Final Hydraulic Design

for

State Project 171-305

New Britain – Hartford Busway

Location: Un-named Tributary of Piper Brook, Newington

Site-5 Busway Station 250+40

September, 2009

Rev. January, 2010

Prepared By:	Prepared For:
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In association with	
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STATE OF CONNECTICUT
MANISH K. GUPTA
No. 21453
LICENSED
PROFESSIONAL ENGINEER

Contents

Introduction

As a result of transportation planning studies for the Hartford West Corridor, a Bus Rapid Transit (BRT) system has been proposed and is currently in the design phase. This exclusive Busway will run along active and inactive railroad rights-of-way from New Britain, through Newington and West Hartford with its terminus in Hartford. As part of the design of the Busway and coordination with Amtrak, various stream crossing structures were flagged for investigation and potential upgrading.

This Hydraulic Design Report addresses the replacement of an existing 3' X 4' Twin-Cell Box Culvert conveying a tributary to Piper Brook under the railway embankment at Busway Station 250+40 (41°43'09" N, 72°44'04" W). The culvert was originally constructed of corrugated metal pipes which subsequently began to fail at the inlet. According to records; in 2003, the inlet and headwall was rebuilt with stone masonry. Currently, the inlet is again in poor condition and from design computations the crossing is undersized for the design flow of 100-years (design flow recurrence interval prescribed by Amtrak); therefore, the culvert is slated for replacement.

The existing conditions analysis using prescribed hydrologic and geometric design data reveals that at this stream crossing, the railway is overtopped for flows equal to or exceeding approximately 460 cfs (between a 25- and 50-year event). The top elevation of the railway embankment is at an elevation of approximately 72', which at overtopping creates a backwater elevation of over 72'. Four hundred feet upstream from the subject crossing is a 48" metal culvert which carries Spring Street over the Piper Brook Tributary. The elevation of Spring Street in the vicinity of the tributary is approximately 64' (based on the Year 2000 LIDAR Topographic Survey for Connecticut).

The following report documents the results of the hydraulic design for replacing the existing culvert with a 7.5 foot (90 inch) diameter reinforced concrete culvert, including potential effects of the replacement on adjacent properties. Additionally, a temporary conditions (during construction) water handling design and channel protection design has been included with this report.

Survey that was used in the following analysis was based on NGVD '29.

FEMA data used in this analysis was based on NAVD '88 → NGVD '29 = NAVD '88 + 0.90'

Hydrology

Design flow values used for the hydraulic design of the Site 5 Amtrak crossing of Tributary to Piper Brook were developed by GARG Consulting Services, Inc. of Rocky Hill, CT. The results of the hydrologic analysis were submitted to and approved by the Connecticut Department of Transportation, and as such have been established for use in this hydraulic analysis. The following flows are used for the hydraulic design of the Site 5 crossing of the tributary to Piper Brook.

2-yr	10-yr	25-yr	50-yr	100-yr
153 cfs	320 cfs	405 cfs	486 cfs	573 cfs

Table 1 – Approved design flow rates for Site 5 culvert replacement

For reference, the narrative and design computations applicable to these approved flows are included in Appendix A

Selected Boundary Conditions for the Hydraulic Design of Site 5 Culvert Crossing

For the design of the Site 5 culvert crossing, the approved hydrologic analysis results were to be used. For the 500-year check or "superflood" event, the 100-year discharge was multiplied by 1.7 to estimate the flow rate as the 500-year discharge was not included in the approved hydrologic analysis. This estimated flow rate is 974 cfs.

Tailwater conditions used for the subsequent Site 5 analysis will be based on the joint probability of coincidence of peak flows from the tributary watershed to the Piper Brook Watershed following guidelines set forth in the ConnDOT Drainage Manual (§8.3.6 Tailwater Relationship – Confluence with a Main Stream or Large Water Body). The basin area of the Piper Brook Tributary at the railway embankment is 0.82 sq mi (GARG – 2008), and the Piper Brook watershed near this confluence is approximately 14.6 sq mi (delineated by USGS Streamstats – and hand checked). This equates to an area ratio of 18:1. Based on table 8-3 from the Drainage Manual, the tributary should be analyzed for a 100-year event with a tailwater elevation from Piper Brook reflecting a 50-year event for areas with a 10:1 ratio. Tailwater elevations will be taken from the Hartford County Flood Insurance Study (FIS). For the check event of a 500-year flood, the 250-year tailwater as statistically computed from the published FIS results for Piper Brook. The following table documents the starting water surface elevations to be used for the hydraulic analysis. The following table shows the tributary recurrence interval with the corresponding main stream recurrence interval and associated static water surface elevation. Subsequent to the development of the tailwater relationships to design flows, the elevations used were converted to NGVD '29 by adding 0.90' to the NAVD '88 elevations.

Tributary flows	10-yr	50-yr	100-yr	500-yr
	320	486	573	974
Piper Brook event	10-yr	25-yr	50-yr	250-year
Static water surface elevation	54.4 feet	55.5 feet	56.4 feet	57.8 feet

Table 2 – Boundary conditions for the Site 5 culvert replacement – NGVD '29

Hydraulic Analysis

Contributing factors to the design of this culvert crossing include potential changes to floodplain storage in comparison to flood mitigation benefits as well as constructability (including utility conflicts) and construction expense.

Culvert performance was analyzed using HEC-RAS version 4.0. Stream channel sections and relevant site geometry were based off of data prepared by GARG Consulting Services, Inc. of Rocky Hill, CT as supplied by Baker Engineering. This data was supplemented with design plans for the proposed Busway and Amtrak Access Road, and amended by additional survey (6-8-2009) provided by ConnDOT. Amendments to the survey include verification of the inverts of the existing culvert and inlet and outlet conditions.

Runoff generated in the contributing basin is conveyed through a well defined natural channel with little to no floodplain area in the reach adjacent to the subject crossing. This crossing, as it exists consists of twin box culverts (as reported by the amended survey).

The contributing drainage area to this culvert is 0.82 sq. mi. and is classified as a small structure requiring a 50-year event for design; however, Amtrak has applied greater design criteria for culvert crossings of a railway. As such the subject site will be designed for a 100-year event and checked for a 500-year event.

Existing Conditions

The existing conditions model based on geometric information provided as discussed previously reveals that the twin stone box culvert does not have adequate capacity to carry the approved design discharges without overtopping of the railbed. This model indicates that flood flows of approximately 486 cfs will overtop the railbed (between a 25- and 50-year flood). The 100-year design event overtops the existing crossing by approximately 0.25 feet resulting in a headwater (HW) depth of approximately 20.5 feet (with a HW/D ratio of over 5 – more than three times the allowable inlet submergence criterion as stipulated in the Drainage Manual).

The hydraulic computations were executed using starting values (boundary conditions) as discussed in the previous section; based on the probability of influence of Piper Brook on the tributary. The resulting headwater for the existing twin stone box culvert is as follows:

10-yr	50-yr	100-yr	500-yr
63.99 feet	72.04 feet	72.23 feet	74.79 feet

Table 3 – Headwater elevations in feet computed for existing conditions.

Proposed Conditions

The proposed replacement of the existing twin box culvert will be constructed approximately 5' to the south of the existing conduits. This will facilitate maintenance of flows through the existing culverts during construction as well as provide the appropriate clearances for the jacking operations. An additional benefit to this proposed culvert alignment is that the angle of attack of flows will be decreased from existing conditions.

The flowline of the culvert was defined by holding the existing outlet invert and progressing to the inlet location at 0.5% slope. The inlet location took into account the proposed improvements to the embankment to accommodate the proposed Busway corridor. This negative slope of the flow line is a significant improvement over the existing condition which has a positive slope with an inlet elevation one foot lower than the outlet elevation. Once the replacement culvert is in place, the existing culverts will be filled, capped and abandoned.

The single culvert was proposed for replacement in order to minimize the openings required for the passage of flood flows. The use of a single opening is desirable in that blockage potential from debris can be minimized. Additionally, due to the anticipated construction method of pipe jacking, it is advantageous to install a single pipe crossing thereby reducing the potential risk of soil heave and settlement in relation to the tracks.

The 90" pipe diameter was selected based on the criterion for maximum headwater elevation as set in the Drainage Manual. The attempt was to improve conditions upstream and at the railway crossing by: decreasing the 50-year headwater to increase the capacity of the 48" CMP under Spring Street (400' upstream) so that the Spring Street crossing is within regulated design standards (50-year flood conveyance) and maintaining the 100-year flood event at the Amtrak Railroad without overtopping. This was to be achieved without excessively opening the crossing which would have needlessly increased downstream flows.

Under design flood conditions, the computed headwater elevation will be 65.2 feet, providing 6.8 feet of freeboard from the top of the embankment. The resulting headwater to pipe diameter ratio is 1.5. Under "superflood" or 500-year flooding conditions, the headwater will be 72.2 feet, overtopping the railbed by 0.2 feet.

Material for Selection

The recommended pipe material for the construction of the Site 5 Crossing of Amtrak is a Class V Reinforced Concrete Pipe. This pipe type is required by Amtrak for track crossings.

Computations are included in Appendix B.

Flow Training and Channel Protection

The proposed culvert, as stated previously, is to be constructed 5 feet to the south of the existing culvert. For this reason, the new flow line will have to be trained into the existing tributary channel. From survey obtained, it appears that training the flows from the new crossing location should be attainable within 20' of the proposed culvert outlet through grading and channel protection.

Outlet Protection

Riprap sizing was based on the highest calculated velocities for the 100-year event near the outlet of the culvert. At station 4 approximately 25 feet from the outlet of the culvert, flow velocity is computed at approximately 8.5 fps, which, for the streambed and associated bank slopes, would call for an intermediate gradation riprap (8" dia. stone).

In determining the extent of channel to be lined, the procedure for potential scour dimensions (as documented in HEC-14 Chapter 5) was used. It was found that over 80 feet of channel and bank would have to be lined, which was determined to be excessive. For this reason, an alternate procedure was used. A riprap basin was designed to protect and dissipate the energy of the flow coming out of the outlet of the 7.5' diameter culvert.

Following the guidelines of Chapter 10 in HEC-14 the dimensions of a riprap basin lined with intermediate riprap were determined as shown in Figure 1 using results from the hydraulic modeling.

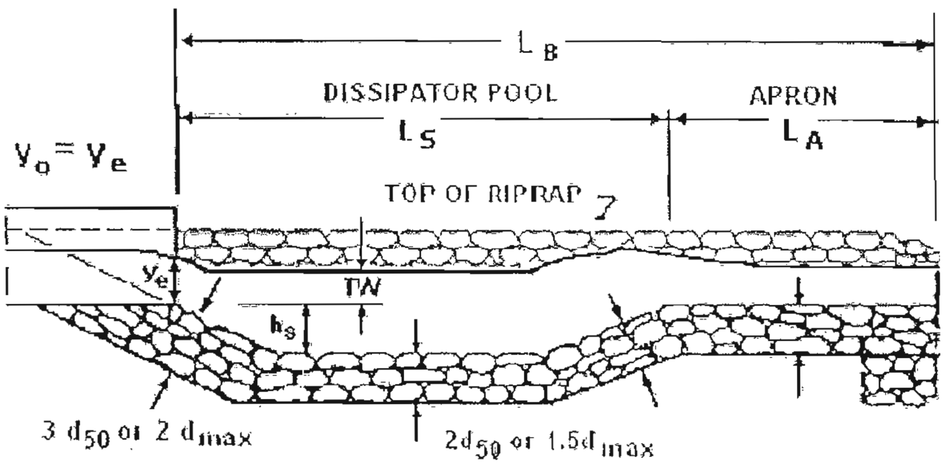


Figure 1 – Profile of Riprap Basin

L_s = 22.5 feet, L_A = 9.35 feet, L_B = 31.85 feet, h_s = 1.87 feet

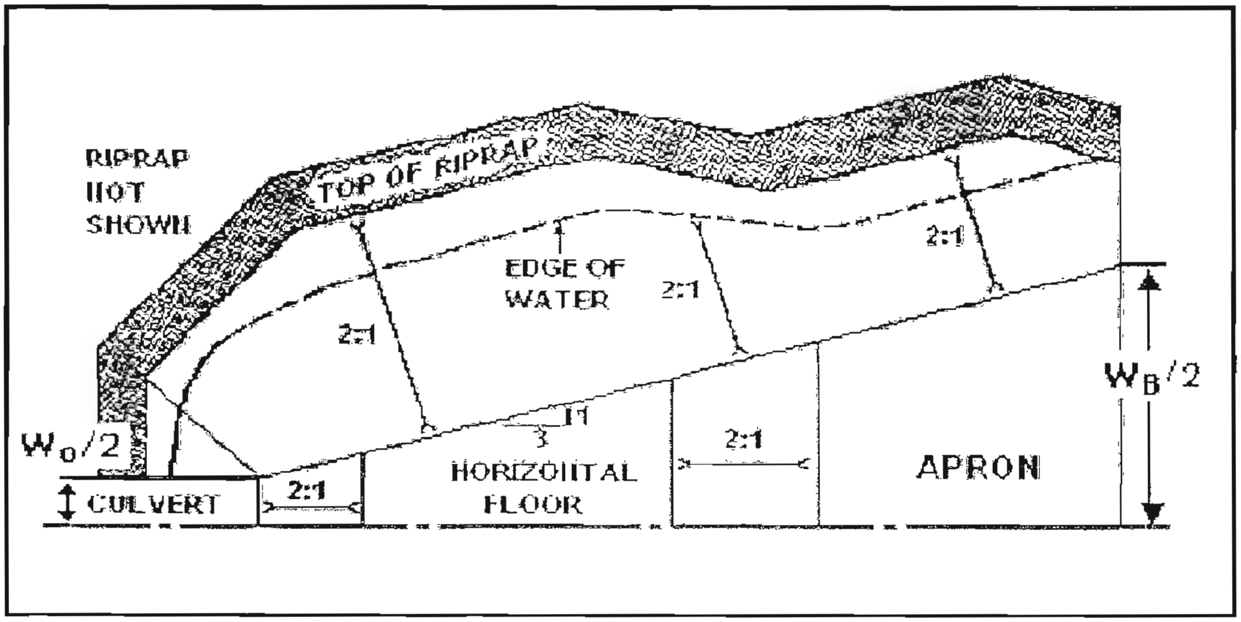


Figure 2 – Half Plan of Riprap Basin

W_O = diameter of the culvert = 7.5 feet, W_B = 28.7 feet.

Computations supporting the results of the riprap basin design are attached in Appendix C. In a check of the velocity for critical depth at the end of the basin, it was determined that the exit velocity from the basin would be near the computed natural channel velocity at the associated section. The computed critical velocity was 9.1 fps and the computed channel velocity was 8.5 fps for the 100-year event.

Inlet Protection

As stated previously, flow training into the newly relocated inlet will be required. As such, protection of the disturbed earth is recommended to mitigate the potential for erosion at the proposed culvert inlet. Following design guidelines as stated in Chapter 7 of the ConnDOT Drainage Manual, a minimum riprap stone size was computed for protection of the newly formed inlet reach of the Tributary to Piper Brook. Figures 7-25.1, 7-26, 7-27.1 from the Drainage Manual were used to determine the required rock size. The velocity taken for rock design was approximately 2-fps, and working through the design process, it was determined that modified riprap would withstand the potential erosive forces of the range of flow rates at the inlet of the Site 5 crossing.

Temporary Conditions and Water Handling

Water handling for the construction of this culvert replacement is to be completed in two phases. Phase 1 will include maintaining existing flows through the existing twin stone box culvert. The work area will be cordoned off through the use of a cofferdam and temporary flow diversion barrier upstream and downstream. In addition to the cofferdams, a bypass pipe was designed to convey flows around the work area at the downstream side.

Hydrology for Temporary Conditions

The temporary flood recurrence interval has been set as a two year event using engineering judgment. The conventional method for temporary conditions determination is not easily applied in this case due to the travel way being a railroad. However, there is a low potential for loss of life, and limited property damage would be inflicted in the case of an embankment failure. Further, the drainage area contributing flows to the project site is less than a square mile. For these reasons, a two year event seems reasonable for design of a water handling method.

In addition to the two year event, a one year rainfall event was also investigated to provide an option for the design of temporary facilities. The one year flow rate was determined as a direct relationship to differences between the two and one year rainfall rates. From Table 7.2 of the DEP – 2004 Connecticut Stormwater Quality Manual, the one and two year rainfall rates are 2.6 and 3.2 inches/24 hours for Hartford County. This equates to the 1-year event being 81% of the 2-year event. This ratio was applied to the computed two year event as documented in the DOT Approved Hydrologic Analysis for the design of Site 5. The documented two year event is 153-cfs resulting in a one year event of 124-cfs.

Temporary Conditions Hydraulics

During the jacking of the proposed pipe, it is expected that the flows will be maintained with the existing crossing. Due to the existing flow line of the receiving stream following a dog-leg south, past the location of the proposed pipe outlet, a cofferdam and bypass pipe have been designed to convey the 2-year flood around the project location (jacking site).

Downstream Temporary Facilities

The existing conditions model was used to build the temporary conditions geometry for analysis. Section four, following the existing culvert bounding section has been removed in order to accommodate the 60 feet of required bypass pipe. Various combinations of pipe(s) and cofferdam height were analyzed to determine a nominal pipe configuration with dam height. As a result, it was found that two 36" HDPE pipes in conjunction with a 6' high cofferdam would be required to pass the 2-year flood with minimal (7.7 cfs) overtopping of the dam These pipes are to project 35 feet from the outlet of the existing culvert and turn to the southeast using a 90° long sweep elbow. Twenty-five feet from the 90° elbow, the bypass pipe will then outlet the conveyed flows back into the natural channel. This configuration should provide for approximately 40 feet of workspace projected out from the proposed outlet location of the 7.5' diameter pipe.

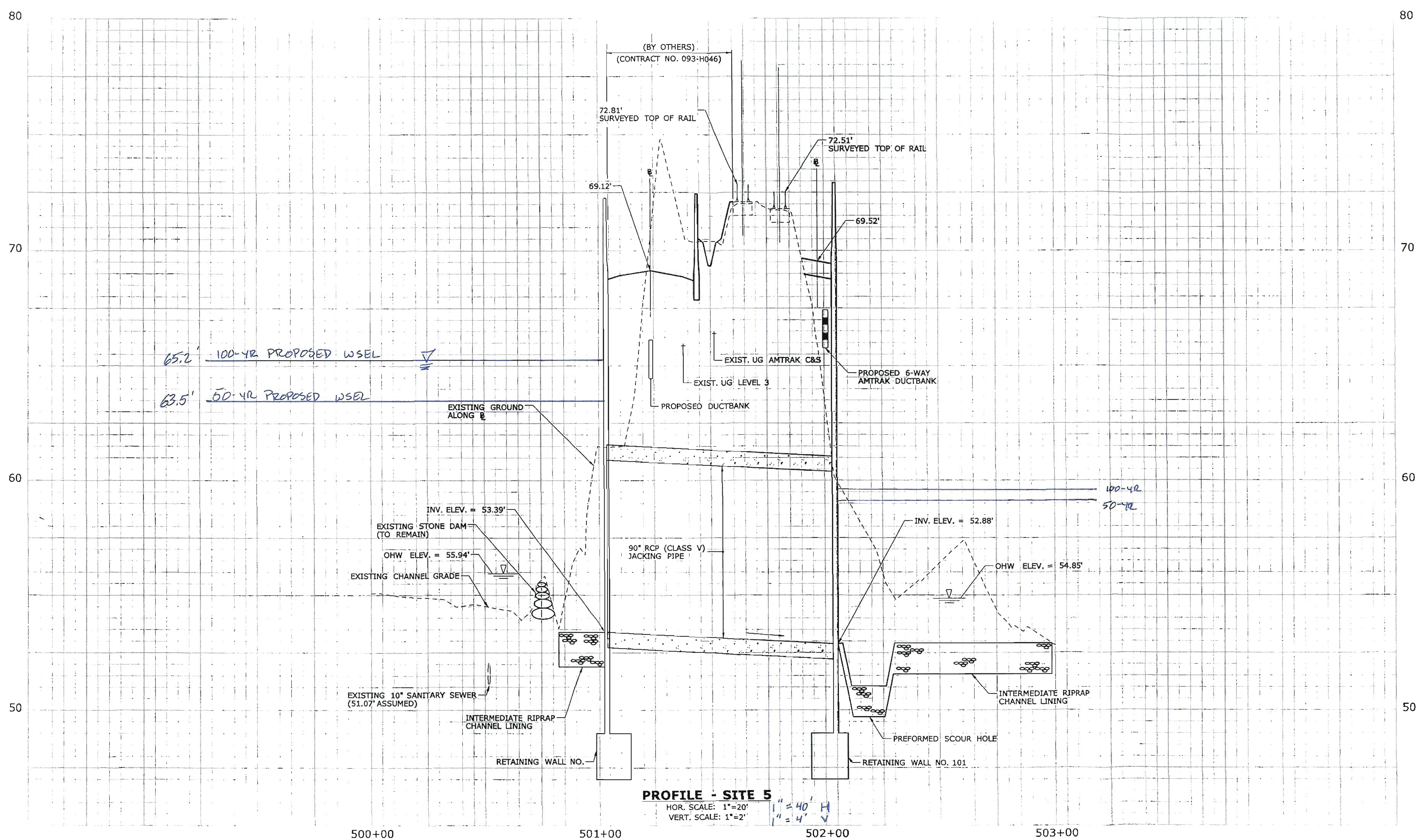
Additional height could be added to the dam but is not necessary since the recommended temporary bypass configuration of only approximately 7.7 cfs was computed to overtop for the two year flow. It should be noted that the hydrology for this project was computed using assumptions of a full build out of the watershed with no flow attenuation potential from upstream crossings. These assumptions were made to design with the full lifetime of the crossing in mind. Current conditions within the watershed indicate that a full build out (based on Current Newington and West Hartford Zoning areas) has yet to be achieved, and that there are some intrinsic storage areas along the watercourse created by upstream crossings. Overtopping of the proposed cofferdam during a two year event is not likely to occur during the construction phase of this project.

The results of the one year (estimated) flow rate indicate that for a cofferdam elevation of 58 feet (NGVD) there would be no overtopping of the cofferdam. This total cofferdam height would be 0.5 feet less than the 2-year designed facility (approximately 5.5 feet). Note is made that the two 36" bypass pipes would still be flowing full as in the two-year design.

Upstream Temporary Facilities

Based on water handling design plans supplied by the Structural Designer, cofferdams (blocked obstructions) were coded into the temporary facilities model at the bounding and approach sections to the crossing. The locations of the cofferdams were scaled from the provided plans at the model's section locations based on downstream reach lengths used in the model and the distance between the bounding section and the roadway. It was found that for a one year temporary design event the cofferdam elevation required to maintain a dry work area would be 59-feet, and for a two year temporary design event, the cofferdam elevation would be 60.5-feet.

Computations associated with the Temporary Conditions Hydraulic Analysis are included in Appendix D.



PROFILE - SITE 5

HOR. SCALE: 1"=20' 1" = 40' H
VERT. SCALE: 1"=2' 1" = 4' V

PRELIMINARY DESIGN REVIEW

REV.	DATE	REVISION DESCRIPTION	SHEET NO.
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	40-	-	-

THE INFORMATION, INCLUDING ESTIMATED QUANTITIES OF WORK, SHOWN ON THESE SHEETS IS BASED ON LIMITED INVESTIGATIONS BY THE STATE AND IS IN NO WAY WARRANTED TO INDICATE THE CONDITIONS OF ACTUAL QUANTITIES OF WORK WHICH WILL BE REQUIRED.

Plotted: 1/11/2010

DESIGNER/DRAFTER: PB-CJF/PB-CJF
CHECKED BY: ALM

HORIZ. SCALE IN FEET 0 20 40
VERT. SCALE IN FEET 0 2 4

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

Filename: ...\HW_MSH_093_H052_MDS-SITE 5 PROFILE.dgn

MICHAEL BAKER ENGINEERING, INC.

APPROVED BY: - DATE: -

PROJECT TITLE: NEW BRITAIN - HARTFORD BUSWAY AMTRAK ACCESS ROAD

TOWN: NEWINGTON, WEST HARTFORD & HARTFORD

DRAWING TITLE: SITE 5 - PROFILE

PROJECT NO. 093-H052

DRAWING NO. -

SHEET NO. $54

Appendix A

1. Boundary Condition Development
2. Approved Hydrologic Analysis Excerpts - GARG Consulting (2008)

Table 8-3 Joint Probability Analysis

AREA RATIO	FREQUENCIES FOR COINCIDENTAL OCCURRENCE							
	10-Year Design		25-Year Design		50-Year Design		100-Year Design	
	Main Stream	Tributary	Main Stream	Tributary	Main Stream	Tributary	Main Stream	Tributary
10,000 TO 1	2 10	10 2	2 25	25 2	2 50	50 2	2 100	100 2
1,000 TO 1	2 10	10 2	2 25	25 2	5 50	50 5	10 100	100 10
100 TO 1	5 10	10 5	5 25	25 5	10 50	50 10	25 100	100 25
10 TO 1	10 10	10 10	10 25	25 10	25 50	50 25	50 100	100 50
1 TO 1	10 10	10 10	25 25	25 25	50 50	50 50	100 100	100 100

Notes: Shaded values denote design combination for coincidental frequency occurrence.
Non-shaded values denote check combination for coincidental frequency occurrence.

8.3.7 Minimum Culvert Size

Culverts providing for passage of storm runoff from one side of the highway to the other shall not be smaller than 600mm (24 in) for interstate systems and 450mm (18 in) for other systems.

8.3.8 Maximum Velocity

The maximum velocity at the culvert outlet shall be consistent with the velocity in the natural channel or shall be mitigated with outlet protection measures, energy dissipation and if required, channel stabilization. (See Section 8.7 and Chapter 7.)

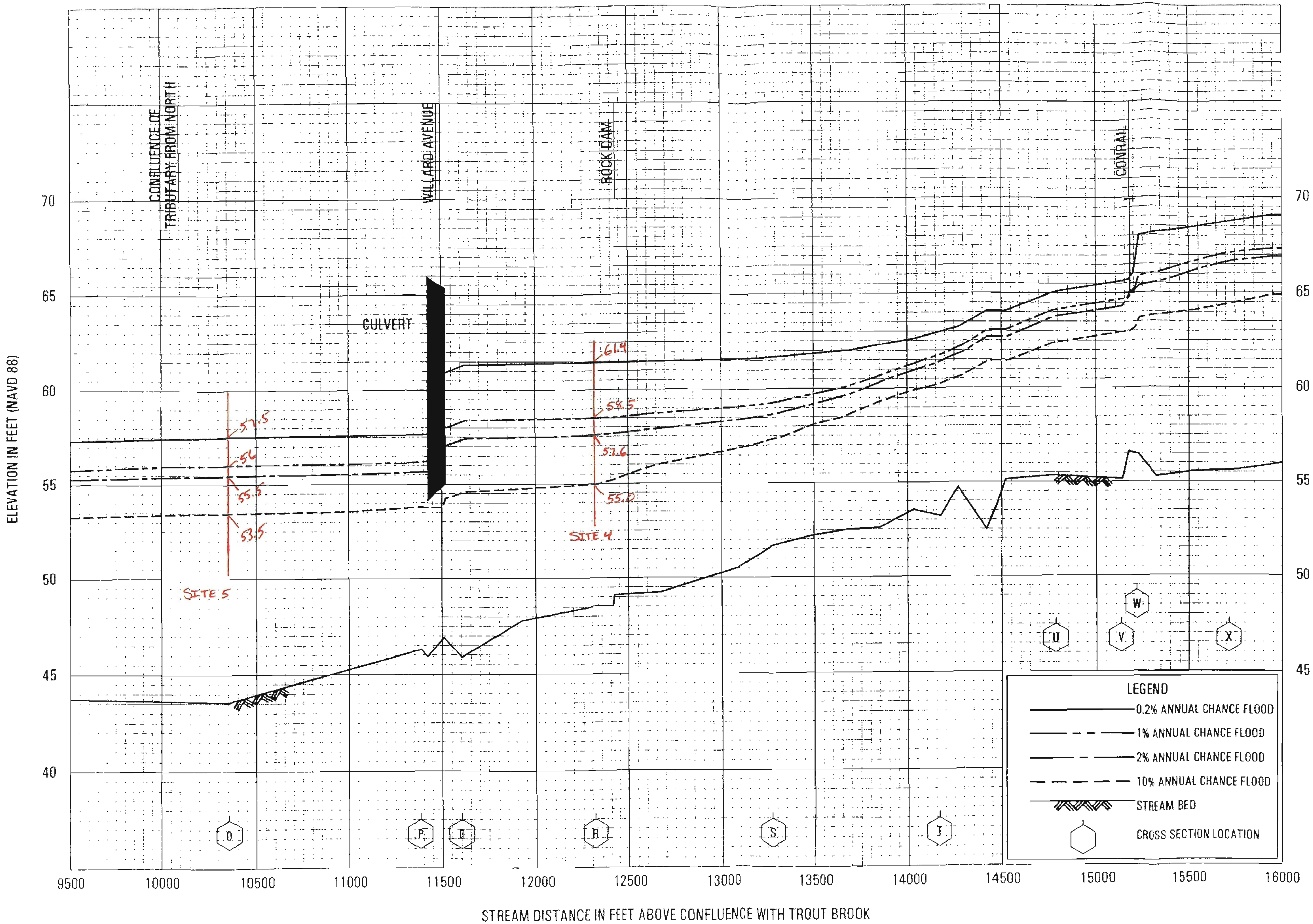
8.3.9 Minimum Velocity

The minimum velocity in the culvert barrel shall result in a tractive force ($\tau = \gamma dS$) greater than critical τ of the transported streambed material at low flow rates, unless material is required to aid in fish passage. See Section 7.6.6 for a detailed discussion on tractive force.

8.3.10 Storage - Temporary or Permanent

If storage is being assumed upstream of the culvert, consideration shall be given to:

- limiting the total area of flooding
- limiting the average time that bankfull stage is exceeded for the design flood to 48 hr in rural areas or 6 hr in urban areas
- ensuring that the storage area will remain available for the life of the culvert through the purchase of right-of-way or easement



FLOOD PROFILES

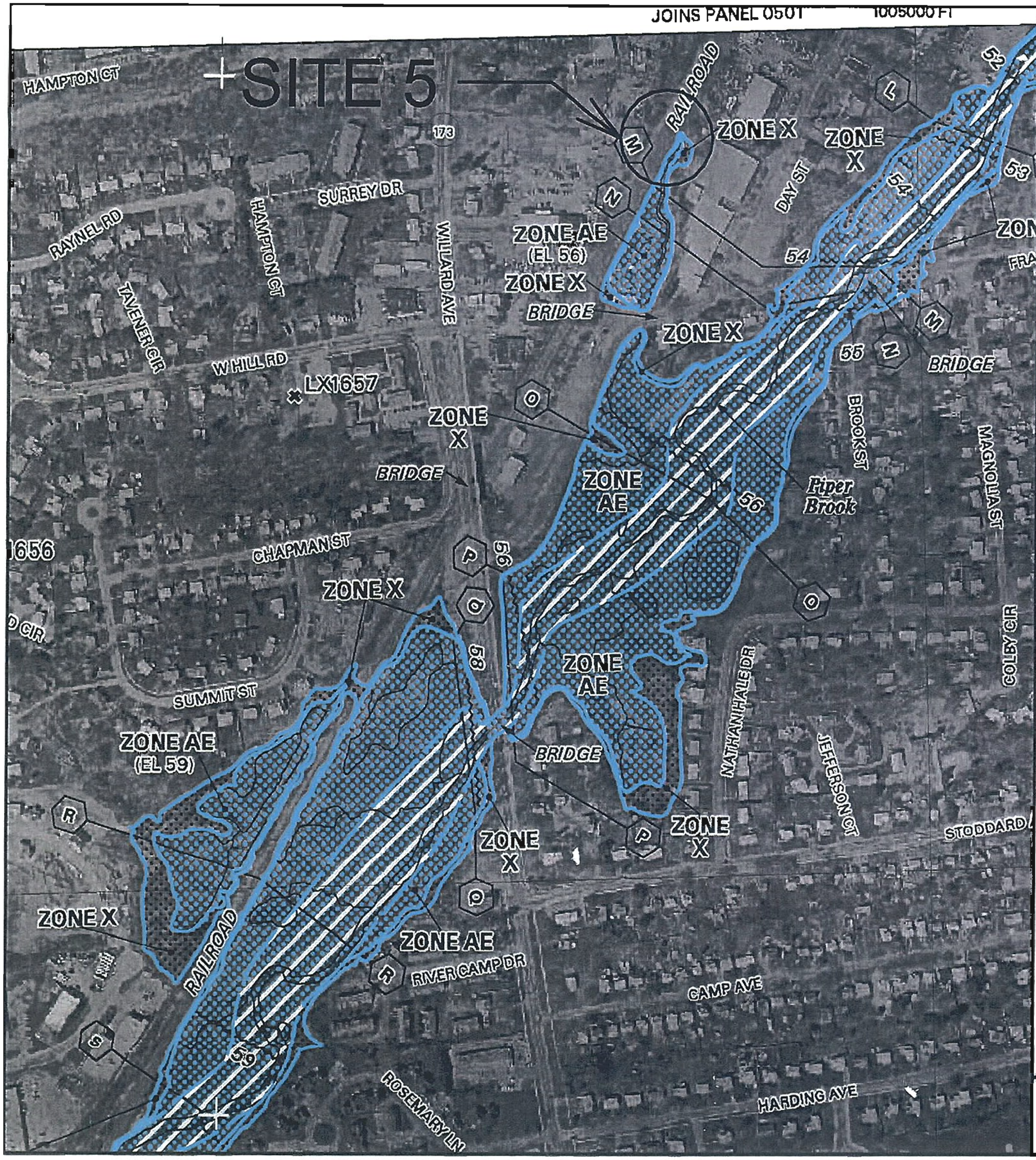
PIPER BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARTFORD COUNTY, CT

(ALL JURISDICTIONS)

314P



FIRM
FLOOD INSURANCE RATE MAP

NATIONAL FLOOD INSURANCE PROGRAM

NFIP

PANEL 0503F

HARTFORD COUNTY,
CONNECTICUT
(ALL JURISDICTIONS)

PANEL 503 OF 675

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
NEWINGTON, TOWN OF	[illegible]	0503	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
09003C0503F

EFFECTIVE DATE:
SEPTEMBER 26, 2008

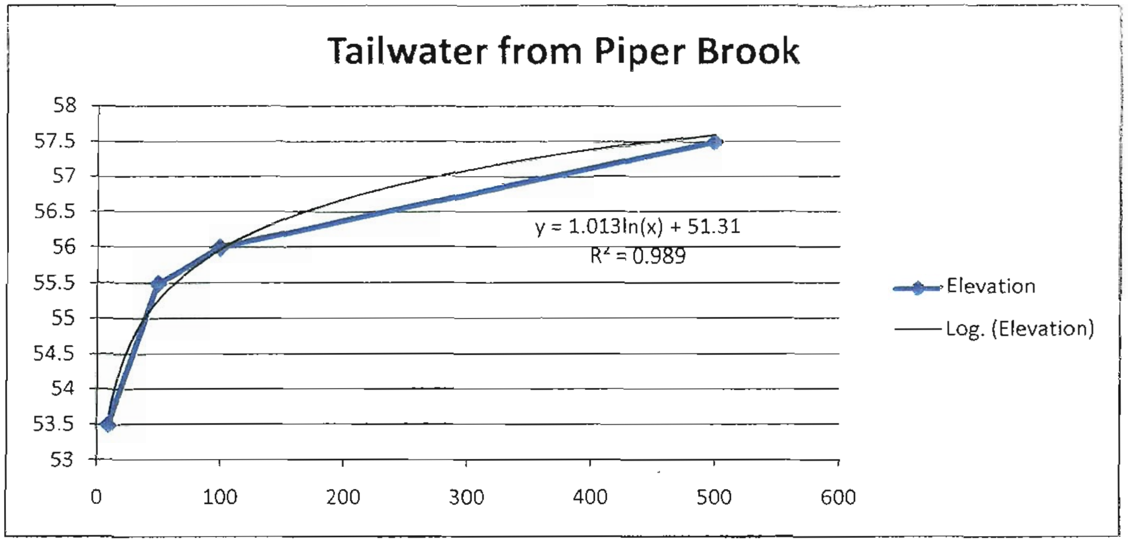
Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

Tailwater Rating Curve for Site 5
to be used in HEC-RAS analysis

RI	Elevation
10	53.5
50	55.5
100	56
500	57.5

	CWSEL NAVD'88
10	53.64252
25	54.57072
50	55.27288
100	55.97504
250	56.90324
500	57.6054



Conversion from NAVD - NGVD for busway culverts

1/8/110

Original Horizontal Coordinates:
NAD 83, Connecticut - 0600, U.S. Survey Feet
Translated Horizontal Coordinates:
NAD 83, Connecticut - 0600, U.S. Survey Feet
Input Vertical Coordinates: NAVD 88, U.S. Survey Feet
Output Vertical Coordinates: NGVD 29, U.S. Survey Feet

Name		Input	Output
test		822200.00000 N	822200.00000 N
		1003800.00000 E	1003800.00000 E
	Elevation	100.00000	100.90
	Convergence	00 00 33.22403	00 00 33.22403
	Scale Factor	0.999988281	0.999988281
	Combined Factor	0.999983498	0.999983498

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

HYDROLOGY REPORT

FOR

STATE PROJECT NO. 171-305

NEW BRITAIN TO HARTFORD BUSWAY
NEW BRITAIN, NEWINGTON, WEST HARTFORD, AND HARTFORD, CONNECTICUT

LOCATION: Un-Named Tributary of Piper Brook, Newington

SITE: 5

PREPARED BY

GARG CONSULTING SERVICES, INC.
ROCKY HILL, CT

FOR

BAKER ENGINEERING NY, INC.
ROCKY HILL, CT

DECEMBER 2002

REVISIONS		
	DATE	ENGINEER
☒	1/20/03	J. A. Scala
☒	2/24/03	J. A. Scala
☐		

TABLE OF CONTENTS

1. SITE NARRATIVE

The purpose of this project is to provide an exclusive busway system from the City of New Britain to the City of Hartford. The exclusive roadway will be constructed along the existing railroad corridor for approximately 9.4 miles. The roadway will be comprised of two lanes with minimal shoulders. Within the project limits, the busway crosses 7 waterways within the upper Connecticut River Basin.

Site 5 is associated with the crossing of an un-named tributary of Piper Brook in the Town of Newington. This area discharges into the tributary at coordinate 41.71912 deg, 72.73458 deg. NAD83 datum into an existing twin culverts under the railroad bed. The conditions at the inlet side are poor with nearly complete collapse of one culvert and partial collapse of the other the inlet culverts are constructed of corrugated metal pipe. The inlet headwalls and wing walls are failing and have limited ability to support the embankments. The outlet side is in good condition and consists of twin 3'X3' stone box culverts.

The watershed area for this site is delineated and measured from U.S.G.S. quadrangle sheet New Britain and Hartford South [illegible] The drainage area has been verified using 200-scale mapping provided by MDC of Hartford. In addition, the delineation was field reviewed.

The associated drainage area of 0.82 square miles is well developed with residential, commercial and individual properties. Based on the extent of development and drainage area the SCS TR-55 Method is considered the most appropriate method of hydrology analysis. This watershed is well developed with more than 30 percent urbanization.

Comparison flow rates using the USGS Regression, and Rational Methods were calculated.

Backup computations and information is contained in subsequent sections of this report.

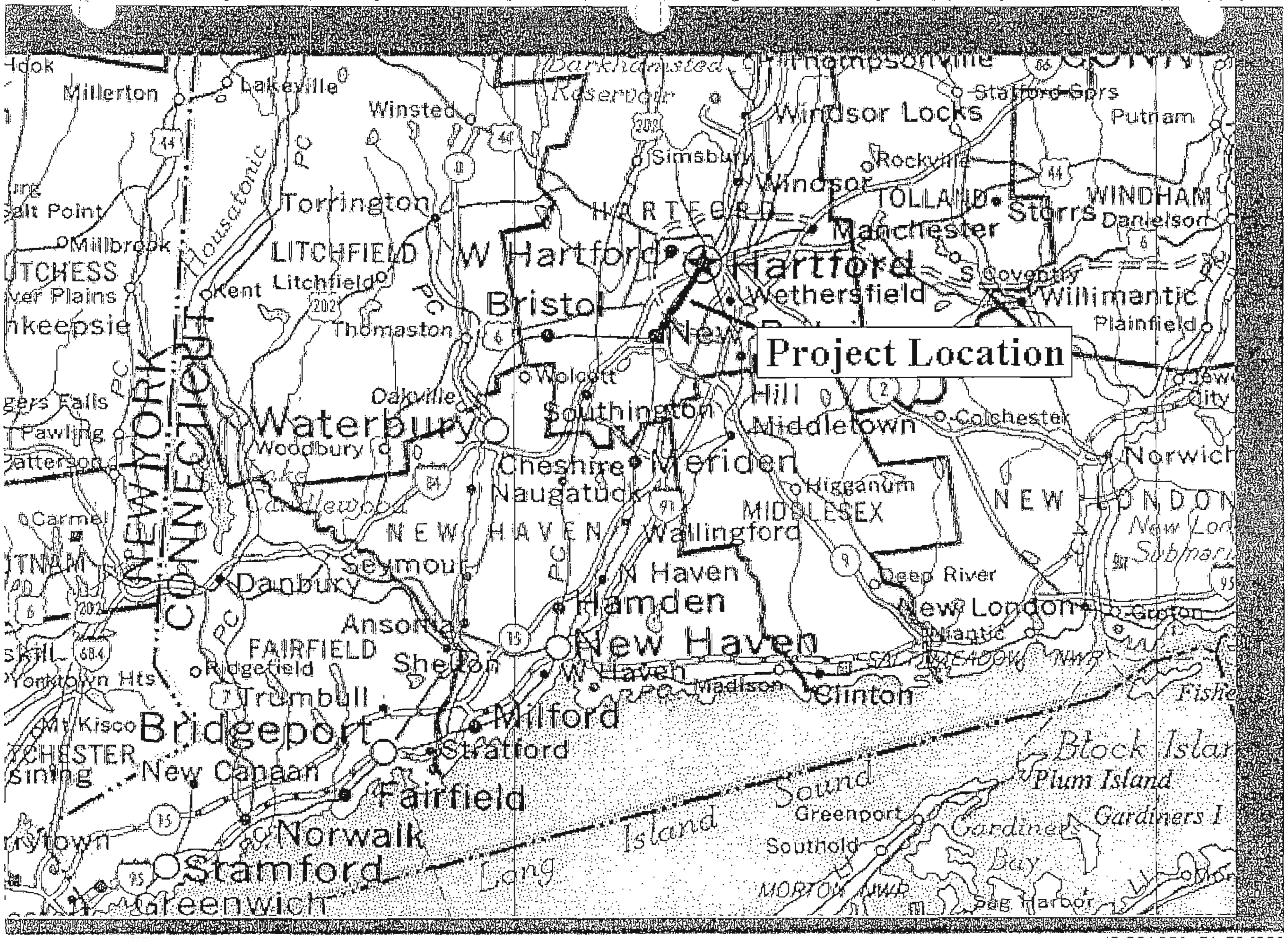
2. SUMMARY OF DISCHARGES

METHODOLOGY	2	10	25	50	100	500
USGS Regression with Urban Adjustment	74	142	200	256	283	
TR-55 Method	153	320	405	486	573	
Rational Method	148	222	285	355	416	

3. RECOMMENDATIONS:

Based on the analysis, field conditions and flooding potential in the area a flow value of 573 cfs for the 100 year design storm is recommended.

[redacted].05[redacted]73.[redacted]4° [redacted]2.05[redacted]93°



40.98123°, 73.78134° NAD83

40.98123°, 71.79693°

E4

MN TN 14½°

10 0 10 20 30 MILES

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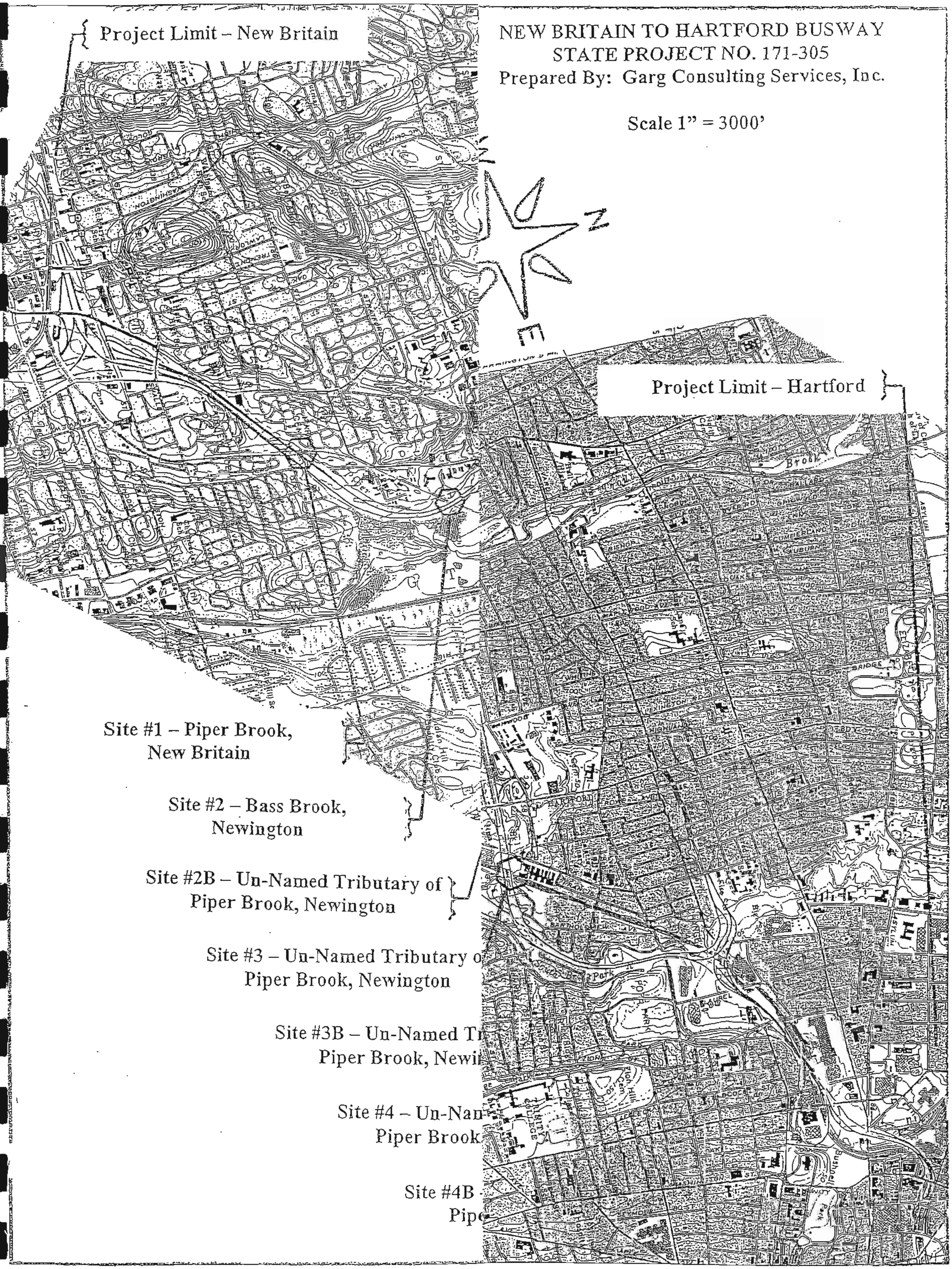
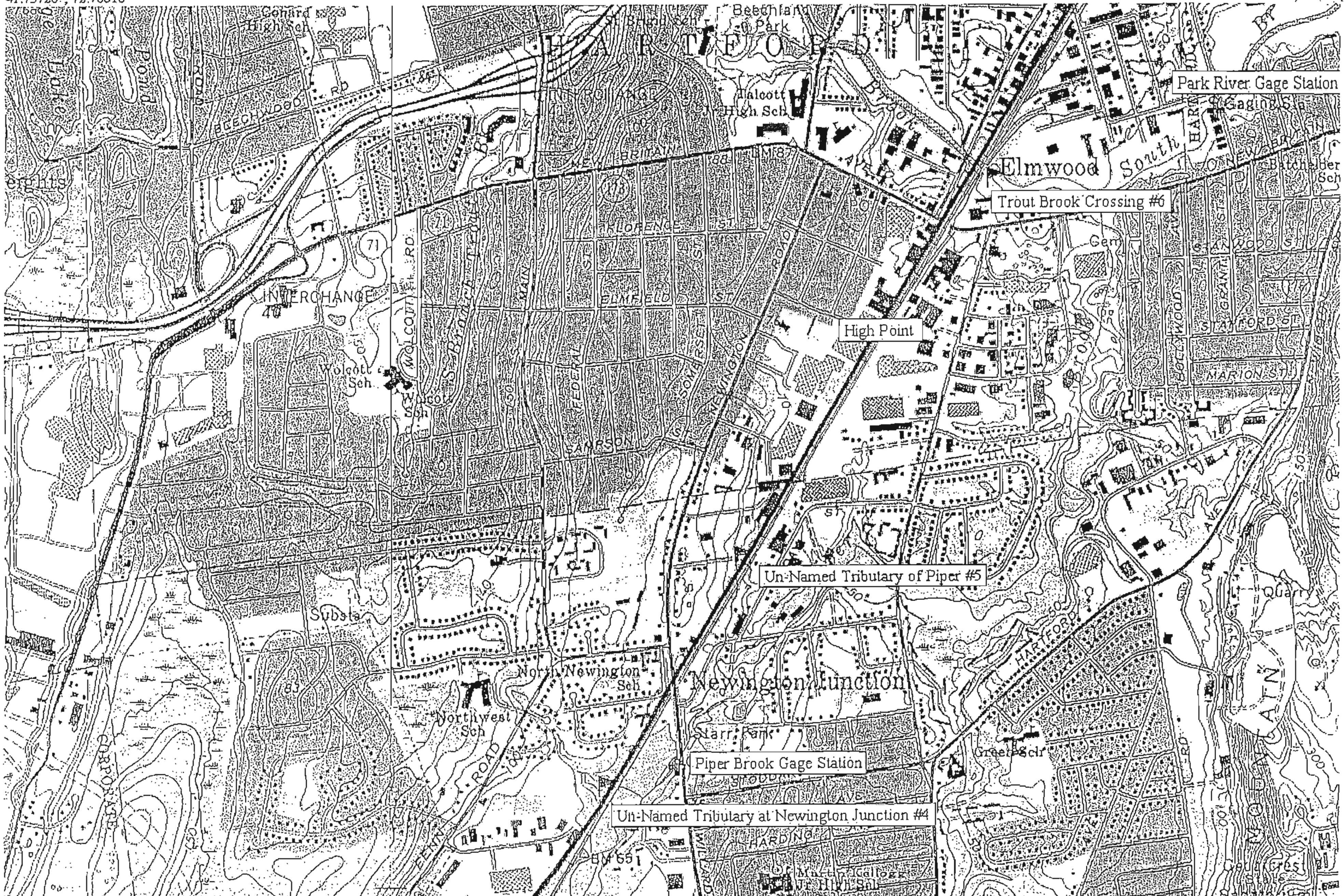

NEW BRITAIN TO HARTFORD BUSWAY
STATE PROJECT NO. 171-305
Prepared By: Garg Consulting Services, Inc.
Scale 1" = 3000'
Project Limit – New Britain
Project Limit – Hartford
Site #1 – Piper Brook, New Britain
Site #2 – Bass Brook, Newington
Site #2B – Un-Named Tributary of Piper Brook, Newington
Site #3 – Un-Named Tributary o
Piper Brook, Newington
Site #3B – Un-Named T
Piper Brook, Newi
Site #4 – Un-Nam
Piper Brook
Site #4B
Pipe

41.73720°, 72.76616° 41.73720°, 72.707



41.70797°, 72.76616° NAD83 41.70797°, 72.707

MN TN 15°

0 1/2 1 MILE
1000 0 1000 2000 3000 4000 FEET

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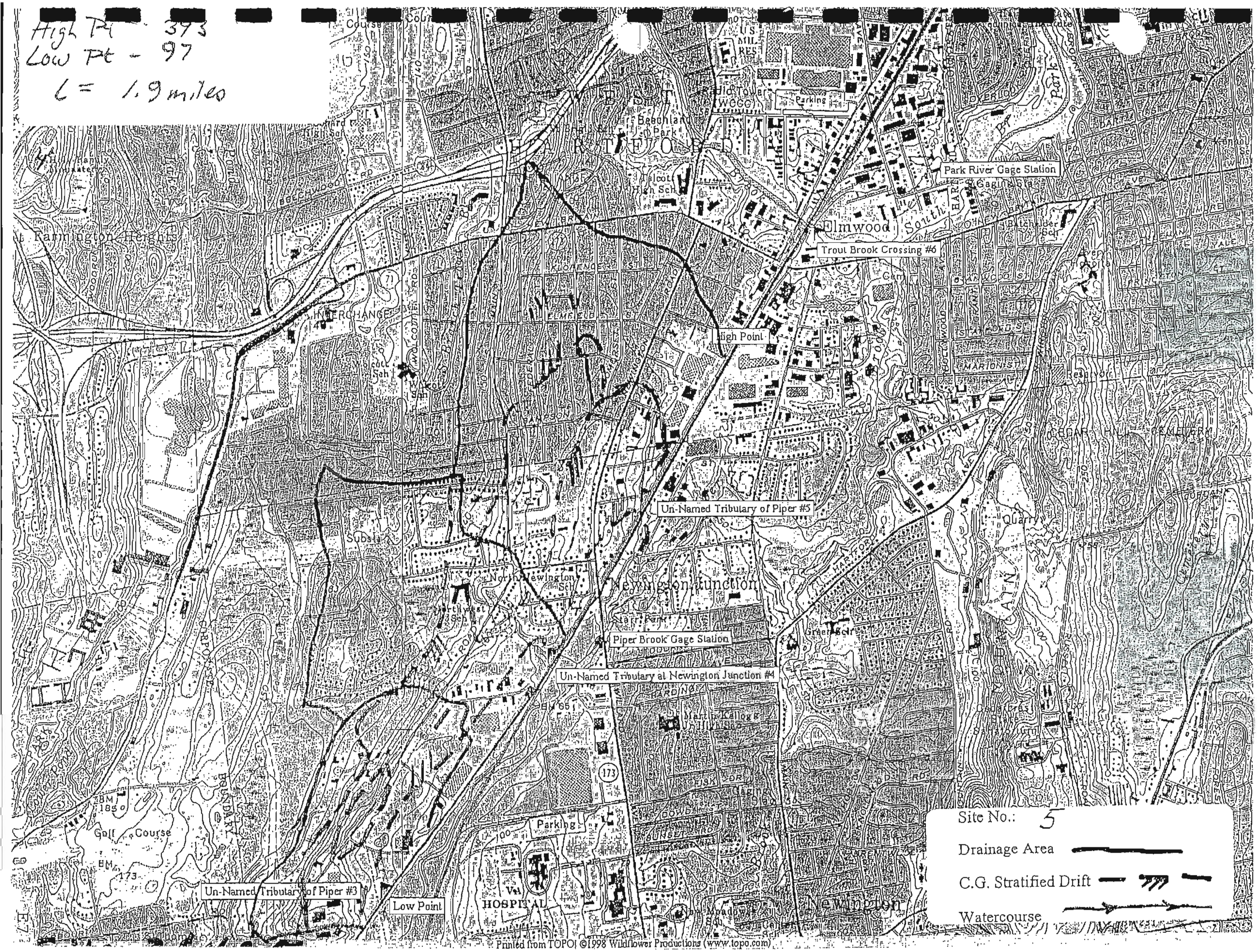
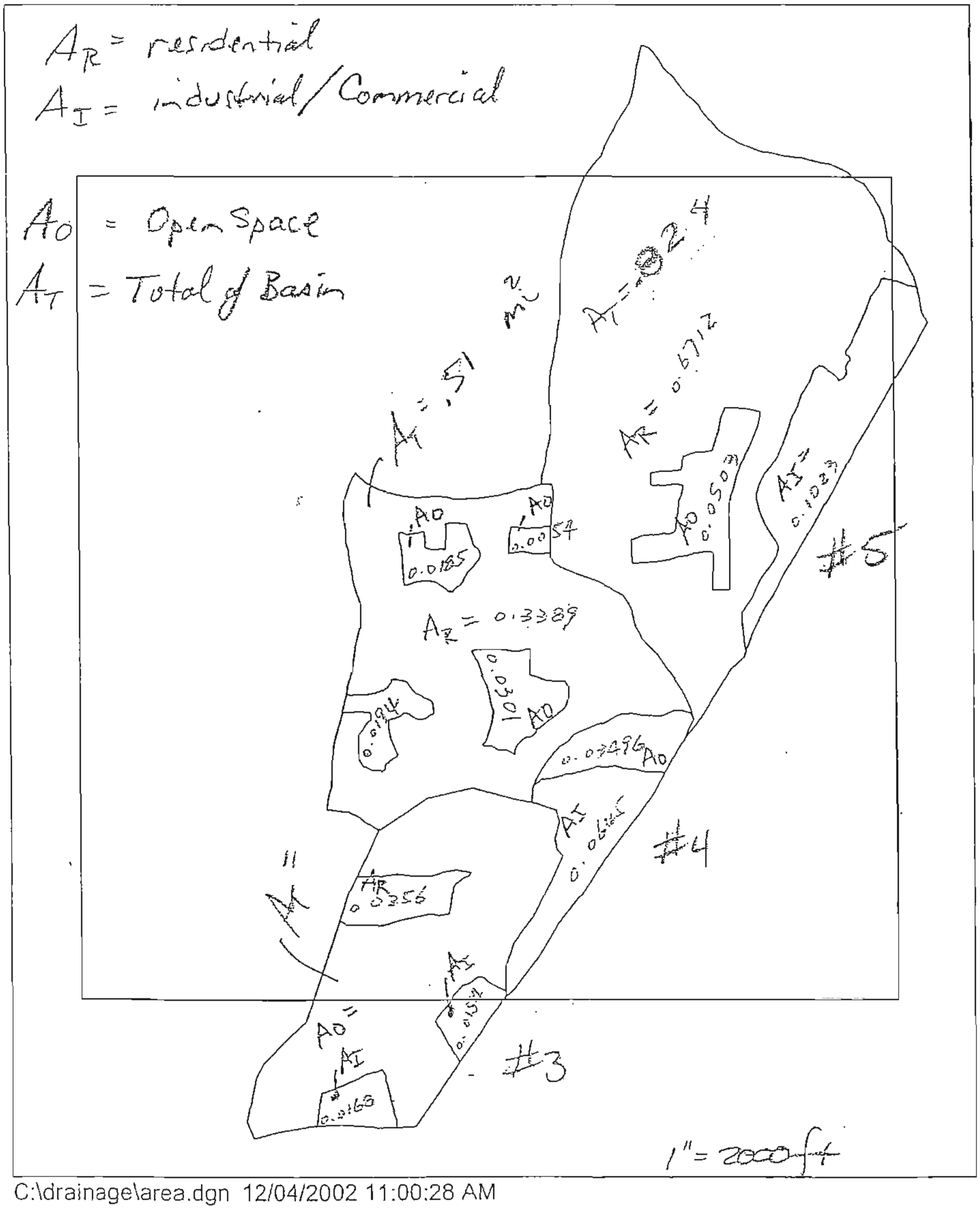

High Pt - 393
Low Pt - 97
L = 1.9 miles
Park River Gage Station
Elmwood
Trout Brook Crossing #6
High Point
Farmington Heights
Un-Named Tributary of Piper #5
Newington Junction
Piper Brook Gage Station
Un-Named Tributary at Newington Junction #4
Un-Named Tributary of Piper #3
Low Point
HOSPITAL
Newington
Golf Course
Parking
Site No.: 5
Drainage Area
C.G. Stratified Drift
Watercourse
Printed from TOPO! ©1998 Wildflower Productions (www.topo.com)

SITE # 5



C:\drainage\area.dgn 12/04/2002 11:00:28 AM

Worksheet 3: Time of Concentration (Tc) or Travel Time (Tt)

Project	By	Date
New Britian to Hartford Busway	J. Scala	2/24/03
Location: Site 5 Un-Named Tributary of Piper Brook	Checked	Date: 2/25/03

Check one: ☑ Present ☐ Developed

Check one: ☑ Tc ☐ Tt through subarea

Notes: Space for as many as two segments per flow type can be used for each worksheet. Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to Tc only)

	Segment ID				
1.	Surface description (table 3-1)	Woods/ Grass			
2.	Manning's roughness coefficient, n (table 3-1) .... ft	0.4			
3.	Flow length, L (total L + 300 ft)	300			
4.	Two-year 24-hour rainfall, P2 .... in	3.25			
5.	Land slope, s .... ft/ft	0.01			
	Compute Tt .... hr	1.1284995	+		= 1.1285

6. Tt = $\frac{0.007\ (nL)\ 0.8}{P2\ 0.5\ s\ 0.4}$

Shallow concentrated flow

	Segment ID				
7.	Surface description (paved or unpaved)	Un - Paved			
8.	Flow length, L .... ft	4910			
9.	Watercourse slope, s .... ft/ft	0.019			
10.	Average veocity, V (figure 3-1) .... ft/s	2.2			
11.	Tt = $\frac{L}{3600\ V}$ Compute Tt .... hr	0.6199495	+		= 0.61995

Channel Flow

	Segment ID				
12.	Cross sectional flow area, a .... trap. B= 4, D=2.5 ft	20			
13.	Wetted perimeter, Pw .... ft	15.2			
14.	Hydraulic radius, r= a/Pw Compute r .... ft	1.3			
15,	Channel slope, s .... ft/ft	0.0079			
16.	Manning's roughness coefficient, n	0.03			
17.	V = 1.49r2/3s1/2 / n ft/s	5.258704596			
18.	Flow length, L ft	4860			
19.	Tt = $\frac{L}{3600V}$ Compute Tt .... hr	0.2567172	+		= 0.25672

20. Watershed or subarea Tc or Tt (add Tt in steps 6, 11, 19) .... Hr 2.00517

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Natural Resources Conservation Service Technical Release 55

Worksheet 2: Runoff Curve Number and Runoff

Project: New Britian to Hartford Busway	By: J. Scala	Date: 2/24/03	
Location: Site 5 Un-Named Tributary of Piper Brook	Checked: RD	Date: 2/25/03	

Check one: ☑ Present ☐ Developed

1. Runoff curve number

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious areea ratio)	CN Table 2-2	CN Table 2-3	CN Table 2-4	Area ☐ acre ☑ sq mi ☐ %	Product of CN x area
Wethersfiled, Branford, Berlin B/C	Residential Areas, 38% Impervious	79			0.6712	53.0248
B/C	Urban Commercial / Industrial, 78.5 % Impervious	91			0.1023	9.3093
B/C	Open Space, Woods, Cemeteries, Grass Cover, fair to good condition	70			0.0503	3.521
						0
						0
						0
						0
						0
Use only one CN source per line		Totals			0.8238	65.8551

CN (weighted) = total product / total area = 79.94064093

Use CN → 80

2. Runoff

		Storm #1	Storm #2	Storm #3	Storm #4	Storm #5
Frequency	yr	25	50	100	2	10
Rainfall, P (24-hour)	in	5.5	6.2	6.9	3.2	4.7
Runoff, Q	in	3.33	3.96	4.6	1.4	2.63

(Use P and CN with table 2-1, figure 2-1, or equations 2-3 and 2-4)

s= 2.5

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Worksheet 4: Graphical Peak Discharge Method

Project	By	Date
New Britian to Hartford Busway	J. Scala	02/24/03
Location	**Checked**	**Date**
Site 5 Un-Named Tributary of Piper Brook		2/25/03

Check one: ☑ Present ☐ Developed

1. Data

Drainage area .... Am = 0.8238 mi2 (acres/640)

Runoff curve number .... CN = 80 (From worksheet 2)

Time of concentration .... Tc = 2.01 hr (From worksheet 3)

Rainfall distribution .... = III (I, IA, II, III)

Pond and swamp areas spread throughout watershed .... = 6.25 percent of Am
(________ acres or mi2 covered)

		Storm #1	Storm #2	Storm #3	Storm #4	Storm #5
2. Frequency	yr	25	50	100	2	10
3. Rainfall, P (24-hour)	in	5.5	6.2	6.9	3.2	4.7
4. Initial abstraction, Ia (Use CN with table 4-1)	in	0.5	0.5	0.5	0.5	0.5
5. Compute 1A/P		0.091	0.081	0.072	0.156	0.106
6. Unit peak discharge, qu (Use Tc and Ia/P with exhibit 4-_ III	csm/in	205	207	210	185	205
7. Runoff, Q (From worksheet 2) Figure 2-6	in	3.33	3.96	4.6	1.4	2.63
8. Pond and swamp adjustment factor, Fp (Use percent pond and swamp area with table 4.2.) (Factor is 1.0 for zero percent pond and swamp area.)		0.72	0.72	0.72	0.72	0.72
9. Peak discharge, qp (Where qp = quAmQFp)	ft3/s	404.9	486.2	573	153.6	319.8

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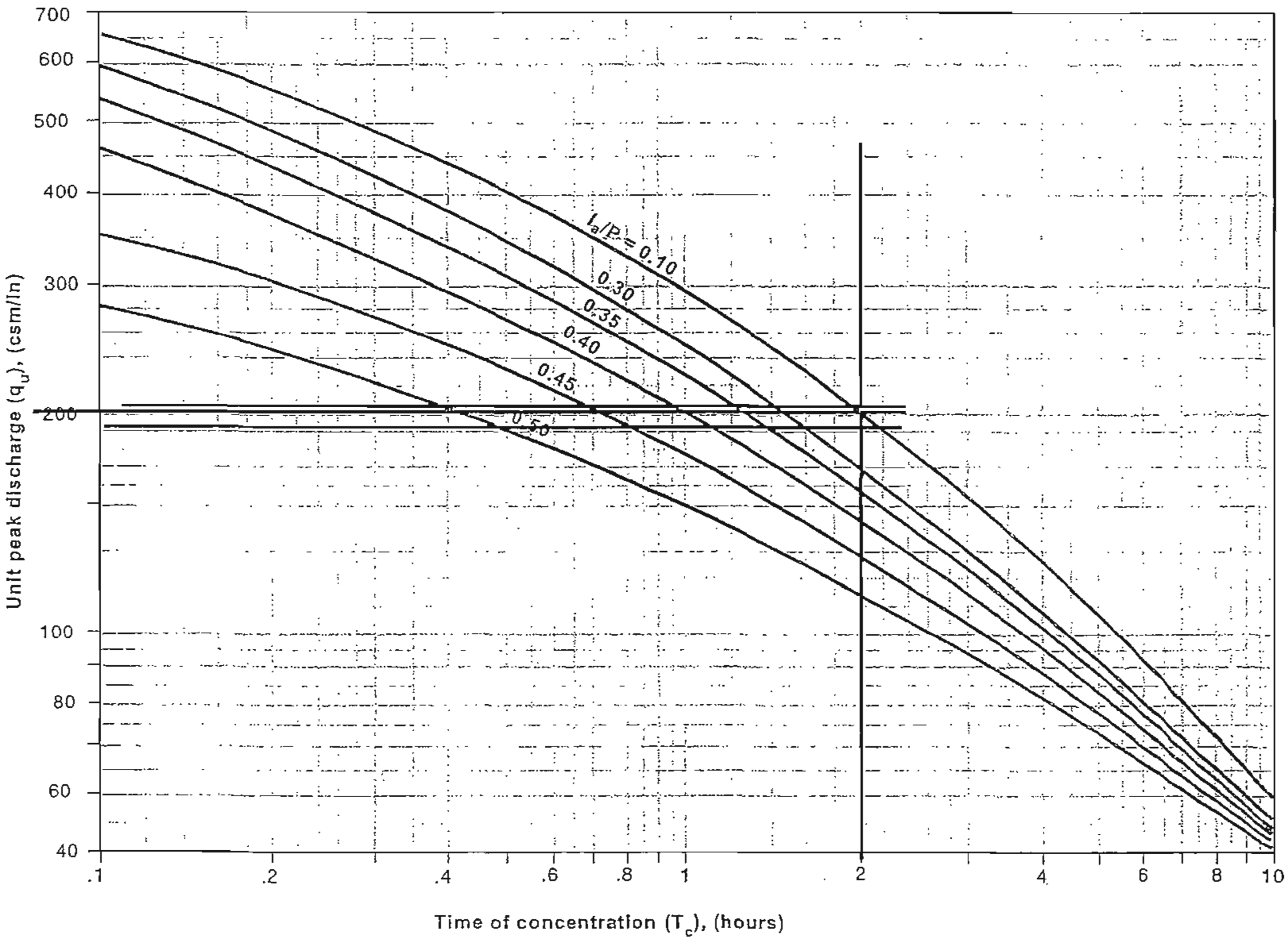
Exhibit 4-III *Unit peal discharge (q_u) for NRCS (SCS) type III rainfall distribution*



New Britain to Hartford Busway

Project No. 0126

SITE 5 -- Un-Named Tributary of Piper Brook - Newington

Rational Method as Check

HYDROLOGIC DATA					
Drainage Area (sq. mi.)	0.823				
Length (mi)	1.88				
High Point Elevation (ft)	393				
Low Point Elevation (ft)	97				
Stream Slope10% to 85% (ft/ft)	0.039759				
Sheet Flow Length(ft)	300				
Sheet Flow Slope(ft/ft)	0.01				
Sheet Flow Mannings No. (n)	0.4				
2 yr - 24 hour storm (in)	3.2				
Sheet Flow Tc (hr)	1.137282				
Shallow Concentrated Flow Condition	Paved				
SCF Length (ft)	4910				
SCF Slope (ft/ft)	0.019				
SCF Tc (hr)	0.486742				
Channel Length (ft)	4860				
Channel Slope (ft/ft)	0.0079				
Channel Over Bank Depth (ft)	3.5				
Approximate Velocity (ft/sec.)	4.6	Select Velocity			
Channel Tc (hr)	0.293478				
Estimated Tc (minutes)	115.0501				
Year Storm	2	10	25	50	100
100-yr Rainfall Intensity (in/hr)	0.8	1.2	1.4	1.6	1.8
Improved Area Percent(I=.6)	40.70909				
Unimproved (I=.18)	59.29091				
Runoff Coefficient	0.350978	0.350978	0.386076	0.421174	0.438723
Flow (CFS)	147.8938	221.8407	284.6955	354.9451	415.9513

By:

Checked By:

DURATION	DURATION	RAINFALL INTENSITY (in/hr)					
		2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
91	1.52	0.9	1.2	1.4	1.7	1.9	2.1
92	1.53	0.9	1.2	1.4	1.7	1.9	2.1
93	1.55	0.9	1.2	1.4	1.7	1.9	2.1
94	1.57	0.9	1.2	1.4	1.6	1.8	2.1
95	1.58	0.9	1.2	1.4	1.6	1.8	2.0
96	1.60	0.9	1.2	1.4	1.6	1.8	2.0
97	1.62	0.9	1.2	1.3	1.6	1.8	2.0
98	1.63	0.9	1.1	1.3	1.6	1.8	2.0
99	1.65	0.9	1.1	1.3	1.6	1.8	2.0
100	1.67	0.9	1.1	1.3	1.6	1.8	2.0
101	1.68	0.9	1.1	1.3	1.6	1.8	2.0
102	1.70	0.9	1.1	1.3	1.6	1.7	1.9
103	1.72	0.9	1.1	1.3	1.5	1.7	1.9
104	1.73	0.8	1.1	1.3	1.5	1.7	1.9
105	1.75	0.8	1.1	1.3	1.5	1.7	1.9
106	1.77	0.8	1.1	1.3	1.5	1.7	1.9
107	1.78	0.8	1.1	1.3	1.5	1.7	1.9
108	1.80	0.8	1.1	1.2	1.5	1.7	1.9
109	1.82	0.8	1.1	1.2	1.5	1.7	1.9
110	1.83	0.8	1.1	1.2	1.5	1.7	1.8
111	1.85	0.8	1.1	1.2	1.5	1.6	1.8
112	1.87	0.8	1.0	1.2	1.5	1.6	1.8
113	1.88	0.8	1.0	1.2	1.4	1.6	1.8
114	1.90	0.8	1.0	1.2	1.4	1.6	1.8
115	1.92	0.8	1.0	1.2	1.4	1.6	1.8
116	1.93	0.8	1.0	1.2	1.4	1.6	1.8
117	1.95	0.8	1.0	1.2	1.4	1.6	1.8
118	1.97	0.8	1.0	1.2	1.4	1.6	1.8
119	1.98	0.8	1.0	1.2	1.4	1.6	1.7
120	2.00	0.8	1.0	1.2	1.4	1.6	1.7

Rainfall Intensity/Duration/Frequency Relationship for Connecticut (English Units)
Table B-2.1 continued

New Britain to Hartford Busway

Project No. 0126

SITE 5 -- Un-Named Tributary of Piper Brook - Newington

Location Description: The drainage basin is moderately urbanized with relatively flat slopes and some development of stormwater drainage systems. The drainage area is developed with a number of industries and manufacturing facilities. The site is locate

USGS Connecticut Regression Formulas for Rural Watersheds

HYDROLOGIC DATA	
Drainage Area (sq. mi.)	0.823
Length (mi)	1.88
High Point Elevation (ft)	393
Low Point Elevation (ft)	97
Stream Slope10% to 85% (ft/mi)	209.9291
Area C.G. Stratified Drift (%)	79.95
2-Yr 24-Hour Rainfall (in)	2.625
10-Yr 24-Hour Rainfall (in)	4.375
25-Yr 24-Hour Rainfall (in)	5.65
50-Yr 24-Hour Rainfall (in)	7.25
100-Yr 24-Hour Rainfall (in)	7.9

Q = FREQUENCY DISCHARGES (CFS)		URBAN ADJUSTED
2-year	25.48	74.19957033
10-year	60.11	142.3209831
25-year	94.20	199.6970715
50-year	128.26	255.5358066
100-year	144.21	282.8191148
500- year *	*245.15*	*480.79*

* 100 year X 1.7

DESIGN RATE (Q/Sq. Mile)
175.22

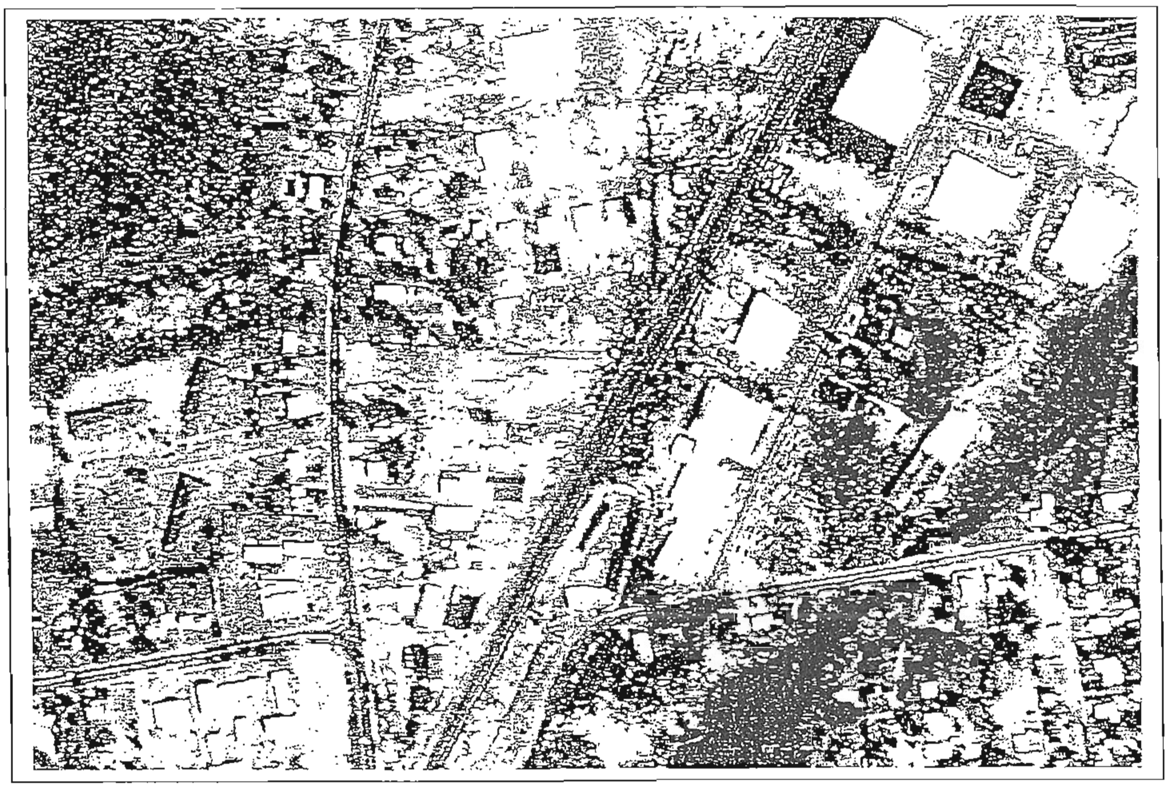
Urban Adjustments

Basin Characteristics	Upper Third	Middle Third	Lower Third
Channel Improvements		1	1
Channel Lining	0	0	1
Storm Drains or Systems	1	1	1
Curb and Gutter Streets	1	1	1
Subtotal	2	3	4
Total BDF			9

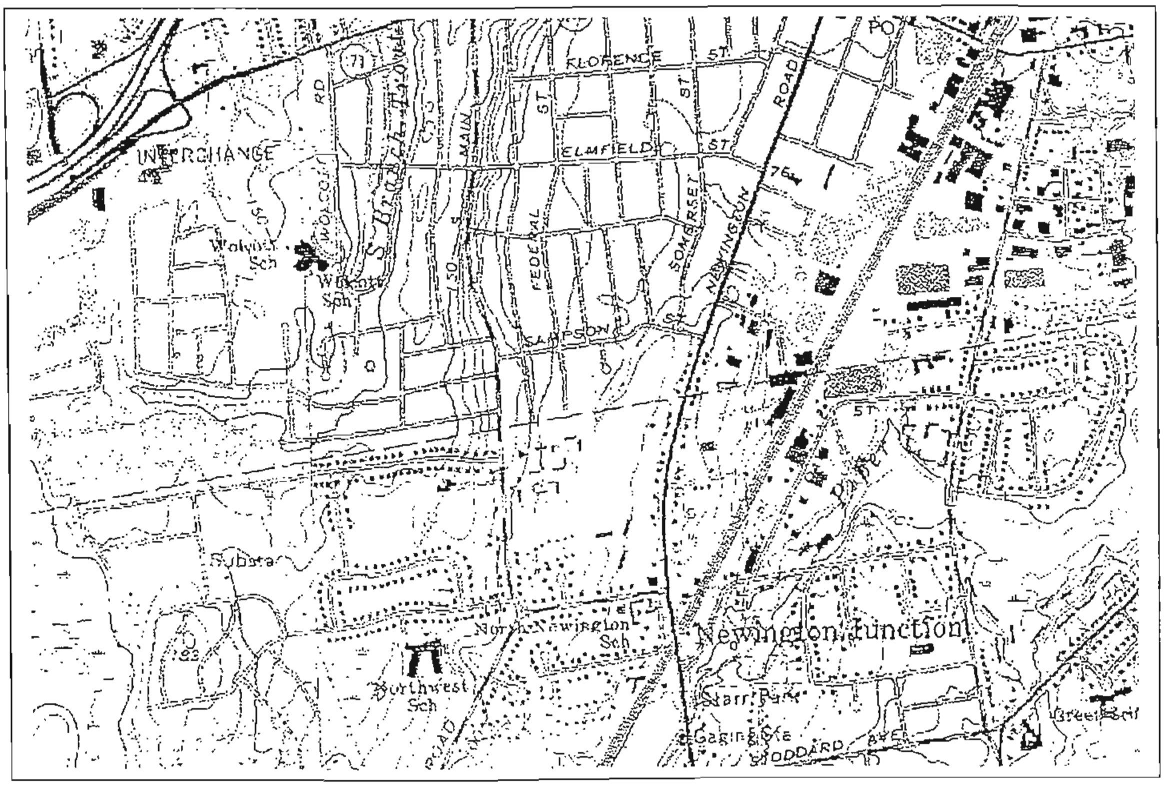
By: [signature]

Checked By: [signature]

2/24/03 11:03 AM

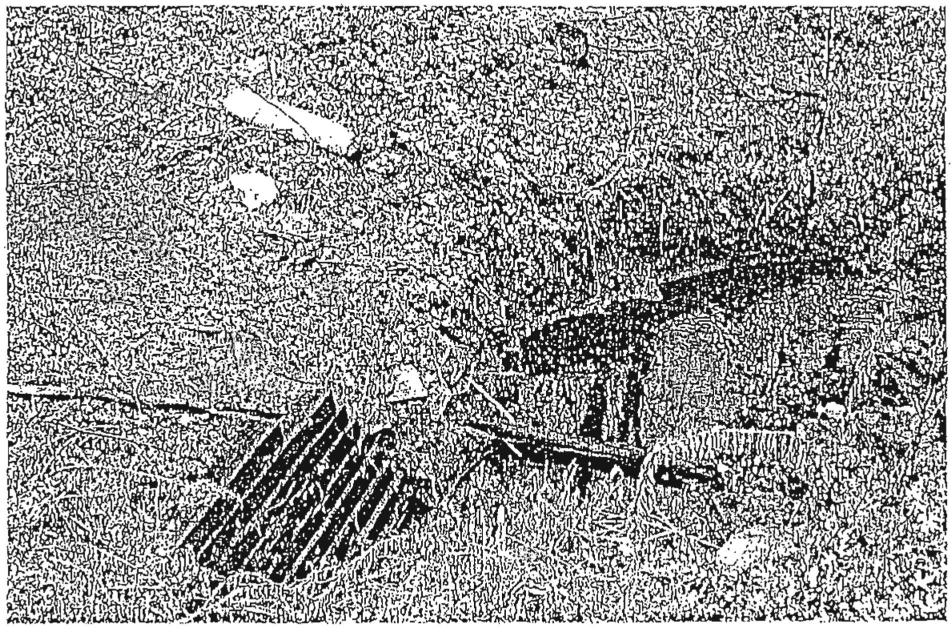


JACOBS BROOK



JACOBS BROOK TOPO

Bridge ID:		**Project No.:**	171-305
Feature Carried:	Un-Named Tributary of Piper Brook	**Inspection Date:**	7/29/02
Feature Crossed:	Existing Railroad bed and active track	**Location:**	Site 5 Newington, Connecticut



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Description: Up Stream at Inlet.

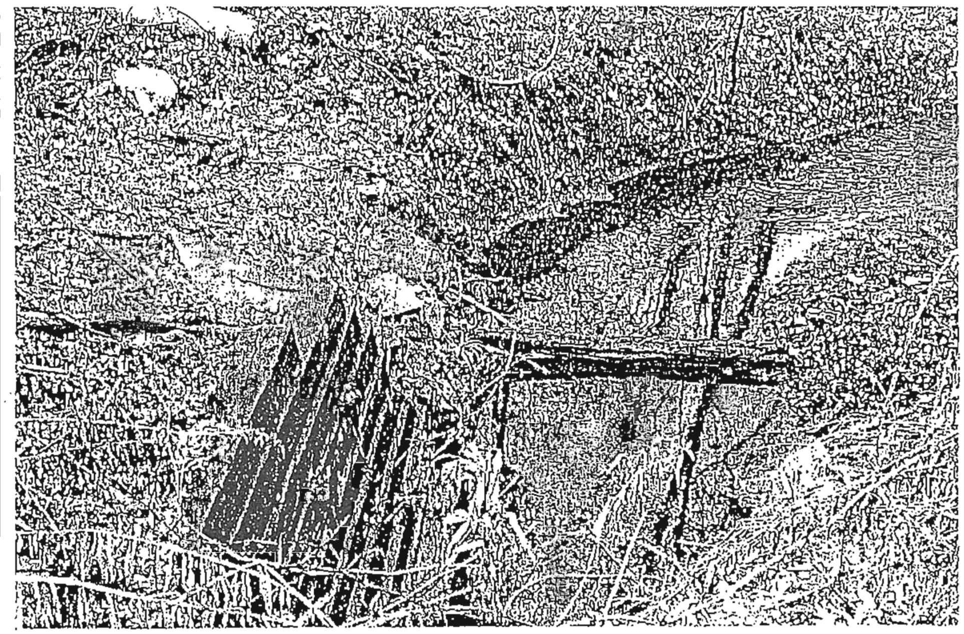

Photo File #: 1528
Description: Up Stream at Inlet

E17

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Bridge ID:		Project No.:	171-305
Feature Carried:	Un-Named Tributary of Piper Brook	Inspection Date:	7/29/02
Feature Crossed:	Existing Railroad bed and active track	Location:	Site 5 Newington, Connecticut

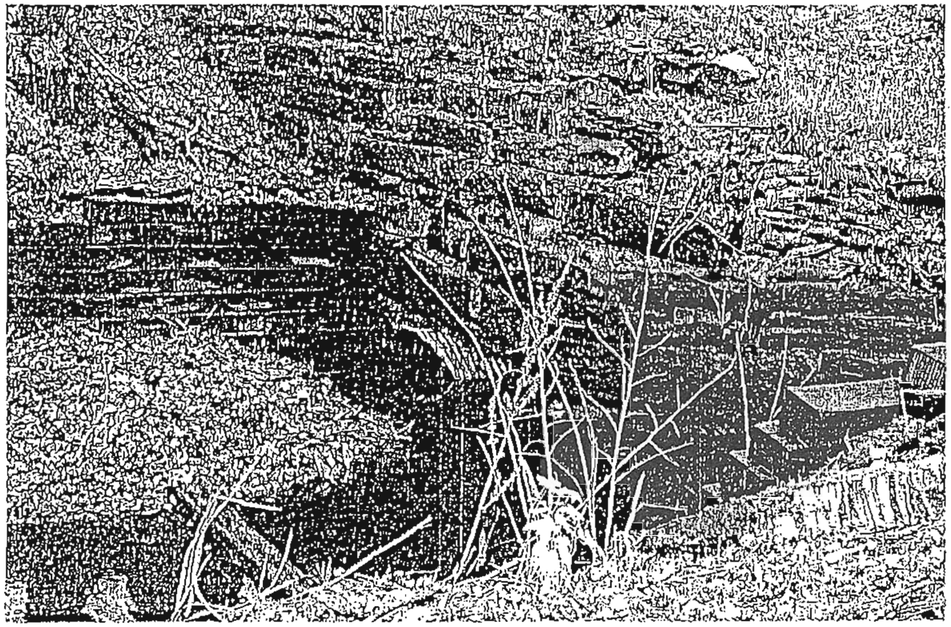

Photo File #: 1529
Description: Down Stream at Inlet

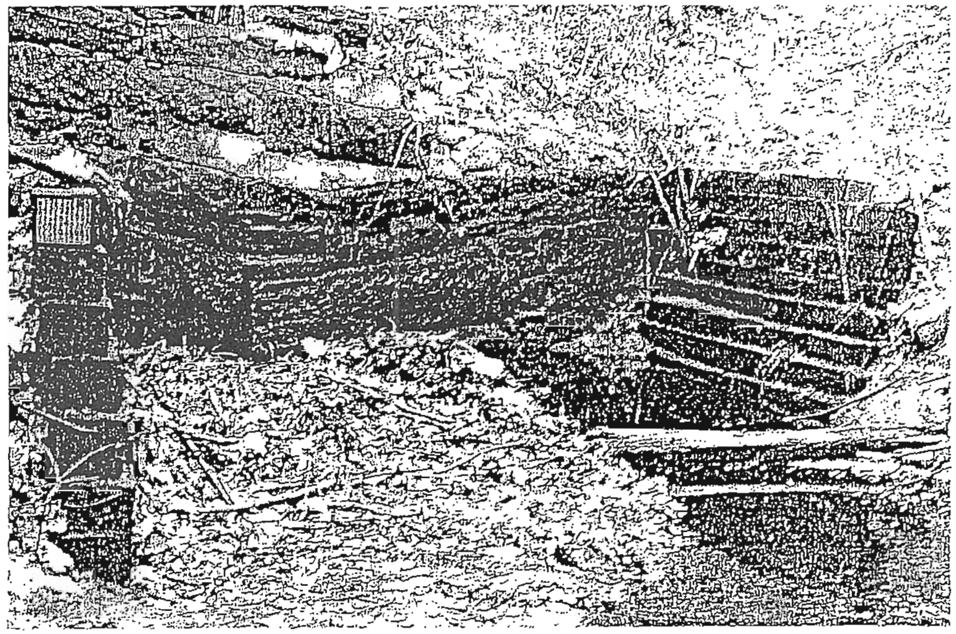

Photo File #: 1530
Description: Down Stream at Inlet

E18

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ENGINEERS • CONSULTANTS • CONSTRUCTION MANAGERS

Bridge ID:		Project No.:	171-305
Feature Carried:	Un-Named Tributary of Piper Brook	Inspection Date:	7/29/02
Feature Crossed:	Existing Railroad bed and active track	Location:	Site 5 Newington, Connecticut

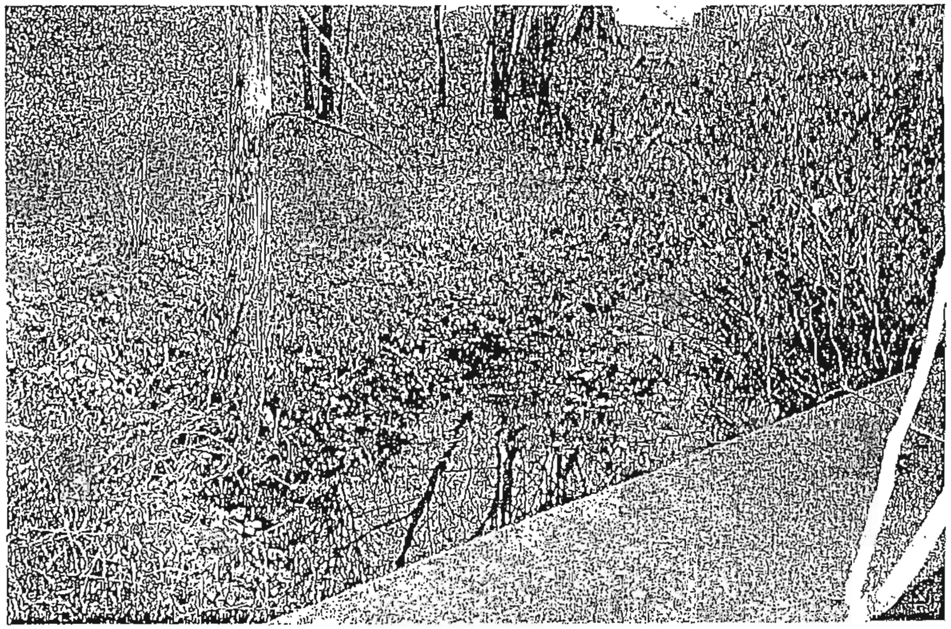
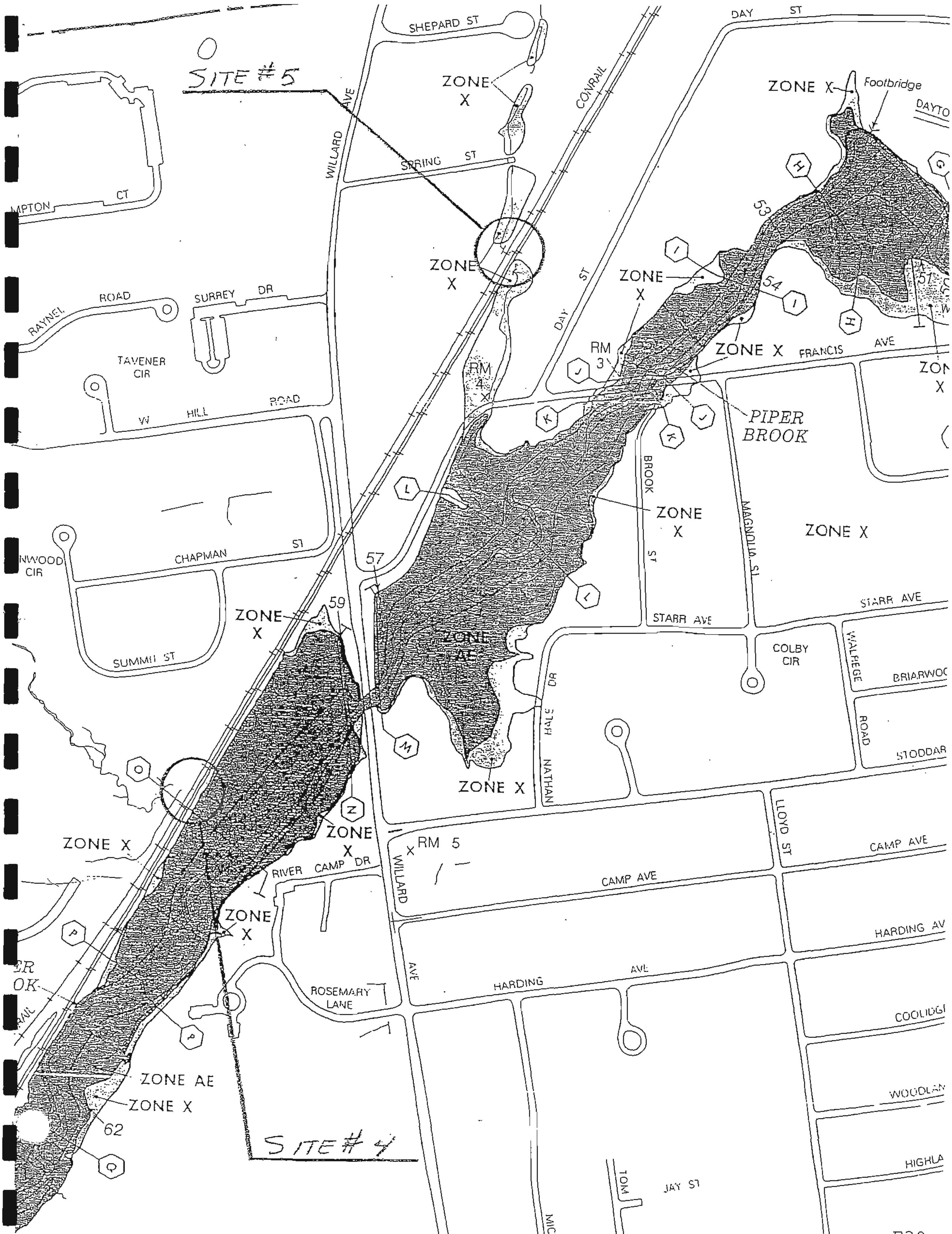


Photo File #: 1531
Description: Down Stream at Outlet

Photo File #: 1532
Description: Up Stream at Outlet

E19



SITE #5
SITE #4
SHEPARD ST
DAY ST
CONRAIL
ZONE X
Footbridge
WILLARD AVE
SPRING ST
MPTON CT
ZONE AE
PIPER BROOK
RM 3
RM 4
RM 5
FRANCIS AVE
RAYNEL ROAD
SURREY DR
TAVENER CIR
W HILL ROAD
BROOK ST
MAGNOLIA ST
CHAPMAN ST
NWOOD CIR
STARR AVE
COLBY CIR
WALFIEGE
BRIARWOO
ROAD
STODDAR
SUMMIT ST
HALE ST
NATHAN DR
LLOYD ST
CAMP AVE
RIVER CAMP DR
HARDING AVE
ROSEMARY LANE
COOLIDG
WOODLAN
HIGHLA
TOM
JAY ST
53
54
57
59
62

Appendix B

Existing and Proposed Culvert Design Computations

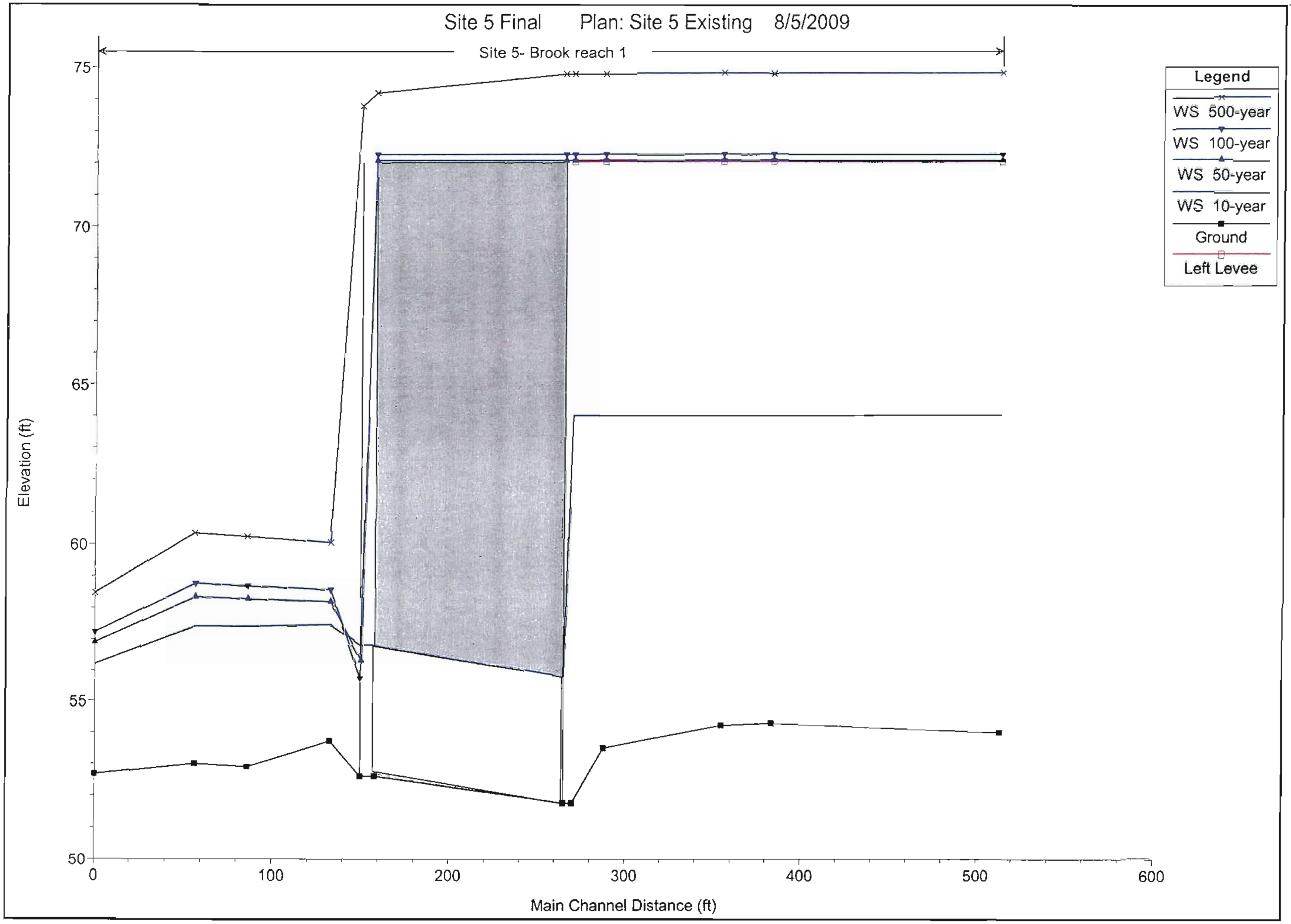
Existing Conditions HEC-RAS

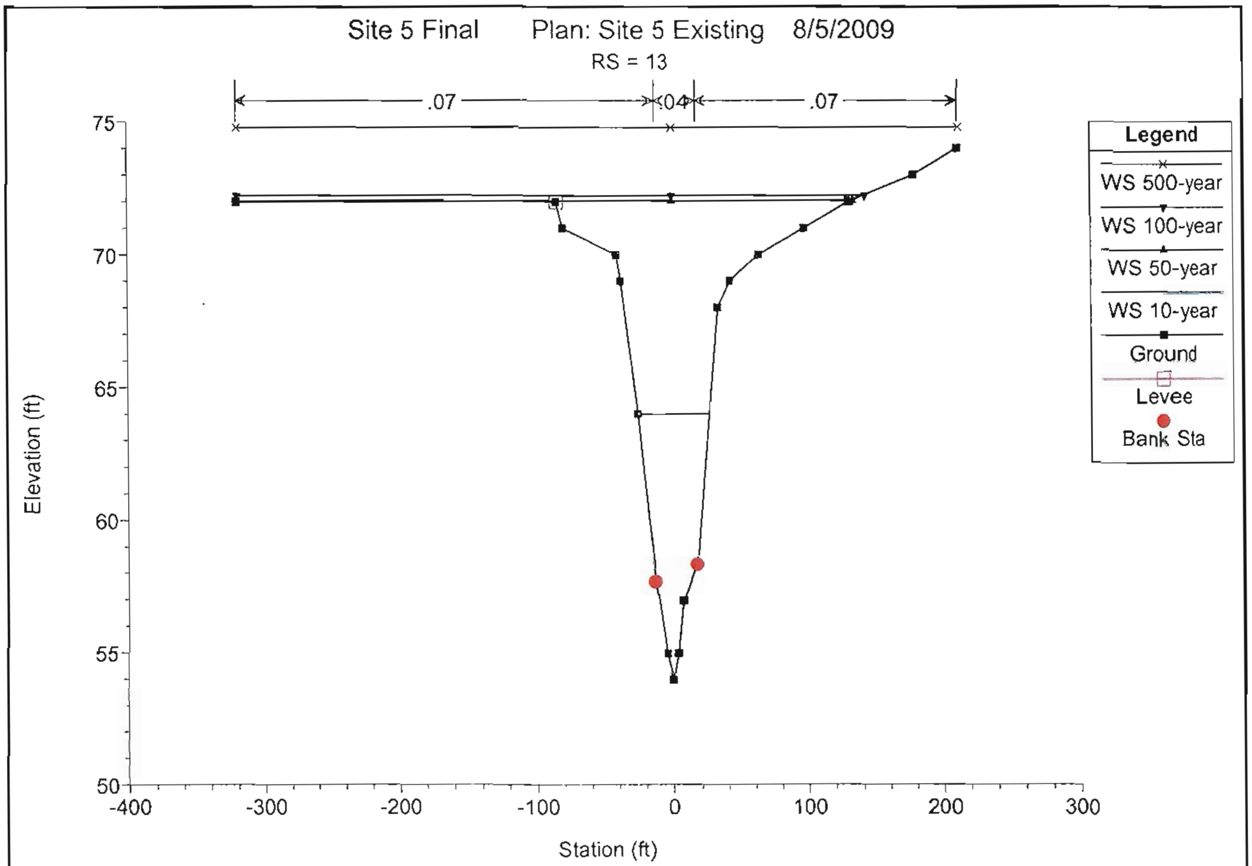
Profile

Sections

Standard Output Table

Culvert Output Tables


Site 5 Final Plan: Site 5 Existing 8/5/2009
Site 5- Brook reach 1
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Left Levee
Elevation (ft)
Main Channel Distance (ft)
75
70
65
60
55
50
0
100
200
300
400
500
600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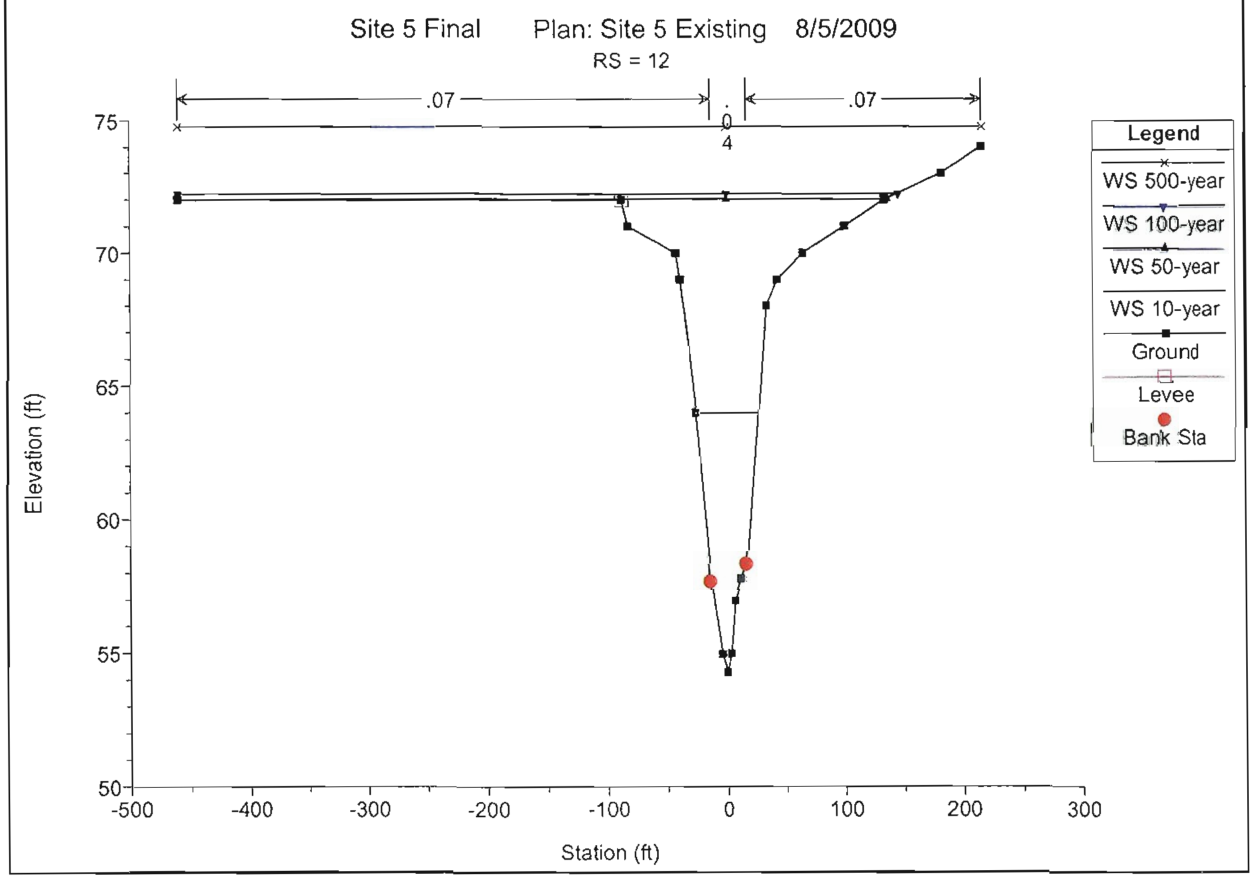
RS = 13
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-400
-300
-200
-100
0
100
200
300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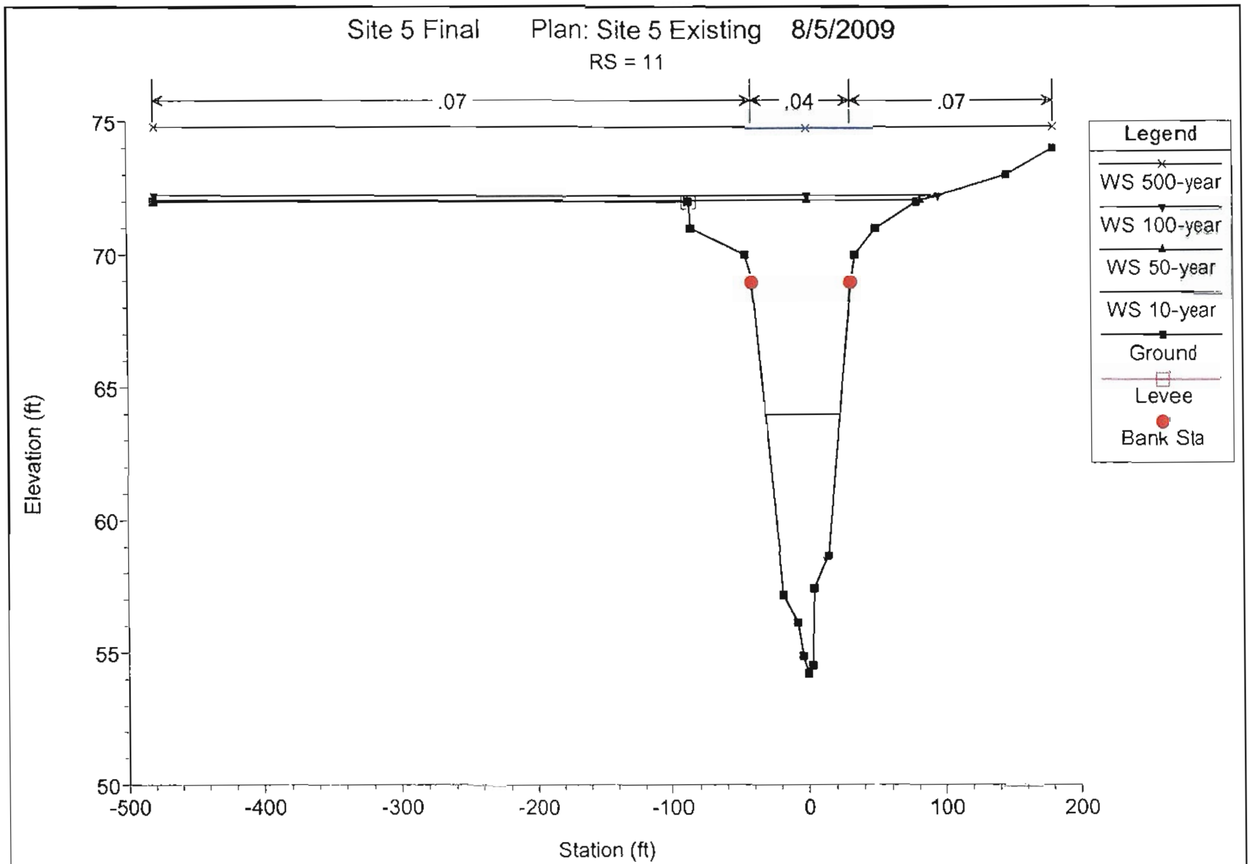
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200
300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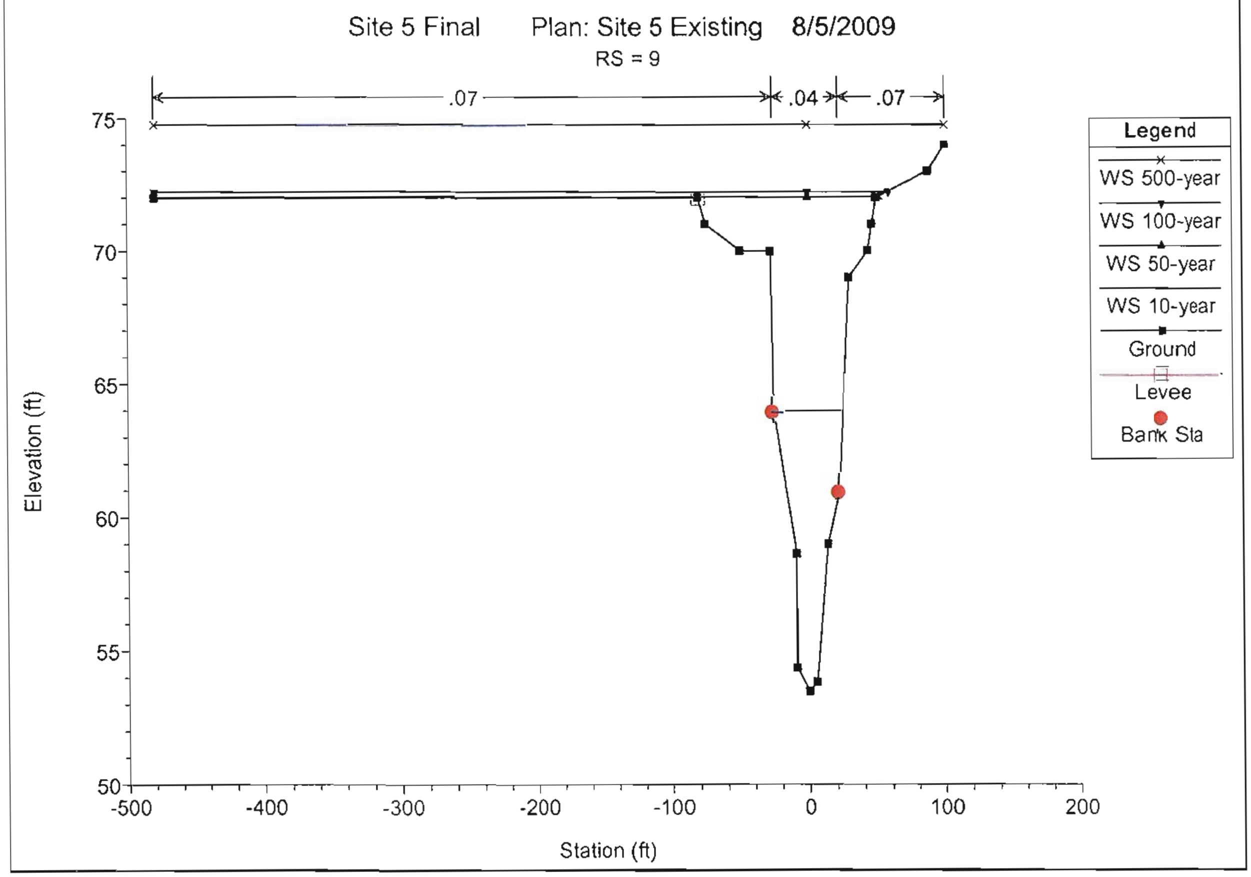
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200


Site 5 Final Plan: Site 5 Existing 8/5/2009
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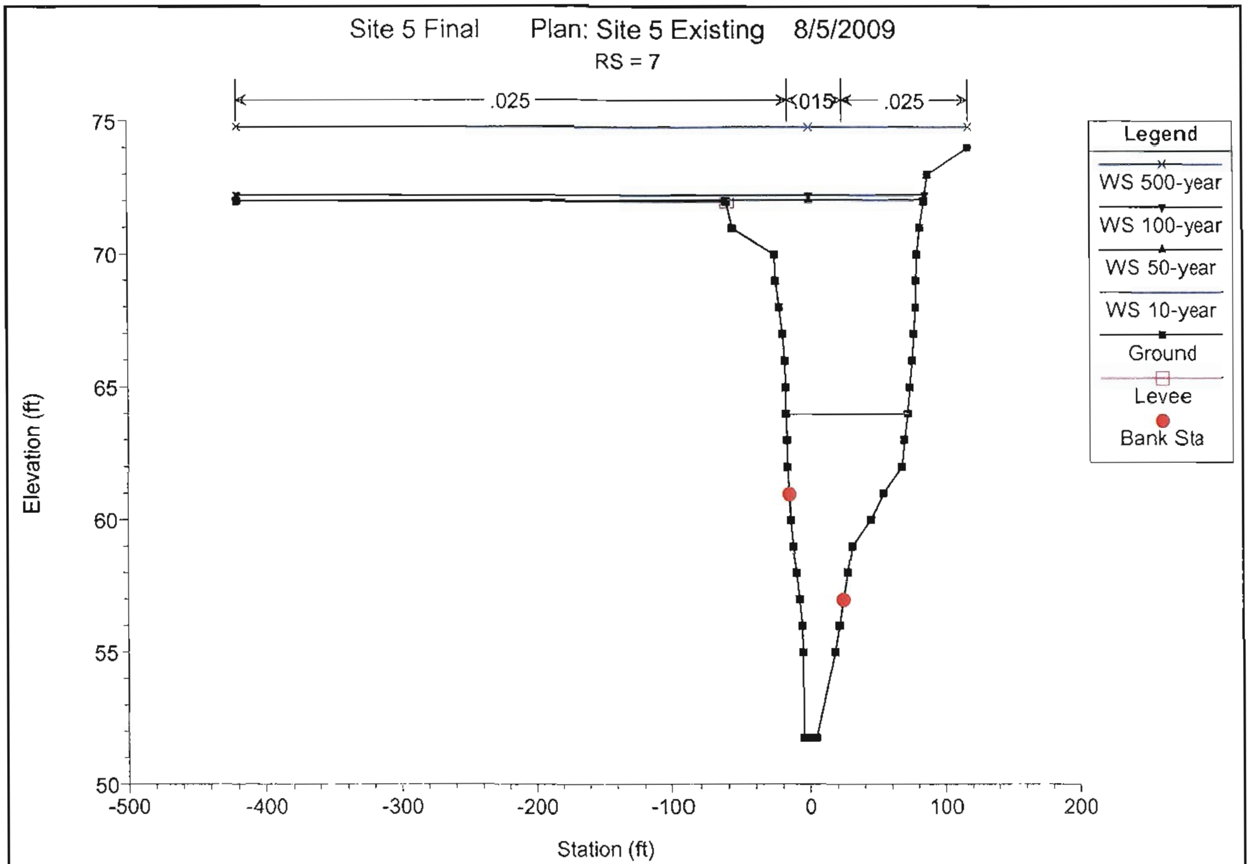
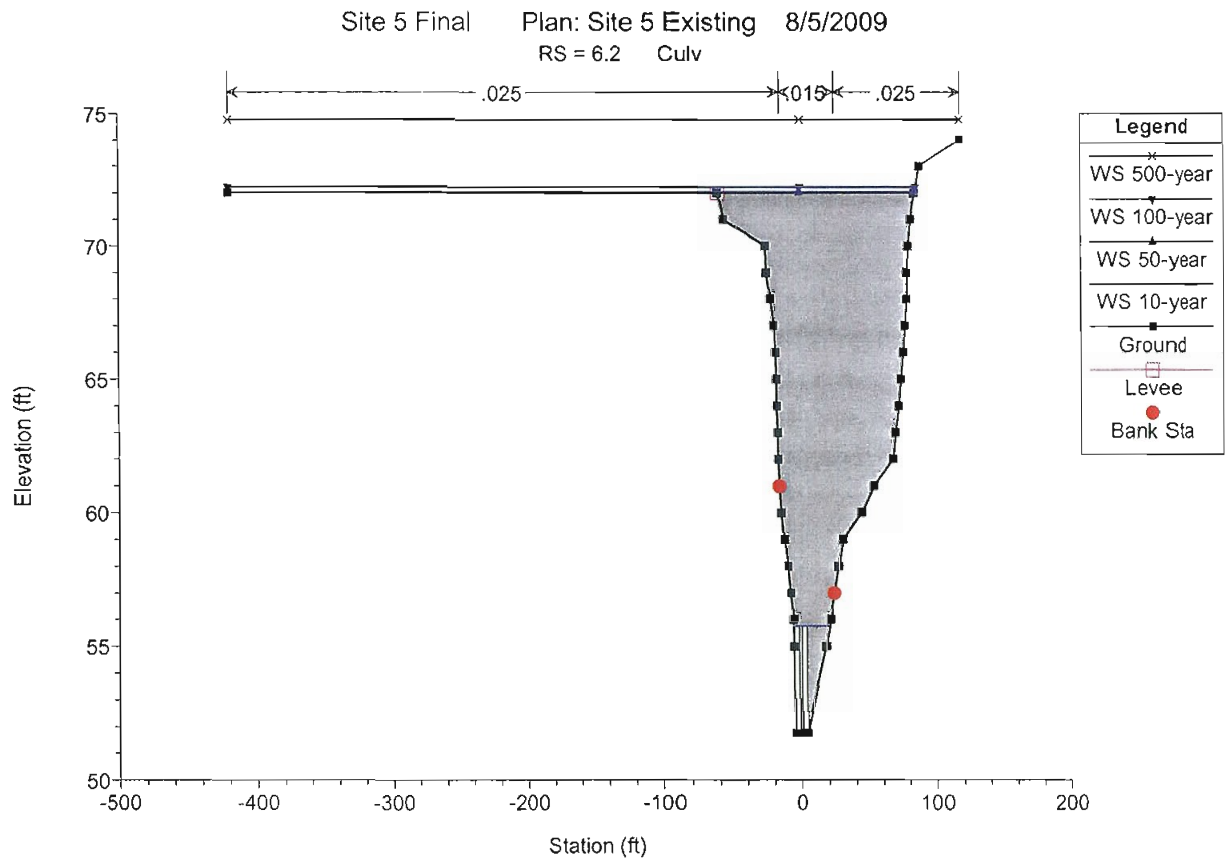
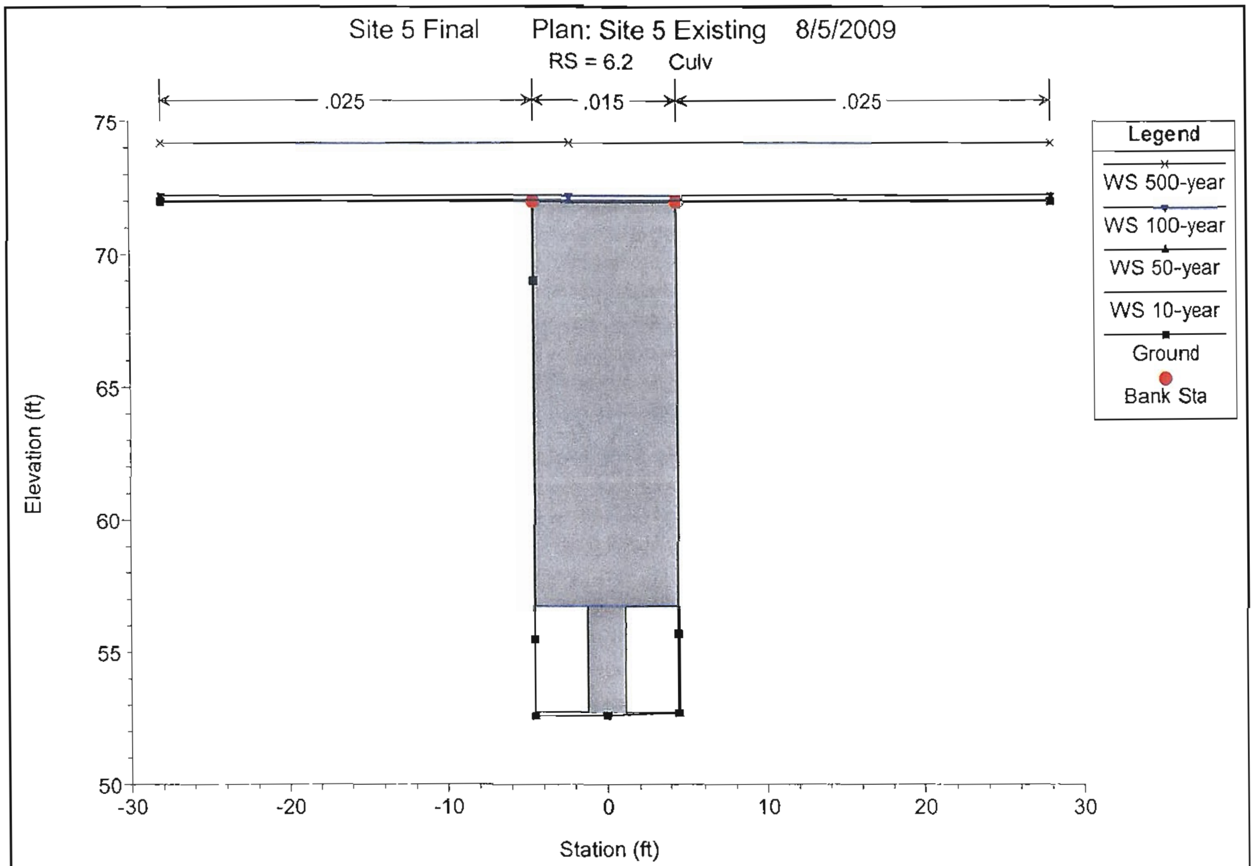
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200



Site 5 Final Plan: Site 5 Existing 8/5/2009
RS = 7
.025
.015
.025
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200
Station (ft)



Site 5 Final Plan: Site 5 Existing 8/5/2009
RS = 6.2 Culv
.025
.015
.025
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200
Station (ft)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Plan: Site 5 Existing
8/5/2009
RS = 6.2
Culv
.025
.015
.025
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
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60
55
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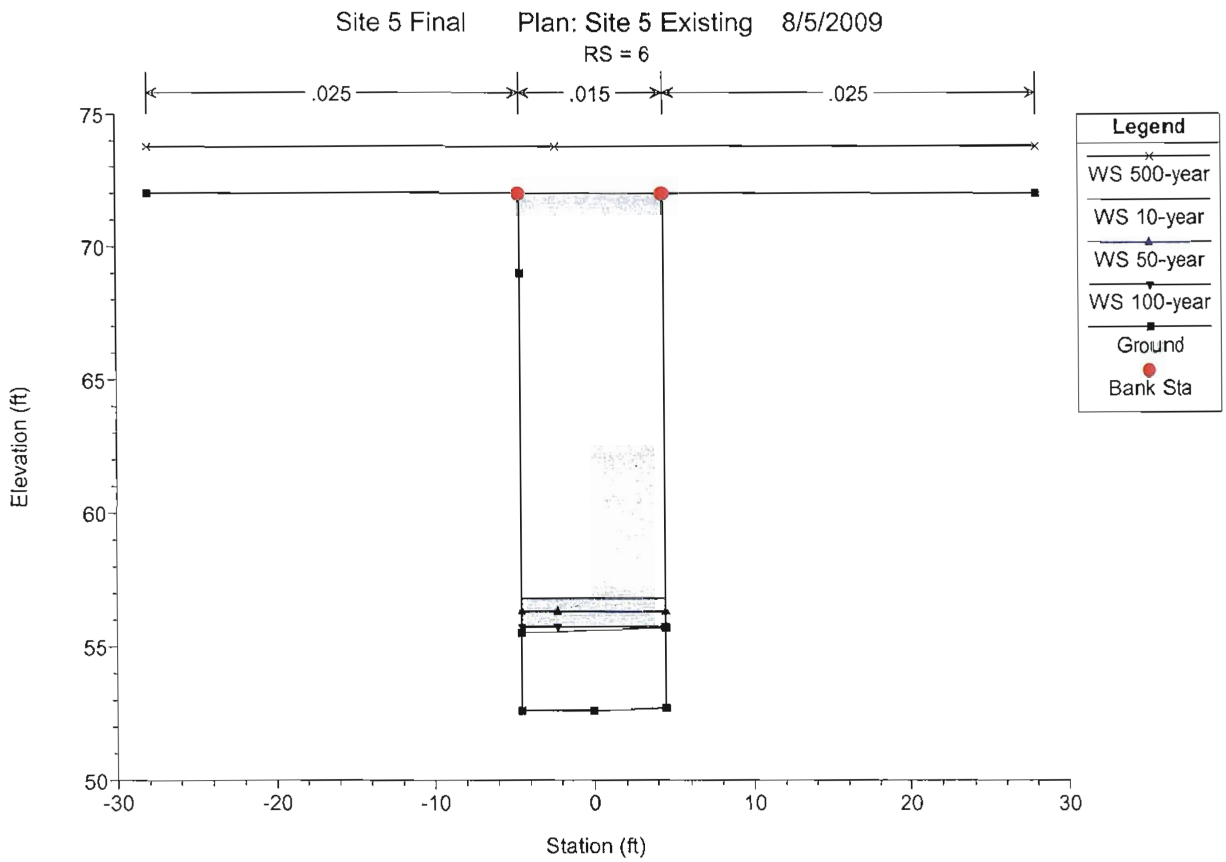
0
10
20
30


Site 5 Final
Plan: Site 5 Existing
8/5/2009
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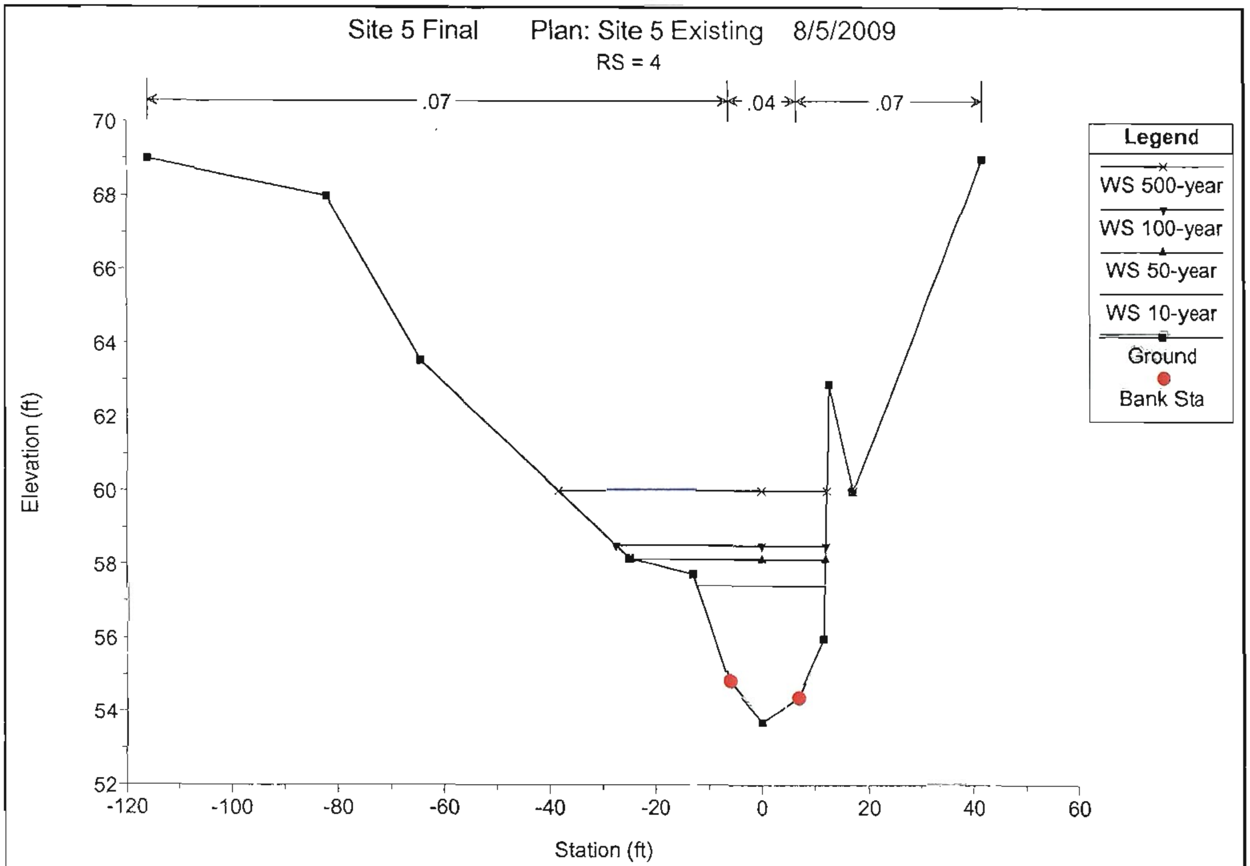
.015
.025
Legend
WS 500-year
WS 10-year
WS 50-year
WS 100-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-30
-20
-10
0
10
20
30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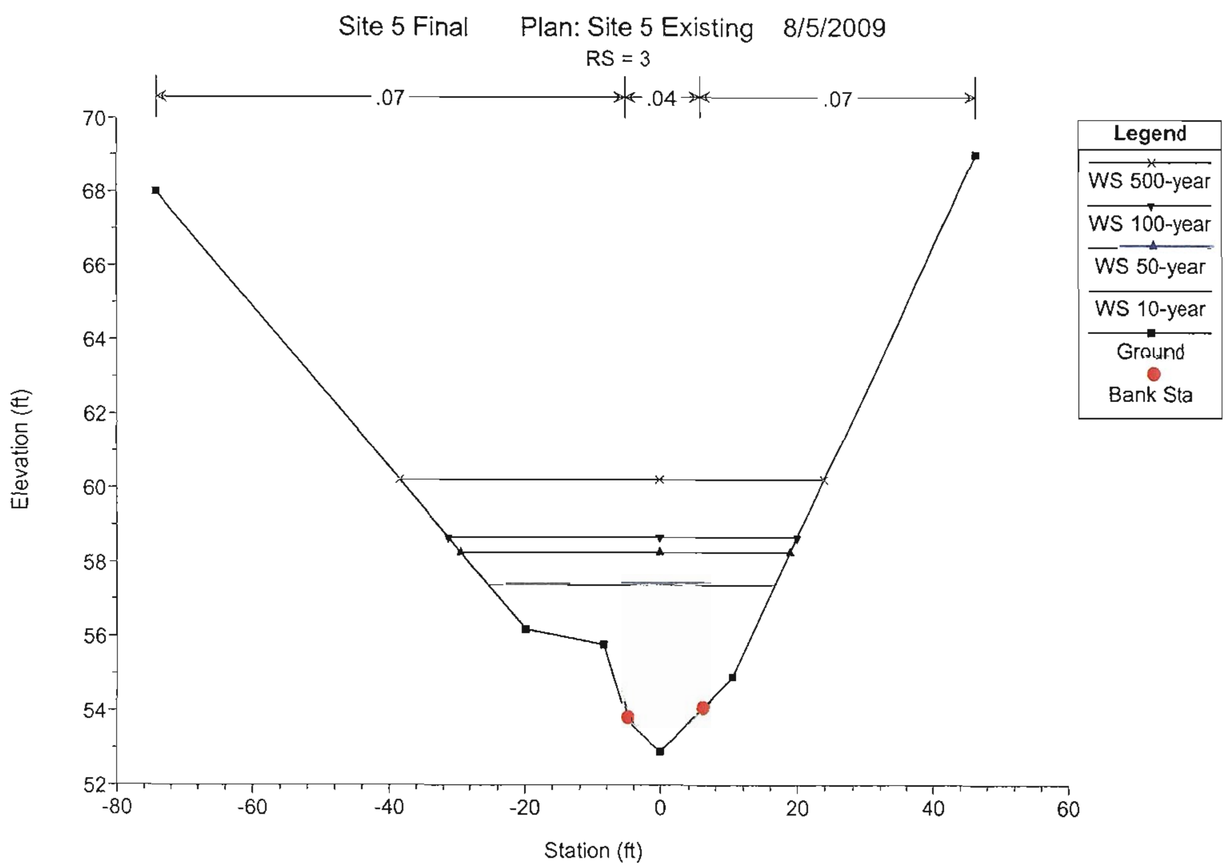
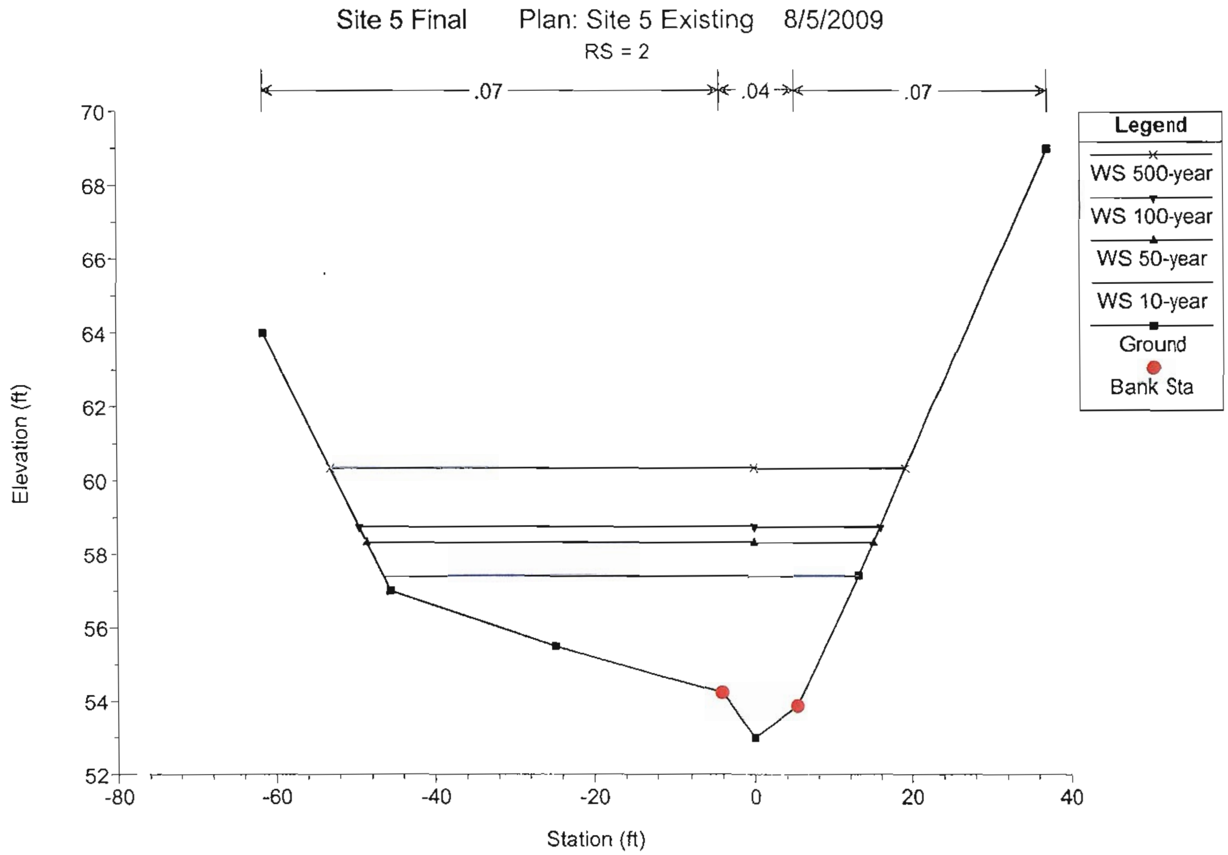
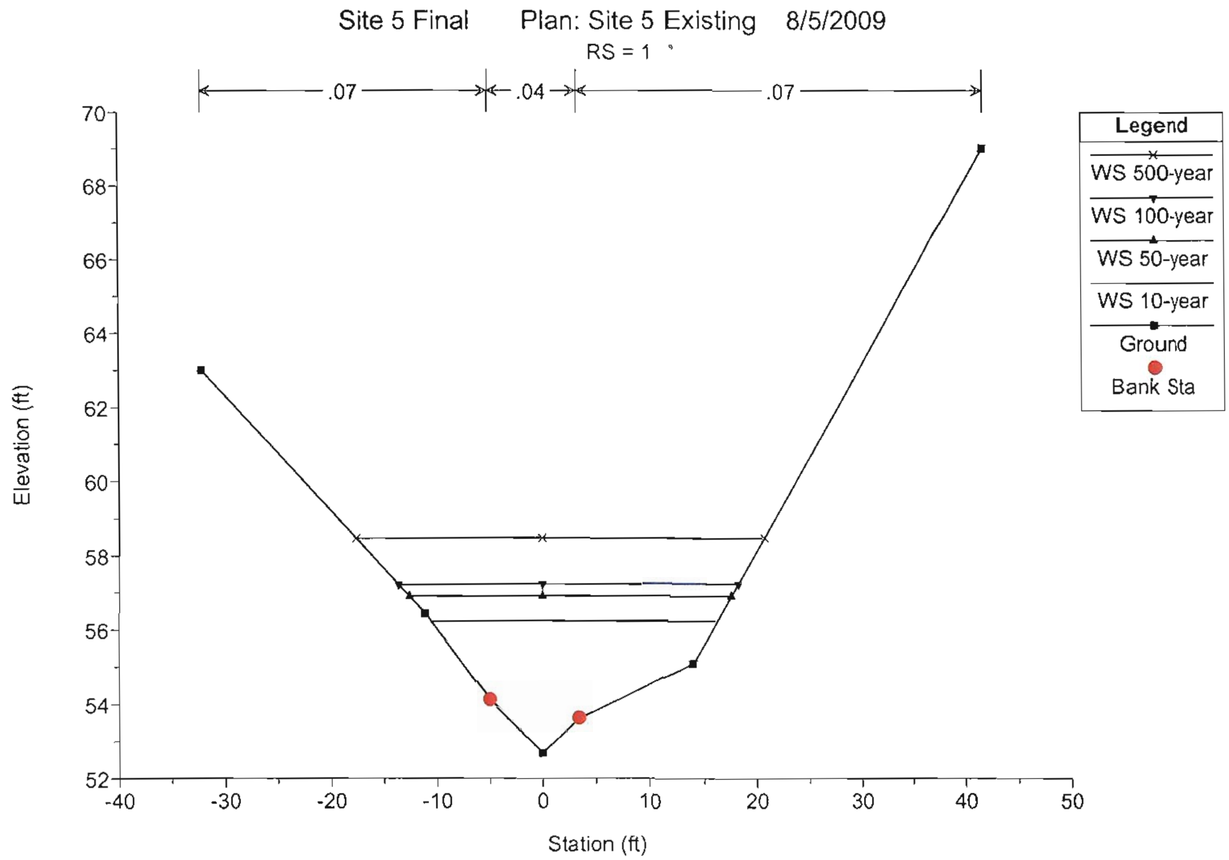
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-120
-100
-80
-60
-40
-20
0
20
40
60


Site 5 Final Plan: Site 5 Existing 8/5/2009
RS = 3
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-80
-60
-40
-20
0
20
40
60



Site 5 Final Plan: Site 5 Existing 8/5/2009
RS = 2
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-80
-60
-40
-20
0
20
40



Site 5 Final Plan: Site 5 Existing 8/5/2009
RS = 1
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-40
-30
-20
-10
0
10
20
30
40
50

HEC-RAS Plan: Site 5 Exist River: Site 5- Brook Reach: reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
reach 1	13	10-year	320.00	53.97	64.01	57.61	64.03	0.000081	1.27	298.91	52.16	0.08
reach 1	13	50-year	486.00	53.97	72.04	58.27	72.05	0.000015	0.88	1064.58	453.07	0.04
reach 1	13	100-year	573.00	53.97	72.23	58.52	72.24	0.000019	1.01	1149.83	461.94	0.04
reach 1	13	500-year	974.00	53.97	74.79	59.49	74.80	0.000017	1.04	2453.27	531.00	0.04
reach 1	12	10-year	320.00	54.28	64.00	57.64	64.02	0.000078	1.25	304.58	53.41	0.08
reach 1	12	50-year	486.00	54.28	72.04	58.27	72.05	0.000015	0.87	1094.33	596.27	0.04
reach 1	12	100-year	573.00	54.28	72.23	58.52	72.24	0.000019	0.99	1206.03	605.33	0.04
reach 1	12	500-year	974.00	54.28	74.79	59.48	74.80	0.000014	0.96	2880.63	676.21	0.04
reach 1	11	10-year	320.00	54.21	64.00	57.66	64.02	0.000085	1.03	310.39	53.97	0.08
reach 1	11	50-year	486.00	54.21	72.04	58.31	72.05	0.000010	0.57	982.71	562.80	0.03
reach 1	11	100-year	573.00	54.21	72.23	58.58	72.24	0.000013	0.66	1088.93	575.27	0.03
reach 1	11	500-year	974.00	54.21	74.79	59.51	74.80	0.000012	0.70	2716.21	661.00	0.03
reach 1	9	10-year	320.00	53.48	63.99	56.22	64.01	0.000097	1.11	291.33	50.51	0.08
reach 1	9	50-year	486.00	53.48	72.04	56.95	72.05	0.000012	0.70	879.16	531.63	0.03
reach 1	9	100-year	573.00	53.48	72.23	57.29	72.24	0.000016	0.80	978.48	538.75	0.04
reach 1	9	500-year	974.00	53.48	74.79	58.62	74.79	0.000015	0.86	2437.14	580.80	0.04
reach 1	7	10-year	320.00	51.76	64.00	54.45	64.01	0.000003	0.74	547.99	89.50	0.04
reach 1	7	50-year	486.00	51.76	72.04	55.13	72.05	0.000001	0.51	1416.57	505.13	0.02
reach 1	7	100-year	573.00	51.76	72.23	55.44	72.24	0.000001	0.58	1510.81	505.69	0.02
reach 1	7	500-year	974.00	51.76	74.79	56.62	74.79	0.000001	0.74	2847.30	538.00	0.03
reach 1	6.2		Culvert									
reach 1	6	10-year	320.00	52.60	56.79	55.57	59.00	0.012495	11.94	26.79		1.03
reach 1	6	50-year	486.00	52.60	56.30	55.65	61.41	0.028820	18.14	26.79		1.66
reach 1	6	100-year	573.00	52.60	55.73	55.66	62.83	0.040062	21.39	26.79		2.13
reach 1	6	500-year	974.00	52.60	73.78	73.78	74.79	0.006556	9.56	126.61	56.00	0.29
reach 1	4	10-year	320.00	53.71	57.44	56.68	58.03	0.006398	6.54	61.89	24.18	0.63
reach 1	4	50-year	486.00	53.71	58.17	57.42	59.05	0.007466	8.07	82.35	36.53	0.71
reach 1	4	100-year	573.00	53.71	58.54	57.68	59.48	0.007316	8.47	96.54	39.57	0.71
reach 1	4	500-year	974.00	53.71	60.02	59.32	61.13	0.006443	9.65	163.31	50.73	0.70
reach 1	3	10-year	320.00	52.90	57.39	56.36	57.74	0.003453	5.43	93.01	42.07	0.48
reach 1	3	50-year	486.00	52.90	58.27	57.03	58.68	0.003396	6.15	132.55	48.33	0.49
reach 1	3	100-year	573.00	52.90	58.67	57.34	59.11	0.003347	6.43	152.59	51.21	0.49
reach 1	3	500-year	974.00	52.90	60.22	58.43	60.75	0.003139	7.40	240.79	62.32	0.50
reach 1	2	10-year	320.00	53.01	57.40	56.27	57.61	0.002718	4.71	127.59	59.68	0.42
reach 1	2	50-year	486.00	53.01	58.33	56.81	58.54	0.002270	4.97	184.80	63.70	0.40
reach 1	2	100-year	573.00	53.01	58.75	57.14	58.96	0.002153	5.11	211.89	65.52	0.39
reach 1	2	500-year	974.00	53.01	60.34	57.92	60.59	0.001919	5.76	321.85	72.44	0.39
reach 1	1	10-year	320.00	52.68	56.22	56.22	57.22	0.015646	9.27	51.54	26.78	0.96
reach 1	1	50-year	486.00	52.68	56.90	56.90	58.16	0.015716	10.68	70.86	30.19	0.99
reach 1	1	100-year	573.00	52.68	57.22	57.22	58.59	0.015460	11.22	80.98	31.88	1.00
reach 1	1	500-year	974.00	52.68	58.47	58.47	60.21	0.014719	13.16	124.74	38.36	1.02

Plan: Site 5 Exist   Site 5- Brook   reach 1 RS: 6.2   Culv Group: Culvert #1   Profile: 10-year

Q Culv Group (cfs)	160.00	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	11.76
Q Barrel (cfs)	160.00	Culv Vel DS (ft/s)	11.76
E.G. US. (ft)	64.01	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	64.00	Culv Inv El Dn (ft)	52.78
E.G. DS (ft)	59.00	Culv Frctn Ls (ft)	3.93
W.S. DS (ft)	56.79	Culv Exit Loss (ft)	0.00
Delta EG (ft)	5.00	Culv Entr Loss (ft)	1.07
Delta WS (ft)	7.21	Q Weir (cfs)	
E.G. IC (ft)	60.02	Weir Sta Lft (ft)	
E.G. OC (ft)	64.01	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	
Culv WS Outlet (ft)	56.78	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist   Site 5- Brook   reach 1 RS: 6.2   Culv Group: Culvert #1   Profile: 50-year

Q Culv Group (cfs)	233.33	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	17.16
Q Barrel (cfs)	233.33	Culv Vel DS (ft/s)	17.16
E.G. US. (ft)	72.05	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	72.04	Culv Inv El Dn (ft)	52.78
E.G. DS (ft)	61.41	Culv Frctn Ls (ft)	8.35
W.S. DS (ft)	56.30	Culv Exit Loss (ft)	0.00
Delta EG (ft)	10.64	Culv Entr Loss (ft)	2.29
Delta WS (ft)	15.75	Q Weir (cfs)	19.33
E.G. IC (ft)	65.43	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	72.05	Weir Sta Rgt (ft)	85.18
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	0.06
Culv WS Outlet (ft)	56.78	Weir Avg Depth (ft)	0.06
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	30.34
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist   Site 5- Brook   reach 1 RS: 6.2   Culv Group: Culvert #1   Profile: 100-year

Q Culv Group (cfs)	219.38	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	16.13
Q Barrel (cfs)	219.38	Culv Vel DS (ft/s)	16.13
E.G. US. (ft)	72.24	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	72.23	Culv Inv El Dn (ft)	52.78
E.G. DS (ft)	62.83	Culv Frctn Ls (ft)	7.39
W.S. DS (ft)	55.73	Culv Exit Loss (ft)	0.00
Delta EG (ft)	9.41	Culv Entr Loss (ft)	2.02
Delta WS (ft)	16.50	Q Weir (cfs)	134.24
E.G. IC (ft)	64.25	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	72.24	Weir Sta Rgt (ft)	85.66
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	0.22
Culv WS Outlet (ft)	56.78	Weir Avg Depth (ft)	0.22
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	110.46
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist   Site 5- Brook   reach 1 RS: 6.2   Culv Group: Culvert #1   Profile: 500-year

Q Culv Group (cfs)	5.23	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	0.38
Q Barrel (cfs)	5.23	Culv Vel DS (ft/s)	0.38
E.G. US. (ft)	74.79	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	74.79	Culv Inv El Dn (ft)	52.78
E.G. DS (ft)	74.79	Culv Frctn Ls (ft)	0.00
W.S. DS (ft)	73.78	Culv Exit Loss (ft)	0.00
Delta EG (ft)	0.01	Culv Entr Loss (ft)	0.00
Delta WS (ft)	1.01	Q Weir (cfs)	943.86
E.G. IC (ft)	52.43	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	74.79	Weir Sta Rgt (ft)	118.00
Culvert Control	Outlet	Weir Submerg	1.00
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	2.79
Culv WS Outlet (ft)	56.78	Weir Avg Depth (ft)	2.71
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	1456.18
Culv Crt Depth (ft)	0.42	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist   Site 5- Brook   reach 1 RS: 6.2   Culv Group: Culvert #2   Profile: 10-year

Q Culv Group (cfs)	160.00	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	11.76
Q Barrel (cfs)	160.00	Culv Vel DS (ft/s)	11.76
E.G. US. (ft)	64.01	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	64.00	Culv Inv El Dn (ft)	52.76
E.G. DS (ft)	59.00	Culv Frctn Ls (ft)	3.93
W.S. DS (ft)	56.79	Culv Exit Loss (ft)	0.00
Delta EG (ft)	5.00	Culv Entr Loss (ft)	1.07
Delta WS (ft)	7.21	Q Weir (cfs)	
E.G. IC (ft)	60.02	Weir Sta Lft (ft)	
E.G. OC (ft)	64.01	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	
Culv WS Outlet (ft)	56.76	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist   Site 5- Brook   reach 1 RS: 6.2   Culv Group: Culvert #2   Profile: 50-year

Q Culv Group (cfs)	233.33	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	17.16
Q Barrel (cfs)	233.33	Culv Vel DS (ft/s)	17.16
E.G. US. (ft)	72.05	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	72.04	Culv Inv El Dn (ft)	52.76
E.G. DS (ft)	61.41	Culv Frctn Ls (ft)	8.35
W.S. DS (ft)	56.30	Culv Exit Loss (ft)	0.00
Delta EG (ft)	10.64	Culv Entr Loss (ft)	2.29
Delta WS (ft)	15.75	Q Weir (cfs)	19.33
E.G. IC (ft)	65.43	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	72.05	Weir Sta Rgt (ft)	85.18
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	0.06
Culv WS Outlet (ft)	56.76	Weir Avg Depth (ft)	0.06
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	30.34
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #2 Profile: 100-year

Q Culv Group (cfs)	219.38	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	16.13
Q Barrel (cfs)	219.38	Culv Vel DS (ft/s)	16.13
E.G. US. (ft)	72.24	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	72.23	Culv Inv El Dn (ft)	52.76
E.G. DS (ft)	62.83	Culv Frctn Ls (ft)	7.39
W.S. DS (ft)	55.73	Culv Exit Loss (ft)	0.00
Delta EG (ft)	9.41	Culv Entr Loss (ft)	2.02
Delta WS (ft)	16.50	Q Weir (cfs)	134.24
E.G. IC (ft)	64.25	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	72.24	Weir Sta Rgt (ft)	85.66
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	0.22
Culv WS Outlet (ft)	56.76	Weir Avg Depth (ft)	0.22
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	110.46
Culv Crt Depth (ft)	4.00	Min El Weir Flow (ft)	72.01

Plan: Site 5 Exist Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #2 Profile: 500-year

Q Culv Group (cfs)	5.23	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	0.38
Q Barrel (cfs)	5.23	Culv Vel DS (ft/s)	0.38
E.G. US. (ft)	74.79	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	74.79	Culv Inv El Dn (ft)	52.76
E.G. DS (ft)	74.79	Culv Frctn Ls (ft)	0.00
W.S. DS (ft)	73.78	Culv Exit Loss (ft)	0.00
Delta EG (ft)	0.01	Culv Entr Loss (ft)	0.00
Delta WS (ft)	1.01	Q Weir (cfs)	943.86
E.G. IC (ft)	52.43	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	74.79	Weir Sta Rgt (ft)	118.00
Culvert Control	Outlet	Weir Submerg	1.00
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	2.79
Culv WS Outlet (ft)	56.76	Weir Avg Depth (ft)	2.71
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	1456.18
Culv Crt Depth (ft)	0.42	Min El Weir Flow (ft)	72.01

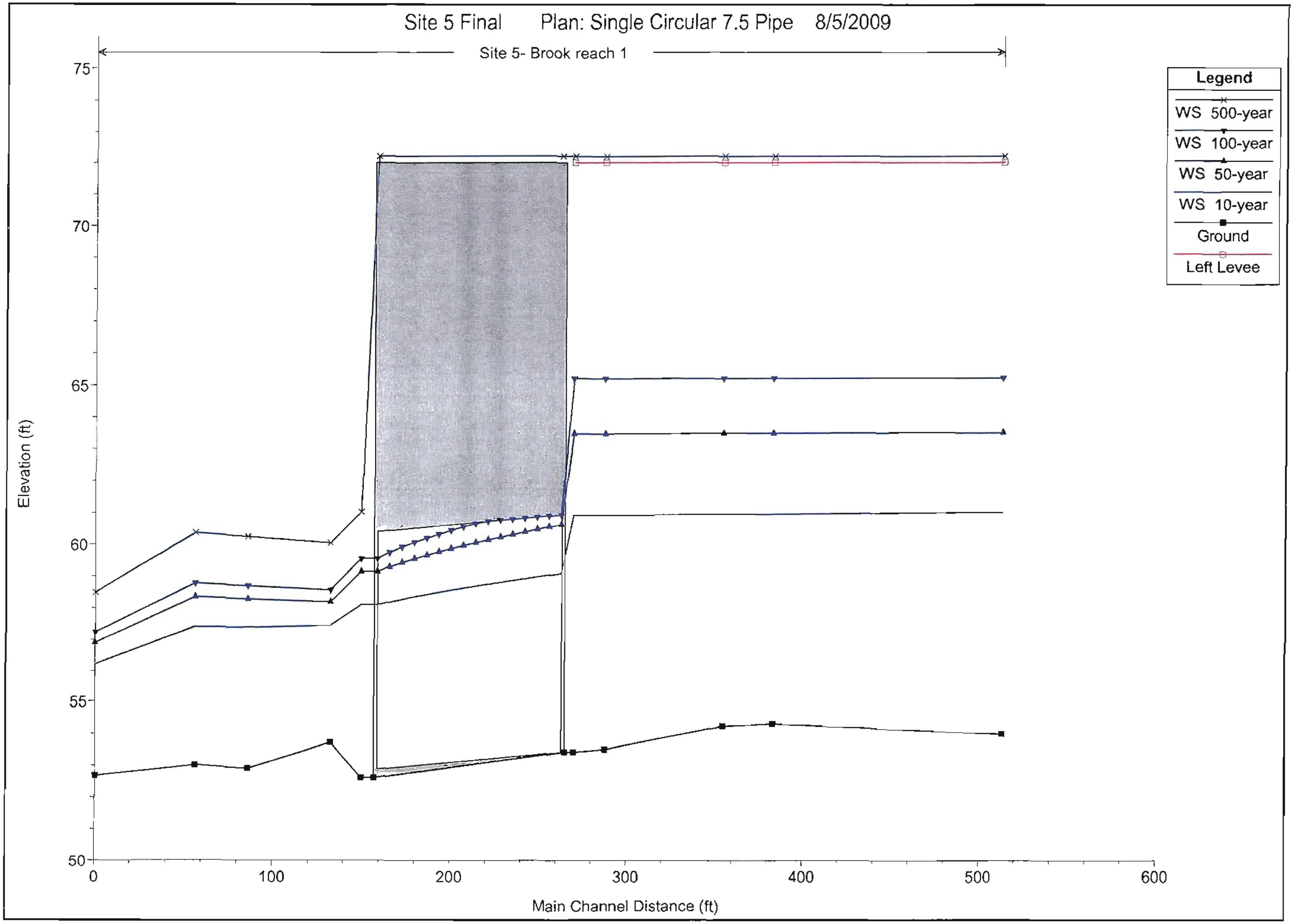
Proposed Conditions HEC-RAS

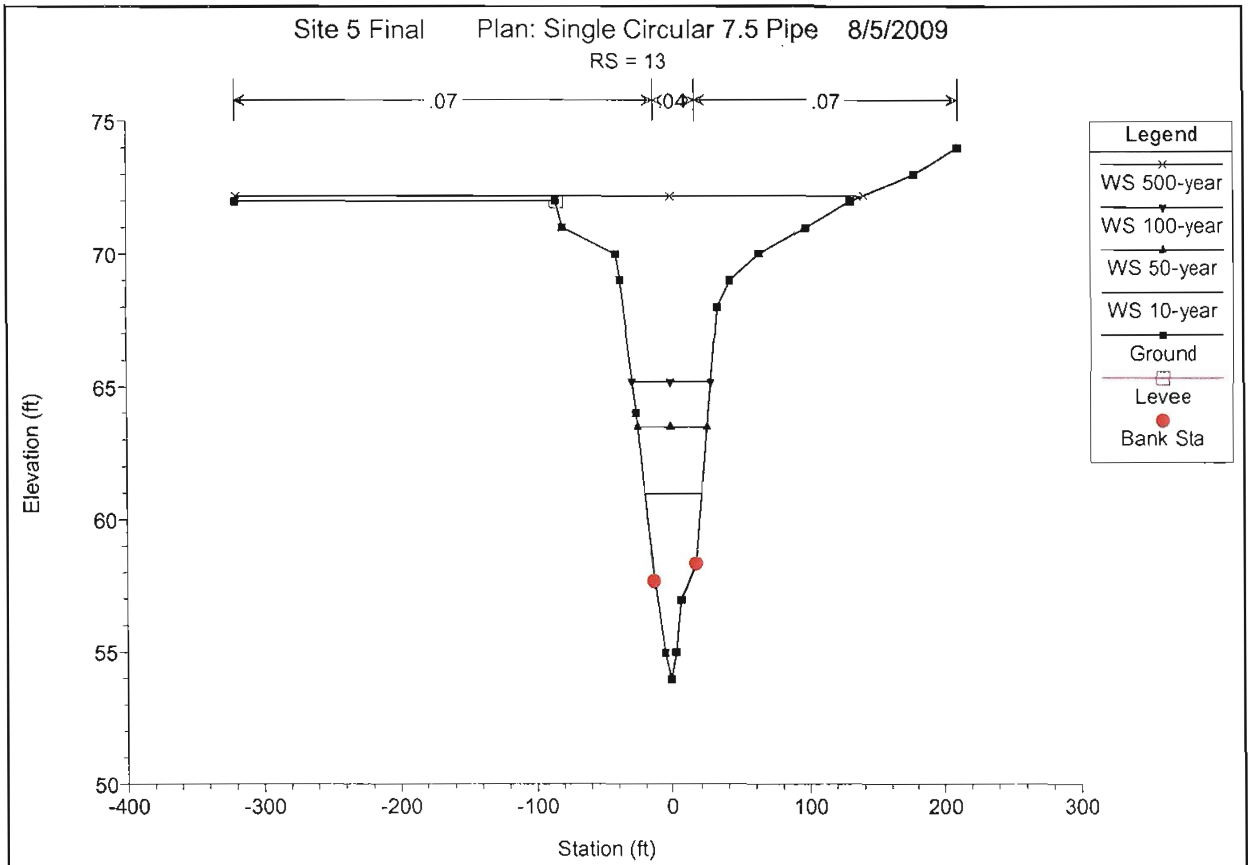
Profile

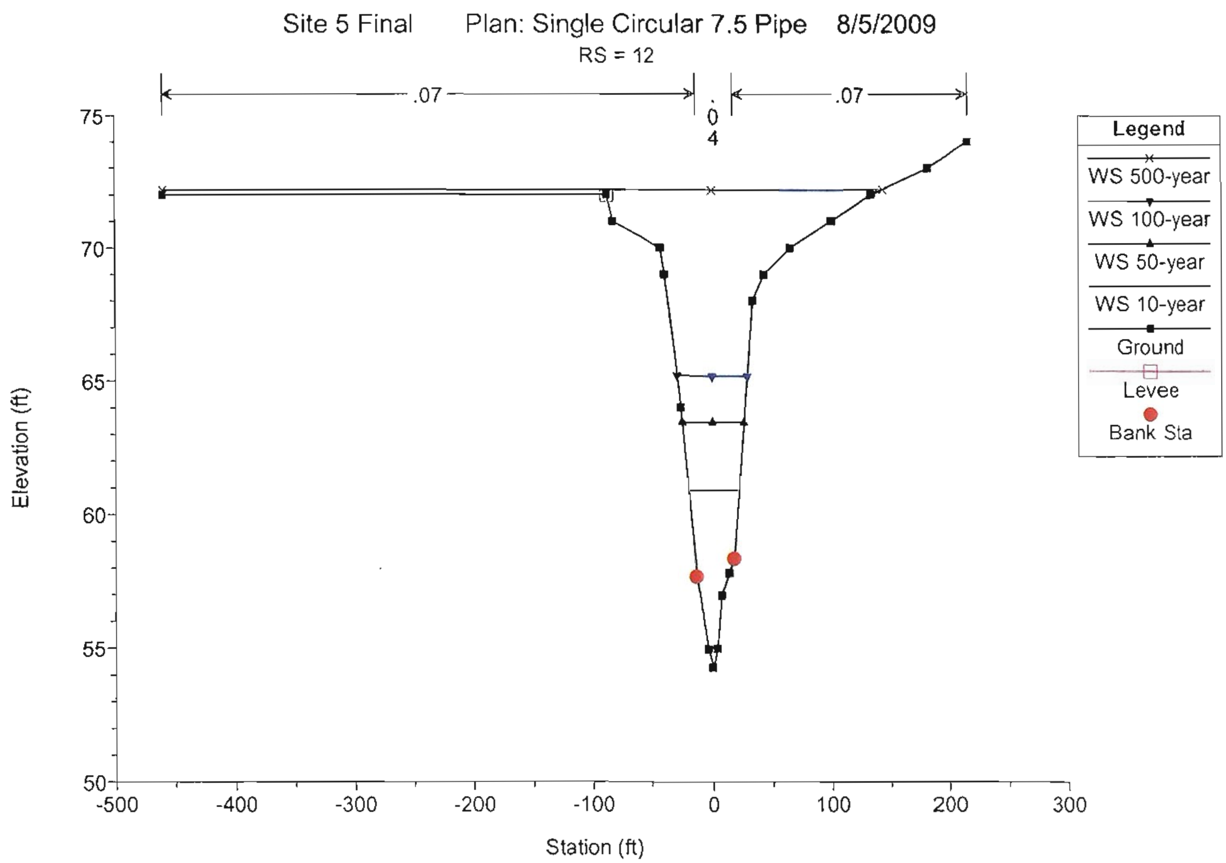
Sections

Standard Output Table

Culvert Output Tables


Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
Site 5- Brook reach 1
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Left Levee
Elevation (ft)
Main Channel Distance (ft)
75
70
65
60
55
50
0
100
200
300
400
500
600


Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 13
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-400
-300
-200
-100
0
100
200
300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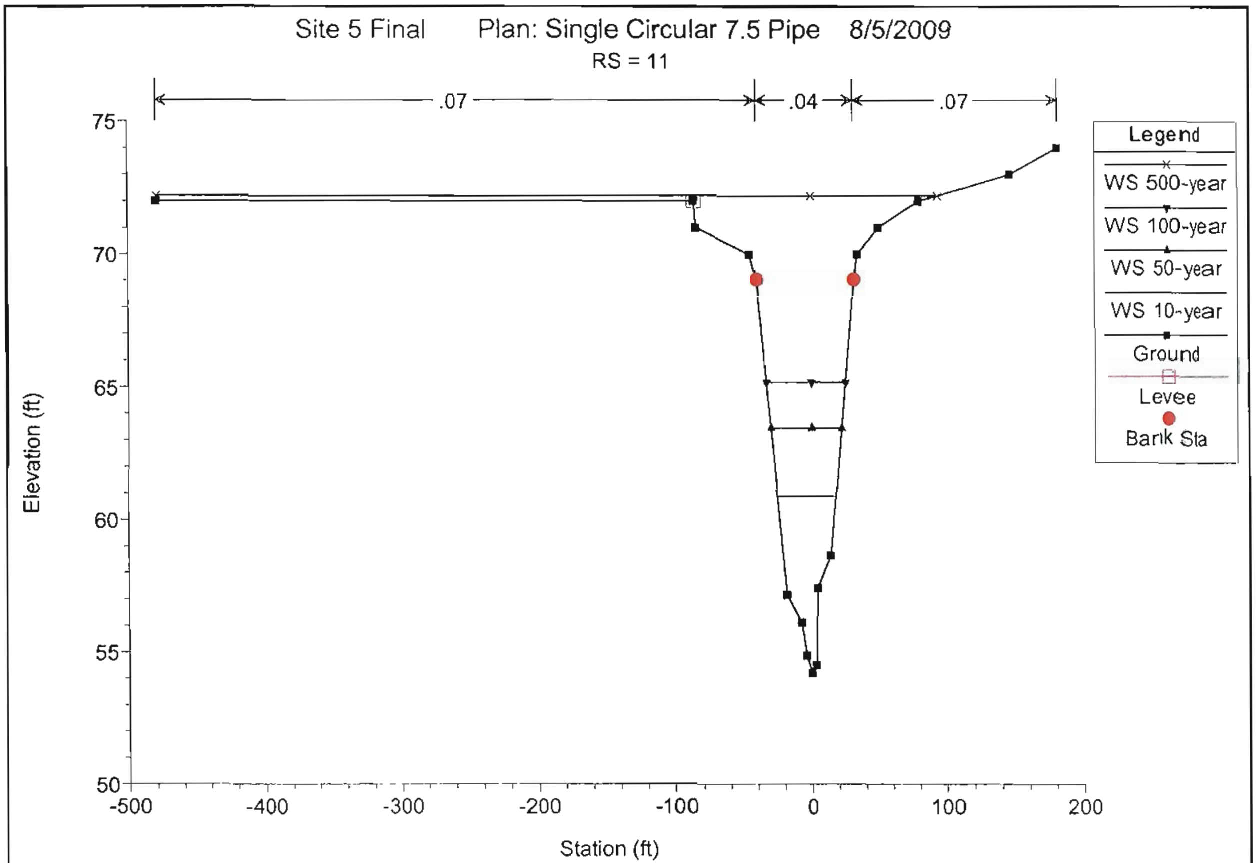
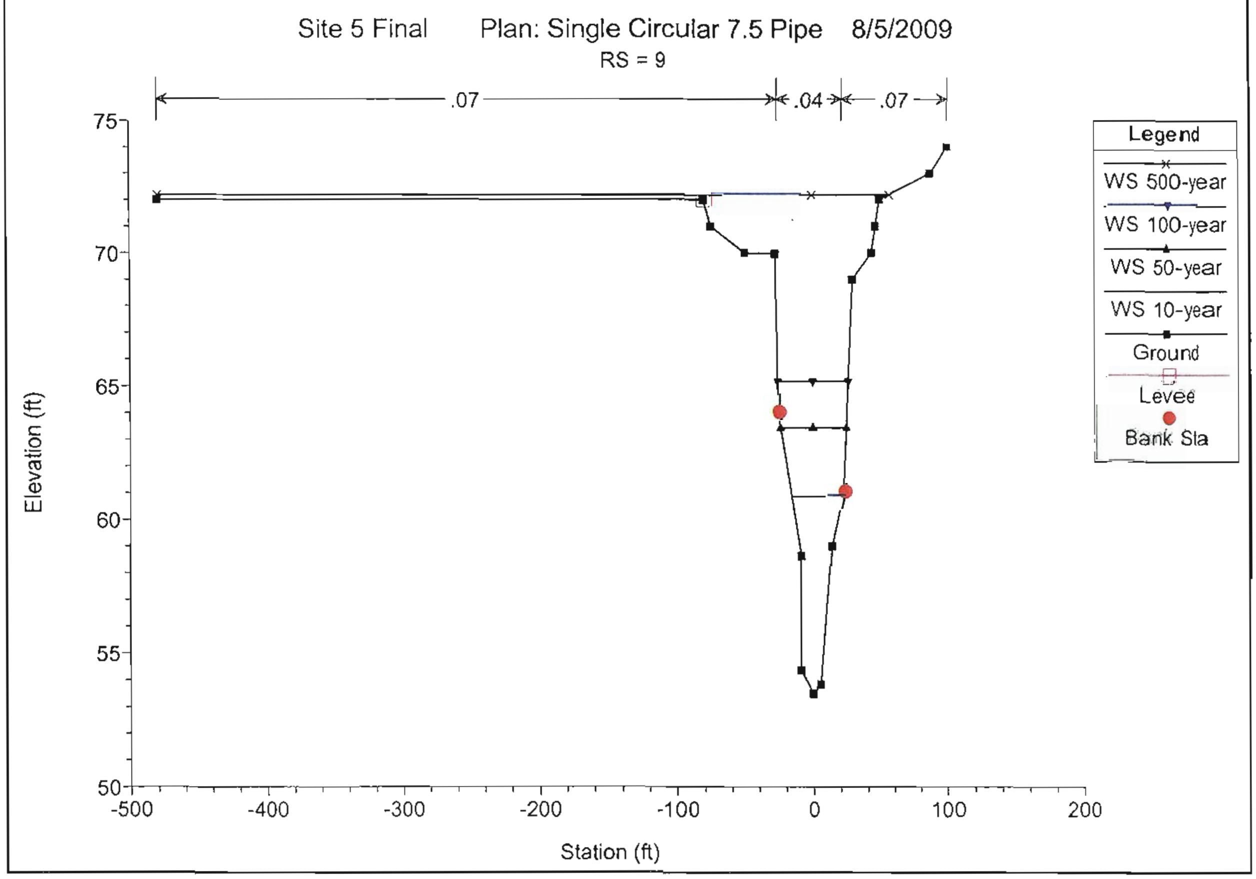
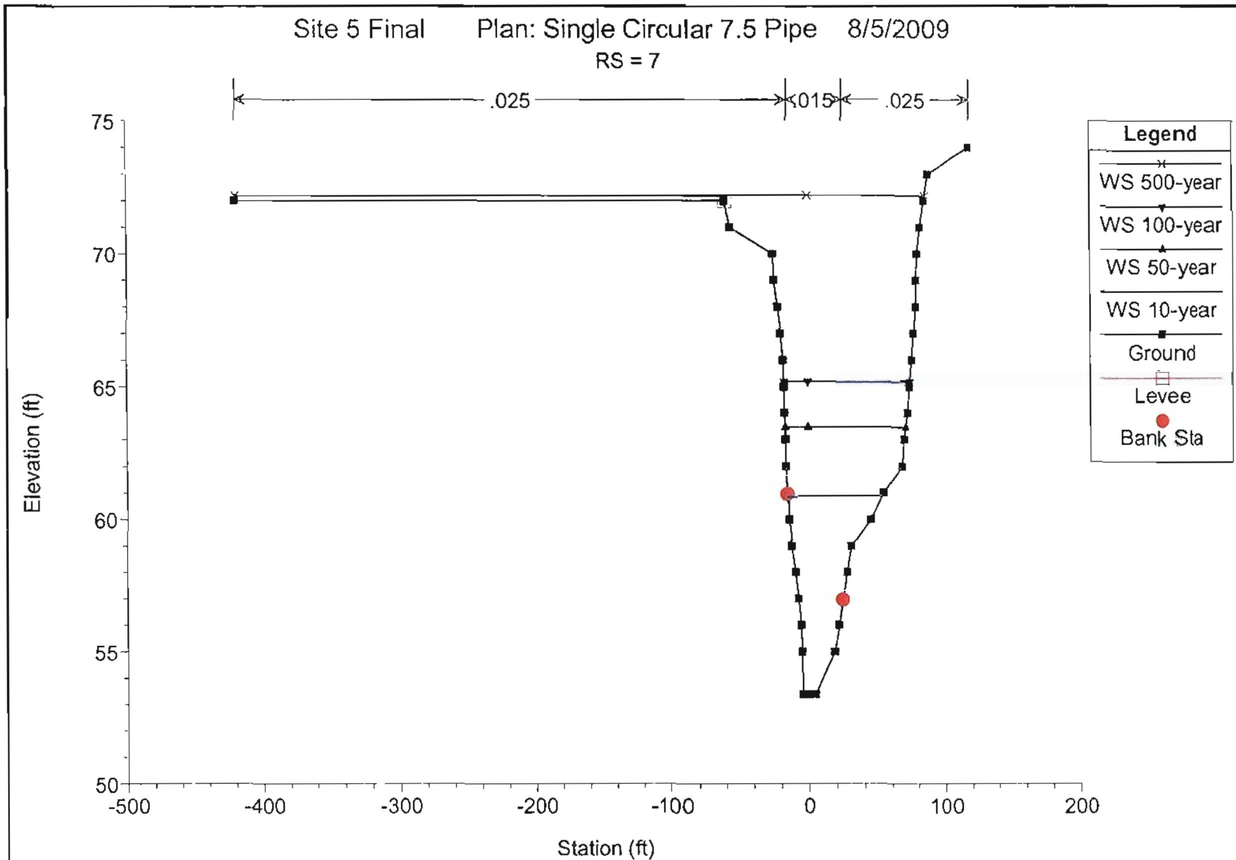
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200
300

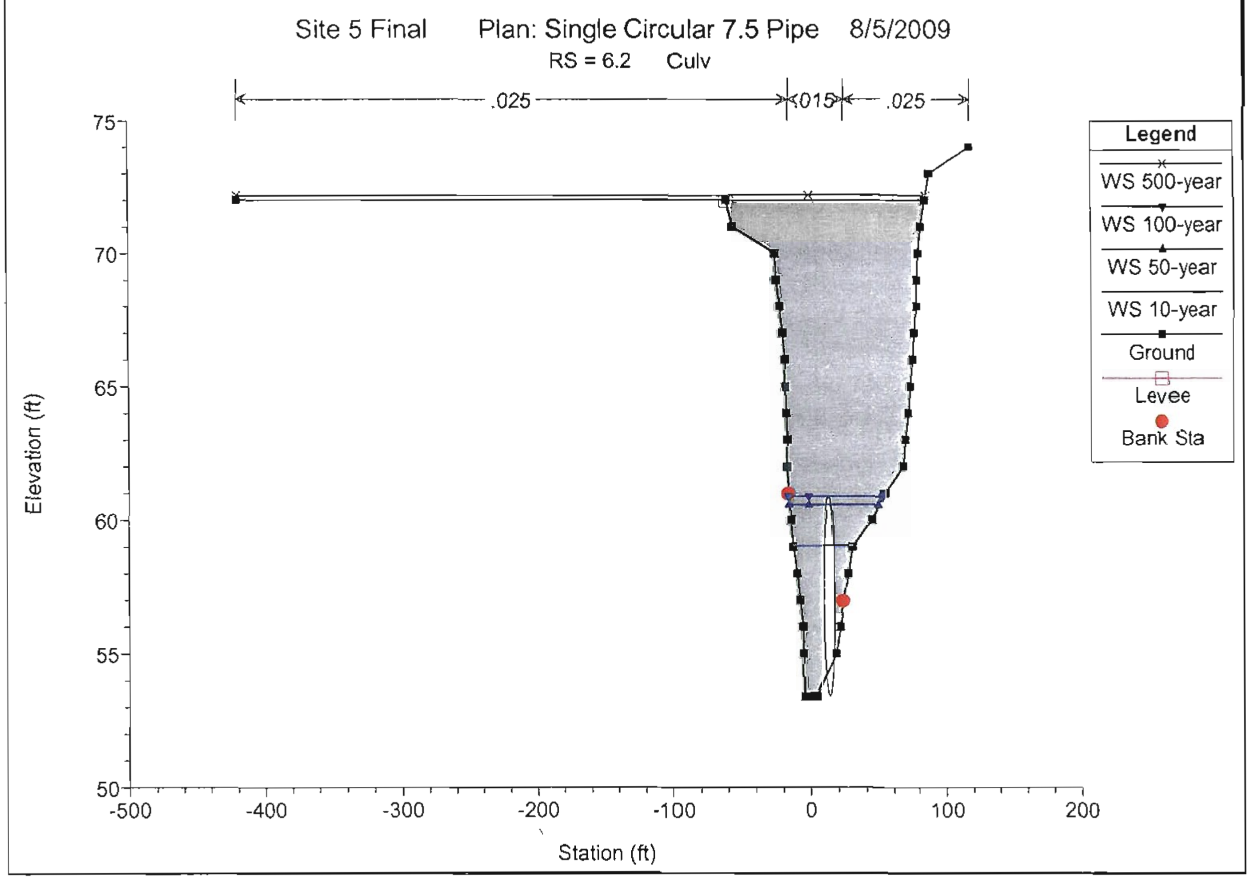


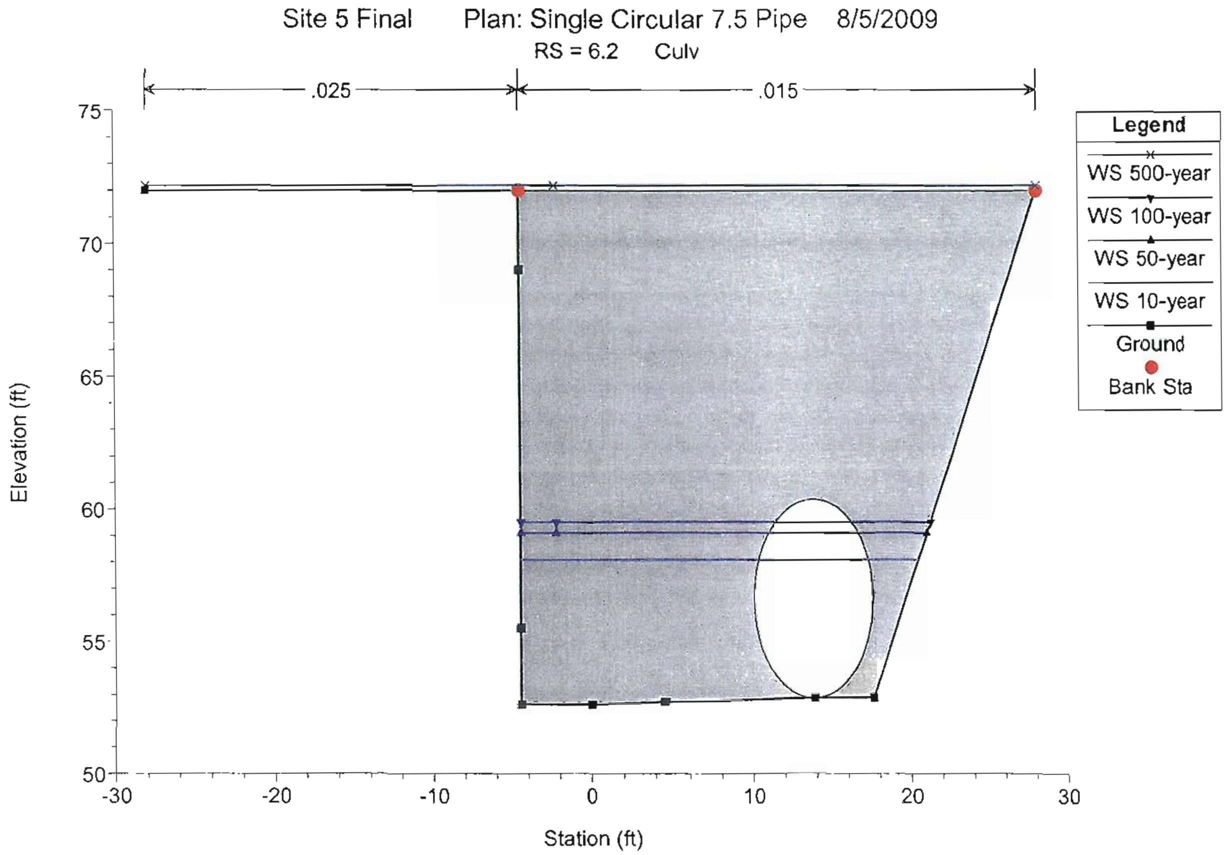
Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 11
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)



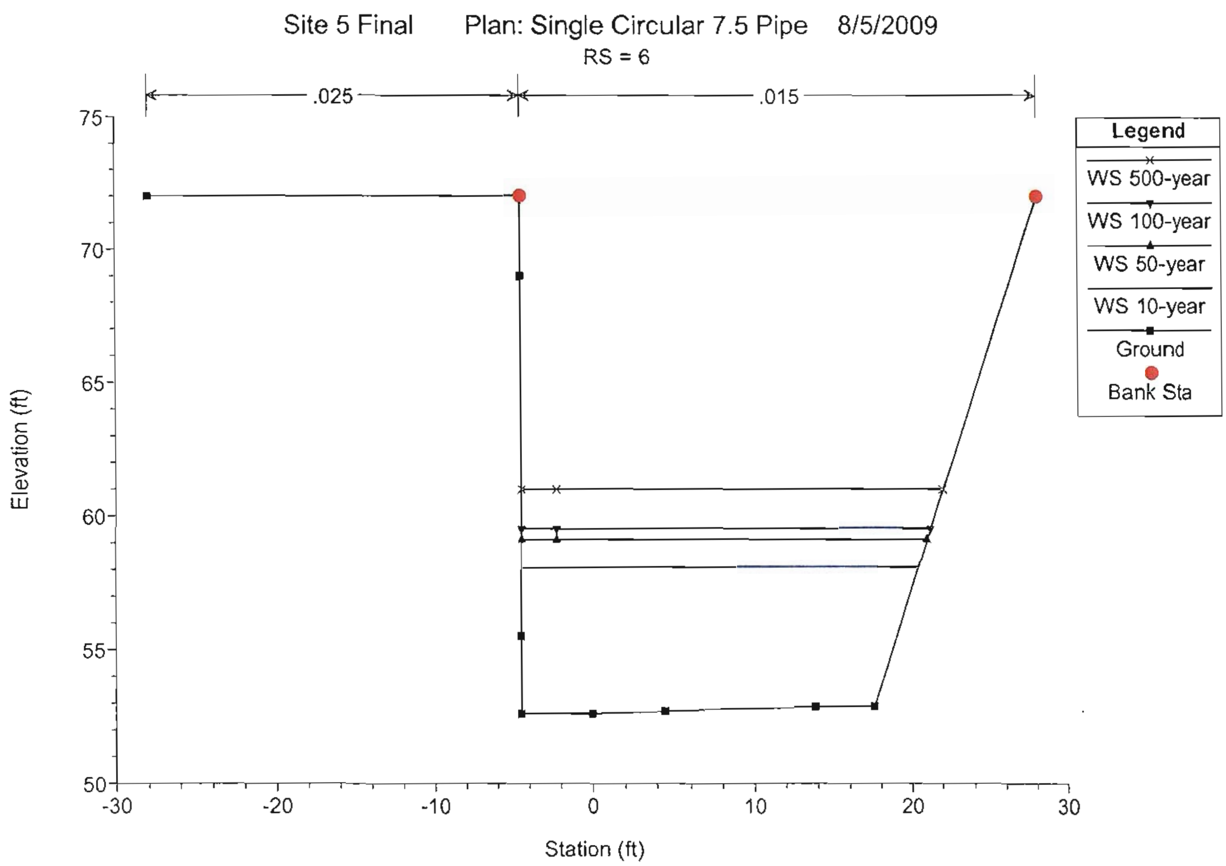
Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 9
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 7
.025
.015
.025
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200

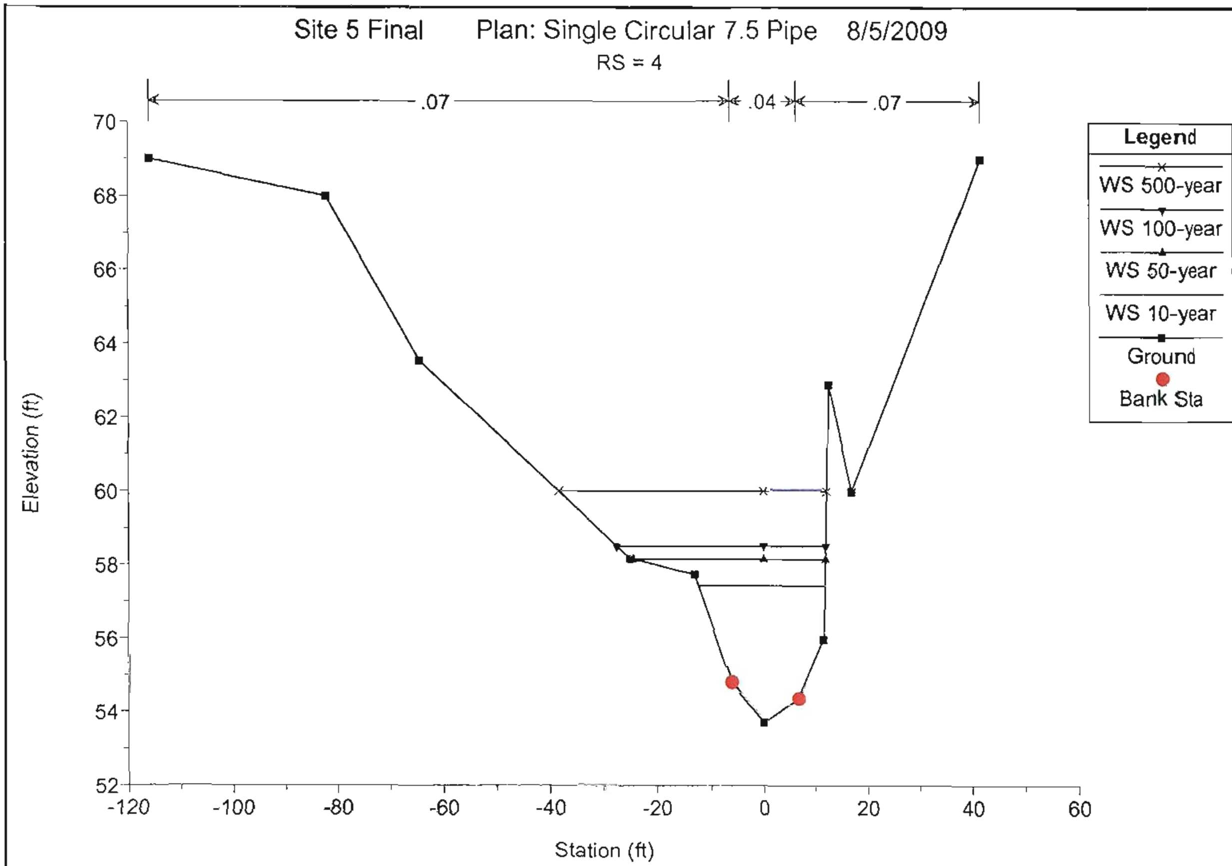

Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 6.2 Culv
.025
.015
.025
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200

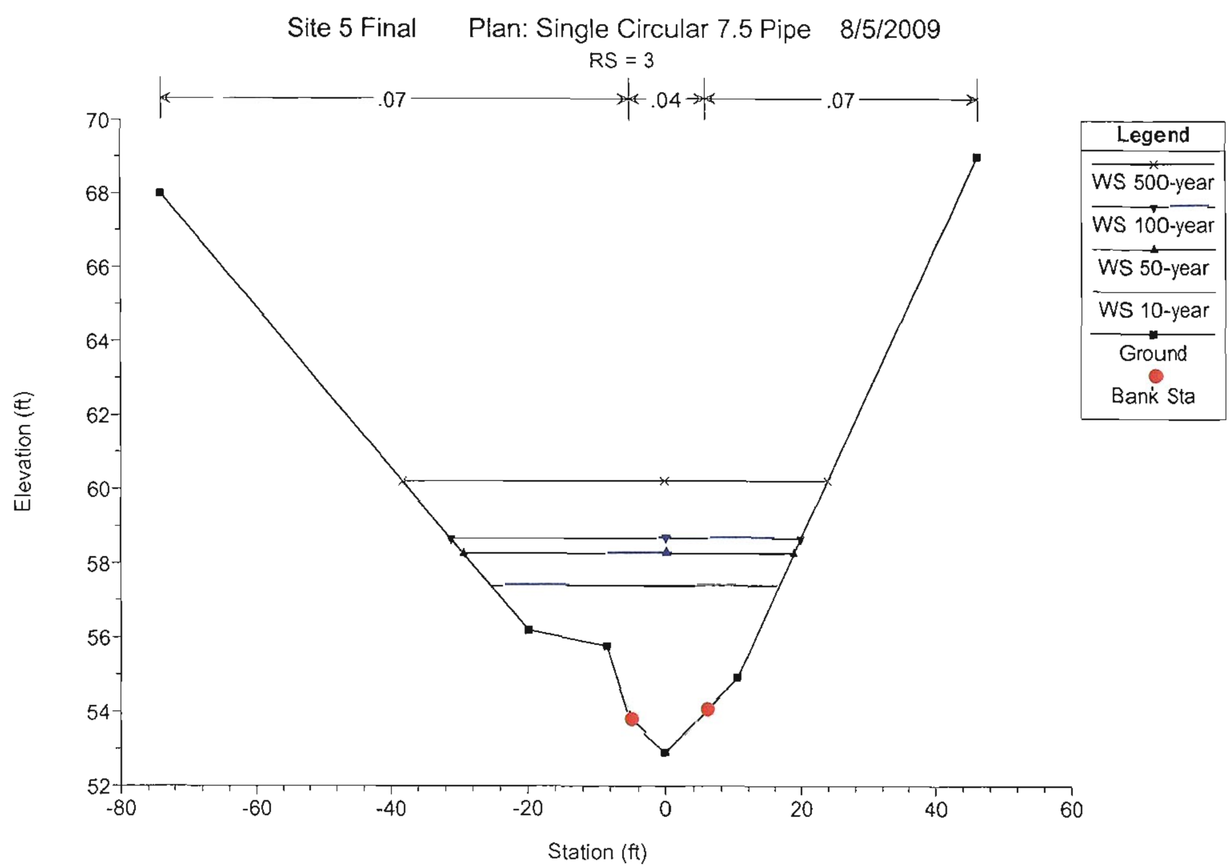


Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 6.2 Culv
.025
.015
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-30
-20
-10
0
10
20
30



Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 6
.025
.015
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-30
-20
-10
0
10
20
30


Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 4
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-120
-100
-80
-60
-40
-20
0
20
40
60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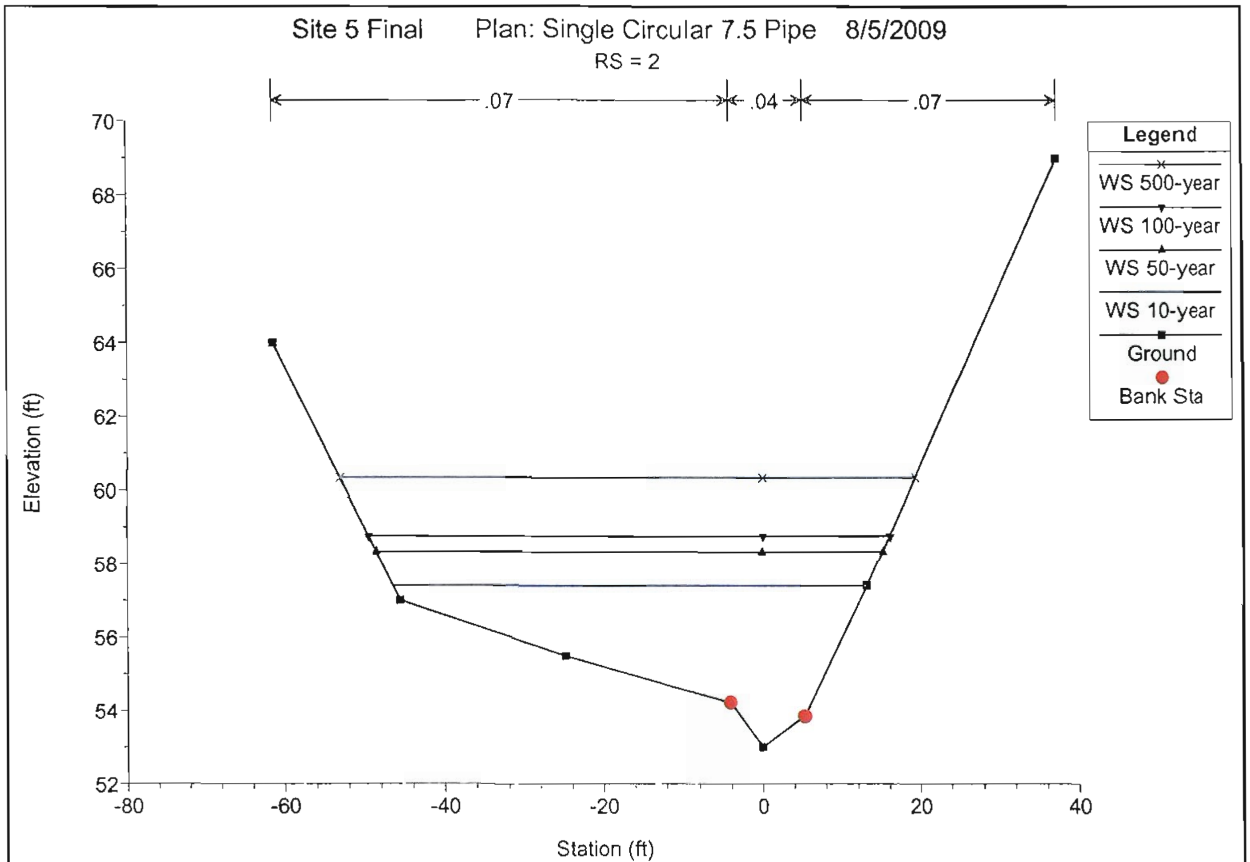
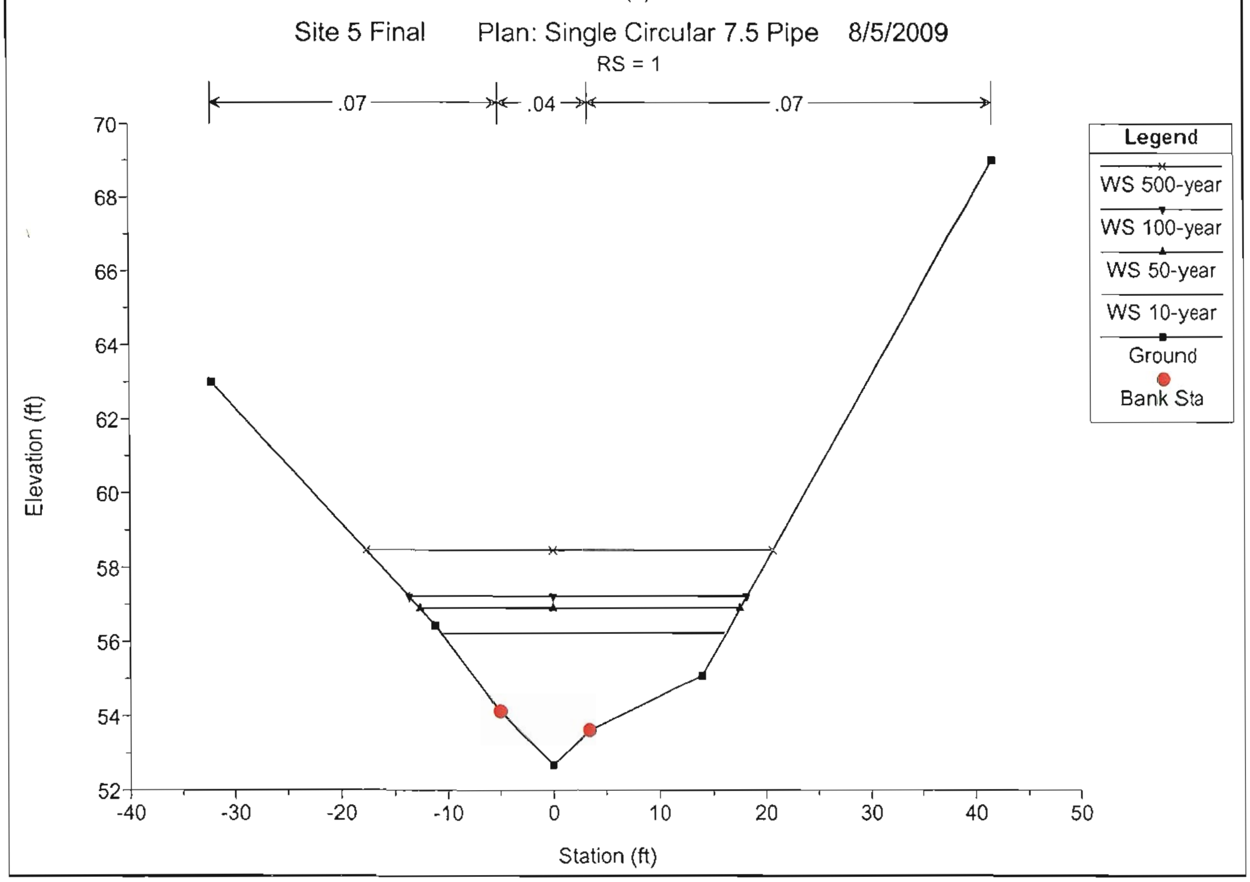
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-80
-60
-40
-20
0
20
40
60



Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 2
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Site 5 Final Plan: Single Circular 7.5 Pipe 8/5/2009
RS = 1
.07
.04
.07
Legend
WS 500-year
WS 100-year
WS 50-year
WS 10-year
Ground
Bank Sta
Elevation (ft)
Station (ft)

HEC-RAS Plan: single 7.5 River: Site 5- Brook Reach: reach 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
reach 1	13	10-year	320.00	53.97	60.98	57.61	61.05	0.000470	2.20	157.82	40.96	0.18
reach 1	13	50-year	486.00	53.97	63.50	58.27	63.56	0.000239	2.09	272.73	50.27	0.14
reach 1	13	100-year	573.00	53.97	65.22	58.52	65.28	0.000153	1.93	365.43	57.12	0.11
reach 1	13	500-year	974.00	53.97	72.20	59.49	72.24	0.000057	1.72	1134.45	460.35	0.08
reach 1	12	10-year	320.00	54.28	60.92	57.64	60.99	0.000477	2.19	157.96	41.74	0.18
reach 1	12	50-year	486.00	54.28	63.47	58.27	63.53	0.000233	2.06	276.77	51.40	0.14
reach 1	12	100-year	573.00	54.28	65.21	58.52	65.26	0.000148	1.90	372.19	58.45	0.11
reach 1	12	500-year	974.00	54.28	72.19	59.48	72.23	0.000055	1.70	1183.22	603.49	0.08
reach 1	11	10-year	320.00	54.21	60.91	57.66	60.97	0.000558	1.99	160.61	42.96	0.18
reach 1	11	50-year	486.00	54.21	63.47	58.31	63.52	0.000257	1.72	282.36	52.09	0.13
reach 1	11	100-year	573.00	54.21	65.21	58.58	65.25	0.000157	1.51	378.50	58.29	0.10
reach 1	11	500-year	974.00	54.21	72.20	59.51	72.22	0.000039	1.12	1071.86	573.29	0.06
reach 1	9	10-year	320.00	53.48	60.86	56.22	60.93	0.000604	2.10	152.64	37.71	0.18
reach 1	9	50-year	486.00	53.48	63.44	56.95	63.50	0.000295	1.85	264.33	48.36	0.14
reach 1	9	100-year	573.00	53.48	65.19	57.29	65.24	0.000169	1.65	353.06	51.99	0.11
reach 1	9	500-year	974.00	53.48	72.19	58.62	72.22	0.000047	1.37	957.95	537.29	0.06
reach 1	7	10-year	320.00	53.40	60.89	55.71	60.92	0.000021	1.37	264.01	67.96	0.10
reach 1	7	50-year	486.00	53.40	63.47	56.28	63.49	0.000012	1.29	473.87	87.84	0.08
reach 1	7	100-year	573.00	53.40	65.21	56.55	65.23	0.000008	1.18	631.14	91.96	0.07
reach 1	7	500-year	974.00	53.40	72.20	57.56	72.21	0.000003	1.03	1468.22	505.60	0.04
reach 1	6.2		Culvert									
reach 1	6	10-year	320.00	52.60	58.08		58.18	0.000115	2.56	125.15	24.91	0.20
reach 1	6	50-year	486.00	52.60	59.11		59.27	0.000153	3.21	151.23	25.48	0.23
reach 1	6	100-year	573.00	52.60	59.52		59.72	0.000176	3.54	161.82	25.70	0.25
reach 1	6	500-year	974.00	52.60	61.00		61.37	0.000279	4.86	200.29	26.50	0.31
reach 1	4	10-year	320.00	53.71	57.44		58.03	0.006398	6.54	61.89	24.18	0.63
reach 1	4	50-year	486.00	53.71	58.17		59.05	0.007466	8.07	82.35	36.53	0.71
reach 1	4	100-year	573.00	53.71	58.54		59.48	0.007316	8.47	96.54	39.57	0.71
reach 1	4	500-year	974.00	53.71	60.02		61.13	0.006443	9.65	163.31	50.73	0.70
reach 1	3	10-year	320.00	52.90	57.39		57.74	0.003453	5.43	93.01	42.07	0.46
reach 1	3	50-year	486.00	52.90	58.27		58.68	0.003396	6.15	132.55	48.33	0.49
reach 1	3	100-year	573.00	52.90	58.67		59.11	0.003347	6.43	152.59	51.21	0.49
reach 1	3	500-year	974.00	52.90	60.22		60.75	0.003139	7.40	240.79	62.32	0.50
reach 1	2	10-year	320.00	53.01	57.40		57.61	0.002718	4.71	127.59	59.68	0.42
reach 1	2	50-year	486.00	53.01	58.33		58.54	0.002270	4.97	184.80	63.70	0.40
reach 1	2	100-year	573.00	53.01	58.75		58.96	0.002153	5.11	211.89	65.52	0.39
reach 1	2	500-year	974.00	53.01	60.34		60.59	0.001919	5.76	321.85	72.44	0.39
reach 1	1	10-year	320.00	52.68	56.22	56.22	57.22	0.015646	9.27	51.54	26.78	0.96
reach 1	1	50-year	486.00	52.68	56.90	56.90	58.16	0.015716	10.68	70.86	30.19	0.99
reach 1	1	100-year	573.00	52.68	57.22	57.22	58.59	0.015460	11.22	80.98	31.88	1.00
reach 1	1	500-year	974.00	52.68	58.47	58.47	60.21	0.014719	13.16	124.74	38.36	1.02

Plan: single 7.5 Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #1 Profile: 10-year

Q Culv Group (cfs)	320.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	8.98
Q Barrel (cfs)	320.00	Culv Vel DS (ft/s)	9.80
E.G. US. (ft)	60.92	Culv Inv El Up (ft)	53.40
W.S. US. (ft)	60.89	Culv Inv El Dn (ft)	52.88
E.G. DS (ft)	58.18	Culv Frctn Ls (ft)	0.73
W.S. DS (ft)	58.08	Culv Exit Loss (ft)	1.39
Delta EG (ft)	2.74	Culv Entr Loss (ft)	0.63
Delta WS (ft)	2.81	Q Weir (cfs)	
E.G. IC (ft)	60.47	Weir Sta Lft (ft)	
E.G. OC (ft)	60.92	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	59.04	Weir Max Depth (ft)	
Culv WS Outlet (ft)	58.08	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	6.20	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	4.62	Min El Weir Flow (ft)	72.01

Plan: single 7.5 Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #1 Profile: 50-year

Q Culv Group (cfs)	486.00	Culv Full Len (ft)	
# Barrels	1	Culv Vel US (ft/s)	11.16
Q Barrel (cfs)	486.00	Culv Vel DS (ft/s)	12.39
E.G. US. (ft)	63.49	Culv Inv El Up (ft)	53.40
W.S. US. (ft)	63.47	Culv Inv El Dn (ft)	52.88
E.G. DS (ft)	59.27	Culv Frctn Ls (ft)	1.03
W.S. DS (ft)	59.11	Culv Exit Loss (ft)	2.22
Delta EG (ft)	4.22	Culv Entr Loss (ft)	0.97
Delta WS (ft)	4.35	Q Weir (cfs)	
E.G. IC (ft)	63.22	Weir Sta Lft (ft)	
E.G. OC (ft)	63.49	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	60.59	Weir Max Depth (ft)	
Culv WS Outlet (ft)	59.11	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	7.50	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	5.71	Min El Weir Flow (ft)	72.01

Plan: single 7.5 Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #1 Profile: 100-year

Q Culv Group (cfs)	573.00	Culv Full Len (ft)	45.68
# Barrels	1	Culv Vel US (ft/s)	12.97
Q Barrel (cfs)	573.00	Culv Vel DS (ft/s)	13.84
E.G. US. (ft)	65.23	Culv Inv El Up (ft)	53.40
W.S. US. (ft)	65.21	Culv Inv El Dn (ft)	52.88
E.G. DS (ft)	59.72	Culv Frctn Ls (ft)	1.42
W.S. DS (ft)	59.52	Culv Exit Loss (ft)	2.78
Delta EG (ft)	5.51	Culv Entr Loss (ft)	1.31
Delta WS (ft)	5.69	Q Weir (cfs)	
E.G. IC (ft)	65.10	Weir Sta Lft (ft)	
E.G. OC (ft)	65.23	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	60.90	Weir Max Depth (ft)	
Culv WS Outlet (ft)	59.52	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	7.50	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	6.16	Min El Weir Flow (ft)	72.01

Plan: single 7.5 Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #1 Profile: 500-year

Q Culv Group (cfs)	827.64	Culv Full Len (ft)	104.00
# Barrels	1	Culv Vel US (ft/s)	18.73
Q Barrel (cfs)	827.64	Culv Vel DS (ft/s)	18.73
E.G. US. (ft)	72.21	Culv Inv El Up (ft)	53.40
W.S. US. (ft)	72.20	Culv Inv El Dn (ft)	52.88
E.G. DS (ft)	61.37	Culv Frctn Ls (ft)	3.04
W.S. DS (ft)	61.00	Culv Exit Loss (ft)	5.08
Delta EG (ft)	10.85	Culv Entr Loss (ft)	2.72
Delta WS (ft)	11.20	Q Weir (cfs)	146.36
E.G. IC (ft)	72.23	Weir Sta Lft (ft)	-420.00
E.G. OC (ft)	72.21	Weir Sta Rgt (ft)	85.69
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	60.90	Weir Max Depth (ft)	0.23
Culv WS Outlet (ft)	60.38	Weir Avg Depth (ft)	0.23
Culv Nml Depth (ft)	7.50	Weir Flow Area (sq ft)	117.01
Culv Crt Depth (ft)	7.01	Min El Weir Flow (ft)	72.01

Appendix C

Channel Protection Computations

GM2 Associates
Engineers • Inspectors • Surveyors

Job Busway Site 5 Culvert — Computed By EWB — Date 8/09
Description — Checked By MKG — Date 8/15
Riprap Basin Design Chapter 10 HEC-14 — Sheet 1 of 2

Step 1 Culvert outlet Velocity (V_o) and depth (y_o)

V_o = 13.84 FPS y_o = 6.64 Ft

Outlet Froude # $= \frac{V}{(g \cdot y_e)^{0.5}}$ $y_e = (A/2)^{0.5}$ 4.55' flow area @ outlet

$Q = AV$

$573 = A \cdot 13.84$

$A = 41.40$

$Fr_o = \frac{13.84}{(32.2 \cdot 4.56)^{0.5}} = 1.14$

Step 2 C_o = Tailwater Parameter using eqs 10.1 & 10.2

TW = 6.9' TW/y_e = 1.52 ⇒ C_o = 2.4

Trial 1
Assume D_{50} 8" (ok)

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}(Fr_o) - C_o$$

$$= 0.86\,(0.67/4.55)^{-0.55}(1.14) - 2.4$$

$\frac{h_s}{y_e} = 0.41$, $h_s = 1.87$ Ft

check $h_s/D_{50} = 2.79$ ✓

$D_{50}/y_e = 0.1$ ✓

Step 3 Length of Dissipation Pool $L_s = 10\,h_s = 18.7$ Ft

but not less than $3W_o = 22.5'$

Final $L_s = 22.5'$

L_A = Length of Apron $= 5 \cdot h_s = 9.35'$, No less than W_o

Final $L_A = 9.35$

Length of Basin Final $L_B = 31.85'$

basin width @ Exit $W_b = 28.7'$

basin depth = h_s 1.87' down from outlet invert.

GM2 Associates
Engineers • Inspectors • Surveyors

Job ______ Computed By ______ Date ______

Description ______ Checked By mkn Date 8/15

Riprap Basin Design Cont... Sheet 2 of 2

Step 4 $\frac{Q^2}{g} = 10196 = \frac{[Y_c(W_b + Z Y_c)]^3}{(W_b + 2 Z Y_c)}$

Take $z = 2$
$Wb = 28.7$

IF $Y_c = 2.19'$ then ⇒ 10150 close

So $Y_c = 2.19$
$A_c = W_b \cdot Y_c = 62.85 \text{ ft}^2$

$V_c = Q/A_c = 573/62.85 = 9.12$ FPS

V_{allow} would be Natural channel velocity AFTER Basin
NEAR SECTION 4 $V_{ch} = 8.47$ Close $\Delta 0.6$ FPS

Recommend Basin Design as of Sheet 1 of 2

SITE 5 INLET PROTECTION

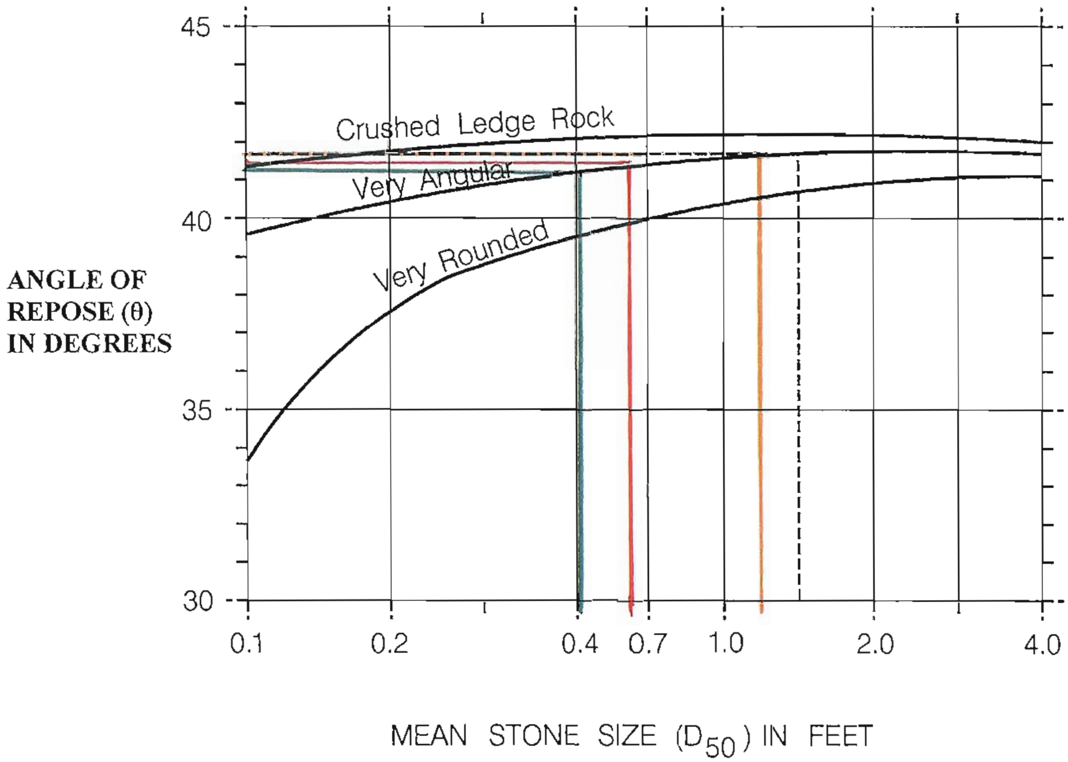
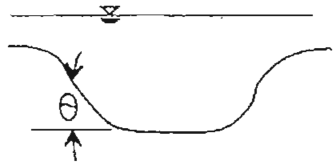


Figure 7-27.1 Angle Of Repose Of Riprap in Terms Of Mean Size and Shape Of Stone (English units)

— MODIFIED (5") $\Phi = 41.25°$
— INTERMEDIATE (8") $\Phi = 41.50°$
— STANDARD (15") $\Phi = 41.75°$

SITE 5 INLET PROTECTION



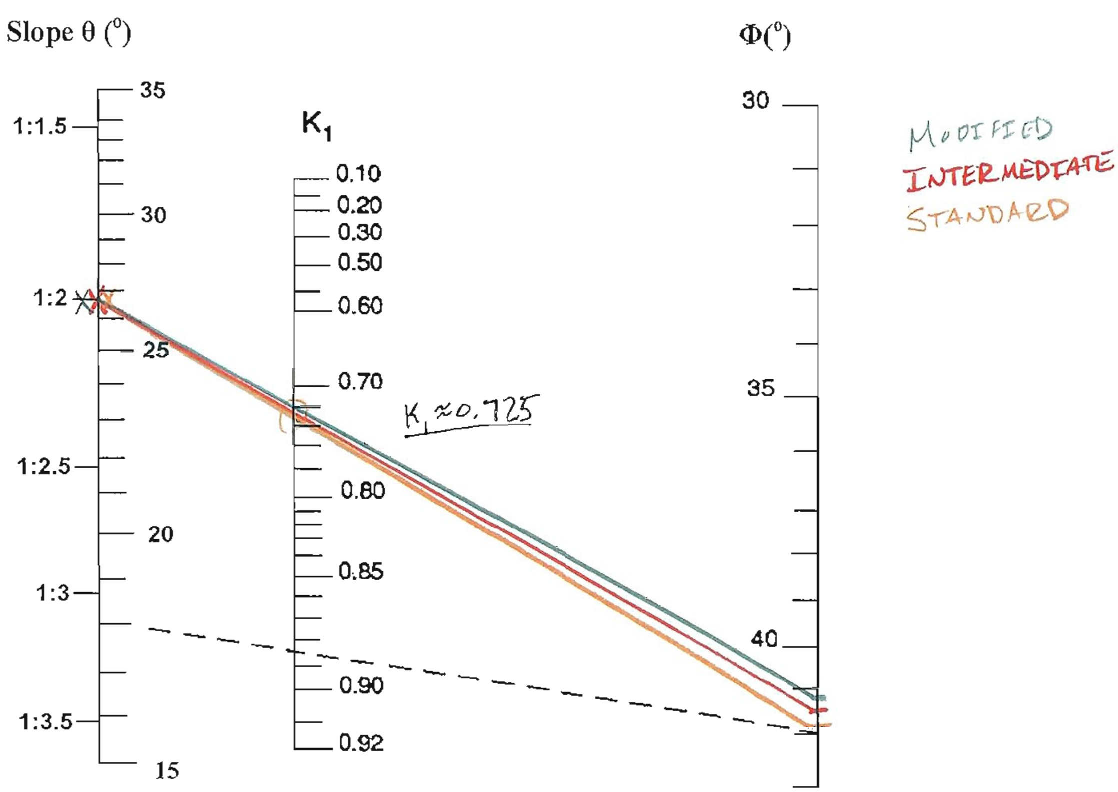
$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\Phi} \right]^{0.5}$$

θ = Bank angle with horizontal

θ =Bank angle with horizontal

Φ = Material angle of repose

See Figure 7-27 or 7-27.1



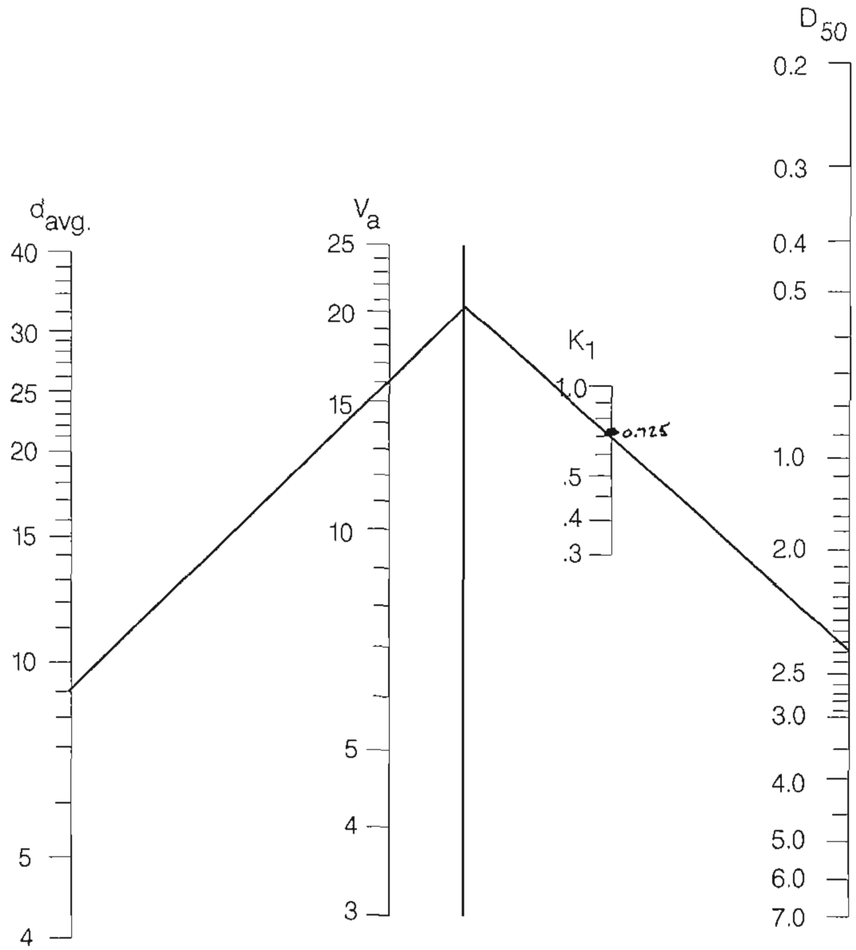
Example

Given:	Find:	Solution:
θ = 18°	K_1	Φ = 42°
Very angular		K_1 = 0.885
D_{50} = 457 mm (1.5 ft)		

Figure 7-26 Bank Angle Correction Factor (K_1) Nomograph

$D_{50} = 0.001\, V_a^3 / (d_{avg.}^{1/2} K_1^{3/2})$

D_{50} = Median Riprap Size (ft.)
V_a = Average velocity in main channel (ft/sec)
$d_{avg.}$ = Average depth in main channel (ft.)
K_1 = Bank angle correction term



Required stone size less than 0.2'
Recommend modified Riprap

INLET VELOCITY ≈ 2 FPS

Example:

Given:

V_a = 16 ft/sec.
$d_{avg.}$ = 9 ft.
k_1 = 0.72

Find:

D_{50}

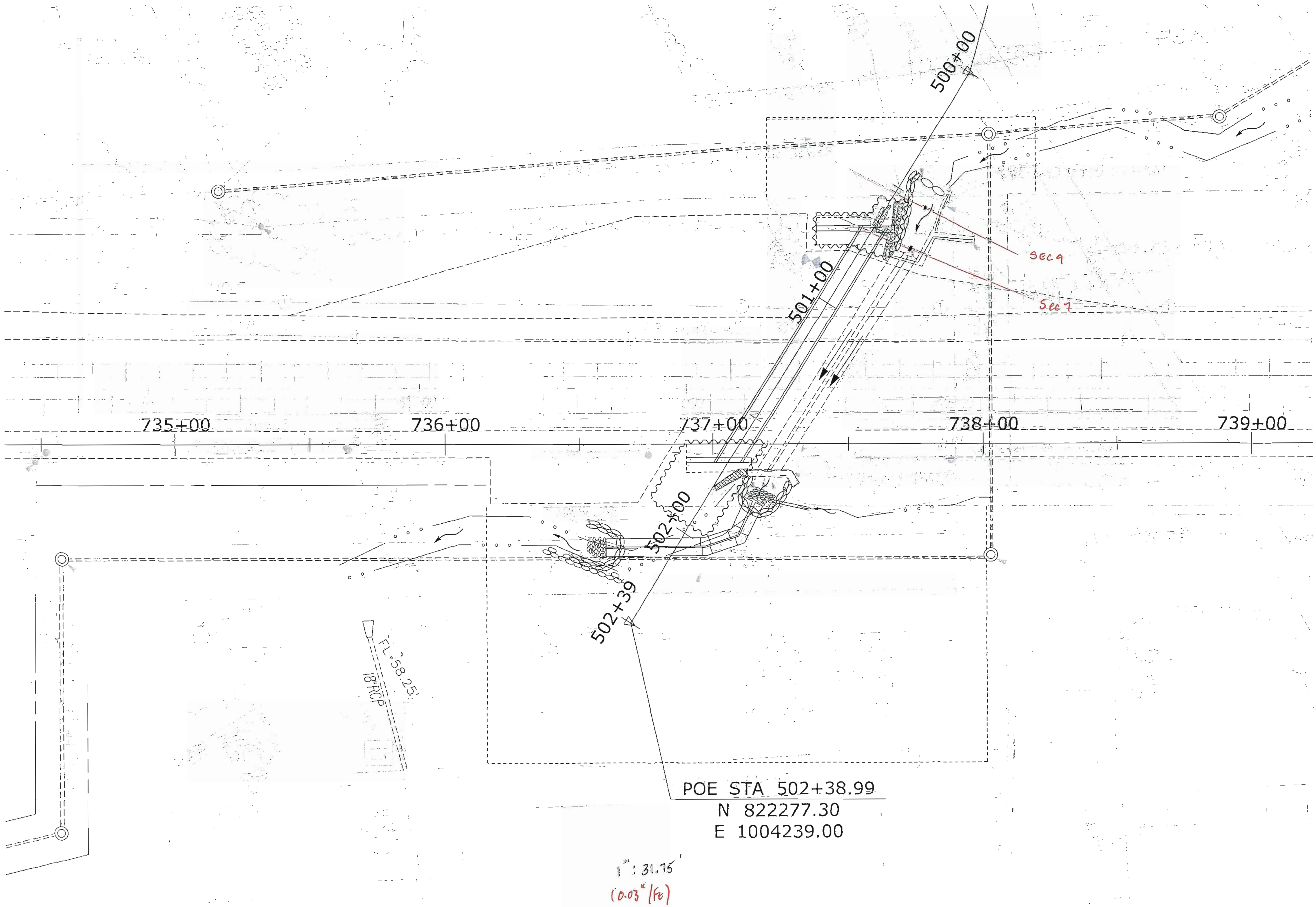
Solution:

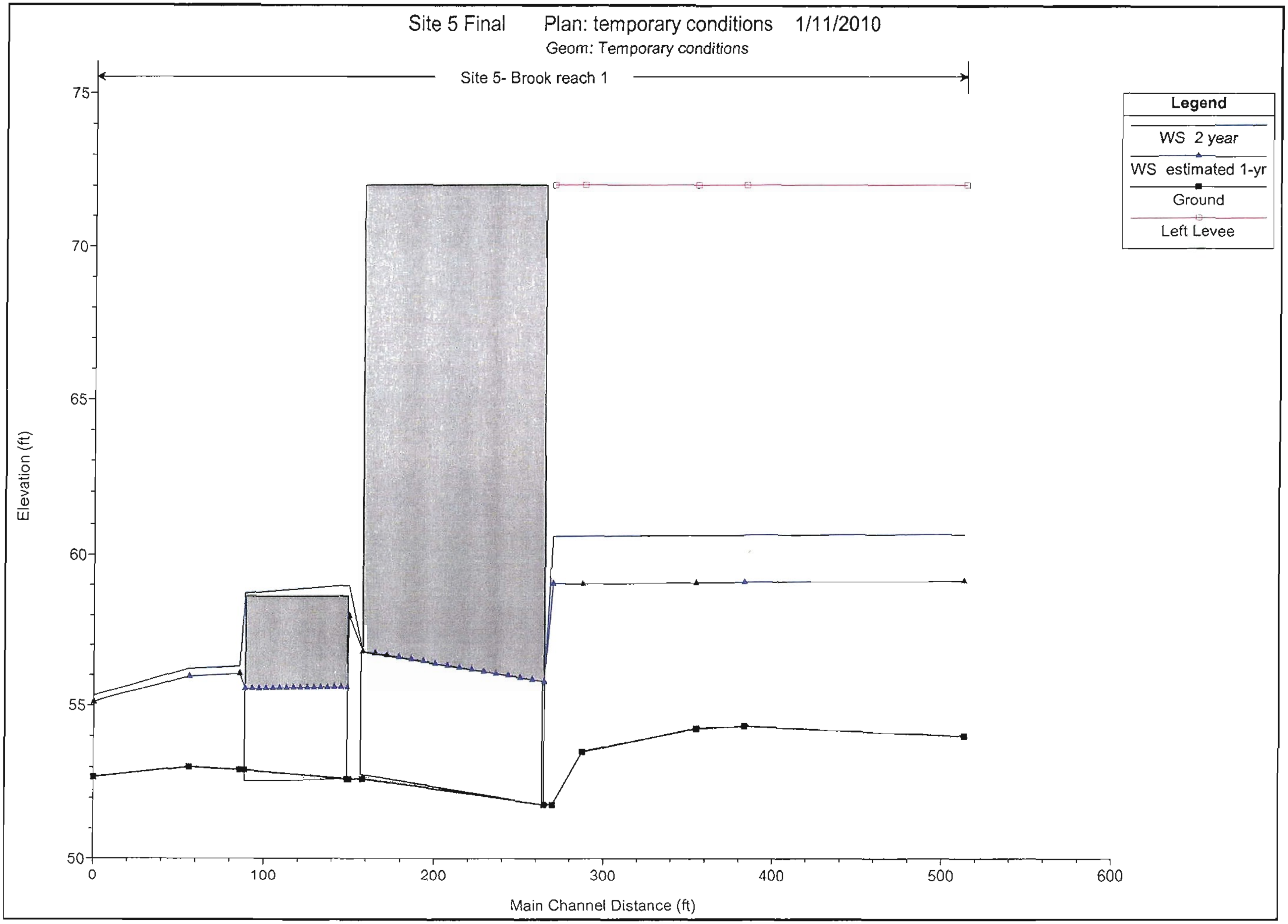
D_{50} = 2.25

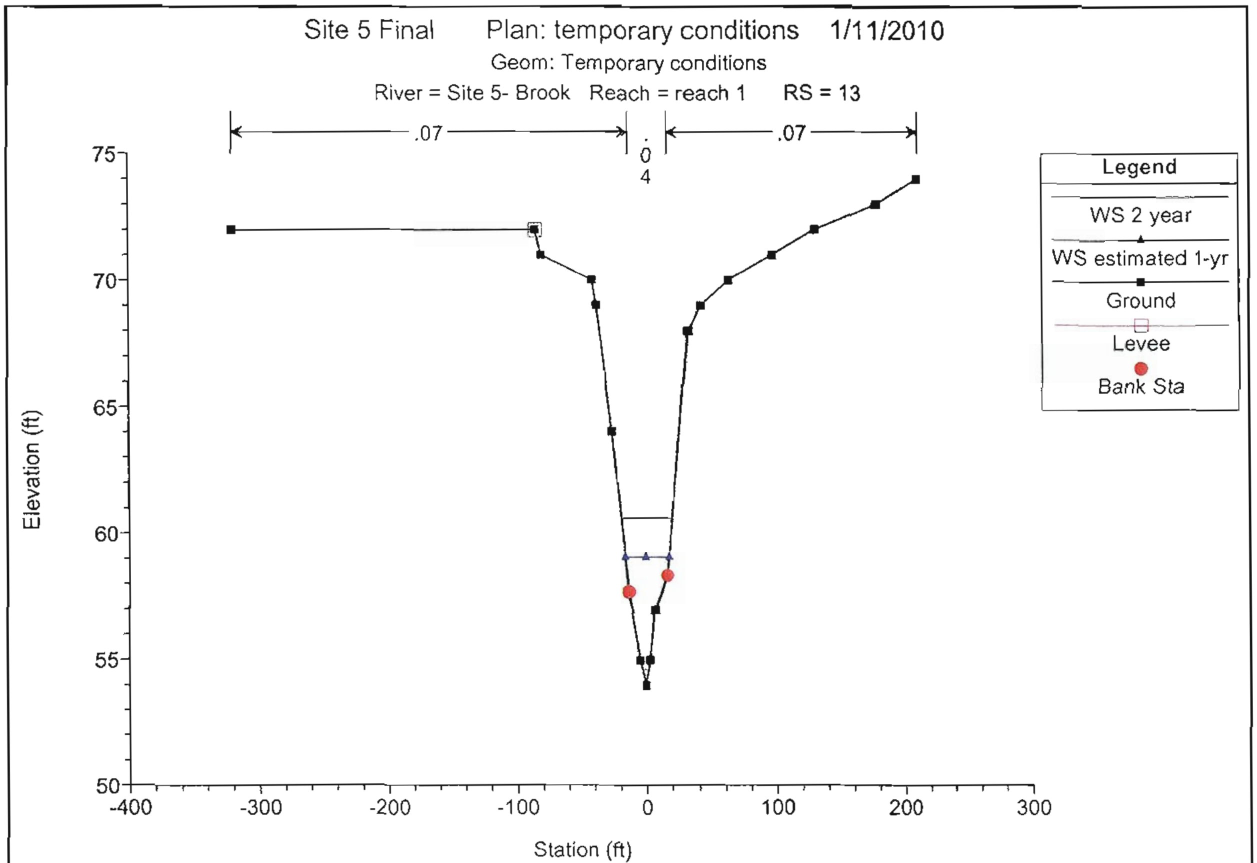
Figure 7-25.1 Riprap Size Relationship (English units)

Appendix D

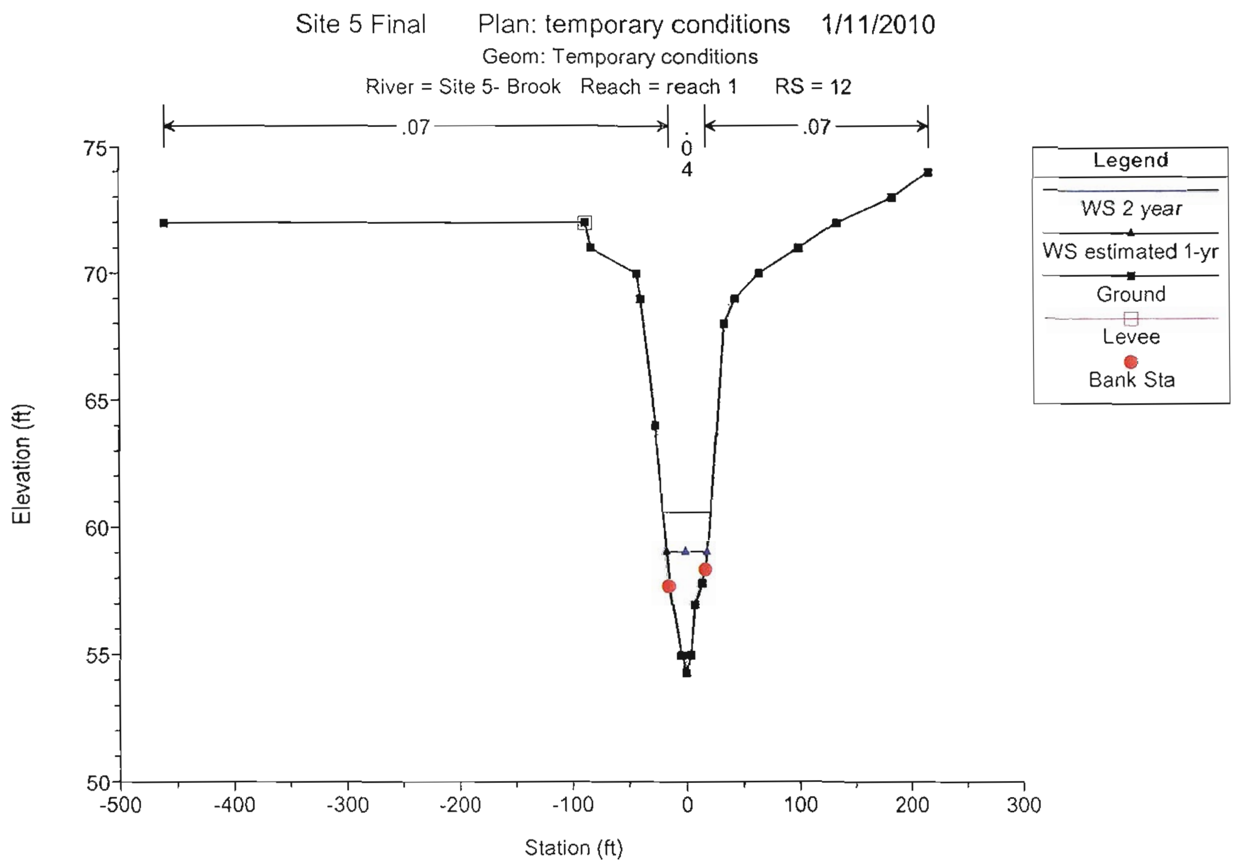
Temporary Conditions Hydraulic Analysis


500+00
501+00
502+00
502+39
735+00
736+00
737+00
738+00
739+00
Sec 9
Sec 7
FL=58.25'
18"RCP
POE STA 502+38.99
N 822277.30
E 1004239.00
1" : 31.75'
(0.03"/Ft)

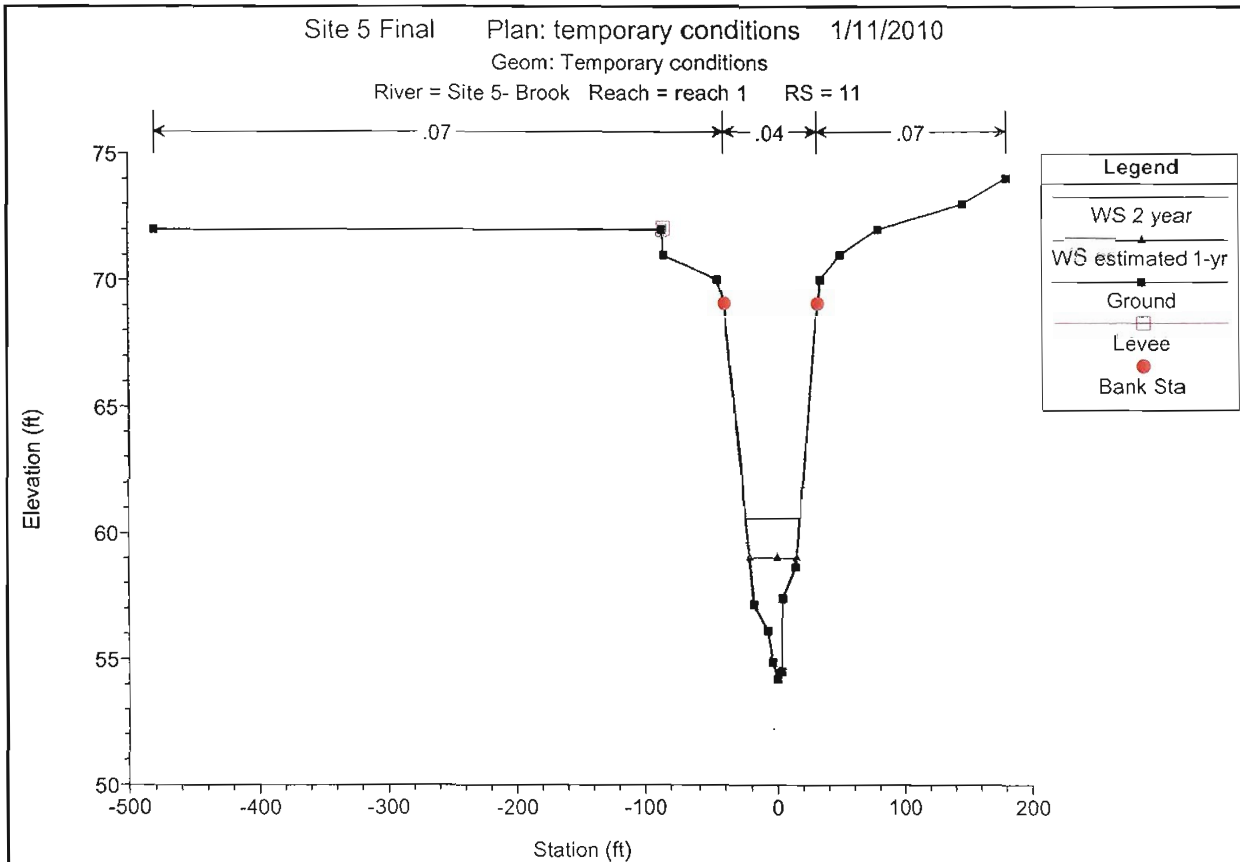

Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
Site 5- Brook reach 1
Legend
WS 2 year
WS estimated 1-yr
Ground
Left Levee
Elevation (ft)
75
70
65
60
55
50
0
100
200
300
400
500
600
Main Channel Distance (ft)



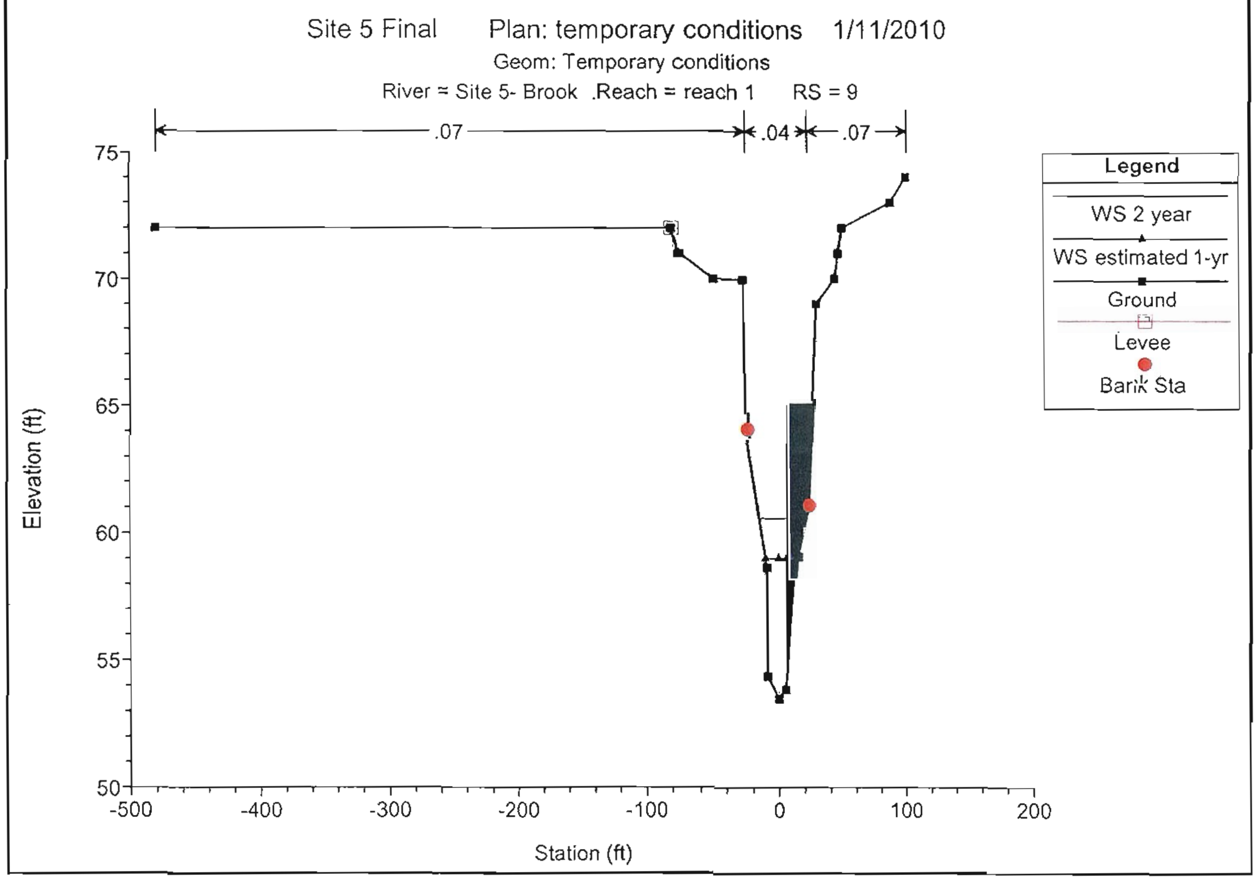
Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 13
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)



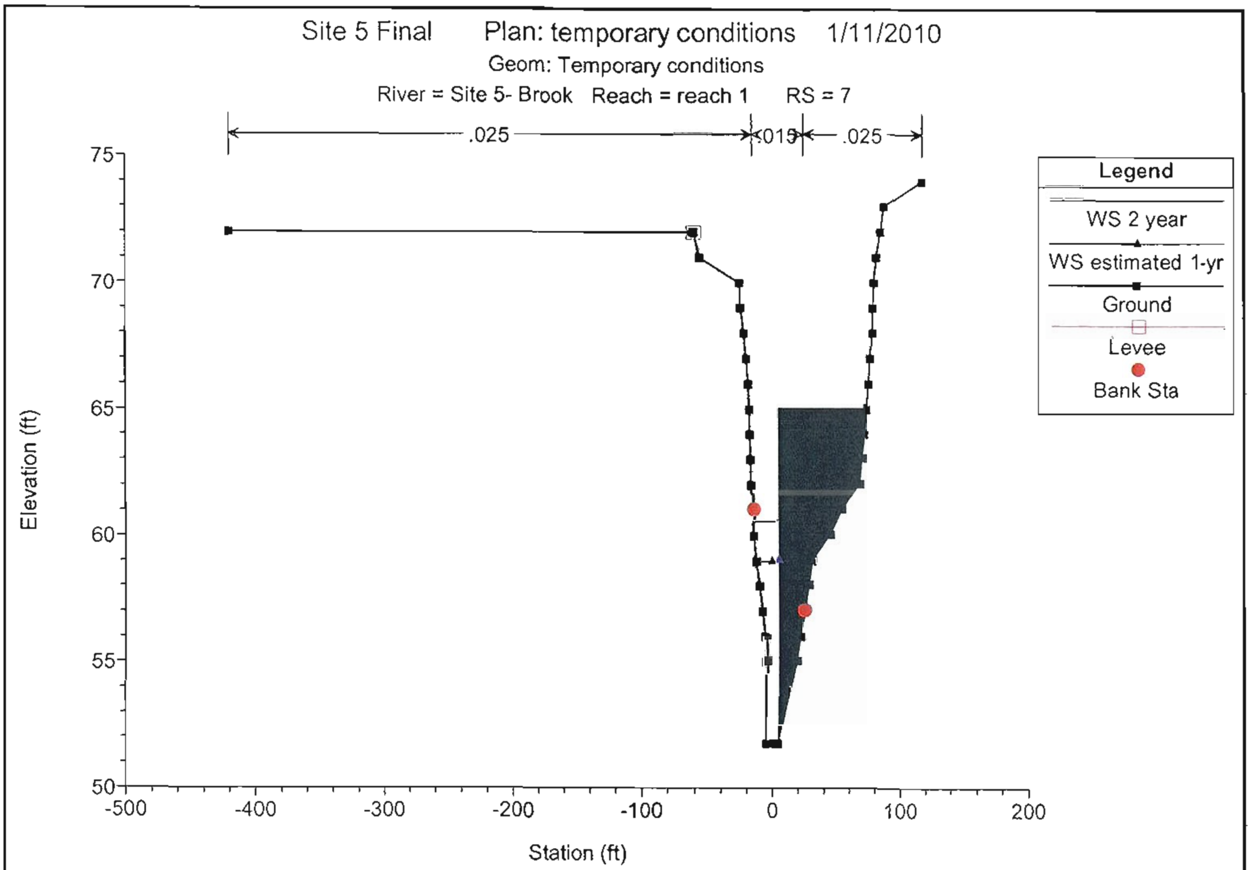
Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 12
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)

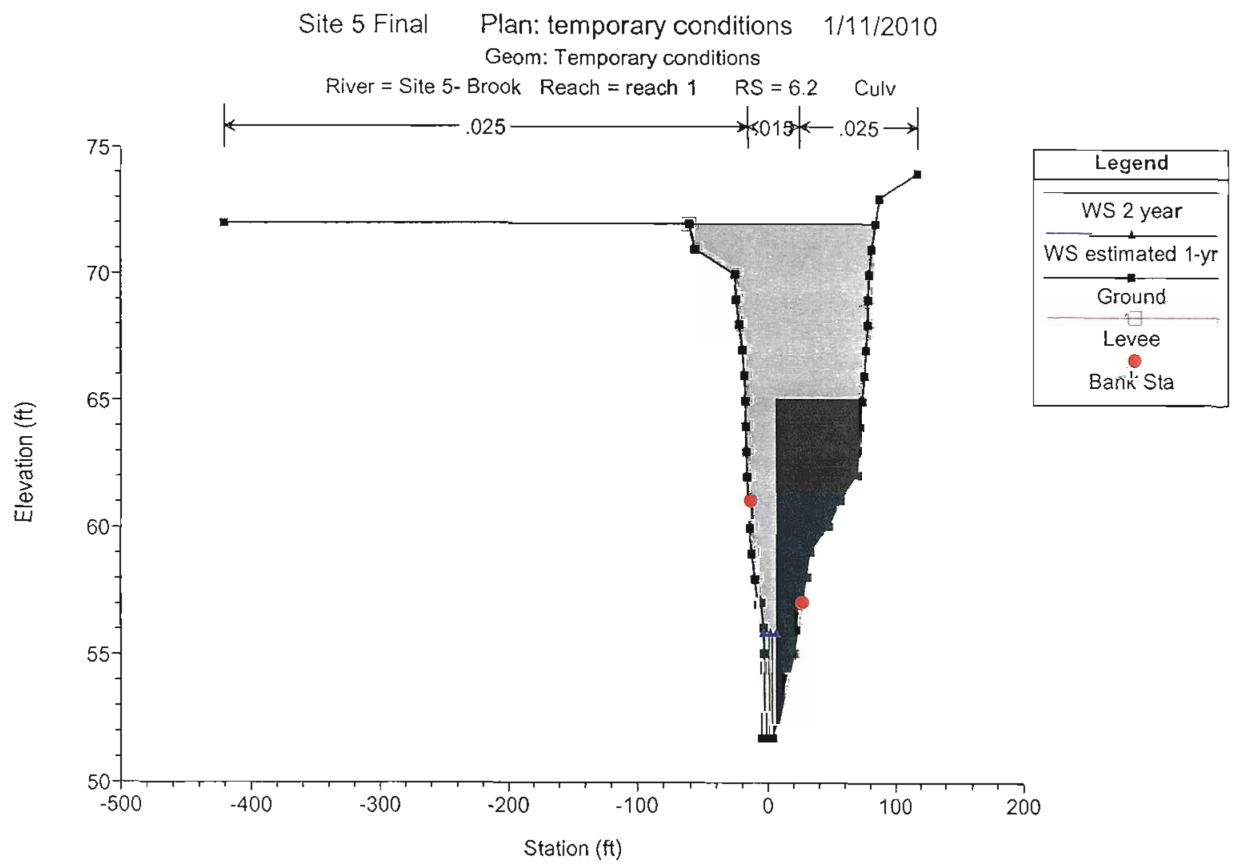


Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 11
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)



Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook .Reach = reach 1 RS = 9
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Site 5 Final
Plan: temporary conditions
1/11/2010
Geom: Temporary conditions
River = Site 5- Brook
Reach = reach 1
RS = 7
.025
.015
.025
Legend
WS 2 year
WS estimated 1-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
-200
-100
0
100
200


Site 5 Final
Plan: temporary conditions
1/11/2010
Geom: Temporary conditions
River = Site 5- Brook
Reach = reach 1
RS = 6.2
Culv
.025
.015
.025
Legend
WS 2 year
WS estimated 1-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-500
-400
-300
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-100
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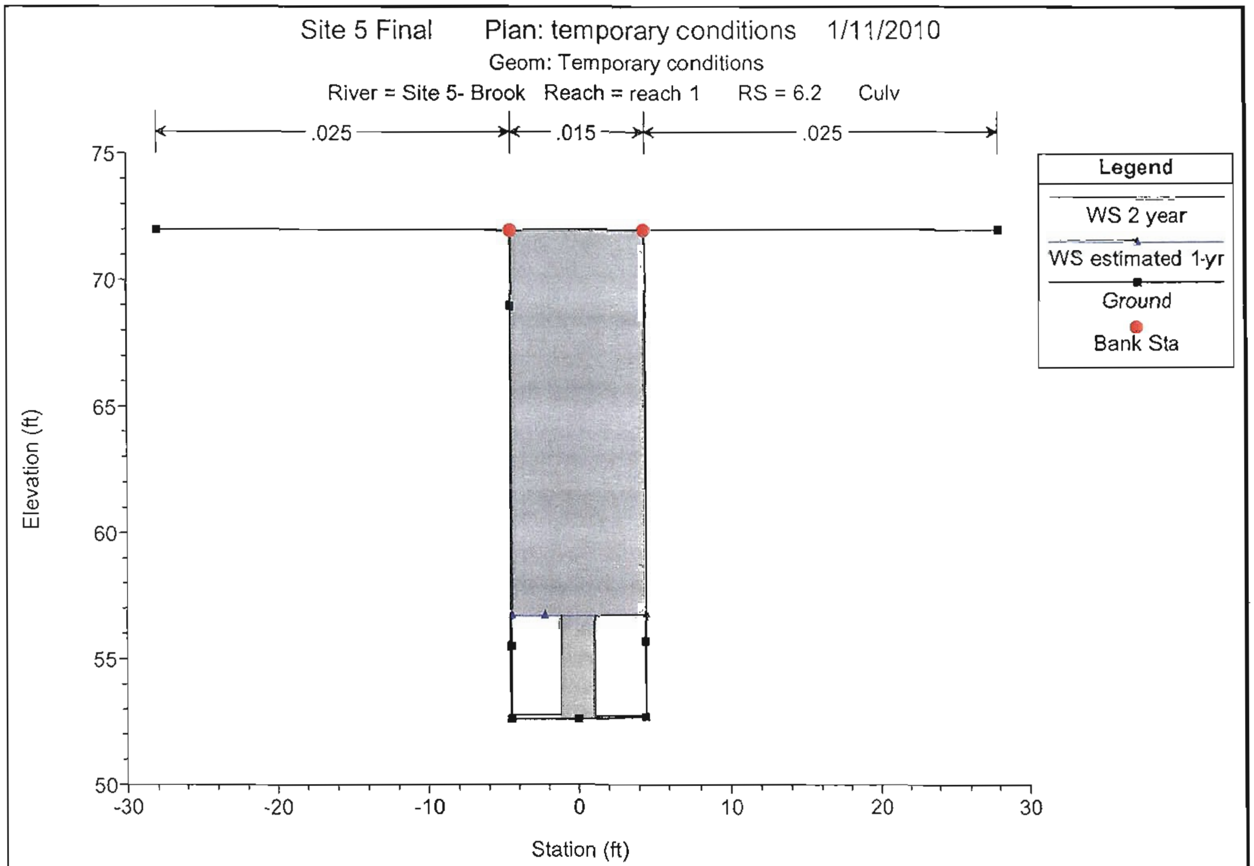
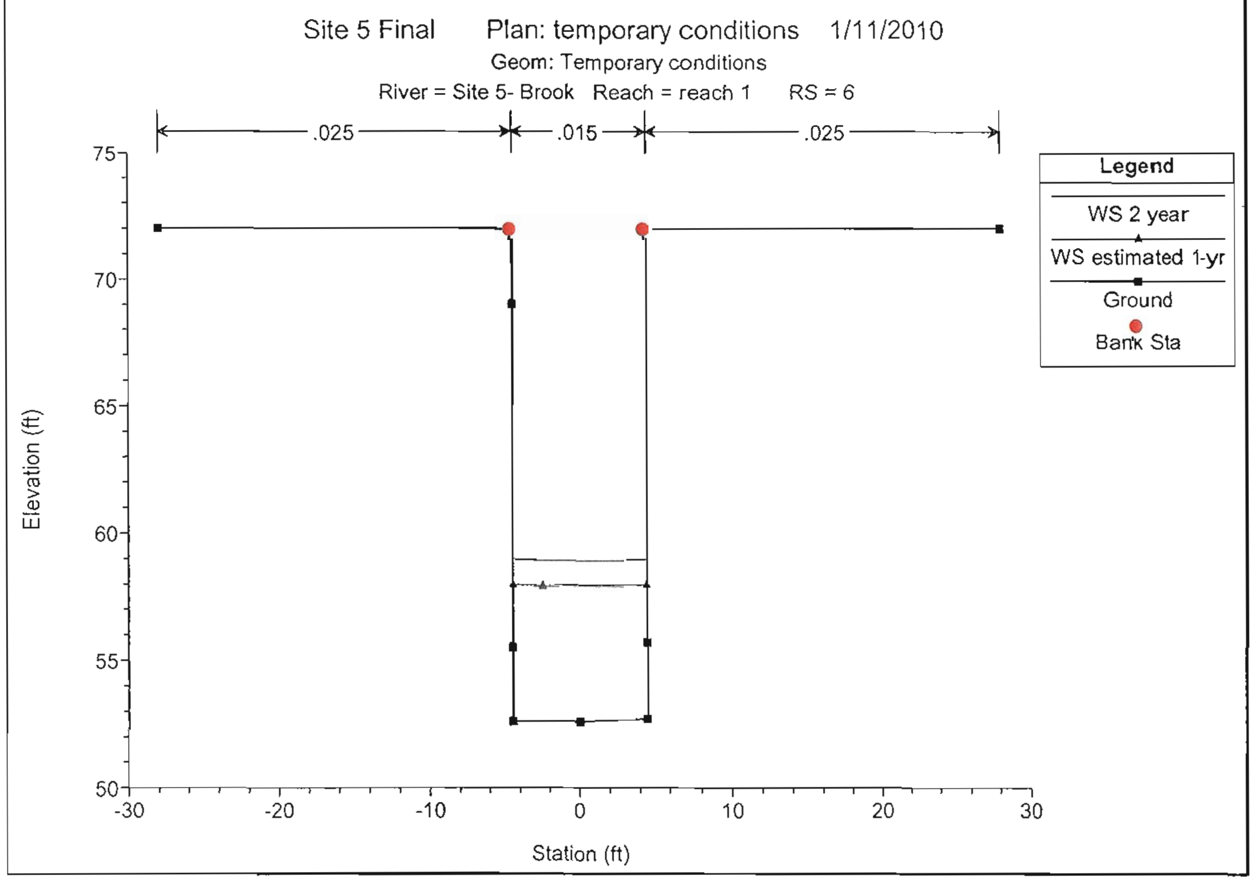
100
200


Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 6.2 Culv
.025
.015
.025
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-30
-20
-10
0
10
20
30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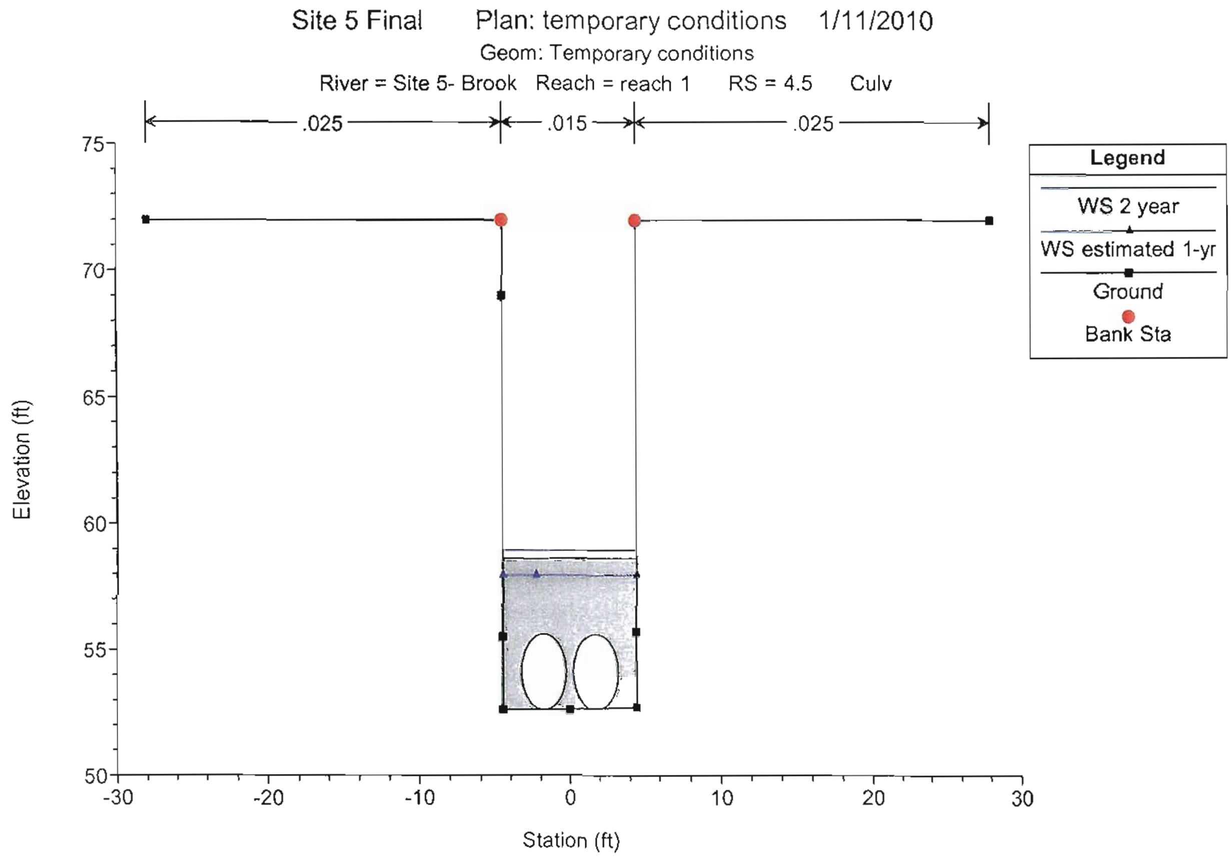
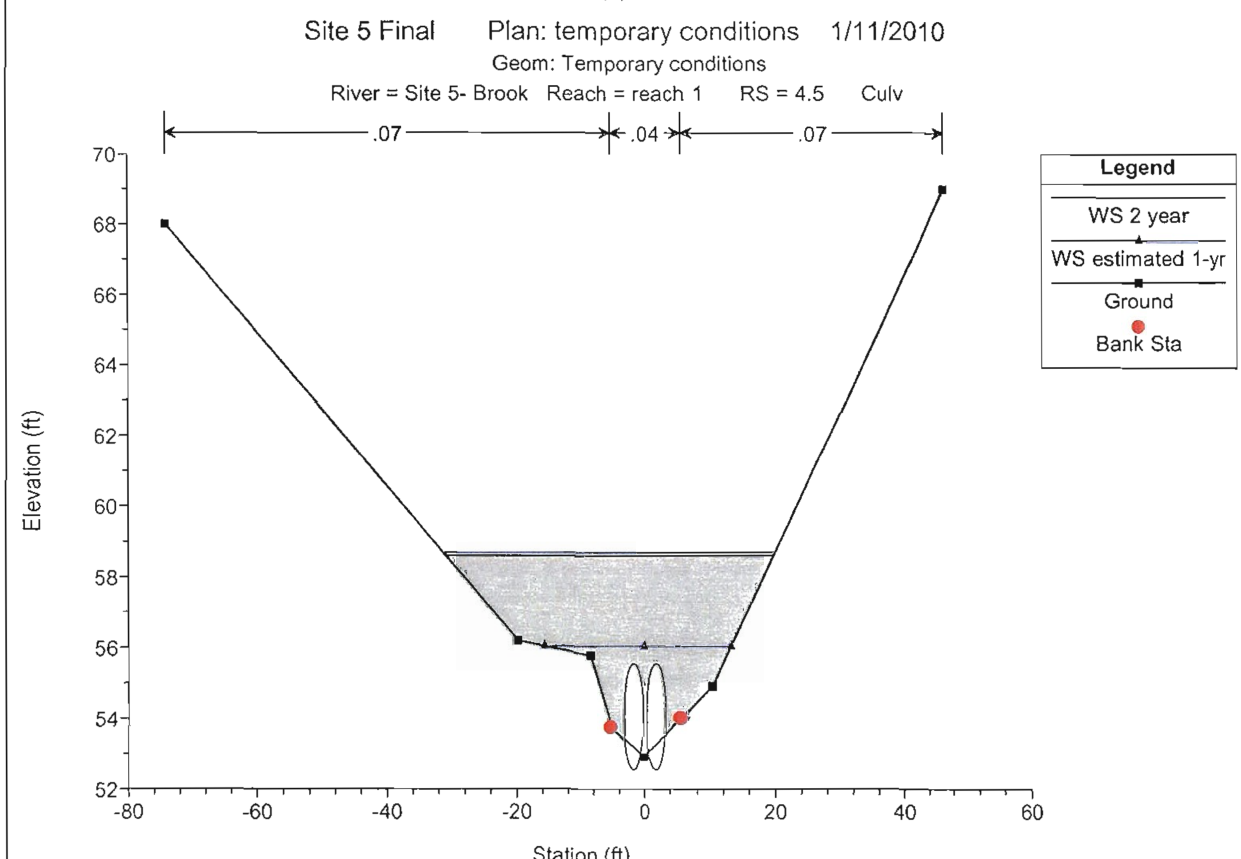
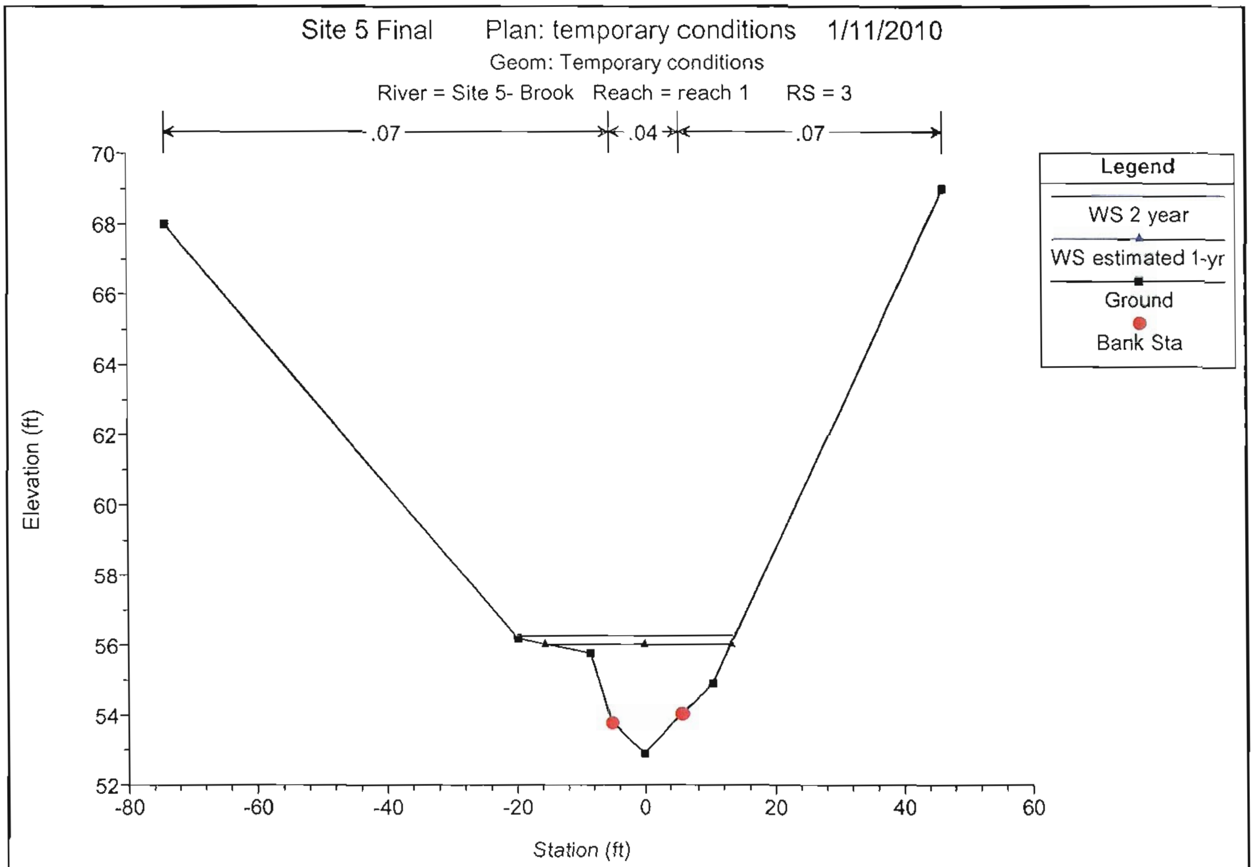
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 6
.025
.015
.025
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-30
-20
-10
0
10
20
30



Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 4.5 Culv
.025
.015
.025
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
75
70
65
60
55
50
-30
-20
-10
0
10
20
30



Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 4.5 Culv
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-80
-60
-40
-20
0
20
40
60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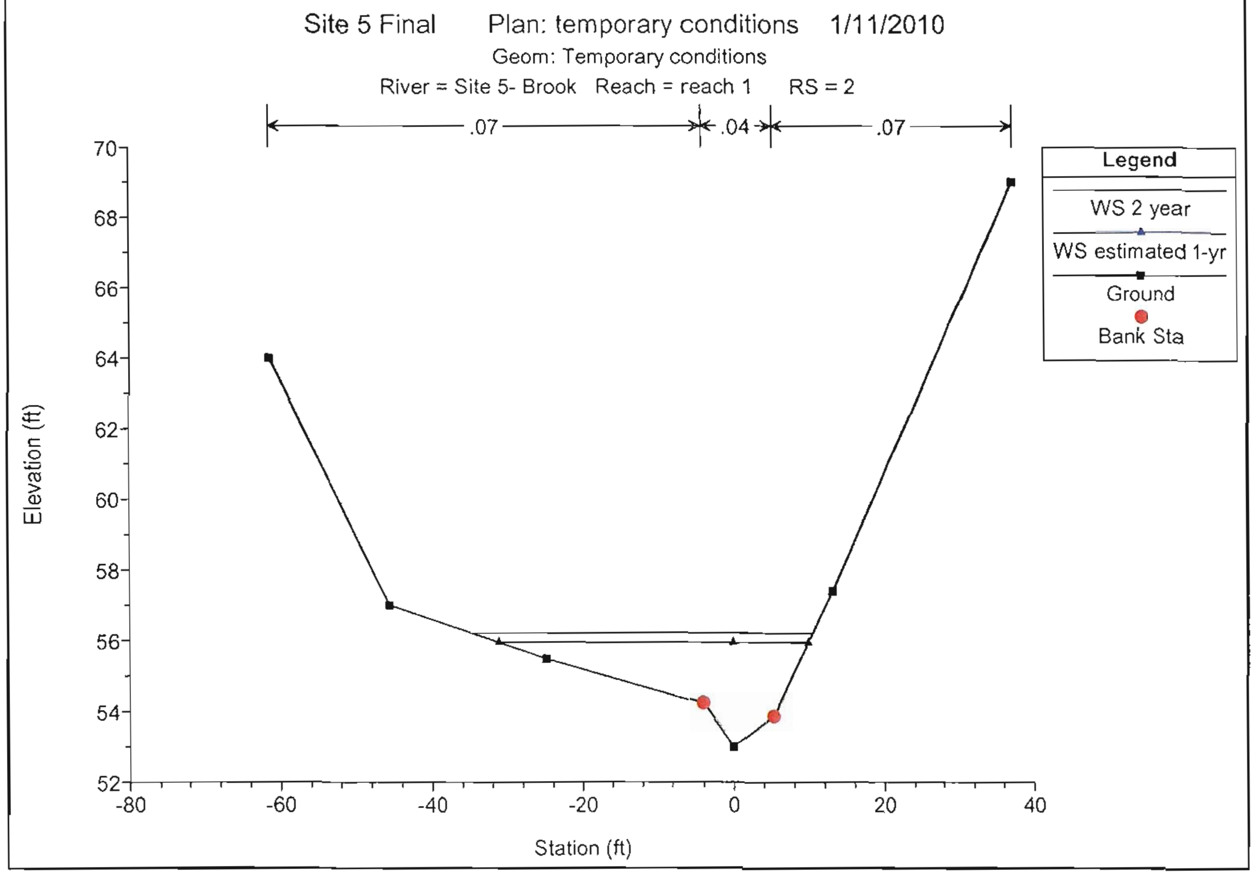
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 3
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-80
-60
-40
-20
0
20
40
60


Site 5 Final Plan: temporary conditions 1/11/2010
Geom: Temporary conditions
River = Site 5- Brook Reach = reach 1 RS = 2
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-80
-60
-40
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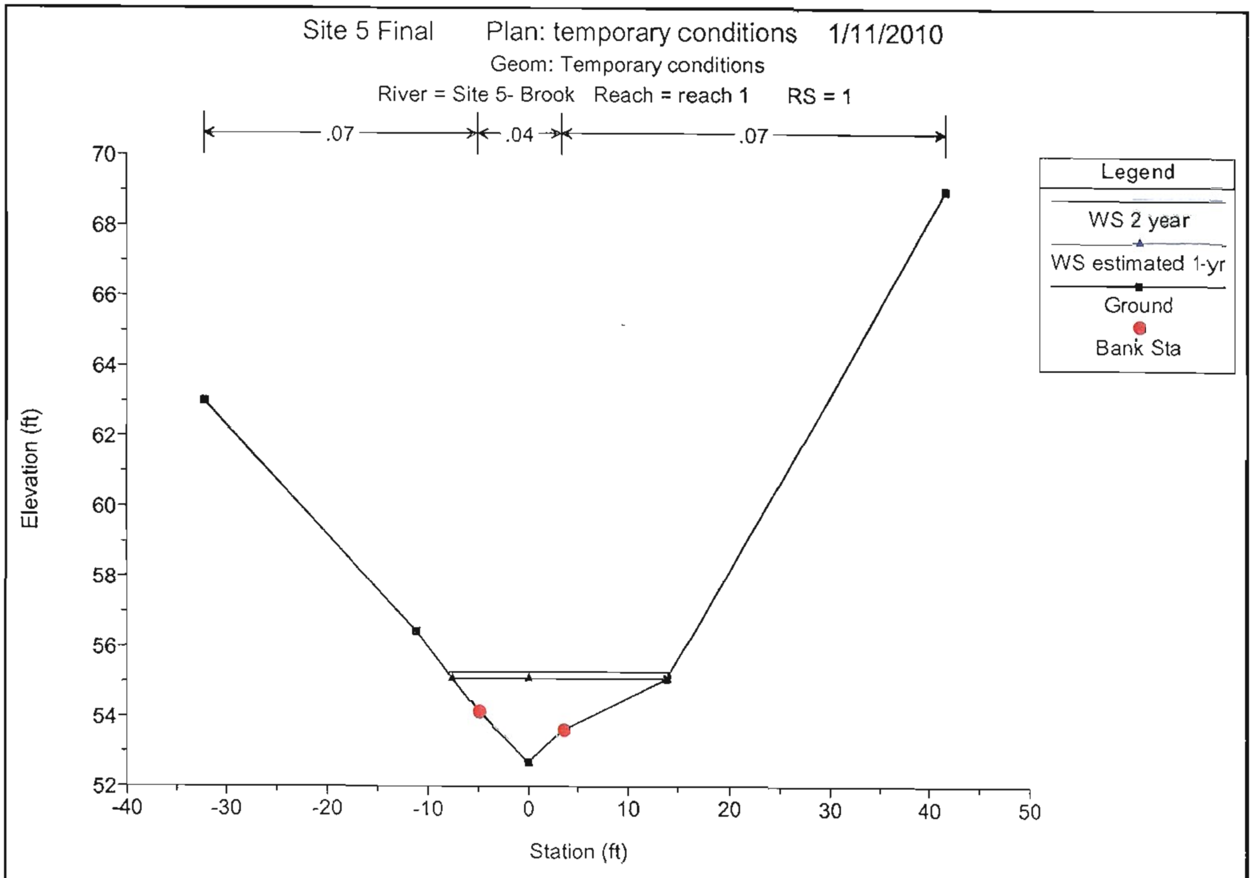
0
20
40


Site 5 Final
Plan: temporary conditions
1/11/2010
Geom: Temporary conditions
River = Site 5- Brook
Reach = reach 1
RS = 1
.07
.04
.07
Legend
WS 2 year
WS estimated 1-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
70
68
66
64
62
60
58
56
54
52
-40
-30
-20
-10
0
10
20
30
40
50

HEC-RAS Plan: temp River: Site 5- Brook Reach: reach 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
reach 1	13	2 year	153.00	53.97	60.62	56.56	60.64	0.000141	1.14	143.58	39.66	0.10
reach 1	13	estimated 1-yr	124.00	53.97	59.11	56.34	59.14	0.000396	1.44	87.84	34.07	0.15
reach 1	12	2 year	153.00	54.28	60.61	56.63	60.63	0.000139	1.13	145.20	40.57	0.10
reach 1	12	estimated 1-yr	124.00	54.28	59.06	56.41	59.09	0.000418	1.46	86.95	34.71	0.15
reach 1	11	2 year	153.00	54.21	60.60	56.76	60.62	0.000163	1.04	147.65	41.87	0.10
reach 1	11	estimated 1-yr	124.00	54.21	59.05	56.51	59.08	0.000515	1.43	86.75	36.32	0.16
reach 1	9	2 year	153.00	53.48	60.57	55.31	60.60	0.000283	1.41	108.46	21.21	0.11
reach 1	9	estimated 1-yr	124.00	53.48	59.01	55.12	59.05	0.000393	1.57	78.97	16.47	0.13
reach 1	7	2 year	153.00	51.76	60.57	53.79	60.60	0.000040	1.40	109.61	19.44	0.10
reach 1	7	estimated 1-yr	124.00	51.76	59.01	53.52	59.04	0.000059	1.53	80.87	16.93	0.12
reach 1	6.2		Culvert									
reach 1	6	2 year	153.00	52.60	58.97	54.70	59.08	0.000201	2.68	57.07	9.00	0.19
reach 1	6	estimated 1-yr	124.00	52.60	57.97	54.43	58.07	0.000205	2.58	48.09	9.00	0.20
reach 1	4.5		Culvert									
reach 1	3	2 year	153.00	52.90	56.28	55.21	56.51	0.003150	4.17	50.61	34.11	0.43
reach 1	3	estimated 1-yr	124.00	52.90	56.03	54.99	56.23	0.002941	3.80	42.73	28.86	0.41
reach 1	2	2 year	153.00	53.01	56.21	55.45	56.40	0.003404	4.13	63.30	45.30	0.44
reach 1	2	estimated 1-yr	124.00	53.01	55.95	55.24	56.13	0.003503	3.92	52.05	41.14	0.44
reach 1	1	2 year	153.00	52.68	55.30	55.30	56.00	0.016198	7.34	28.89	22.53	0.91
reach 1	1	estimated 1-yr	124.00	52.68	55.11	55.11	55.72	0.016036	6.82	24.60	21.63	0.89

Plan: temp Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #1 Profile: 2 year

Q Culv Group (cfs)	76.50	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	5.63
Q Barrel (cfs)	76.50	Culv Vel DS (ft/s)	5.63
E.G. US. (ft)	60.60	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	60.57	Culv Inv El Dn (ft)	52.78
E.G. DS (ft)	59.08	Culv Frctn Ls (ft)	0.90
W.S. DS (ft)	58.97	Culv Exit Loss (ft)	0.38
Delta EG (ft)	1.52	Culv Entr Loss (ft)	0.25
Delta WS (ft)	1.60	Q Weir (cfs)	
E.G. IC (ft)	55.83	Weir Sta Lft (ft)	
E.G. OC (ft)	60.60	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	
Culv WS Outlet (ft)	56.78	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.51	Min El Weir Flow (ft)	72.01

Plan: temp Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #1 Profile: estimated 1-yr

Q Culv Group (cfs)	62.00	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	4.56
Q Barrel (cfs)	62.00	Culv Vel DS (ft/s)	4.56
E.G. US. (ft)	59.04	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	59.01	Culv Inv El Dn (ft)	52.78
E.G. DS (ft)	58.07	Culv Frctn Ls (ft)	0.59
W.S. DS (ft)	57.97	Culv Exit Loss (ft)	0.22
Delta EG (ft)	0.97	Culv Entr Loss (ft)	0.16
Delta WS (ft)	1.04	Q Weir (cfs)	
E.G. IC (ft)	55.28	Weir Sta Lft (ft)	
E.G. OC (ft)	59.04	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	
Culv WS Outlet (ft)	56.78	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.18	Min El Weir Flow (ft)	72.01

Plan: temp Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #2 Profile: 2 year

Q Culv Group (cfs)	76.50	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	5.63
Q Barrel (cfs)	76.50	Culv Vel DS (ft/s)	5.63
E.G. US. (ft)	60.60	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	60.57	Culv Inv El Dn (ft)	52.76
E.G. DS (ft)	59.08	Culv Frctn Ls (ft)	0.90
W.S. DS (ft)	58.97	Culv Exit Loss (ft)	0.38
Delta EG (ft)	1.52	Culv Entr Loss (ft)	0.25
Delta WS (ft)	1.60	Q Weir (cfs)	
E.G. IC (ft)	55.83	Weir Sta Lft (ft)	
E.G. OC (ft)	60.60	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	
Culv WS Outlet (ft)	56.76	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.51	Min El Weir Flow (ft)	72.01

Plan: temp Site 5- Brook reach 1 RS: 6.2 Culv Group: Culvert #2 Profile: estimated 1-yr

Q Culv Group (cfs)	62.00	Culv Full Len (ft)	107.00
# Barrels	1	Culv Vel US (ft/s)	4.56
Q Barrel (cfs)	62.00	Culv Vel DS (ft/s)	4.56
E.G. US. (ft)	59.04	Culv Inv El Up (ft)	51.76
W.S. US. (ft)	59.01	Culv Inv El Dn (ft)	52.76
E.G. DS (ft)	58.07	Culv Frctn Ls (ft)	0.59
W.S. DS (ft)	57.97	Culv Exit Loss (ft)	0.22
Delta EG (ft)	0.97	Culv Entr Loss (ft)	0.16
Delta WS (ft)	1.04	Q Weir (cfs)	
E.G. IC (ft)	55.28	Weir Sta Lft (ft)	
E.G. OC (ft)	59.04	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.76	Weir Max Depth (ft)	
Culv WS Outlet (ft)	56.76	Weir Avg Depth (ft)	
Culv Nml Depth (ft)		Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.18	Min El Weir Flow (ft)	72.01

Plan: temp Site 5- Brook reach 1 RS: 4.5 Culv Group: Culvert #1 Profile: 2 year

Q Culv Group (cfs)	145.29	Culv Full Len (ft)	60.00
# Barrels	2	Culv Vel US (ft/s)	10.28
Q Barrel (cfs)	72.64	Culv Vel DS (ft/s)	10.28
E.G. US. (ft)	59.08	Culv Inv El Up (ft)	52.60
W.S. US. (ft)	58.97	Culv Inv El Dn (ft)	52.54
E.G. DS (ft)	56.51	Culv Frctn Ls (ft)	0.34
W.S. DS (ft)	56.28	Culv Exit Loss (ft)	1.40
Delta EG (ft)	2.57	Culv Entr Loss (ft)	0.82
Delta WS (ft)	2.69	Q Weir (cfs)	7.71
E.G. IC (ft)	59.39	Weir Sta Lft (ft)	-4.50
E.G. OC (ft)	59.08	Weir Sta Rgt (ft)	4.50
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	55.60	Weir Max Depth (ft)	0.48
Culv WS Outlet (ft)	55.54	Weir Avg Depth (ft)	0.48
Culv Nml Depth (ft)	3.00	Weir Flow Area (sq ft)	4.29
Culv Crt Depth (ft)	2.69	Min El Weir Flow (ft)	58.61

Plan: temp Site 5- Brook reach 1 RS: 4.5 Culv Group: Culvert #1 Profile: estimated 1-yr

Q Culv Group (cfs)	124.00	Culv Full Len (ft)	60.00
# Barrels	2	Culv Vel US (ft/s)	8.77
Q Barrel (cfs)	62.00	Culv Vel DS (ft/s)	8.77
E.G. US. (ft)	58.07	Culv Inv El Up (ft)	52.60
W.S. US. (ft)	57.97	Culv Inv El Dn (ft)	52.54
E.G. DS (ft)	56.23	Culv Frctn Ls (ft)	0.25
W.S. DS (ft)	56.03	Culv Exit Loss (ft)	0.99
Delta EG (ft)	1.84	Culv Entr Loss (ft)	0.60
Delta WS (ft)	1.94	Q Weir (cfs)	
E.G. IC (ft)	58.47	Weir Sta Lft (ft)	
E.G. OC (ft)	58.07	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.60	Weir Max Depth (ft)	
Culv WS Outlet (ft)	55.54	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	3.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.54	Min El Weir Flow (ft)	58.61

Plan: temp Site 5- Brook reach 1 RS: 4.5 Culv Group: Culvert #1 Profile: 2 year

Q Culv Group (cfs)	145.29	Culv Full Len (ft)	60.00
# Barrels	2	Culv Vel US (ft/s)	10.28
Q Barrel (cfs)	72.64	Culv Vel DS (ft/s)	10.28
E.G. US. (ft)	59.08	Culv Inv El Up (ft)	52.60
W.S. US. (ft)	58.97	Culv Inv El Dn (ft)	52.54
E.G. DS (ft)	56.51	Culv Frctn Ls (ft)	0.34
W.S. DS (ft)	56.28	Culv Exit Loss (ft)	1.40
Delta EG (ft)	2.57	Culv Entr Loss (ft)	0.82
Delta WS (ft)	2.69	Q Weir (cfs)	7.71
E.G. IC (ft)	59.39	Weir Sta Lft (ft)	-4.50
E.G. OC (ft)	59.08	Weir Sta Rgt (ft)	4.50
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	55.60	Weir Max Depth (ft)	0.48
Culv WS Outlet (ft)	55.54	Weir Avg Depth (ft)	0.48
Culv Nml Depth (ft)	3.00	Weir Flow Area (sq ft)	4.29
Culv Crt Depth (ft)	2.69	Min El Weir Flow (ft)	58.61

Plan: temp Site 5- Brook reach 1 RS: 4.5 Culv Group: Culvert #1 Profile: estimated 1-yr

Q Culv Group (cfs)	124.00	Culv Full Len (ft)	60.00
# Barrels	2	Culv Vel US (ft/s)	8.77
Q Barrel (cfs)	62.00	Culv Vel DS (ft/s)	8.77
E.G. US. (ft)	58.07	Culv Inv El Up (ft)	52.60
W.S. US. (ft)	57.97	Culv Inv El Dn (ft)	52.54
E.G. DS (ft)	56.23	Culv Frctn Ls (ft)	0.25
W.S. DS (ft)	56.03	Culv Exit Loss (ft)	0.99
Delta EG (ft)	1.84	Culv Entr Loss (ft)	0.60
Delta WS (ft)	1.94	Q Weir (cfs)	
E.G. IC (ft)	58.47	Weir Sta Lft (ft)	
E.G. OC (ft)	58.07	Weir Sta Rgt (ft)	
Culvert Control	Outlet	Weir Submerg	
Culv WS Inlet (ft)	55.60	Weir Max Depth (ft)	
Culv WS Outlet (ft)	55.54	Weir Avg Depth (ft)	
Culv Nml Depth (ft)	3.00	Weir Flow Area (sq ft)	
Culv Crt Depth (ft)	2.54	Min El Weir Flow (ft)	58.61

Appendix E

Culvert Site Data and

Design Forms

CDOT Drainage Manual Sections 8.F and 8.G

Appendix F – Data Collection and Field Review Form

I. GENERAL PROJECT DATA

Bridge No.: ____________
Town: Newington
County: Hartford
Feature carried: -Amtrak Railroad
Feature crossed: Tributary to Piper Brook
Quadrangle: 52 - Hartford South
DEP watershed basin no.: 4402-00

Functional class:

- ☐ urban principal arterial-interstate
- ☐ urban principal arterial-other expwy.
- ☐ urban principal arterial-other
- ☐ urban minor arterial
- ☐ urban collector
- ☐ urban local
- ☐ rural principal arterial-interstate
- ☐ rural principal arterial-other expwy.
- ☐ rural principal arterial-other
- ☐ rural minor arterial
- ☐ rural major collector
- ☐ rural minor collector
- ☐ rural local

Year built: Ca. 1900
Year of reconstruction: ____________
Overall NBIS structure rating: ____________
Sufficiency rating: ____________

Plans available?: ☐ yes ☒ no

II. HYDROLOGIC AND HYDRAULIC INFORMATION

Watershed area: 0.82 sqmi km^2 (sq. mi.)

Is it tidally influenced? ☐ yes ☒ no

What information is available?

- ☐ hydraulic report
- ☐ SCEL analysis
- ☐ Other: ____________
- ☐ floodway analysis report
- ☒ FEMA F.I.S. - For Starting WSEL @ Piper Brook

	Source	2 Yr. Event	10 Yr. Event	50 Yr. Event	100 Yr. Event	500 Yr. Event
Flow rates m^3/s (cfs)	TR-55	153	320	486	573	974*
Precipitation mm (in)		3.2	4.7	6.2	6.9	
Tidal elevations m (ft)						

*Estimated - $Q_{100} \cdot 1.7$

Elevations m (ft.)						
At Structure		Water Surface at Approach Cross Section				
Streambed	Roadway	2 Yr. Event	10 Yr. Event	50 Yr. Event	100 Yr. Event	500 Yr. Event
52.73'	72.00'		72.08	72.29	72.37	74.79

Comments: Existing twin stone box (3'x3') not adequate For computed Design Flows

III. CULVERT DATA

Type

☐ concrete ☒ stone masonry

☐ corrugated metal

☐ steel ☐ aluminum

structural plate ☐ yes ☐ no

corrugations
☐ 68mm x 13mm (2 ⅔" x ½")
☐ 75mm x 25mm (3" x 1")
☐ 125mm x 25mm (5" x 1")
☐ 152mm x 51mm (6" x 2")
☐ 19 x 19 x 190mm (¾" x ¾" 7 ½")

☐ Other ______

Shape / **Size [diameter or (width x height)]**

☐ circular ______ mm (inch)
☒ box 36" mm (in.) x 36" mm(in.)
☐ arch ______ mm (in.) x ______ mm(in.)
☐ elliptical ______ mm (in.) x ______ mm(in.)
☐ other ______

End Treatment

☐ standard endwall ☒ standard wing type endwall
☐ stone masonry ☐ projecting ☐ mitered ☐ slope paving
☐ other ______

Inlet Edge

☒ square ☐ beveled ☐ socket end in headwall

Length 103.5' m (ft)

IV. APPROACH ROADWAY, EMBANKMENT AND CULVERT CONDITION

See ConnDOT Drainage Manual, Chapter 4, Culvert Repair, Materials, and Structural Design, Appendix A, Culvert Inspection Guideline

Approach Roadway and Embankment:

Evidence of:

	yes	no
settlement	☐ yes	☒ no
patching or otherwise pavement built-up	☐ yes	☒ no
cracks running parallel to the culvert centerline	☐ yes	☒ no
erosion or failure of the embankment slope over the culvert	☐ yes	☒ no
sink holes over the culvert	☐ yes	☒ no

Comment on roadway alignment and sight distance at the culvert Active Amtrak Railroad. No signs of culvert failure, however inlet in poor condition

Width of travelway 55' m (ft.) Width of shoulders ______ m (ft.)

Comment on objects in clear zone including culvert appurtenances ______

Safety features present: ☐ metal beam rail ☐ cable guide rail
☐ other ______

Embankment erosion protection: ☐ vegetation ☐ crushed stone
☐ modified riprap ☐ intermediate riprap ☐ standard riprap
☐ slope paving ☒ other Ballast material protecting

Note the overall adequacy of this protection and note any vegetation near the culvert where root systems may damage the culvert: Ballast material in good condition
inlet Heavy vegetation but culvert is deep
outlet Light vegetation

Culvert Barrel and End Treatments:

Check the culvert headwall, wingwalls, cutoff walls and footings (bottomless culverts) for any deficiencies or deterioration, undermining, scour, piping, tipping, or settlement. Note condition and/or deficiencies:
Inlet - accumulation of Debris - Stone masonry Headwall Appears to be in Fair Condition. Water ponding @ inlet
outlet - Concrete Headwall & wings on Stone masonry (original) outlet No major cracks or settling observed. Downstream is rock Gabion Protected bank

Check the culvert barrel for deformations, settlement, leaking or distressed joints and other deficiencies or signs of deterioration. Check for evidence that lateral earth pressure is causing bulging, flattening, peaking, sliding or rotation in the barrel. Note condition and/or deficiencies:

No deformations noticed this visit 11/6/08. Previous reports indicate Failing inlet, but condition must have been corrected.

Note: Where practical, the floors of metal pipe culverts should be sounded with a metal rod in an attempt to locate voids due to undermining.

Dimensions should be taken at the inlet, outlet, mid-length and at 8m (26 ft.) intervals (maximum) as applicable, if access to the interior of the culvert is possible. Locations of sagging, bulging, flattening or peaking should also be measured.

inlet	3'x3' mm (in)	____	____ mm (in)
mid-length	Not Accessable mm (in)	____	____ mm (in)
outlet	3'x3' mm (in)	____	____ mm (in)

Any separation of the culvert barrel from the headwalls or cutoff walls. ☐ yes ☒ no

V. VISUAL SCOUR EVIDENCE

History of scour problem at outlet: ☐ yes ☐ no

Outlet protection

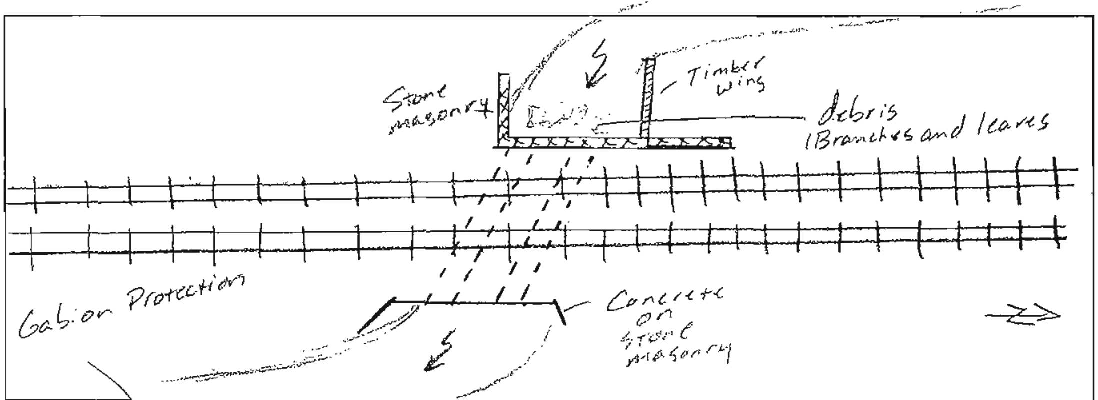
Type:	☐ modified	☐ intermediate	☐ standard	☐ slope paving
	☐ concrete	☐ other	☒ none	
Condition:	☐ good	☐ weathered	☐ slumped	☐ missing
	☐ fair	☐ poor	☒ N/A	

Comments: No evidence of outlet protection, however bank seems Stable and there is only a slight depression in streambed at the outlet

* Note: For bottomless culverts, complete item VIII Visual Scour Evidence 9.A-9 to 9.A-11.

VI. SITE DATA

A. Existing structure(s) – Provide sketch of culvert/structure with dimensions and brief description.



Comments: ~~Include~~ structure or culvert type and condition. Note particularly any scour adjacent to abutments or at culvert outlet and the presence of debris or sediment. Also note the location of any utilities in the area of the crossing.

B. High water marks – Describe the nature and location of any apparent high water marks and relate to a date of occurrence, if possible.

C. Maximum allowable headwater – Describe the nature of the apparent controlling feature and note its location.

Maximum allowable Headwater is approximately 64' - Controlled by Spring Street Bridge deck elevation and Habitable Structure Downstream (2000 CT Lidar Topographic Survey)

D. Fish passage requirements – Comment on the apparent need for fish passage or impediments to same; such as dams or restrictive crossings in the area.

VII. PERIPHERAL SITE DATA

A. Hydraulic control - Note location and description.

Control appears to be the subject culvert. There is another culvert under Francis ave ≈ 600' Downstream however FEMA shows this To maintain 100-yr event

B. Upstream and downstream structures - Provide sketches and brief descriptions of existing bridges/culverts. Include dimensions.

See Site pictures

Comments: Downstream - Francis Ave crossing in good condition

C. Watershed area – Check watershed boundaries for accuracy. Note current land uses within watershed.

0.82 sq. mi.

D. Flow control structures within watershed – Note the location and type of all significant flow control structures (dams, etc.) within the watershed. Provide sketches with dimensions as required.

E. Site photographs – Attach to report. Include an index and sketch of photograph locations.

VIII. STREAM CHANNEL AND RELATED ASPECTS

A. Stream characterization

Twenty Groupings of Stream Characteristics (check box)

	Identifier	Drainage Area	Streambed Slope	Streambed Soils	Land Use
☐	A	Large	Low	SD	S/F
☐	B	Large	Low	SD	Urban
☐	C	Large	Moderate	SD	Forested
☐	D	Medium	Moderate	SD	Urban
☐	E	Medium	Moderate	SD	S/F
☐	F	Medium	Moderate	CLAY	S/F
☐	G	Medium	Moderate	TILL	S/F
☐	H	Medium	Moderate	SD	Forested
☐	I	Medium	Moderate	TILL	Forested
☐	J	Small	Low	SD	Urban
☐	K	Small	Moderate	TILL	Urban
☐	L	Small	Low	SD	S/F
☐	M	Small	Moderate	SD	S/F
☐	N	Small	Moderate	SD	Forested
☐	O	Small	Low	CLAY	S/F
☐	P	Small	Steep	TILL	S/F
☐	Q	Small	Moderate	TILL	S/F
☒	R	Small	Low	TILL	S/F
☐	S	Small	Moderate	TILL	Forested
☐	T	Small	Steep	TILL	Forested

Drainage area	Small (circled)	$\leq 64.75\text{km}^2$ (25 mi^2)
	Medium	$> 64.75\text{km}^2$ (25 mi^2) and ≤ 259 km^2 (100 mi^2)
	Large	> 259 km^2 (100 mi^2)
Streambed slope	Low (circled)	≤ 4.76 m/km (25 ft/mi)
	Moderate	> 4.76 m/km (25 ft/mi) and ≤ 19.05 m/km (100 ft.mi)
	Steep	> 19.05 m/km (100 ft/mi)
Streambed soils	SD = Stratified Drift	
Land Use	S/F (circled) = Suburban or Farming	

B. Channel stability

Previous NBIS Item 61 rating: ____________

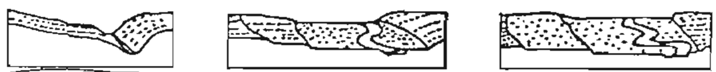
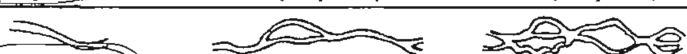
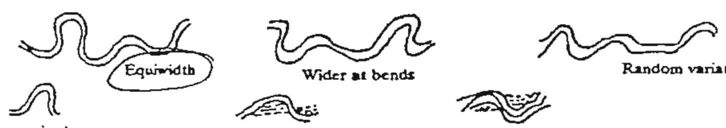
Lateral stability: ☒ stable ☐ unstable

Bank erosion:
☐ none ☒ light fluvial erosion ☐ heavy fluvial erosion ☐ mass wasting

Streambed: ☒ stable ☐ aggradating ☐ degrading

Armoring potential: ☒ none ☐ low ☐ moderate ☐ high

Geomorphic factors that affect stream stability (circle factors that apply)

STREAM SIZE	Small (< 30 m wide) · Medium (30–150 m) · Wide (> 150 m)
FLOW HABIT	Ephemeral · (Intermittent) · Perennial but flashy · Perennial
BED MATERIAL	Silt-clay · Silt · Sand · Gravel · Cobble or boulder
VALLEY SETTING	 No valley; alluvial fan · Low relief valley (< 30 m deep) · Moderate relief (30-300 m) · High relief (> 300 m)
FLOOD PLAINS	 Little or none (< 2X channel width) · Narrow (2-10 channel width) · Wide (> 10X channel width)
NATURAL LEVEES	 Little or None · Mainly on Concave · Well Developed on Both Banks
APPARENT INCISION	 Not Incised · Probably Incised
CHANNEL BOUNDARIES	 Alluvial · Semi-alluvial · Non-alluvial
TREE COVER ON BANKS	<50 percent of bankline · 50-90 percent · >90 percent
SINUOSITY	 Straight Sinuosity 1-1.05) · Sinuous (1.06-1.25) · Meandering (1.25-2.0) · Highly meandering (> 2)
BRAIDED STREAMS	 Not braided (< 5 percent) · Locally braided (5-35 percent) · Generally braided (> 35 percent)
ANABRANCHED STREAMS	 Not anabranched (< 5 percent) · Locally anabranched (5-35 percent) · Generally anabranched (> 35 percent)
VARIABILITY OF WIDTH AND DEVELOPMENT OF BARS	 Equiwidth · Wider at bends · Random variation · Narrow point bars · Wide point bars · Irregular point and lateral bars

Source: Adapted From Brice and Blodgett, 1978

(See also FHWA HEC-20, "Stream Stability at Highway Structures" for discussion of the above factors)

Secondary bed material: ☒ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Bank protection

Type ☒ none ☐ modified ☐ intermediate ☐ standard
☐ concrete ☐ slope paving ☐ absent
☐ other

Condition ☒ n/a ☐ good ☐ weathered ☐ slumped
☐ poor ☐ missing ☐ fair

Comment on the need (if any) for training walls, cutoff walls or special slope or channel protection.

At downstream reach, there is a limited amount of Gabion protection along east bank. Shows evidence of lateral migration however banks appear to be stable.

C. Channel and overbank roughness coefficients

Basic channel description: ☒ channel in earth ☐ channel cut into rock
☐ channel fine gravel ☐ channel coarse gravel

Surface irregularity of channel:

☒ smooth – best obtainable section for materials involved
☐ minor – slightly eroded or scoured side slopes
☐ moderate – moderately sloughed or eroded side slopes.
☐ severe – badly sloughed banks of natural channels or badly eroded sides of man-made channels - jagged and irregular sides or bottom sections of channels in rock.

Variations in shape and size of cross sections

☒ changes in size or shape occurring gradually
☐ large and small sections alternating occasionally or shape changes causing occasional shifting of main flow from side to side.
☐ large and small sections alternating frequently or shape changes causing frequent shifting of main flow from side to side.

Channel obstructions – (Judge the relative effect of obstructions – consider the degree to which the obstructions reduce the average cross sectional area, character of obstructions, and location and spacing of obstructions).

NOTE: Smooth or rounded objects create less turbulence than sharp, angular objects.

The effect of obstructions is:

☒ negligible
☐ minor
☐ appreciable
☐ severe

Degree of vegetation – (Note amount and character of foliage).

The effect of vegetative growth upon flow conditions is:

☐ LOW - Dense growths of flexible turf grasses where average depth of flow is 2 to 3 times the height of vegetation. Supple seedling tree switches where the average depth of flow is 3 to 4 times the height of the vegetation.

☒ MEDIUM - Turf grasses where the average depth of flow is 1 to 2 times the height of vegetation. Stemmy grasses, weeds or tree seedlings, (moderate cover), average depth of flow 2 to 3 times the height of vegetation. Bushy growths, (moderately dense), along channel side slopes with no significant vegetation along channel bottom.

☐ HIGH - Turf grasses where average height is about equal to the average depth of flow. Willow of Cottonwood trees 8 to 10 years old with some weeds or brush. Bushy growths about 1 year old with some weeks. No significant vegetation along channel bottom.

☐ VERY HIGH - Turf grasses where the average depth of flow is less than one half the height of vegetation. Bushy growths about 1 year old intergrown with weeds. Dense growth of cattails along channel bottom. Trees intergrown with weeds and brush (thick growth).

Additional comments:

____

____

____

____

____

IX. HYDRAULIC VULNERABILITY

Previous Item 71 rating: ________

Is there confluence present? ☐ yes ☒ no

Angle of attack (flood flow): ☒ yes ☐ no

Bends in channel: ☒ upstream of bridge ☒ downstream of bridge ☐ straight channel reach ☒ at bridge

Velocity order of magnitude: ____ m/s (ft/s) Upstream <1 FPS Downstream ≥ 10 FPS

Trapping potential: ☐ low ☒ medium ☐ high

Debris potential: ☐ low ☐ moderate ☒ high

Overtopping relief: ☐ none ☐ left approach ☐ right approach ☒ on bridge ☐ relief bridge ☐ cannot be determined

Primary bed material: ☐ sand ☒ silt/clay ☐ gravel ☐ cobble ☐ boulders ☐ bedrock ☐ manmade

Comments: ____

Appendix G – Culvert Design Data Form

Prepared by: Eric Buckley
Date: 1/9/09
Checked: ______
Date: ______

Project No. 171-305
Town Newington
Route Amtrak
Location 41-43-09 N, 72-44-04 W
"Site 5"

1. DRAINAGE AREA

   a) Total area 0.82 sq mi
   b) Special Considerations Following guidelines set forth by Amtrak, this crossing should be adequate for 100-yr event regardless of Basin Size
   c) Existing culverts Twin 36" x 36" Stone Box

2. DESIGN DISCHARGE 573 CFS for 100 year frequency

   a) Rational Formula less than 81 ha (200 acres)
      T_c (Min) ______ Rainfall intensity mm/hr (in/hr) ______
      Coefficient of Imperviousness ______
   b) ______ HEC-1 SCS ______ TR20 ______ TR55 ✓
      CN 71* T_c (Hr.) 2 hrs
      Rainfall distribution: ✓ SCS Type III-24 Hr.
   c) Other ______

* After taking into account the swamp areas

3. FISH PASSAGE REQUIRED? ______ Yes ✓ No

   a) Special considerations ______

4. CULVERT HYDRAULIC DATA – Recommended

   a) Size 90" (7.5') dia Circular Culvert Type RCP
   b) Maximum permissible headwater elevation
      100-YR = 72' at Amtrak Railroad, 50-YR = 64' at Spring Street (private bridge)
   c) Proposed headwater elevation
      100-YR = 64.0', 50 yr. = 62.5'
   d) Elevation of channel bed at outlet 52.55' Inlet 52.73'
   e) Length 103' Slope 0
   f) Inlet invert elevation 52.55 Outlet 52.55
   g) Improved inlet Yes ______ No X
      ______ Beveled Edge ______ Side-Tapered ______ Slope-Tapered
      TAPER = ___:1 ______ (4:1 TO 6:1) FALL = ____ S_f ____:1 (2:1 to 3:1)
   h) Entrance loss coefficient 0.5
   i) Type and location of hydraulic control Outlet Control

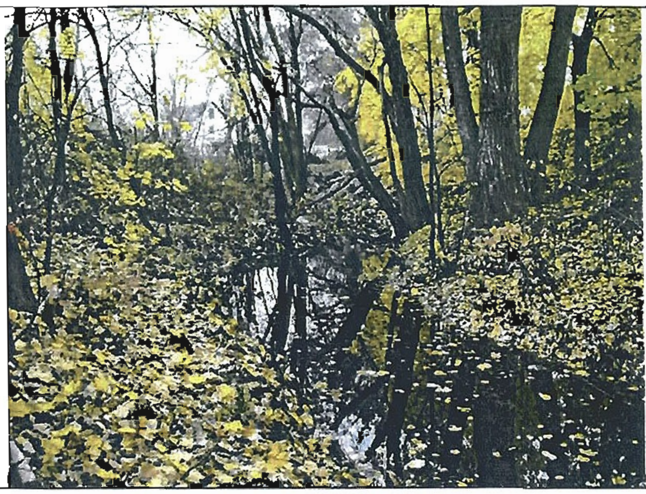
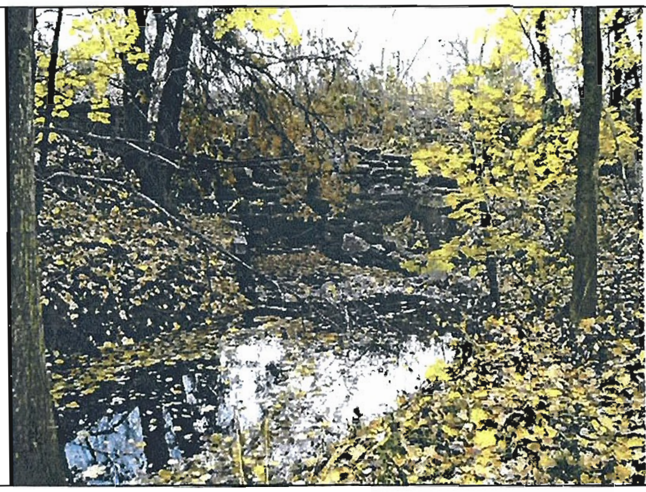
5. MISCELLANEOUS DATA

a) Height of cover - 11' From outside diameter
b) Culvert strength requirements: CMP ____________ (wall or plate thickness)
RCP 5 (Class)
c) End treatment Concrete Headwall with wingwalls (inlet and outlet)
d) Entrance channel Rock Riprap Apron + cutoff wall
e) Outlet channel Pre-Formed scour Hole
f) Bank protection Rock Riprap

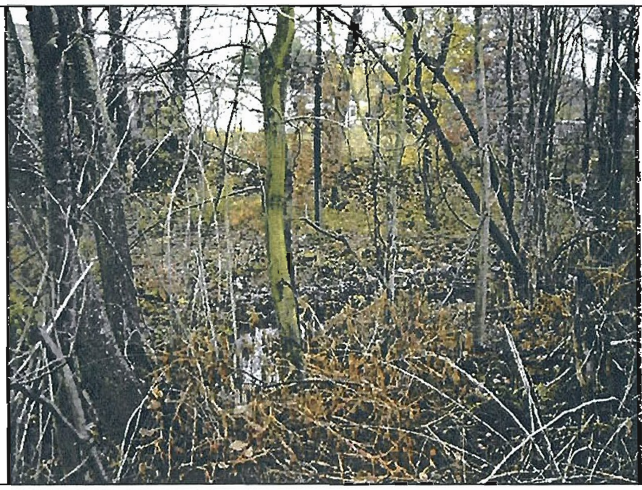
* Inlet and outlet protection to be designed in Final design phase. Aforementioned treatments are expected.

Appendix F

Site Pictures

	Picture 1 Upstream reach of tributary
	Picture 2 Upstream approach to subject culvert
	Picture 3 upstream face of existing subject crossing Note debris accumulation

	Picture 4 Downstream face of existing subject culvert Access limited
	Picture 5 Southern wingwall at outlet
	Picture 6 Northern wingwall at outlet

	Picture 7 Exit reach of tributary from railway embankment
	Picture 8 Downstream reach of tributary Note – rock gabion bank protection on left bank

Appendix G

Pipe Jacking Operations Information

Baker

Phone Call Report

Project/Location:	NB-Hartford Busway Sites 4 and 5, Newington, CT	S.O. No.:	RB25624
		Date:	July 19, 2007
		Contract No.:	171-305
To:	Caron Pipe Jacking, Inc.	From:	Baker Engineering
Repres.:	Dave Caron	Repres.:	Norman Perkins
Phone No.:	860-828-0050	Phone No.:	860-563-3044

Subject: Jacking concrete culverts under Amtrak at sites 4 and 5.

DC informed NP that jacking box culverts is very difficult and round sections should be used whenever possible.

Caron PJ has jacked 9'x9' and 14'x14' culverts in the past at a jacking cost of $4,200/ft and $5,000/ft respectively. These prices do not include the following items that must be accounted for:

1. Price of the culvert.
2. Pre-grouting of the soil (1,000 psi) for stabilization of the soil and RR tracks. If this step is not completed, the jacking process will "drag" the soil and tracks as the culvert travels through the ground.
3. Creation of the cutting shield is required to be built for each individual culvert size.

DC mentioned that jacking in the (2) Newington locations will be difficult due to the wetlands on each side of the track. The wetlands will make jacking pit construction cumbersome and the wetland soil will not resist jacking forces very well.

For comparison purposes, 72" diameter RCP pipe can be jacked for $800-$900/ft (additional material price of $300-$400/ft).

Prepared by: N. Perkins Title: Engineer Page: 1 of 1

GM2 Associates, Inc
TELEPHONE MEMO

Date: 12/5/2008 **Time:** 8:30

Project: 171-305 - New Britain to Hartford Busway

From: EWB

Contact: Dave Caron

Company: Caron Pipe Jacking

Re: Requirements for jacking - various pipe sizes and clearance/cover

Tel. No.: 860 828-0050

Conversation:

Constructability questions.
Q - Minimum cover requirements for jacking operations
A - 5.5'-6' below top of tie
Q - minimum clearance between twin pipes
A - 2'-3'
Grouting for soil stabilization. Apparently, soil stabilization through grouting is applied within the envelope of the proposed culvert. Approximately 3-4 feet of soil is grouted from the crown of the pipe down with 800-1000 psi grout. From there the pipe is jacked through as the stabilized soil is removed either by hand or by small excavator.

Jacking pits are not feasible because the pipes are to be installed at the toe of the embankment. An at grade backstop or buttress will be required.

DC also expressed that a single larger diameter pipe would be less costly than multiple smaller diameter pipes.

Naturally, geotech information will be required to determine soil cohesiveness. Minimum clearances and cover requirements can then be more refined. Soil investigation will also be required for the jacking areas to determine extent of backstop foundation.

GM2 Associates, Inc
TELEPHONE MEMO

Date: 12/9/2008 **Time:** 15:30

Project: 171-305 - New Britain to Hartford Busway

From: EWB

Contact: Bill Lane

Company: Amtrak

Re: Requirements for jacking - various pipe sizes and clearance/cover

Tel. No.: 203-410-9044

Conversation:

BL had indicated that jacking a pipe within 5.5 to 6' of the top of tie is feasible. Major concerns on his part were the receiving pit - sheeting requirements to protect the embankment, pipe type being class V with C wall (getting 90' length may be difficult from pipe manufacturer), lubrication and grout holes in the pipe.

EB asked if there was a design manual that Amtrak relied on for this type of operation, BL indicated that he can get a "Pipeline Occupancy Agreement" which includes all of Amtrak's specifications for jacking.

Cover requirements are more of a clearance requirement for future track maintenance. Apparently the tamping machines dig into the embankment when adjusting the track and ballast.

GM2 Associates, Inc
TELEPHONE MEMO

Date: 12/30/2008 **Time:** 10:20

Project: 171-305 - New Britain to Hartford Busway

From: EWB

Contact: Maurice (owner)

Company: M&P Pipe Jacking Corp

Re: Discussion on various pipe shapes and experience

Tel. No.: 860 667-0896

Conversation:

M indicated that they do not jack anything greater than 84"

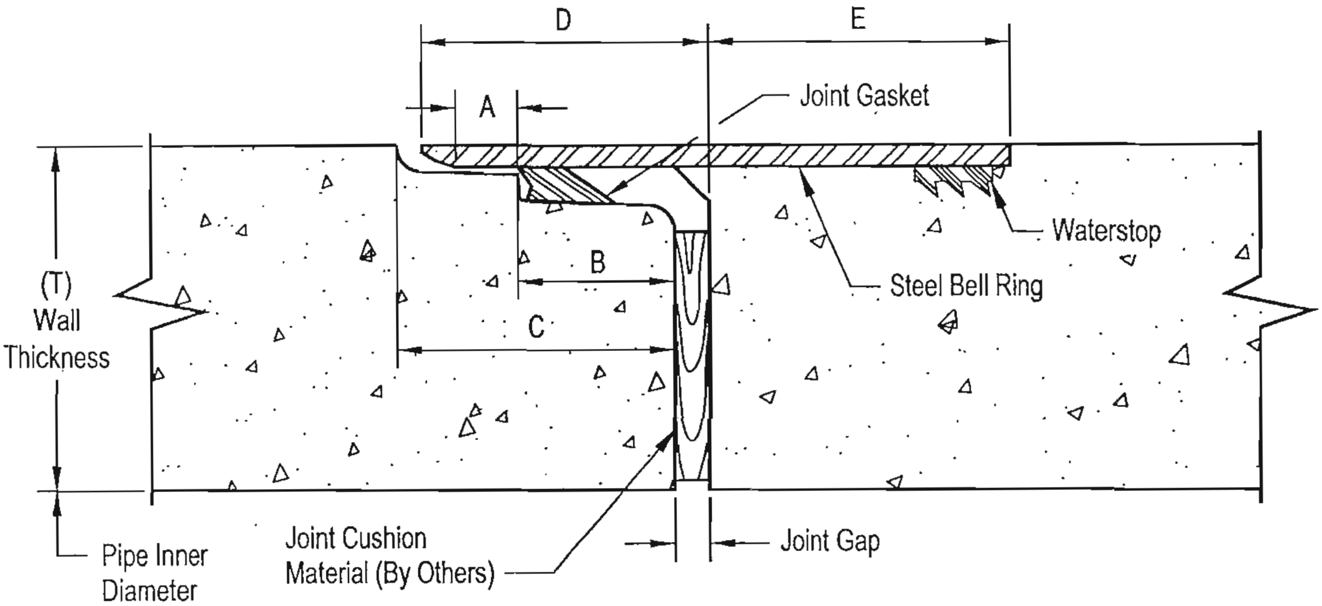
Also, no experience with elliptical in the capacity and size we are looking for. Limited experience in jacking the shape though. He said that it is difficult to keep joints lined up. He had jacked a vertical elliptical pipe through an existing culvert.

5.5 to 6 feet of cover will be required. (already known)

Has had experience jacking under railways - recently jacked a 72" within 6 feet of track and controlled the operation eliminating potential movement of tracks.

Will need soils information for the operation.

Reinforced Concrete Jacking Pipe
24" - 96" Diameter



Dia.	T	A	B	C	D	E
24"Ø	3"	7/8"	2 1/4"	3 3/4"	3 7/8"	4 1/8"
30"Ø	3 1/2"	7/8"	2 1/4"	3 3/4"	3 7/8"	4 1/8"
36"Ø	4"	1"	2 1/4"	3 7/8"	4"	4"
42"Ø	4 1/2"	1"	2 1/4"	3 7/8"	4"	4"
48"Ø	5"	1 1/8"	2 1/4"	4"	4 1/8"	4 3/8"
54"Ø	5 1/2"	1 1/8"	2 1/4"	4"	4 1/8"	4 3/8"
60"Ø	6"	1 1/4"	2 1/4"	4 1/8"	4 1/4"	4 3/4"
66"Ø	6 1/2"	1 1/4"	2 1/4"	4 1/8"	4 1/4"	4 3/4"
72"Ø	7"	1 3/8"	2 1/4"	4 1/4"	4 3/8"	5 1/8"
78"Ø	7 1/2"	1 3/8"	2 1/4"	4 1/4"	4 3/8"	5 1/8"
84"Ø	8"	1 1/2"	2 1/4"	4 3/8"	4 1/2"	5 1/2"
90"Ø	8 1/2"	1 1/2"	2 1/4"	4 3/8"	4 1/2"	5 1/2"
96"Ø	9"	1 1/2"	2 1/4"	4 3/8"	4 1/2"	5 1/2"

Pipe dimensions and steel joint band may vary depending upon equipment availability.

Notes:

1. Produced to meet ASTM Specifications.
2. Pipe diameters larger than 96" are available.
3. Contact a Concrete Pipe Division representative for details not listed on this sheet.