 23.88 | 19.83 | 0.43 | |
| BENTON | 40 | PF 1 | 68.90 | 817.50 | 821.43 | 819.07 | 821.47 | 0.000417 | 1.89 | 49.70 | 25.56 | 0.17 | |
| BENTON | 30 | PF 1 | 68.90 | 817.00 | 821.40 | 818.32 | 821.46 | 0.000276 | 1.96 | 35.20 | 30.14 | 0.16 | |

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- Square Edge with Headwall
- Groove End with Headwall
- Groove End Projecting

Critical Depth (ft)

Critical Velocity (ft/s)

Q = Discharge (cfs) ← 10-YR FLOW

Culvert Barrel Slope (ft/ft)

Culvert diameter (ft)

Headwater (ft)

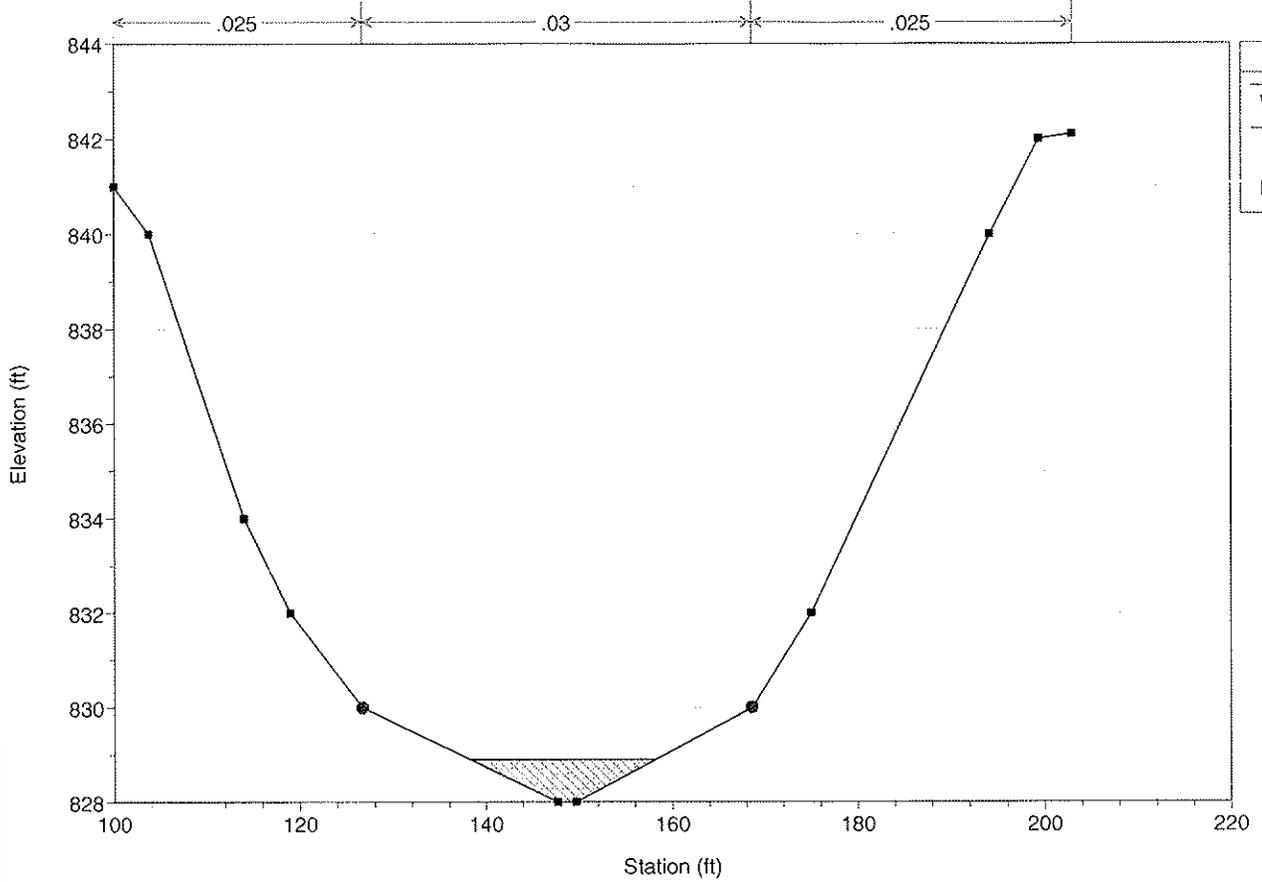
Calc

Units

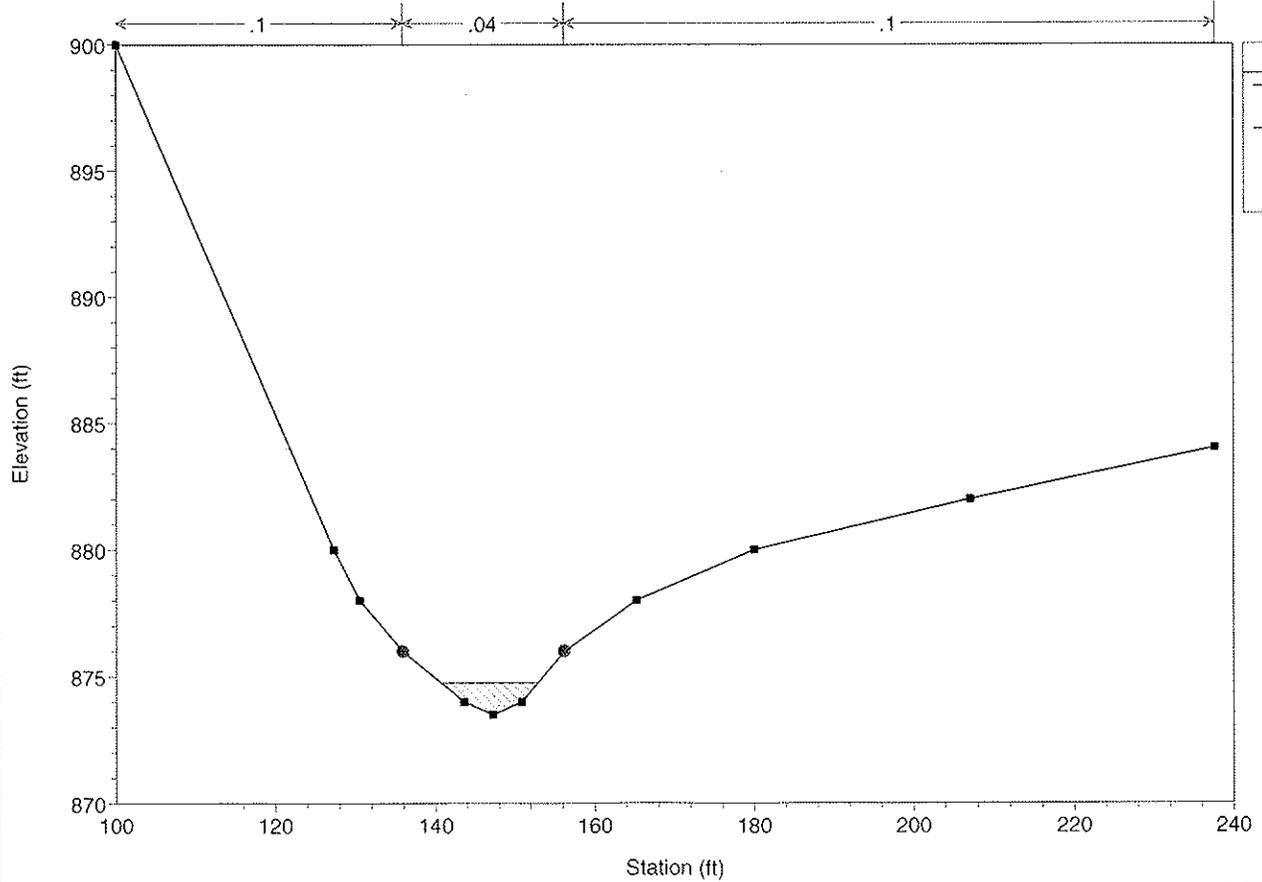
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Metric

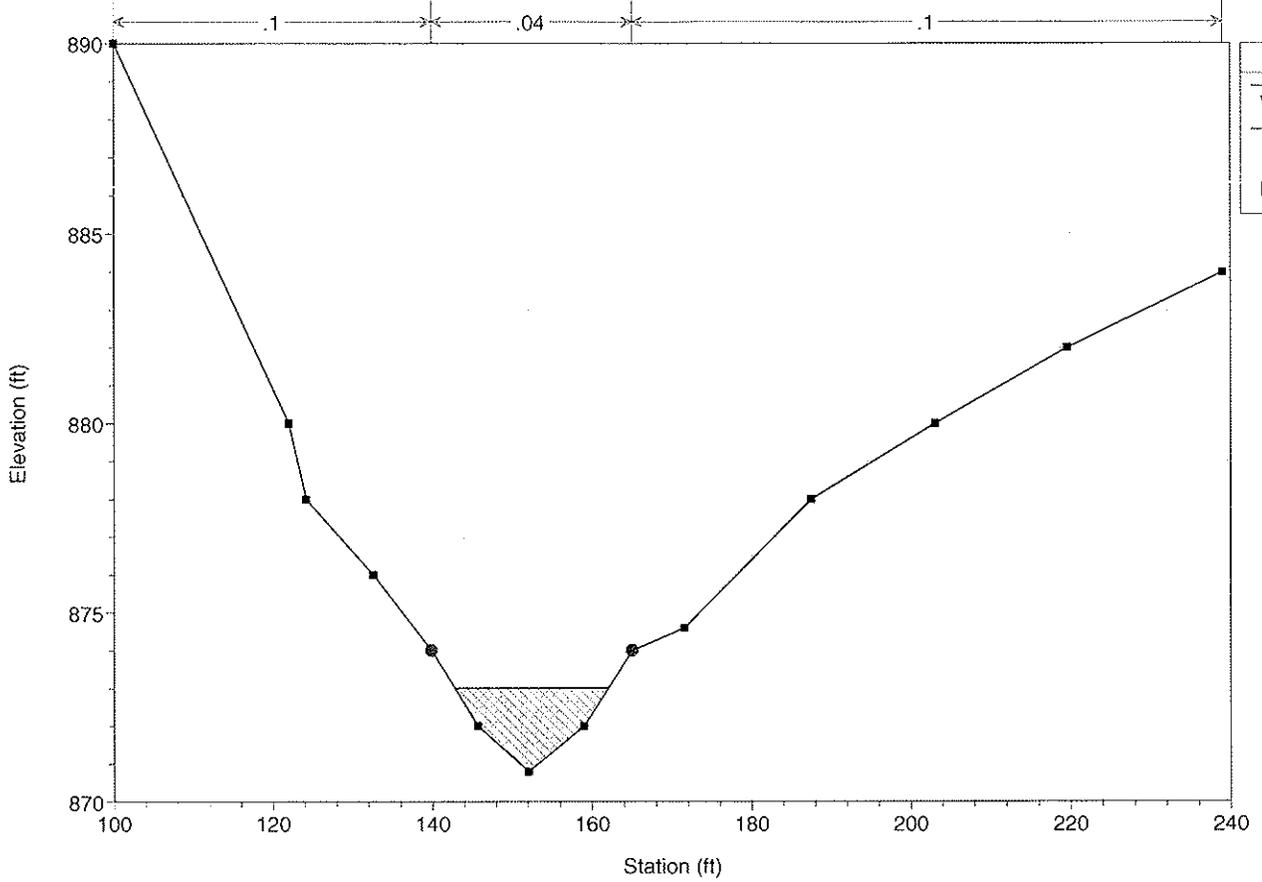
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 160



BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 215



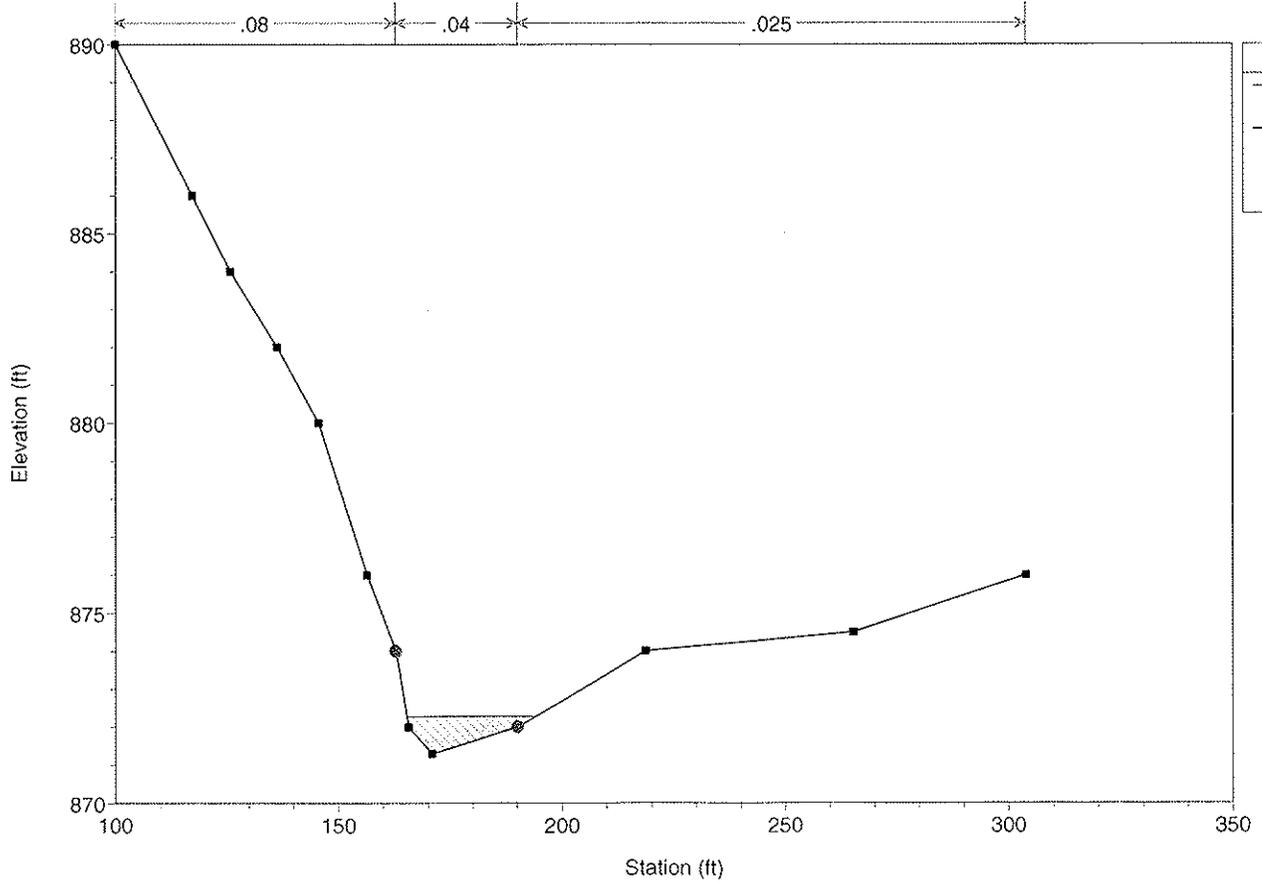
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 210



Legend

- WS PF 1
- Ground
- Bank Sta

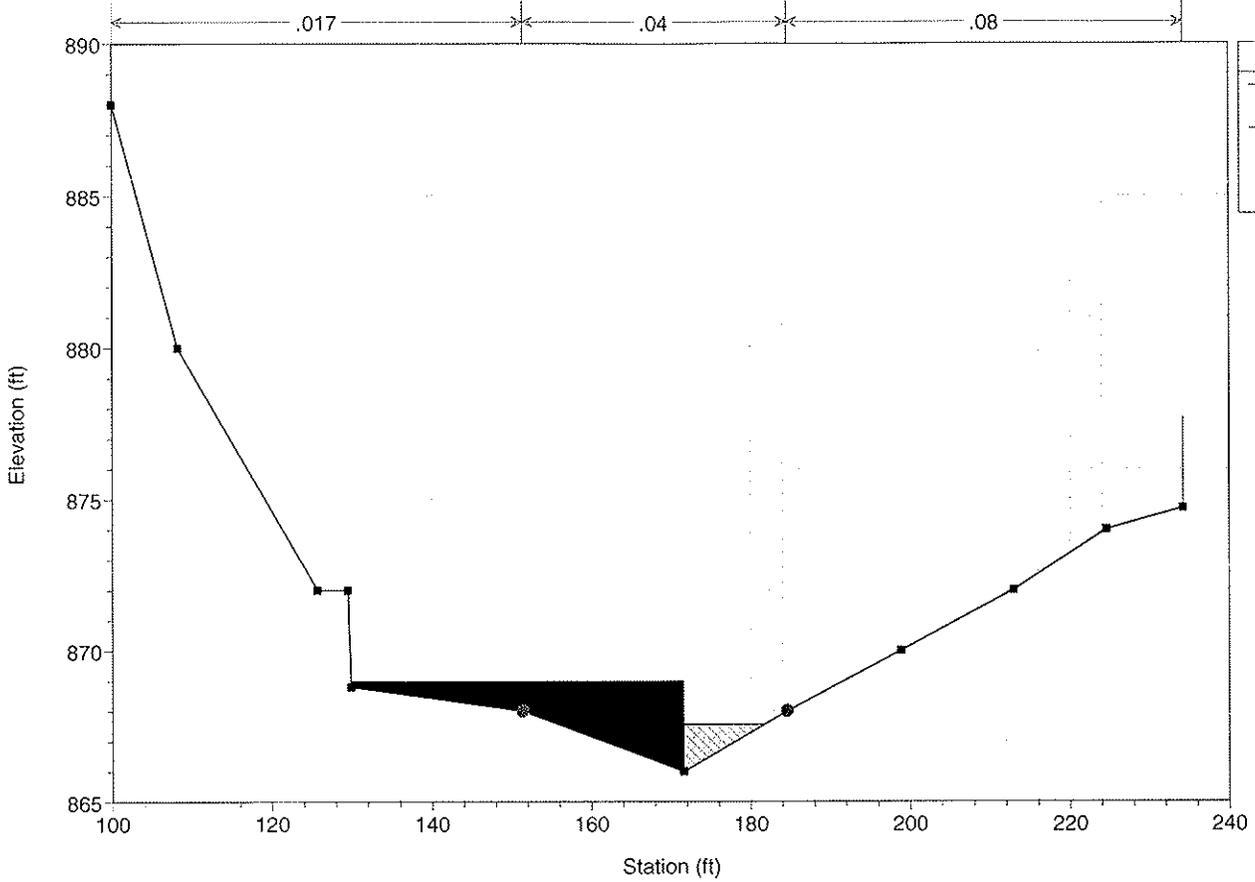
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 205



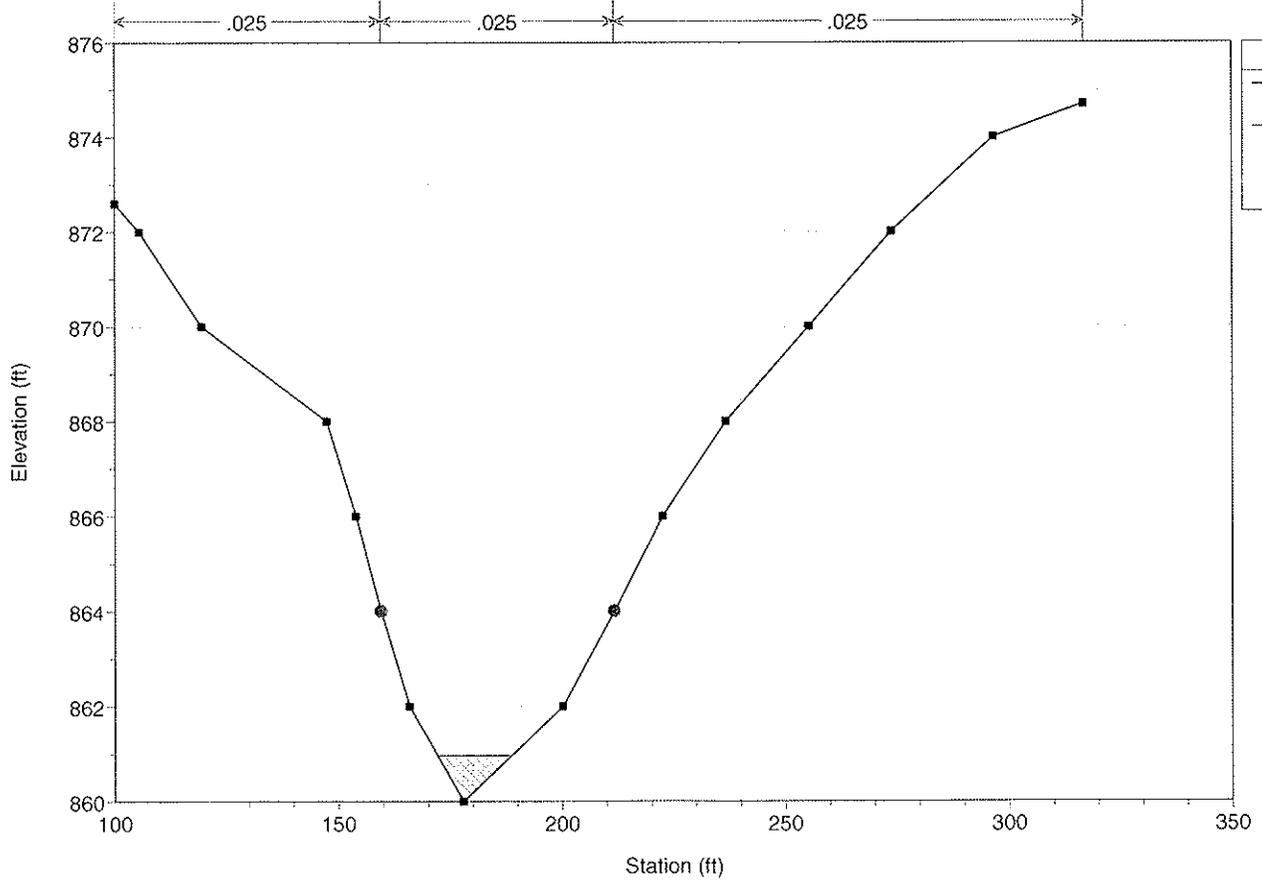
Legend

- WS PF 1
- Ground
- Bank Sta

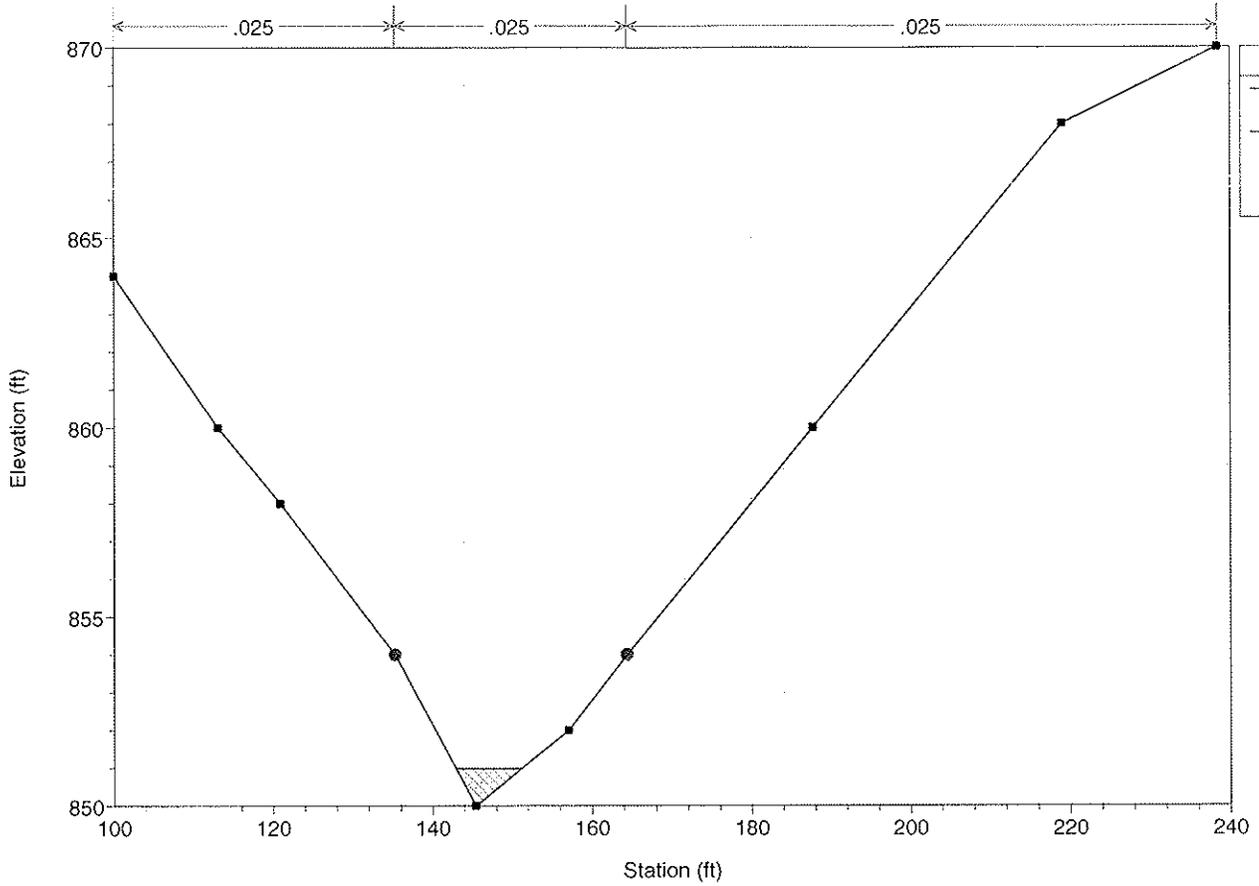
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 200



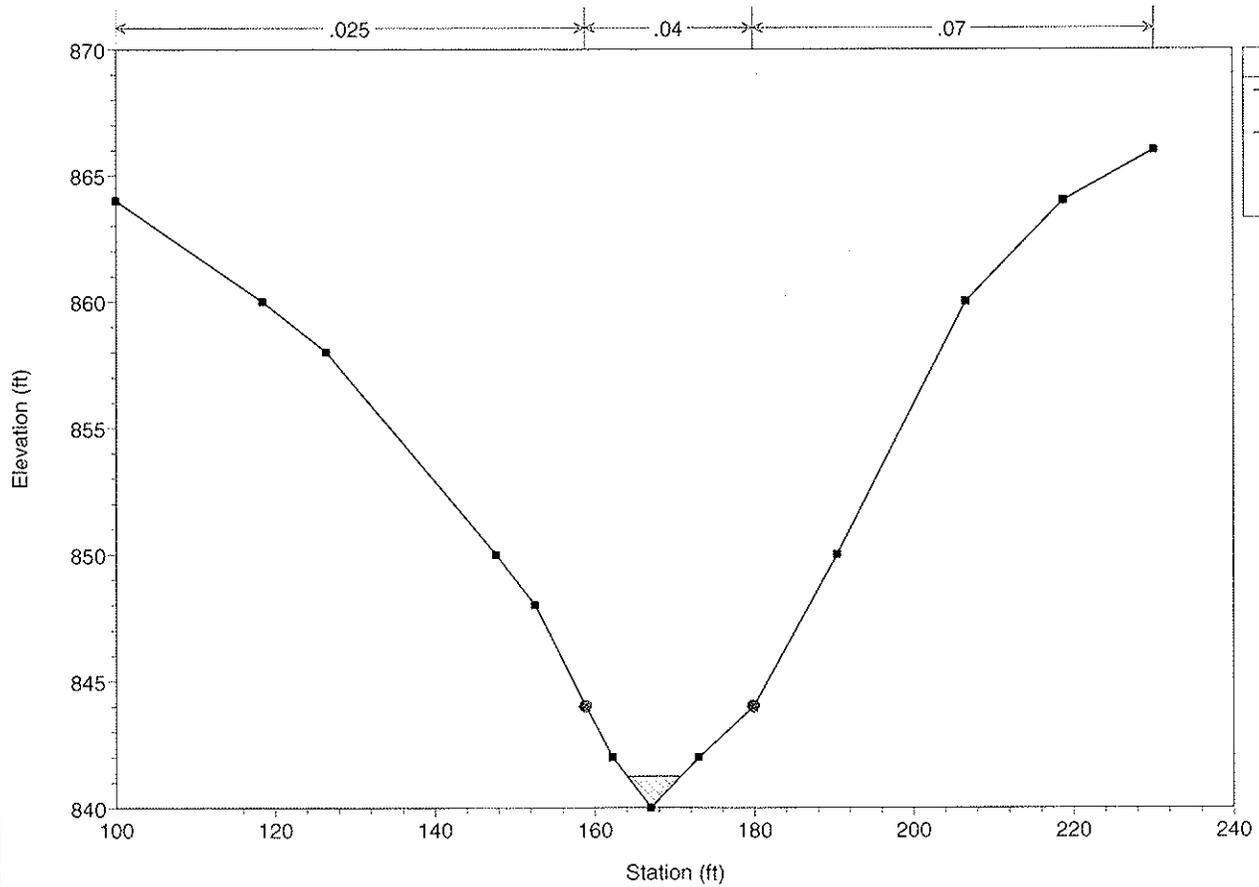
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 195



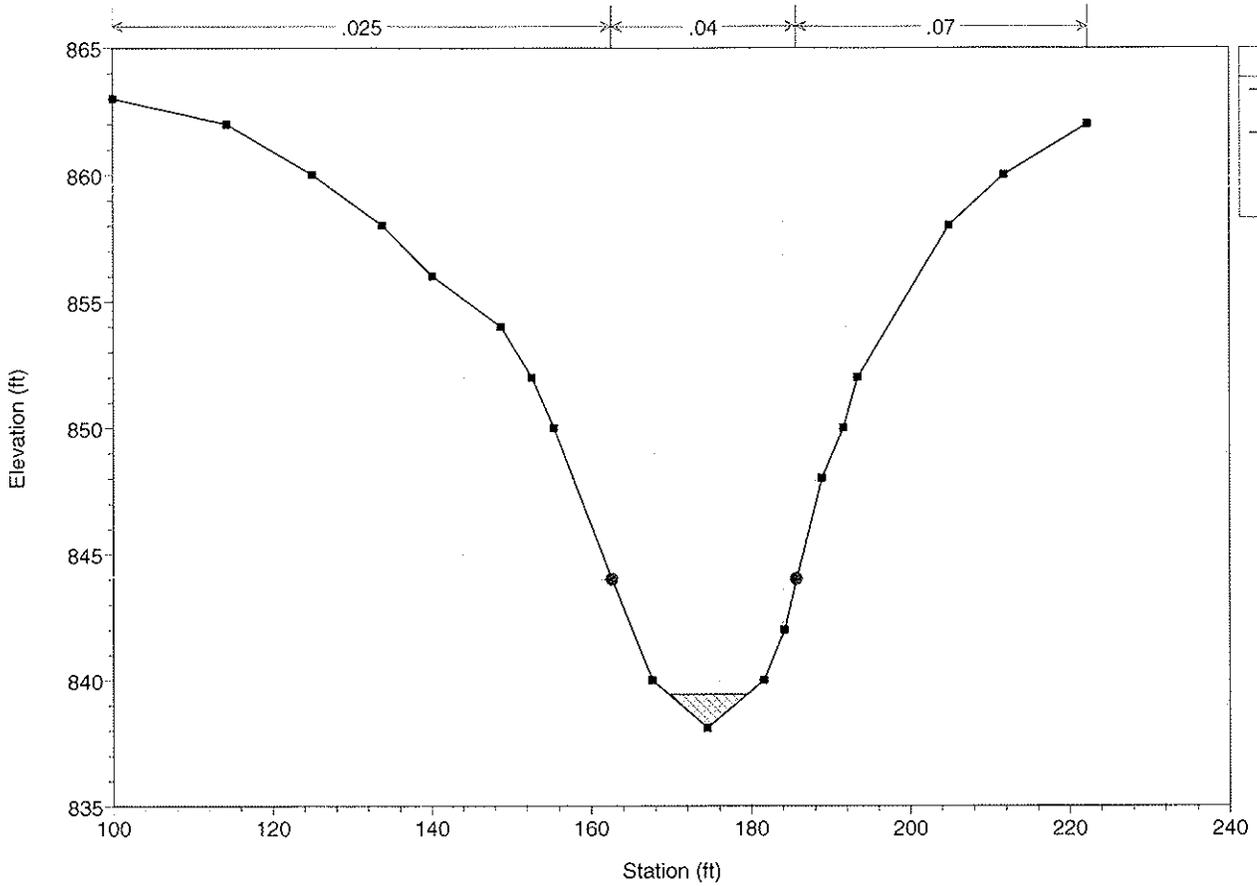
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 190



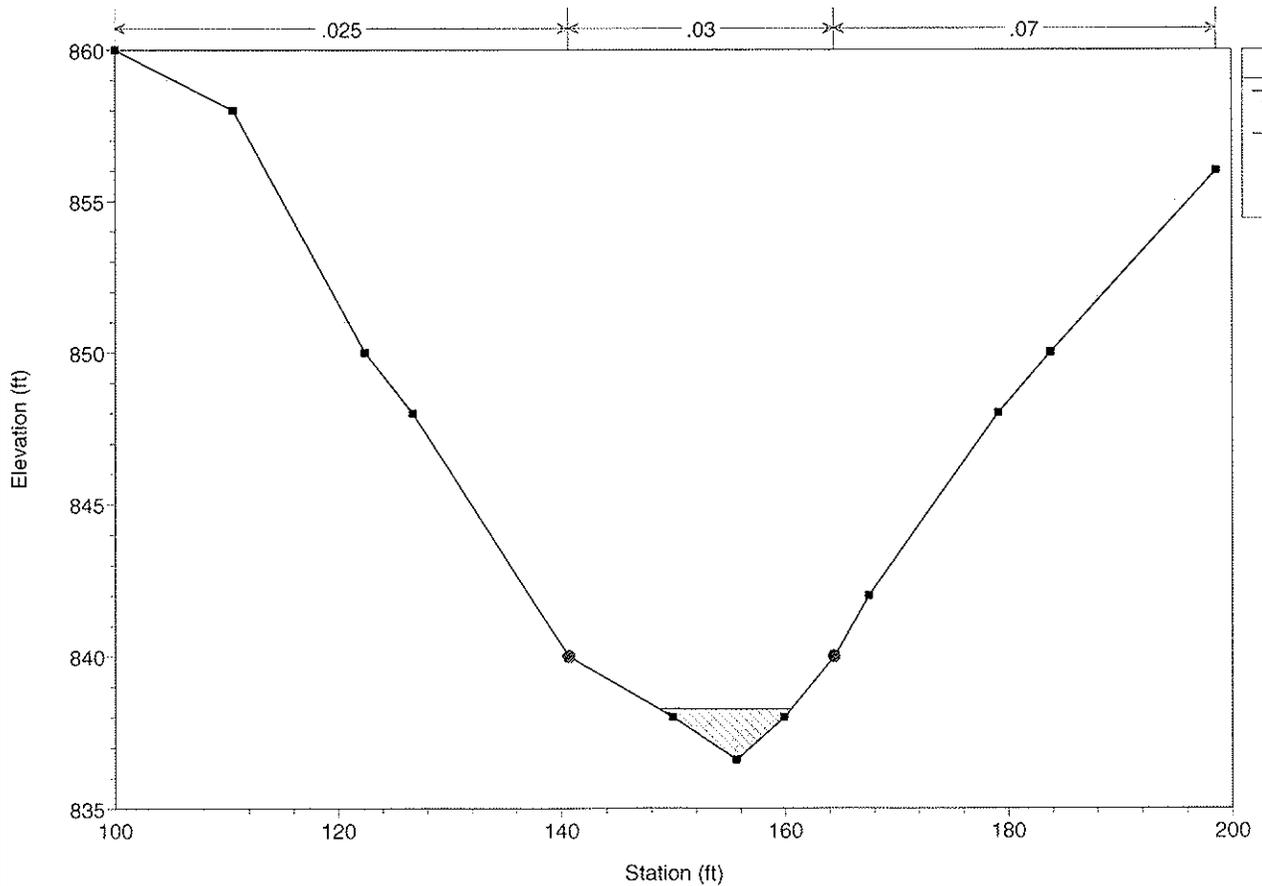
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 185



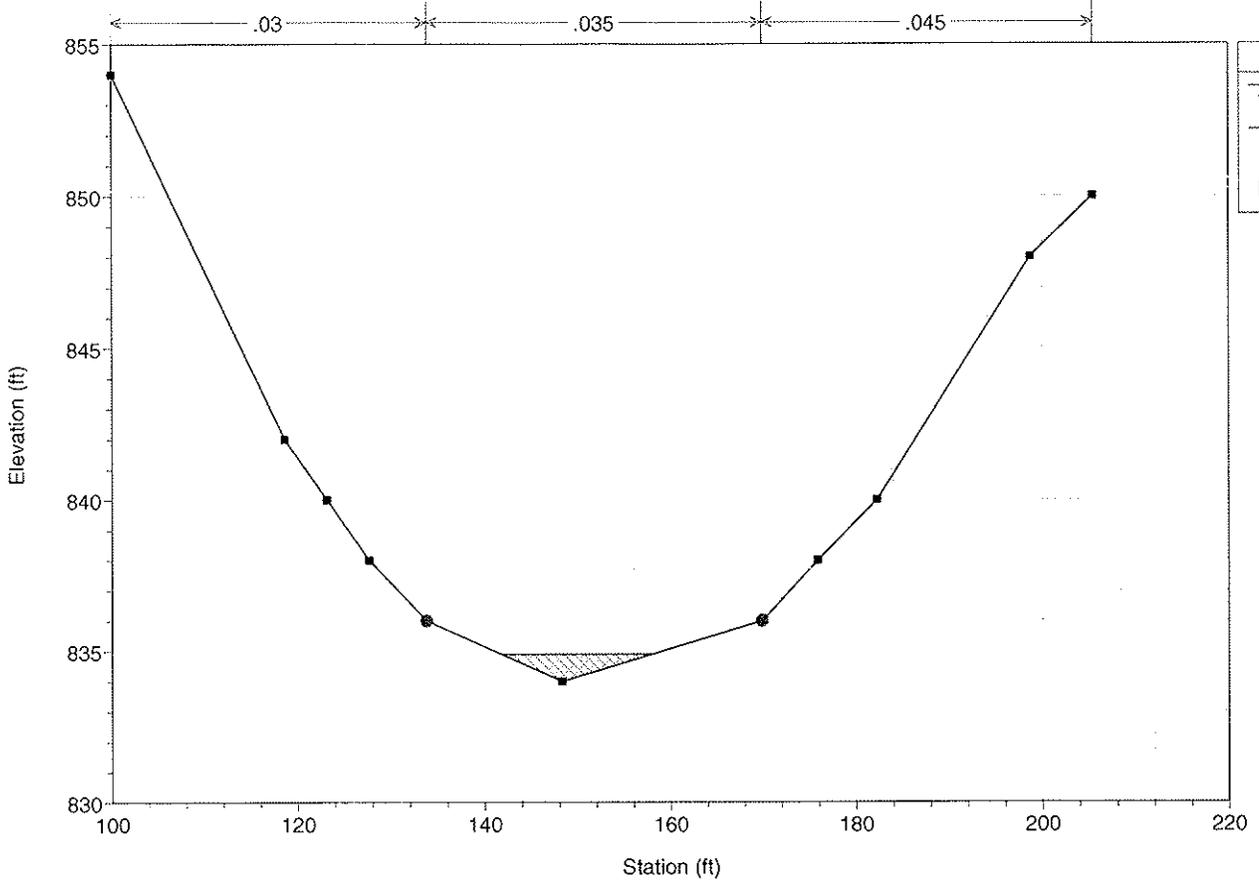
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 180



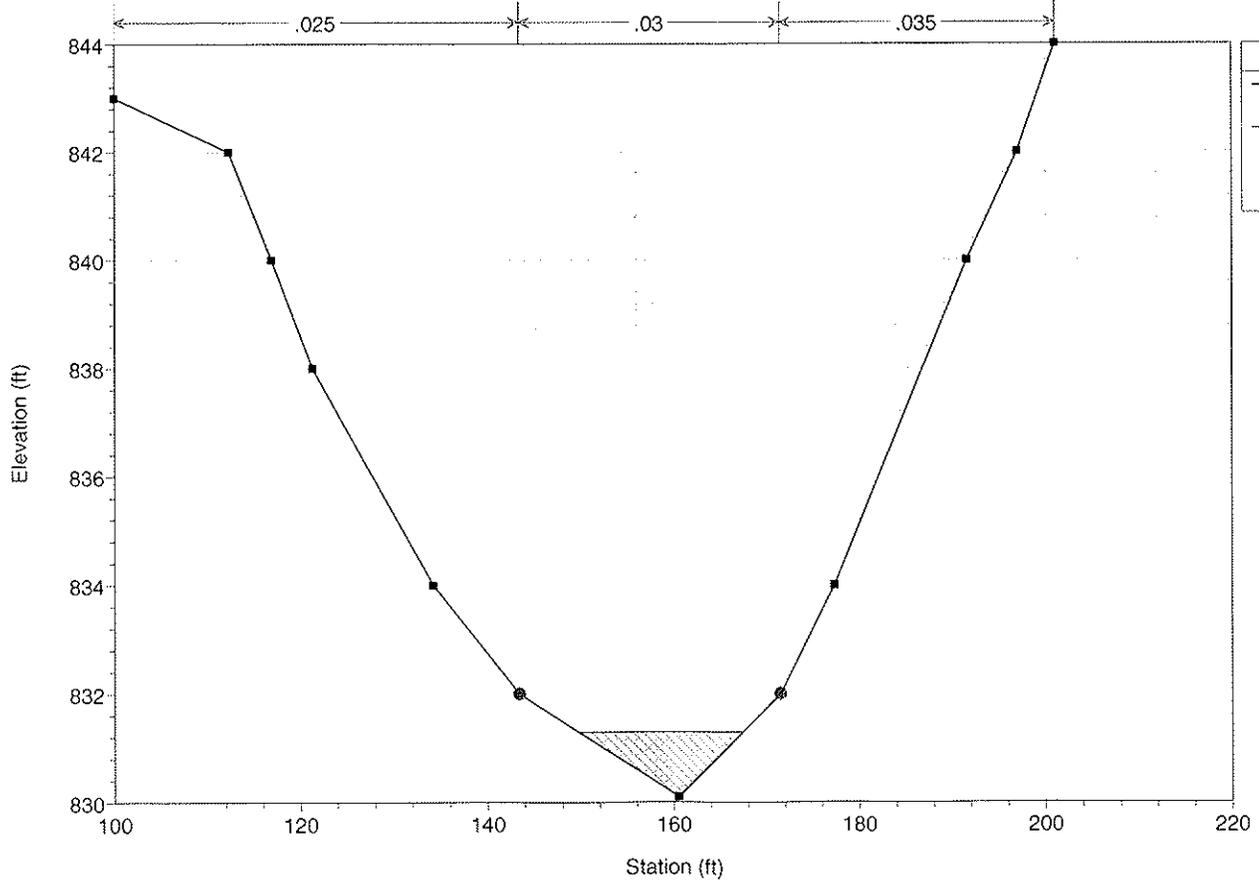
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 175



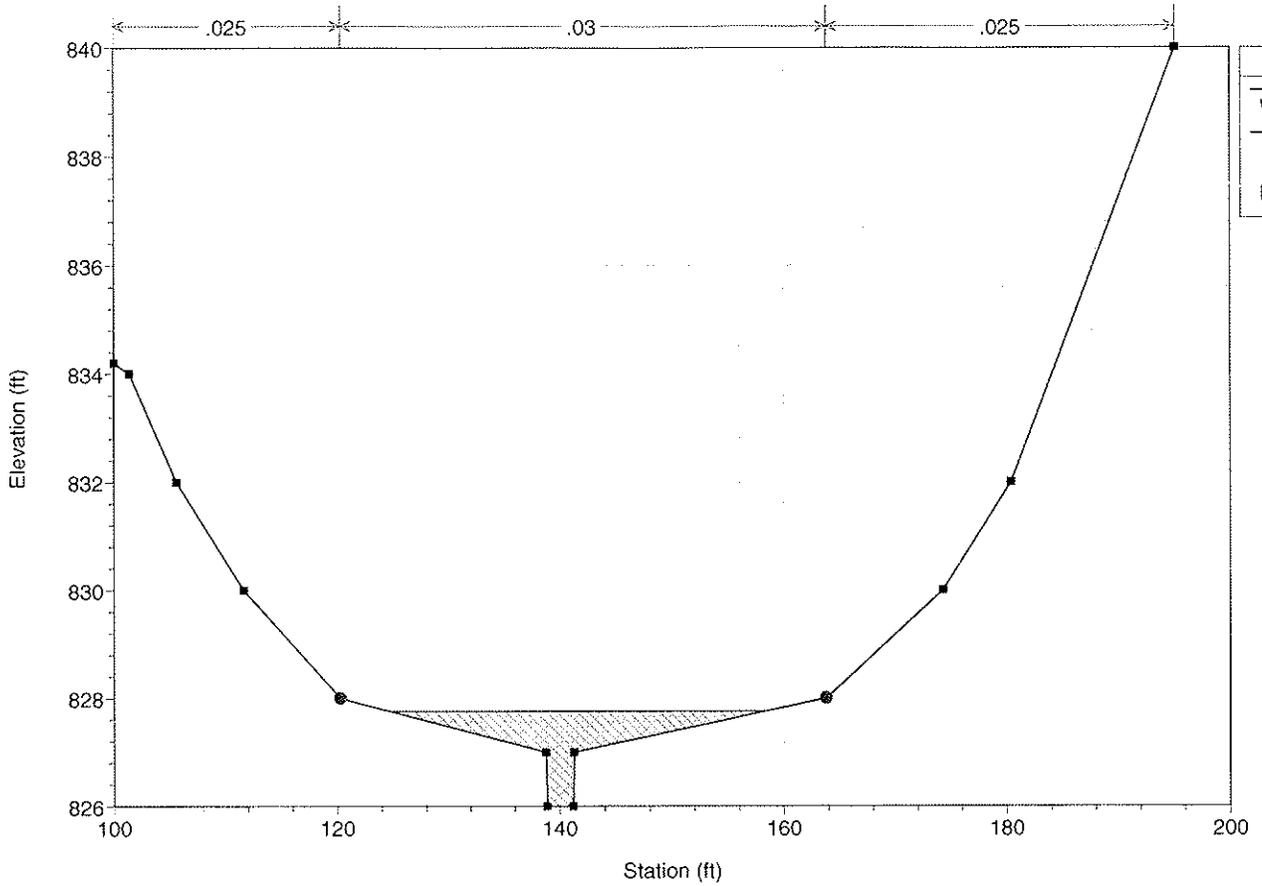
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 170



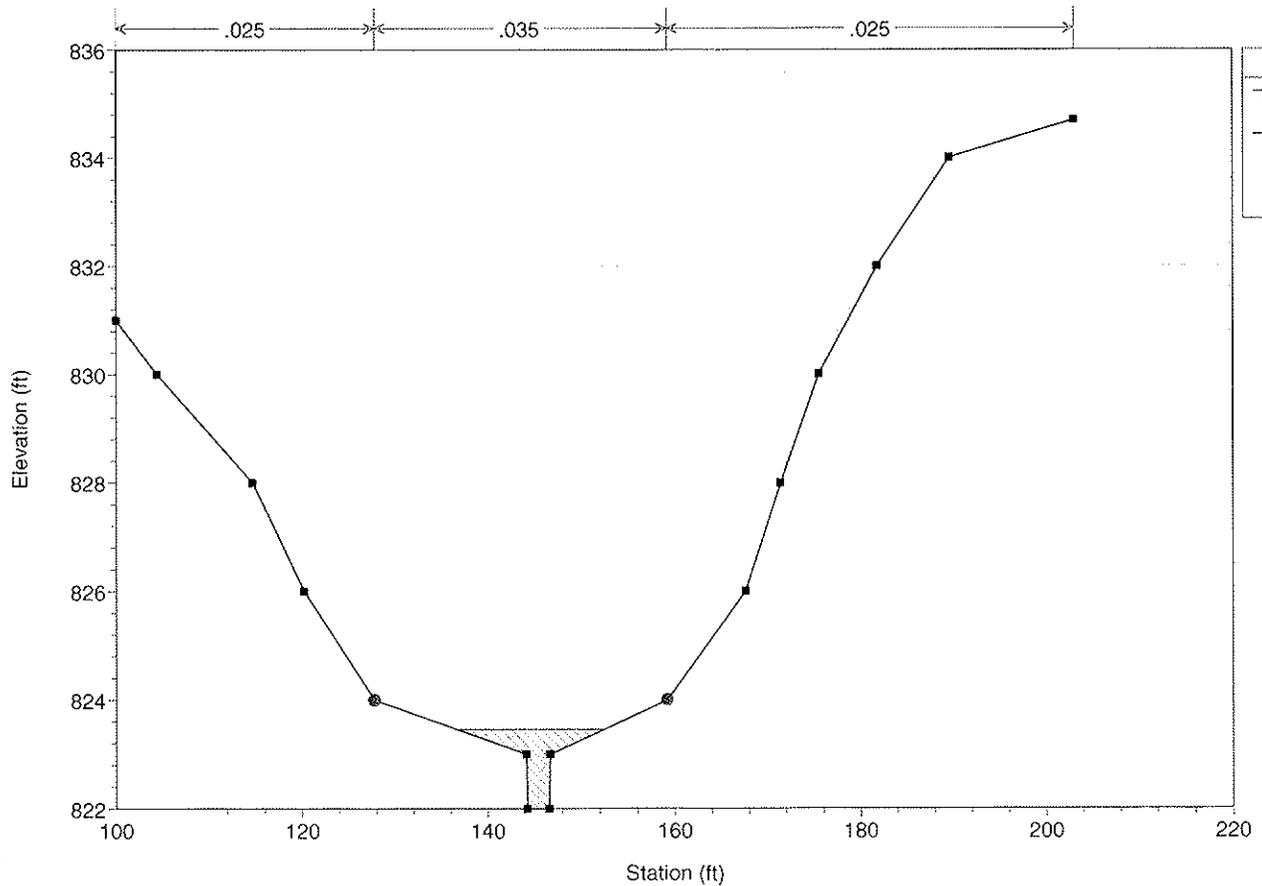
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 165



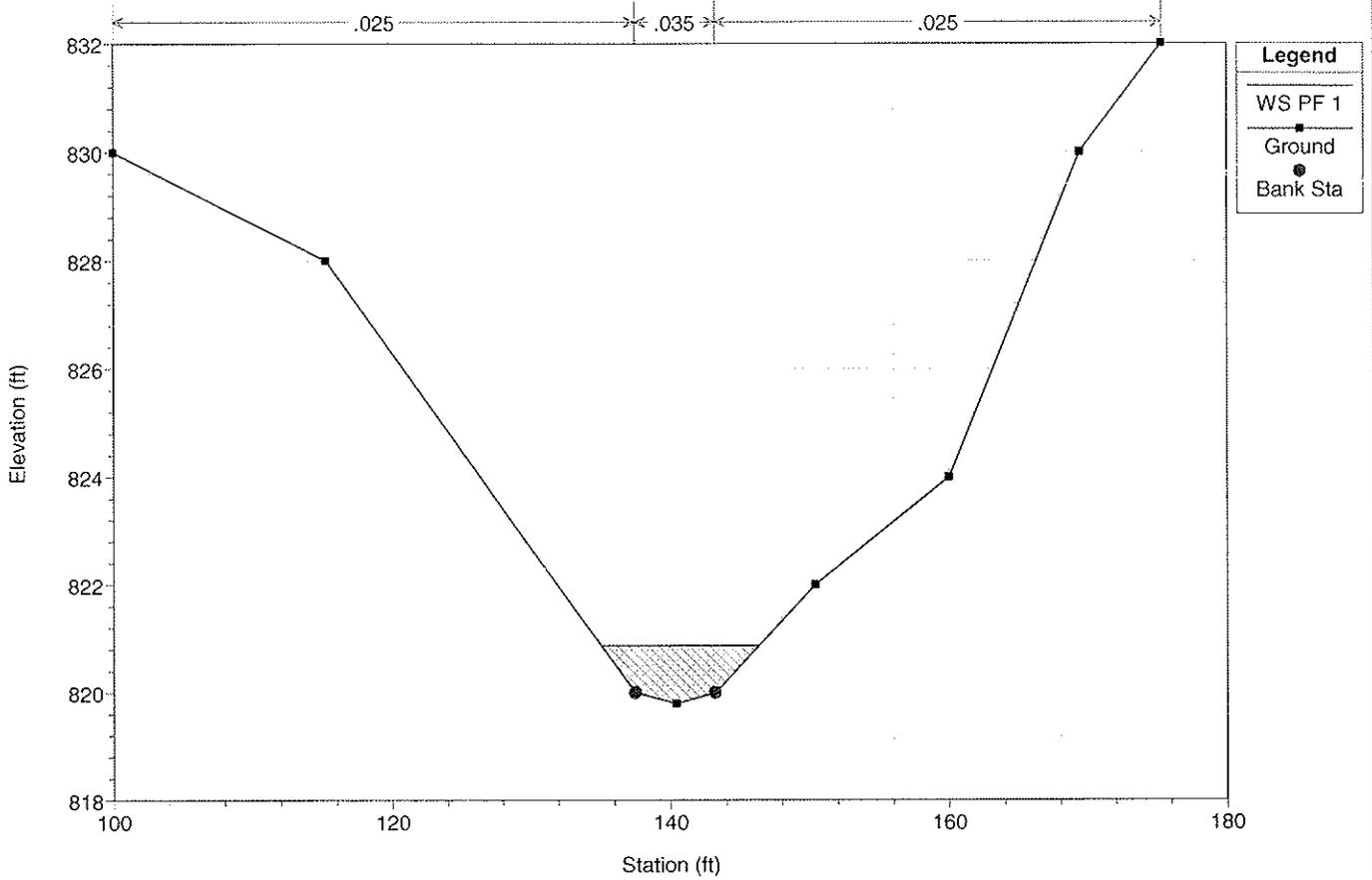
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 155



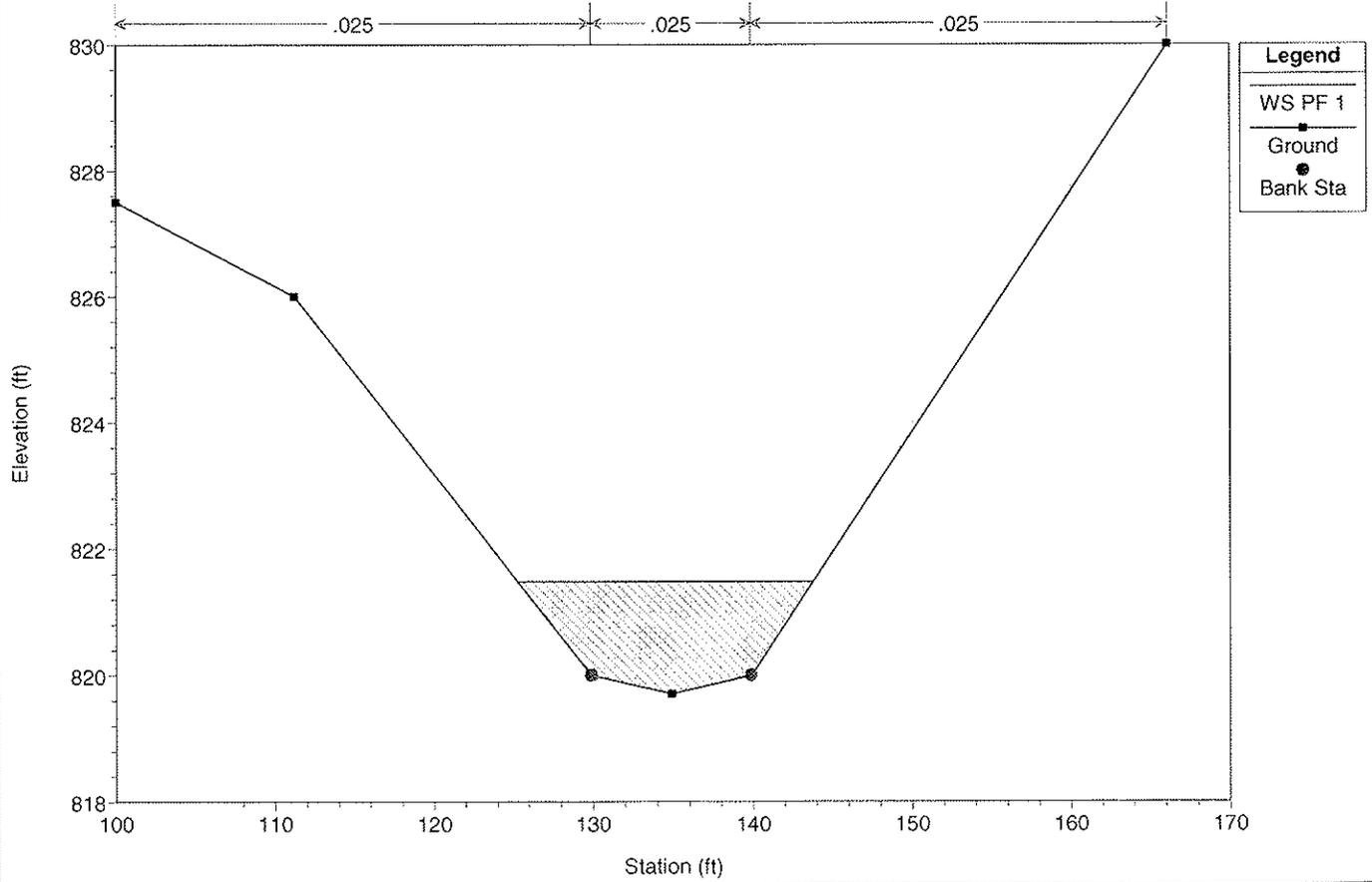
BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 150



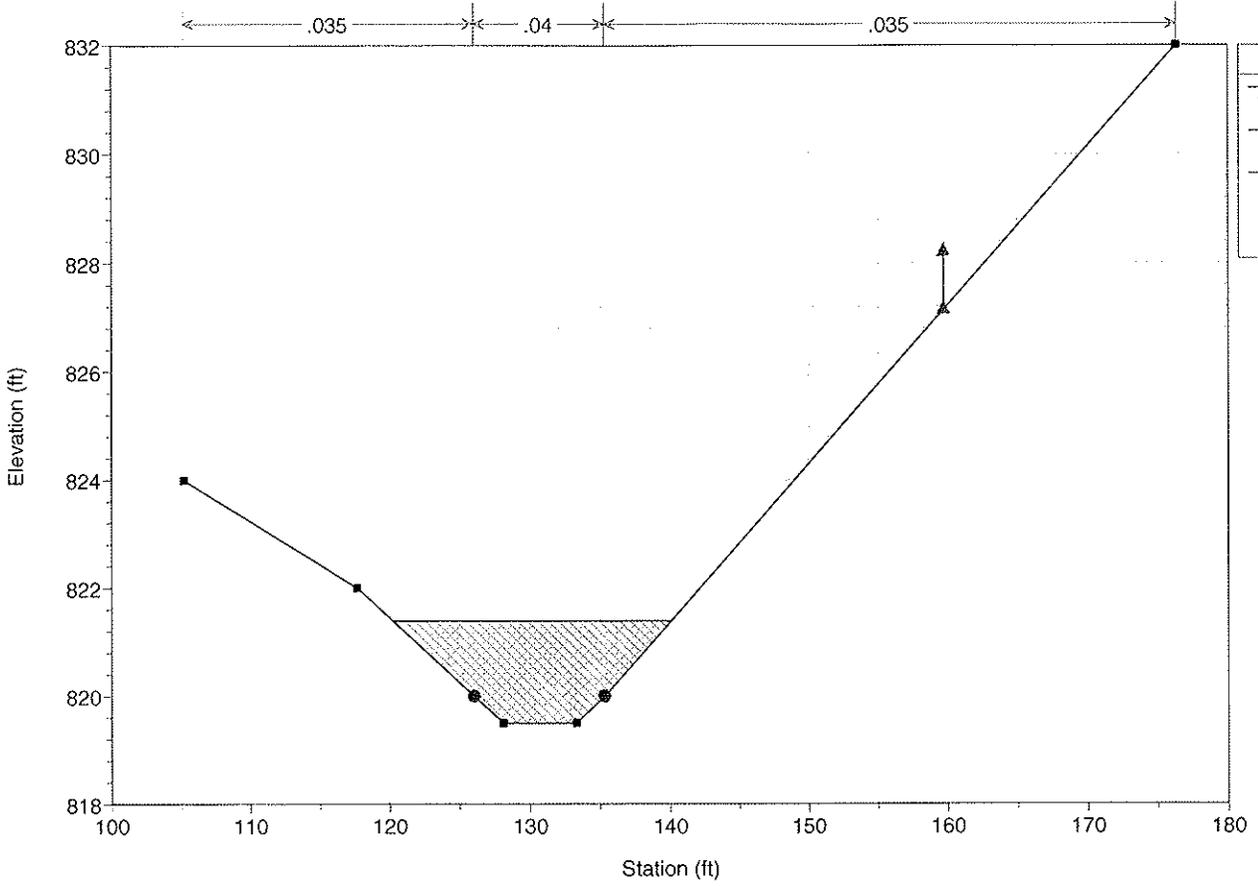
BENTON Plan: 10-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 125



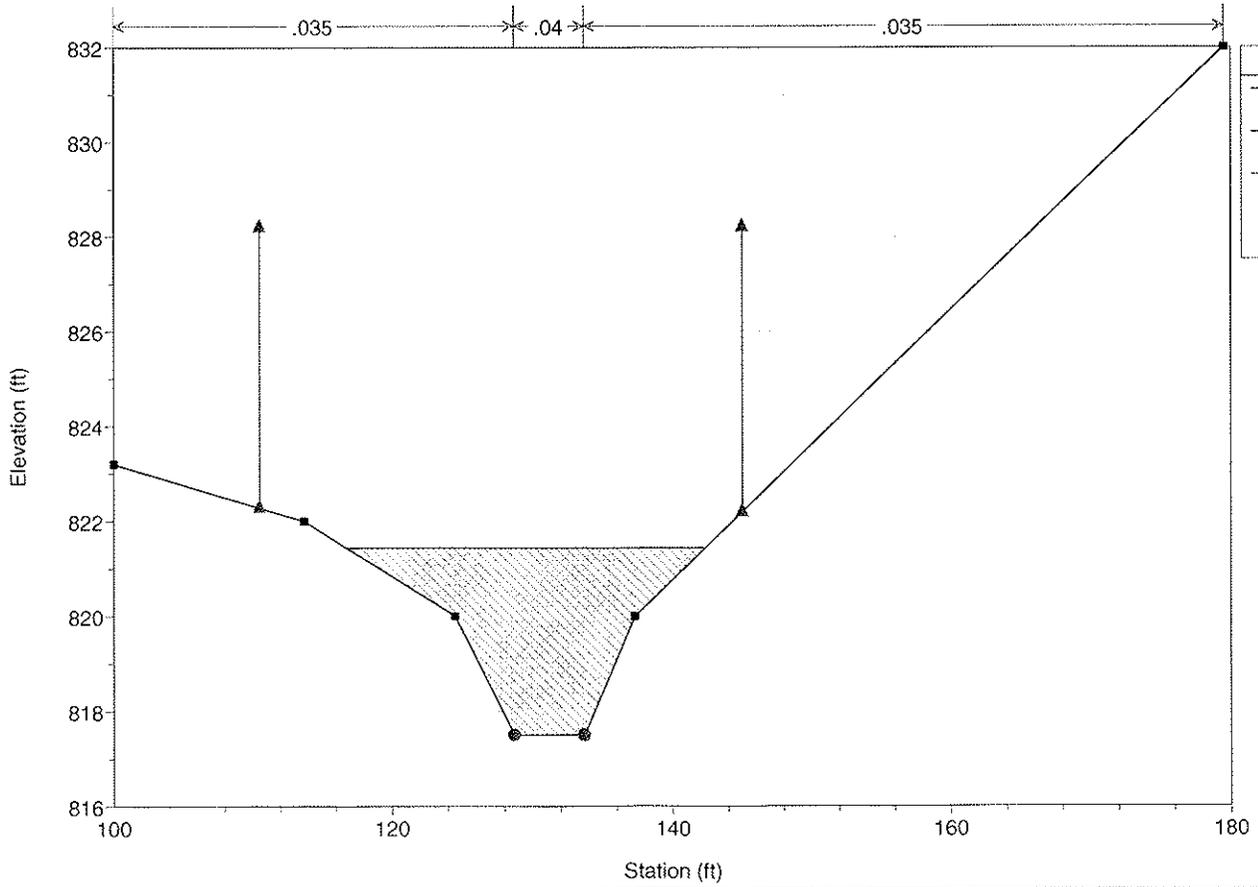
BENTON Plan: 10-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 100



BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 50

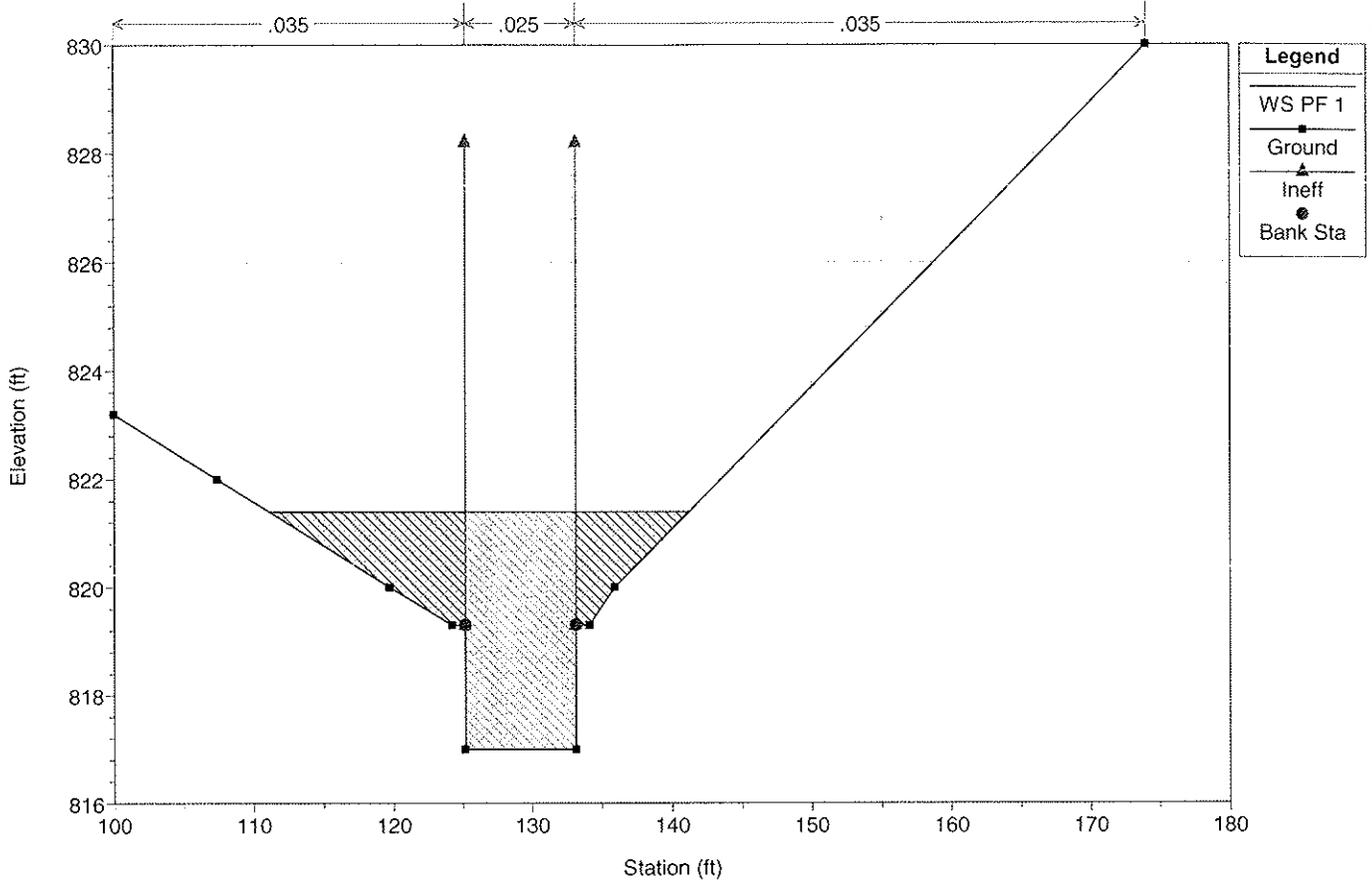


BENTON Plan: 10-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 40



BENTON Plan: 10-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 30



HEC-RAS Plan: 50-yr Exist River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W. S. Elev (ft) | Crit W. S. (ft) | E. G. Elev (ft) | E. G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|------------------|-------------------|--------------------|--------------------|--------------------|------------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 215 | PF 1 | 87.80 | 873.50 | 874.90 | 875.20 | 875.88 | 0.060042 | 7.96 | 11.03 | 13.15 | 1.53 | |
| BENTON | 210 | PF 1 | 87.80 | 870.80 | 873.17 | 872.52 | 873.33 | 0.005060 | 3.19 | 27.55 | 20.19 | 0.48 | |
| BENTON | 205 | PF 1 | 87.80 | 871.30 | 872.39 | 872.39 | 872.71 | 0.023879 | 4.62 | 19.36 | 30.69 | 0.95 | |
| BENTON | 200 | PF 1 | 87.80 | 866.00 | 867.71 | 868.11 | 869.03 | 0.092540 | 9.20 | 9.54 | 11.14 | 1.75 | |
| BENTON | 195 | PF 1 | 87.80 | 860.00 | 861.06 | 861.44 | 862.33 | 0.054106 | 9.03 | 9.72 | 18.29 | 2.18 | |
| BENTON | 190 | PF 1 | 87.80 | 850.00 | 851.11 | 851.93 | 855.65 | 0.190506 | 17.11 | 5.13 | 9.27 | 4.05 | |
| BENTON | 185 | PF 1 | 87.80 | 840.00 | 841.35 | 842.29 | 846.32 | 0.427993 | 17.89 | 4.91 | 7.28 | 3.84 | |
| BENTON | 180 | PF 1 | 87.80 | 838.10 | 839.55 | 840.11 | 841.55 | 0.149917 | 11.34 | 7.75 | 10.68 | 2.35 | |
| BENTON | 175 | PF 1 | 87.80 | 836.60 | 838.42 | 838.65 | 839.28 | 0.026776 | 7.44 | 11.79 | 12.87 | 1.37 | |
| BENTON | 170 | PF 1 | 87.80 | 834.00 | 835.00 | 835.42 | 836.49 | 0.136344 | 9.81 | 8.95 | 17.98 | 2.45 | |
| BENTON | 165 | PF 1 | 87.80 | 830.10 | 831.40 | 831.64 | 832.16 | 0.035466 | 6.97 | 12.59 | 19.30 | 1.52 | |
| BENTON | 160 | PF 1 | 87.80 | 828.00 | 829.00 | 829.27 | 829.84 | 0.049603 | 7.34 | 11.96 | 21.94 | 1.75 | |
| BENTON | 155 | PF 1 | 87.80 | 826.00 | 827.88 | 827.89 | 828.17 | 0.018891 | 4.32 | 20.34 | 38.44 | 1.05 | |
| BENTON | 150 | PF 1 | 87.80 | 822.00 | 823.54 | 824.00 | 825.46 | 0.235309 | 11.14 | 7.88 | 17.98 | 2.96 | |
| BENTON | 125 | PF 1 | 87.80 | 819.80 | 822.65 | 821.43 | 822.74 | 0.000947 | 2.56 | 38.41 | 23.42 | 0.27 | |
| BENTON | 100 | PF 1 | 87.80 | 819.70 | 822.65 | | 822.71 | 0.000348 | 2.20 | 48.24 | 25.23 | 0.23 | |
| BENTON | 50 | PF 1 | 87.80 | 819.50 | 822.65 | 820.97 | 822.69 | 0.000634 | 1.94 | 55.14 | 30.67 | 0.20 | |
| BENTON | 40 | PF 1 | 87.80 | 817.50 | 822.65 | 819.30 | 822.67 | 0.000157 | 1.39 | 87.76 | 40.41 | 0.11 | |
| BENTON | 30 | PF 1 | 87.80 | 817.00 | 822.60 | 818.55 | 822.66 | 0.000200 | 1.96 | 44.80 | 42.11 | 0.15 | |

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- Square Edge with Headwall
- Groove End with Headwall
- Groove End Projecting

2.912

Critical Depth (ft)

10.262

Calc

Critical Velocity (ft/s)

87.8

Q = Discharge (cfs)

← 50-YR FLOW

0.02

Culvert Barrel Slope (ft/ft)

3.5

Culvert diameter (ft)

5.625

Headwater (ft)

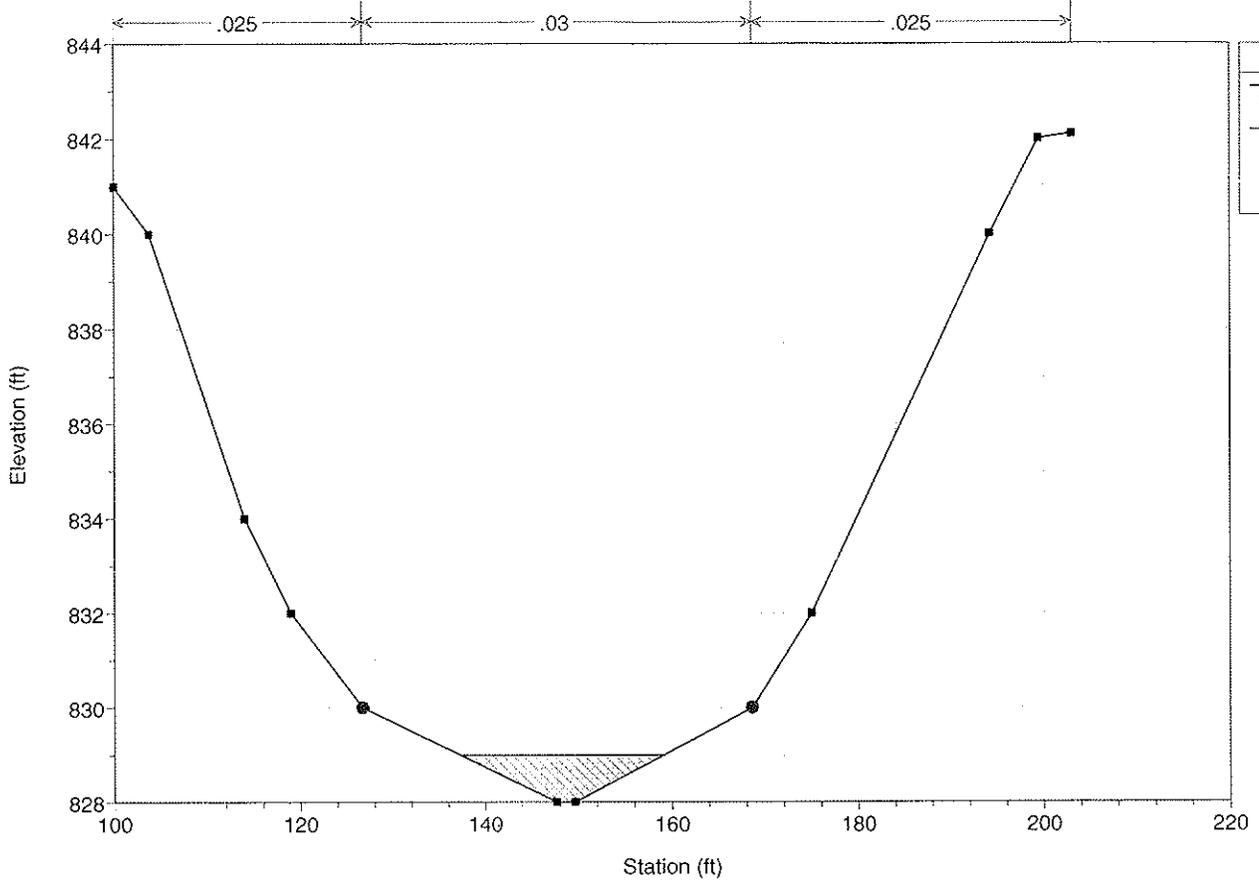
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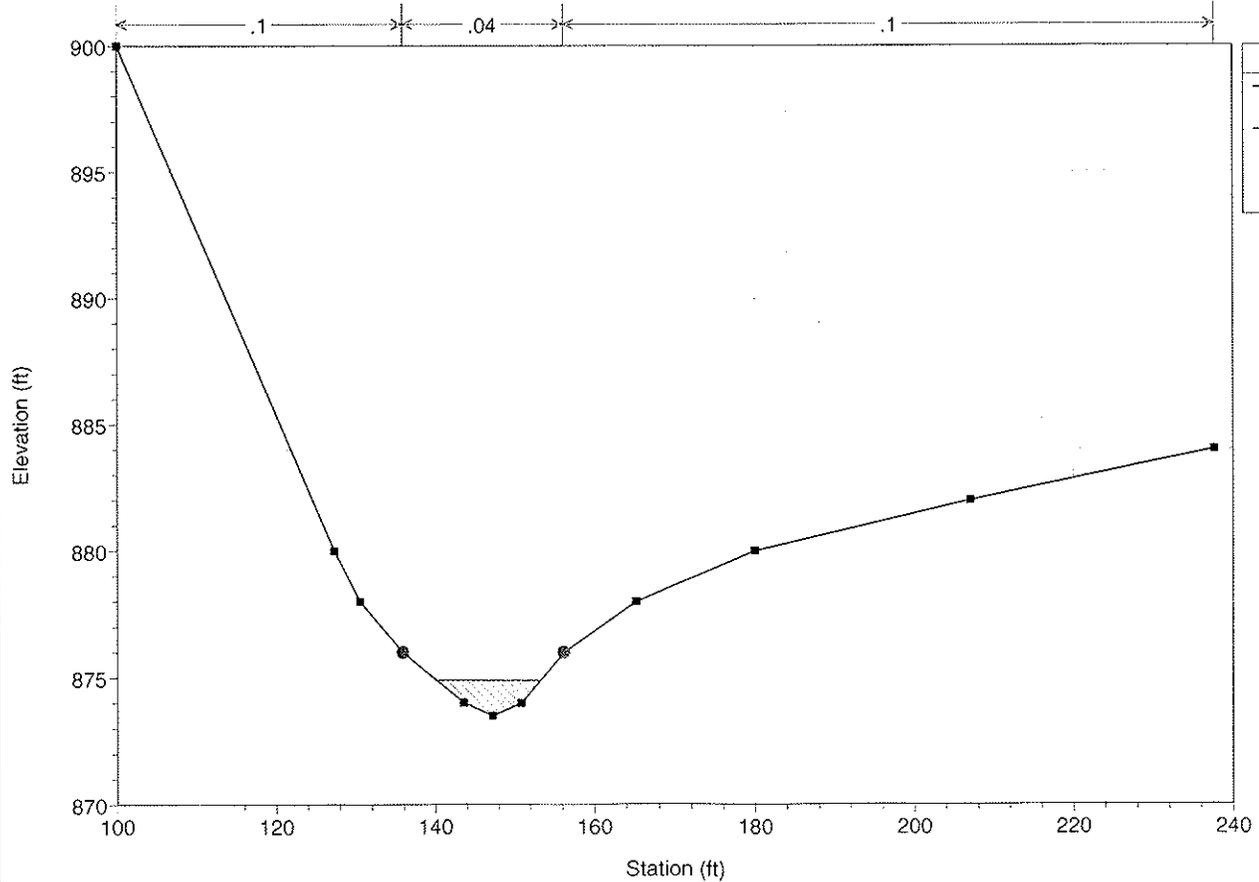
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Metric

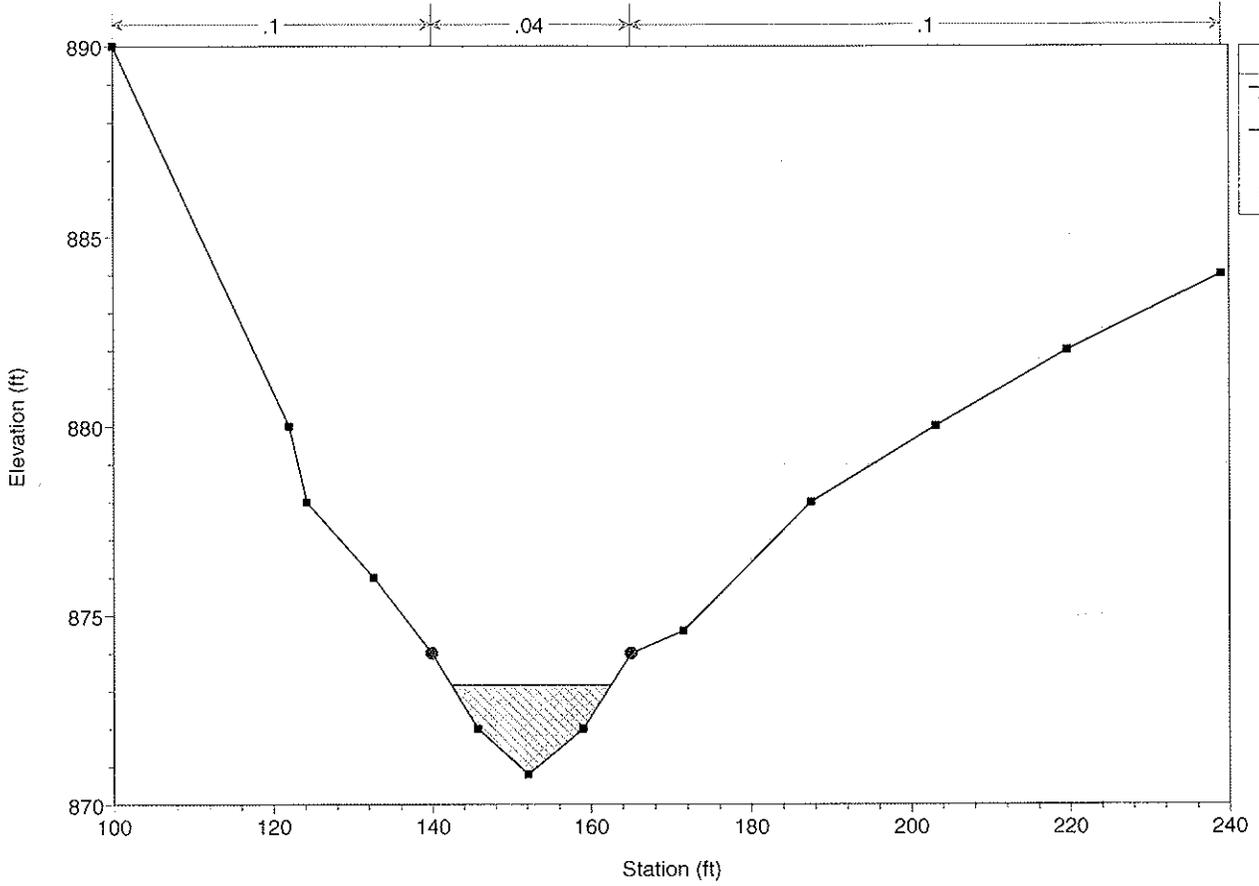
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 160



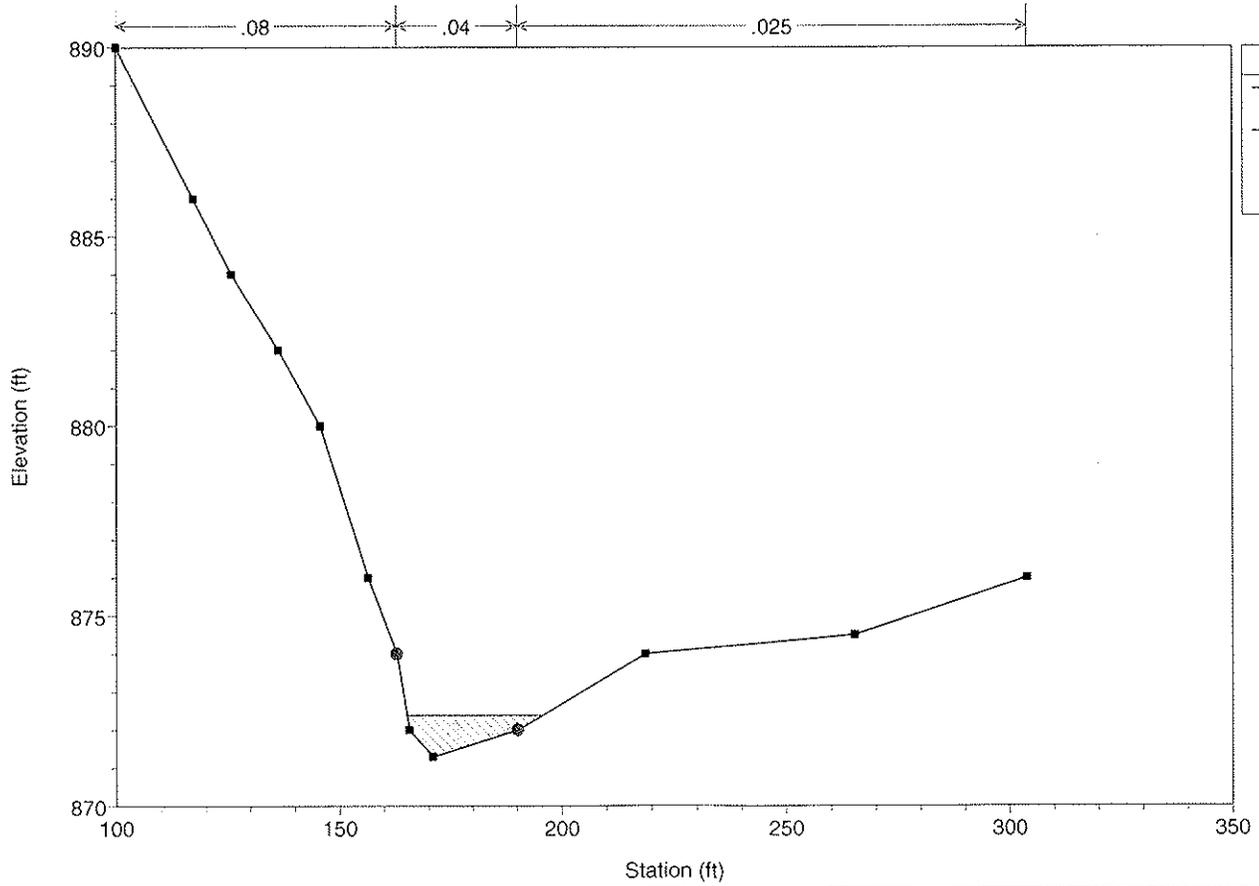
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 215



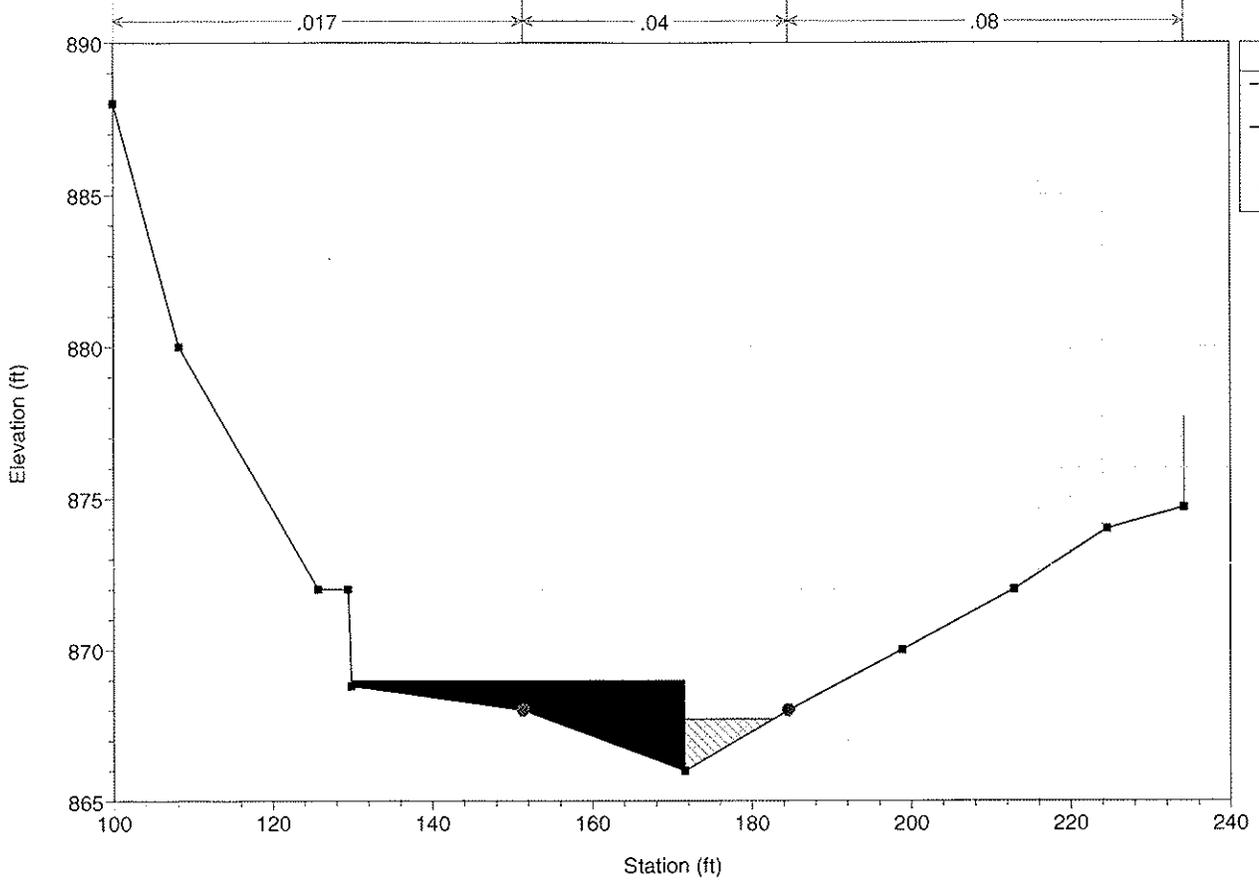
BENTON Plan: 50-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 210



BENTON Plan: 50-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 205



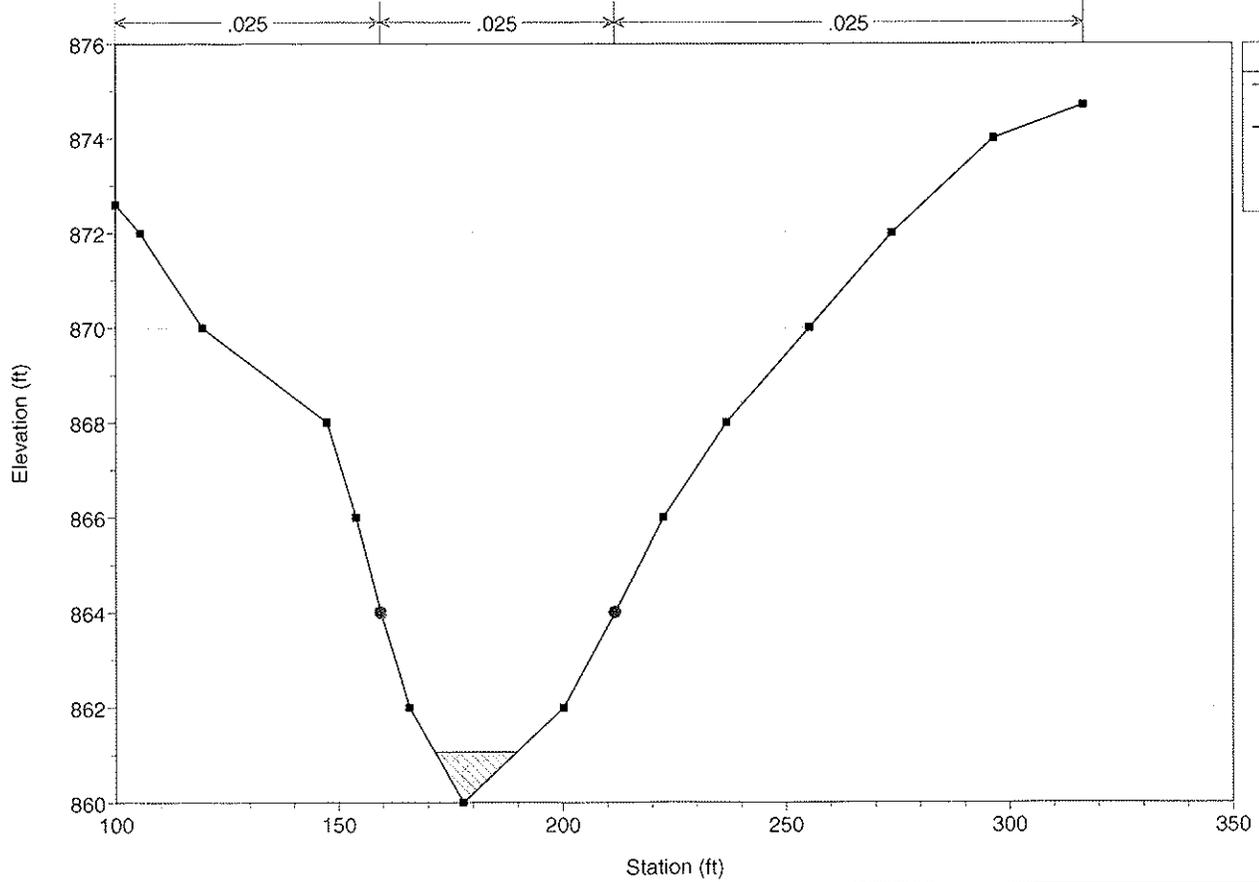
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 200



Legend

- WS PF 1
- Ground
- Bank Sta

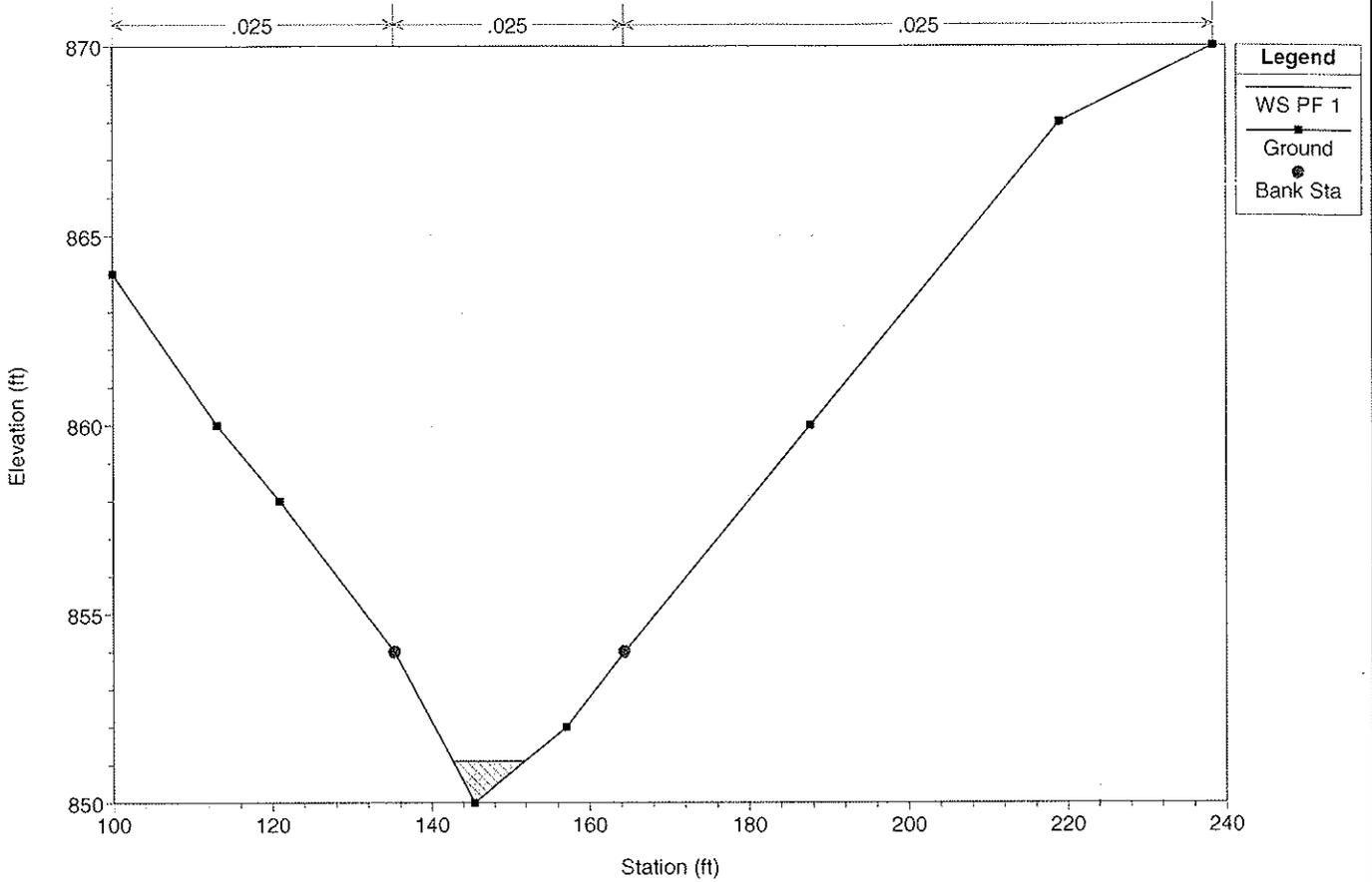
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 195



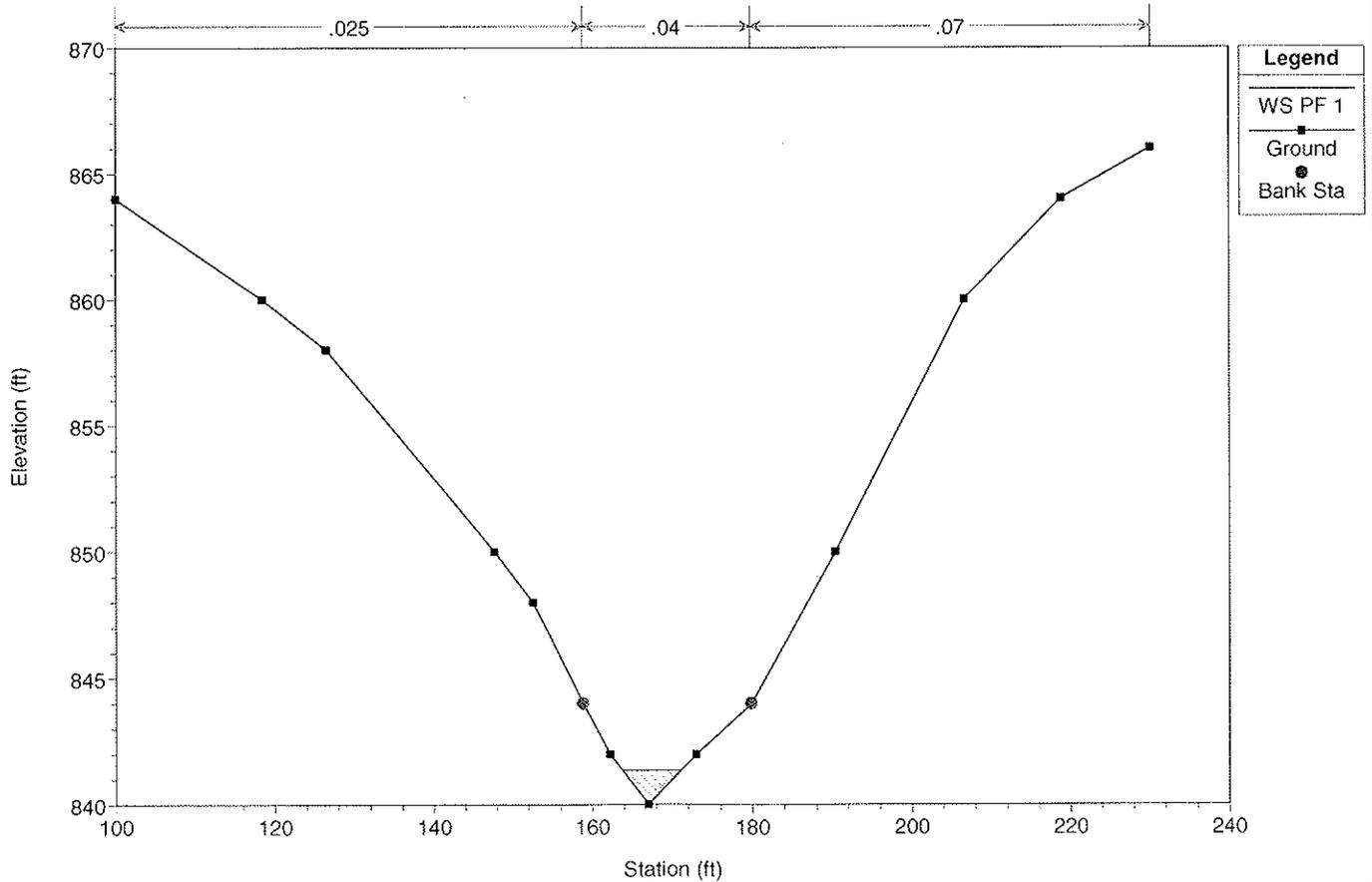
Legend

- WS PF 1
- Ground
- Bank Sta

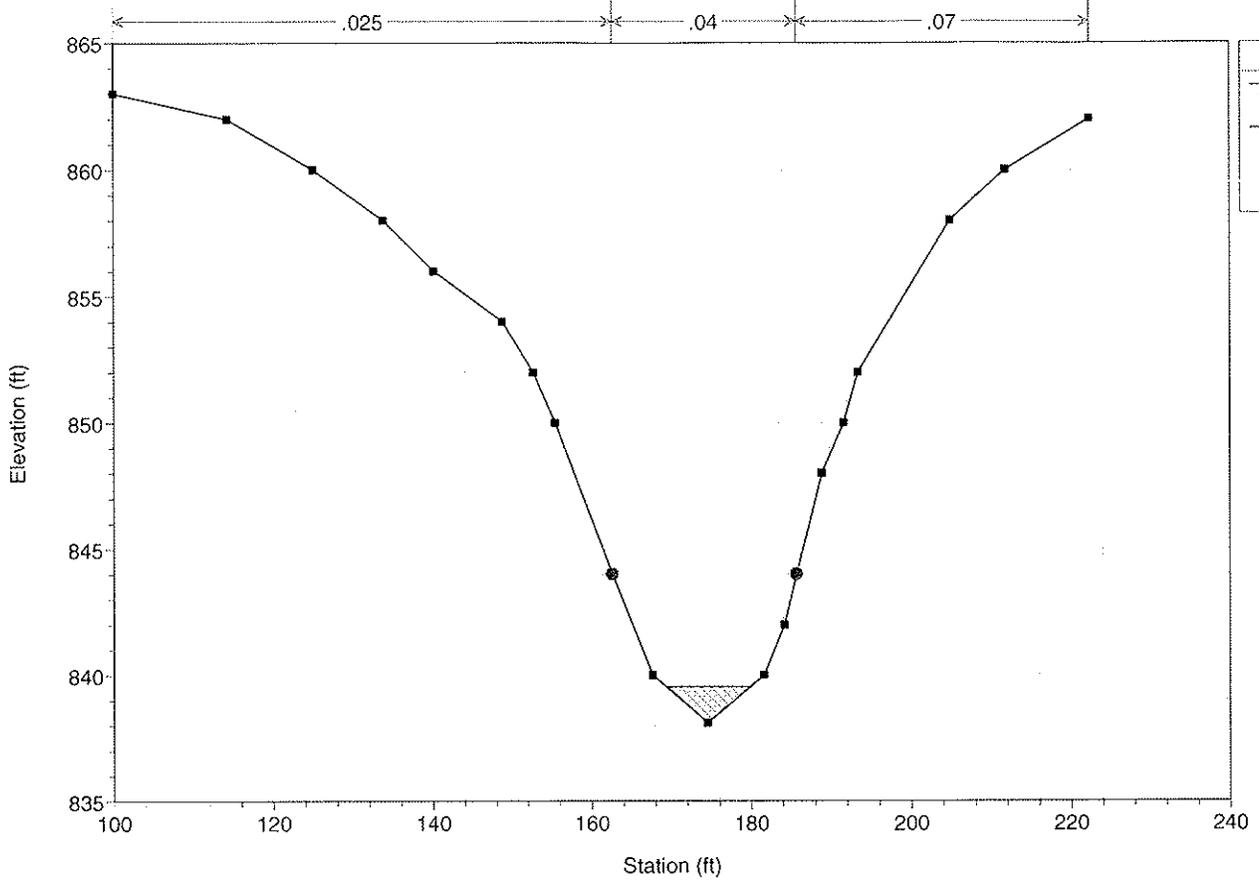
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 190



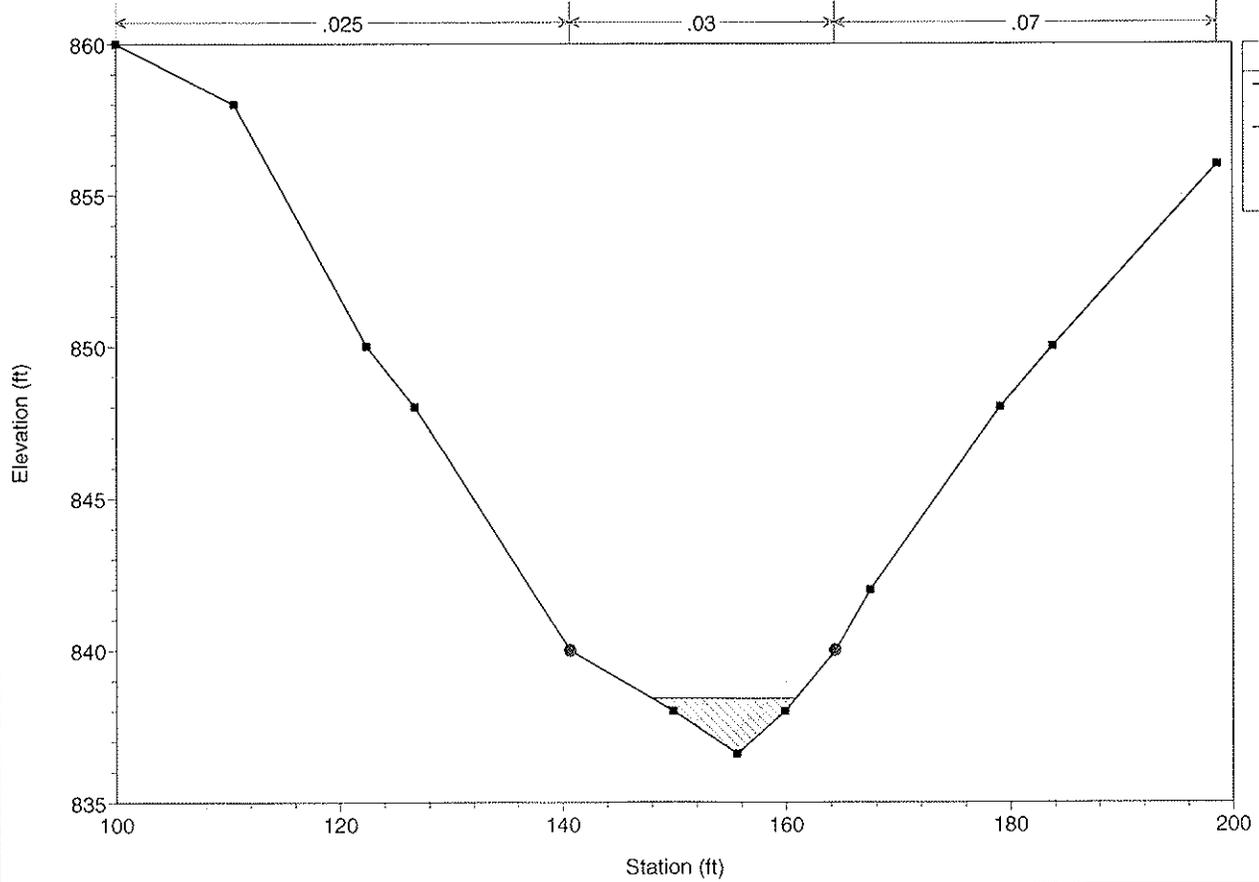
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 185



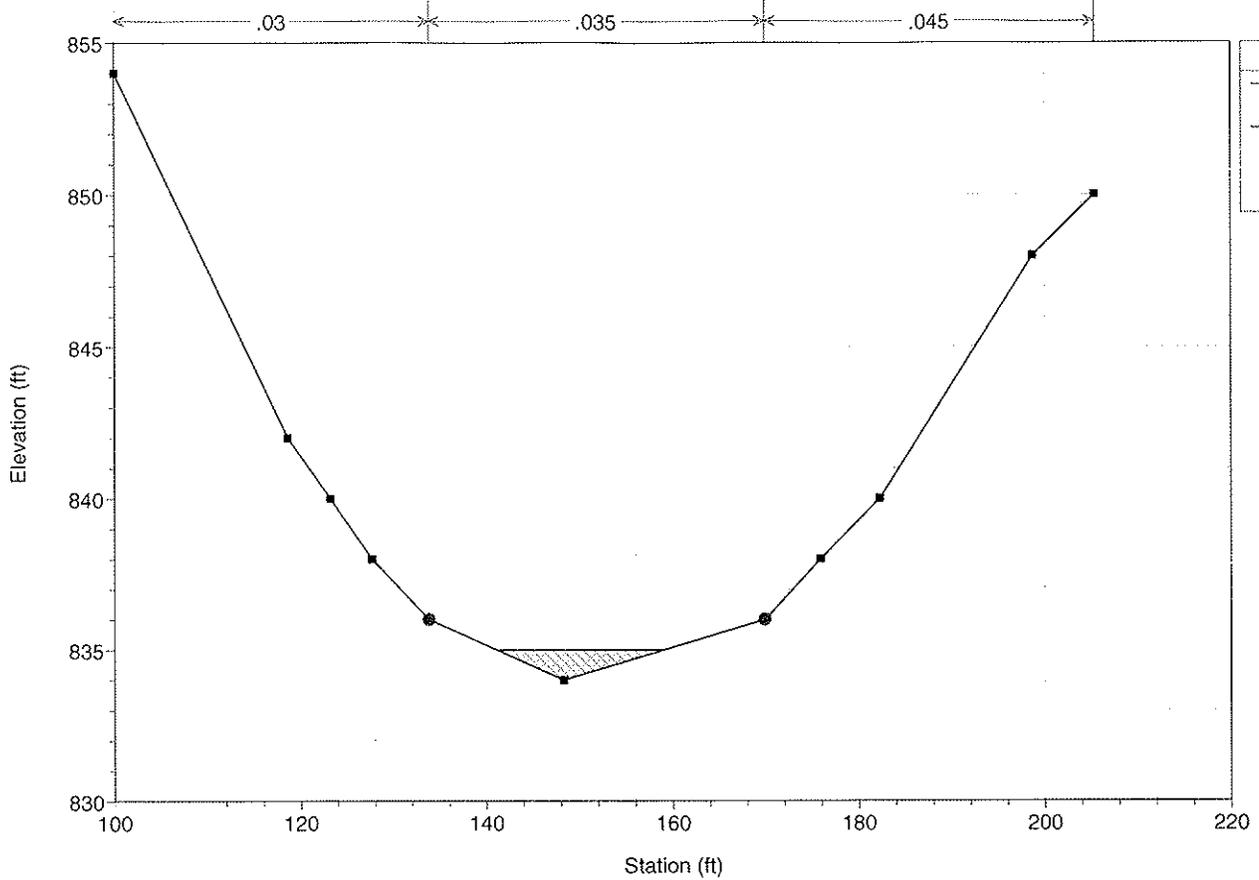
BENTON Plan: 50-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 180



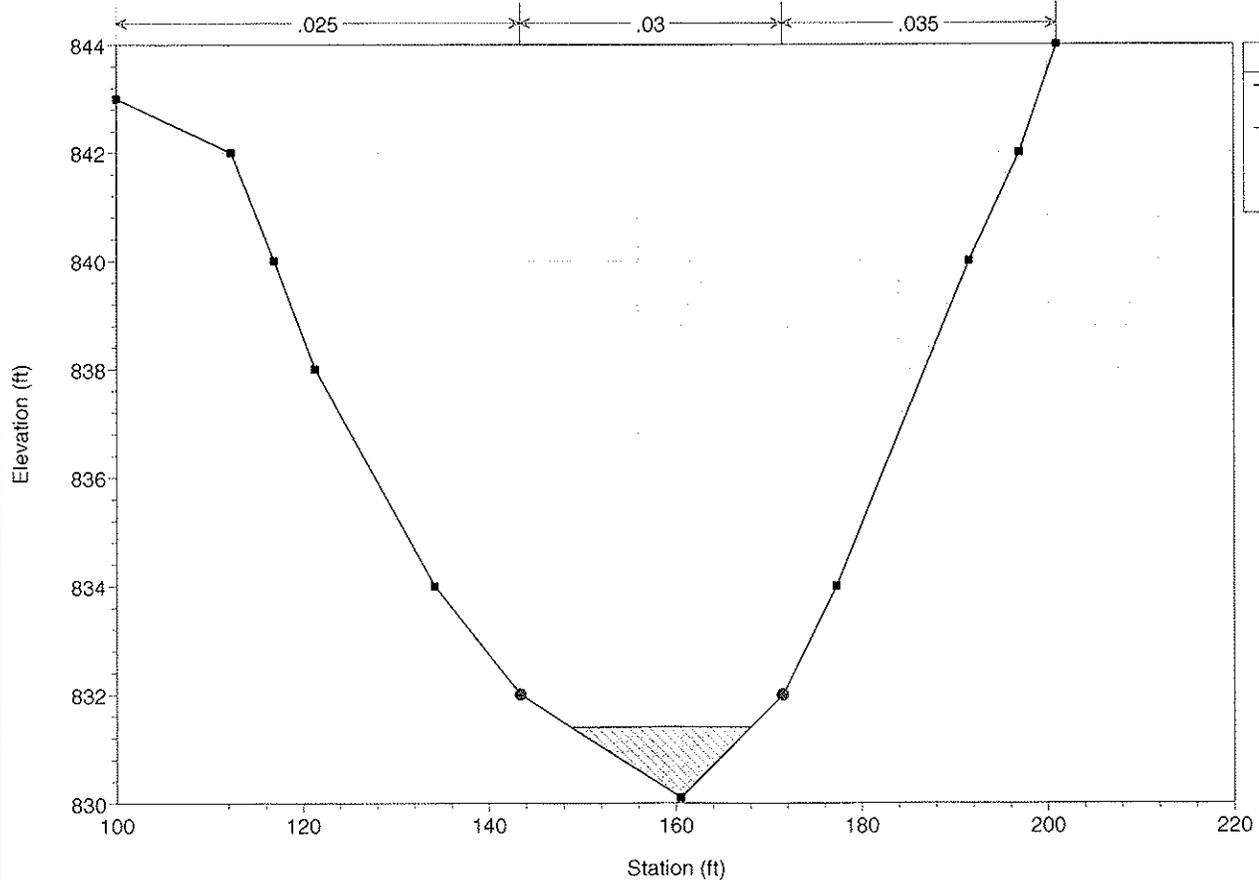
BENTON Plan: 50-yr Exist 2/19/2009
River = BENTON Reach = BENTON RS = 175



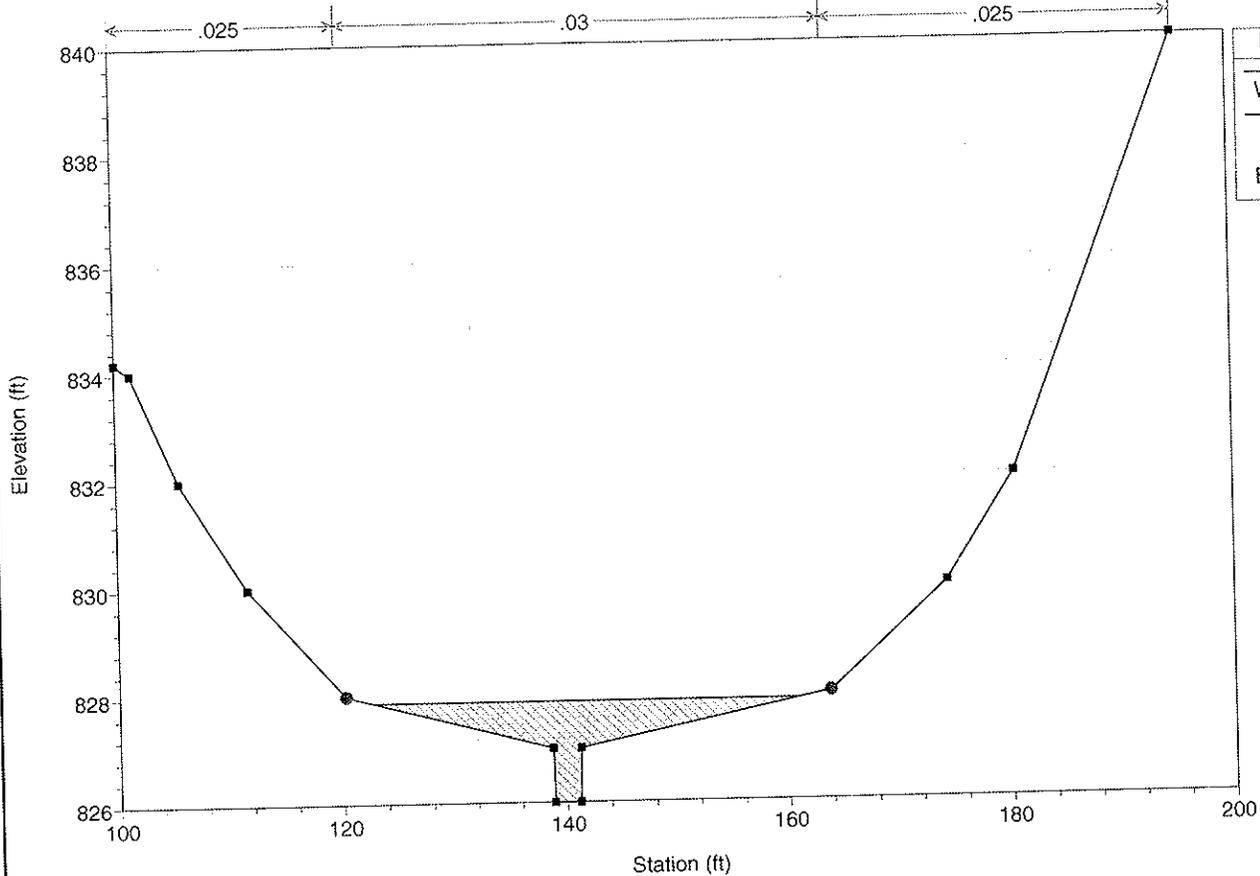
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 170



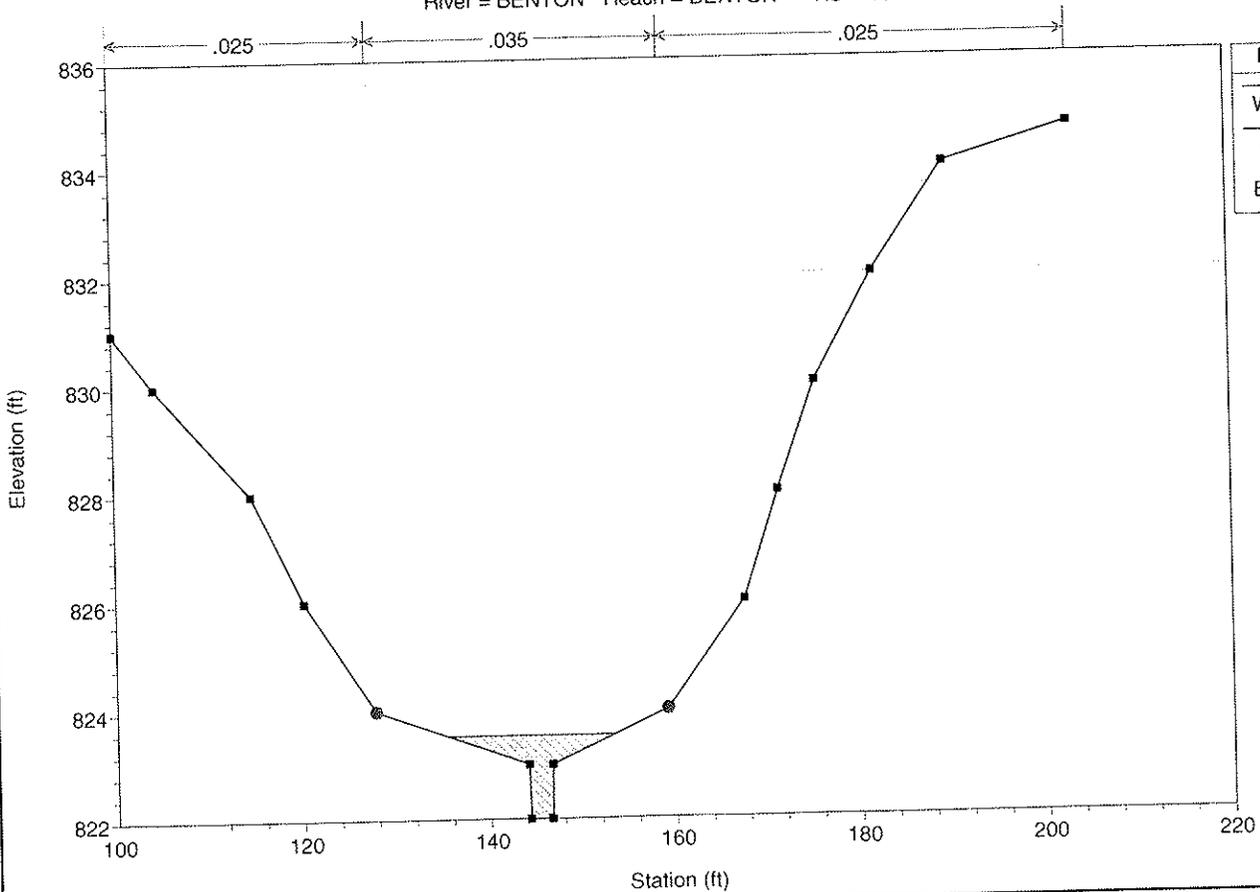
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 165



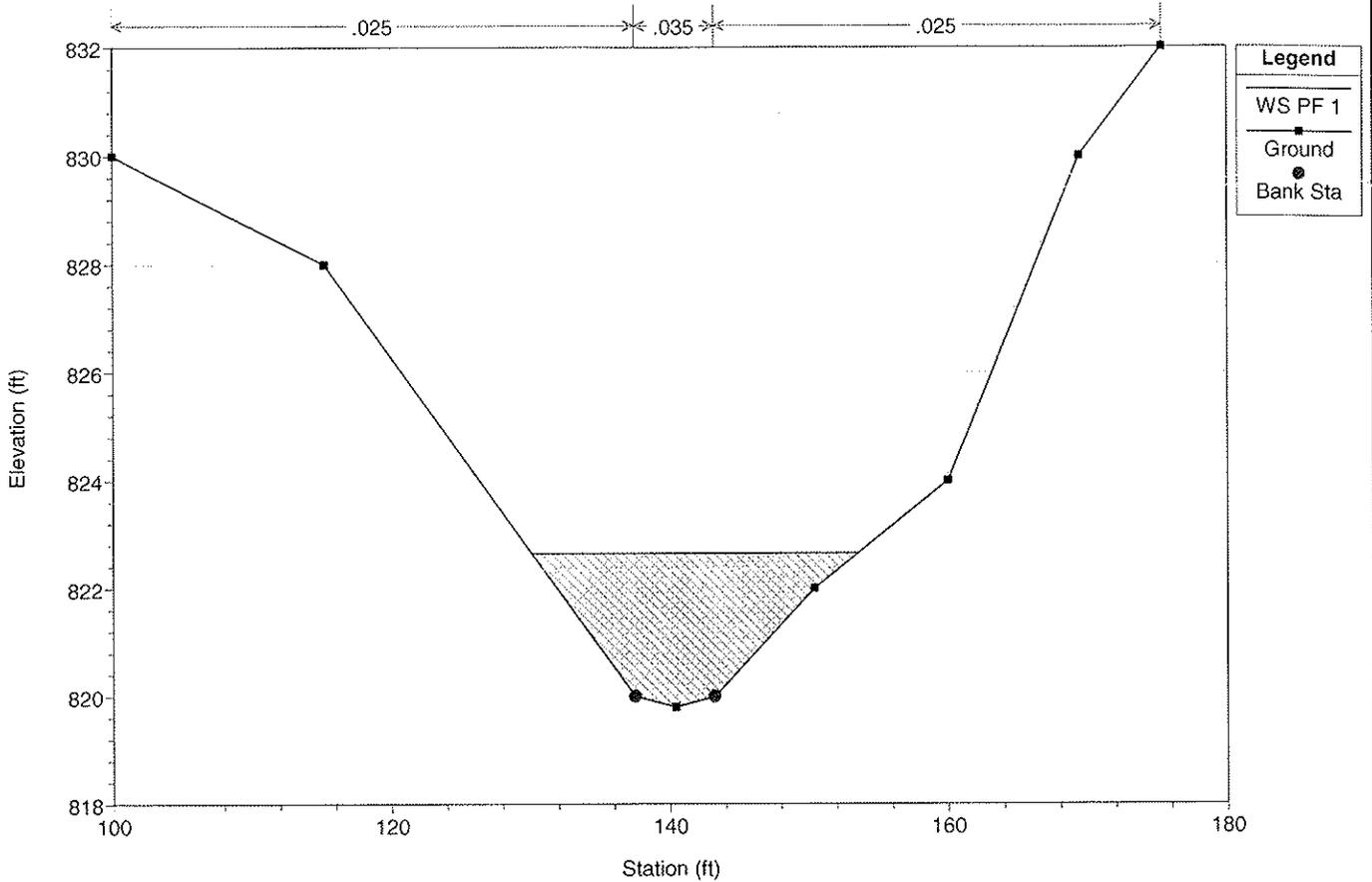
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 155



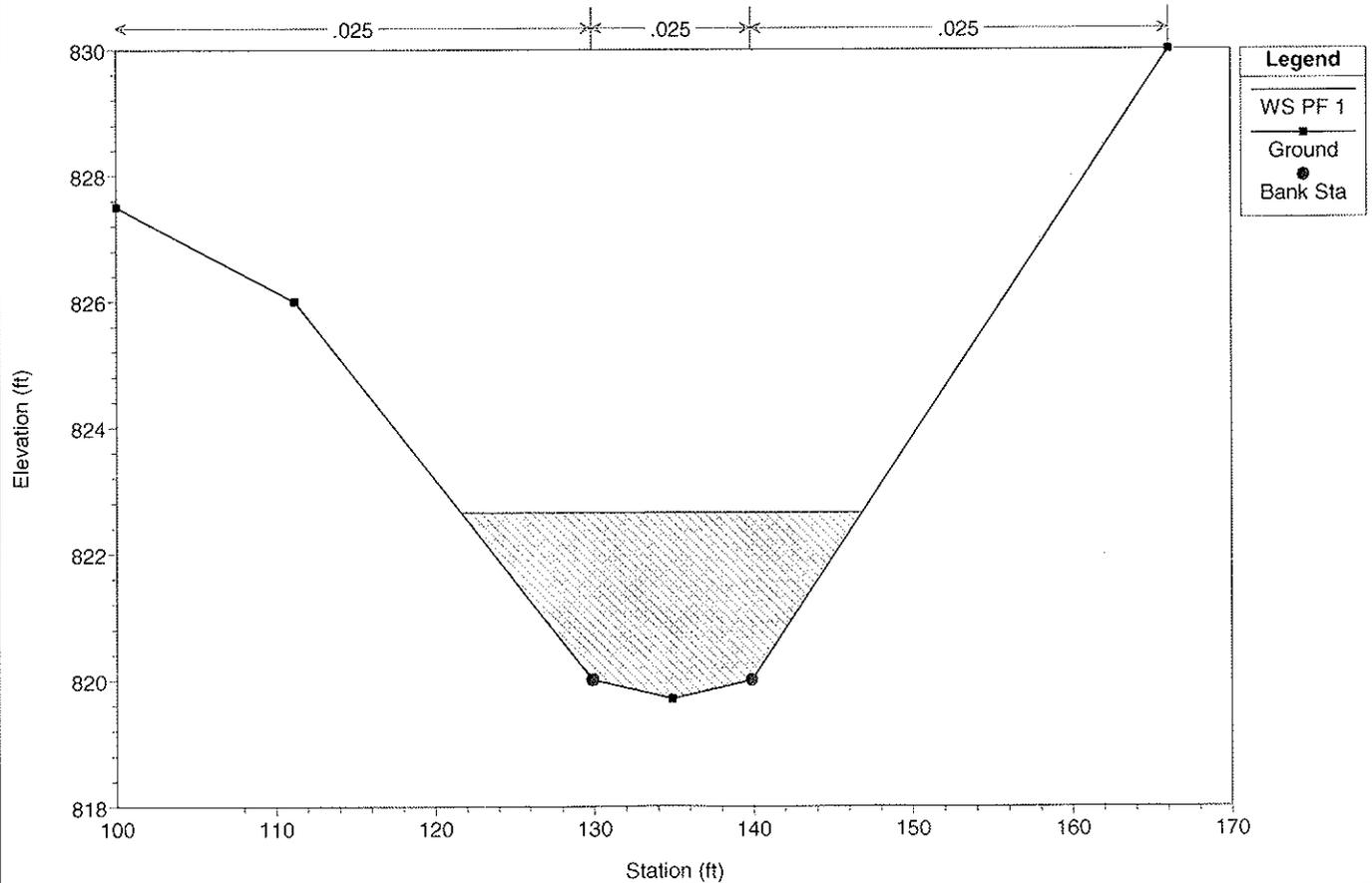
BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 150



BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 125

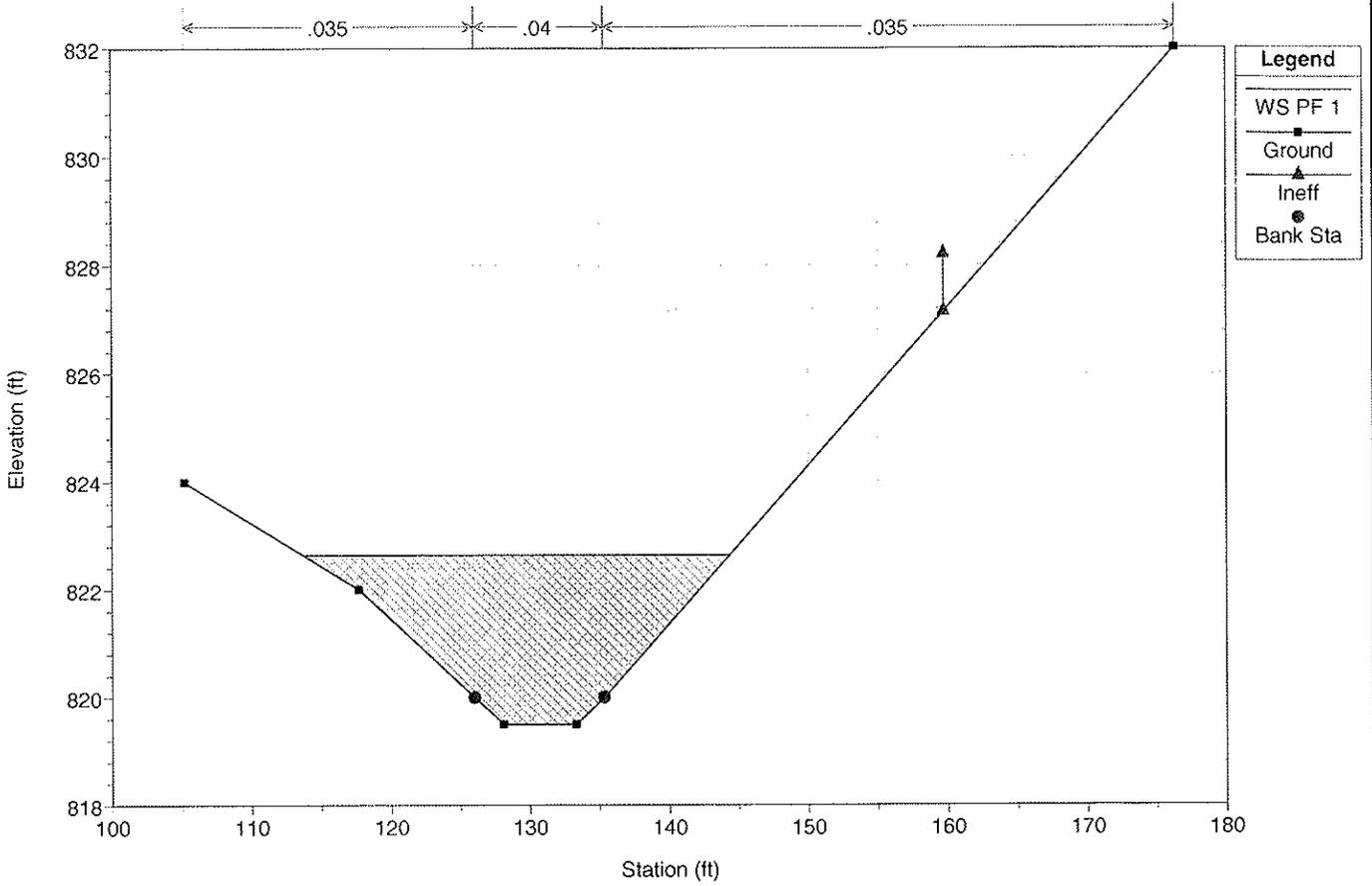


BENTON Plan: 50-yr Exist 2/19/2009
 River = BENTON Reach = BENTON RS = 100



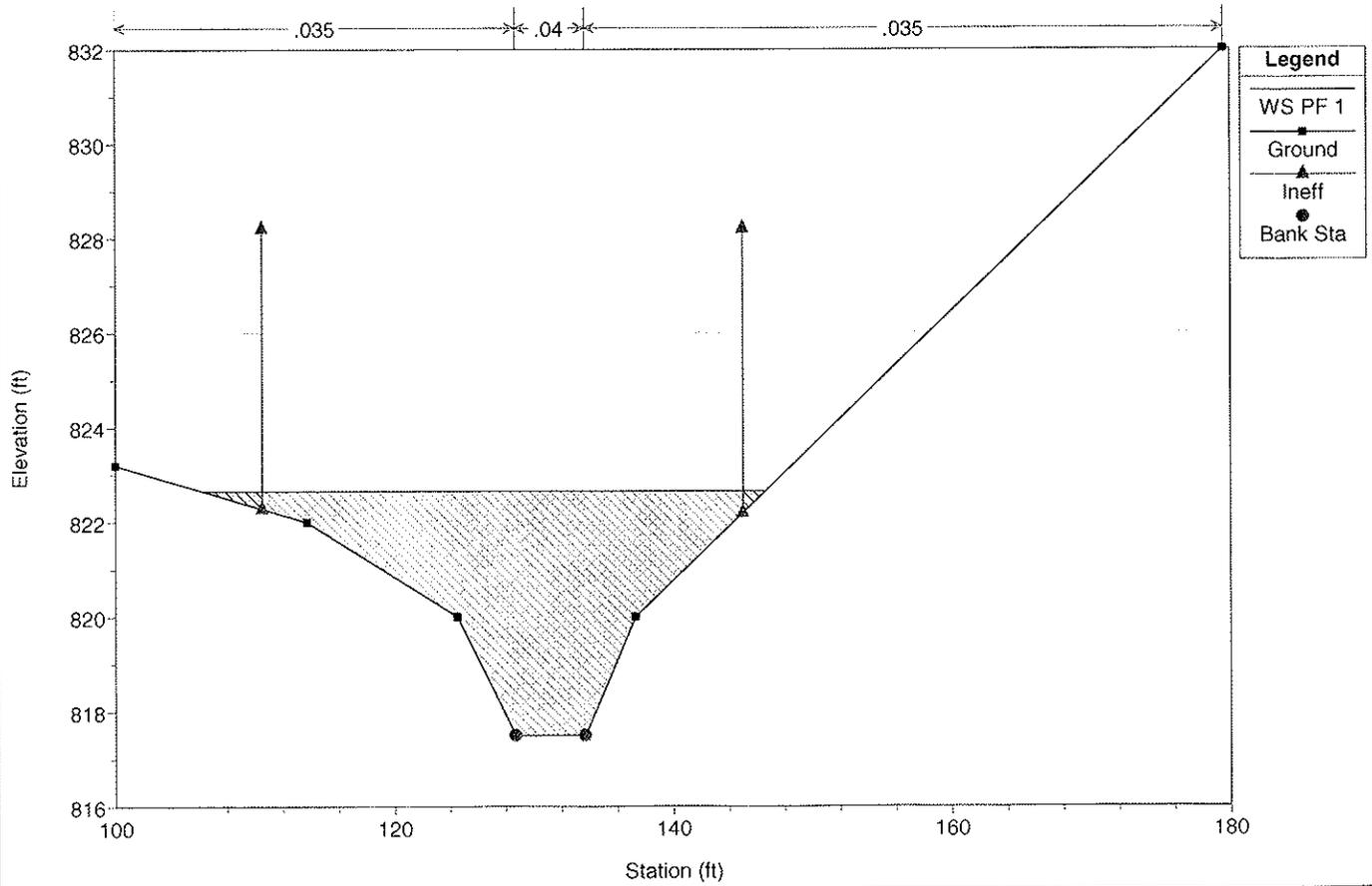
BENTON Plan: 50-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 50



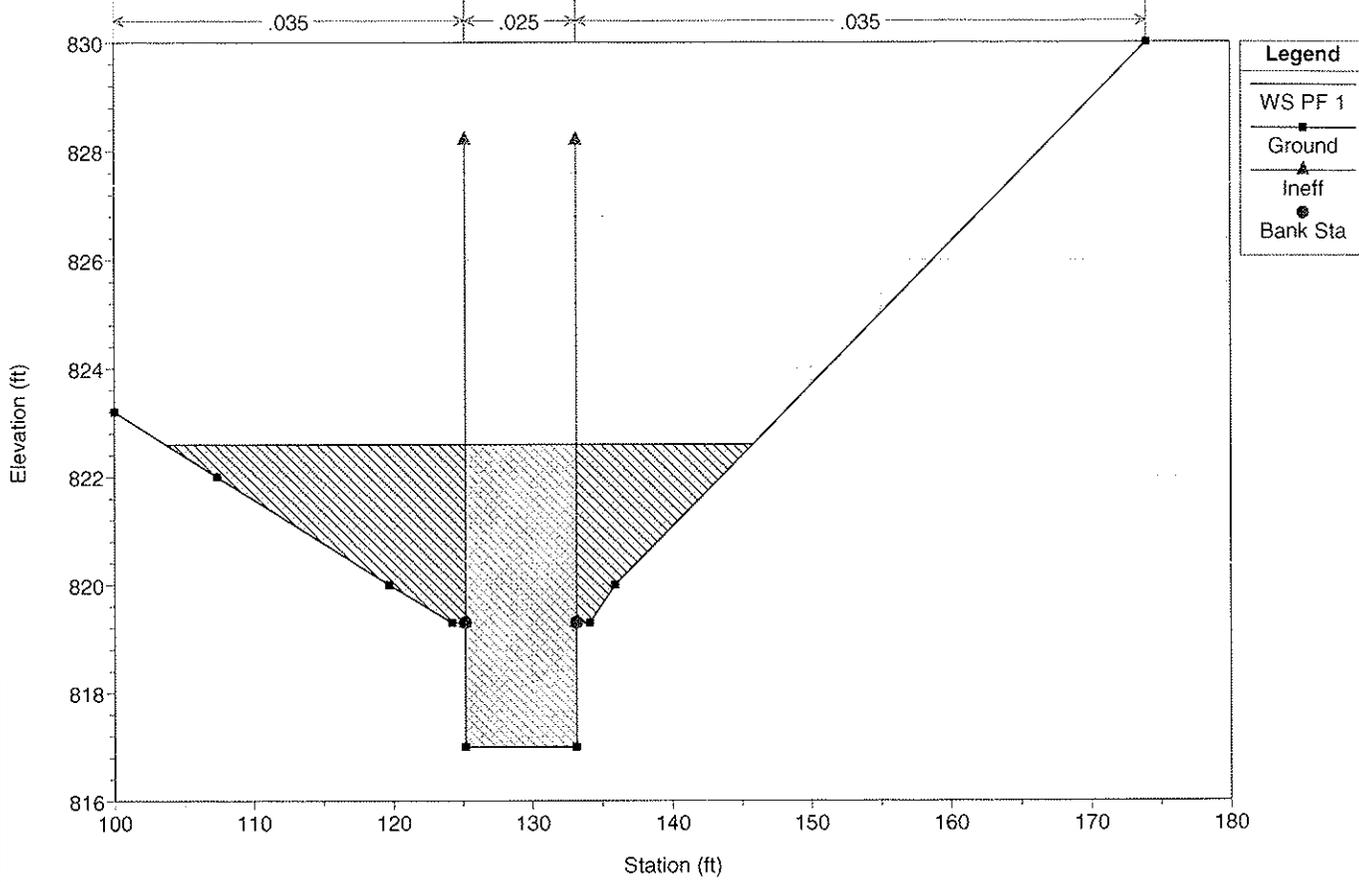
BENTON Plan: 50-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 40



BENTON Plan: 50-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 30



HEC-RAS Plan: 100-yr Exist River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 215 | PF 1 | 103.80 | 873.50 | 875.01 | 875.34 | 876.08 | 0.060045 | 8.33 | 12.46 | 13.84 | 1.55 | |
| BENTON | 210 | PF 1 | 103.80 | 870.80 | 873.28 | 872.64 | 873.47 | 0.005619 | 3.47 | 29.92 | 20.87 | 0.51 | |
| BENTON | 205 | PF 1 | 103.80 | 871.30 | 872.47 | 872.47 | 872.82 | 0.022663 | 4.82 | 21.99 | 32.00 | 0.95 | |
| BENTON | 200 | PF 1 | 103.80 | 866.00 | 867.82 | 868.27 | 869.25 | 0.092518 | 9.60 | 10.82 | 11.86 | 1.77 | |
| BENTON | 195 | PF 1 | 103.80 | 860.00 | 861.13 | 861.54 | 862.52 | 0.054571 | 9.45 | 10.99 | 19.44 | 2.21 | |
| BENTON | 190 | PF 1 | 103.80 | 850.00 | 851.19 | 852.06 | 855.93 | 0.179873 | 17.46 | 5.94 | 9.98 | 3.99 | |
| BENTON | 185 | PF 1 | 103.80 | 840.00 | 841.43 | 842.45 | 846.86 | 0.430433 | 18.70 | 5.55 | 7.74 | 3.89 | |
| BENTON | 180 | PF 1 | 103.80 | 838.10 | 839.63 | 840.24 | 841.89 | 0.158076 | 12.06 | 8.61 | 11.26 | 2.43 | |
| BENTON | 175 | PF 1 | 103.80 | 836.60 | 838.52 | 838.80 | 839.49 | 0.027857 | 7.88 | 13.17 | 13.58 | 1.41 | |
| BENTON | 170 | PF 1 | 103.80 | 834.00 | 835.07 | 835.51 | 836.65 | 0.132082 | 10.11 | 10.27 | 19.26 | 2.44 | |
| BENTON | 165 | PF 1 | 103.80 | 830.10 | 831.48 | 831.74 | 832.32 | 0.036114 | 7.32 | 14.18 | 20.48 | 1.55 | |
| BENTON | 160 | PF 1 | 103.80 | 828.00 | 829.07 | 829.36 | 829.98 | 0.049293 | 7.64 | 13.59 | 23.37 | 1.77 | |
| BENTON | 155 | PF 1 | 103.80 | 826.00 | 827.94 | 827.96 | 828.26 | 0.019705 | 4.56 | 22.75 | 40.92 | 1.08 | |
| BENTON | 150 | PF 1 | 103.80 | 822.00 | 823.61 | 824.08 | 825.53 | 0.215039 | 11.11 | 9.34 | 20.19 | 2.88 | |
| BENTON | 125 | PF 1 | 103.80 | 819.80 | 823.96 | 821.58 | 823.99 | 0.000212 | 1.57 | 75.43 | 33.32 | 0.14 | |
| BENTON | 100 | PF 1 | 103.80 | 819.70 | 823.96 | | 823.98 | 0.000102 | 1.54 | 85.92 | 32.69 | 0.13 | |
| BENTON | 50 | PF 1 | 103.80 | 819.50 | 823.96 | 821.11 | 823.97 | 0.000170 | 1.28 | 103.65 | 43.34 | 0.11 | |
| BENTON | 40 | PF 1 | 103.80 | 817.50 | 823.96 | 819.48 | 823.97 | 0.000060 | 1.00 | 132.75 | 51.22 | 0.07 | |
| BENTON | 30 | PF 1 | 103.80 | 817.00 | 823.90 | 818.73 | 823.96 | 0.000140 | 1.88 | 55.20 | 50.76 | 0.13 | |

Headwater Depth for Concrete Pipe Culverts with Inlet Control

- Square Edge with Headwall
- Groove End with Headwall
- Groove End Projecting

| | | |
|--------|--------|--|
| 3.110 | } Calc | Critical Depth (ft) |
| 11.490 | | Critical Velocity (ft/s) |
| 103.8 | | Q = Discharge (cfs) 100-YR FLOW |
| 0.02 | | Culvert Barrel Slope (ft/ft) |
| 3.5 | | Culvert diameter (ft) |
| 6.943 | | Headwater (ft) |

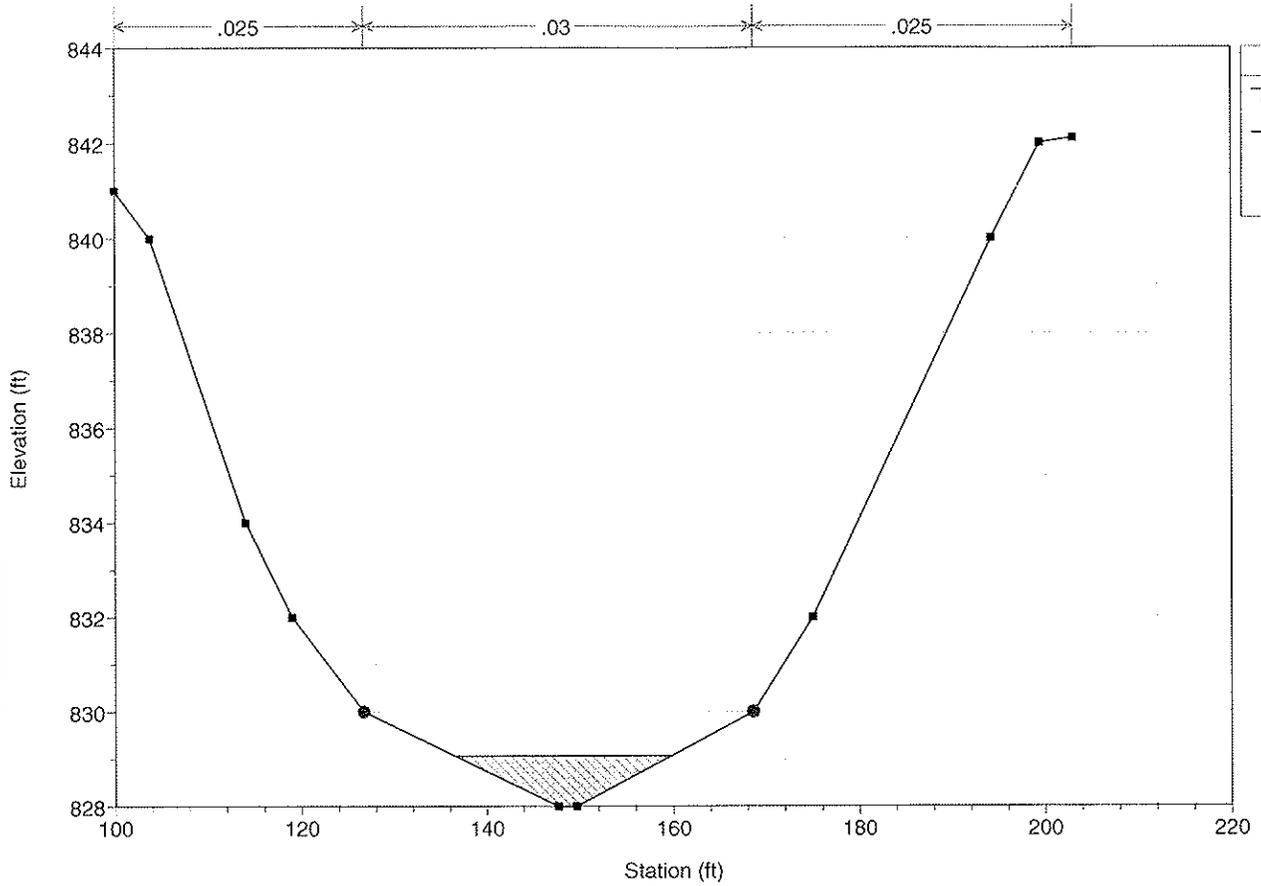
Calc

Units

English Metric

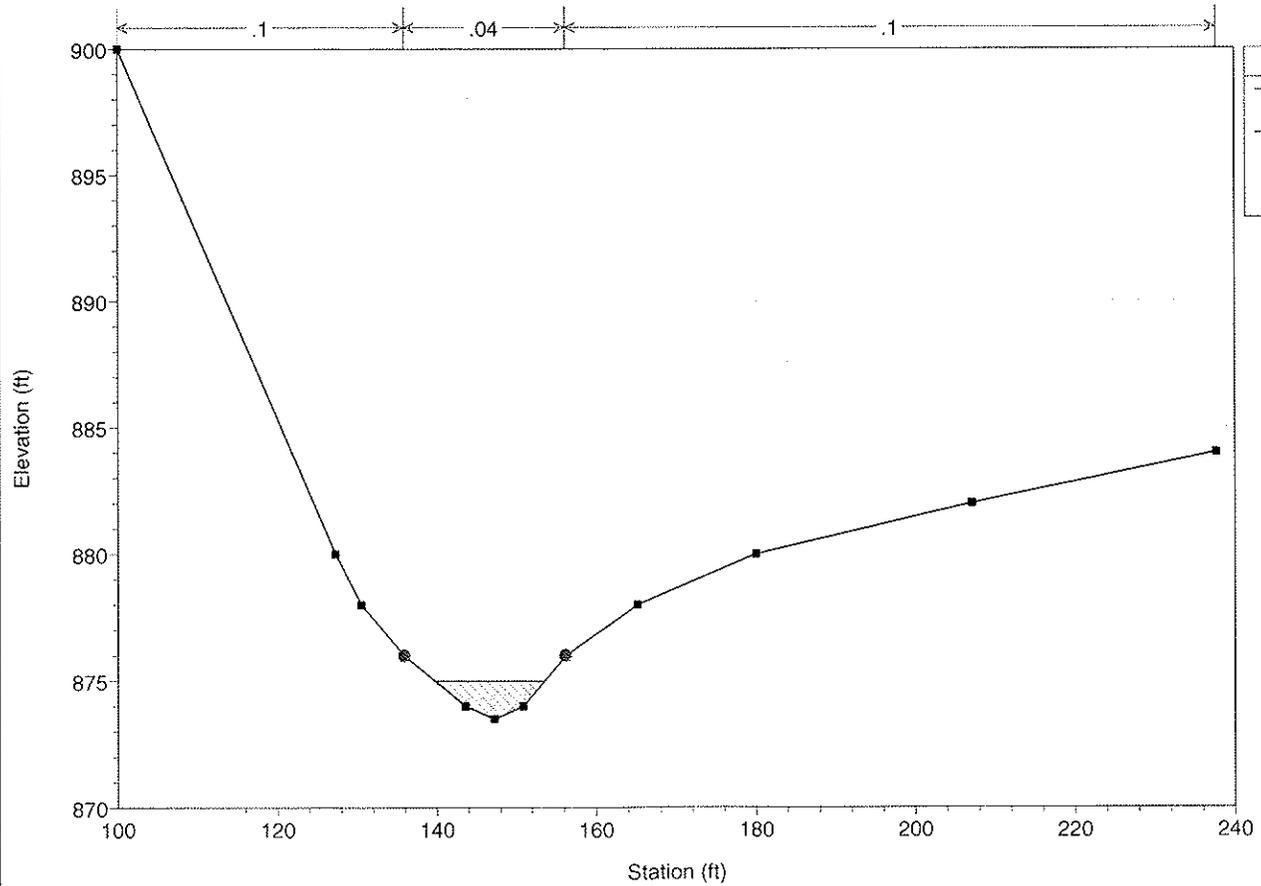
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 160



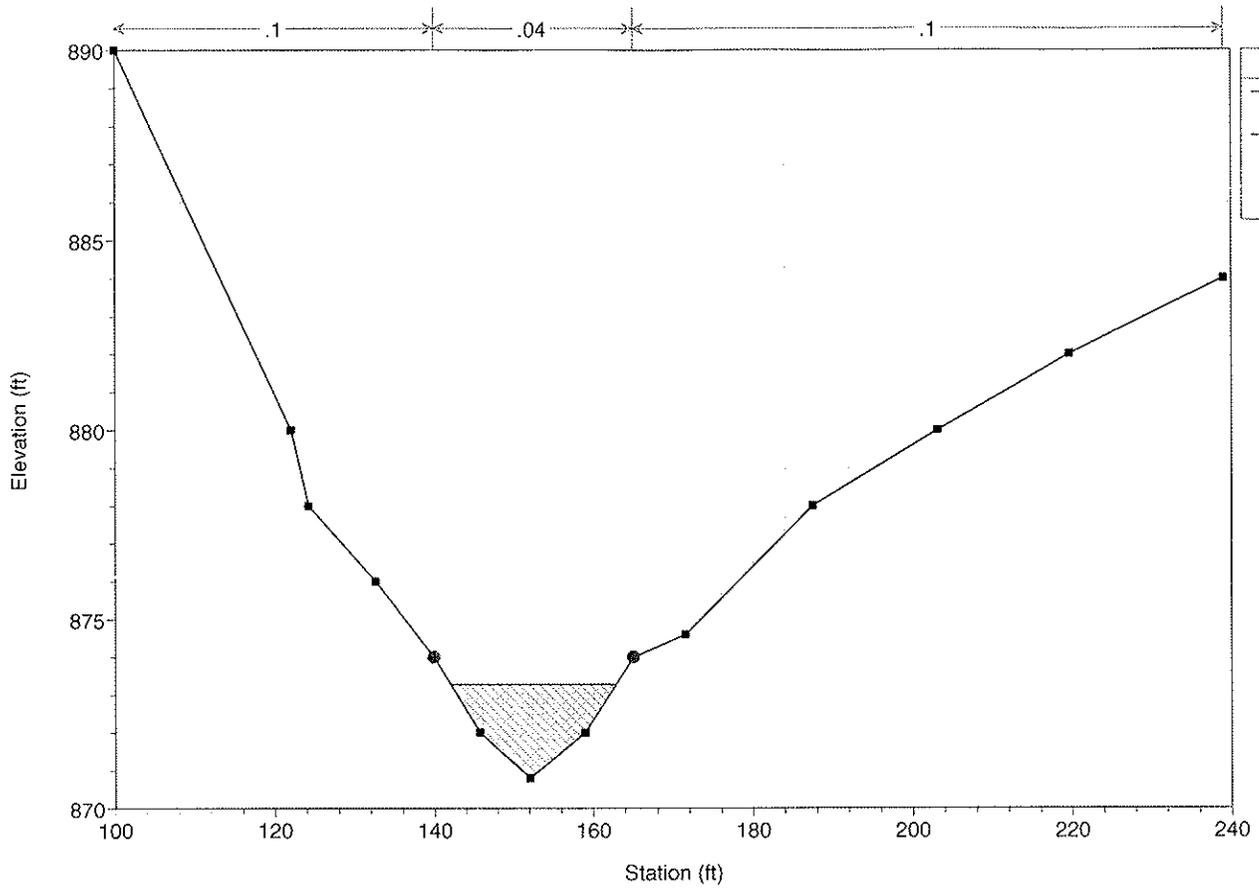
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 215



BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 210

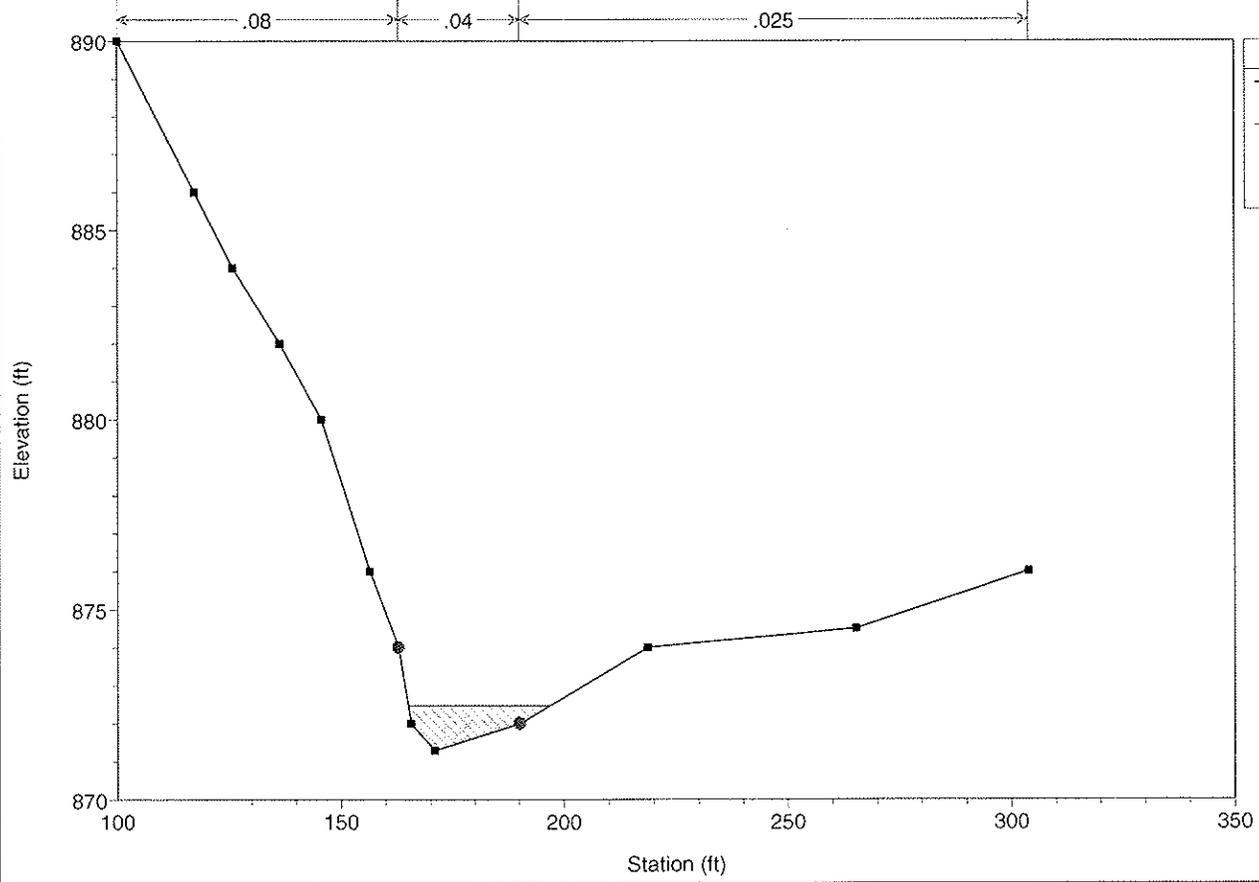


Legend

- WS PF 1
- Ground
- Bank Sta

BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 205

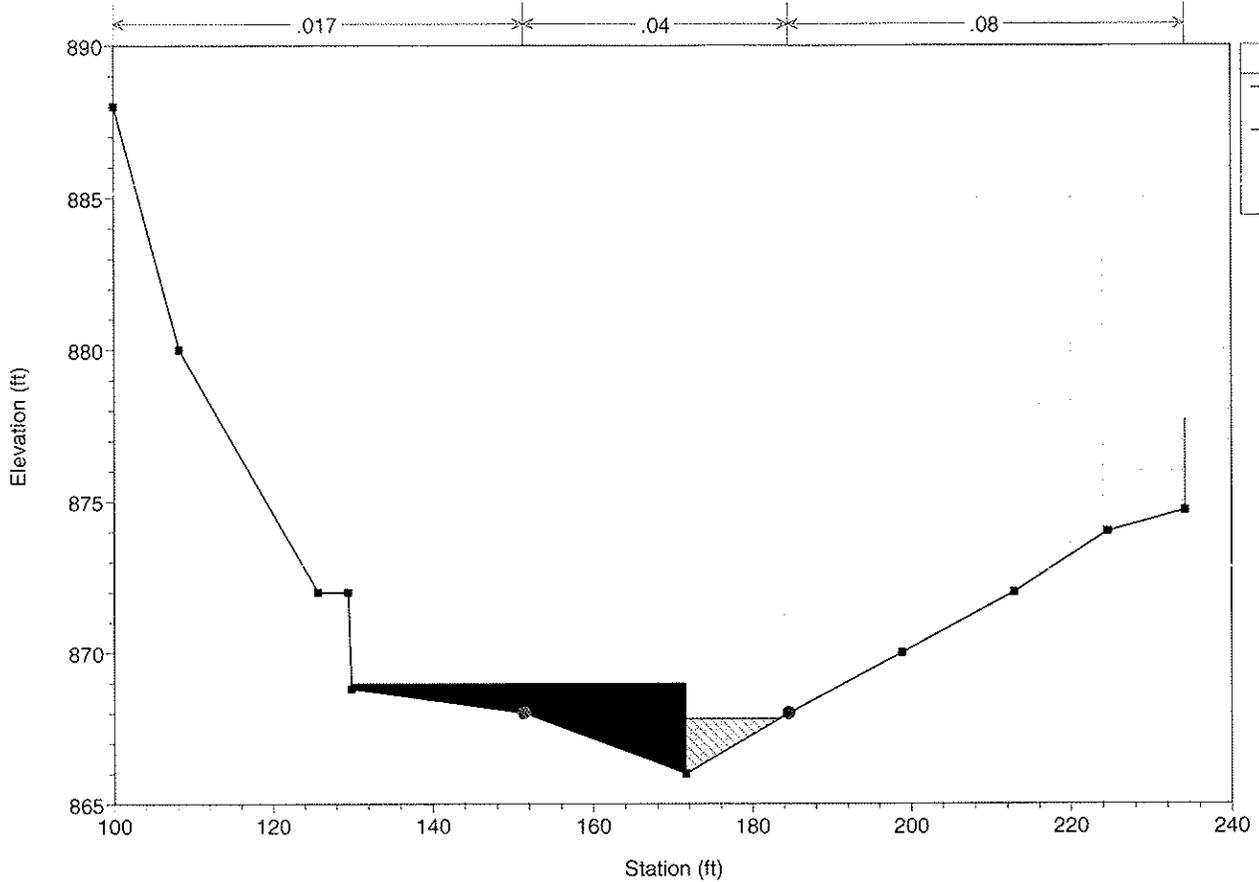


Legend

- WS PF 1
- Ground
- Bank Sta

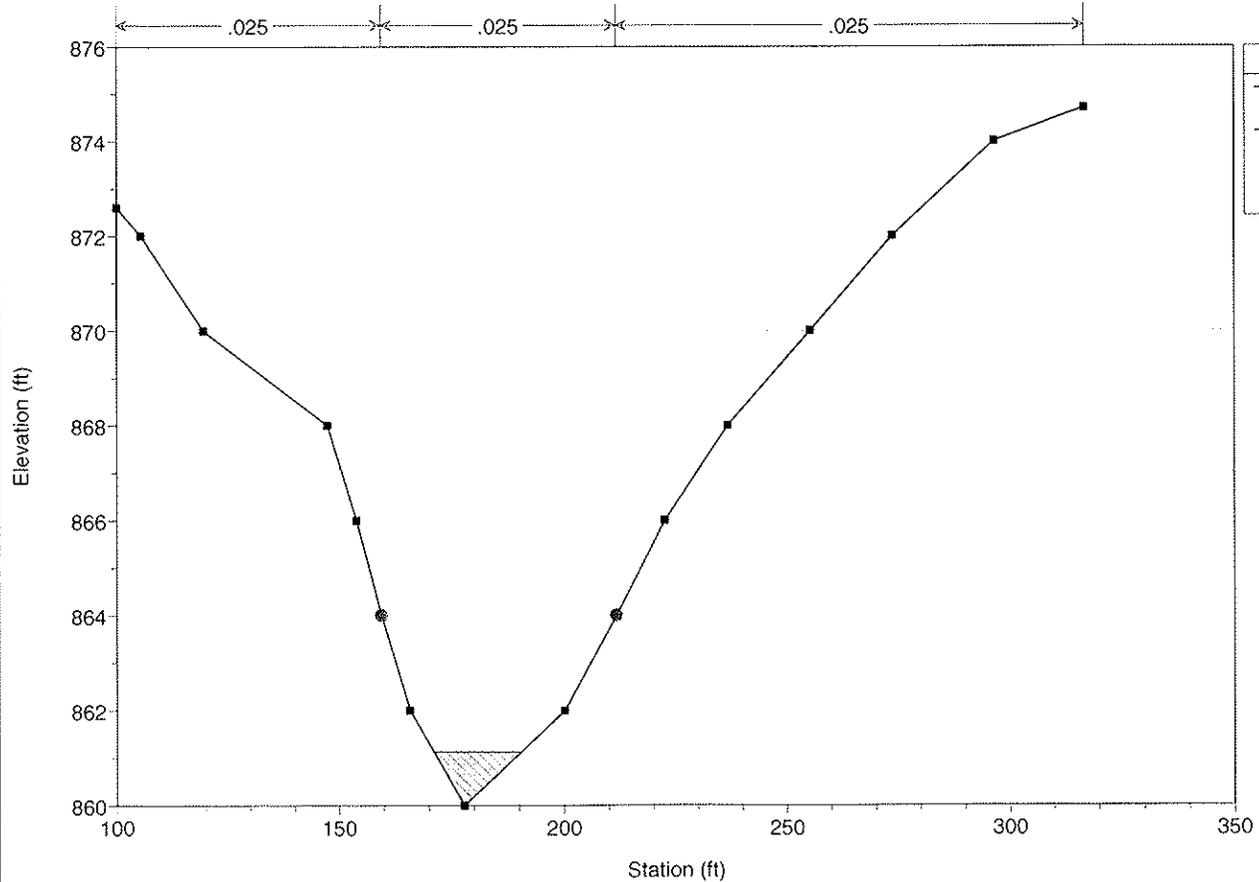
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 200



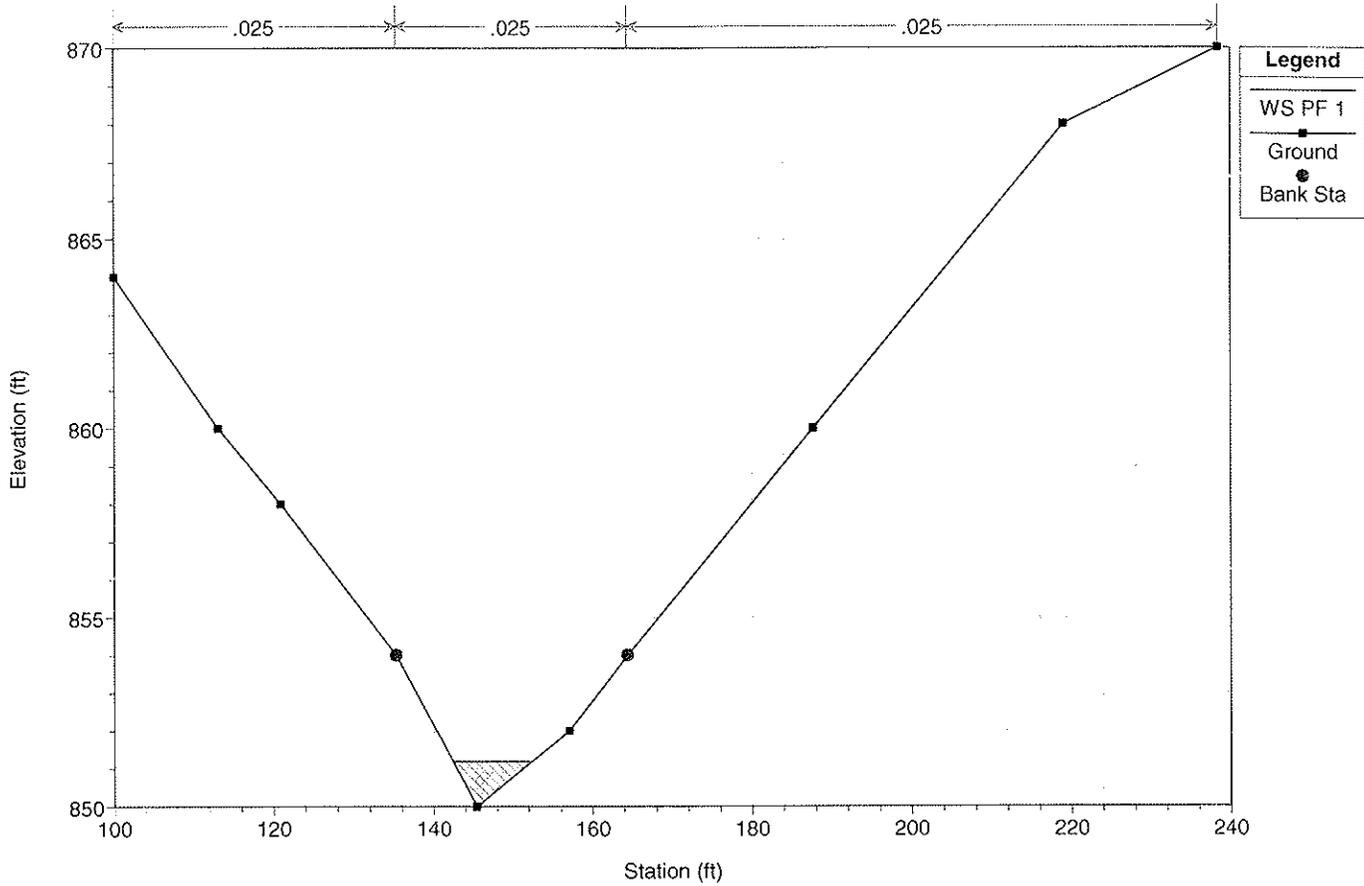
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 195



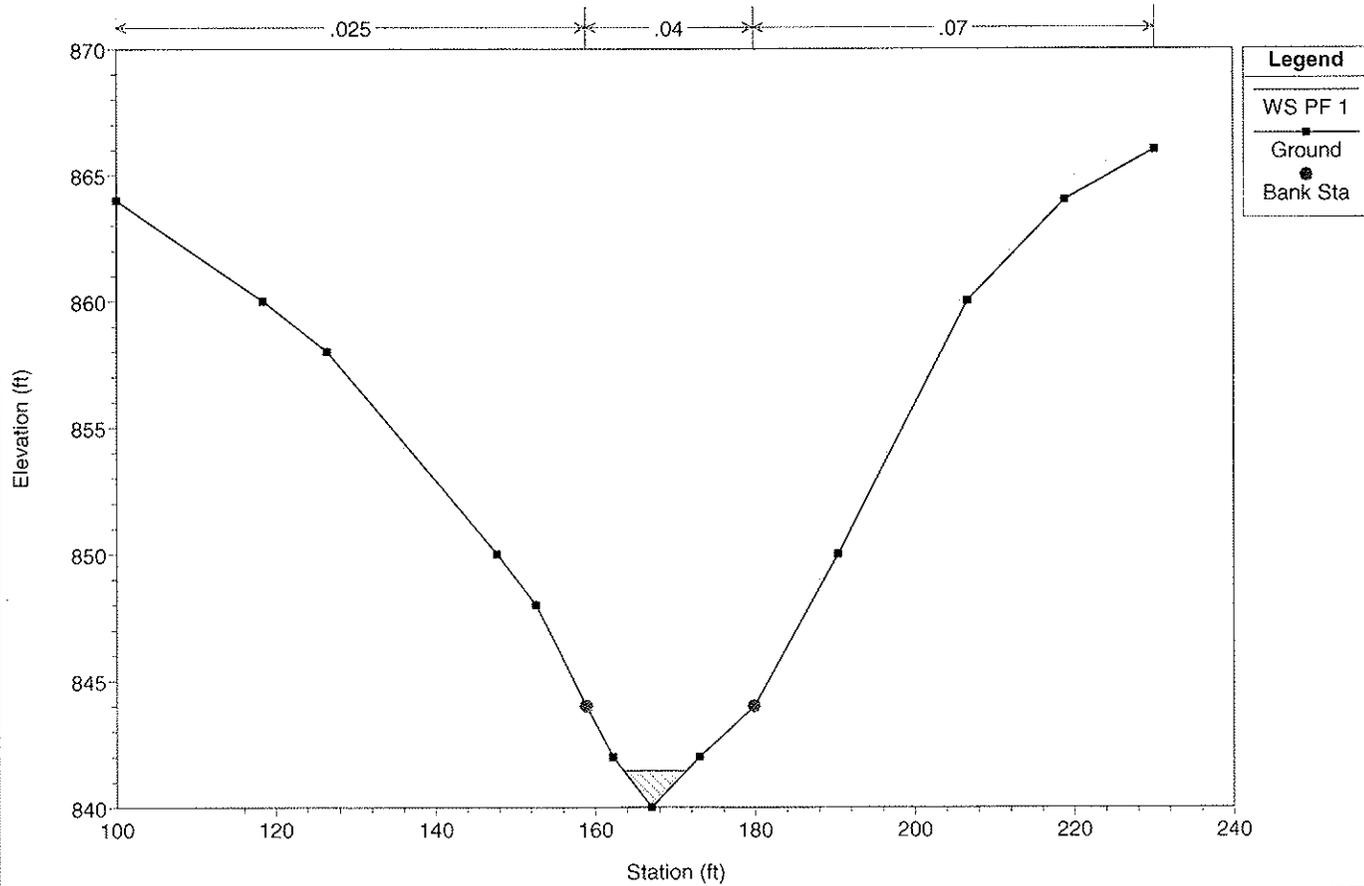
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 190



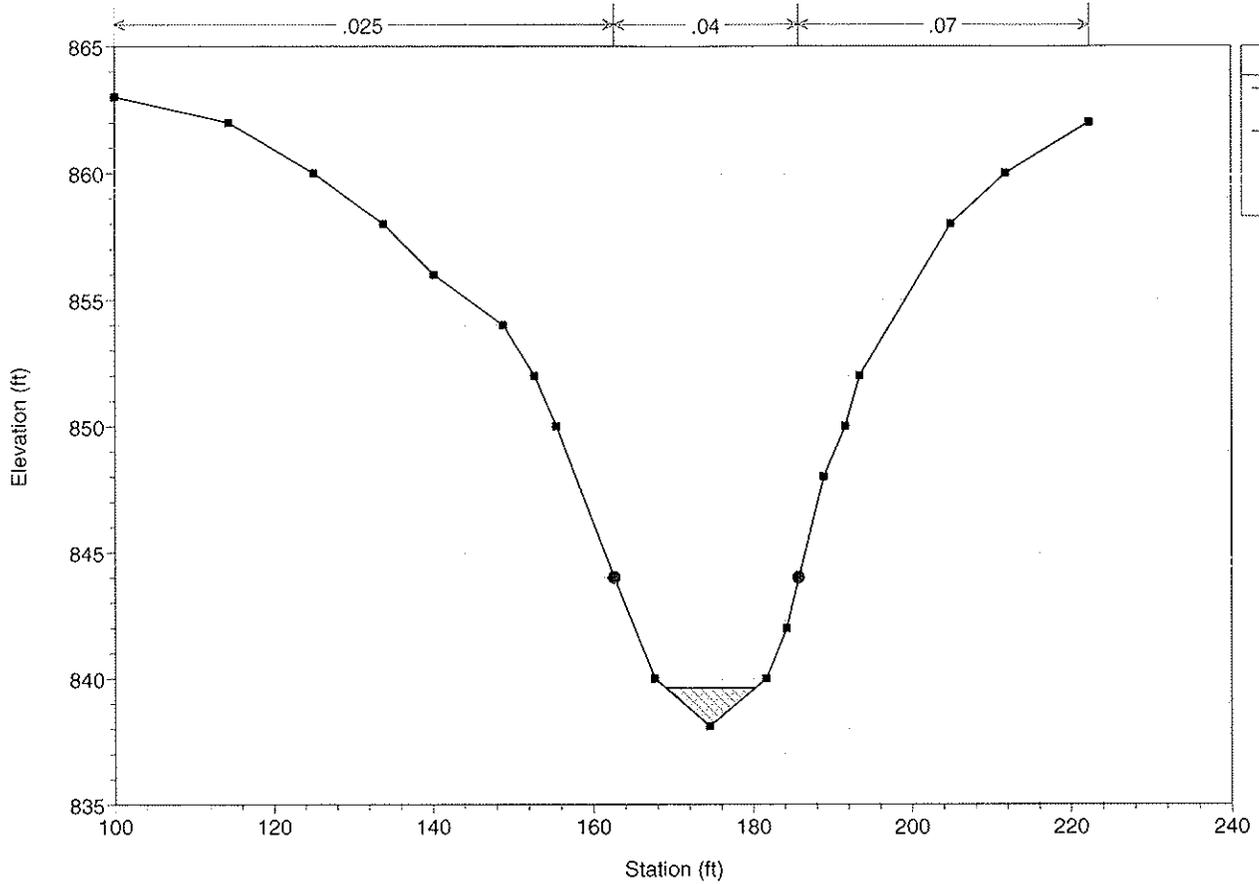
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 185



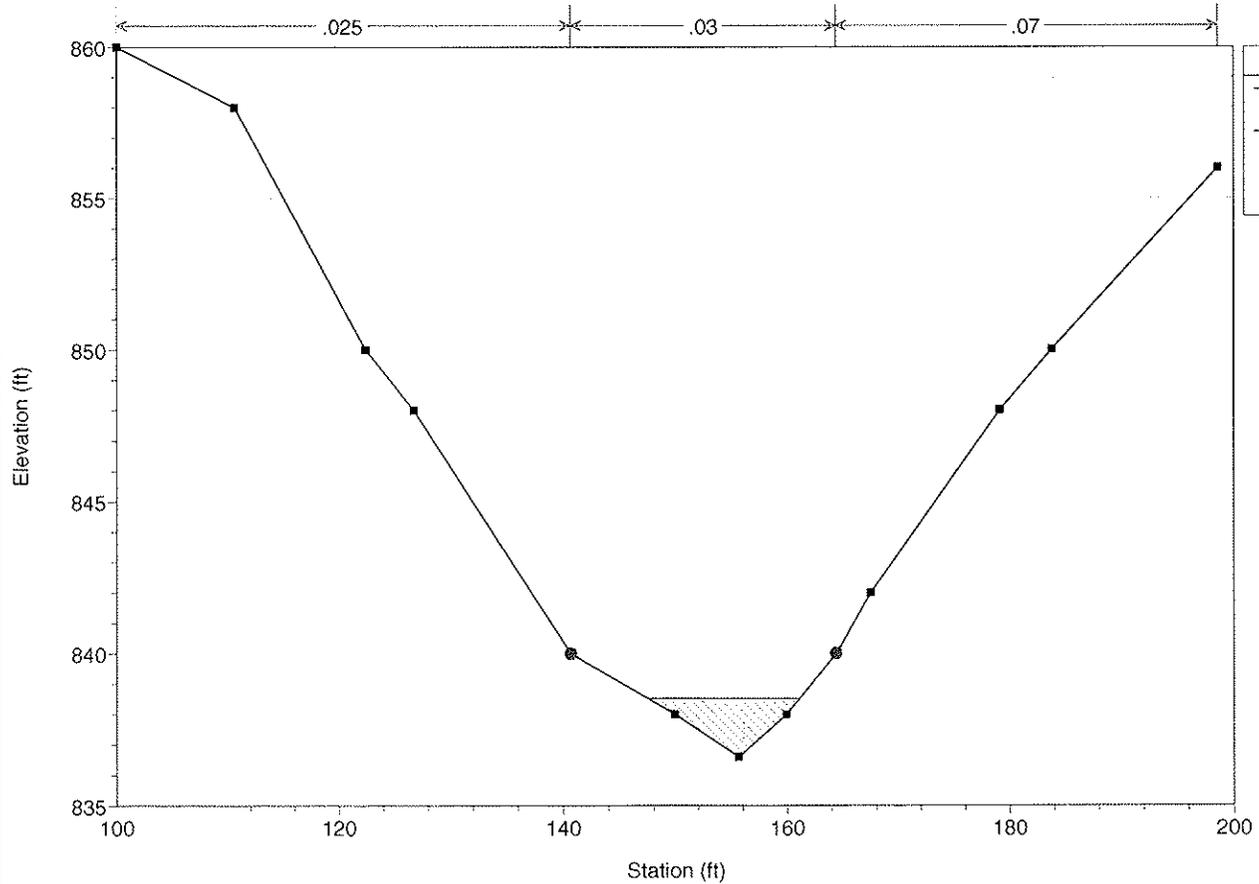
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 180



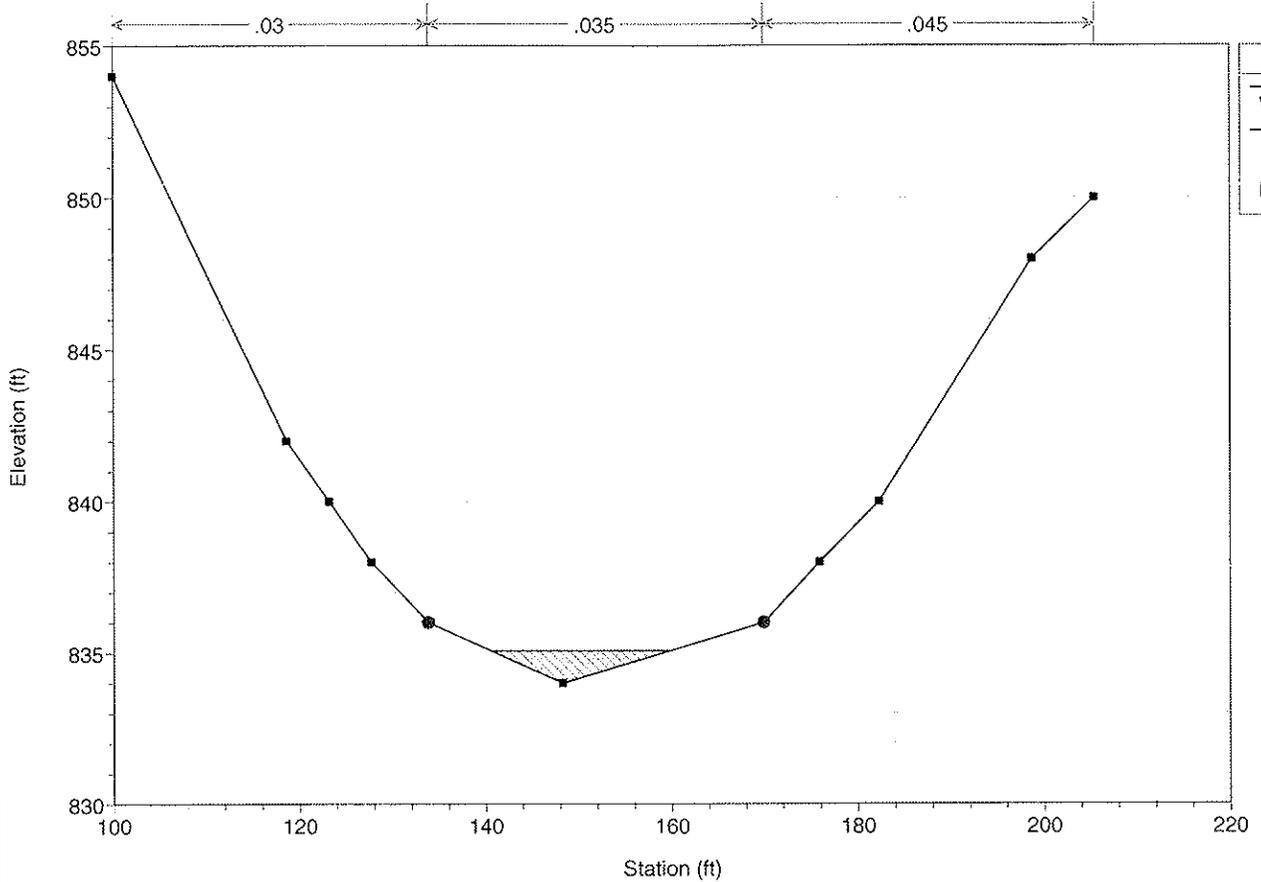
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 175



BENTON Plan: 100-yr Exist 2/19/2009

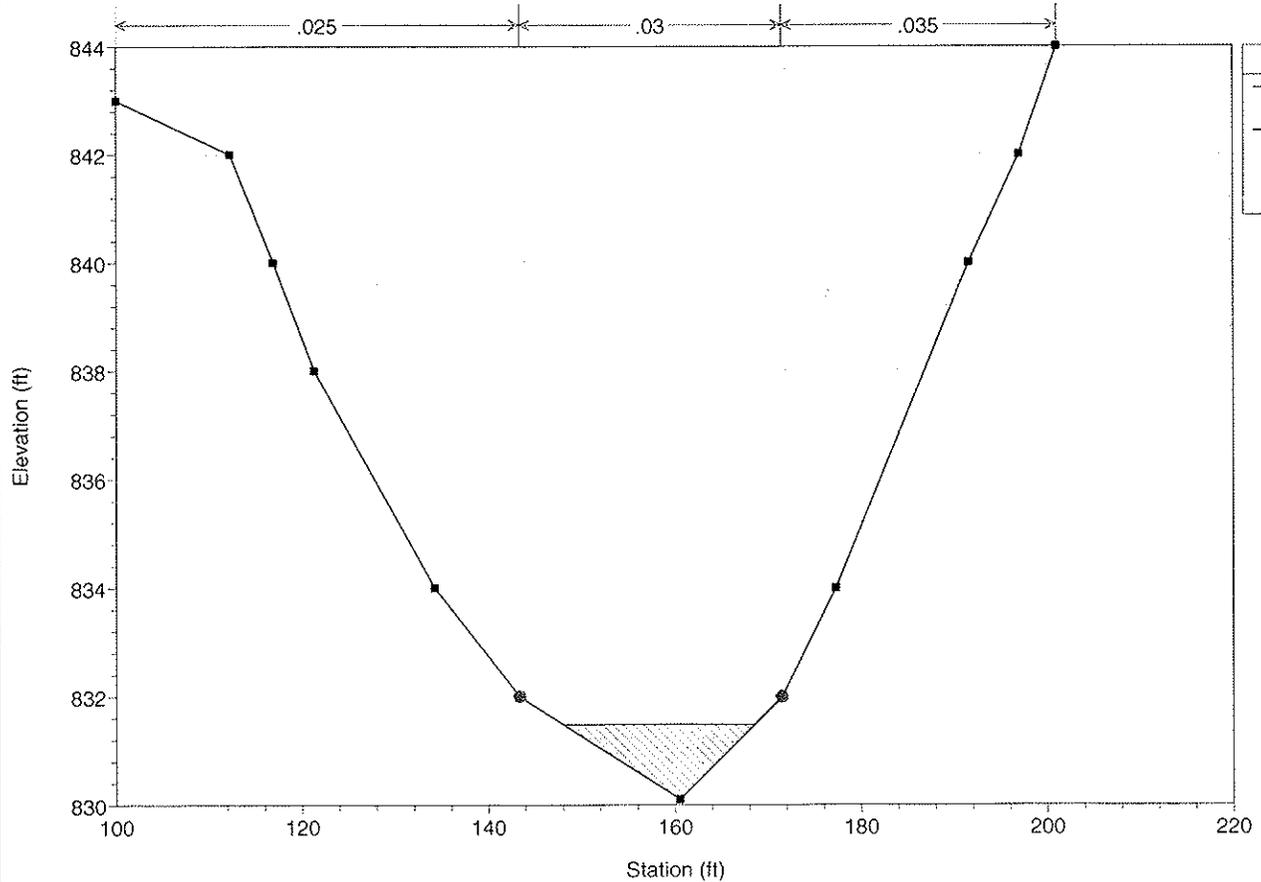
River = BENTON Reach = BENTON RS = 170



| Legend | |
|--------|----------|
| —■— | WS PF 1 |
| —●— | Ground |
| ● | Bank Sta |

BENTON Plan: 100-yr Exist 2/19/2009

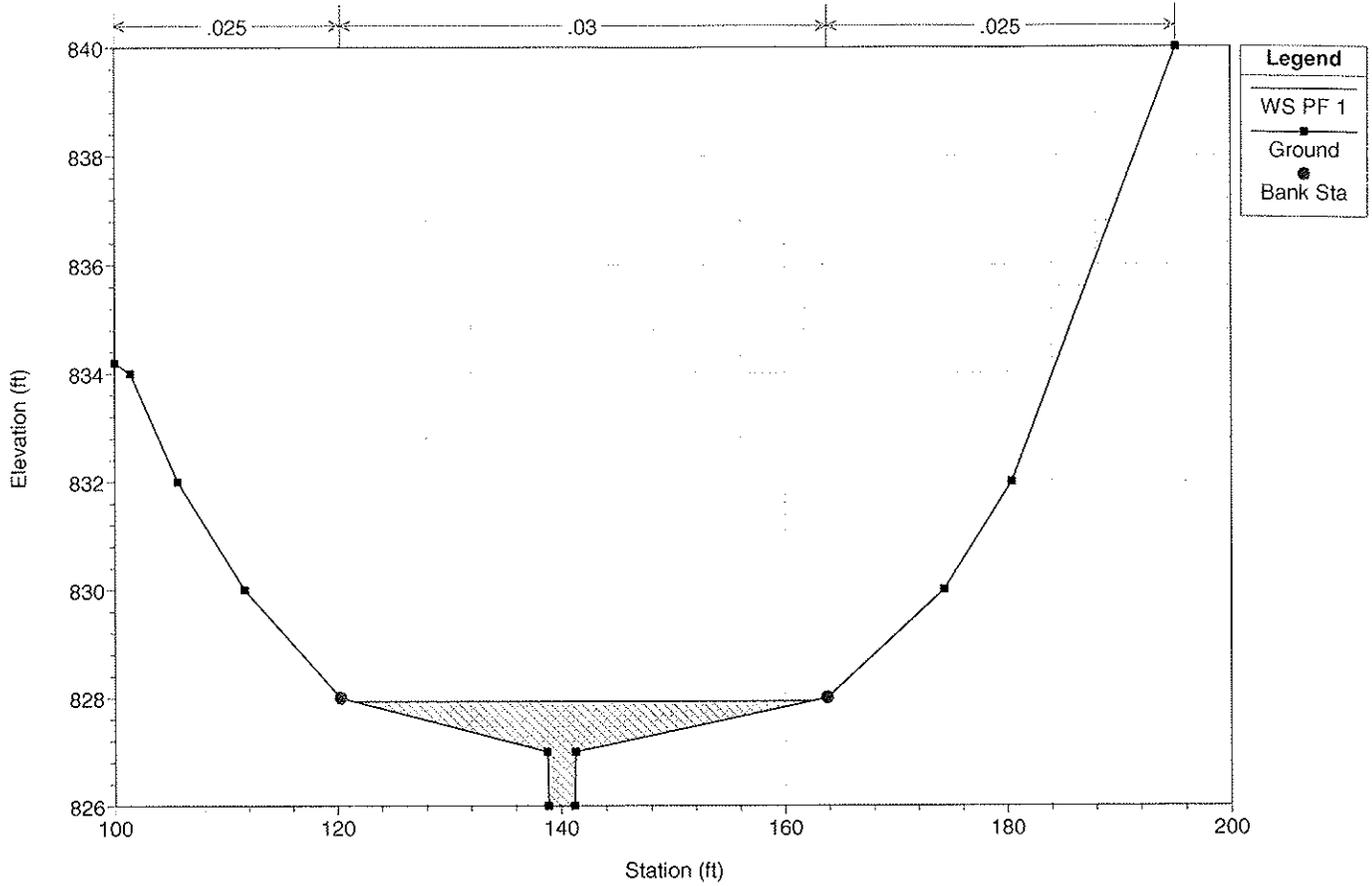
River = BENTON Reach = BENTON RS = 165



| Legend | |
|--------|----------|
| —■— | WS PF 1 |
| —●— | Ground |
| ● | Bank Sta |

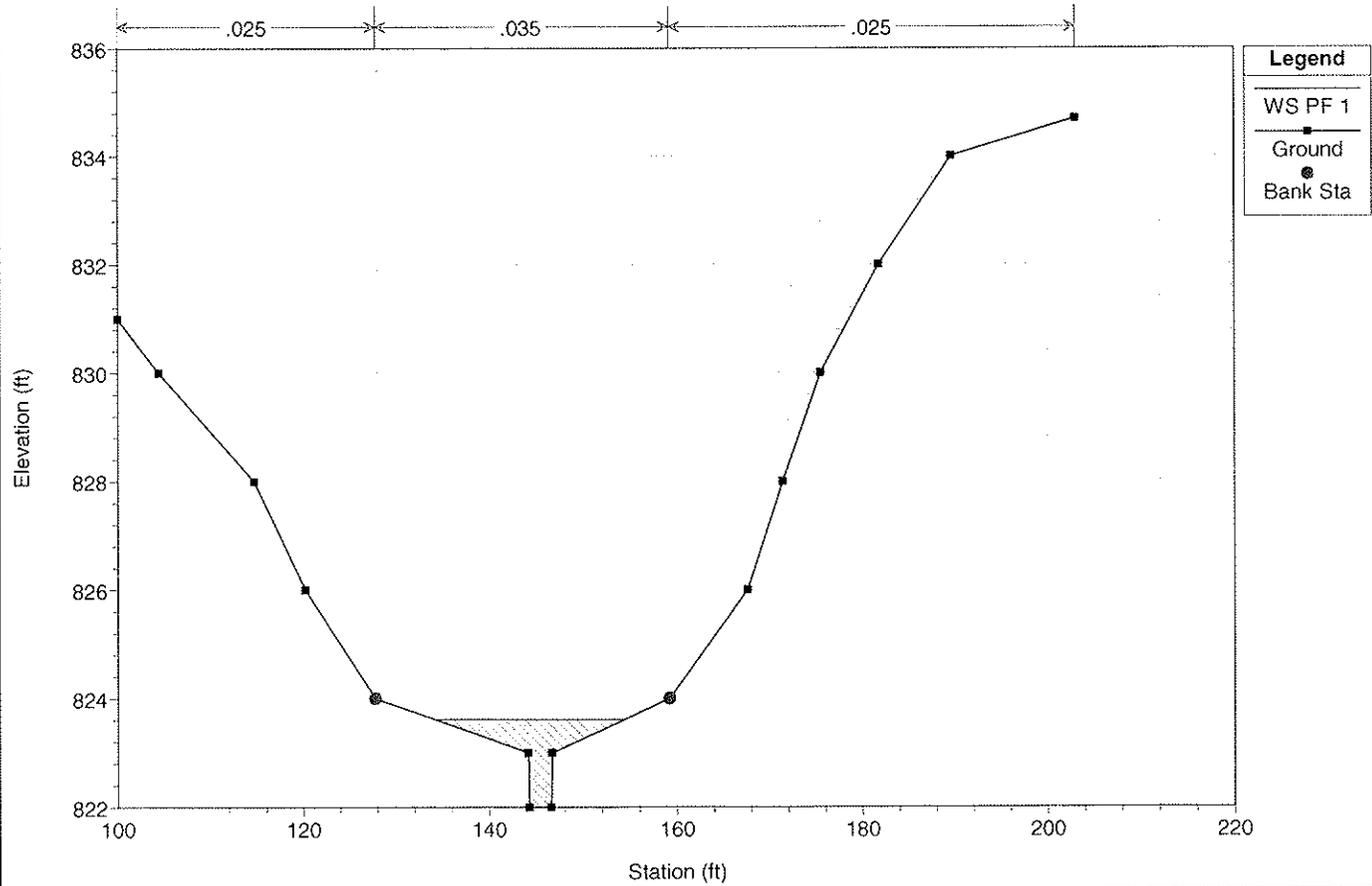
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 155



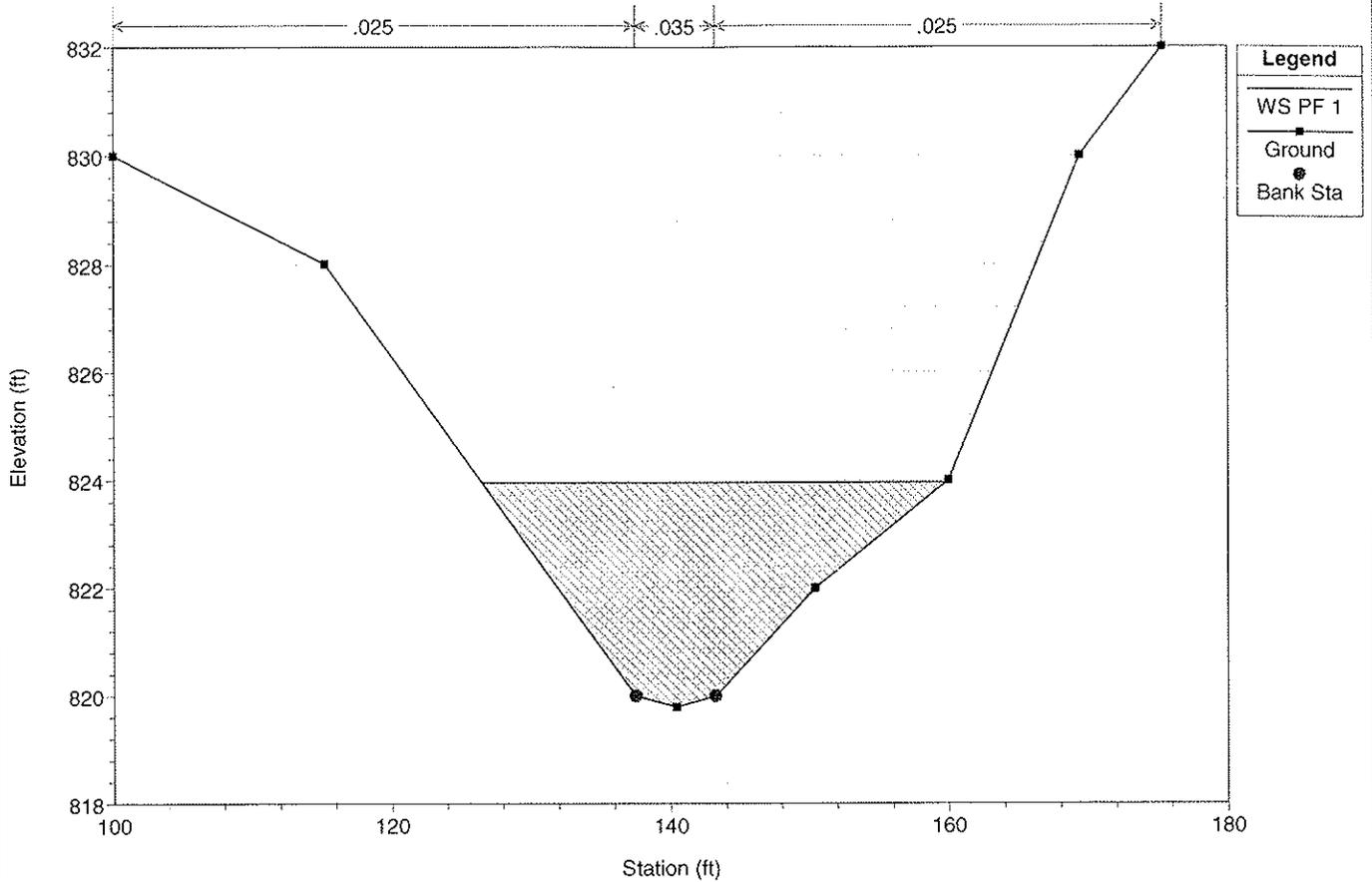
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 150



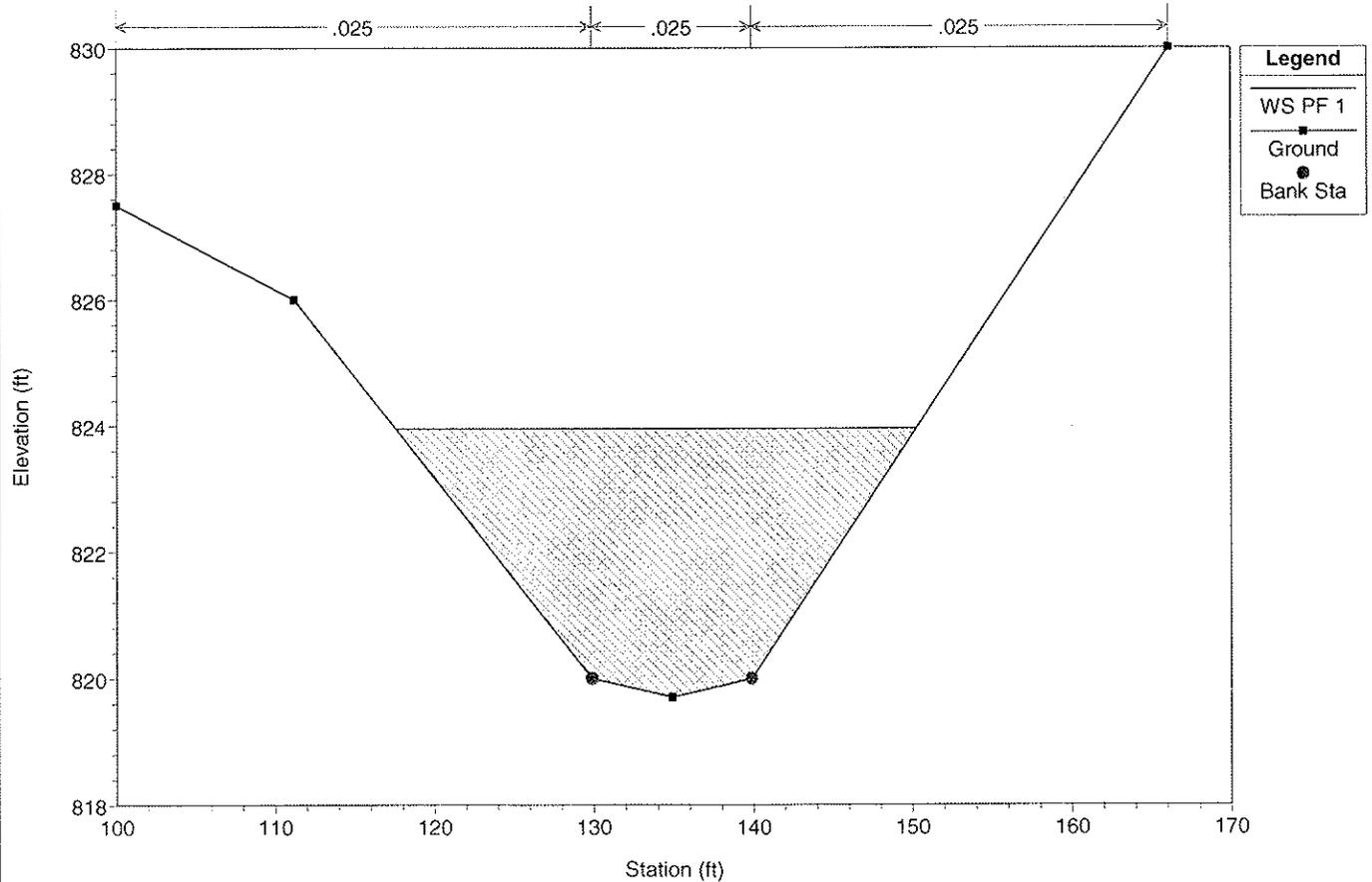
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 125



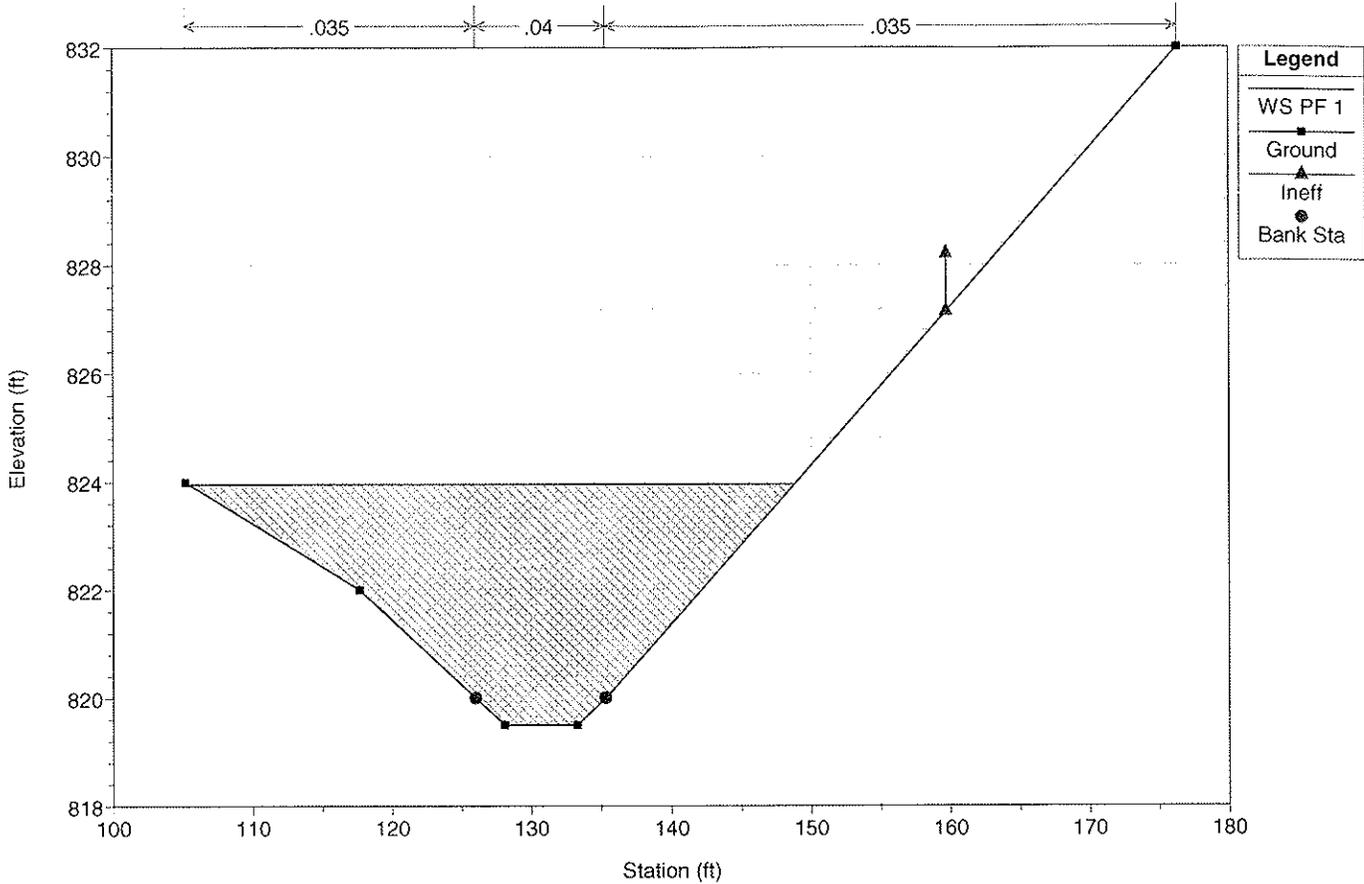
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 100



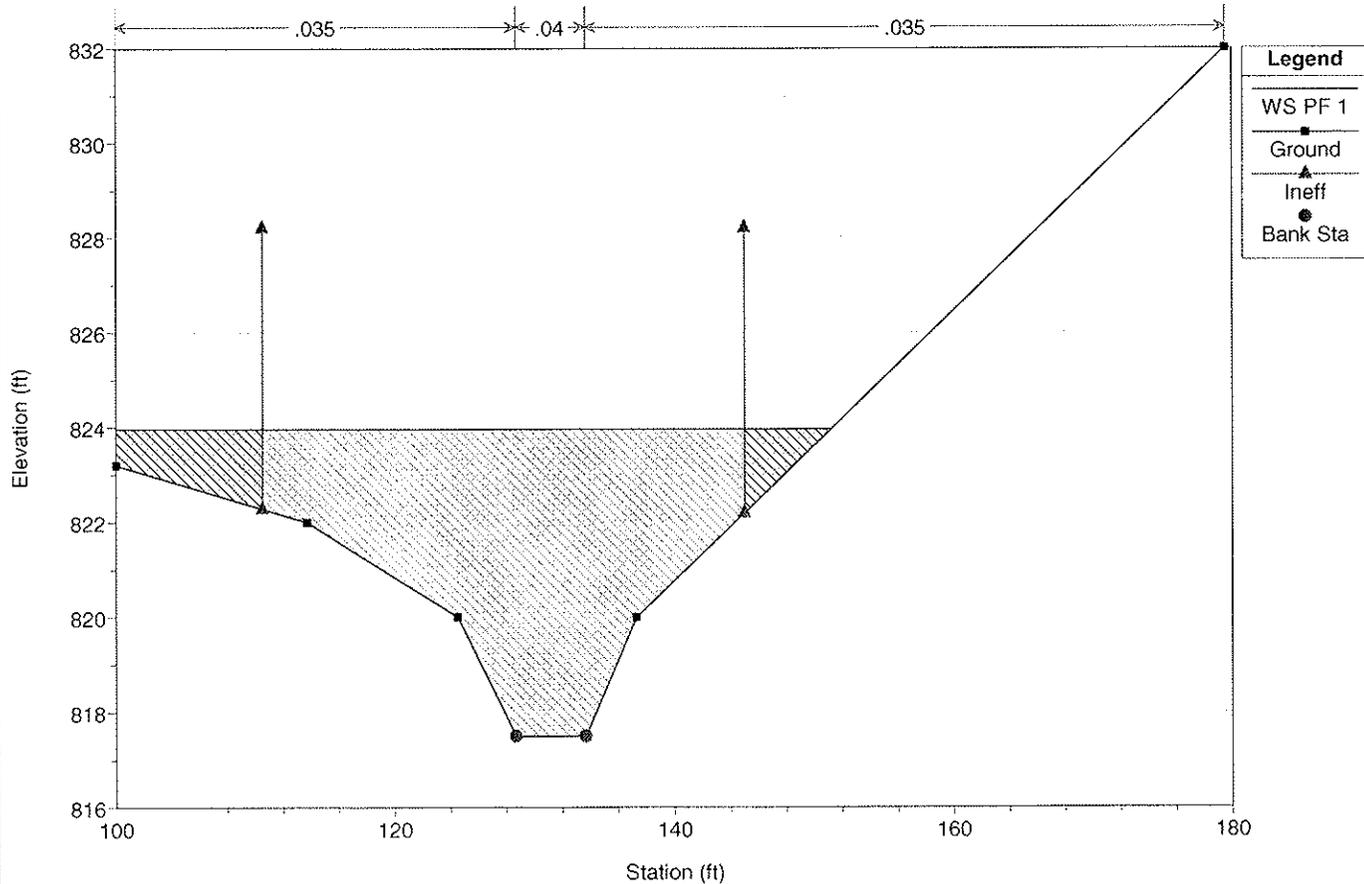
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 50



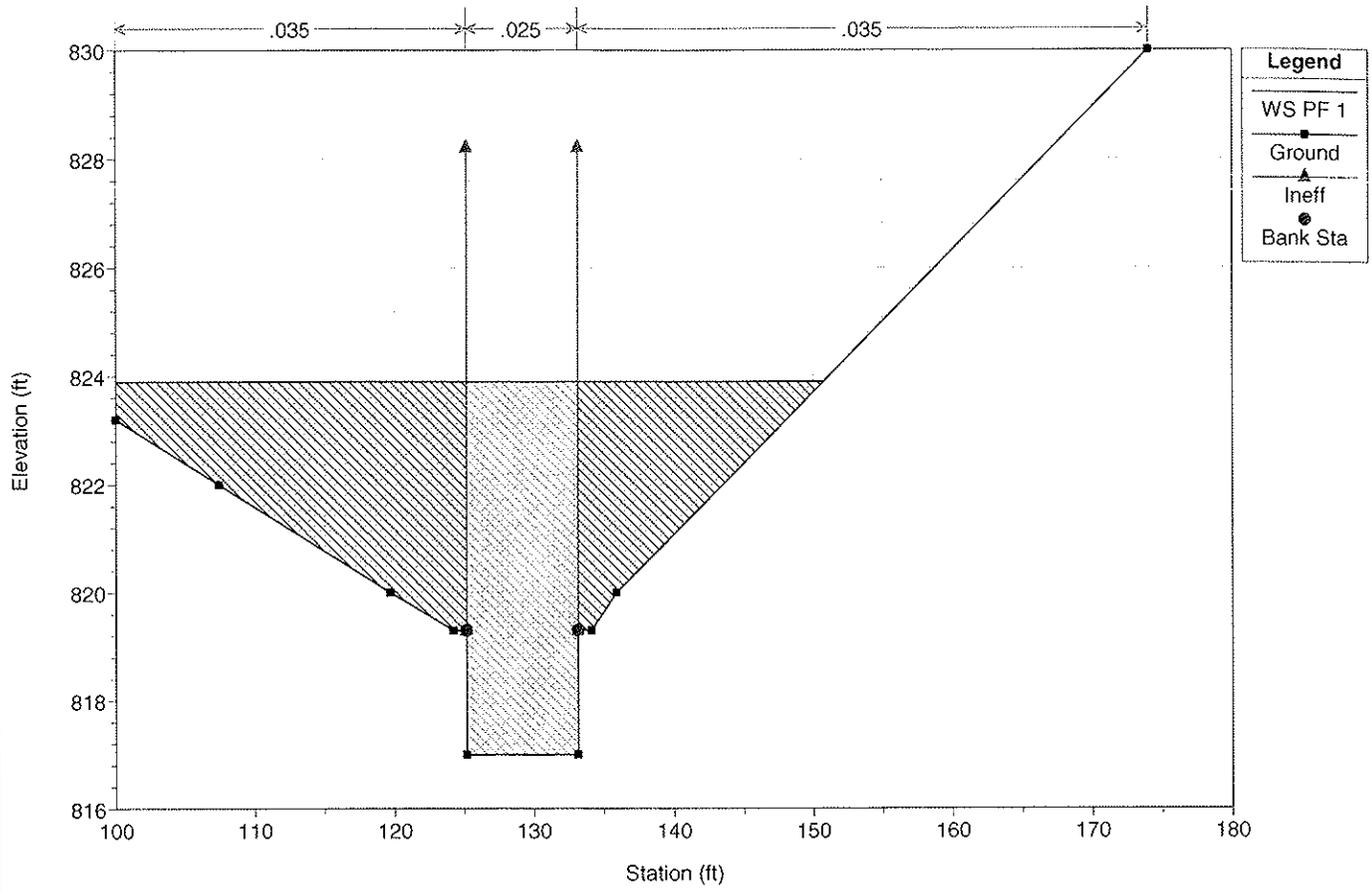
BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 40



BENTON Plan: 100-yr Exist 2/19/2009

River = BENTON Reach = BENTON RS = 30



HEC-RAS River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 215 | PF 1 | 2-yr PROP | 44.30 | 873.50 | 874.54 | 874.74 | 875.21 | 0.060031 | 6.55 | 6.76 | 10.84 | 1.46 | |
| BENTON | 215 | PF 1 | 2-yr Exist | 44.30 | 873.50 | 874.54 | 874.74 | 875.21 | 0.060031 | 6.55 | 6.76 | 10.84 | 1.46 | |
| BENTON | 210 | PF 1 | 2-yr PROP | 44.30 | 870.80 | 872.73 | 872.10 | 872.81 | 0.003524 | 2.30 | 19.25 | 17.60 | 0.39 | |
| BENTON | 210 | PF 1 | 2-yr Exist | 44.30 | 870.80 | 872.75 | 872.10 | 872.83 | 0.003325 | 2.25 | 19.65 | 17.74 | 0.38 | |
| BENTON | 205 | PF 1 | 2-yr PROP | 44.30 | 871.30 | 872.15 | 872.12 | 872.35 | 0.023172 | 3.55 | 12.57 | 27.00 | 0.89 | |
| BENTON | 205 | PF 1 | 2-yr Exist | 44.30 | 871.30 | 872.12 | 872.12 | 872.35 | 0.030134 | 3.85 | 11.56 | 26.41 | 1.00 | |
| BENTON | 200 | PF 1 | 2-yr PROP | 44.30 | 868.00 | 869.62 | 869.62 | 870.04 | 0.031607 | 5.18 | 8.54 | 10.54 | 1.01 | |
| BENTON | 200 | PF 1 | 2-yr Exist | 44.30 | 866.00 | 867.35 | 867.62 | 868.23 | 0.085501 | 7.53 | 5.88 | 8.75 | 1.62 | |
| BENTON | 195 | PF 1 | 2-yr PROP | 44.30 | 862.00 | 862.78 | 863.10 | 863.89 | 0.182678 | 8.44 | 5.25 | 13.43 | 2.38 | |
| BENTON | 195 | PF 1 | 2-yr Exist | 44.30 | 860.00 | 860.82 | 861.10 | 861.73 | 0.054557 | 7.63 | 5.80 | 14.13 | 2.10 | |
| BENTON | 190 | PF 1 | 2-yr PROP | 44.30 | 852.00 | 853.13 | 853.47 | 854.20 | 0.111393 | 8.29 | 5.34 | 9.46 | 1.94 | |
| BENTON | 190 | PF 1 | 2-yr Exist | 44.30 | 850.00 | 850.82 | 851.47 | 854.60 | 0.234641 | 15.60 | 2.84 | 6.90 | 4.28 | |
| BENTON | 185 | PF 1 | 2-yr PROP | 44.30 | 842.00 | 843.01 | 843.75 | 846.96 | 0.495862 | 15.94 | 2.78 | 5.48 | 3.94 | |
| BENTON | 185 | PF 1 | 2-yr Exist | 44.30 | 840.00 | 841.06 | 841.75 | 844.36 | 0.390683 | 14.57 | 3.04 | 5.73 | 3.53 | |
| BENTON | 180 | PF 1 | 2-yr PROP | 44.30 | 840.10 | 841.26 | 841.64 | 842.50 | 0.125704 | 8.94 | 4.95 | 8.54 | 2.07 | |
| BENTON | 180 | PF 1 | 2-yr Exist | 44.30 | 838.10 | 839.27 | 839.64 | 840.47 | 0.120072 | 8.79 | 5.04 | 8.62 | 2.03 | |
| BENTON | 175 | PF 1 | 2-yr PROP | 44.30 | 838.60 | 840.16 | 840.17 | 840.56 | 0.027443 | 5.09 | 8.70 | 11.10 | 1.01 | |
| BENTON | 175 | PF 1 | 2-yr Exist | 44.30 | 836.60 | 838.03 | 838.17 | 838.60 | 0.024245 | 6.03 | 7.35 | 10.24 | 1.25 | |
| BENTON | 170 | PF 1 | 2-yr PROP | 44.30 | 836.00 | 836.80 | 837.07 | 837.71 | 0.146053 | 7.67 | 5.77 | 14.43 | 2.14 | |
| BENTON | 170 | PF 1 | 2-yr Exist | 44.30 | 834.00 | 834.75 | 835.08 | 835.91 | 0.152200 | 8.61 | 5.14 | 13.63 | 2.47 | |
| BENTON | 165 | PF 1 | 2-yr PROP | 44.30 | 832.10 | 833.24 | 833.27 | 833.57 | 0.032672 | 4.59 | 9.65 | 16.89 | 1.07 | |
| BENTON | 165 | PF 1 | 2-yr Exist | 44.30 | 830.10 | 831.12 | 831.27 | 831.63 | 0.033300 | 5.74 | 7.72 | 15.11 | 1.42 | |
| BENTON | 160 | PF 1 | 2-yr PROP | 44.30 | 829.20 | 829.93 | 830.14 | 830.59 | 0.100676 | 6.50 | 6.82 | 16.60 | 1.79 | |
| BENTON | 160 | PF 1 | 2-yr Exist | 44.30 | 828.00 | 828.75 | 828.94 | 829.36 | 0.051198 | 6.25 | 7.09 | 16.93 | 1.70 | |
| BENTON | 155 | PF 1 | 2-yr PROP | 44.30 | 827.50 | 828.22 | 828.22 | 828.42 | 0.032871 | 3.58 | 12.39 | 31.97 | 1.01 | |
| BENTON | 155 | PF 1 | 2-yr Exist | 44.30 | 826.00 | 827.63 | 827.63 | 827.84 | 0.018149 | 3.64 | 12.18 | 28.43 | 0.98 | |
| BENTON | 153 | PF 1 | 2-yr PROP | 44.30 | 824.00 | 824.35 | 824.61 | 825.36 | 0.291054 | 8.06 | 5.52 | 22.22 | 2.81 | |

HEC-RAS River: BENTON Reach: BENTON Profile: PF 1 (Continued)

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 150 | PF 1 | 2-yr PROP | 44.30 | 822.00 | 823.62 | 823.69 | 823.96 | 0.036825 | 4.63 | 9.57 | 20.52 | 1.19 | |
| BENTON | 150 | PF 1 | 2-yr Exist | 44.30 | 822.00 | 823.27 | 823.69 | 825.06 | 0.268450 | 10.72 | 4.13 | 10.31 | 2.99 | |
| BENTON | 125 | PF 1 | 2-yr PROP | 44.30 | 819.80 | 820.55 | 820.96 | 821.99 | 0.098561 | 9.98 | 4.67 | 9.21 | 2.18 | |
| BENTON | 125 | PF 1 | 2-yr Exist | 44.30 | 819.80 | 820.67 | 820.96 | 821.59 | 0.050297 | 8.01 | 5.85 | 10.00 | 1.60 | |
| BENTON | 100 | PF 1 | 2-yr PROP | 44.30 | 819.70 | 820.99 | 820.68 | 821.16 | 0.002800 | 3.43 | 14.19 | 15.67 | 0.57 | |
| BENTON | 100 | PF 1 | 2-yr Exist | 44.30 | 819.70 | 820.99 | 820.68 | 821.16 | 0.002800 | 3.43 | 14.19 | 15.67 | 0.57 | |
| BENTON | 50 | PF 1 | 2-yr PROP | 44.30 | 819.50 | 820.51 | 820.51 | 820.88 | 0.021065 | 4.99 | 9.39 | 13.18 | 0.93 | |
| BENTON | 50 | PF 1 | 2-yr Exist | 44.30 | 819.50 | 820.51 | 820.51 | 820.88 | 0.021065 | 4.99 | 9.39 | 13.18 | 0.93 | |
| BENTON | 40 | PF 1 | 2-yr PROP | 44.30 | 817.50 | 820.10 | 818.71 | 820.16 | 0.001043 | 2.27 | 23.55 | 13.68 | 0.25 | |
| BENTON | 40 | PF 1 | 2-yr Exist | 44.30 | 817.50 | 820.10 | 818.71 | 820.16 | 0.001043 | 2.27 | 23.55 | 13.68 | 0.25 | |
| BENTON | 30 | PF 1 | 2-yr PROP | 44.30 | 817.00 | 820.10 | 817.99 | 820.15 | 0.000366 | 1.79 | 24.80 | 17.20 | 0.18 | |
| BENTON | 30 | PF 1 | 2-yr Exist | 44.30 | 817.00 | 820.10 | 817.99 | 820.15 | 0.000366 | 1.79 | 24.80 | 17.20 | 0.18 | |

HEC-RAS River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|--------|-----------|---------|-------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| BENTON | 215 | PF 1 | 10-yr PROP | 68.90 | 873.50 | 874.76 | 875.02 | 875.62 | 0.060045 | 7.44 | 9.27 | 12.25 | 1.51 |
| BENTON | 215 | PF 1 | 10-yr Exist | 68.90 | 873.50 | 874.76 | 875.02 | 875.62 | 0.060045 | 7.44 | 9.27 | 12.25 | 1.51 |
| BENTON | 210 | PF 1 | 10-yr PROP | 68.90 | 870.80 | 872.99 | 872.35 | 873.12 | 0.004566 | 2.87 | 24.03 | 19.14 | 0.45 |
| BENTON | 210 | PF 1 | 10-yr Exist | 68.90 | 870.80 | 873.01 | 872.35 | 873.13 | 0.004367 | 2.82 | 24.41 | 19.26 | 0.44 |
| BENTON | 205 | PF 1 | 10-yr PROP | 68.90 | 871.30 | 872.32 | 872.28 | 872.57 | 0.021199 | 4.07 | 17.19 | 29.56 | 0.89 |
| BENTON | 205 | PF 1 | 10-yr Exist | 68.90 | 871.30 | 872.28 | 872.28 | 872.57 | 0.025782 | 4.33 | 16.13 | 28.99 | 0.97 |
| BENTON | 200 | PF 1 | 10-yr PROP | 68.90 | 868.00 | 869.94 | 869.94 | 870.43 | 0.029478 | 5.64 | 12.22 | 12.60 | 1.01 |
| BENTON | 200 | PF 1 | 10-yr Exist | 68.90 | 866.00 | 867.57 | 867.94 | 868.72 | 0.091295 | 8.62 | 7.99 | 10.19 | 1.72 |
| BENTON | 195 | PF 1 | 10-yr PROP | 68.90 | 862.00 | 862.90 | 863.31 | 864.39 | 0.202105 | 9.79 | 7.04 | 15.56 | 2.57 |
| BENTON | 195 | PF 1 | 10-yr Exist | 68.90 | 860.00 | 860.97 | 861.31 | 862.09 | 0.053585 | 8.47 | 8.14 | 16.73 | 2.14 |
| BENTON | 190 | PF 1 | 10-yr PROP | 68.90 | 852.00 | 853.35 | 853.75 | 854.61 | 0.103873 | 9.02 | 7.64 | 11.31 | 1.93 |
| BENTON | 190 | PF 1 | 10-yr Exist | 68.90 | 850.00 | 850.99 | 851.75 | 855.29 | 0.207297 | 16.63 | 4.14 | 8.33 | 4.15 |
| BENTON | 185 | PF 1 | 10-yr PROP | 68.90 | 842.00 | 843.22 | 844.08 | 847.83 | 0.455200 | 17.23 | 4.00 | 6.57 | 3.89 |
| BENTON | 185 | PF 1 | 10-yr Exist | 68.90 | 840.00 | 841.24 | 842.08 | 845.58 | 0.420457 | 16.73 | 4.12 | 6.67 | 3.75 |
| BENTON | 180 | PF 1 | 10-yr PROP | 68.90 | 840.10 | 841.44 | 841.94 | 843.13 | 0.141330 | 10.44 | 6.60 | 9.86 | 2.25 |
| BENTON | 180 | PF 1 | 10-yr Exist | 68.90 | 838.10 | 839.44 | 839.94 | 841.11 | 0.138477 | 10.36 | 6.65 | 9.90 | 2.23 |
| BENTON | 175 | PF 1 | 10-yr PROP | 68.90 | 838.60 | 840.45 | 840.46 | 840.95 | 0.027155 | 5.68 | 12.14 | 13.05 | 1.04 |
| BENTON | 175 | PF 1 | 10-yr Exist | 68.90 | 836.60 | 838.28 | 838.47 | 839.01 | 0.025557 | 6.88 | 10.02 | 11.89 | 1.32 |
| BENTON | 170 | PF 1 | 10-yr PROP | 68.90 | 836.00 | 836.95 | 837.28 | 838.08 | 0.144841 | 8.54 | 8.06 | 17.06 | 2.19 |
| BENTON | 170 | PF 1 | 10-yr Exist | 68.90 | 834.00 | 834.90 | 835.29 | 836.27 | 0.142769 | 9.39 | 7.34 | 16.27 | 2.46 |
| BENTON | 165 | PF 1 | 10-yr PROP | 68.90 | 832.10 | 833.44 | 833.49 | 833.86 | 0.033146 | 5.24 | 13.18 | 19.75 | 1.11 |
| BENTON | 165 | PF 1 | 10-yr Exist | 68.90 | 830.10 | 831.30 | 831.49 | 831.95 | 0.034580 | 6.50 | 10.60 | 17.71 | 1.48 |
| BENTON | 160 | PF 1 | 10-yr PROP | 68.90 | 829.20 | 830.09 | 830.34 | 830.89 | 0.097244 | 7.17 | 9.61 | 19.66 | 1.81 |
| BENTON | 160 | PF 1 | 10-yr Exist | 68.90 | 828.00 | 828.90 | 829.14 | 829.65 | 0.050297 | 6.94 | 9.93 | 20.00 | 1.74 |
| BENTON | 155 | PF 1 | 10-yr PROP | 68.90 | 827.50 | 828.37 | 828.37 | 828.61 | 0.030895 | 3.90 | 17.65 | 38.12 | 1.01 |
| BENTON | 155 | PF 1 | 10-yr Exist | 68.90 | 826.00 | 827.76 | 827.79 | 828.04 | 0.021319 | 4.27 | 16.12 | 33.64 | 1.09 |
| BENTON | 153 | PF 1 | 10-yr PROP | 68.90 | 824.00 | 824.44 | 824.77 | 825.73 | 0.260316 | 9.14 | 7.58 | 23.55 | 2.78 |
| BENTON | 150 | PF 1 | 10-yr PROP | 68.90 | 823.77 | 823.89 | 823.89 | 824.21 | 0.041315 | 5.33 | 12.93 | 24.80 | 1.30 |
| BENTON | 150 | PF 1 | 10-yr Exist | 68.90 | 822.00 | 823.46 | 823.89 | 825.14 | 0.221984 | 10.40 | 6.82 | 15.82 | 2.83 |

HEC-RAS River: BENTON Reach: BENTON Profile: PF 1 (Continued)

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev. (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|-------------|------------------|-------------------|-------------------|-------------------|--------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 125 | PF 1 | 10-yr PROP | 68.90 | 819.80 | 820.78 | 821.25 | 822.34 | 0.072771 | 10.51 | 6.97 | 10.69 | 1.97 | |
| BENTON | 125 | PF 1 | 10-yr Exist | 68.90 | 819.80 | 820.88 | 821.25 | 822.06 | 0.048175 | 9.16 | 8.02 | 11.30 | 1.63 | |
| BENTON | 100 | PF 1 | 10-yr PROP | 68.90 | 819.70 | 821.48 | 820.93 | 821.64 | 0.001773 | 3.46 | 22.60 | 18.50 | 0.48 | |
| BENTON | 100 | PF 1 | 10-yr Exist | 68.90 | 819.70 | 821.48 | 820.93 | 821.64 | 0.001773 | 3.46 | 22.60 | 18.50 | 0.48 | |
| BENTON | 50 | PF 1 | 10-yr PROP | 68.90 | 819.50 | 821.39 | 820.79 | 821.54 | 0.003686 | 3.29 | 23.88 | 19.83 | 0.43 | |
| BENTON | 50 | PF 1 | 10-yr Exist | 68.90 | 819.50 | 821.39 | 820.79 | 821.54 | 0.003686 | 3.29 | 23.88 | 19.83 | 0.43 | |
| BENTON | 40 | PF 1 | 10-yr PROP | 68.90 | 817.50 | 821.43 | 819.07 | 821.47 | 0.000417 | 1.89 | 49.70 | 25.56 | 0.17 | |
| BENTON | 40 | PF 1 | 10-yr Exist | 68.90 | 817.50 | 821.43 | 819.07 | 821.47 | 0.000417 | 1.89 | 49.70 | 25.56 | 0.17 | |
| BENTON | 30 | PF 1 | 10-yr PROP | 68.90 | 817.00 | 821.40 | 818.32 | 821.46 | 0.000276 | 1.96 | 35.20 | 30.14 | 0.16 | |
| BENTON | 30 | PF 1 | 10-yr Exist | 68.90 | 817.00 | 821.40 | 818.32 | 821.46 | 0.000276 | 1.96 | 35.20 | 30.14 | 0.16 | |

HEC-RAS River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|--------|-----------|---------|-------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| BENTON | 215 | PF 1 | 50 YR PROP | 87.80 | 873.50 | 874.90 | 875.20 | 875.88 | 0.060042 | 7.96 | 11.03 | 13.15 | 1.53 |
| BENTON | 215 | PF 1 | 50-yr Exist | 87.80 | 873.50 | 874.90 | 875.20 | 875.88 | 0.060042 | 7.96 | 11.03 | 13.15 | 1.53 |
| BENTON | 210 | PF 1 | 50 YR PROP | 87.80 | 870.80 | 873.15 | 872.52 | 873.31 | 0.005283 | 3.24 | 27.12 | 20.07 | 0.49 |
| BENTON | 210 | PF 1 | 50-yr Exist | 87.80 | 870.80 | 873.17 | 872.52 | 873.33 | 0.005060 | 3.19 | 27.55 | 20.19 | 0.48 |
| BENTON | 205 | PF 1 | 50 YR PROP | 87.80 | 871.30 | 872.42 | 872.39 | 872.72 | 0.020290 | 4.38 | 20.43 | 31.23 | 0.89 |
| BENTON | 205 | PF 1 | 50-yr Exist | 87.80 | 871.30 | 872.39 | 872.39 | 872.71 | 0.023879 | 4.62 | 19.36 | 30.69 | 0.95 |
| BENTON | 200 | PF 1 | 50 YR PROP | 87.80 | 868.00 | 870.13 | 870.13 | 870.68 | 0.027623 | 6.00 | 14.69 | 13.90 | 1.00 |
| BENTON | 200 | PF 1 | 50-yr Exist | 87.80 | 866.00 | 867.71 | 868.11 | 869.03 | 0.092540 | 9.20 | 9.54 | 11.14 | 1.75 |
| BENTON | 195 | PF 1 | 50 YR PROP | 87.80 | 862.00 | 862.98 | 863.44 | 864.77 | 0.219870 | 10.74 | 8.18 | 16.77 | 2.71 |
| BENTON | 195 | PF 1 | 50-yr Exist | 87.80 | 860.00 | 861.06 | 861.44 | 862.33 | 0.054106 | 9.03 | 9.72 | 18.29 | 2.18 |
| BENTON | 190 | PF 1 | 50 YR PROP | 87.80 | 852.00 | 853.49 | 853.93 | 854.87 | 0.099028 | 9.41 | 9.33 | 12.50 | 1.92 |
| BENTON | 190 | PF 1 | 50-yr Exist | 87.80 | 850.00 | 851.11 | 851.93 | 855.65 | 0.190506 | 17.11 | 5.13 | 9.27 | 4.05 |
| BENTON | 185 | PF 1 | 50 YR PROP | 87.80 | 842.00 | 843.35 | 844.29 | 848.36 | 0.432988 | 17.97 | 4.89 | 7.26 | 3.86 |
| BENTON | 185 | PF 1 | 50-yr Exist | 87.80 | 840.00 | 841.35 | 842.29 | 846.32 | 0.427993 | 17.89 | 4.91 | 7.28 | 3.84 |
| BENTON | 180 | PF 1 | 50 YR PROP | 87.80 | 840.10 | 841.55 | 842.11 | 843.55 | 0.150422 | 11.35 | 7.74 | 10.68 | 2.35 |
| BENTON | 180 | PF 1 | 50-yr Exist | 87.80 | 838.10 | 839.55 | 840.11 | 841.55 | 0.149917 | 11.34 | 7.75 | 10.68 | 2.35 |
| BENTON | 175 | PF 1 | 50 YR PROP | 87.80 | 838.60 | 840.61 | 840.64 | 841.19 | 0.026969 | 6.14 | 14.32 | 14.15 | 1.05 |
| BENTON | 175 | PF 1 | 50-yr Exist | 87.80 | 836.60 | 838.42 | 838.65 | 839.28 | 0.026776 | 7.44 | 11.79 | 12.87 | 1.37 |
| BENTON | 170 | PF 1 | 50 YR PROP | 87.80 | 836.00 | 837.03 | 837.42 | 838.32 | 0.146267 | 9.11 | 9.64 | 18.65 | 2.23 |
| BENTON | 170 | PF 1 | 50-yr Exist | 87.80 | 834.00 | 835.00 | 835.42 | 836.49 | 0.136344 | 9.81 | 8.95 | 17.98 | 2.45 |
| BENTON | 165 | PF 1 | 50 YR PROP | 87.80 | 832.10 | 833.55 | 833.63 | 834.05 | 0.033392 | 5.65 | 15.63 | 21.50 | 1.14 |
| BENTON | 165 | PF 1 | 50-yr Exist | 87.80 | 830.10 | 831.40 | 831.64 | 832.16 | 0.035466 | 6.97 | 12.59 | 19.30 | 1.52 |
| BENTON | 160 | PF 1 | 50 YR PROP | 87.80 | 829.20 | 830.18 | 830.46 | 831.07 | 0.095824 | 7.58 | 11.59 | 21.57 | 1.82 |
| BENTON | 160 | PF 1 | 50-yr Exist | 87.80 | 828.00 | 829.00 | 829.27 | 829.84 | 0.049603 | 7.34 | 11.96 | 21.94 | 1.75 |
| BENTON | 155 | PF 1 | 50 YR PROP | 87.80 | 827.50 | 828.46 | 828.46 | 828.72 | 0.029629 | 4.08 | 21.50 | 42.06 | 1.01 |
| BENTON | 155 | PF 1 | 50-yr Exist | 87.80 | 826.00 | 827.88 | 827.89 | 828.17 | 0.018891 | 4.32 | 20.34 | 38.44 | 1.05 |
| BENTON | 153 | PF 1 | 50 YR PROP | 87.80 | 824.00 | 824.50 | 824.88 | 825.97 | 0.244193 | 9.75 | 9.05 | 24.46 | 2.76 |
| BENTON | 150 | PF 1 | 50 YR PROP | 87.80 | 822.00 | 823.86 | 823.99 | 824.38 | 0.044518 | 5.79 | 15.16 | 27.27 | 1.37 |
| BENTON | 150 | PF 1 | 50-yr Exist | 87.80 | 822.00 | 823.54 | 824.00 | 825.46 | 0.235309 | 11.14 | 7.88 | 17.98 | 2.96 |

HEC-RAS River: BENTON Reach: BENTON Profile: PF 1 (Continued)

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # Chl |
|--------|-----------|---------|-------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|--------------|
| BENTON | 125 | PF 1 | 50 YR PROP | 87.80 | 819.80 | 822.65 | 821.43 | 822.74 | 0.000947 | 2.56 | 38.41 | 23.42 | 0.27 |
| BENTON | 125 | PF 1 | 50-yr Exist | 87.80 | 819.80 | 822.65 | 821.43 | 822.74 | 0.000947 | 2.56 | 38.41 | 23.42 | 0.27 |
| BENTON | 100 | PF 1 | 50 YR PROP | 87.80 | 819.70 | 822.65 | | 822.71 | 0.000348 | 2.20 | 48.24 | 25.23 | 0.23 |
| BENTON | 100 | PF 1 | 50-yr Exist | 87.80 | 819.70 | 822.65 | | 822.71 | 0.000348 | 2.20 | 48.24 | 25.23 | 0.23 |
| BENTON | 50 | PF 1 | 50 YR PROP | 87.80 | 819.50 | 822.65 | 820.97 | 822.69 | 0.000634 | 1.94 | 55.14 | 30.67 | 0.20 |
| BENTON | 50 | PF 1 | 50-yr Exist | 87.80 | 819.50 | 822.65 | 820.97 | 822.69 | 0.000634 | 1.94 | 55.14 | 30.67 | 0.20 |
| BENTON | 40 | PF 1 | 50 YR PROP | 87.80 | 817.50 | 822.65 | 819.30 | 822.67 | 0.000157 | 1.39 | 87.76 | 40.41 | 0.11 |
| BENTON | 40 | PF 1 | 50-yr Exist | 87.80 | 817.50 | 822.65 | 819.30 | 822.67 | 0.000157 | 1.39 | 87.76 | 40.41 | 0.11 |
| BENTON | 30 | PF 1 | 50 YR PROP | 87.80 | 817.00 | 822.60 | 818.55 | 822.66 | 0.000200 | 1.96 | 44.80 | 42.11 | 0.15 |
| BENTON | 30 | PF 1 | 50-yr Exist | 87.80 | 817.00 | 822.60 | 818.55 | 822.66 | 0.000200 | 1.96 | 44.80 | 42.11 | 0.15 |

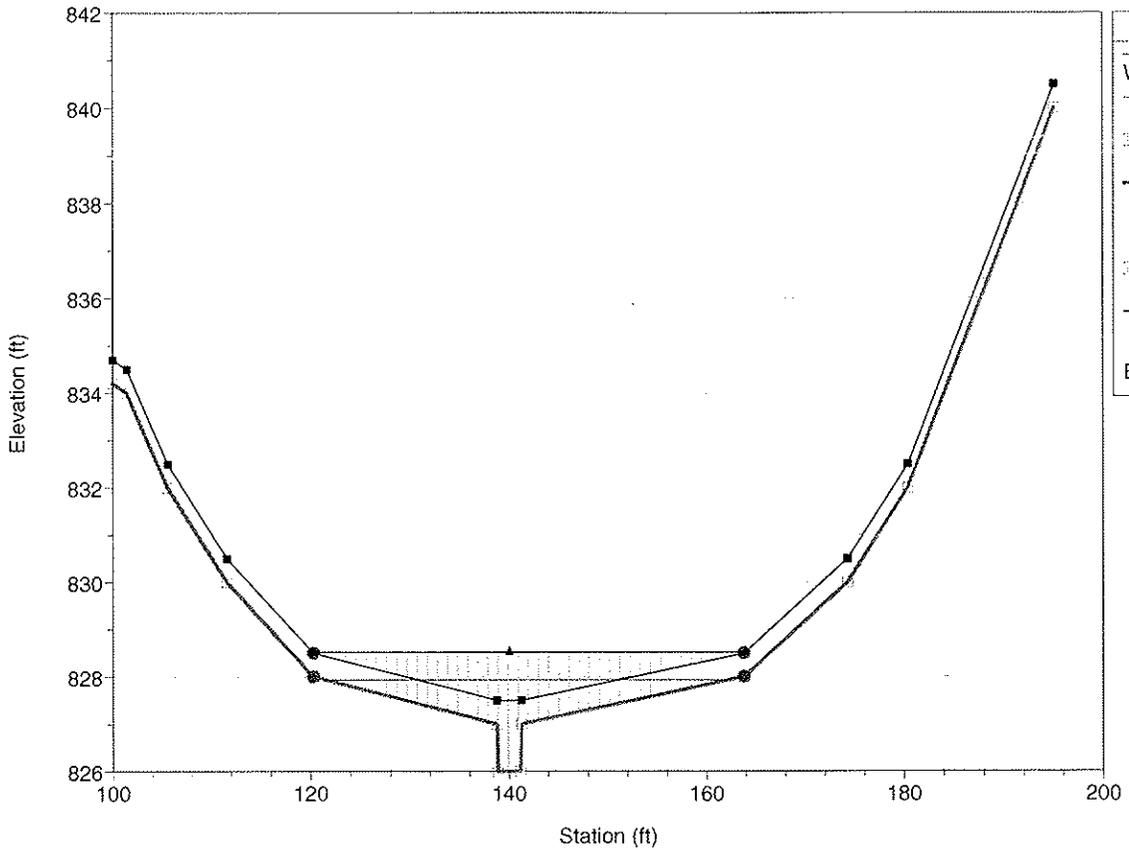
HEC-RAS River: BENTON Reach: BENTON Profile: PF 1

| Reach | River Sta | Profile | Plan | Q Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|--------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 215 | PF 1 | 100-yr PROP | 103.80 | 873.50 | 875.01 | 875.34 | 876.08 | 0.060045 | 8.33 | 12.46 | 13.84 | 1.55 | |
| BENTON | 215 | PF 1 | 100-yr Exist | 103.80 | 873.50 | 875.01 | 875.34 | 876.08 | 0.060045 | 8.33 | 12.46 | 13.84 | 1.55 | |
| BENTON | 210 | PF 1 | 100-yr PROP | 103.80 | 870.80 | 873.26 | 872.64 | 873.45 | 0.005898 | 3.53 | 29.40 | 20.73 | 0.52 | |
| BENTON | 210 | PF 1 | 100-yr Exist | 103.80 | 870.80 | 873.28 | 872.64 | 873.47 | 0.005619 | 3.47 | 29.92 | 20.87 | 0.51 | |
| BENTON | 205 | PF 1 | 100-yr PROP | 103.80 | 871.30 | 872.51 | 872.47 | 872.83 | 0.019441 | 4.59 | 23.13 | 32.55 | 0.88 | |
| BENTON | 205 | PF 1 | 100-yr Exist | 103.80 | 871.30 | 872.47 | 872.47 | 872.82 | 0.022663 | 4.82 | 21.99 | 32.00 | 0.95 | |
| BENTON | 200 | PF 1 | 100-yr PROP | 103.80 | 868.00 | 870.27 | 870.27 | 870.88 | 0.026370 | 6.30 | 16.70 | 14.90 | 0.99 | |
| BENTON | 200 | PF 1 | 100-yr Exist | 103.80 | 866.00 | 867.82 | 868.27 | 869.25 | 0.092518 | 9.60 | 10.82 | 11.86 | 1.77 | |
| BENTON | 195 | PF 1 | 100-yr PROP | 103.80 | 862.00 | 863.04 | 863.55 | 864.98 | 0.219811 | 11.20 | 9.27 | 17.86 | 2.74 | |
| BENTON | 195 | PF 1 | 100-yr Exist | 103.80 | 860.00 | 861.13 | 861.54 | 862.52 | 0.054571 | 9.45 | 10.99 | 19.44 | 2.21 | |
| BENTON | 190 | PF 1 | 100-yr PROP | 103.80 | 852.00 | 853.59 | 854.06 | 855.08 | 0.098913 | 9.81 | 10.58 | 13.31 | 1.94 | |
| BENTON | 190 | PF 1 | 100-yr Exist | 103.80 | 850.00 | 851.19 | 852.06 | 855.93 | 0.179873 | 17.46 | 5.94 | 9.98 | 3.99 | |
| BENTON | 185 | PF 1 | 100-yr PROP | 103.80 | 842.00 | 843.45 | 844.45 | 848.68 | 0.409929 | 18.36 | 5.65 | 7.81 | 3.80 | |
| BENTON | 185 | PF 1 | 100-yr Exist | 103.80 | 840.00 | 841.43 | 842.45 | 846.86 | 0.430433 | 18.70 | 5.55 | 7.74 | 3.89 | |
| BENTON | 180 | PF 1 | 100-yr PROP | 103.80 | 840.10 | 841.63 | 842.24 | 843.87 | 0.155774 | 11.99 | 8.66 | 11.29 | 2.41 | |
| BENTON | 180 | PF 1 | 100-yr Exist | 103.80 | 838.10 | 839.63 | 840.24 | 841.89 | 0.158076 | 12.06 | 8.61 | 11.26 | 2.43 | |
| BENTON | 175 | PF 1 | 100-yr PROP | 103.80 | 838.60 | 840.70 | 840.79 | 841.39 | 0.028168 | 6.64 | 15.71 | 14.81 | 1.09 | |
| BENTON | 175 | PF 1 | 100-yr Exist | 103.80 | 836.60 | 838.52 | 838.80 | 839.49 | 0.027857 | 7.88 | 13.17 | 13.58 | 1.41 | |
| BENTON | 170 | PF 1 | 100-yr PROP | 103.80 | 836.00 | 837.11 | 837.52 | 838.49 | 0.137436 | 9.43 | 11.02 | 19.94 | 2.20 | |
| BENTON | 170 | PF 1 | 100-yr Exist | 103.80 | 834.00 | 835.07 | 835.51 | 836.65 | 0.132082 | 10.11 | 10.27 | 19.26 | 2.44 | |
| BENTON | 165 | PF 1 | 100-yr PROP | 103.80 | 832.10 | 833.63 | 833.73 | 834.20 | 0.034575 | 6.06 | 17.29 | 22.61 | 1.17 | |
| BENTON | 165 | PF 1 | 100-yr Exist | 103.80 | 830.10 | 831.48 | 831.74 | 832.32 | 0.036114 | 7.32 | 14.18 | 20.48 | 1.55 | |
| BENTON | 160 | PF 1 | 100-yr PROP | 103.80 | 829.20 | 830.26 | 830.57 | 831.20 | 0.092273 | 7.79 | 13.32 | 23.11 | 1.81 | |
| BENTON | 160 | PF 1 | 100-yr Exist | 103.80 | 828.00 | 829.07 | 829.36 | 829.98 | 0.049293 | 7.64 | 13.59 | 23.37 | 1.77 | |
| BENTON | 155 | PF 1 | 100-yr PROP | 103.80 | 827.50 | 828.53 | 828.53 | 828.81 | 0.029503 | 4.30 | 24.12 | 43.75 | 1.02 | |
| BENTON | 155 | PF 1 | 100-yr Exist | 103.80 | 826.00 | 827.94 | 827.96 | 828.26 | 0.019705 | 4.56 | 22.75 | 40.92 | 1.08 | |
| BENTON | 153 | PF 1 | 100-yr PROP | 103.80 | 824.00 | 824.56 | 824.96 | 826.12 | 0.224808 | 10.07 | 10.37 | 25.24 | 2.70 | |
| BENTON | 150 | PF 1 | 100-yr PROP | 103.80 | 822.00 | 823.92 | 824.08 | 824.50 | 0.046797 | 6.14 | 16.91 | 29.07 | 1.42 | |
| BENTON | 150 | PF 1 | 100-yr Exist | 103.80 | 822.00 | 823.61 | 824.08 | 825.53 | 0.215039 | 11.11 | 9.34 | 20.19 | 2.88 | |

HEC-RAS, River: BENTON Reach: BENTON Profile: PF 1 (Continued)

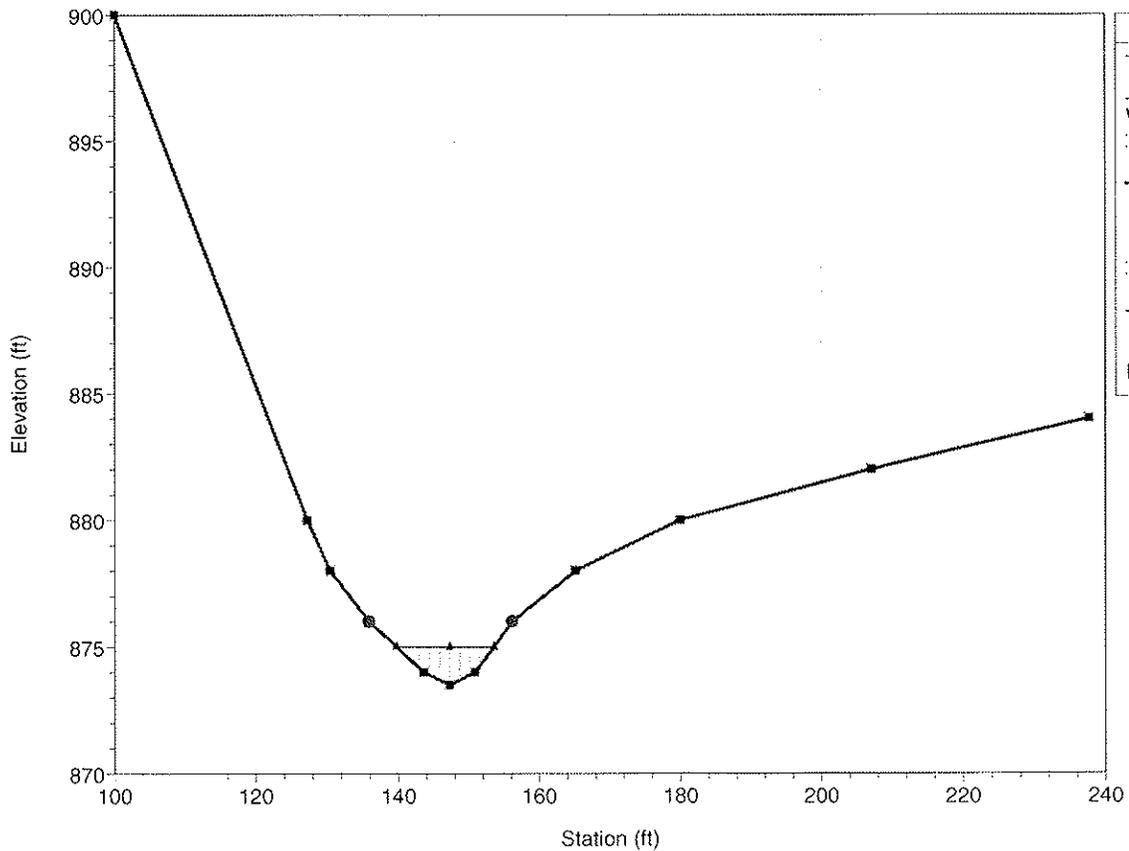
| Reach | River Sta | Profile | Plan | O Total (cfs) | Min Ch El (ft) | W.S. Elev (ft) | Crit W.S. (ft) | E.G. Elev (ft) | E.G. Slope (ft/ft) | Vel Chnl (ft/s) | Flow Area (sq ft) | Top Width (ft) | Froude # | Chl |
|--------|-----------|---------|--------------|------------------|-------------------|-------------------|-------------------|-------------------|-----------------------|--------------------|----------------------|-------------------|----------|-----|
| BENTON | 125 | PF 1 | 100-yr PROP | 103.80 | 819.80 | 823.96 | 821.58 | 823.99 | 0.000212 | 1.57 | 75.43 | 33.32 | 0.14 | |
| BENTON | 125 | PF 1 | 100-yr Exist | 103.80 | 819.80 | 823.96 | 821.58 | 823.99 | 0.000212 | 1.57 | 75.43 | 33.32 | 0.14 | |
| BENTON | 100 | PF 1 | 100-yr PROP | 103.80 | 819.70 | 823.96 | | 823.98 | 0.000102 | 1.54 | 85.92 | 32.69 | 0.13 | |
| BENTON | 100 | PF 1 | 100-yr Exist | 103.80 | 819.70 | 823.96 | | 823.98 | 0.000102 | 1.54 | 85.92 | 32.69 | 0.13 | |
| BENTON | 50 | PF 1 | 100-yr PROP | 103.80 | 819.50 | 823.96 | 821.11 | 823.97 | 0.000170 | 1.28 | 103.65 | 43.34 | 0.11 | |
| BENTON | 50 | PF 1 | 100-yr Exist | 103.80 | 819.50 | 823.96 | 821.11 | 823.97 | 0.000170 | 1.28 | 103.65 | 43.34 | 0.11 | |
| BENTON | 40 | PF 1 | 100-yr PROP | 103.80 | 817.50 | 823.96 | 819.48 | 823.97 | 0.000060 | 1.00 | 132.75 | 51.22 | 0.07 | |
| BENTON | 40 | PF 1 | 100-yr Exist | 103.80 | 817.50 | 823.96 | 819.48 | 823.97 | 0.000060 | 1.00 | 132.75 | 51.22 | 0.07 | |
| BENTON | 30 | PF 1 | 100-yr PROP | 103.80 | 817.00 | 823.90 | 818.73 | 823.96 | 0.000140 | 1.88 | 55.20 | 50.76 | 0.13 | |
| BENTON | 30 | PF 1 | 100-yr Exist | 103.80 | 817.00 | 823.90 | 818.73 | 823.96 | 0.000140 | 1.88 | 55.20 | 50.76 | 0.13 | |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 155



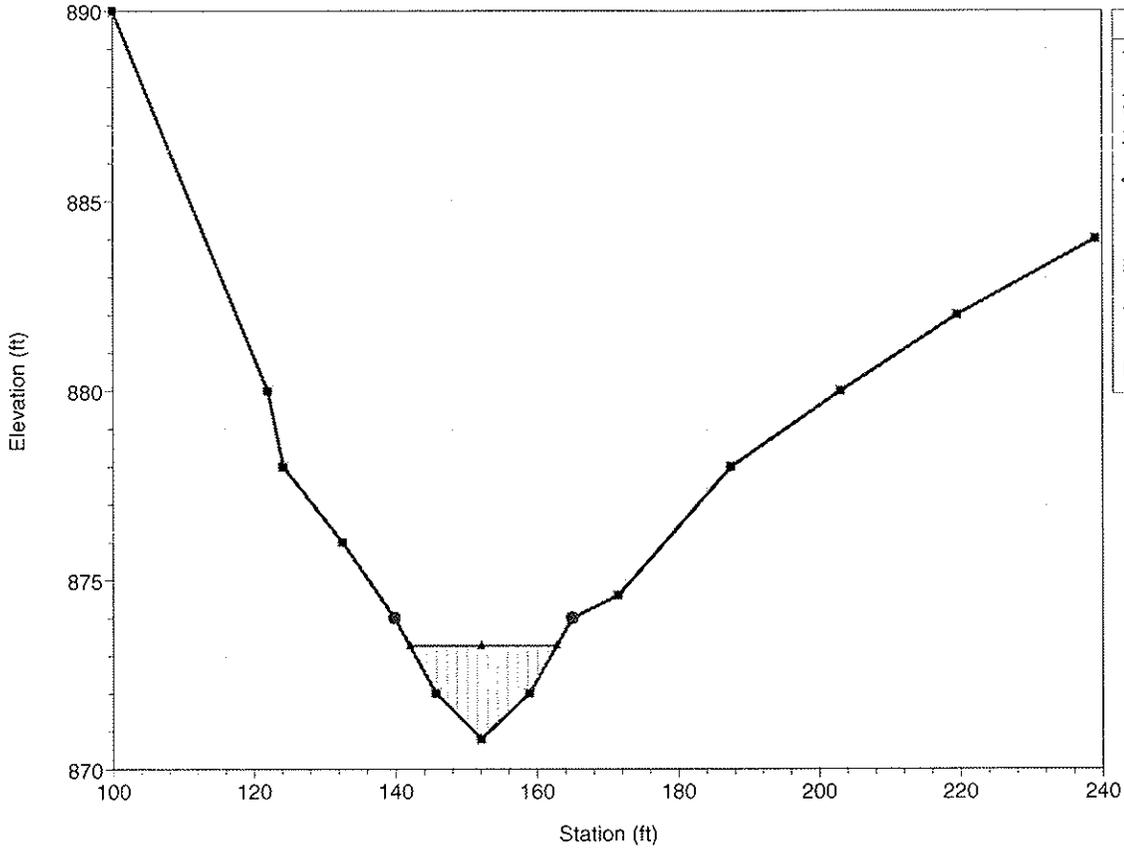
| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| □ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 215



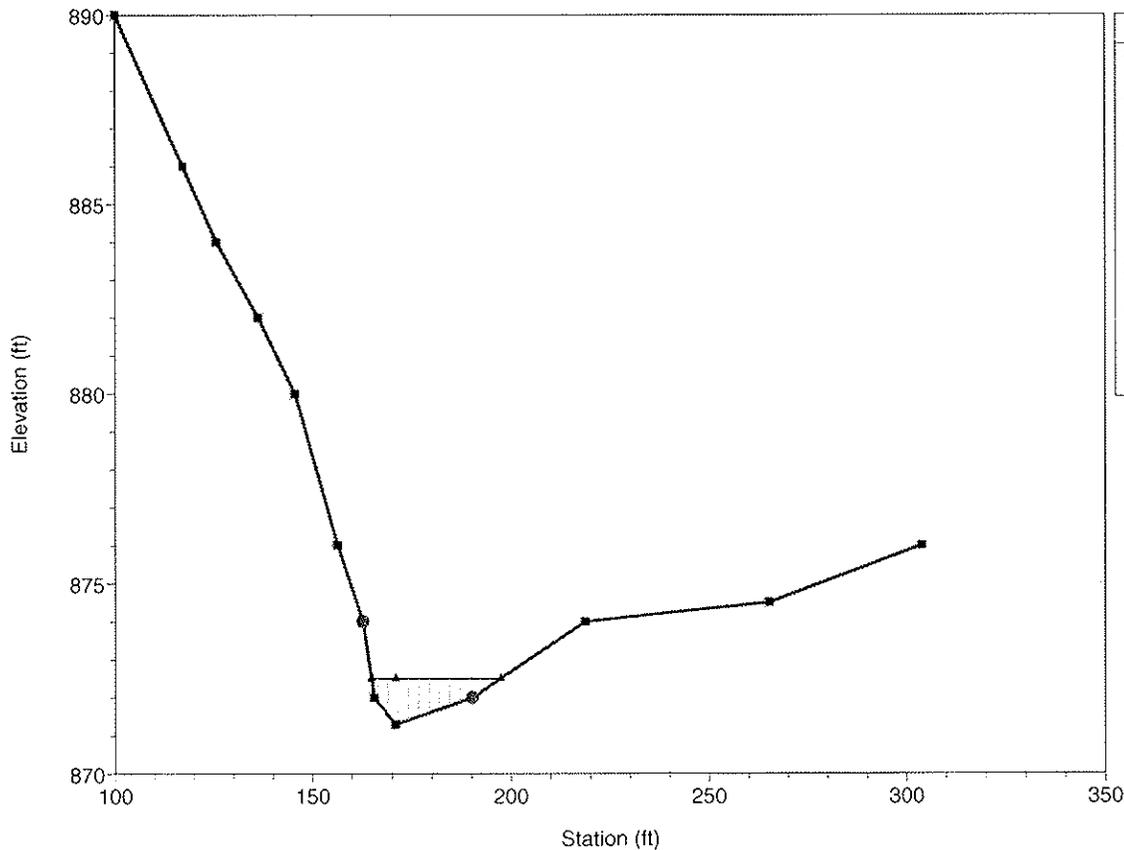
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|--------|-------------------------|
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| ○ | WS PF 1 - 100-yr PROP |
| □ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 210



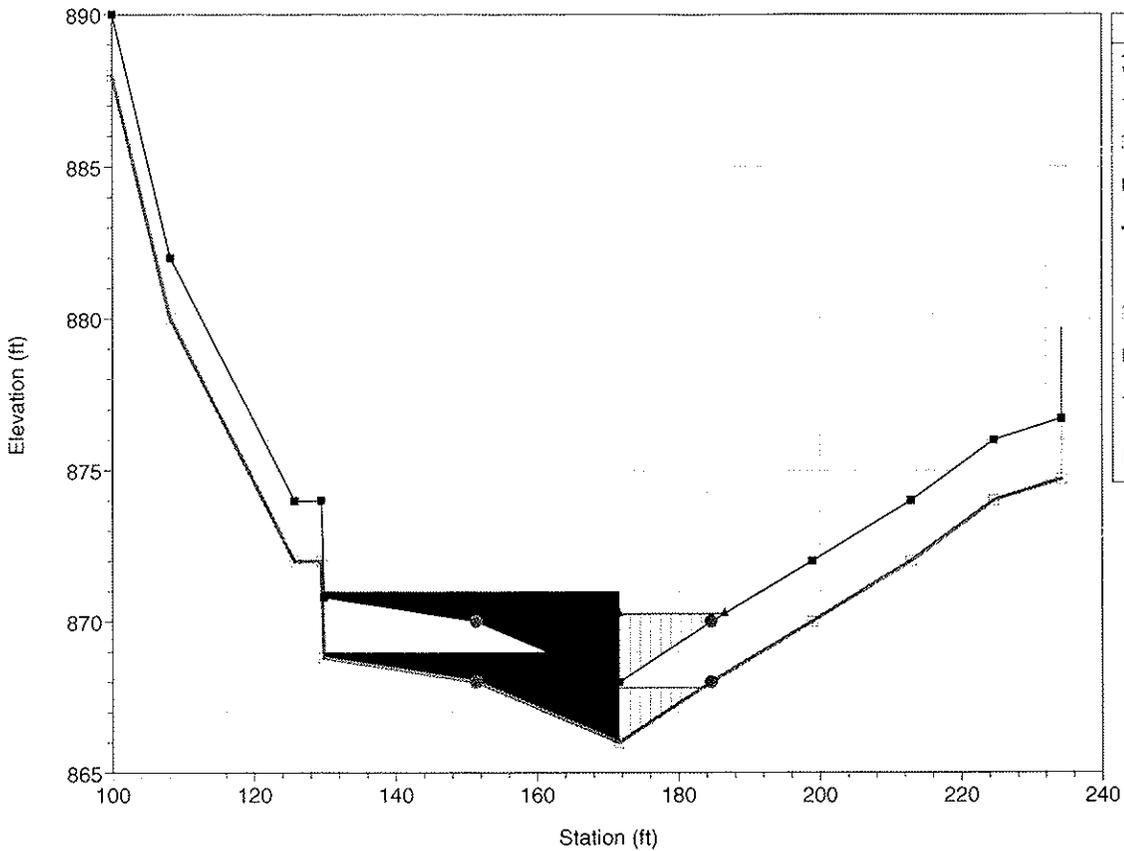
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|---------------------------------------|---|
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| WS PF 1 - 100-yr PROP - 100-yr Exist | ▬ |
| Ground - 100-yr Exist | ● |
| Bank Sta - 100-yr Exist - 100-yr PROP | ○ |
| Ground - 100-yr PROP | ■ |
| Bank Sta - 100-yr PROP | ● |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 205



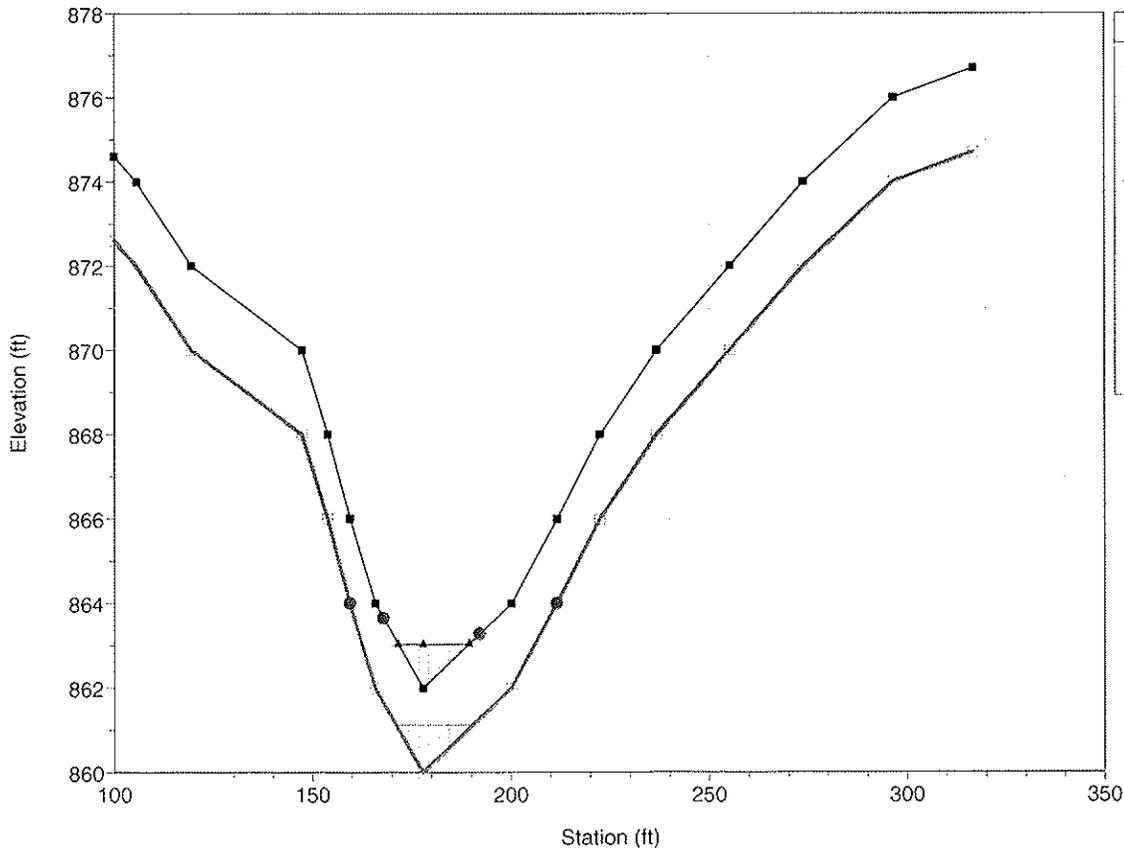
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|---------------------------------------|---|
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| WS PF 1 - 100-yr Exist - 100-yr Exist | ▬ |
| Ground - 100-yr Exist | ● |
| Bank Sta - 100-yr Exist - 100-yr PROP | ○ |
| Ground - 100-yr PROP | ■ |
| Bank Sta - 100-yr PROP | ● |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 200



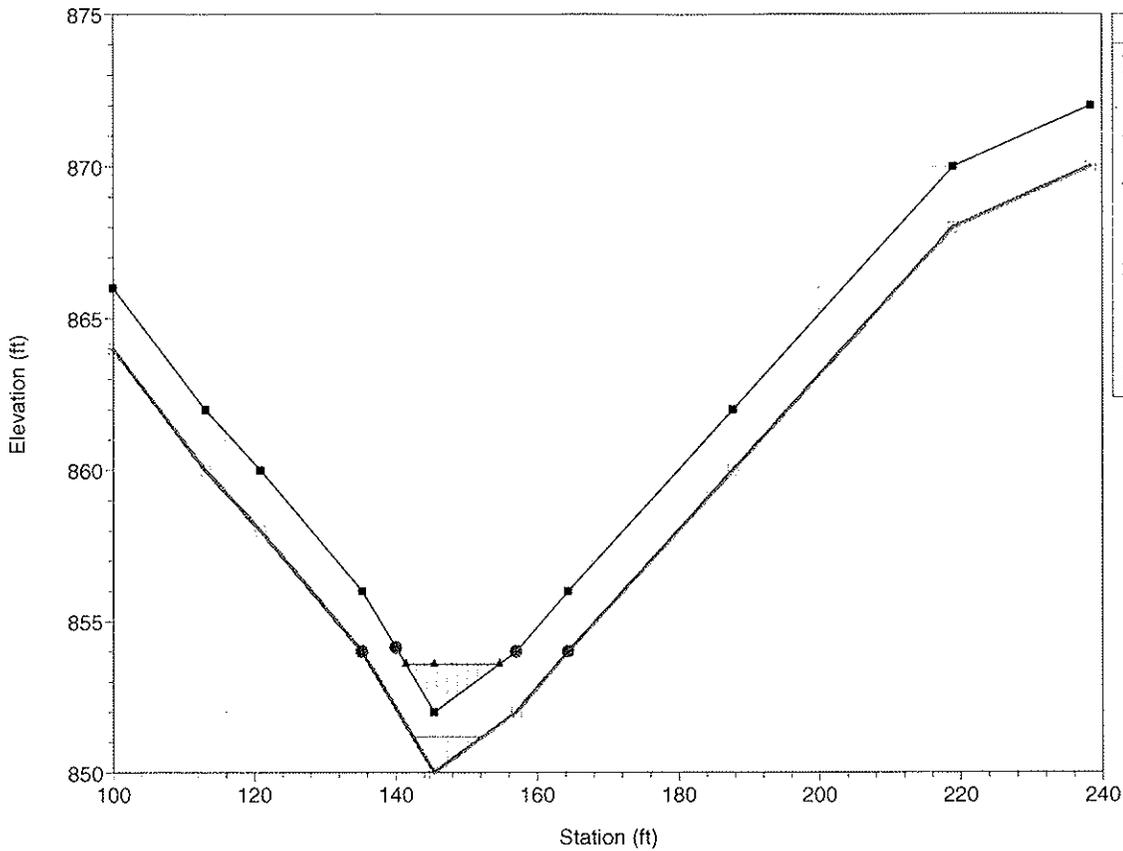
| Legend | |
|--------|-------------------------|
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| ○ | WS PF 1 - 100-yr Exist |
| ■ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 195



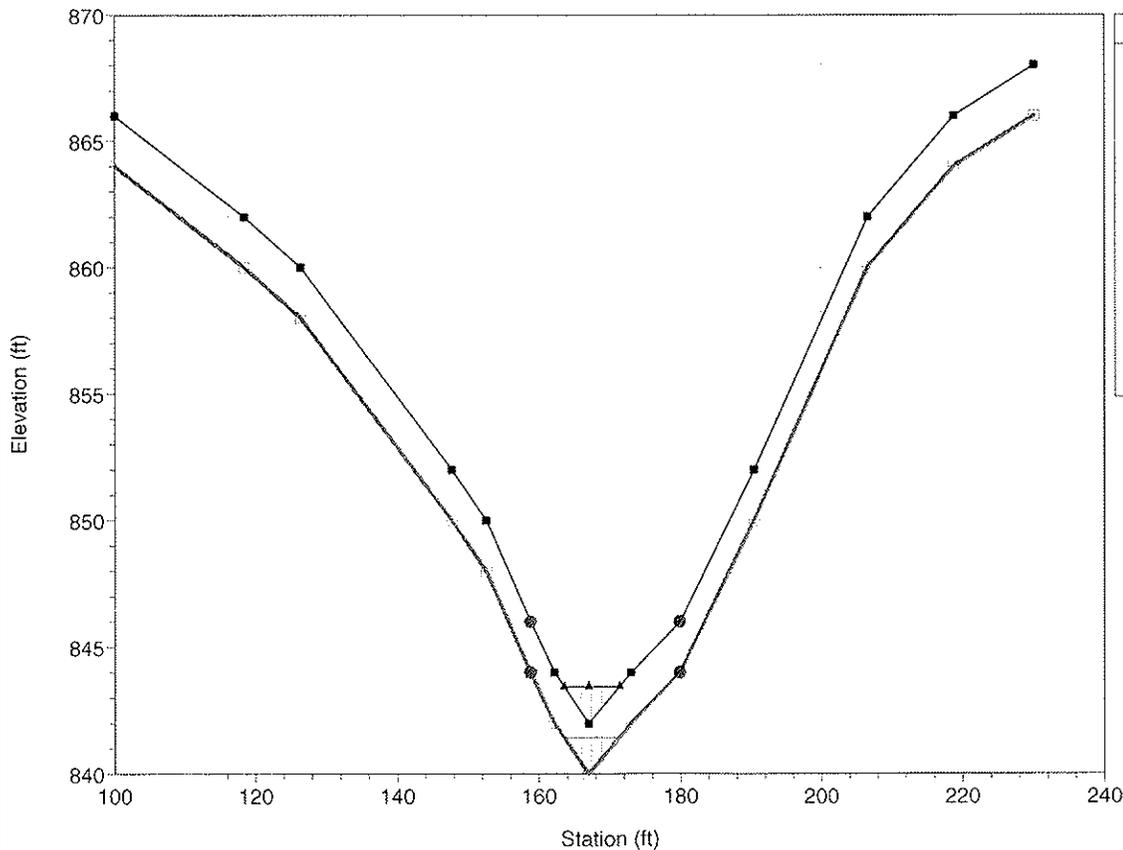
| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ■ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 190



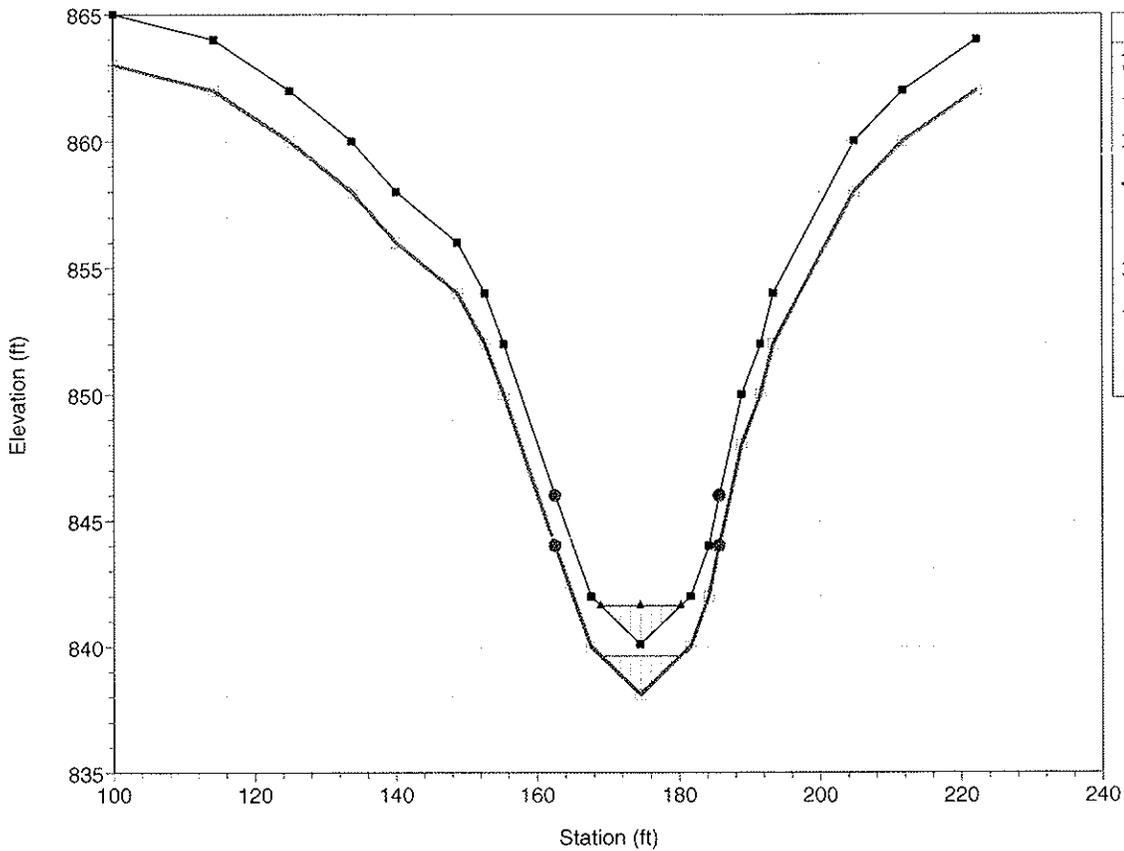
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|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ○ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ○ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 185



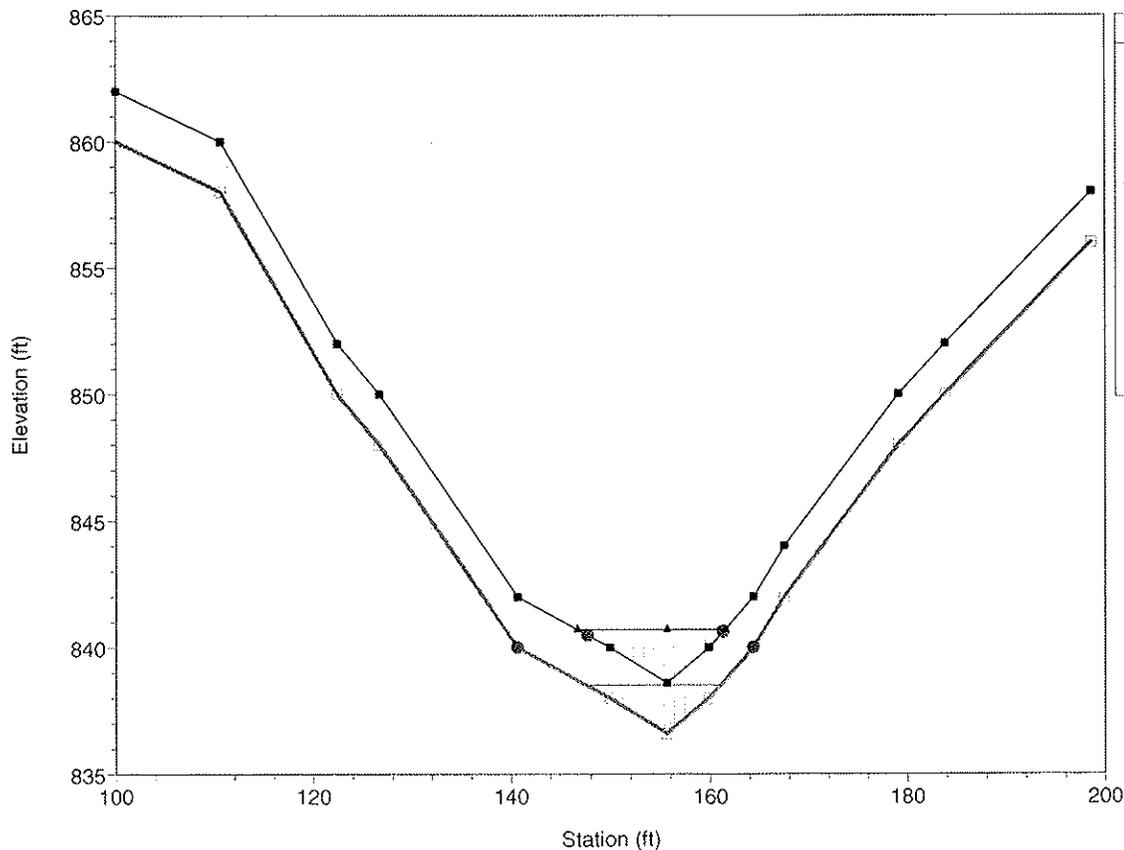
| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ○ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ○ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 180



| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ■ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

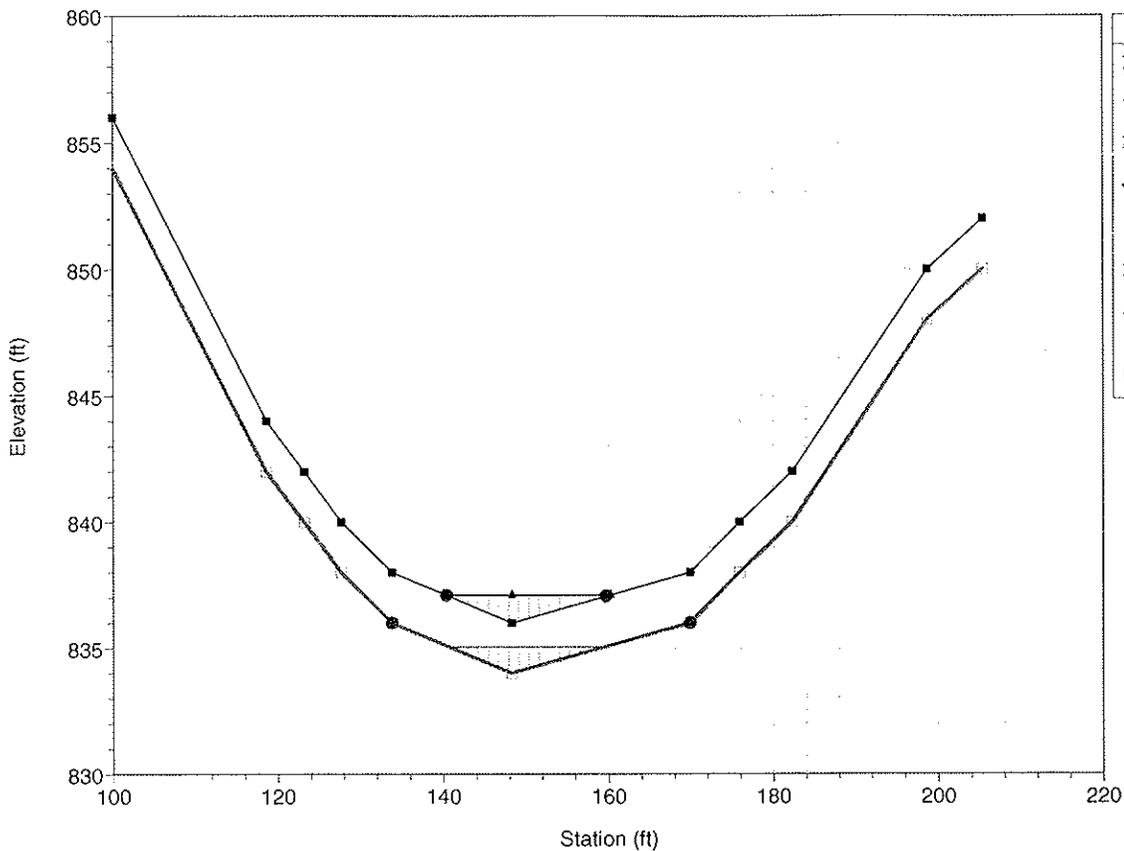
BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 175



| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ○ | WS PF 1 - 100-yr Exist |
| ■ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist

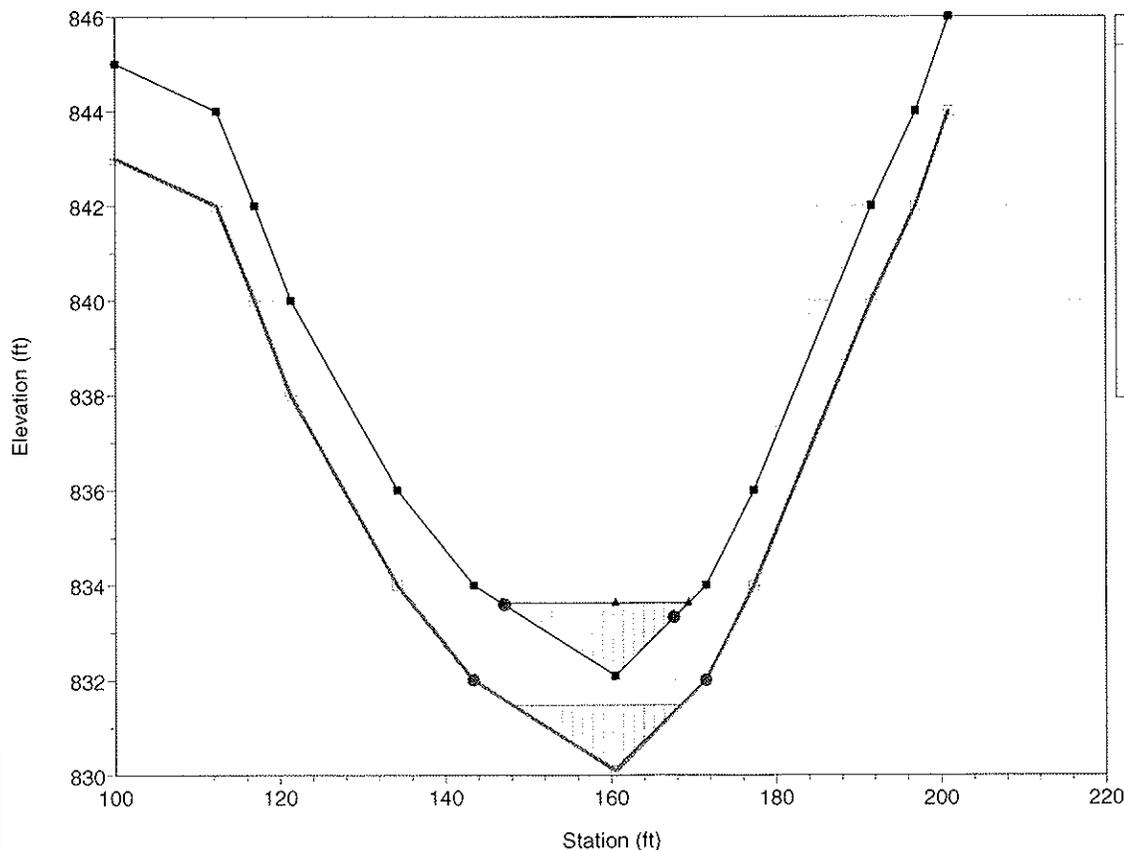
River = BENTON Reach = BENTON RS = 170



| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ● | WS PF 1 - 100-yr Exist |
| ----- | - 100-yr Exist |
| ■ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ----- | - 100-yr PROP |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

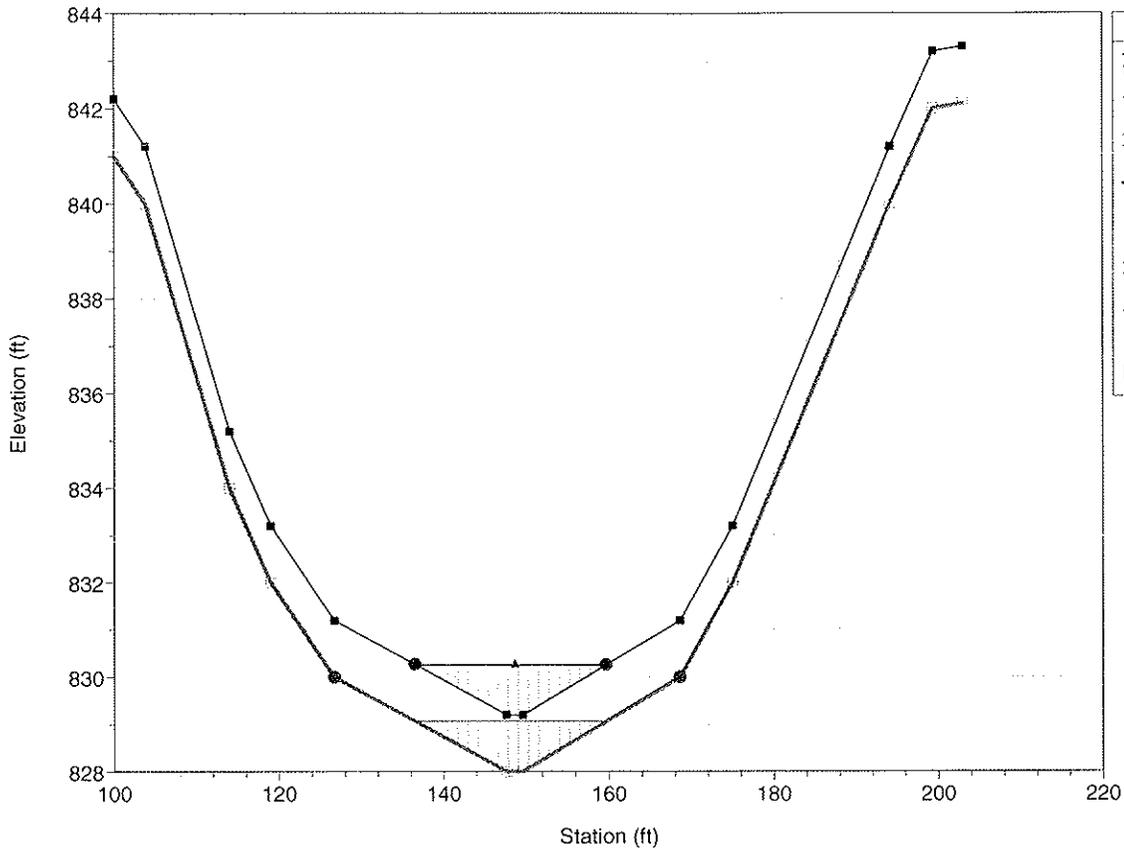
BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist

River = BENTON Reach = BENTON RS = 165



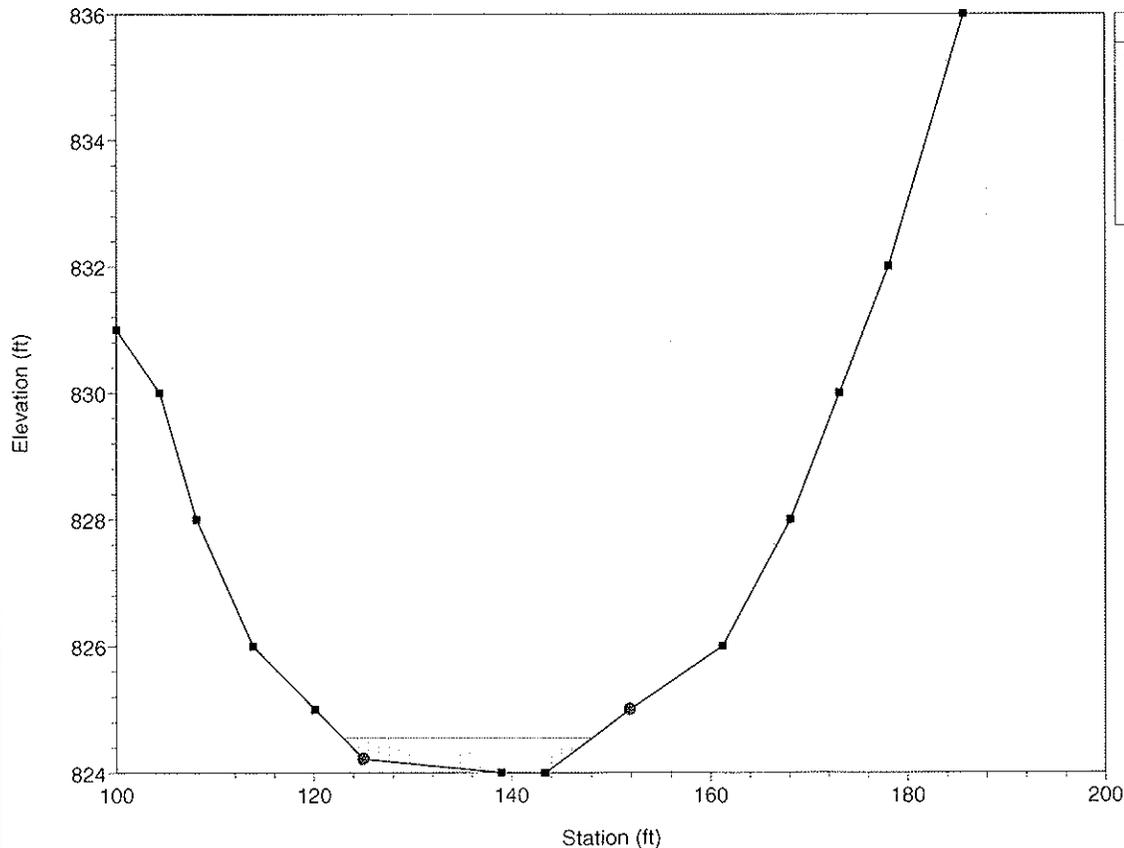
| Legend | |
|--------|-------------------------|
| ▲ | WS PF 1 - 100-yr PROP |
| ● | WS PF 1 - 100-yr Exist |
| ----- | - 100-yr Exist |
| ■ | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| ----- | - 100-yr PROP |
| ■ | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 160



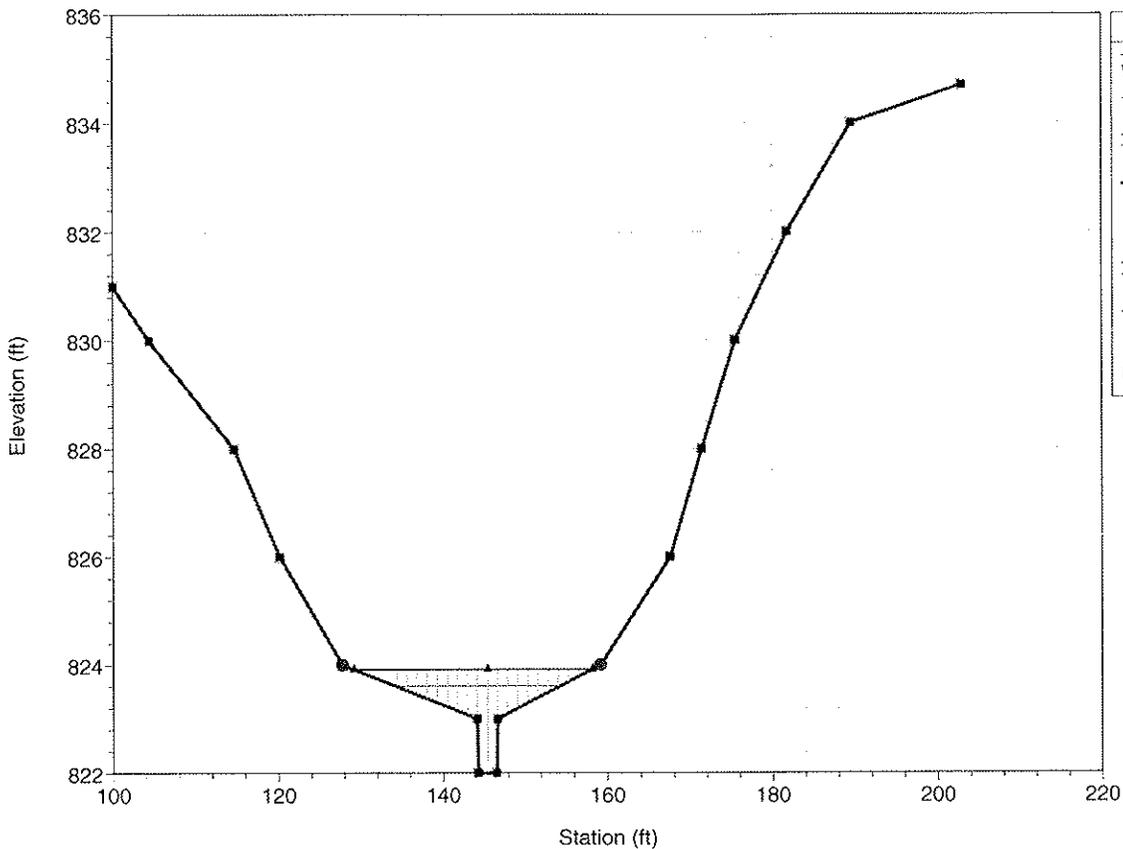
| Legend | |
|-------------|---------------------------------------|
| —▲— | WS PF 1 - 100-yr PROP |
| - - -●- - - | WS PF 1 - 100-yr Exist - 100-yr Exist |
| | Ground - 100-yr Exist |
| ● | Bank Sta - 100-yr Exist |
| - - -●- - - | Bank Sta - 100-yr PROP |
| | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 153 O' FILL - BEGIN FILL

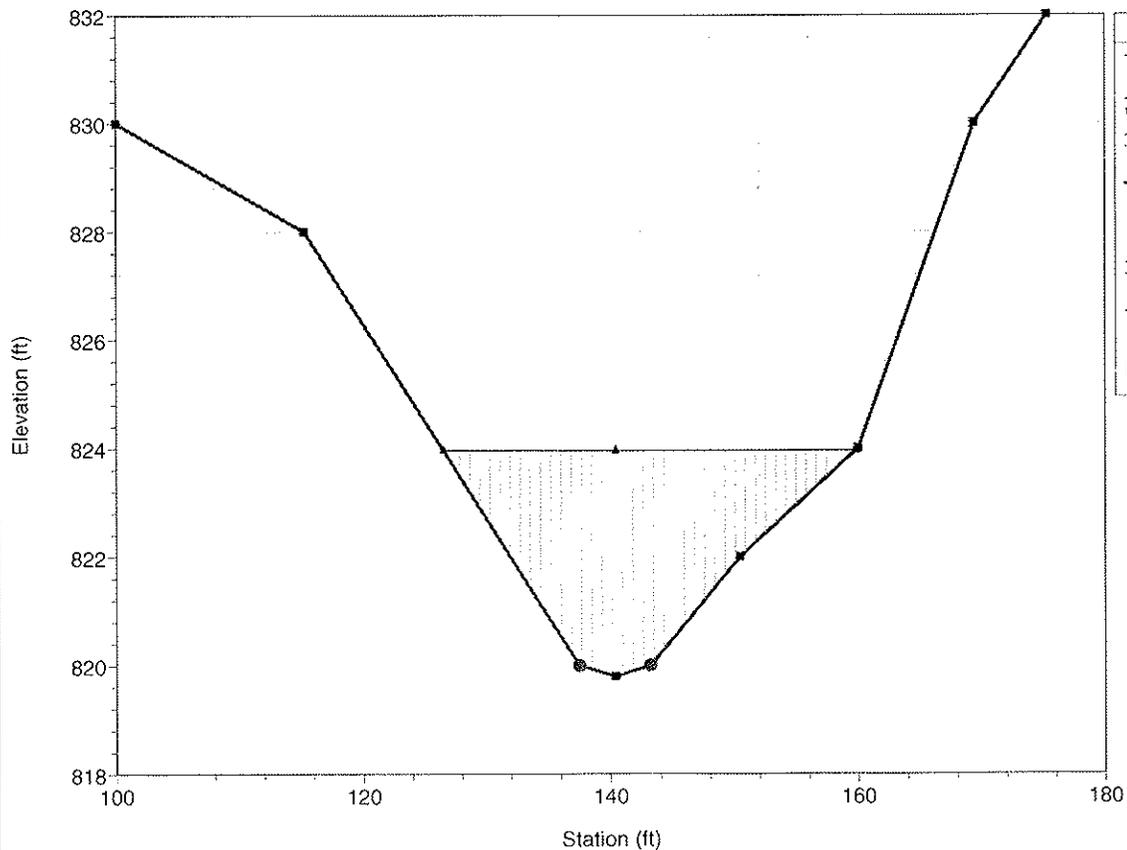


| Legend | |
|-------------|-------------------------------------|
| —▲— | WS PF 1 - 100-yr PROP |
| - - -●- - - | WS PF 1 - 100-yr PROP - 100-yr PROP |
| | Ground - 100-yr PROP |
| ● | Bank Sta - 100-yr PROP |

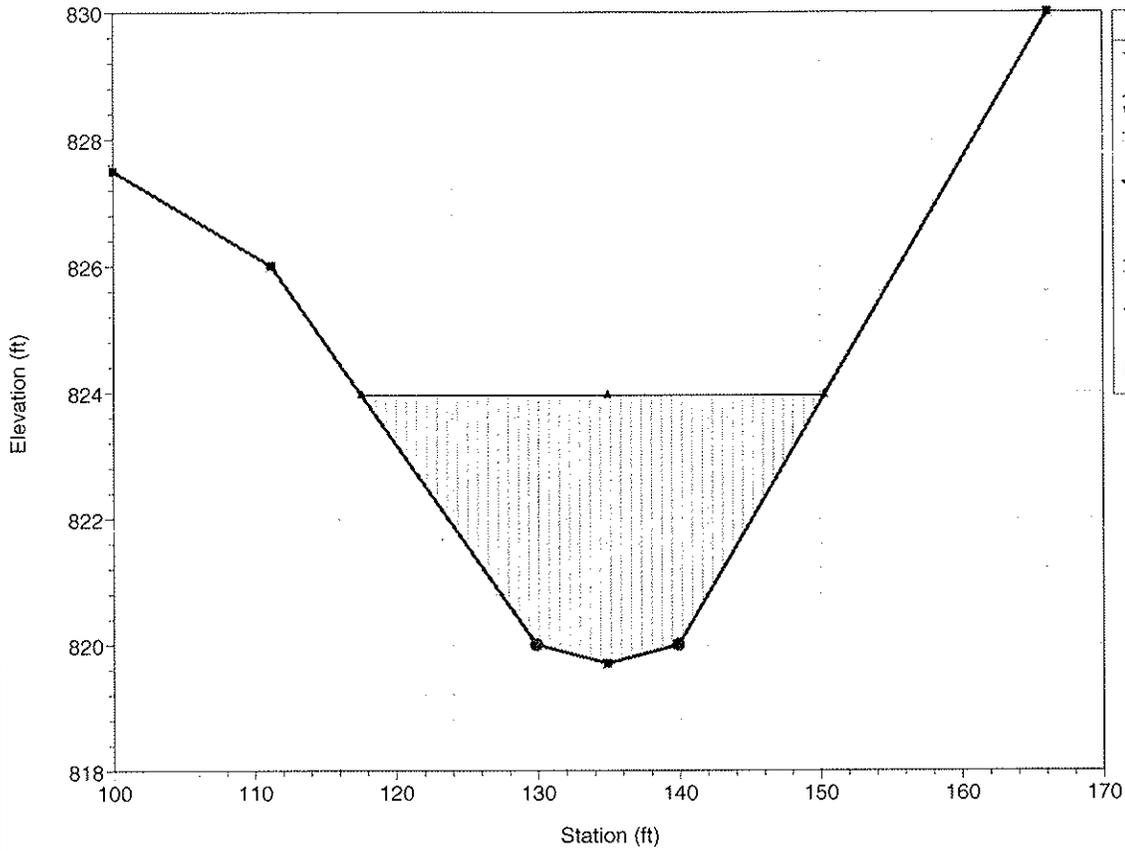
BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 150



BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 125

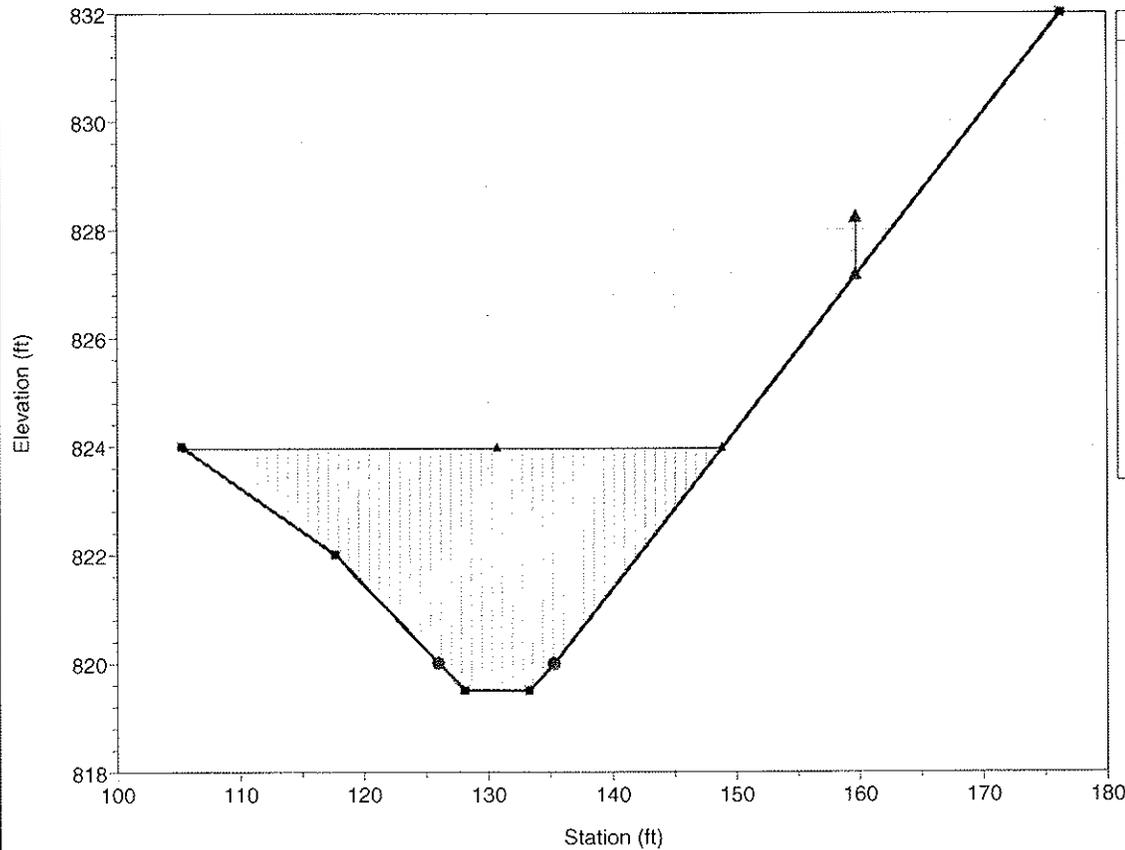


BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 100



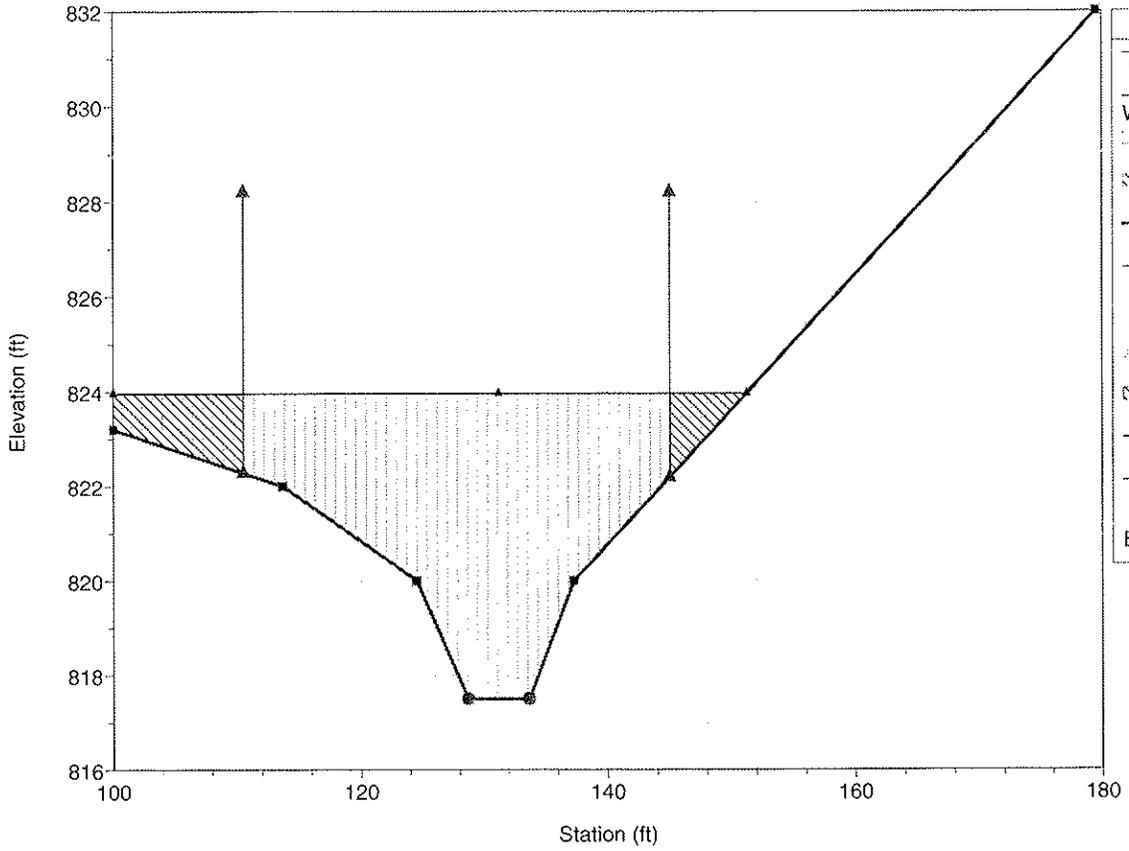
| Legend | |
|--|---|
| WS PF 1 - 100-yr Exist | ▲ |
| WS PF 1 - 100-yr PROP - 100-yr Exist | ▬ |
| Ground - 100-yr Exist | ■ |
| Bank Sta - 100-yr Exist - 100-yr PROP | ● |
| Ground - 100-yr PROP | ■ |
| Bank Sta - 100-yr PROP | ● |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 50



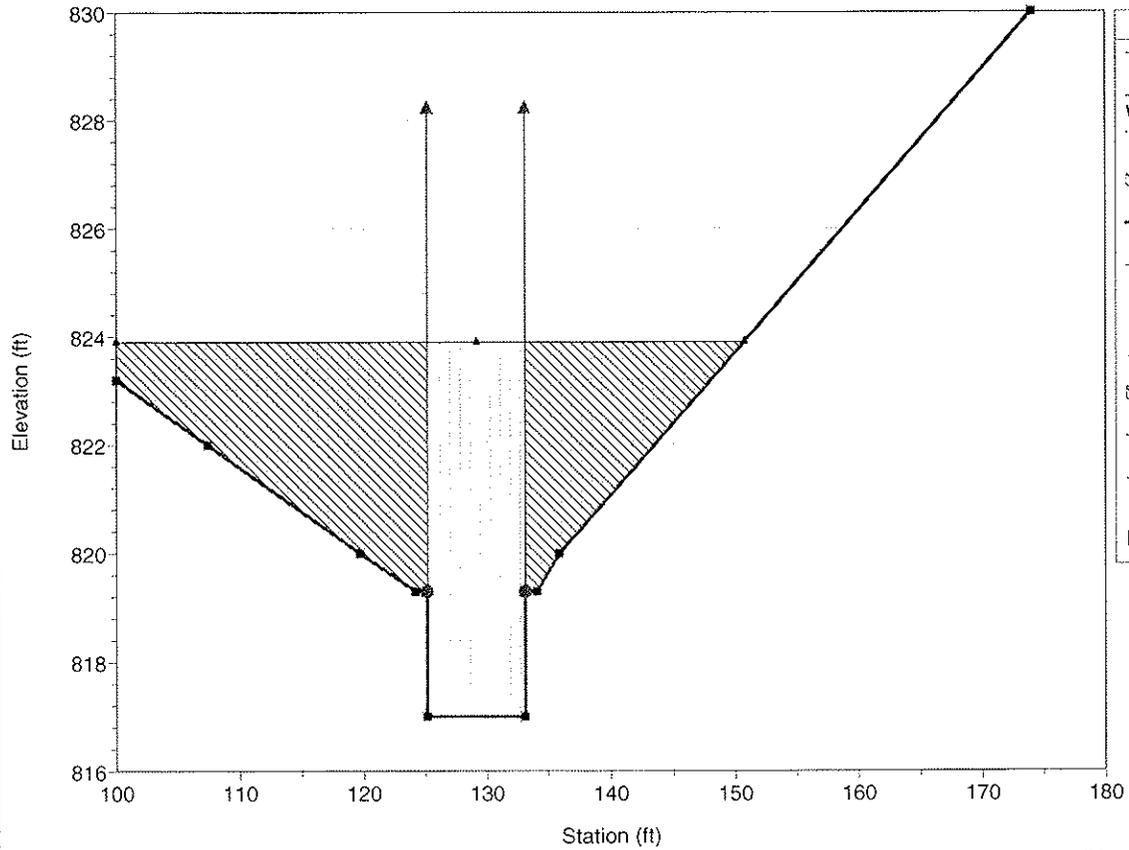
| Legend | |
|--|---|
| WS PF 1 - 100-yr Exist | ▲ |
| WS PF 1 - 100-yr PROP - 100-yr Exist | ▬ |
| Ground - 100-yr Exist | ■ |
| Ineff - 100-yr Exist | ▲ |
| Bank Sta - 100-yr Exist - 100-yr PROP | ● |
| Ground - 100-yr PROP | ■ |
| Ineff - 100-yr PROP | ▲ |
| Bank Sta - 100-yr PROP | ● |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 40



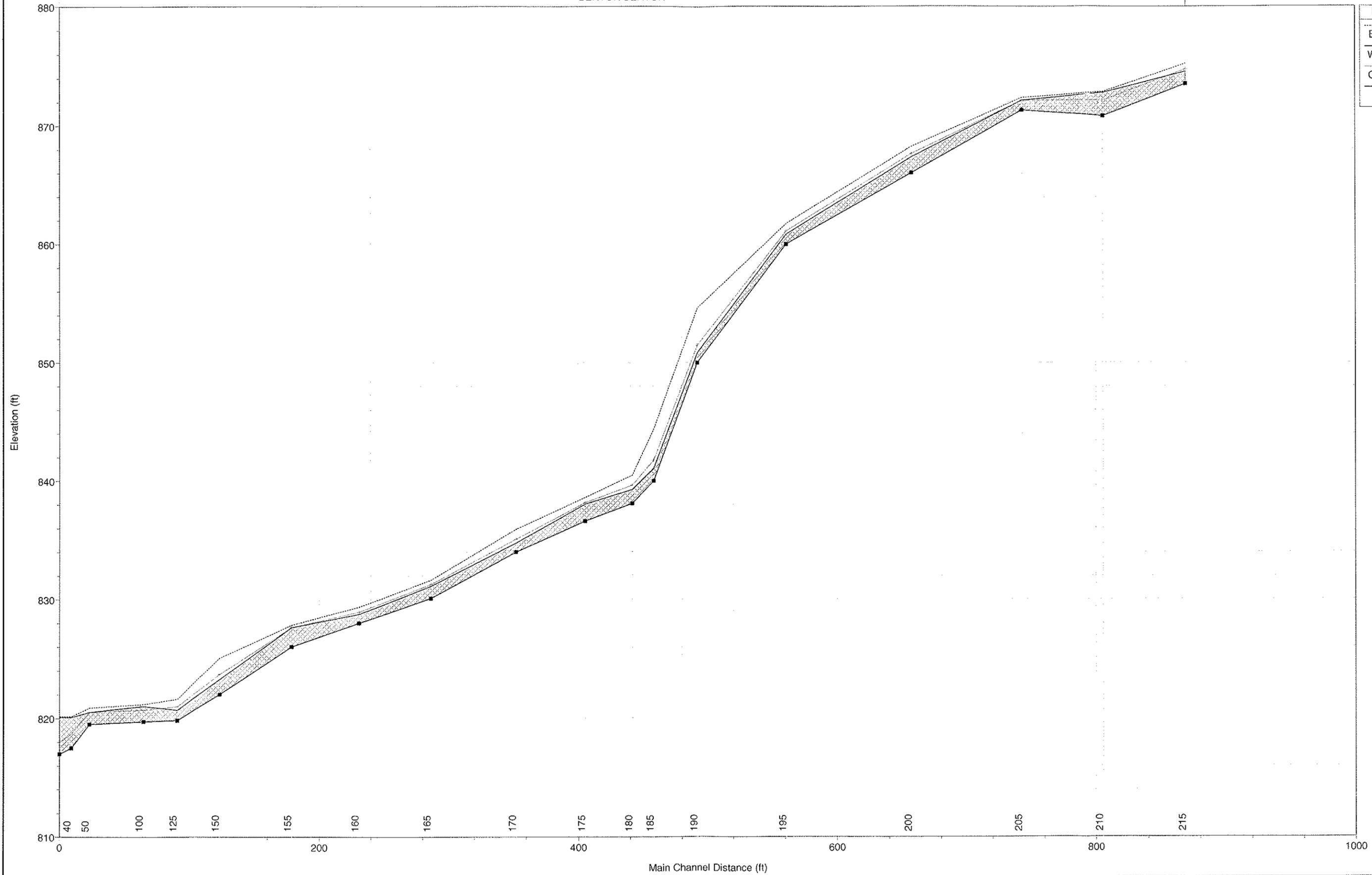
| Legend | |
|-------------------------|---|
| WS PF 1 - 100-yr Exist | ▲ |
| WS PF 1 - 100-yr PROP | ● |
| - 100-yr Exist | ▨ |
| - 100-yr Exist | ▨ |
| Ground - 100-yr Exist | — |
| Ineff - 100-yr Exist | ▲ |
| Bank Sta - 100-yr Exist | ● |
| - 100-yr PROP | ▨ |
| - 100-yr PROP | ▨ |
| Ground - 100-yr PROP | — |
| Ineff - 100-yr PROP | ▲ |
| Bank Sta - 100-yr PROP | ● |

BENTON Plan: 1) 100-yr PROP 2) 100-yr Exist
 River = BENTON Reach = BENTON RS = 30



| Legend | |
|-------------------------|---|
| WS PF 1 - 100-yr Exist | ▲ |
| WS PF 1 - 100-yr PROP | ● |
| - 100-yr Exist | ▨ |
| - 100-yr Exist | ▨ |
| Ground - 100-yr Exist | — |
| Ineff - 100-yr Exist | ▲ |
| Bank Sta - 100-yr Exist | ● |
| - 100-yr PROP | ▨ |
| - 100-yr PROP | ▨ |
| Ground - 100-yr PROP | — |
| Ineff - 100-yr PROP | ▲ |
| Bank Sta - 100-yr PROP | ● |

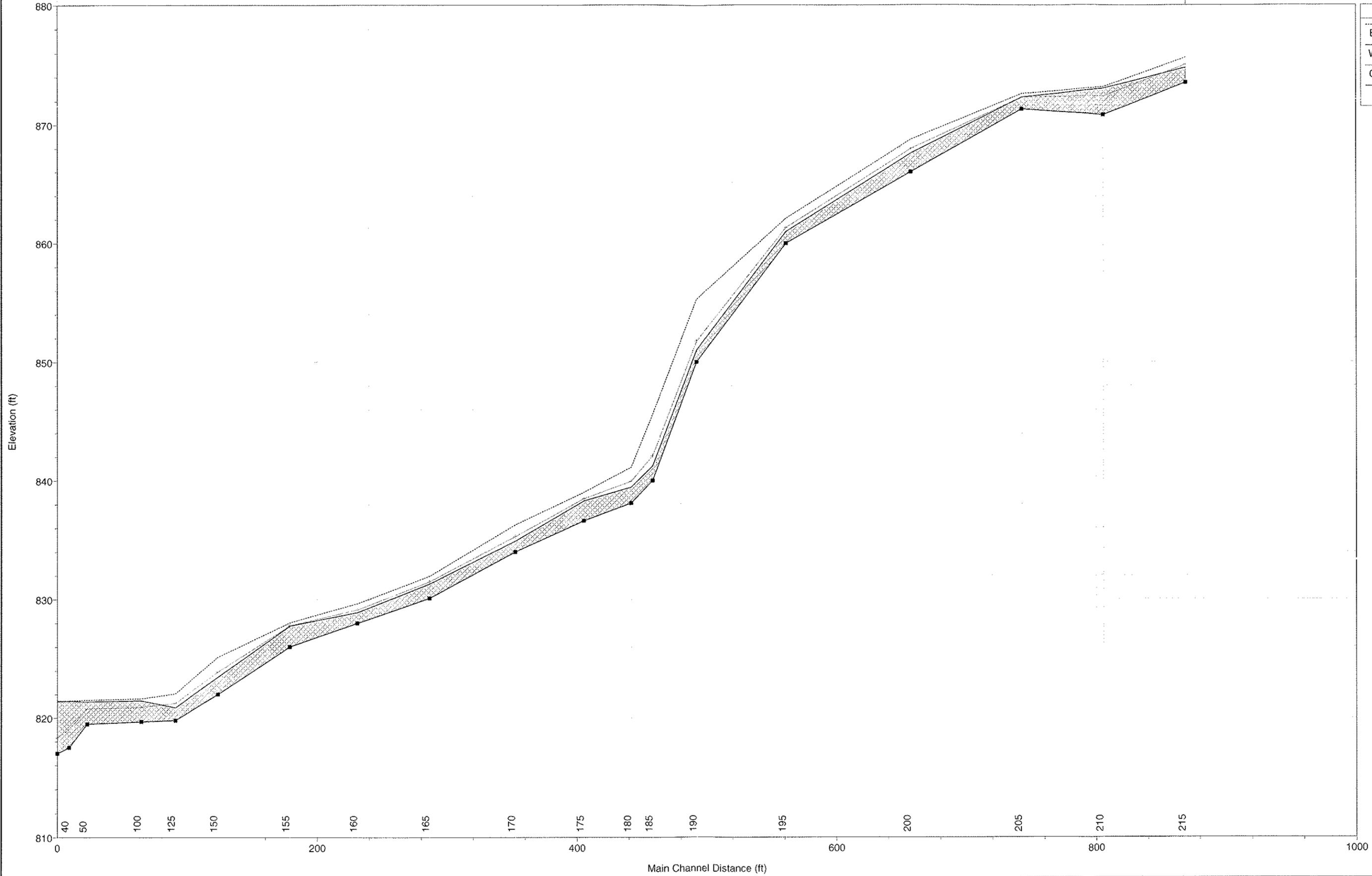
BENTON BENTON



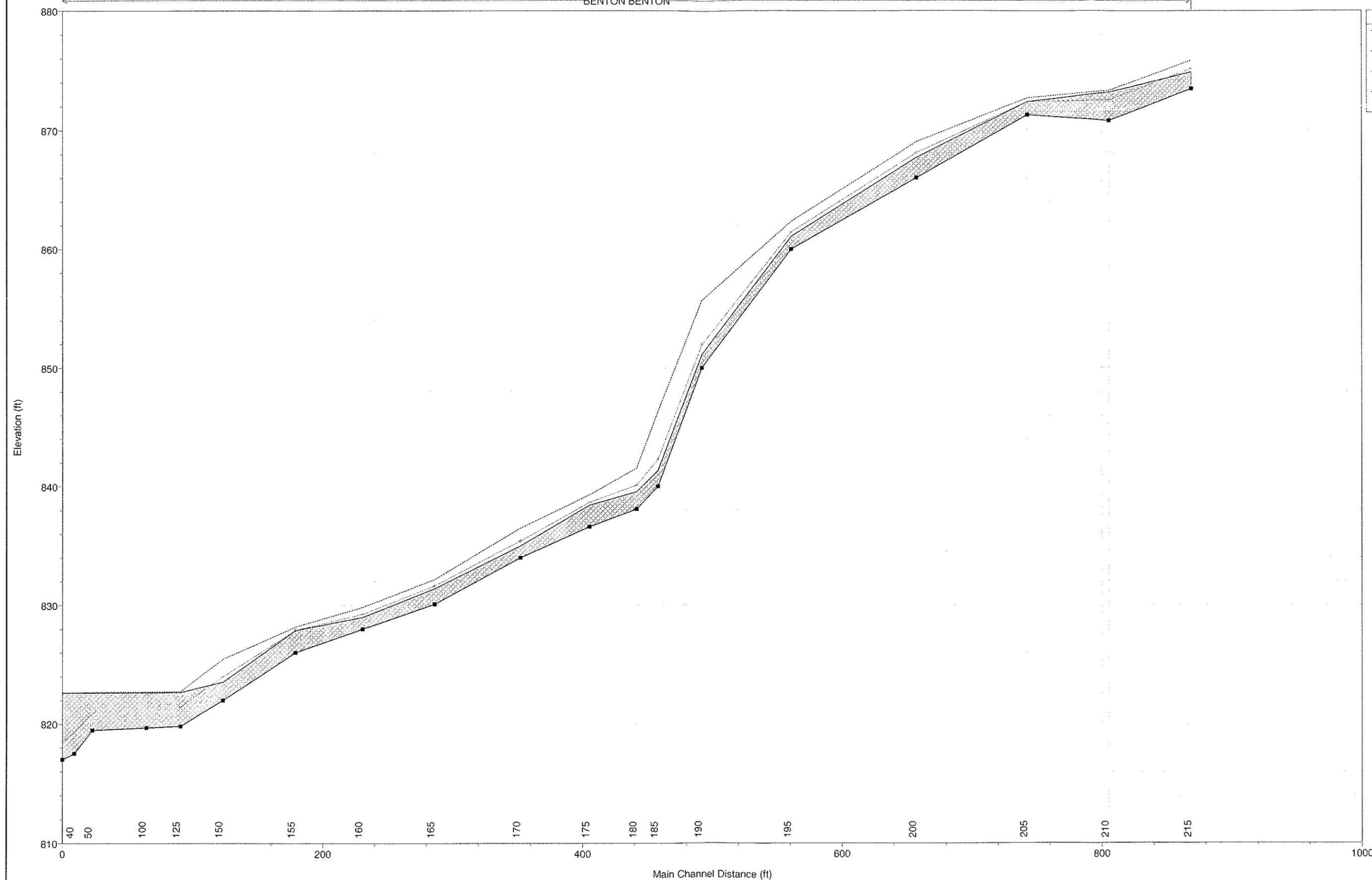
Legend

- EG PF 1
- WS PF 1
- Crit PF 1
- Ground

BENTON BENTON

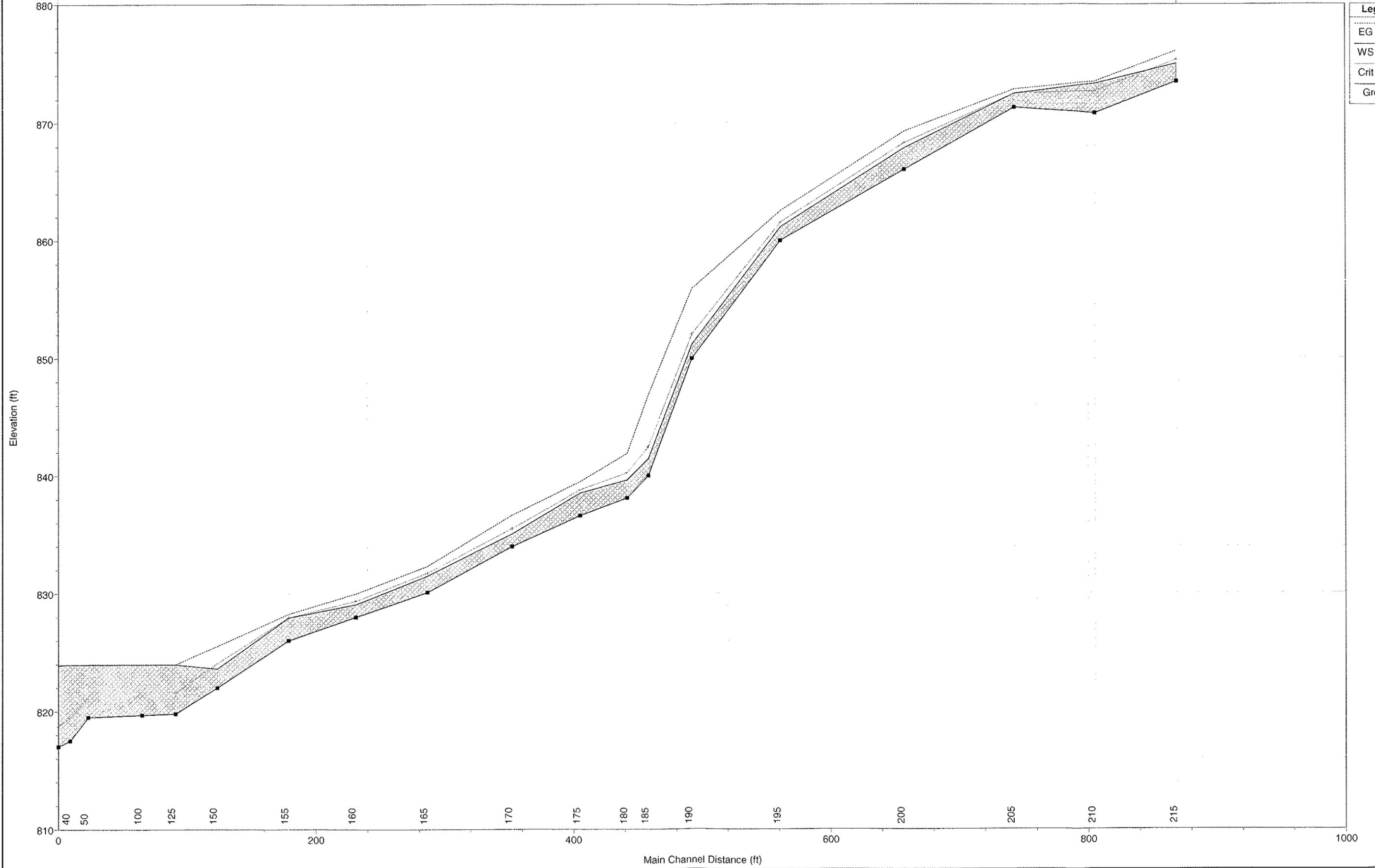


| Legend | |
|-----------|----------------------------|
| EG PF 1 | (Dotted line) |
| WS PF 1 | (Solid line) |
| Crit PF 1 | (Line with square markers) |
| Ground | (Cross-hatched area) |



| Legend | |
|-----------|----------------------------------|
| EG PF 1 | (dotted line) |
| WS PF 1 | (solid line) |
| Crit PF 1 | (solid line with square markers) |
| Ground | (solid line with square markers) |

BENTON BENTON



Legend

EG PF 1

WS PF 1

Crit PF 1

Ground

BENTON BENTON

