Final Hydraulic Design

for

State Project 171-305

New Britain – Hartford Busway

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INLAND WATER RESOURCES DIVISION

Location: Un-named Tributary of Piper Brook, Newington

Site-4 Busway Station 223+50

September, 2009

Rev. April 2010

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7/30/2010

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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 Report addresses the design of the selected replacement of an existing 38" X 36" (W X H) stone box culvert conveying a tributary to Piper Brook under the railway embankment at Busway Station 223+50 (41°42'42"N, 72°44'22"W). Immediately upstream is a triple arch culvert (42"W X 30"H) which supports an MDC sewer trunkline. For utility and environmental reasons, it is not proposed to modify the triple arch culvert.

Under existing conditions for high flows at the triple arch culvert, there is a good amount of overtopping relief over the existing elevation of the sewer berm. For proposed conditions associated with the Busway, there will be a Multi-Use Trail parallel to the proposed Busway alignment. In order to accommodate the proposed Multi Use Trail, this berm and the area between the berm and rail embankment will be filled to match the Busway elevation. Due to the inadequacy of the triple arch culvert for flows greater than about 90 cubic feet per second, it will be necessary to provide an overtopping relief weir over the triple arch approaching the proposed culvert replacement. Since the top of the relief weir is proposed to be set lower than the trail, a bridge will be incorporated into the design to accommodate the multi-use trail at this location.

The following design report documents the hydraulic design of a twin 6.5' dia. concrete culvert for the replacement of the existing 38" X 36" stone box culvert as well as the effects of the proposed structure on the existing triple arch culvert which is to remain. Additionally, included with this report is a recommended sequence of construction with a temporary (during construction) water handling method.

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'

All reference to MDC facilities based on the data found from the project survey ∴ based on NGVD '29

Hydrology

Design flow values used for the hydraulic design of the Site 4 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 design of the site 4 crossing of the tributary to Piper Brook.

Flow Rates (cfs)		
10-yr	50-yr	100-yr
Up/Down	Up/Down	Up/Down
392.0	600.2	699.0

Table 1 – design flows taken from approved hydrologic analysis

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 4 Culvert Crossing

For the design of the Site 4 culvert crossing, the approved hydrologic analysis results were to be used. **Existing conditions** reflect the total flow calculated from areas 1 to 5 applied to the upstream triple arch culvert (culvert 4) and routed flows from areas 1-7 will be used at the upstream face of culvert 5 (subject culvert). Flows computed without storage are used for this hydraulic analysis. For **proposed conditions**, the flows from all 7 sub-watersheds are applied to both culverts due to the fact that the drainage channels between the sewer line embankment and the Railway/Busway embankment will be filled in during construction of the Busway, sloping towards the inlet of the triple arch culvert. Please see Appendix A for information regarding the application of flows from the sub-watersheds. The final design flows (Q_{100}) are:

	Existing		Proposed	
	Design	Superflood	Design	Superflood
Triple Arch Sewer Embankment (culvert 4)	436 cfs	742 cfs	699 cfs	1188 cfs
Subject Culvert Railway/Busway Embankment (culvert 5)	699 cfs	1188 cfs	699 cfs	1188 cfs

Table 2 – upstream flows for culvert analysis. The design flow rate of 699 was selected because of the recommendation made in the Hydrology Report prepared by GARG Consulting (02/08) though it is not clear how the computed design flows increase from the upstream face of the subject culvert to the downstream face by approximately 157 cfs (as reported in the hydrologic results table).

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.

Tailwater conditions used for the subsequent culvert 4 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 0.54 sq mi (GARG – 2008), and the Piper Brook Watershed near this confluence is approximately 14 sq mi (Connecticut Gazetteer of Drainage Areas – 1997). This equates to an area ratio of 26:1. 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 will be used as statistically computed from the published FIS results for Piper Brook. The following table documents the upstream and downstream boundary conditions to be used for the final hydraulic design of the Site 4 Culvert Crossing:

10-yr		50-yr		100-yr		500-yr	
Up	Down	Up	Down	Up	Down	Up	Down
392 cfs	55 ft	600 cfs	56.4 ft	699 cfs	57.6 ft	1188 cfs	60.2 ft

Table 3 - Boundary conditions for culvert analysis

Starting tailwater elevations for the triple arch (culvert 4) will be taken as the headwater results of the Railway embankment specific to the condition analyzed.

Hydraulic Analysis

Existing Conditions

Under existing conditions, runoff generated in the contributing basin is conveyed through swampland to a triple arch culvert (3 – 42" X 30") under an embankment protecting a 24" MDC sanitary sewer trunk line. This culvert without any tailwater effects from either the downstream railway 38" X 36" Stone culvert or standing floodwaters from Piper Brook has enough capacity for approximately 195 cfs, with greater flows overtopping the sanitary sewer embankment. At 195 cfs, the headwater generated would be at elevation 58.5 or approximately 5.25 feet deep at the inlet.

Twenty feet downstream from this triple arch is the subject crossing; a 38" X 36" stone box culvert carrying the railway embankment. This culvert, if downstream tailwater effects were ignored would have the capacity for 183 cfs prior to the flow overtopping the railway embankment. The hydraulic head required to generate the 183 cfs is approximately 13.5 feet above the culvert invert. These numbers show that the more constrictive opening in this existing system of crossings is the stone box culvert.

The previous two site descriptions represent the crossings if they were independent of each other and unaffected by downstream conditions. The worst case scenario for flooding of this crossing would include the potential for standing water from Piper Brook coincident with upstream peak flows resulting from the same storm event. The approach in representing this scenario was to

a) Assign a tailwater elevation to the railway culvert based on the joint probability of peak flows from Piper Brook and the tributary.
b) Compute the culvert hydraulics for the stone box culvert to determine the resulting headwater
c) Assign the headwater computed for the stone box as the tailwater for the triple arch and compute the resulting headwater for the upstream floodplain.

The starting tailwater elevation was based off of detailed hydraulic analysis for Piper Brook as documented in the Flood Insurance Study (FIS) for Hartford County. Published section R for Piper Brook is coincident with the area around this crossing. At this location, the base flood elevation (BFE) is 59 feet as documented on the Flood Insurance Rate Map (FIRM). From the detailed profile published in the FIS for Section R, the 10-, 50-, 100-, and 500-year water surface elevations for Piper Brook are 55, 57.6, 58.5, and 61.4 feet respectively. To set up the tailwater rating curve required by HY-8, these four event elevations were plotted by the respective recurrence interval and a logarithmic trendline assigned essentially developing a stage-discharge curve. Based on the joint probability table (Drainage Manual Table 8-3), the 10 year tributary flow was paired with the 10 year Piper Brook elevation, the 50 year flow with the 25 year elevation (interpolated from the trendline), the 100-year flow with the 50-year elevation, and the 500-year flow with the 250 year elevation (again, computed from the trendline).

The resulting headwater for the existing stone box culvert is documented in the following table:

10-yr	50-yr	100-yr	500-yr
66.3 feet	66.4 feet	66.5 feet	66.7 feet

Table 4 – Existing computed headwater elevations

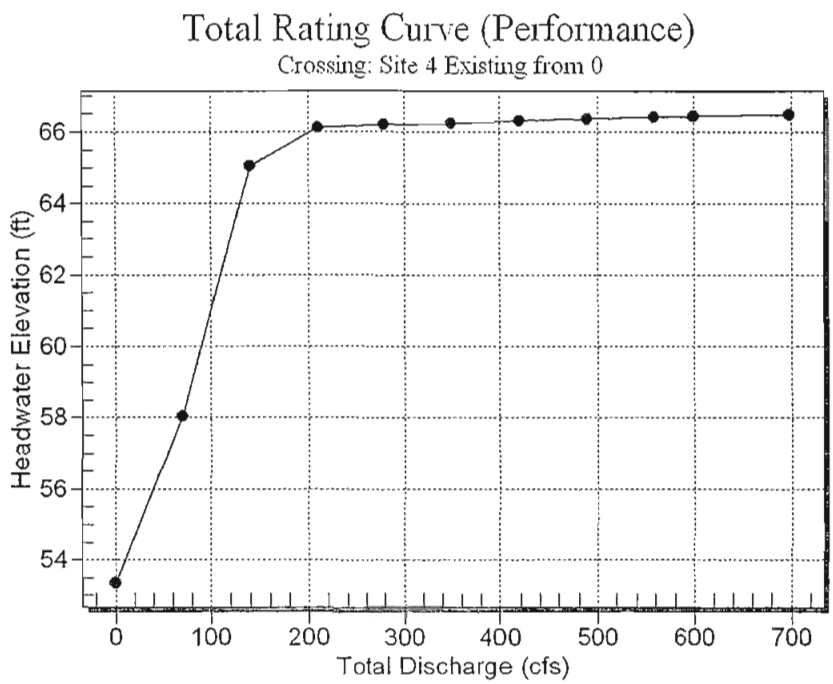
These headwater elevations completely submerge the upstream sewer line embankment effectively establishing a submerged weir condition.

The range of flows was then expanded to analyze the hydraulics of the culvert at lower flows (less than that of a 10-year event). For this culvert computation, the flows start at 0 and increase to the 100-year design flow of 699-cfs. This new range of flow rates required a new tailwater relationship to start the analysis. The tailwater relationship as determined above was used to compute a new rating curve for the flows from 0 to the 100-year event. It was found that the tailwater elevation computed would not have an effect on the crossing until flows reached about 275-cfs (based on the streambed elevation of 52.96'). The resulting tailwater relationship for the existing railway embankment crossing is

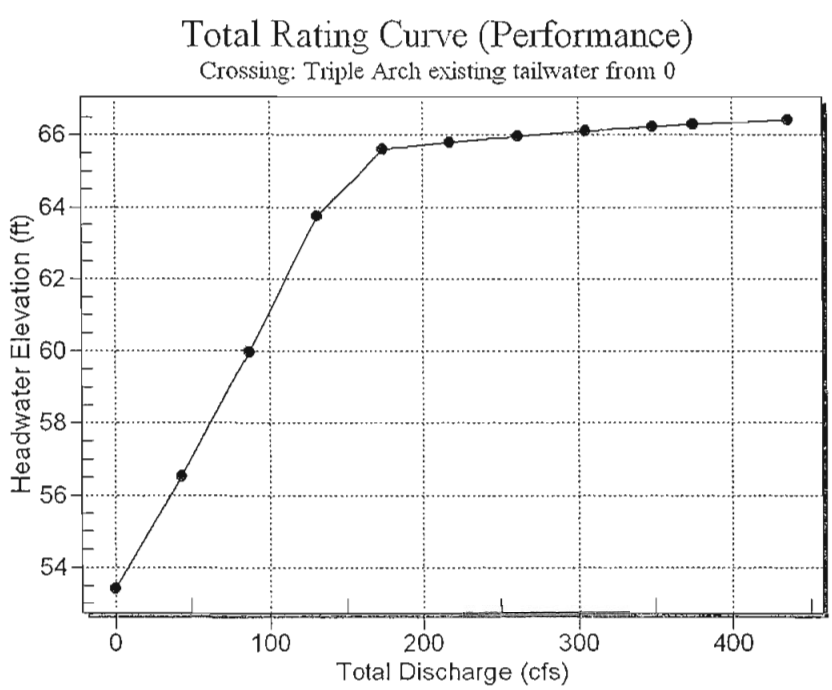
Flow (cfs)	Tailwater (ft)
0	52.96
69.9	52.96
139.8	52.96
209.7	52.96
279.6	53.27
349.5	54.32
419.4	55.17
489.3	55.89
559.2	56.51
600	56.85
699	57.56

Table 5 – Tailwater relationship for low flow conditions – note the tailwater elevation = streambed elevation until 279.6-cfs when Piper Brook flooding may start to influence backwater of this crossing.

The resulting rating curve for the existing 38"x36" stone culvert beneath the Amtrak railway embankment is shown below for flows from 0 to the 100-year event.



This performance curve was then used to compute the headwater for the triple arch culvert crossing of the MDC sewer line from 0 to the 100-year flow event (flows contributing to the inlet of the triple arch culvert. The following headwater rating curve reflects the headwater at the upstream of the triple arch culvert using the headwater computed for the 38"x36" stone culvert as the tailwater for the sewer line embankment culvert.



Proposed Conditions

The proposed conditions of the railway embankment in the vicinity of the crossing are essentially integrating the two subject embankments together through filling the area between the sanitary embankment and the railway embankment to provide a base for the Busway and associated multi-use trail. In order to maintain the existing triple arch culvert upstream and thus not disturb the MDC trunk line, overtopping relief of the existing sanitary sewer embankment is required in order to handle the high flows from the tributary watershed. To this end, a bridge is proposed to carry the multi-use trail over the tributary thereby maintaining a 40' weir opening for the high flows to overtop and enter the proposed culvert.

This proposed culvert crossing will be constructed approximately 5' to the south of the existing crossing which is to be filled, capped and abandoned. In addition, for jacking purposes, each of the proposed 78" pipes will have to be installed a minimum of 5' from each other. As a result of moving the outlet location of this crossing as well as embankment modifications required for the Amtrak Access Road, the downstream channel (which runs for a length along the railway embankment to the north) will be filled. For this change in outlet conditions, it is proposed that the outlet of the culvert will be treated with a riprap splashpad, allowing for even dissipation of the flows along the adjacent wetlands.

Material for Selection

The recommended pipe material for the construction of the Site 4 Crossing of Amtrak is a class V Reinforced Concrete Pipe. This pipe type is required by Amtrak for track crossings.

Railway Culvert

To replace the existing 38" X 36" stone box culvert, a twin reinforced pipe culvert system has been designed. Providing twin 78" diameter pipes will provide the total hydraulic capacity required to convey design flows through the railway embankment with the tailwater resulting from the corresponding flooding conditions of Piper Brook. To meet Amtrak design requirements, the design flow for the pipe represented a 100-year flood event. Maximum headwater depths were held to be equal or less than 150% of the diameter of the pipe (following guidelines set forth in the ConnDOT Drainage Manual). An additional constraint on the sizing of the pipe was clearance to the rail. Since this culvert is proposed to be constructed under an active railway line, boring and jacking the pipe will be required for installation. Correspondence with a jacking contractor revealed that for the safety of the active track, a minimum of 5 feet of clearance from the top of pipe to track elevation would be required. These design elements (as well as surrounding topographic features) constrained the geometry of the proposed crossing to:

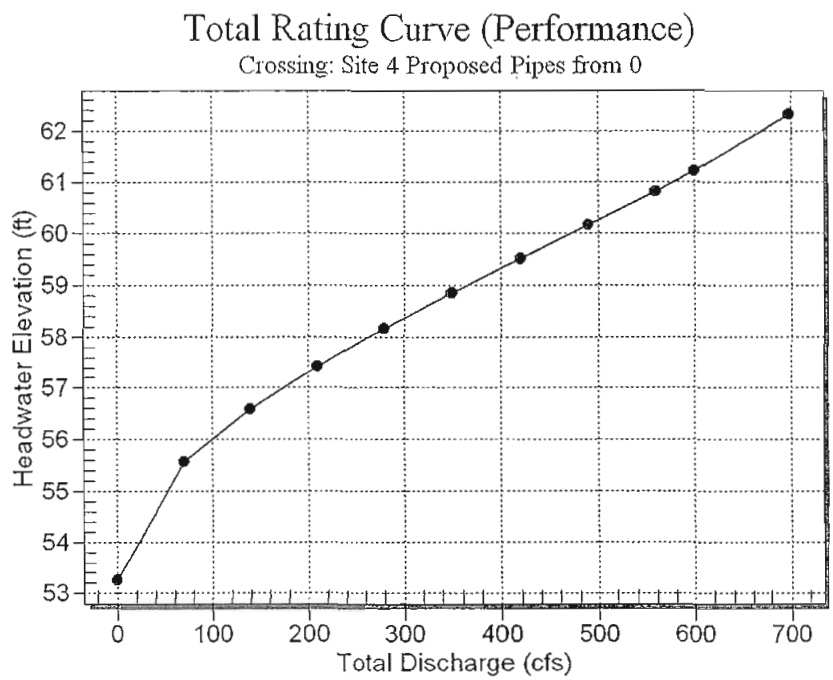
Proposed crossing of the Amtrak railway embankment			
Pipe Type	Pipe Size	Pipe Length	Pipe Slope
Twin Reinforced Concrete Pipe	78"	99.0 feet	0.3%

Using HY8 version 7.1 produced by the Federal Highway Administration, a culvert analysis was run with the boundary conditions previously documented in this report. The results of this culvert analysis are as follows:

10-yr	50-yr	100-yr	500-yr
59.3 feet	61.3 feet	62.3 feet	66.3 feet

Table 6 – Proposed computed headwater elevations for subject crossing

Again, this proposed crossing was then run with flow rates from 0 to the 100-year event using the boundary conditions computed as in the existing conditions. The following performance curve was computed for the proposed crossing and is to be subsequently used as the tailwater condition for the existing triple arch culverts carrying the sewer line pipe.



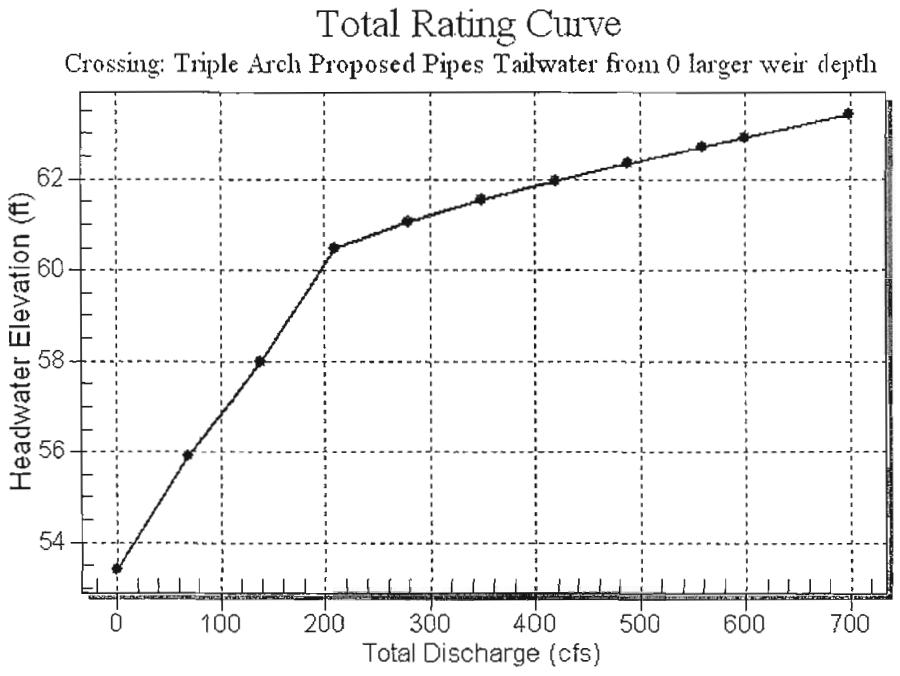
Sewer Line Embankment Culvert

The resulting weir dimensions under the proposed bridge are approximately 40 feet long by 23 feet wide. The bridge length was determined by the minimum opening required to maintain reasonable weir flow over the sewer line embankment approaching the proposed culvert crossing as well as provide headwater relief upstream. In order to model the low chord of the proposed pedestrian bridge, a second culvert was modeled to represent the weir/orifice created by this pedestrian bridge. The dimensions of this second culvert are based on the length of the prescribed weir and the height of the proposed low chord over the proposed weir elevation. Through coordination with the MDC, it has been approved to lower the sewer line embankment elevation to not less than 12" of cover to the soffit of the pipe in this crossing location. From the soffit, the weir will be made up of 12" of sand and encased in 4" of concrete making the crest of the weir. The final crest elevation of the proposed weir is 60.20'. The proposed low chord elevation of the pedestrian bridge is 63.78'. Reasonable weir flow in this case refers to the need for underclearance from the design water surface to the required pedestrian bridge immediately downstream of the weir. In this instance, as the pedestrian bridge is to be owned and maintained by the DOT, the design flood event applied to the bridge requirements is based on a 50-year flood due to the size of the watershed upstream (<1 SM) flowing into a well defined channel. Using the

computed headwater from the subject crossing replacement conditions with the upstream flows computed from the hydrologic analysis, the following results were obtained:

10-yr	50-yr	100-yr
61.9 feet	62.90 feet	63.4 feet

Table 7 – Computed headwater elevations for the sewer line embankment



For a 50-year design event applied to the pedestrian bridge, hydraulics indicates that the weir operates under free flow conditions and provides an underclearance of 0.9 feet.

All of the culvert design computations (existing and proposed) are included in Appendix B

Erosion Control and Channel Protection

Sewer Line Embankment Weir

As stated previously, the proposed conditions of the railway embankment in the vicinity of the crossing are integrating the two subject embankments filling the area between the sanitary embankment and the railway embankment to provide a base for the Busway and Multi-Use Trail. Due to the inadequate capacity of the existing triple arch culvert carrying the sewer line, overtopping relief needs to be maintained for that culvert. To protect the weir, it is proposed to extend the headwalls up to the elevation of the existing top of bank (≈60.20') and filling between the extended headwalls with concrete, effectively making a concrete spillway. Further, to fully take advantage of the existing triple arch hydraulic area, the three pipes should be cleaned out; currently they are heavily sedimented, with the southernmost cell almost completely blocked.

Channel Protection

Between the existing triple arch and the proposed twin 78" RCP culvert, channel protection will be required to maintain a stable entrance to the railway crossing. It is proposed to regrade the remaining area between the two crossings (creating a flow line between the two pipe inverts) and line the area with intermediate riprap. Computations for the riprap sizing in this location are included in Appendix C.

At the outlet of the proposed railway culvert, a riprap apron has been designed. Based on the maximum potential outlet velocities, the required stone size is of standard riprap gradation. The length of the required riprap apron was determined using scour hole geometry prediction as presented in HEC-14 chapter five[1]. The approach was to determine potential scour width and length from the outlet and use the results as the required limits of outlet protection. From this approach, it was determined that the design flows from the outlet of the proposed pipe would create a scour condition that extended approximately 85 feet from the culvert outlet, and would be approximately 40 feet wide. For this site, however, that size of riprap apron using standard gradation rock seemed excessive. Field visits have shown a very stable channel downstream of the existing pipe with no signs of erosion on the adjacent lands. The inlet and outlet of the existing pipe are also very stable. Further, due to the extent of vegetation around the outlet, it appears that there is a high degree of retardation to the flow velocities, thereby reducing the probable scour limits. For these reasons and based on the current downstream channel geometry (where the outlet channel continues parallel to the culvert for approximately 30 feet and turns abruptly 90° to follow along the embankment) a 30' riprap basin at the outlet is suggested. The standard detail for a Type B riprap apron as documented in the ConnDOT Drainage Manual (Figure 11-3) was used to design the required width of the pad at the outlet and terminus. Therefore, a riprap apron 30 feet long with a width of 34.5 feet at the outlet tapering out to 46.5 feet at the limit is recommended for outlet protection.

Temporary Conditions – 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 stone box. The work area upstream and downstream will be cordoned off through the use of a cofferdam and temporary flow diversion barrier. Flow patterns will be maintained as they are existing. Phase 2 will shift the flow line through the newly constructed twin 78" barrels and cofferdams with flow diversion barriers will be used to maintain a dry area to construct the remaining portions of the headwall and endwall, and to fill and cap the 38" X 36" box culvert for abandonment.

This section documents the hydrology and hydraulics and recommended water handling during the construction phase of the project.

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 condition determination is not easily applied in this case due to

[1] The apron sizing method as presented in ConnDOT Drainage Manual §11.13.5 was considered, however, due to the flows and pipe size, the method was considered inappropriate.

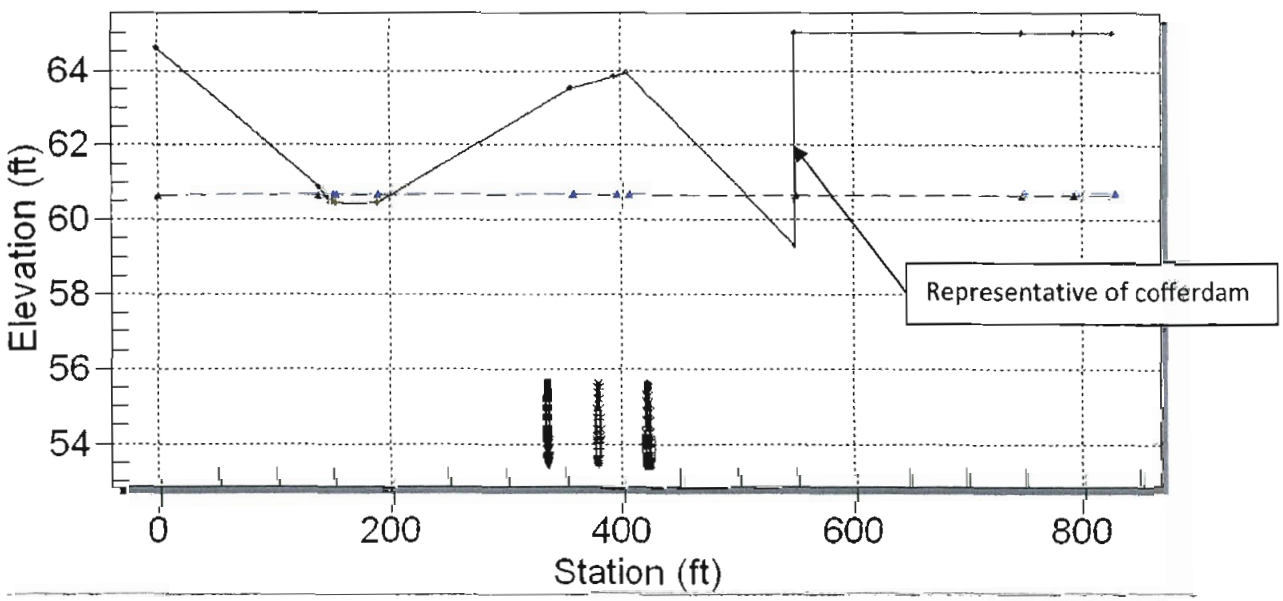
the travel way being a railroad. However, there is a low potential for loss of life, and very limited property damage would be inflicted in the case of an embankment failure – downstream properties are all uninhabited wetland areas between the project site and Piper Brook (receiving waters). Further, 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. Note is made that the two year event used for this temporary conditions analysis is not the two year design event of 190-cfs, but the two year existing event of 88-cfs utilizing existing storage in the watershed.

Temporary Conditions Hydraulics

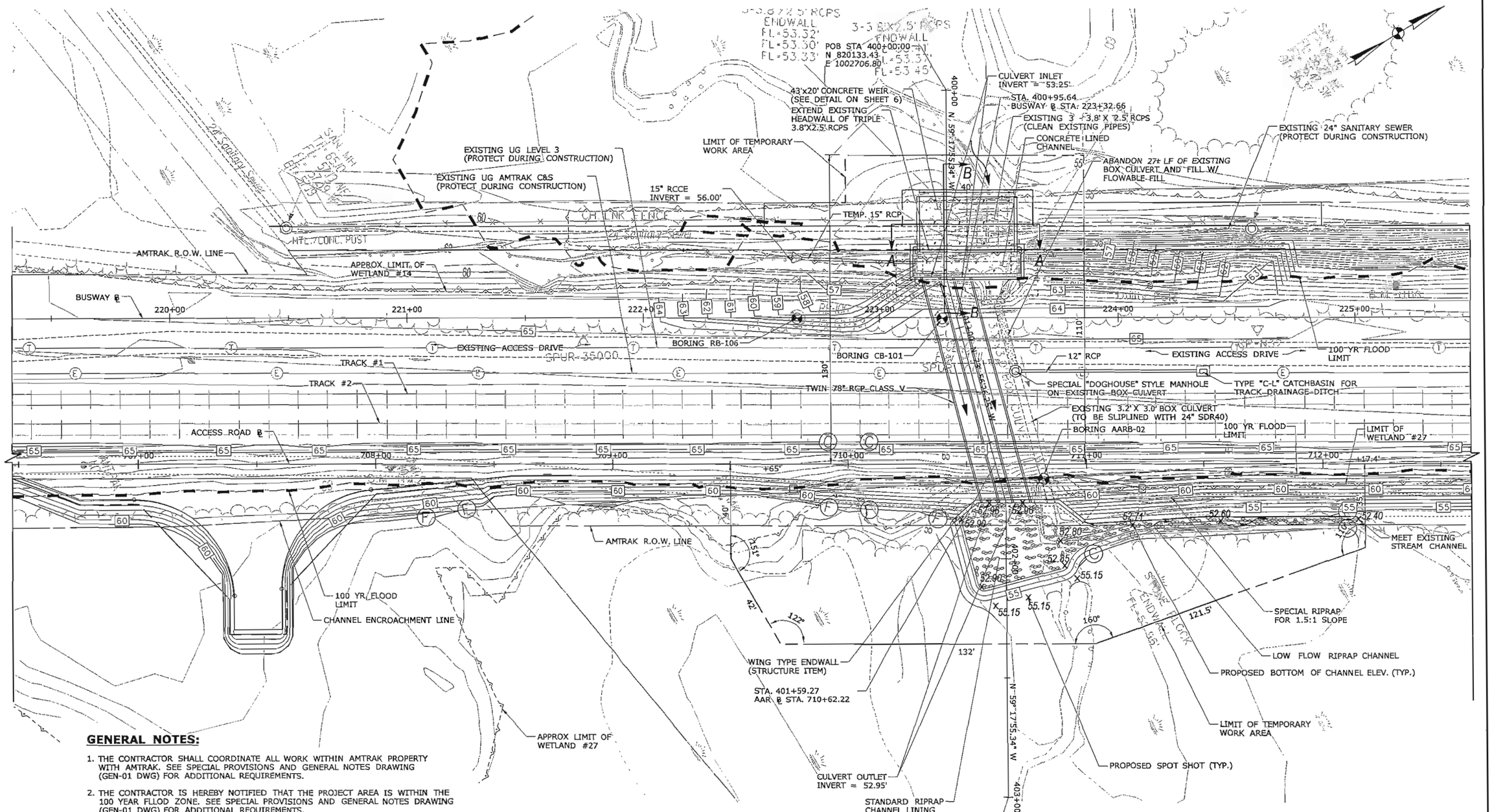
A temporary hydraulic analysis was processed for the first phase of the construction site, as it was determined that this first phase would represent the greatest constriction (and thus highest water surface elevation) for the construction process.

The temporary conditions hydraulic analysis geometry was created by modifying the triple arch embankment geometry to represent impedance to the weir flow, which represented the cofferdam. The system of culverts was then run for a flow rate range of 0 to 90-cfs. The existing railway culvert was run to generate a headwater rating curve for this flow rate range to then be used as the tailwater curve for the temporary conditions crossing. As a result of this temporary conditions analysis, it had been determined that the required cofferdam elevation to maintain a dry work area for the calculated 2-year exiting flow event would be 60.7 feet.

At the outlet for both phases of construction, a specific elevation for cofferdam height cannot be determined due to the very wide and flat floodplain that is receiving the flows. It is a reasonable assumption that once the 2-year temporary flow exits the subject crossing, the top width would spread to infinity thereby taking essentially no depth in the floodplain.



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



GENERAL NOTES:

1. THE CONTRACTOR SHALL COORDINATE ALL WORK WITHIN AMTRAK PROPERTY WITH AMTRAK. SEE SPECIAL PROVISIONS AND GENERAL NOTES DRAWING (GEN-01 DWG) FOR ADDITIONAL REQUIREMENTS.
2. THE CONTRACTOR IS HEREBY NOTIFIED THAT THE PROJECT AREA IS WITHIN THE 100 YEAR FLOOD ZONE. SEE SPECIAL PROVISIONS AND GENERAL NOTES DRAWING (GEN-01 DWG) FOR ADDITIONAL REQUIREMENTS.
3. ALL DISTURBED AREAS WITHIN THE DELINEATED WETLAND BOUNDARIES SHALL BE RESTORED THROUGH WETLAND GRASS ESTABLISHMENT. OTHER PREVIOUSLY VEGETATED OR GRASSED AREAS IMPACTED BY CONSTRUCTION SHALL BE RESTORED WITH CONSERVATION SEED AND/OR TURF ESTABLISHMENT.

GENERAL PLAN

SCALE: 1"=20'

PRELIMINARY DESIGN REVIEW

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

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: $DATE$

DESIGNER/DRAFTER: PB-CF/PB-CF
CHECKED BY: ALM
SCALE IN FEET 0 20 40
SCALE 1"=20'

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

Filename: $FILEA$

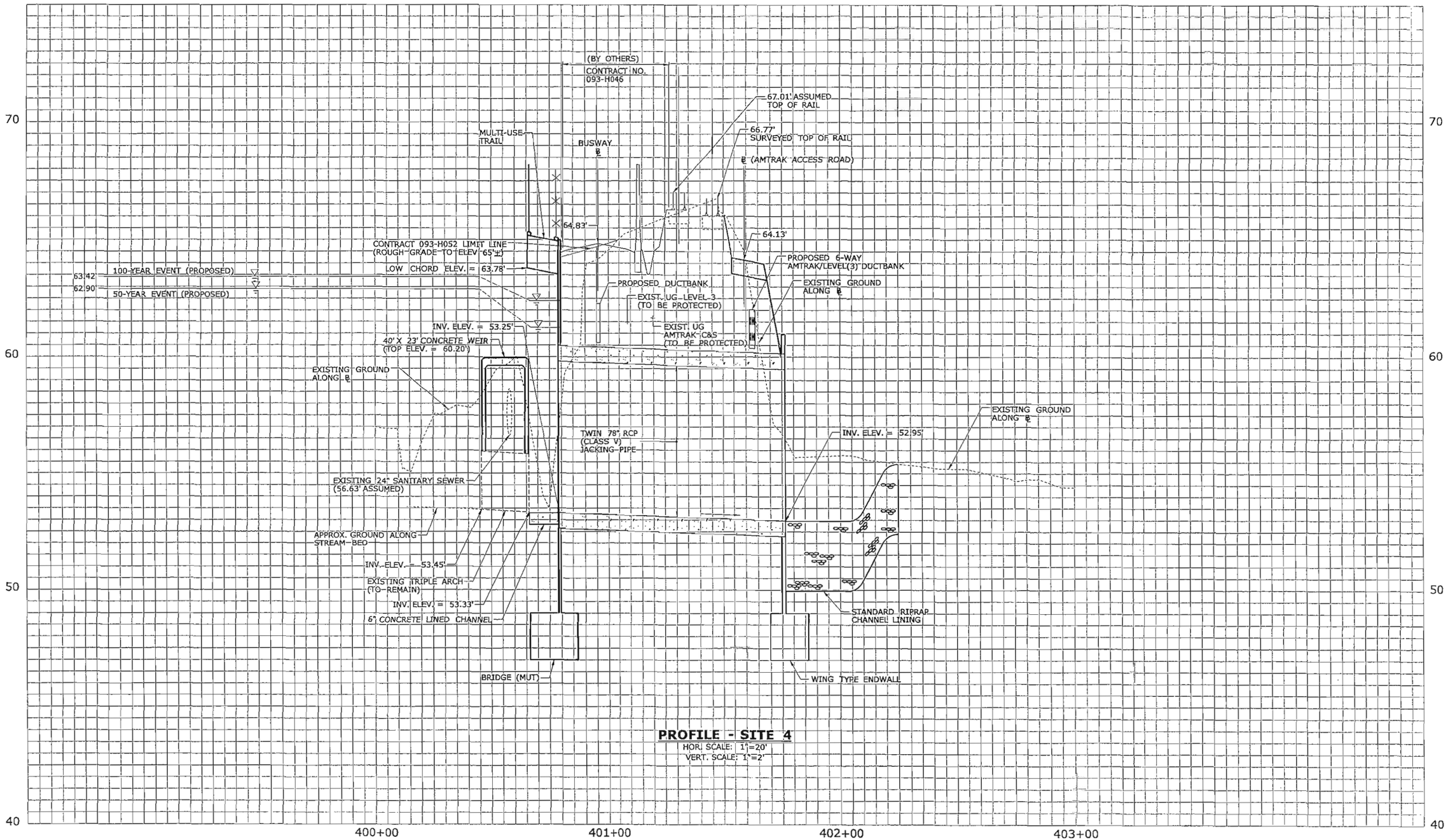
MICHAEL BAKER ENGINEERING, INC.
APPROVED BY: -
DATE: -

PROJECT TITLE: NEW BRITAIN - HARTFORD BUSWAY AMTRAK ACCESS ROAD

TOWN: NEWINGTON, WEST HARTFORD & HARTFORD

DRAWING TITLE: SITE 4 GENERAL PLAN

PROJECT NO. 093-H052
DRAWING NO.
SHEET NO. 2



PROFILE - SITE 4

HOR. SCALE: 1"=20'
VERT. SCALE: 1"=2'

PRELIMINARY DESIGN REVIEW

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

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Plotted: $DATE$

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: $FILE$

MICHAEL BAKER ENGINEERING, INC.
APPROVED BY: -
DATE: -

PROJECT TITLE: NEW BRITAIN - HARTFORD BUSWAY AMTRAK ACCESS ROAD

TOWN: NEWINGTON, WEST HARTFORD & HARTFORD

DRAWING TITLE: SITE 4 - PROFILE

PROJECT NO. 093-H052
DRAWING NO.
SHEET NO. 3

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**	**2**	**25**	**2**	**50**	**2**	**100**
	10	2	25	2	50	2	100	2
1,000 TO 1	**2**	**10**	**2**	**25**	**5**	**50**	**10**	**100**
	10	2	25	2	50	5	100	10
100 TO 1	**5**	**10**	**5**	**25**	**10**	**50**	**25**	**100**
	10	5	25	5	50	10	100	25
10 TO 1	**10**	**10**	**10**	**25**	**25**	**50**	**50**	**100**
	10	10	25	10	50	25	100	50
1 TO 1	**10**	**10**	**25**	**25**	**50**	**50**	**100**	**100**
	10	10	25	25	50	50	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.)

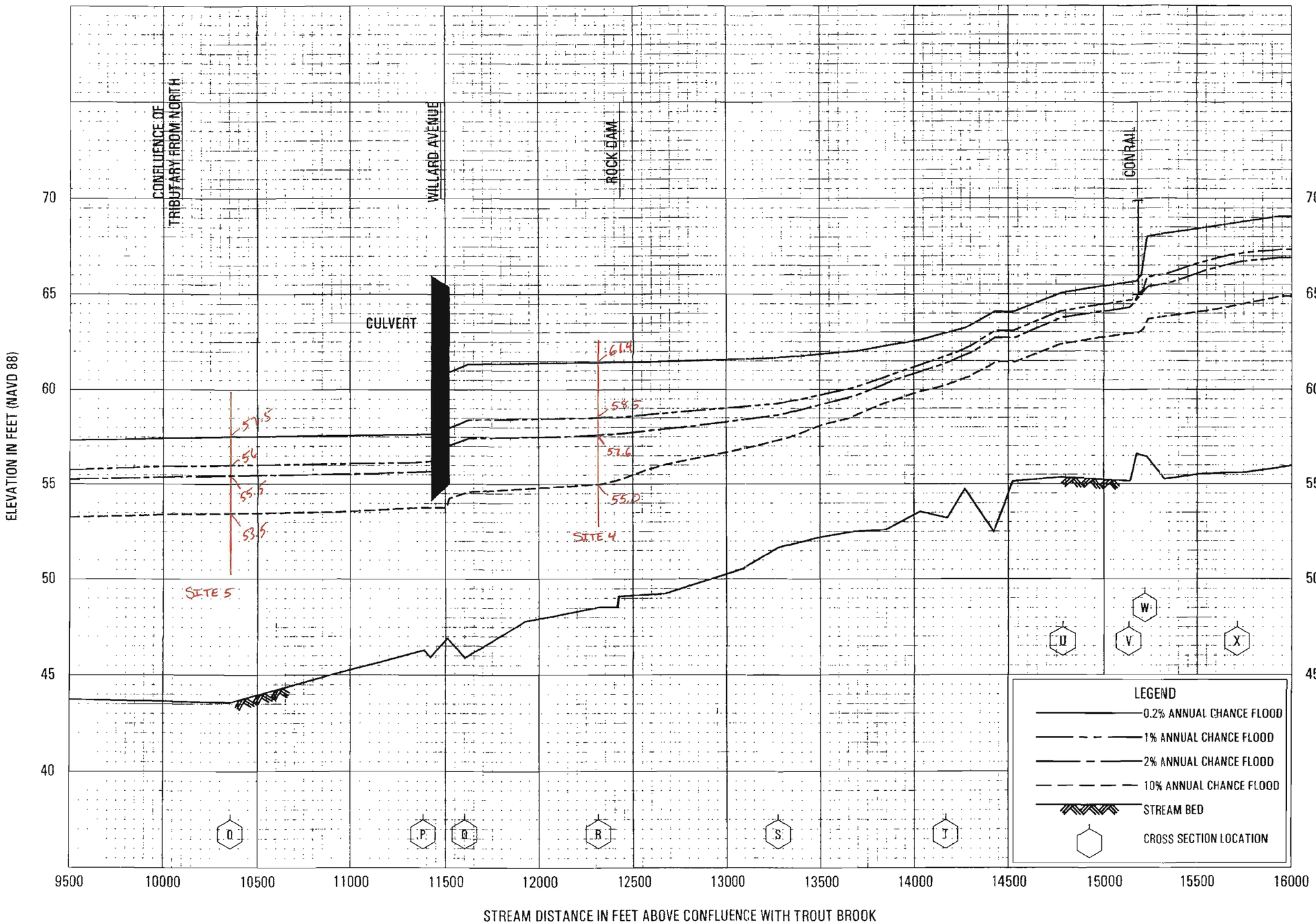
8.3.9 Minimum Velocity

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

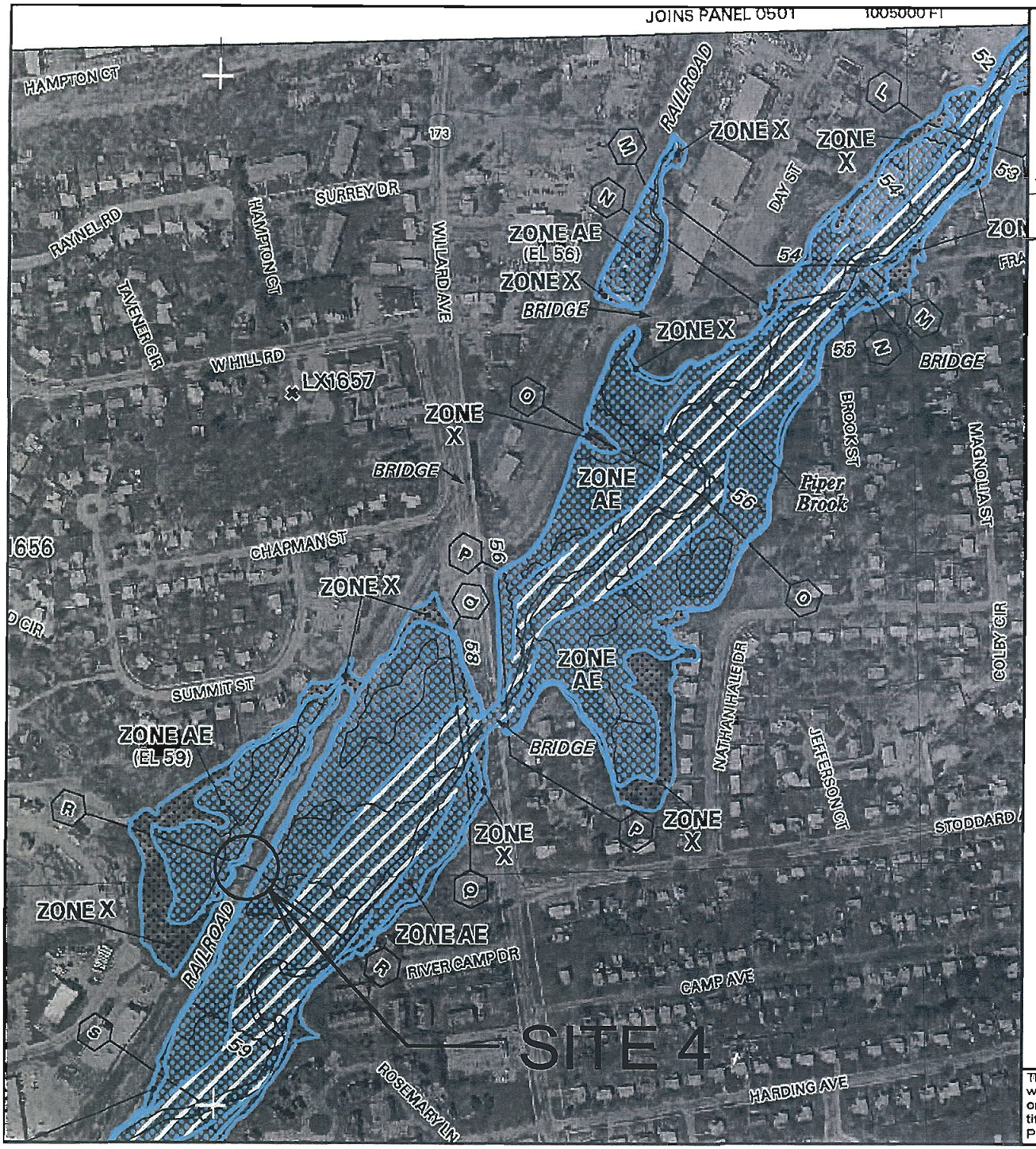
PIPER BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARTFORD COUNTY, CT

(ALL JURISDICTIONS)

314P



MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

PANEL 0503F

FIRM

FLOOD INSURANCE RATE MAP

HARTFORD COUNTY, CONNECTICUT (ALL JURISDICTIONS)

PANEL 503 OF 675

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
NEWINGTON, TOWN OF	090035	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

NATIONAL FLOOD INSURANCE PROGRAM

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

Develop Tailwater relationship for use in HY8 NAVD '88

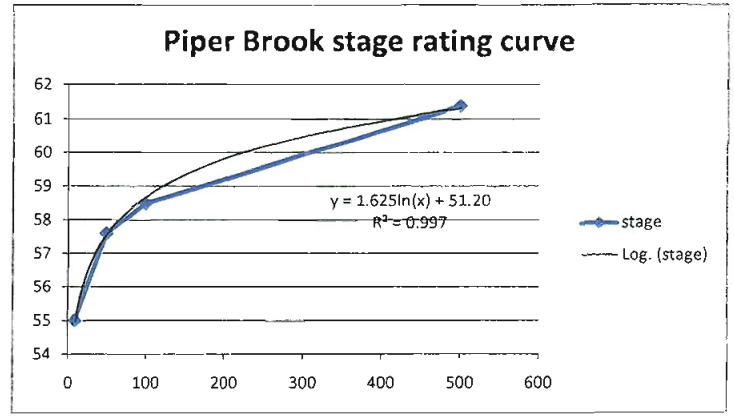
Existing Conditions at Site 4

Tributary design events

year	flow	Tailwater	event trib:TW
10	392	55	10:10
50	600	56.4	50:25
100	699	57.6	100:50
500	1188	60.17	500:250

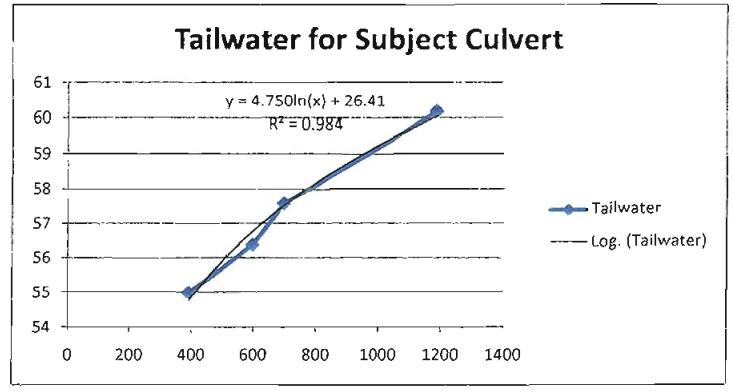
Piper Brook flood elevations

year	stage	
10	55	From FIS
50	57.6	
100	58.5	
500	61.4	
10	54.9417	computed
25	56.43067	
50	57.55704	
100	58.6834	
250	60.17237	
500	61.29874	



HY8 TW Rating Curve

	discharge	TW El. From Trendline	TW El. Direct	Resulting Headwater
Minimum (10-yr)	392	54.7734937	55	66.76
	471.6	55.6516231		66.82
	551.2	56.3924642		66.87
	630.8	57.0331971		66.93
Design	699	57.520841	57.6	66.97
	790	58.1021565		67.02
	869.6	58.5581583		67.07
	949.2	58.9741927		67.11
	1028.8	59.3567047		67.15
	1108.4	59.7106959		67.19
Maximum (500-yr)	1188	60.0401259	60.17	67.23



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

Section 1.0 - **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 4 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 41.71106 deg, 72.74063 deg. NAD83 datum into an existing (3.0W' X 4.0'H) stone box culvert under the railroad bed.

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

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

Section 2.0 – **HYDROLOGY DESCRIPTION**

The associated drainage area of 0.54 square miles is well developed with residential, commercial and individual properties. This watershed is developed with more than 30 percent urbanization.

The drainage basin has some storage available and locations with multiple culverts. The Connecticut Department of Transportation specifically requested that all storage within the basin be accounted for. TR-20 was utilized to model the area. Specifically, the latest windows based version was used, (TR-20 System Controller / Editor, 32-bit Windows Based Application Version – 2002.06). The analysis was run three times. The first run accounted for all of the available storage and the second analysis used only the storage available immediately upstream of the sanitary sewer embankment. The third analysis was run without any storage. This was performed to assess the effect of the storage and to assess the need to acquire flooding easements.

The outlet culverts were assumed to be free of sediment and debris that would reduce the flow rate. No infiltration in the storage areas was included.

Times of Concentration and composite Curve Numbers were calculated using the Windows Based Version of TR-55 (Version Date February 12, 2003).

The enclosed schematic diagrams indicate the layout of the hydrology study using all available storage and are summarized below:

Sub Areas	7 areas with .373 hrs > Tc > 1.13 hrs and 75>CN >80
Reaches	10 reaches with 10 ft >L>1600 ft
Structures	5 structures modeled for storage

Four storage areas along the basin were identified. The available storage at each location was measured from 200-scale MDC contour mapping. Two sets of calculations were used to develop the ratings data and curves. The outflows values to the top of the embankment were calculated

utilizing the procedures as outlined in Hydraulic Design Series No. 5 (HDS No. 5). Once the flow elevation exceeded the embankment, the overtopping flows are added. The overtopping flow rates were calculated using procedures as indicated in the current Drainage Manual as weir flow.

Area 1 flows into Area 2. These two areas collect in a significant swampy area to the west of Anna Reynolds School (also identified as Northwest School). The water is then conveyed through a 36" RCP (culvert 1) along Reservoir Road and outlets into a ravine on the east side of the school. This water in addition to the runoff from Area 3 is conveyed through a 72" concrete culvert (culvert 2) under Fenn Road and outlets southwest of the Fennwood Circle's cul-de-sac. The runoff from Area 4 is combined and passed under a utility easement that connects from Elliott Lane and Summit Street. The crossing under the utility easement consists of a twin 58" x 42" and 62" x 42" C. M. Pipes (culvert 3). This water along with Area 5 flow to an existing triple 30" x 42 " C. M (culvert 4). Pipe under a sanitary sewer embankment. Areas 6 and 7 join the flow immediately upstream of the 3'W x 4'H Stone Box Culvert (culvert 5).

Culvert 4 has several features that control the rate of discharge. The downstream stone box culvert is so close that it affects the culvert 3 tail water. The existing sanitary sewer embankment has two low spots that act like weirs when approaching flow rates are high enough. The weir on the northeast end will start to flow first then the weir on the southwest end will add to the flow rates. The weir flows are collected in ditches located between the sanitary sewer and railroad embankments. These ditches then rejoin the flow from the triple culverts. The flow rates for all these features were calculated and rating curves plotted. Preliminary hydraulic analysis utilizing HDS No. 5 for the stone box culvert was performed to calculate headwater elevations for use as tail water elevations for the triple culverts for equivalent storm events. The flow rate for the individual components was then added together to obtain the combine flow rates of the culvert 3 location for use in the TR-20 analysis.

The input cross section data was obtained from either the MDC mapping or project mapping data specifically gathered at the site. It should be noted that the project mapping and MDC mapping are very similar. The cross sections were selected as general representatives of the channel conditions in the associated reaches.

Section 3.0 - SUMMARY OF PEAK DISCHARGES (cfs)

Location	Flow Rates (cfs)				Remarks
	2-yr	10-yr	50-yr	100-yr	
	Up / Down	Up / Down	Up / Down	Up / Down	
Culvert 1	110.4/25.9	216.8/43.2	330.9/55.3	384.5/84.9	Note 1
	110.4	216.8	330.9	384.5	Note 2
	110.4	216.8	330.9	384.5	Note 3
Culvert 2	27.2/27.2	45.4/45.4	58.6/58.6	88.8/88.8	Note 1
	114.9	226.0	343.9	401.2	Note 2
	114.9	226.0	343.9	401.2	Note 3
Culvert 3	28.5/28.5	55.4/55.1	87.6/87.4	103.6/102.9	Note 1
	118.9	233.6	357.2	416.4	Note 2
	118.9	233.6	357.2	416.4	Note 3
Culvert 4	34.5/28.6	73.2/62.8	116.5/113.5	136.8/134.5	Note 1
	123.3/122.4	245.8/243.9	374.6/367.0	436.4/426.5	Note 2

	123.3	245.8	374.6	436.4	Note 3
Culvert 5	101.8/87.6	220.2/132.9	352.0/178.4	413.3/292.1	Note 1
	186.3/126.7	384.6/301.9	574.1/575.4	668.1/696.9	Note 2
	148.3	302.1	464.9	541.6	Note 3
Outlet	87.6	132.9	178.4	292.1	Note 1
	126.7	301.9	575.4	696.9	Note 2
	190.8	392.0	600.2	699.0	Note 3

Note 1: *This analysis accounted for all of the available storage within the drainage basin.*

Note 2: *This analysis accounted for storage immediately upstream of the sanitary sewer embankment. This analysis represents the recommended results. For the 100-yr storm event the benefits for the storage are minimal, however, for lesser storms some benefits are gained.*

Note 3: *This analysis accounted for no storage.*

Note 4: *These flow rated are recommended for design purposes.*

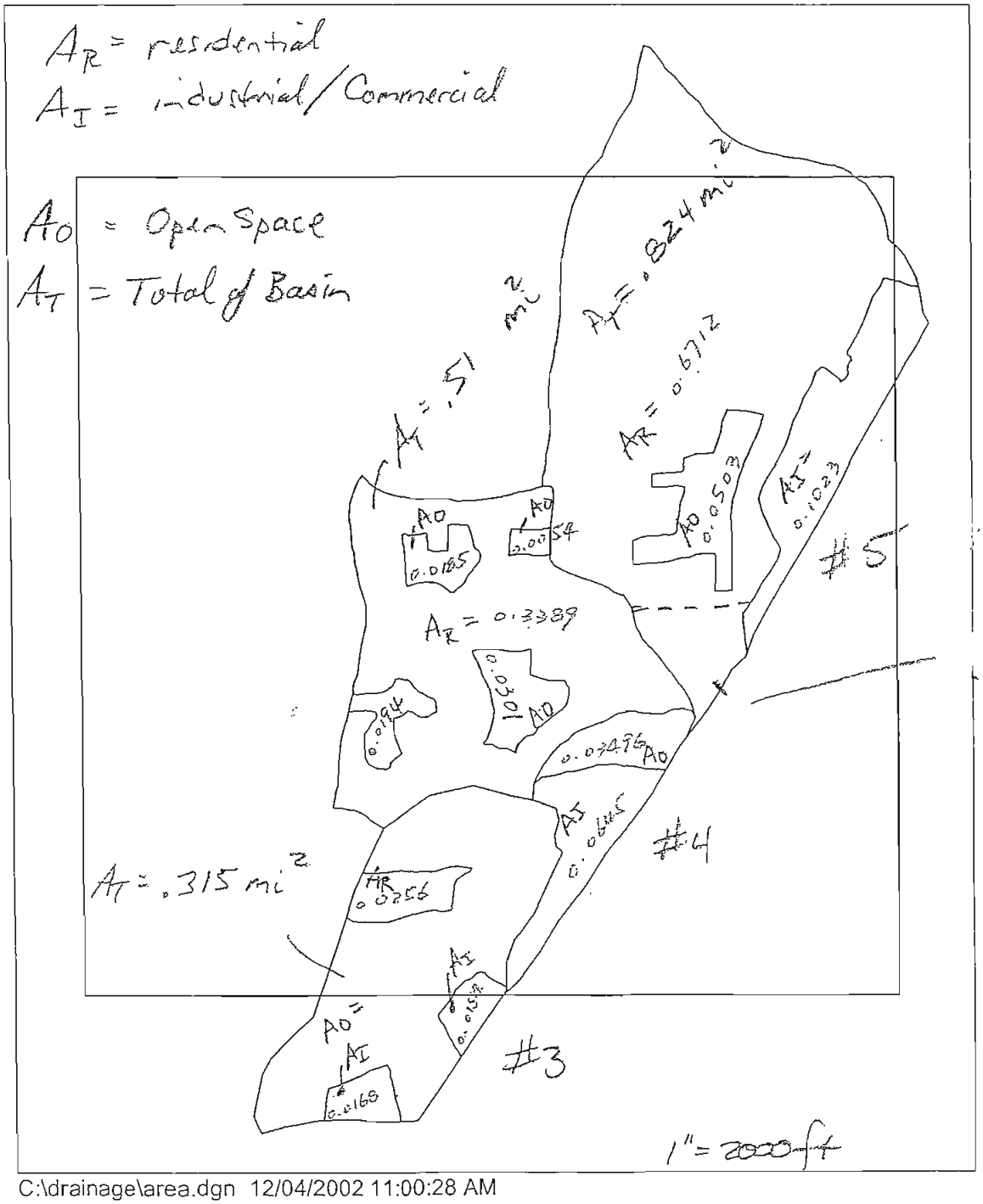
General Notes: *The preliminary analysis of this triple culvert shows that overtopping of the 24" Sanitary Sewer embankment will occur, for flow exceeding 75 CFS. At a flow rate of approximately 70 CFS the headwaters for the 3' x 4' Stone box culvert approached the low point in the 24" Sanitary Sewer embankment. A review of the results shows that a reduction of about 297 CFS was realized by accounting for all of the available storage. Additional and more detailed hydraulic analysis at this location is recommended. The review of the inflow and outflow routing hydrographs at each location was performed. It is apparent that the location with greatest effective storage is associated with the culvert identified as "Culvert 1". It is our analysis that other culvert crossing locations have limited storage because of the relatively small storage areas coupled with large culverts.*

Section 4.0 – RECOMMENDATIONS

The recommended design flow rate for the railroad crossing should be based on the 100-year event with a calculated flow rate of 699 cfs with check computations for the 500-year flow. This recommendation is based on the assumption that no upstream storage will be available in the future.

It is also felt that replacement or significant modifications to the triple pipes under the sanitary sewer embankment would likely affect the function of the upstream wetlands. Any modifications as a result of the project should be carefully analyzed to assess the hydrologic, hydraulic and functional impacts.

SITE #4

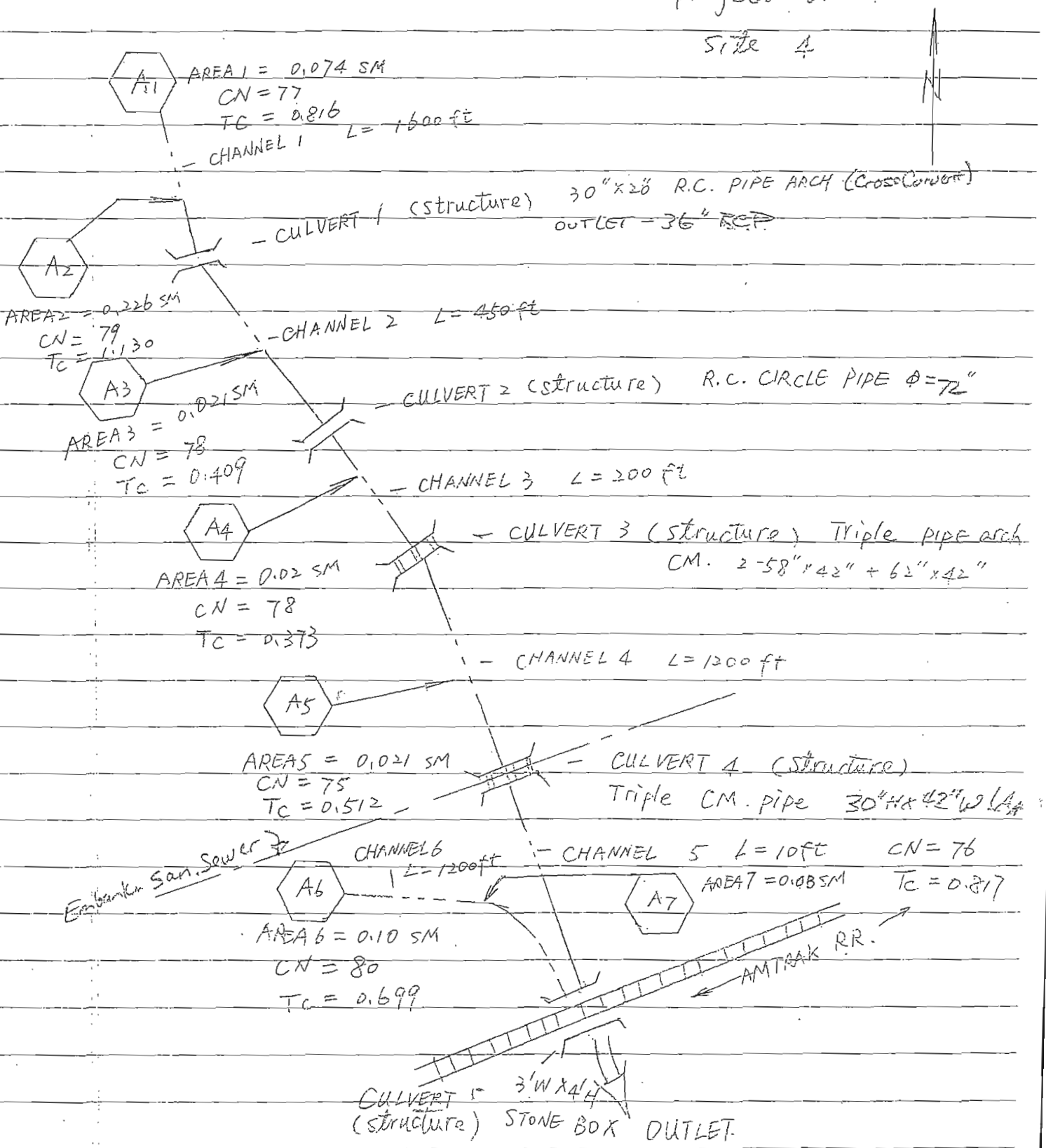


A_{SA} = 3286219 SF = .11787 sq mi

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

project 0126.

site 4

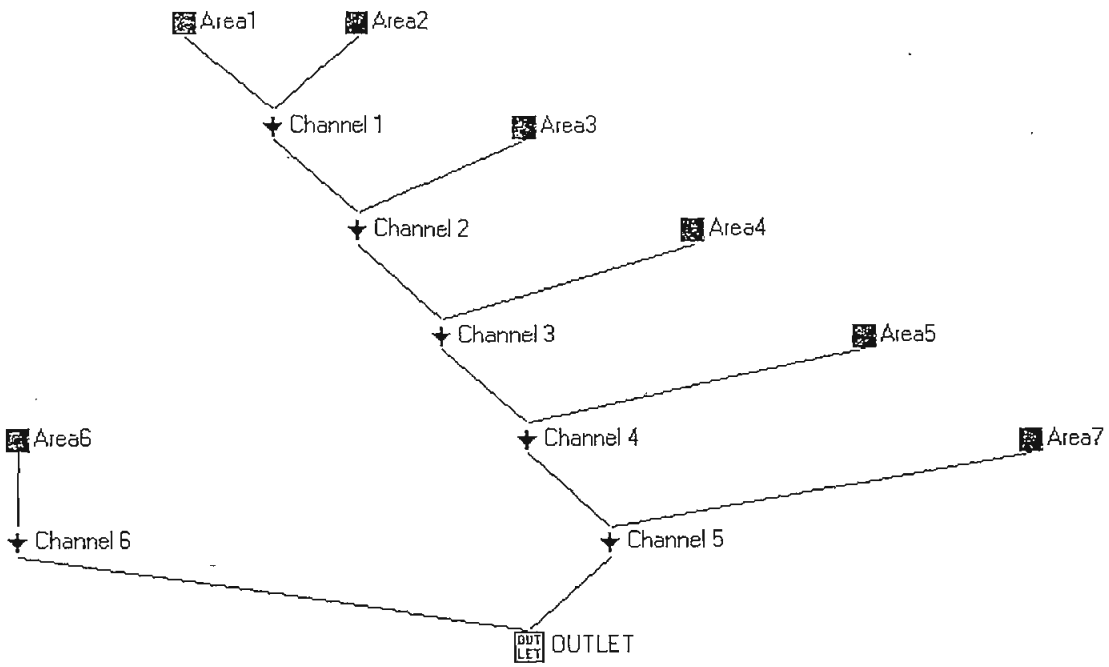


NEW BRITAIN TO HARTFORD BUSWAY
STATE PROJECT NO. 171-305
Prepared By: Garg Consulting Services, Inc.

Scale 1" = NTS

APPENDIX B

TR-20 INPUT DATA AND ANALYSIS RESULTS


Area1
Area2
Channel 1
Area3
Channel 2
Area4
Channel 3
Area5
Area6
Channel 4
Area7
Channel 6
Channel 5
OUTLET

NO STORAGE

TR-20: Version 2001 0 0 0
Site 4 - Existing Conditions

SUB-AREA:

Area1	Channel 1	0.07	77.	0.816	YY YY
Area2	Channel 1	0.23	79.	1.13	YY YY
Area3	Channel 2	0.02	78.	0.409	YY YY
Area4	Channel 3	0.02	78.	0.373	YY YY
Area5	Channel 4	0.02	75.	0.512	YY YY
Area6	Channel 6	0.10	80.	0.699	YY YY
Area7	Channel 5	0.08	76.	0.817	YY YY

STREAM REACH:

Channel 1	Channel 2	Xsec1	1600.
Channel 3	Channel 4	Xsec5	200.
Channel 4	Channel 5	Xsec7	1200.
Channel 6	Outlet	Xsec10	1100.
Channel 5	Outlet	Xsec9	10.
Channel 2	Channel 3	Xsect3	400.

STORM ANALYSIS:

2 yr	0.	3.2	Type III 2	3.2
10 yr	0.	4.7	Type III 2	3.2
50 yr	0.	6.2	Type III 2	3.2
100 yr	0.	6.9	Type III 2	3.2

STREAM CROSS SECTION:

Xsec1 136.

136.	0.	0.	5.	0.0088
136.5	4.009	3.	7.	0.0088
137.	13.752	7.	9.	0.0088
138.	51.289	18.	13.	0.0088
141.	390.	75.	25.	0.0088

Xsec10 56.

56.	0.	0.	5.	0.011
56.5	4.482	3.	7.	0.011
57.	15.375	7.	9.	0.011
58.	57.343	18.	13.	0.011
61.	394.734	75.	25.	0.011

Xsec5 71.

71.	0.	0.	5.	0.04
71.5	8.547	3.	7.	0.04
72.	29.319	7.	9.	0.04
73.	109.348	18.	13.	0.04
76.	752.728	75.	25.	0.04

Xsec9 56.

56.	0.	0.	8.	0.011
56.5	6.991	4.5	10.	0.011
57.	23.191	10.	12.	0.011
58.	81.337	24.	16.	0.011
61.	499.057	90.	28.	0.011
62.0	665.	120.	34.	.011

Xsect3 89.

89.	0.	0.	5.	0.025
89.5	6.757	3.	7.	0.025
90.	23.179	7.	9.	0.025
91.	86.447	18.	13.	0.025
94.	595.084	75.	25.	0.025

Xsec7 71.

71.	0.	0.	8.	0.011
71.5	6.991	4.5	10.	0.011
72.	23.191	10.	12.	0.011
73.	81.337	24.	16.	0.011
76.	499.057	90.	28.	0.011

STRUCTURE RATING:

53.23	0.	0.001
55.	1.	0.003
56.	12.	0.0094
57.	17.	.0644
58.	23.	.3844
59.	36.	1.3594
60.	74.	3.3094
61.	142.	6.2594
62.	227.	8.
64.	431.	10.

GLOBAL OUTPUT:

0.25 YYNYY YYNYYY

Site 4 - Existing Conditions

Name of printed page file:
\\Server-01\Design\CT\PROJECTS\0126-Busway\H&H\Site 4\site4-NoStore 042004.out

STORM 2 yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area1	0.070		1.206		12.58	28.03	400.40

Line
Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

11.250	0.8	1.2	2.1	5.4	16.0	27.0	25.9
13.000	18.4	12.7	9.4	7.5	6.3	5.6	5.0
14.750	4.6	4.2	4.0	3.7	3.5	3.2	2.9
16.500	2.7	2.5	2.4	2.3	2.1	2.0	1.9
18.250	1.8	1.7	1.6	1.6	1.5	1.5	1.4
20.000	1.4	1.4	1.3	1.3	1.3	1.3	1.2
21.750	1.2	1.2	1.1	1.1	1.1	1.1	1.0
23.500	1.0	1.0	0.9	0.9	0.6		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area2	0.230		1.335		12.79	85.26	370.68

Line
art Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

10.500	0.6	1.2	2.0	3.0	4.4	6.9	13.8
12.250	35.2	67.8	84.6	78.3	60.4	45.3	35.2
14.000	28.5	24.0	20.8	18.5	16.7	15.3	14.1
15.750	13.1	12.1	11.2	10.3	9.5	8.9	8.4
17.500	7.9	7.5	7.0	6.6	6.2	5.9	5.6
19.250	5.4	5.3	5.1	5.0	4.9	4.8	4.6
21.000	4.5	4.4	4.3	4.2	4.1	4.0	4.0
22.750	3.9	3.8	3.7	3.6	3.5	3.4	3.2
24.500	2.6	1.8	1.0	0.6			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 1	0.300	Upstream	1.304	138.53	12.72	110.74	369.12

Line
Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

10.500	0.6	1.2	2.0	3.0	5.6	9.0	19.2
12.250	51.2	94.8	110.4	96.7	73.1	54.7	42.7

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.000	34.9	29.6	25.8	23.0	21.0	19.3	17.8
15.750	16.5	15.3	14.1	13.0	12.1	11.3	10.6
17.500	10.0	9.5	8.9	8.4	7.9	7.5	7.2
19.250	7.0	6.8	6.6	6.4	6.2	6.1	5.9
21.000	5.8	5.7	5.6	5.4	5.3	5.2	5.1
22.750	4.9	4.8	4.7	4.6	4.4	4.3	4.0
24.500	3.2	1.8	1.0	0.6			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 1	0.300	Downstream	1.303	138.52	12.79	110.39	367.96

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	0.9	1.8	2.6	5.0	7.7	14.5	38.4
12.500	82.2	109.1	103.1	80.5	59.8	46.0	37.0
14.250	31.1	26.9	23.8	21.6	19.8	18.3	16.9
16.000	15.7	14.5	13.4	12.4	11.5	10.8	10.2
17.750	9.7	9.1	8.6	8.0	7.6	7.3	7.0
19.500	6.8	6.6	6.5	6.3	6.1	6.0	5.9
21.250	5.7	5.6	5.5	5.3	5.2	5.1	5.0
23.000	4.9	4.7	4.6	4.5	4.4	4.2	3.5
24.750	2.1	1.2	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area3	0.020		1.079		12.31	11.65	582.33

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.500	0.7	1.3	4.1	11.3	9.1	5.0	3.0
13.250	2.2	1.9	1.7	1.5	1.4	1.3	1.2
15.000	1.1	1.1	1.0	0.9	0.8	0.8	0.7
16.750	0.7	0.7	0.6	0.6	0.5	0.5	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 2	0.320	Upstream	1.255	91.17	12.79	114.93	359.17

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	0.9	1.8	2.6	5.0	7.7	14.5	38.4
12.500	82.2	114.1	106.1	82.7	61.6	47.7	38.6
14.250	32.5	28.2	25.0	22.7	20.9	19.3	17.8
16.000	16.5	15.3	14.1	13.0	12.2	11.5	10.8
17.750	10.2	9.6	8.6	8.0	7.6	7.3	7.0
19.500	6.8	6.6	6.5	6.3	6.1	6.0	5.9
21.250	5.7	5.6	5.5	5.3	5.2	5.1	5.0
23.000	4.9	4.7	4.6	4.5	4.4	4.2	3.5
24.750	2.1	1.2	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 2	0.320	Downstream	1.255	91.17	12.79	114.93	359.17

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.0	1.7	2.6	4.9	7.4	13.8	36.3
12.500	79.6	112.7	107.3	84.1	62.7	48.3	39.0
14.250	32.8	28.4	25.2	22.8	21.0	19.4	17.9
16.000	16.6	15.3	14.1	13.1	12.2	11.5	10.9
17.750	10.2	9.7	8.6	8.1	7.6	7.3	7.0
19.500	6.8	6.6	6.5	6.3	6.1	6.0	5.9
21.250	5.7	5.6	5.5	5.4	5.2	5.1	5.0
23.000	4.9	4.7	4.6	4.5	4.4	4.2	3.6
24.750	2.2	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area4	0.020		1.079		12.28	12.08	604.11

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.500	0.7	1.4	4.5	12.0	8.8	4.6	2.8
13.250	2.1	1.8	1.7	1.5	1.4	1.3	1.2
15.000	1.1	1.1	1.0	0.9	0.8	0.8	0.7
16.750	0.7	0.6	0.6	0.6	0.5	0.5	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 3	0.340	Upstream	1.245	73.04	12.79	118.98	349.95

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.0	1.7	2.6	5.6	8.9	18.4	48.3
12.500	88.3	117.3	110.0	86.2	64.5	50.0	40.5
14.250	34.2	29.7	26.4	24.0	22.1	20.4	18.8
16.000	17.4	16.1	14.9	13.8	12.9	12.1	11.4
17.750	10.8	10.2	8.6	8.1	7.6	7.3	7.0
19.500	6.8	6.6	6.5	6.3	6.1	6.0	5.9
21.250	5.7	5.6	5.5	5.4	5.2	5.1	5.0
23.000	4.9	4.7	4.6	4.5	4.4	4.2	3.6
24.750	2.2	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 3	0.340	Downstream	1.245	73.04	12.79	118.90	349.72

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.0	1.7	2.6	5.5	8.7	18.0	47.3
12.500	87.3	117.1	110.5	86.8	65.0	50.3	40.7
14.250	34.3	29.8	26.5	24.0	22.1	20.4	18.9
16.000	17.5	16.1	14.9	13.8	12.9	12.1	11.5
17.750	10.8	10.2	8.6	8.1	7.6	7.3	7.1
19.500	6.8	6.7	6.5	6.3	6.2	6.0	5.9
21.250	5.7	5.6	5.5	5.4	5.2	5.1	5.0
23.000	4.9	4.7	4.6	4.5	4.4	4.2	3.6
24.750	2.2	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area5	0.020		0.909		12.40	8.92	446.11

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.750	0.7	2.4	7.6	8.3	5.3	3.2	2.2
13.500	1.8	1.6	1.4	1.3	1.2	1.1	1.1
15.250	1.0	0.9	0.9	0.8	0.7	0.7	0.6
17.000	0.6	0.6	0.5	0.5			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Upstream	1.226	73.30	12.79	123.47	342.98

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.0	1.7	2.6	5.4	9.4	20.4	54.9
12.500	95.6	122.3	113.6	89.1	66.8	51.9	42.2
14.250	35.6	31.0	27.6	25.1	23.1	21.3	19.7
16.000	18.3	16.9	15.6	14.4	13.5	12.7	12.0
17.750	11.3	10.2	8.6	8.1	7.6	7.3	7.1
19.500	6.8	6.7	6.5	6.3	6.2	6.0	5.9
21.250	5.7	5.6	5.5	5.4	5.2	5.1	5.0
23.000	4.9	4.7	4.6	4.5	4.4	4.2	3.6
24.750	2.2	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Downstream	1.226	73.30	12.85	123.29	342.47

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.2	1.4	2.3	4.6	8.3	16.6	45.3
12.500	86.7	117.9	117.8	95.1	71.2	54.7	44.1
14.250	36.9	31.9	28.3	25.6	23.5	21.7	20.1
16.000	18.6	17.2	15.9	14.7	13.7	12.9	12.2
17.750	11.5	10.3	8.7	8.2	7.7	7.4	7.1
19.500	6.9	6.7	6.5	6.4	6.2	6.0	5.9
21.250	5.8	5.6	5.5	5.4	5.3	5.1	5.0
23.000	4.9	4.8	4.7	4.5	4.4	4.3	3.8
24.750	2.6	1.5	0.8				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area7	0.080		1.147		12.59	30.20	377.54

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
11.250	0.6	1.1	2.1	5.5	16.9	29.0	28.0
13.000	20.1	13.9	10.3	8.2	7.0	6.1	5.5
14.750	5.0	4.7	4.4	4.1	3.8	3.6	3.3
16.500	3.0	2.8	2.7	2.5	2.4	2.2	2.1
18.250	2.0	1.9	1.8	1.7	1.7	1.6	1.6
20.000	1.6	1.5	1.5	1.5	1.4	1.4	1.4
21.750	1.3	1.3	1.3	1.2	1.2	1.2	1.1
23.500	1.1	1.1	1.1	1.0	0.6		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
annel 5	0.440	Upstream	1.211	58.48	12.80	148.33	337.11

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	0.9	1.4	3.0	5.7	10.4	22.2	62.2
12.500	115.6	145.8	137.8	109.0	81.5	63.0	51.1
14.250	43.1	37.4	33.3	30.3	27.9	25.8	23.9
16.000	22.2	20.4	18.9	17.5	16.4	15.4	14.5
17.750	13.7	12.4	10.7	10.1	9.5	9.1	8.8
19.500	8.5	8.3	8.1	7.9	7.7	7.5	7.3
21.250	7.2	7.0	6.8	6.7	6.5	6.4	6.2
23.000	6.1	5.9	5.8	5.6	5.5	5.2	4.4
24.750	2.6	1.5	0.8				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 5	0.440	Downstream	1.211	58.48	12.80	148.31	337.07

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	0.9	1.5	3.0	5.7	10.3	22.1	62.1
12.500	115.5	145.8	137.8	109.0	81.6	63.0	51.1
14.250	43.1	37.4	33.3	30.3	27.9	25.9	23.9
16.000	22.2	20.4	18.9	17.5	16.4	15.4	14.5
17.750	13.7	12.4	10.7	10.1	9.5	9.1	8.8
19.500	8.5	8.3	8.1	7.9	7.7	7.5	7.3
21.250	7.2	7.0	6.8	6.7	6.5	6.4	6.2
23.000	6.1	5.9	5.8	5.6	5.5	5.2	4.4
24.750	2.6	1.5	0.8				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area6	0.100		1.398		12.49	51.07	510.73

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.500	0.8	1.2	1.7	2.3	3.3	5.3	12.7
12.250	35.6	51.0	40.7	26.4	17.7	13.1	10.7
14.000	9.3	8.2	7.4	6.9	6.5	6.1	5.7
15.750	5.3	4.8	4.4	4.1	3.8	3.6	3.4
17.500	3.2	3.1	2.9	2.7	2.5	2.5	2.4
19.250	2.3	2.3	2.2	2.2	2.1	2.0	2.0

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
21.000	2.0	1.9	1.9	1.8	1.8	1.7	1.7
22.750	1.7	1.6	1.6	1.5	1.5	1.4	1.2
24.500	0.7						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 6	0.100	Upstream	1.398	57.85	12.49	51.07	510.73

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.500	0.8	1.2	1.7	2.3	3.3	5.3	12.7
12.250	35.6	51.0	40.7	26.4	17.7	13.1	10.7
14.000	9.3	8.2	7.4	6.9	6.5	6.1	5.7
15.750	5.3	4.8	4.4	4.1	3.8	3.6	3.4
17.500	3.2	3.1	2.9	2.7	2.5	2.5	2.4
19.250	2.3	2.3	2.2	2.2	2.1	2.0	2.0
21.000	2.0	1.9	1.9	1.8	1.8	1.7	1.7
22.750	1.7	1.6	1.6	1.5	1.5	1.4	1.2
24.500	0.7						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 6	0.100	Downstream	1.396	57.85	12.58	50.96	509.62

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.1	1.5	2.1	3.0	4.5	9.6	27.9
12.500	49.7	45.1	29.9	19.6	14.1	11.2	9.6
14.250	8.5	7.6	7.0	6.6	6.2	5.8	5.4
16.000	5.0	4.5	4.2	3.9	3.7	3.5	3.3
17.750	3.1	2.9	2.7	2.6	2.5	2.4	2.3
19.500	2.3	2.2	2.2	2.1	2.1	2.0	2.0
21.250	1.9	1.9	1.8	1.8	1.8	1.7	1.7
23.000	1.6	1.6	1.5	1.5	1.5	1.3	0.8

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.540		1.246		12.74	190.83	353.39

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	1.9	3.0	5.1	8.7	14.9	31.8	90.0
12.500	165.1	190.8	167.7	128.6	95.7	74.3	60.7
14.250	51.5	45.1	40.4	36.9	34.1	31.6	29.3
16.000	27.1	25.0	23.1	21.4	20.1	18.9	17.8
17.750	16.8	15.3	13.5	12.7	12.0	11.5	11.1
19.500	10.8	10.5	10.2	10.0	9.7	9.5	9.3
21.250	9.1	8.9	8.7	8.5	8.3	8.1	7.9
23.000	7.7	7.5	7.3	7.1	6.9	6.5	5.2
24.750	2.6	1.5	0.8				

STORM 10 yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area1	0.070		2.367		12.58	56.51	807.25

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.750	0.6	0.9	1.2	1.6	2.1	2.7	3.4
11.500	4.5	6.7	13.9	35.4	55.3	50.8	35.2
13.250	23.8	17.3	13.6	11.4	9.9	8.8	8.0
15.000	7.5	7.0	6.5	6.0	5.6	5.1	4.7
16.750	4.4	4.1	3.9	3.7	3.5	3.3	3.1
18.500	2.9	2.8	2.7	2.6	2.5	2.5	2.4
20.250	2.3	2.3	2.2	2.2	2.1	2.1	2.0
22.000	2.0	1.9	1.9	1.8	1.8	1.8	1.7
23.750	1.7	1.6	1.4	0.9			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area2	0.230		2.543		12.75	165.71	720.48

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.000	0.6	1.1	1.7	2.5	3.5	4.5	5.8
10.750	7.3	9.2	11.5	14.5	19.8	34.8	76.9
12.500	137.6	165.7	148.6	112.4	83.3	63.7	51.0
14.250	42.4	36.5	32.1	28.9	26.4	24.2	22.3
16.000	20.6	19.0	17.5	16.2	15.1	14.2	13.3
17.750	12.6	11.8	11.1	10.5	9.9	9.5	9.1
19.500	8.9	8.6	8.4	8.2	7.9	7.8	7.6
21.250	7.4	7.2	7.1	6.9	6.7	6.6	6.4
23.000	6.3	6.1	5.9	5.8	5.6	5.3	4.3
24.750	2.9	1.7	1.0	0.5			

Site 4 - Existing Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
.annel 1	0.300	Upstream	2.501	139.47	12.68	217.14	723.81

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.000	0.6	1.1	1.7	2.5	4.4	5.8	7.4
10.750	9.4	11.9	14.9	19.1	26.5	48.9	112.2
12.500	192.7	216.5	183.9	136.2	100.5	77.3	62.4
14.250	52.4	45.2	40.1	36.3	33.3	30.6	28.3
16.000	26.2	24.1	22.2	20.6	19.2	18.1	17.0
17.750	16.1	15.1	14.2	13.3	12.7	12.1	11.7
19.500	11.4	11.1	10.8	10.5	10.2	10.0	9.7
21.250	9.5	9.3	9.1	8.9	8.7	8.5	8.3
23.000	8.1	7.8	7.6	7.4	7.2	6.7	5.3
24.750	3.3	1.7	1.0	0.5			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 1	0.300	Downstream	2.501	139.47	12.75	216.80	722.67

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.8	1.6	2.3	3.6	5.3	7.0	8.9
11.000	11.2	14.0	17.8	23.9	40.3	90.9	174.4
12.750	216.8	195.4	148.3	108.7	82.5	65.8	54.7
14.500	46.9	41.3	37.2	34.1	31.3	28.9	26.7
16.250	24.6	22.7	21.0	19.5	18.4	17.3	16.3
18.000	15.4	14.4	13.5	12.8	12.3	11.8	11.5
19.750	11.2	10.9	10.6	10.3	10.0	9.8	9.6
21.500	9.4	9.2	8.9	8.7	8.5	8.3	8.1
23.250	7.9	7.7	7.5	7.3	6.9	5.7	3.9
25.000	2.0	1.1	0.6				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area3	0.020		2.389		12.30	22.99	1149.36

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.250	0.6	0.7	0.9	1.1	1.4	2.0	3.4
12.000	9.2	22.6	17.3	9.2	5.4	3.9	3.3
13.750	2.9	2.7	2.4	2.3	2.1	2.0	1.9
15.500	1.7	1.6	1.4	1.3	1.2	1.2	1.1

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
17.250	1.1	1.0	0.9	0.9	0.8	0.8	0.8
19.000	0.7	0.7	0.7	0.7	0.7	0.7	0.6
20.750	0.6	0.6	0.6	0.6	0.6	0.6	0.5
22.500	0.5	0.5	0.5				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 2	0.320	Upstream	2.474	91.82	12.75	226.03	706.35

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.8	1.6	2.3	3.6	5.3	7.0	8.9
11.000	11.2	14.0	17.8	23.9	40.3	113.5	191.7
12.750	225.9	200.8	152.2	112.0	85.4	68.5	57.1
14.500	49.2	43.4	39.2	35.9	33.0	30.5	28.2
16.250	26.0	23.9	22.1	20.7	19.4	18.3	17.2
18.000	16.2	15.2	14.3	13.6	13.0	12.6	12.2
19.750	11.8	11.5	11.2	10.9	10.7	10.4	10.2
21.500	10.0	9.7	9.5	9.3	9.1	8.8	8.6
23.250	7.9	7.7	7.5	7.3	6.9	5.7	3.9
25.000	2.0	1.1	0.6				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 2	0.320	Downstream	2.473	91.82	12.75	226.03	706.35

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.6	1.5	2.2	3.5	5.2	6.9	8.8
11.000	11.1	13.9	17.6	23.5	39.0	108.1	188.5
12.750	226.0	202.8	154.5	113.6	86.4	69.2	57.6
14.500	49.5	43.7	39.4	36.1	33.2	30.6	28.3
16.250	26.1	24.0	22.2	20.7	19.5	18.3	17.3
18.000	16.3	15.3	14.4	13.6	13.0	12.6	12.2
19.750	11.9	11.5	11.2	11.0	10.7	10.4	10.2
21.500	10.0	9.7	9.5	9.3	9.1	8.8	8.6
23.250	7.8	7.7	7.5	7.3	6.9	5.8	4.0
25.000	2.0	1.1	0.6				

Site 4 - Existing Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
a4	0.020		2.388		12.27	23.84	1192.08

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.250	0.6	0.7	0.9	1.1	1.5	2.0	3.7
12.000	10.0	23.8	16.5	8.4	5.1	3.7	3.2
13.750	2.9	2.6	2.4	2.2	2.1	2.0	1.8
15.500	1.7	1.6	1.4	1.3	1.2	1.2	1.1
17.250	1.0	1.0	0.9	0.9	0.8	0.8	0.8
19.000	0.7	0.7	0.7	0.7	0.7	0.7	0.6
20.750	0.6	0.6	0.6	0.6	0.6	0.6	0.5
22.500	0.5	0.5	0.5				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 3	0.340	Upstream	2.443	73.58	12.75	234.47	689.63

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.6	1.5	2.2	3.5	5.2	6.9	8.8
11.000	11.1	13.9	17.6	23.5	39.0	131.9	205.0
12.750	234.4	207.9	158.2	116.8	89.3	71.8	60.0
14.500	51.7	45.8	41.4	37.9	34.9	32.2	29.7
16.250	27.4	25.2	23.4	21.8	20.5	19.3	18.2
18.000	17.1	16.1	15.2	14.4	13.8	13.3	12.9
19.750	12.6	12.2	11.9	11.6	11.3	11.0	10.8
21.500	10.5	10.3	10.1	9.8	9.6	9.4	9.1
23.250	7.8	7.7	7.5	7.3	6.9	5.8	4.0
25.000	2.0	1.1	0.6				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 3	0.340	Downstream	2.443	73.58	12.68	233.61	687.10

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.9	1.5	2.2	3.5	5.2	6.8	8.7
11.000	11.0	13.8	17.5	23.3	38.5	132.5	203.9
12.750	233.2	208.7	159.6	117.5	89.6	72.1	60.2
14.500	51.9	45.8	41.4	38.0	34.9	32.2	29.8
16.250	27.4	25.3	23.4	21.9	20.5	19.4	18.2
18.000	17.2	16.1	15.2	14.4	13.8	13.3	12.9

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
19.750	12.6	12.2	11.9	11.6	11.3	11.0	10.8
21.500	10.6	10.3	10.1	9.8	9.6	9.4	9.1
23.250	7.9	7.7	7.5	7.3	7.0	5.8	4.0
25.000	2.0	1.2	0.6				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area5	0.020		2.127		12.39	18.70	934.85

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	0.6	0.8	1.0	1.4	2.3	6.1	16.6
12.500	16.9	10.3	6.1	4.2	3.3	2.9	2.6
14.250	2.3	2.2	2.0	1.9	1.8	1.7	1.5
16.000	1.4	1.3	1.2	1.1	1.1	1.0	1.0
17.750	0.9	0.8	0.8	0.8	0.7	0.7	0.7
19.500	0.7	0.7	0.6	0.6	0.6	0.6	0.6
21.250	0.6	0.6	0.5	0.5	0.5	0.5	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
ıannel 4	0.360	Upstream	2.390	74.18	12.68	245.82	682.82

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.9	1.5	2.2	3.5	5.2	6.8	8.7
11.000	11.0	13.8	17.5	23.3	38.5	132.5	220.7
12.750	243.6	214.8	163.8	120.8	92.5	74.7	62.5
14.500	54.0	47.9	43.4	39.8	36.6	33.8	31.2
16.250	28.7	26.5	24.5	22.9	21.6	20.3	19.1
18.000	18.0	16.9	15.9	15.1	14.5	14.0	13.6
19.750	13.2	12.9	12.5	12.2	11.9	11.6	11.4
21.500	11.1	10.9	10.6	10.4	10.1	9.4	9.1
23.250	7.9	7.7	7.5	7.3	7.0	5.8	4.0
25.000	2.0	1.2	0.6				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Downstream	2.390	74.18	12.75	245.80	682.79

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	1.2	1.4	2.0	3.1	5.1	6.5	8.3
11.000	10.6	13.3	16.7	21.9	34.2	115.8	203.4
12.750	245.7	223.1	173.8	127.7	96.9	77.6	64.5
14.500	55.5	48.9	44.1	40.4	37.2	34.3	31.7
16.250	29.2	26.9	24.9	23.2	21.8	20.5	19.4
18.000	18.2	17.1	16.1	15.3	14.6	14.1	13.7
19.750	13.3	12.9	12.6	12.3	12.0	11.7	11.4
21.500	11.2	10.9	10.7	10.4	10.2	9.7	9.2
23.250	8.0	7.7	7.5	7.3	7.1	6.1	4.4
25.000	2.3	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area7	0.080		2.285		12.55	62.03	775.33

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.000	0.8	1.1	1.6	2.1	2.7	3.5	4.7
11.750	7.1	14.9	38.5	60.9	56.1	39.0	26.5
13.500	19.2	15.1	12.7	11.1	9.8	9.0	8.3
15.250	7.8	7.3	6.8	6.2	5.7	5.3	4.9
17.000	4.6	4.4	4.1	3.9	3.7	3.4	3.2
18.750	3.1	3.0	2.9	2.8	2.8	2.7	2.6
20.500	2.6	2.5	2.4	2.4	2.3	2.3	2.2
22.250	2.2	2.1	2.1	2.0	2.0	1.9	1.9
24.000	1.8	1.6	1.1	0.5			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 5	0.440	Upstream	2.370	59.59	12.75	302.05	686.48

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	1.2	1.4	2.0	3.5	6.2	8.1	10.4
11.000	13.3	16.8	21.4	29.0	49.3	154.2	263.8
12.750	301.8	262.2	200.3	146.9	112.1	90.3	75.6
14.500	65.3	57.9	52.5	48.2	44.4	41.0	37.9
16.250	34.9	32.1	29.8	27.8	26.2	24.7	23.3
18.000	21.9	20.5	19.3	18.4	17.6	17.0	16.5
19.750	16.1	15.6	15.2	14.8	14.5	14.1	13.8
21.500	13.5	13.2	12.9	12.6	12.3	11.8	11.2
23.250	9.9	9.7	9.4	9.1	8.7	7.2	4.8
25.000	2.3	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
.annel 5	0.440	Downstream	2.370	59.58	12.75	302.00	686.37

Line Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	1.2	1.4	2.0	3.5	6.2	8.1	10.4
11.000	13.3	16.8	21.4	29.0	49.3	154.0	263.6
12.750	301.7	262.2	200.4	147.0	112.1	90.3	75.6
14.500	65.3	57.9	52.5	48.2	44.5	41.0	37.9
16.250	34.9	32.1	29.8	27.8	26.2	24.7	23.3
18.000	21.9	20.5	19.3	18.4	17.6	17.0	16.5
19.750	16.1	15.6	15.2	14.8	14.5	14.1	13.8
21.500	13.5	13.2	12.9	12.6	12.3	11.8	11.2
23.250	9.9	9.7	9.4	9.1	8.7	7.2	4.8
25.000	2.3	1.3	0.7				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area6	0.100		2.629		12.47	97.11	971.14

Line Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.000	0.7	1.1	1.5	1.9	2.4	3.0	3.7
10.750	4.6	5.7	7.0	9.0	13.3	28.6	71.6
12.500	97.1	75.0	47.6	31.4	22.9	18.5	15.9
14.250	14.0	12.7	11.7	11.0	10.2	9.5	8.8
16.000	8.1	7.5	6.9	6.4	6.1	5.7	5.4
17.750	5.1	4.8	4.5	4.2	4.1	4.0	3.9
19.500	3.8	3.7	3.6	3.5	3.4	3.3	3.2
21.250	3.2	3.1	3.0	2.9	2.9	2.8	2.7
23.000	2.7	2.6	2.5	2.5	2.4	2.1	1.1

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 6	0.100	Upstream	2.629	58.35	12.47	97.11	971.14

Line Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.000	0.7	1.1	1.5	1.9	2.4	3.0	3.7
10.750	4.6	5.7	7.0	9.0	13.3	28.6	71.6
12.500	97.1	75.0	47.6	31.4	22.9	18.5	15.9
14.250	14.0	12.7	11.7	11.0	10.2	9.5	8.8
16.000	8.1	7.5	6.9	6.4	6.1	5.7	5.4

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
17.750	5.1	4.8	4.5	4.2	4.1	4.0	3.9
19.500	3.8	3.7	3.6	3.5	3.4	3.3	3.2
21.250	3.2	3.1	3.0	2.9	2.9	2.8	2.7
23.000	2.7	2.6	2.5	2.5	2.4	2.1	1.1

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 6	0.100	Downstream	2.627	58.35	12.55	97.00	970.02

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	1.0	1.4	1.8	2.3	2.9	3.6	4.4
11.000	5.4	6.7	8.5	11.9	23.4	60.3	96.2
12.750	81.9	52.7	34.2	24.4	19.3	16.4	14.4
14.500	12.9	11.9	11.1	10.4	9.7	9.0	8.3
16.250	7.6	7.0	6.5	6.1	5.8	5.5	5.2
18.000	4.9	4.6	4.3	4.1	4.0	3.9	3.8
19.750	3.7	3.6	3.5	3.4	3.3	3.2	3.2
21.500	3.1	3.0	3.0	2.9	2.8	2.8	2.7
23.250	2.6	2.5	2.5	2.4	2.2	1.3	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.540		2.418		12.60	391.95	725.84

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	2.2	2.8	3.9	5.8	9.1	11.6	14.8
11.000	18.8	23.4	29.9	40.9	72.9	214.2	359.2
12.750	383.7	315.1	234.6	171.4	131.4	106.8	90.0
14.500	78.2	69.8	63.6	58.6	54.1	50.0	46.2
16.250	42.5	39.1	36.3	34.0	32.0	30.2	28.4
18.000	26.7	25.1	23.6	22.5	21.6	20.9	20.3
19.750	19.7	19.2	18.7	18.2	17.8	17.4	17.0
21.500	16.6	16.2	15.9	15.5	15.1	14.5	13.9
23.250	12.6	12.2	11.9	11.5	10.8	8.5	4.8
25.000	2.3	1.3	0.7				

STORM 50 yr

Site 4 - Existing Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
ea1	0.070		3.647		12.58	87.19	1245.59

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

8.750	0.7	0.9	1.3	1.7	2.1	2.6	3.2
10.500	3.8	4.7	5.7	6.8	8.6	12.1	23.8
12.250	56.9	86.0	77.3	52.9	35.4	25.4	19.8
14.000	16.6	14.3	12.7	11.5	10.7	10.0	9.3
15.750	8.6	8.0	7.3	6.7	6.2	5.9	5.6
17.500	5.2	4.9	4.6	4.3	4.1	3.9	3.8
19.250	3.7	3.6	3.5	3.4	3.3	3.2	3.2
21.000	3.1	3.0	2.9	2.9	2.8	2.7	2.7
22.750	2.6	2.5	2.5	2.4	2.3	2.3	2.0
24.500	1.3	0.6					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area2	0.230		3.857		12.76	251.67	1094.24

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

8.000	0.9	1.4	2.0	2.7	3.6	4.7	6.0
9.750	7.4	9.0	10.8	12.9	15.4	18.4	22.0
11.500	26.8	35.4	58.9	123.2	212.8	251.3	223.0
13.250	167.0	122.6	93.2	74.1	61.3	52.4	45.9
15.000	41.2	37.5	34.3	31.6	29.2	26.9	24.7
16.750	22.8	21.3	20.0	18.8	17.7	16.7	15.6
18.500	14.7	13.9	13.3	12.8	12.4	12.1	11.8
20.250	11.4	11.1	10.9	10.6	10.4	10.1	9.9
22.000	9.7	9.4	9.2	9.0	8.8	8.5	8.3
23.750	8.1	7.8	7.4	6.0	4.1	2.4	1.3
25.500	0.8						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 1	0.300	Upstream	3.807	140.48	12.69	331.75	1105.84

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

8.000	0.9	1.4	2.0	2.7	4.6	6.0	7.6
9.750	9.5	11.6	14.0	16.7	20.1	24.1	28.9
11.500	35.5	47.5	83.0	180.2	298.6	328.5	275.9

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
13.250	202.5	148.1	113.0	90.7	75.6	65.0	57.4
15.000	51.9	47.5	43.6	40.2	37.1	34.2	31.4
16.750	29.1	27.2	25.5	24.0	22.7	21.3	20.0
18.500	18.8	17.8	17.1	16.5	16.0	15.6	15.2
20.250	14.8	14.4	14.0	13.7	13.4	13.1	12.8
22.000	12.5	12.2	11.9	11.6	11.3	11.0	10.7
23.750	10.4	10.1	9.4	7.4	4.7	2.4	1.3
25.500	0.8						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 1	0.300	Downstream	3.806	140.48	12.76	330.88	1102.92

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.000	0.9	1.2	1.8	2.5	4.2	5.6	7.2
9.750	9.0	11.1	13.4	16.0	19.2	23.0	27.6
11.500	33.6	43.6	70.2	150.2	274.2	330.4	292.9
13.250	219.6	159.6	120.3	95.4	78.8	67.3	59.1
15.000	53.1	48.5	44.5	41.0	37.9	34.9	32.1
16.750	29.6	27.6	25.9	24.4	23.0	21.6	20.3
18.500	19.1	18.0	17.3	16.6	16.1	15.7	15.3
20.250	14.9	14.5	14.1	13.8	13.4	13.1	12.8
22.000	12.5	12.2	12.0	11.7	11.4	11.1	10.8
23.750	10.5	10.2	9.7	8.0	5.4	2.8	1.5
25.500	0.9						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area3	0.020		3.722		12.29	35.15	1757.33

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.250	0.6	0.7	0.9	1.0	1.2	1.5	1.8
11.000	2.1	2.6	3.5	5.9	15.0	34.6	25.8
12.750	13.5	7.9	5.6	4.7	4.2	3.8	3.5
14.500	3.2	3.0	2.8	2.6	2.4	2.3	2.1
16.250	1.9	1.8	1.7	1.6	1.5	1.4	1.3
18.000	1.2	1.2	1.1	1.1	1.1	1.0	1.0
19.750	1.0	0.9	0.9	0.9	0.9	0.9	0.8
21.500	0.8	0.8	0.8	0.8	0.7	0.7	0.7
23.250	0.7	0.7	0.6	0.6			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
ıannel 2	0.320	Upstream	3.789	92.52	12.76	343.92	1074.76

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

8.000	0.9	1.2	1.8	2.5	4.2	5.6	7.2
9.750	9.0	11.1	13.4	16.0	19.2	23.0	30.2
11.500	37.1	49.5	85.4	184.6	300.0	343.9	300.8
13.250	225.2	164.3	124.5	99.2	82.3	70.6	62.1
15.000	56.0	51.1	46.9	43.2	39.9	36.7	33.8
16.750	31.3	29.2	27.4	25.8	24.3	22.9	21.5
18.500	20.2	19.1	18.3	17.7	17.1	16.7	16.2
20.250	15.8	15.4	15.0	14.6	14.3	14.0	13.6
22.000	13.3	13.0	12.7	12.4	12.1	11.8	11.4
23.750	11.1	10.8	9.7	8.0	5.4	2.8	1.5
25.500	0.9						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Channel 2	0.320	Downstream	3.789	92.52	12.76	343.92	1074.76

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

8.000	0.8	1.2	1.8	2.5	4.1	5.6	7.1
9.750	9.0	11.0	13.3	15.9	19.0	22.8	30.2
11.500	36.7	48.7	82.8	179.2	295.8	343.8	303.7
13.250	228.4	166.5	125.9	100.1	82.9	71.0	62.4
15.000	56.2	51.3	47.1	43.4	40.1	36.9	33.9
16.750	31.4	29.3	27.5	25.9	24.4	22.9	21.5
18.500	20.2	19.2	18.3	17.7	17.2	16.7	16.2
20.250	15.8	15.4	15.0	14.6	14.3	14.0	13.7
22.000	13.3	13.0	12.7	12.4	12.1	11.8	11.5
23.750	11.1	10.8	9.8	8.1	5.5	2.9	1.5
25.500	0.9						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Peak Flow Time (hr)	Peak Flow Rate (cfs)	Peak Flow Rate (csm)
Area4	0.020		3.723		12.25	36.44	1822.12

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

9.250	0.6	0.7	0.9	1.1	1.3	1.5	1.8
11.000	2.2	2.7	3.6	6.3	16.2	36.4	24.6

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
12.750	12.3	7.3	5.4	4.6	4.2	3.8	3.4
14.500	3.2	3.0	2.8	2.6	2.4	2.2	2.0
16.250	1.9	1.7	1.7	1.6	1.5	1.4	1.3
18.000	1.2	1.1	1.1	1.1	1.0	1.0	1.0
19.750	1.0	0.9	0.9	0.9	0.9	0.9	0.8
21.500	0.8	0.8	0.8	0.8	0.7	0.7	0.7
23.250	0.7	0.7	0.6	0.6			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 3	0.340	Upstream	3.770	74.16	12.69	357.46	1051.36

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.000	0.8	1.2	1.8	2.5	4.1	5.6	7.1
9.750	9.0	11.0	13.3	15.9	19.0	22.8	30.2
11.500	40.3	55.0	99.4	215.2	320.4	356.1	311.1
13.250	233.8	171.1	130.1	103.9	86.4	74.2	65.4
15.000	59.0	53.9	49.5	45.6	42.1	38.7	35.7
16.750	33.0	30.8	29.0	27.3	25.7	24.1	22.7
18.500	21.3	20.2	19.4	18.7	18.2	17.7	17.2
20.250	16.7	16.3	15.9	15.5	15.1	14.8	14.5
22.000	14.1	13.8	13.5	13.1	12.8	12.5	12.1
23.750	11.8	11.4	9.8	8.1	5.5	2.9	1.5
25.500	0.9						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 3	0.340	Downstream	3.770	74.16	12.69	357.23	1050.67

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.000	0.8	1.2	1.7	2.5	4.0	5.6	7.1
9.750	8.9	11.0	13.2	15.8	19.0	22.8	30.1
11.500	40.3	54.7	97.9	212.9	318.9	356.4	312.3
13.250	235.1	172.0	130.7	104.3	86.6	74.4	65.6
15.000	59.1	54.0	49.6	45.7	42.2	38.8	35.7
16.750	33.1	30.9	29.0	27.3	25.7	24.2	22.7
18.500	21.4	20.2	19.4	18.7	18.2	17.7	17.2
20.250	16.7	16.3	15.9	15.5	15.2	14.8	14.5
22.000	14.1	13.8	13.5	13.1	12.8	12.5	12.1
23.750	11.8	11.5	9.8	8.1	5.6	2.9	1.5
25.500	0.9						

Site 4 - Existing Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
ea5	0.020		3.421		12.37	29.46	1473.00

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.750	0.6	0.7	0.9	1.1	1.3	1.6	2.0
11.500	2.7	4.3	10.6	26.6	26.2	15.7	9.1
13.250	6.2	4.9	4.2	3.8	3.4	3.2	3.0
15.000	2.8	2.6	2.4	2.2	2.0	1.9	1.7
16.750	1.6	1.5	1.5	1.4	1.3	1.2	1.1
18.500	1.1	1.0	1.0	1.0	1.0	0.9	0.9
20.250	0.9	0.9	0.9	0.8	0.8	0.8	0.8
22.000	0.8	0.7	0.7	0.7	0.7	0.7	0.7
23.750	0.6	0.6					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Upstream	3.738	75.11	12.69	375.24	1042.33

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.000	0.8	1.2	1.7	2.5	4.0	5.6	7.1
9.750	8.9	11.0	13.2	15.8	19.0	22.8	30.1
11.500	40.3	59.1	108.7	239.4	345.0	372.1	321.4
13.250	241.3	176.9	134.9	108.1	90.0	77.5	68.5
15.000	61.9	56.6	52.0	47.9	44.2	40.7	37.4
16.750	34.7	32.4	30.4	28.7	27.0	25.4	23.8
18.500	22.4	21.3	20.4	19.7	19.1	18.6	18.1
20.250	17.6	17.2	16.7	16.3	16.0	15.6	15.3
22.000	14.9	14.5	14.2	13.8	13.5	13.1	12.8
23.750	12.4	12.1	9.8	8.1	5.6	2.9	1.5
25.500	0.9						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Downstream	3.738	75.11	12.76	374.56	1040.45

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.250	1.1	1.7	2.3	3.6	5.2	6.8	8.6
10.000	10.6	12.8	15.3	18.4	22.0	28.2	38.7
11.750	54.3	95.6	213.6	330.4	374.4	334.1	255.6
13.500	186.6	141.1	112.1	92.8	79.5	69.9	62.9

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
15.250	57.5	52.8	48.6	44.8	41.3	38.0	35.1
17.000	32.8	30.8	29.0	27.3	25.7	24.1	22.7
18.750	21.5	20.6	19.8	19.2	18.7	18.2	17.7
20.500	17.3	16.8	16.4	16.0	15.7	15.3	15.0
22.250	14.6	14.3	13.9	13.5	13.2	12.8	12.5
24.000	12.1	10.7	8.5	6.0	3.4	1.8	1.0

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area7	0.080		3.547		12.57	96.99	1212.41

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.750	0.6	0.8	1.2	1.6	2.1	2.6	3.3
10.500	4.0	4.9	6.0	7.3	9.2	13.1	25.9
12.250	62.7	95.5	86.2	59.1	39.7	28.5	22.3
14.000	18.6	16.1	14.3	13.0	12.1	11.2	10.5
15.750	9.7	9.0	8.2	7.6	7.0	6.6	6.3
17.500	5.9	5.6	5.2	4.9	4.6	4.4	4.3
19.250	4.2	4.0	3.9	3.8	3.7	3.6	3.6
21.000	3.5	3.4	3.3	3.2	3.2	3.1	3.0
22.750	2.9	2.9	2.8	2.7	2.6	2.6	2.3
24.500	1.5	0.7					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 5	0.440	Upstream	3.703	60.75	12.69	464.90	1056.60

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.250	1.1	1.7	2.3	4.4	6.4	8.4	10.7
10.000	13.2	16.1	19.3	23.3	28.0	35.5	47.9
11.750	67.5	121.8	276.4	425.4	460.4	393.3	295.4
13.500	215.2	163.4	130.7	108.9	93.8	82.9	75.0
15.250	68.7	63.3	58.3	53.8	49.5	45.6	42.2
17.000	39.4	37.0	34.9	32.9	30.9	29.0	27.3
18.750	25.9	24.8	24.0	23.3	22.6	22.0	21.4
20.500	20.9	20.4	19.9	19.4	19.0	18.6	18.1
22.250	17.7	17.3	16.8	16.4	16.0	15.6	15.1
24.000	14.7	13.0	10.0	6.7	3.4	1.8	1.0

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Time (hr)	Peak Flow Rate (cfs)	Rate (csm)
ıannel 5	0.440	Downstream	3.703	60.75	12.69	464.90	1056.60

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.250	1.1	1.7	2.3	4.4	6.4	8.4	10.7
10.000	13.2	16.1	19.3	23.3	28.0	35.5	47.9
11.750	67.4	121.6	276.1	425.3	460.5	393.4	295.5
13.500	215.3	163.4	130.8	108.9	93.8	82.9	75.0
15.250	68.7	63.3	58.3	53.8	49.5	45.6	42.2
17.000	39.4	37.0	34.9	32.9	30.9	29.0	27.3
18.750	25.9	24.8	24.0	23.3	22.6	22.0	21.4
20.500	20.9	20.4	19.9	19.4	19.0	18.6	18.1
22.250	17.7	17.3	16.8	16.4	16.0	15.6	15.1
24.000	14.7	13.0	10.0	6.7	3.4	1.8	1.0

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Time (hr)	Peak Flow Rate (cfs)	Rate (csm)
Area6	0.100		3.958		12.46	145.82	1458.15

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.750	0.6	0.9	1.2	1.5	2.0	2.5	3.1
9.500	3.8	4.6	5.4	6.3	7.5	8.9	10.5
11.250	12.5	15.7	22.5	46.3	110.3	145.5	110.5
13.000	69.4	45.4	32.9	26.5	22.7	19.9	17.9
14.750	16.6	15.5	14.4	13.4	12.4	11.4	10.5
16.500	9.6	9.0	8.5	8.0	7.6	7.1	6.7
18.250	6.3	5.9	5.7	5.5	5.4	5.2	5.1
20.000	5.0	4.8	4.7	4.6	4.5	4.4	4.3
21.750	4.2	4.1	4.0	3.9	3.8	3.7	3.6
23.500	3.5	3.4	3.3	2.9	1.6	0.6	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Time (hr)	Peak Flow Rate (cfs)	Rate (csm)
Channel 6	0.100	Upstream	3.958	58.79	12.46	145.82	1458.15

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.750	0.6	0.9	1.2	1.5	2.0	2.5	3.1
9.500	3.8	4.6	5.4	6.3	7.5	8.9	10.5
11.250	12.5	15.7	22.5	46.3	110.3	145.5	110.5
13.000	69.4	45.4	32.9	26.5	22.7	19.9	17.9

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.750	16.6	15.5	14.4	13.4	12.4	11.4	10.5
16.500	9.6	9.0	8.5	8.0	7.6	7.1	6.7
18.250	6.3	5.9	5.7	5.5	5.4	5.2	5.1
20.000	5.0	4.8	4.7	4.6	4.5	4.4	4.3
21.750	4.2	4.1	4.0	3.9	3.8	3.7	3.6
23.500	3.5	3.4	3.3	2.9	1.6	0.6	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 6	0.100	Downstream	3.957	58.78	12.50	145.49	1454.91

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.000	0.8	1.1	1.4	1.9	2.4	3.0	3.7
9.750	4.4	5.2	6.1	7.2	8.6	10.2	12.1
11.500	14.9	20.5	39.0	95.5	145.2	120.0	76.2
13.250	49.0	34.8	27.5	23.3	20.4	18.3	16.8
15.000	15.7	14.6	13.6	12.6	11.6	10.7	9.8
16.750	9.1	8.6	8.1	7.7	7.2	6.8	6.4
18.500	6.0	5.7	5.6	5.4	5.3	5.1	5.0
20.250	4.9	4.7	4.6	4.5	4.4	4.3	4.2
22.000	4.1	4.0	3.9	3.8	3.7	3.6	3.5
23.750	3.4	3.3	3.0	1.8	0.8		

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.540		3.750		12.62	600.21	1111.51

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.000	1.0	2.2	3.1	4.2	6.8	9.4	12.1
9.750	15.1	18.5	22.2	26.5	31.8	38.2	47.6
11.500	62.9	88.0	161.0	371.7	569.6	580.3	469.8
13.250	344.6	250.1	190.9	154.1	129.3	112.1	99.7
15.000	90.7	83.4	76.9	71.0	65.5	60.2	55.3
16.750	51.3	48.0	45.2	42.6	40.1	37.7	35.4
18.500	33.3	31.6	30.4	29.4	28.6	27.8	27.0
20.250	26.3	25.6	25.0	24.4	23.9	23.3	22.8
22.000	22.3	21.7	21.2	20.7	20.1	19.6	19.1
23.750	18.6	18.0	16.0	11.9	7.5	3.4	1.8
25.500	1.0						

STORM 100 yr

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
ea1	0.070		4.269		12.53	101.79	1454.17

Line
Start Time — Flow Values @ time increment of 0.250 hr —
(hr) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs)

8.250	0.6	0.8	1.1	1.5	1.9	2.4	2.9
10.000	3.5	4.2	5.0	6.0	7.2	8.6	10.7
11.750	14.9	28.8	67.4	100.6	90.0	61.3	40.9
13.500	29.3	22.8	19.0	16.4	14.5	13.2	12.2
15.250	11.4	10.6	9.8	9.1	8.3	7.6	7.1
17.000	6.7	6.3	6.0	5.6	5.3	4.9	4.7
18.750	4.5	4.3	4.2	4.1	4.0	3.9	3.8
20.500	3.7	3.6	3.5	3.4	3.3	3.3	3.2
22.250	3.1	3.0	3.0	2.9	2.8	2.7	2.7
24.000	2.6	2.3	1.5	0.7			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area2	0.230		4.491		12.72	292.05	1269.80

Line
Start Time — Flow Values @ time increment of 0.250 hr —
(hr) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs)

7.500	0.8	1.3	1.9	2.6	3.3	4.3	5.4
9.250	6.8	8.3	10.1	12.0	14.2	16.6	19.6
11.000	23.1	27.4	33.1	43.2	70.7	146.1	249.3
12.750	291.7	258.0	192.7	141.1	107.0	84.8	70.1
14.500	59.8	52.4	46.9	42.7	39.0	35.9	33.1
16.250	30.5	28.1	25.9	24.2	22.7	21.3	20.1
18.000	18.9	17.7	16.7	15.8	15.1	14.5	14.1
19.750	13.7	13.3	13.0	12.6	12.3	12.0	11.7
21.500	11.5	11.2	10.9	10.7	10.4	10.2	9.9
23.250	9.6	9.4	9.1	8.9	8.3	6.8	4.6
25.000	2.7	1.5	0.8				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 1	0.300	Upstream	4.438	140.95	12.65	384.82	1282.75

Line
Start Time — Flow Values @ time increment of 0.250 hr —
(hr) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs) (cfs)

7.500	0.8	1.3	1.9	2.6	4.2	5.4	6.9
9.250	8.7	10.7	13.0	15.6	18.4	21.6	25.6
11.000	30.3	36.0	43.8	58.2	99.5	213.4	349.7

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
12.750	381.5	319.3	233.7	170.3	129.8	103.8	86.5
14.500	74.3	65.5	59.1	54.1	49.6	45.7	42.2
16.250	38.8	35.7	33.0	30.9	29.0	27.3	25.7
18.000	24.2	22.7	21.3	20.2	19.4	18.7	18.2
19.750	17.7	17.2	16.7	16.3	15.9	15.5	15.2
21.500	14.8	14.5	14.1	13.8	13.5	13.1	12.8
23.250	12.5	12.1	11.8	11.4	10.6	8.4	5.4
25.000	2.7	1.5	0.8				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 1	0.300	Downstream	4.437	140.95	12.72	384.52	1281.74

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.8	1.2	1.7	2.4	3.7	5.1	6.5
9.250	8.2	10.2	12.4	14.9	17.7	20.8	24.6
11.000	29.1	34.5	41.6	53.5	84.9	179.5	322.7
12.750	384.0	338.8	253.2	183.3	138.0	109.2	90.1
14.500	76.9	67.4	60.5	55.2	50.6	46.6	43.0
16.250	39.6	36.4	33.6	31.3	29.4	27.7	26.1
18.000	24.5	23.0	21.6	20.5	19.6	18.9	18.3
19.750	17.8	17.3	16.8	16.4	16.0	15.6	15.2
21.500	14.9	14.6	14.2	13.9	13.5	13.2	12.9
23.250	12.5	12.2	11.9	11.5	10.9	9.0	6.1
25.000	3.2	1.7	1.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area3	0.020		4.349		12.29	40.89	2044.61

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.750	0.5	0.7	0.8	1.0	1.2	1.4	1.6
10.500	1.9	2.3	2.7	3.2	4.3	7.1	17.8
12.250	40.4	29.8	15.5	9.0	6.4	5.4	4.8
14.000	4.4	4.0	3.7	3.4	3.2	3.0	2.8
15.750	2.6	2.3	2.1	2.0	1.9	1.8	1.7
17.500	1.6	1.5	1.4	1.3	1.3	1.2	1.2
19.250	1.2	1.1	1.1	1.1	1.0	1.0	1.0
21.000	1.0	1.0	0.9	0.9	0.9	0.9	0.8
22.750	0.8	0.8	0.8	0.8	0.7	0.7	

Site 4 - Existing Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
,annel 2	0.320	Upstream	4.418	92.86	12.72	401.17	1253.65

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

7.500	0.8	1.2	1.7	2.4	3.7	5.1	6.5
9.250	8.2	10.2	12.4	14.9	17.7	20.8	24.6
11.000	31.8	37.7	45.9	60.7	102.8	219.4	352.6
12.750	399.6	347.8	259.6	188.7	142.9	113.5	94.1
14.500	80.5	70.8	63.7	58.2	53.4	49.2	45.4
16.250	41.8	38.4	35.5	33.1	31.1	29.3	27.6
18.000	25.9	24.4	22.9	21.7	20.8	20.0	19.4
19.750	18.9	18.4	17.9	17.4	17.0	16.6	16.2
21.500	15.8	15.5	15.1	14.7	14.4	14.0	13.7
23.250	13.3	13.0	12.6	12.2	11.2	9.0	6.1
25.000	3.2	1.7	1.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 2	0.320	Downstream	4.418	92.86	12.72	401.17	1253.65

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

7.500	0.6	1.2	1.7	2.4	3.6	5.0	6.5
9.250	8.2	10.1	12.3	14.8	17.5	20.6	24.4
11.000	31.8	37.4	45.4	59.7	99.8	213.3	347.9
12.750	400.0	351.2	263.3	191.2	144.4	114.5	94.8
14.500	81.0	71.2	64.0	58.4	53.6	49.4	45.5
16.250	41.9	38.5	35.6	33.2	31.2	29.4	27.7
18.000	26.0	24.4	22.9	21.7	20.8	20.1	19.5
19.750	18.9	18.4	17.9	17.4	17.0	16.6	16.2
21.500	15.8	15.5	15.1	14.8	14.4	14.0	13.7
23.250	13.3	13.0	12.6	12.3	11.3	9.1	6.2
25.000	3.3	1.8	1.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area4	0.020		4.349		12.26	42.45	2122.56

Line Start Time (hr) — Flow Values @ time increment of 0.250 hr (cfs)

8.750	0.5	0.7	0.8	1.0	1.2	1.4	1.6
10.500	1.9	2.3	2.7	3.3	4.4	7.5	19.3

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
12.250	42.4	28.4	14.1	8.4	6.2	5.3	4.8
14.000	4.3	3.9	3.6	3.4	3.2	3.0	2.8
15.750	2.5	2.3	2.1	2.0	1.9	1.8	1.7
17.500	1.6	1.5	1.4	1.3	1.3	1.2	1.2
19.250	1.2	1.1	1.1	1.1	1.0	1.0	1.0
21.000	1.0	1.0	0.9	0.9	0.9	0.9	0.8
22.750	0.8	0.8	0.8	0.8	0.7	0.7	

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 3	0.340	Upstream	4.397	74.43	12.72	416.37	1224.60

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.6	1.2	1.7	2.4	3.6	5.0	6.5
9.250	8.2	10.1	12.3	14.8	17.5	20.6	24.4
11.000	31.8	40.7	49.8	67.3	119.2	255.0	376.3
12.750	414.2	359.6	269.5	196.5	149.2	118.9	98.7
14.500	84.7	74.6	67.2	61.4	56.4	51.9	47.9
16.250	44.0	40.5	37.5	35.0	32.9	31.0	29.2
18.000	27.4	25.7	24.2	23.0	22.0	21.2	20.6
19.750	20.0	19.5	19.0	18.5	18.0	17.6	17.2
21.500	16.8	16.4	16.0	15.6	15.2	14.9	14.5
23.250	14.1	13.7	13.3	13.0	11.3	9.1	6.2
25.000	3.3	1.8	1.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 3	0.340	Downstream	4.397	74.43	12.72	416.37	1224.60

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.5	1.2	1.7	2.4	3.5	5.0	6.4
9.250	8.1	10.1	12.3	14.8	17.5	20.6	24.3
11.000	31.7	40.5	49.6	66.9	117.7	252.5	374.7
12.750	414.4	361.0	271.0	197.5	149.9	119.3	99.0
14.500	84.9	74.7	67.3	61.5	56.4	52.0	47.9
16.250	44.1	40.6	37.6	35.0	32.9	31.0	29.2
18.000	27.4	25.7	24.2	23.0	22.0	21.2	20.6
19.750	20.0	19.5	19.0	18.5	18.0	17.6	17.2
21.500	16.8	16.4	16.0	15.6	15.3	14.9	14.5
23.250	14.1	13.7	13.4	13.0	11.3	9.2	6.2
25.000	3.3	1.8	1.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
ea5	0.020		4.029		12.36	34.68	1734.03

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
9.500	0.7	0.8	1.0	1.2	1.4	1.7	2.1
11.250	2.6	3.4	5.3	12.8	31.6	30.6	18.2
13.000	10.5	7.1	5.6	4.8	4.4	3.9	3.6
14.750	3.4	3.2	3.0	2.7	2.5	2.3	2.1
16.500	2.0	1.9	1.8	1.7	1.6	1.5	1.4
18.250	1.3	1.2	1.2	1.2	1.1	1.1	1.1
20.000	1.1	1.0	1.0	1.0	1.0	0.9	0.9
21.750	0.9	0.9	0.9	0.8	0.8	0.8	0.8
23.500	0.7	0.7	0.7	0.5			

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Upstream	4.364	75.55	12.65	436.38	1212.15

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.5	1.2	1.7	2.4	3.5	5.0	6.4
9.250	8.1	10.1	12.3	14.8	17.5	20.6	24.3
11.000	31.7	40.5	53.0	72.2	130.6	283.8	405.2
12.750	432.7	371.5	278.2	203.1	154.7	123.7	102.9
14.500	88.5	78.1	70.5	64.5	59.2	54.5	50.3
16.250	46.2	42.6	39.4	36.8	34.6	32.6	30.7
18.000	28.8	27.0	25.5	24.2	23.2	22.4	21.7
19.750	21.1	20.5	20.0	19.5	19.0	18.5	18.1
21.500	17.7	17.3	16.9	16.5	16.1	15.7	15.3
23.250	14.9	14.5	14.1	13.7	11.9	9.2	6.2
25.000	3.3	1.8	1.0				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 4	0.360	Downstream	4.363	75.55	12.72	436.38	1212.15

Line
Start Time ---------- Flow Values @ time increment of 0.250 hr ----------

(hr)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.750	0.9	1.6	2.2	3.2	4.8	6.2	7.8
9.500	9.7	11.9	14.3	17.0	20.0	23.6	29.9
11.250	37.9	50.8	67.4	115.3	254.2	388.9	435.2
13.000	386.7	294.4	214.2	161.8	128.2	106.0	90.7

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
14.750	79.7	71.7	65.5	60.1	55.3	51.0	46.9
16.500	43.2	39.9	37.2	34.9	32.9	31.0	29.1
18.250	27.3	25.7	24.4	23.3	22.5	21.8	21.2
20.000	20.6	20.1	19.6	19.1	18.6	18.2	17.8
21.750	17.4	17.0	16.6	16.2	15.8	15.4	15.0
23.500	14.5	14.1	13.7	12.4	9.6	6.8	3.9
25.250	2.0	1.1					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Area7	0.080		4.163		12.57	113.68	1421.05

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
8.500	0.7	1.1	1.4	1.9	2.4	3.0	3.7
10.250	4.4	5.3	6.4	7.7	9.2	11.6	16.2
12.000	31.4	74.5	112.1	100.6	68.7	46.0	32.9
13.750	25.6	21.4	18.5	16.4	14.9	13.8	12.9
15.500	12.0	11.1	10.2	9.4	8.6	8.0	7.6
17.250	7.1	6.7	6.4	6.0	5.6	5.3	5.0
19.000	4.9	4.7	4.6	4.5	4.4	4.3	4.1
20.750	4.1	4.0	3.9	3.8	3.7	3.6	3.5
22.500	3.4	3.3	3.3	3.2	3.1	3.0	2.9
24.250	2.6	1.7	0.8				

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Elevation (ft)	Peak Flow Time (hr)	Rate (cfs)	Rate (csm)
Channel 5	0.440	Upstream	4.326	61.26	12.65	541.65	1231.03

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.750	0.9	1.6	2.2	3.8	5.8	7.6	9.7
9.500	12.1	14.9	18.0	21.4	25.3	30.0	37.6
11.250	47.2	62.4	83.7	146.9	328.7	500.9	535.7
13.000	455.4	340.5	247.2	187.4	149.6	124.6	107.0
14.750	94.6	85.5	78.3	72.0	66.4	61.2	56.3
16.500	51.8	48.0	44.8	42.1	39.6	37.3	35.1
18.250	32.9	31.0	29.4	28.2	27.2	26.4	25.7
20.000	25.0	24.3	23.7	23.1	22.6	22.1	21.6
21.750	21.1	20.6	20.1	19.6	19.1	18.6	18.1
23.500	17.6	17.1	16.7	15.1	11.3	7.6	3.9
25.250	2.0	1.1					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
.annel 5	0.440	Downstream	4.326	61.26	12.65	541.62	1230.95

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.750	0.9	1.6	2.2	3.8	5.8	7.6	9.7
9.500	12.1	14.9	18.0	21.4	25.3	30.0	37.6
11.250	47.1	62.3	83.6	146.7	328.4	500.7	535.8
13.000	455.6	340.7	247.3	187.5	149.7	124.6	107.1
14.750	94.6	85.5	78.3	72.1	66.4	61.2	56.3
16.500	51.8	48.0	44.8	42.1	39.7	37.3	35.1
18.250	32.9	31.0	29.4	28.2	27.2	26.4	25.7
20.000	25.0	24.3	23.7	23.1	22.6	22.1	21.6
21.750	21.1	20.6	20.1	19.6	19.1	18.6	18.1
23.500	17.6	17.1	16.7	15.1	11.3	7.6	3.9
25.250	2.0	1.1					

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Area6	0.100		4.598		12.47	169.12	1691.21

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.250	0.6	0.8	1.1	1.5	1.8	2.3	2.8
9.000	3.5	4.2	5.0	5.9	6.9	8.0	9.4
10.750	11.1	13.0	15.3	19.1	27.0	54.7	128.7
12.500	168.3	127.3	79.7	52.0	37.6	30.2	25.8
14.250	22.6	20.4	18.8	17.6	16.4	15.2	14.1
16.000	13.0	11.9	10.9	10.2	9.6	9.1	8.6
17.750	8.1	7.6	7.1	6.7	6.4	6.3	6.1
19.500	5.9	5.8	5.6	5.5	5.3	5.2	5.1
21.250	5.0	4.9	4.8	4.6	4.5	4.4	4.3
23.000	4.2	4.1	4.0	3.9	3.7	3.2	1.8
24.750	0.7						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 6	0.100	Upstream	4.598	58.99	12.47	169.12	1691.21

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.250	0.6	0.8	1.1	1.5	1.8	2.3	2.8
9.000	3.5	4.2	5.0	5.9	6.9	8.0	9.4

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
10.750	11.1	13.0	15.3	19.1	27.0	54.7	128.7
12.500	168.3	127.3	79.7	52.0	37.6	30.2	25.8
14.250	22.6	20.4	18.8	17.6	16.4	15.2	14.1
16.000	13.0	11.9	10.9	10.2	9.6	9.1	8.6
17.750	8.1	7.6	7.1	6.7	6.4	6.3	6.1
19.500	5.9	5.8	5.6	5.5	5.3	5.2	5.1
21.250	5.0	4.9	4.8	4.6	4.5	4.4	4.3
23.000	4.2	4.1	4.0	3.9	3.7	3.2	1.8
24.750	0.7						

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
Channel 6	0.100	Downstream	4.597	58.99	12.52	168.85	1688.48

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.8	1.1	1.4	1.7	2.2	2.7	3.3
9.250	4.1	4.9	5.8	6.7	7.8	9.1	10.7
11.000	12.6	14.8	18.2	24.7	46.6	112.2	168.1
12.750	138.0	87.3	56.0	39.7	31.3	26.5	23.1
14.500	20.7	19.1	17.8	16.6	15.5	14.3	13.2
16.250	12.1	11.1	10.3	9.7	9.2	8.7	8.2
18.000	7.7	7.2	6.8	6.5	6.3	6.1	6.0
19.750	5.8	5.7	5.5	5.4	5.2	5.1	5.0
21.500	4.9	4.8	4.7	4.6	4.4	4.3	4.2
23.250	4.1	4.0	3.9	3.8	3.4	2.1	0.8

Area or Reach Identifier	Drainage Area (sq mi)	Rain Gage ID or Location	Runoff Amount (in)	Peak Flow Elevation (ft)	Time (hr)	Rate (cfs)	Rate (csm)
OUTLET	0.540		4.376		12.65	698.99	1294.42

Line Start Time (hr)	Flow Values @ time increment of 0.250 hr (cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
7.500	0.8	2.0	3.0	4.0	5.9	8.5	10.9
9.250	13.8	17.0	20.7	24.7	29.2	34.4	40.7
11.000	50.2	62.0	80.5	108.5	193.6	440.6	668.4
12.750	673.6	543.0	396.8	287.0	218.8	176.2	147.7
14.500	127.8	113.7	103.3	94.9	87.5	80.7	74.4
16.250	68.4	62.9	58.3	54.5	51.3	48.3	45.5
18.000	42.8	40.1	37.8	35.9	34.5	33.4	32.4
19.750	31.5	30.7	29.9	29.1	28.4	27.7	27.1
21.500	26.5	25.8	25.2	24.6	24.0	23.4	22.8
23.250	22.2	21.6	21.0	20.4	18.5	13.4	8.5
25.000	3.9	2.0	1.1				

Site 4 - Existing Conditions

Area or Reach Identifier	Drainage Area (sq mi)	Alternate	Peak Flow by Storm 2 yr (cfs)	10 yr (cfs)	50 yr (cfs)	100 yr (cfs)
ɜa1	0.07		28.0	56.5	87.2	101.8
Area2	0.23		85.3	165.7	251.7	292.1
Area3	0.02		11.6	23.0	35.1	40.9
Area4	0.02		12.1	23.8	36.4	42.5
Area5	0.02		8.9	18.7	29.5	34.7
Area6	0.10		51.1	97.1	145.8	169.1
Area7	0.08		30.2	62.0	97.0	113.7
Channel 1	0.30		110.7	217.1	331.8	384.8
DOWNSTREAM			110.4	216.8	330.9	384.5
Channel 3	0.34		119.0	234.5	357.5	416.4
DOWNSTREAM			118.9	233.6	357.2	416.4
Channel 4	0.36		123.5	245.8	375.2	436.4
DOWNSTREAM			123.3	245.8	374.6	436.4
Channel 6	0.10		51.1	97.1	145.8	169.1
DOWNSTREAM			51.0	97.0	145.5	168.8
Channel 5	0.44		148.3	302.1	464.9	541.7
DOWNSTREAM			148.3	302.0	464.9	541.6
Channel 2	0.32		114.9	226.0	343.9	401.2
DOWNSTREAM			114.9	226.0	343.9	401.2
OUTLET	0.54		190.8	392.0	600.2	699.0

Appendix B

Existing and Proposed Culvert Design Computations

HY-8 Culvert Analysis Report
Site 4 Existing Conditions
Flows from 0

Headwater Elevation (ft)	Total Discharge (cfs)	Existing Discharge (cfs)	Roadway Discharge (cfs)	Iterations
53.34	0.00	0.00	0.00	1
58.03	69.90	69.90	0.00	1
65.06	139.80	139.80	0.00	1
66.12	209.70	147.68	61.21	7
66.19	279.60	148.23	130.57	5
66.25	349.50	148.67	199.75	4
66.31	419.40	149.07	269.85	4
66.36	489.30	149.42	338.41	3
66.41	559.20	138.92	419.96	4
66.44	600.00	136.46	463.09	3
66.50	699.00	131.00	567.72	3
66.00	146.83	146.83	0.00	Overtopping

Table 1 - Summary of Culvert Flows at Crossing: Site 4 Existing from 0

Rating Curve Plot for Crossing: Site 4 Existing from 0

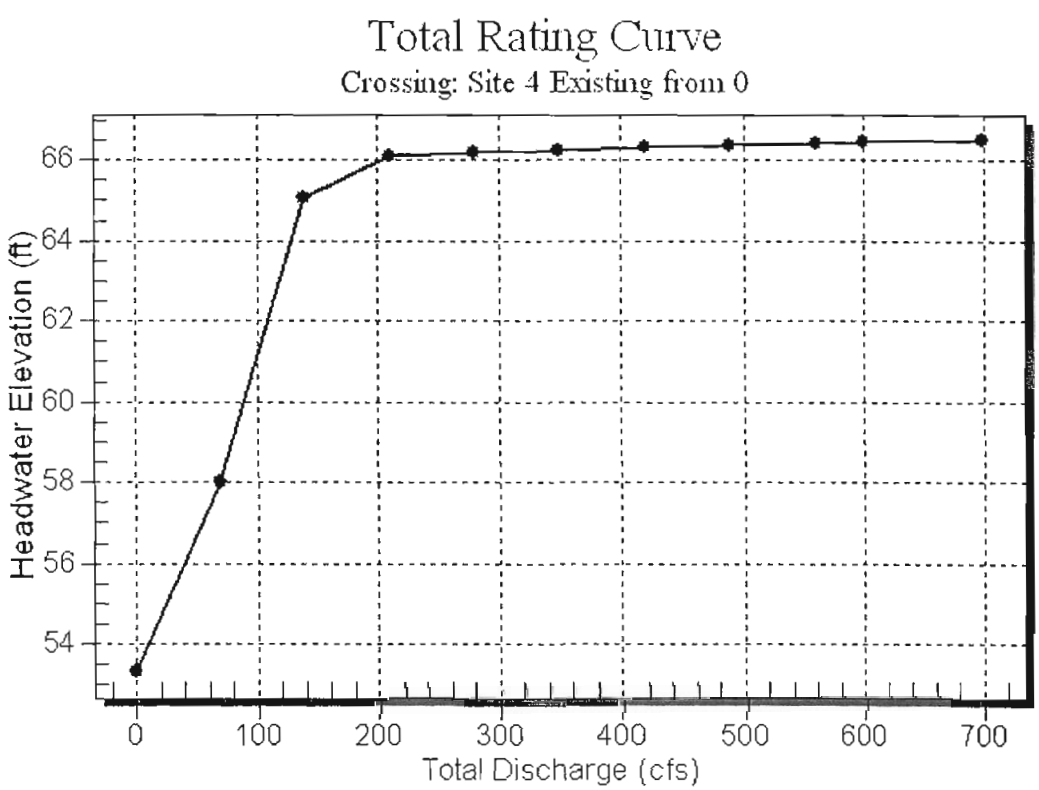


Table 2 - Culvert Summary Table: Existing

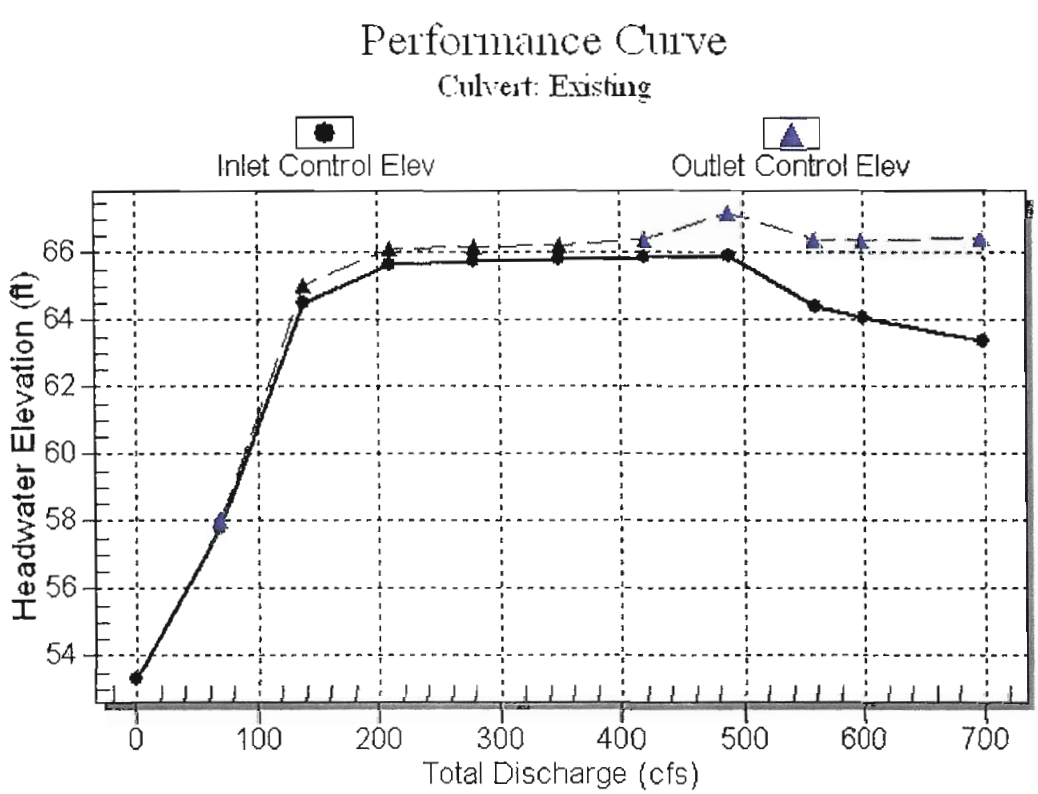
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.34	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
69.90	69.90	58.03	4.464	4.686	7-M2c	3.000	2.461	2.454	0.000	8.902	0.000
139.80	139.80	65.06	11.191	11.721	6-FFc	3.000	3.000	3.000	0.000	14.562	0.000
209.70	147.68	66.12	12.315	12.776	6-FFc	3.000	3.000	3.000	0.000	15.384	0.000
279.60	148.23	66.19	12.394	12.851	6-FFc	3.000	3.000	3.000	1.213	15.440	0.000
349.50	148.67	66.25	12.460	12.913	6-FFc	3.000	3.000	3.000	2.258	15.486	0.000
419.40	149.07	66.31	12.518	13.080	4-FFf	3.000	3.000	3.000	3.112	15.528	0.000
489.30	149.42	66.36	12.570	13.850	4-FFf	3.000	3.000	3.000	3.834	15.564	0.000
559.20	138.92	66.41	11.069	13.066	4-FFf	3.000	3.000	3.000	4.459	14.471	0.000
600.00	136.46	66.44	10.733	13.080	4-FFf	3.000	3.000	3.000	4.789	14.214	0.000
699.00	131.00	66.50	10.009	13.115	4-FFf	3.000	3.000	3.000	5.504	13.646	0.000

* theoretical depth is impractical. Depth reported is corrected.

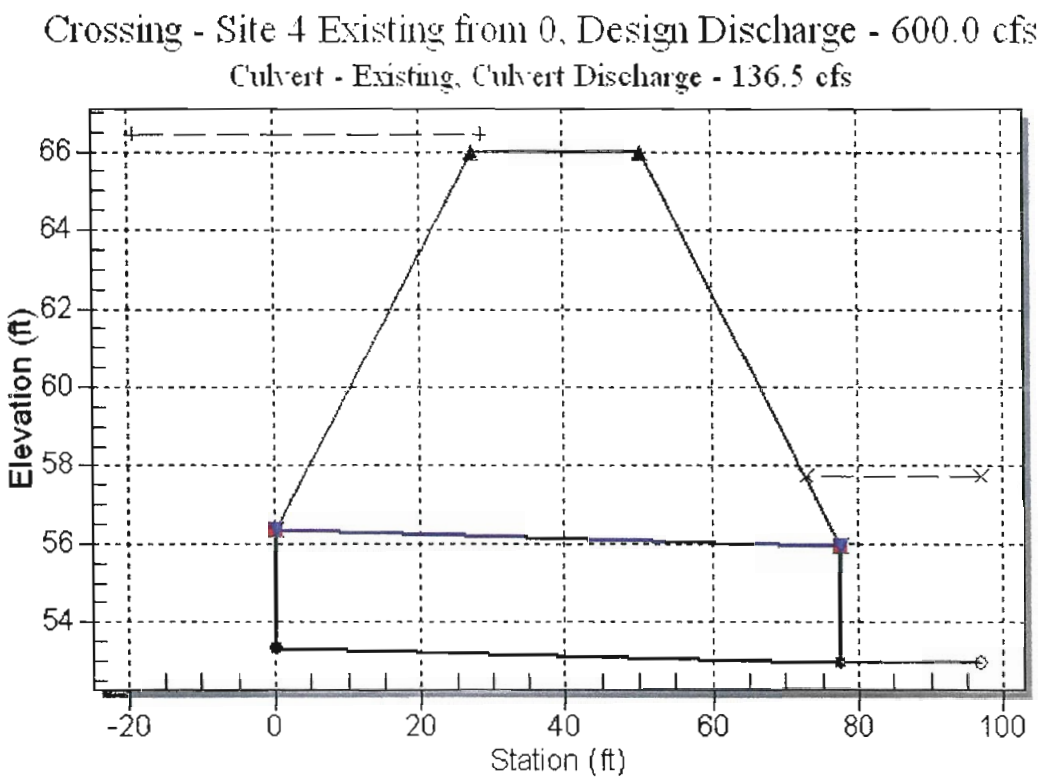
Inlet Elevation (invert): 53.34 ft, Outlet Elevation (invert): 52.96 ft

Culvert Length: 77.45 ft, Culvert Slope: 0.0049

Culvert Performance Curve Plot: Existing



Water Surface Profile Plot for Culvert: Existing



Site Data - Existing

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 53.34 ft

Outlet Station: 77.45 ft

Outlet Elevation: 52.96 ft

Number of Barrels: 1

Culvert Data Summary - Existing

Barrel Shape: Concrete Box

Barrel Span: 3.20 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0200

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Site 4 Existing from 0)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	52.96	0.00
69.90	52.96	0.00
139.80	52.96	0.00
209.70	52.96	0.00
279.60	54.17	1.21
349.50	55.22	2.26
419.40	56.07	3.11
489.30	56.79	3.83
559.20	57.42	4.46
600.00	57.75	4.79
699.00	58.46	5.50

Tailwater Channel Data - Site 4 Existing from 0

Tailwater Channel Option: Enter Rating Curve

Roadway Data for Crossing: Site 4 Existing from 0

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 600.00 ft

Crest Elevation: 66.00 ft

Roadway Surface: Gravel

Roadway Top Width: 23.00 ft

HY-8 Culvert Analysis Report
Triple Arch Existing Tailwater
Flows From 0

Headwater Elevation (ft)	Total Discharge (cfs)	Triple arch Discharge (cfs)	Roadway Discharge (cfs)	Iterations
53.41	0.00	0.00	0.00	1
56.53	43.60	43.60	0.00	1
59.97	87.20	39.90	47.50	5
63.74	130.80	39.83	91.11	5
65.64	174.40	39.84	136.28	3
65.80	218.00	39.85	178.15	38
65.93	261.60	39.87	221.73	31
66.04	305.20	39.88	265.32	27
66.14	348.80	39.89	308.90	24
66.19	375.00	39.90	328.24	14
66.30	436.00	39.92	396.06	4
58.51	66.09	66.09	0.00	Overtopping

Table 1 - Summary of Culvert Flows at Crossing: Triple Arch existing tailwater from 0

Rating Curve Plot for Crossing: Triple Arch existing tailwater from 0

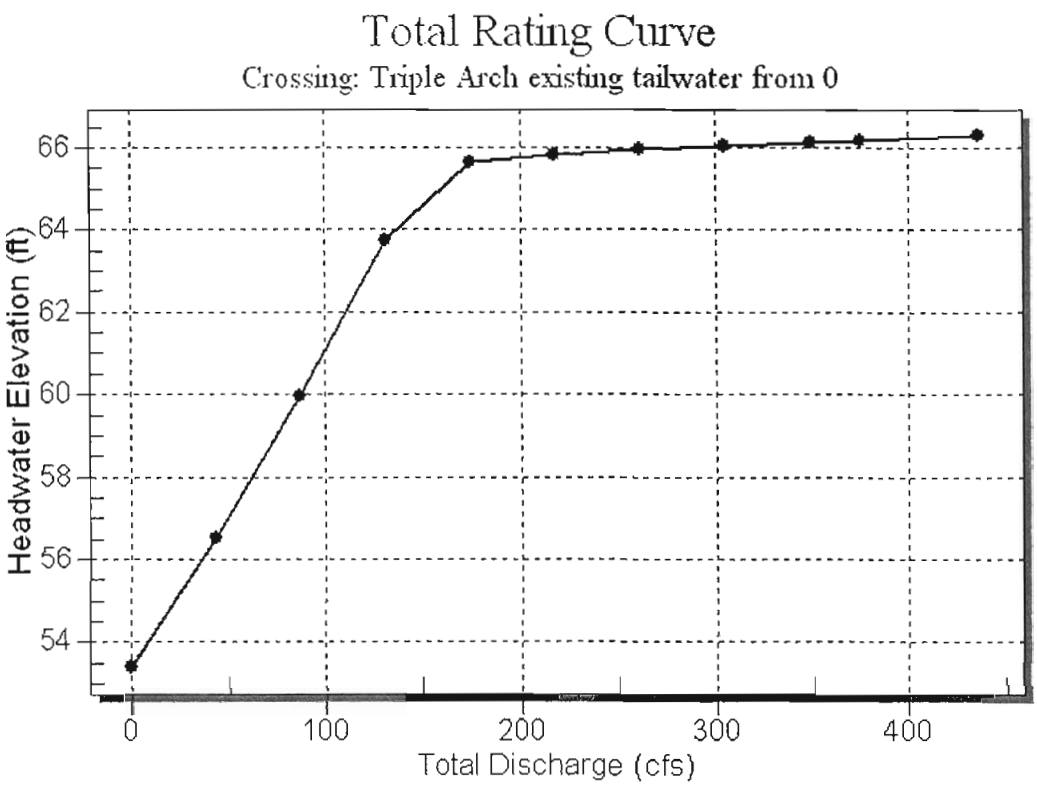


Table 2 - Culvert Summary Table: Triple arch

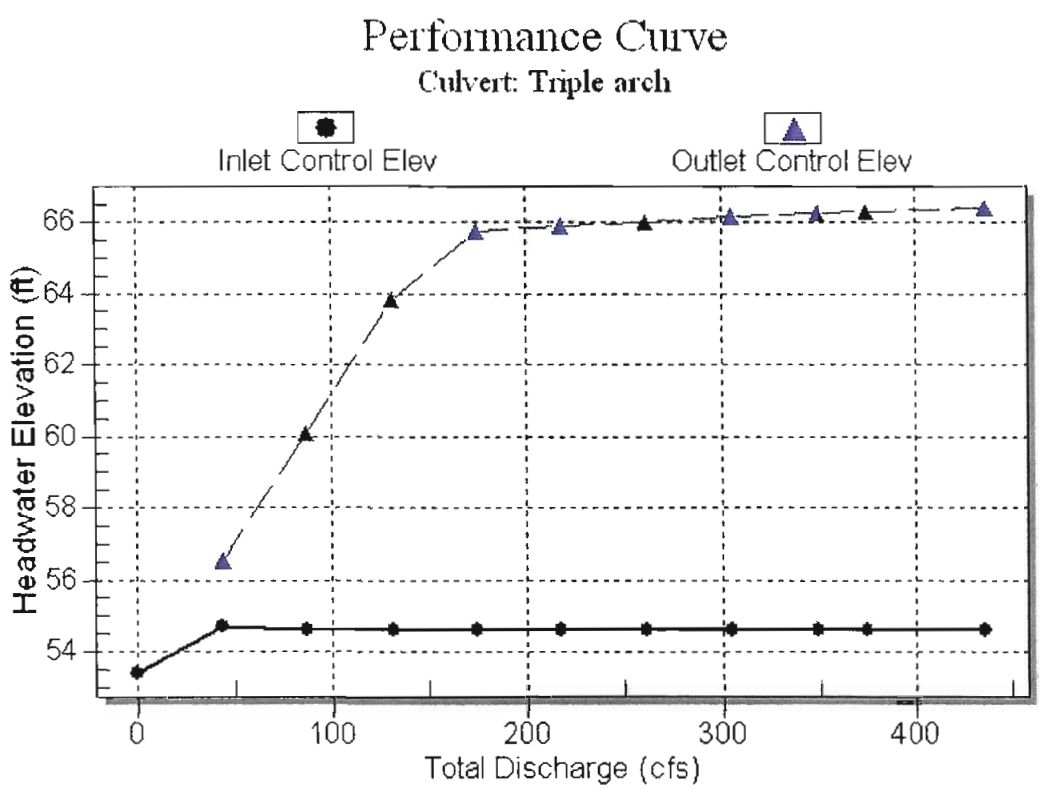
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.41	0.000	0.0*	0-NF	0.000	0.000	0.000	-0.228	0.000	0.000
43.60	43.60	56.53	1.298	3.115	4-FFf	0.853	0.909	2.218	3.112	2.310	0.000
87.20	39.90	59.97	1.223	6.648	4-FFf	0.801	0.862	2.218	6.663	2.114	0.000
130.80	39.83	63.74	1.222	10.421	4-FFf	0.800	0.861	2.218	10.437	2.110	0.000
174.40	39.84	65.64	1.222	12.326	4-FFf	0.800	0.861	2.218	12.342	2.111	0.000
218.00	39.85	65.80	1.222	12.485	4-FFf	0.801	0.862	2.218	12.501	2.111	0.000
261.60	39.87	65.93	1.222	12.615	4-FFf	0.801	0.862	2.218	12.630	2.112	0.000
305.20	39.88	66.04	1.223	12.725	4-FFf	0.801	0.862	2.218	12.740	2.113	0.000
348.80	39.89	66.14	1.223	12.820	4-FFf	0.801	0.862	2.218	12.835	2.114	0.000
375.00	39.90	66.19	1.223	12.872	4-FFf	0.801	0.862	2.218	12.887	2.114	0.000
436.00	39.92	66.30	1.224	12.979	4-FFf	0.802	0.863	2.218	12.994	2.115	0.000

* theoretical depth is impractical. Depth reported is corrected.

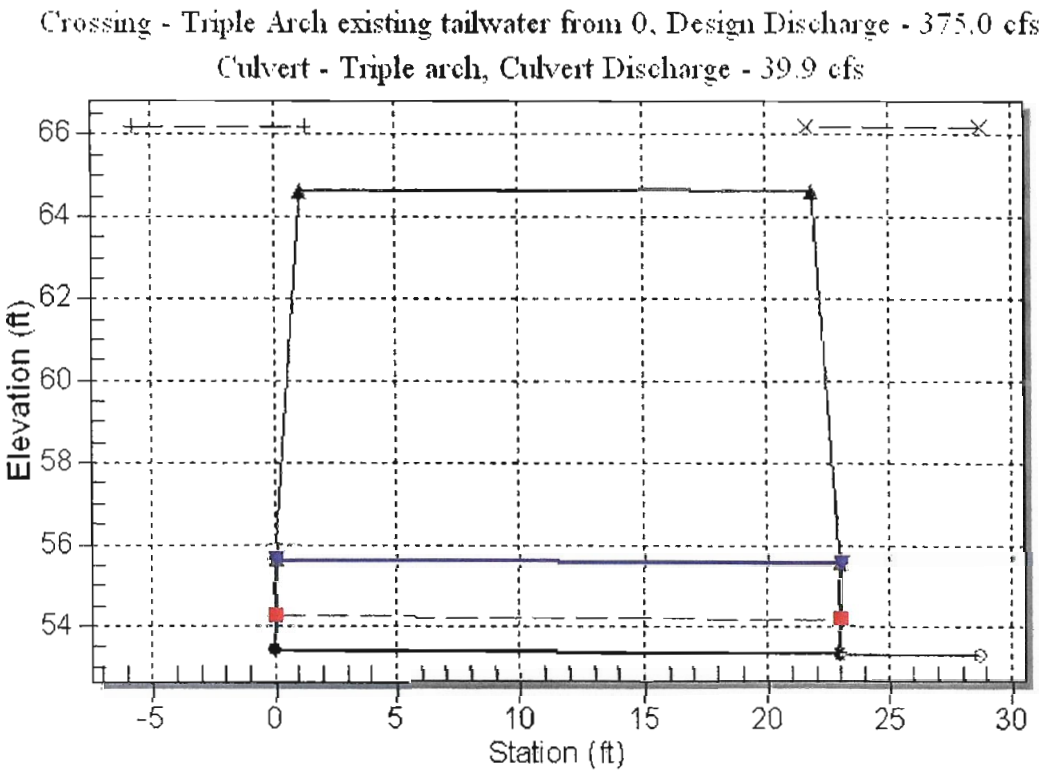
Inlet Elevation (invert): 53.41 ft, Outlet Elevation (invert): 53.32 ft

Culvert Length: 23.00 ft, Culvert Slope: 0.0039

Culvert Performance Curve Plot: Triple arch



Water Surface Profile Plot for Culvert: Triple arch



Site Data - Triple arch

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 53.41 ft

Outlet Station: 23.00 ft

Outlet Elevation: 53.32 ft

Number of Barrels: 3

Culvert Data Summary - Triple arch

Barrel Shape: Pipe Arch

Barrel Span: 43.75 in

Barrel Rise: 26.62 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Grooved Edge Projecting

Inlet Depression: None

Table 3 - **Downstream Channel Rating Curve (Crossing: Triple Arch existing tailwater from 0)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	53.07	-0.23
43.60	56.41	3.11
87.20	59.96	6.66
130.80	63.74	10.44
174.40	65.64	12.34
218.00	65.80	12.50
261.60	65.93	12.63
305.20	66.04	12.74
348.80	66.14	12.84
375.00	66.19	12.89
436.00	66.29	12.99

Tailwater Channel Data - Triple Arch existing tailwater from 0

Tailwater Channel Option: Enter Rating Curve

Roadway Data for Crossing: Triple Arch existing tailwater from 0

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
1	0.00	64.60
2	137.59	60.88
3	148.71	60.44
4	151.53	60.41
5	188.77	60.41
6	356.01	63.52
7	357.09	63.52
8	357.46	63.54
9	394.64	63.82
10	405.61	63.97
11	568.35	59.29
12	682.87	58.51
13	748.66	59.05
14	793.09	59.28
15	826.22	59.11

Coefficient of Discharge: 2.6000

Roadway Top Width: 20.70 ft

HY-8 Culvert Analysis Report
Site 4 Proposed Pipes
Flows From 0

Table 1 - Summary of Culvert Flows at Crossing: Site 4 Proposed Pipes from 0

Headwater Elevation (ft)	Total Discharge (cfs)	Proposed Pipes Discharge (cfs)	Roadway Discharge (cfs)	Iterations
53.25	0.00	0.00	0.00	1
55.56	69.90	69.90	0.00	1
56.59	139.80	139.80	0.00	1
57.42	209.70	209.70	0.00	1
58.16	279.60	279.60	0.00	1
58.85	349.50	349.50	0.00	1
59.51	419.40	419.40	0.00	1
60.16	489.30	489.30	0.00	1
60.83	559.20	559.20	0.00	1
61.23	600.00	600.00	0.00	1
62.42	699.00	699.00	0.00	1
66.00	910.68	910.68	0.00	Overtopping

Rating Curve Plot for Crossing: Site 4 Proposed Pipes from 0

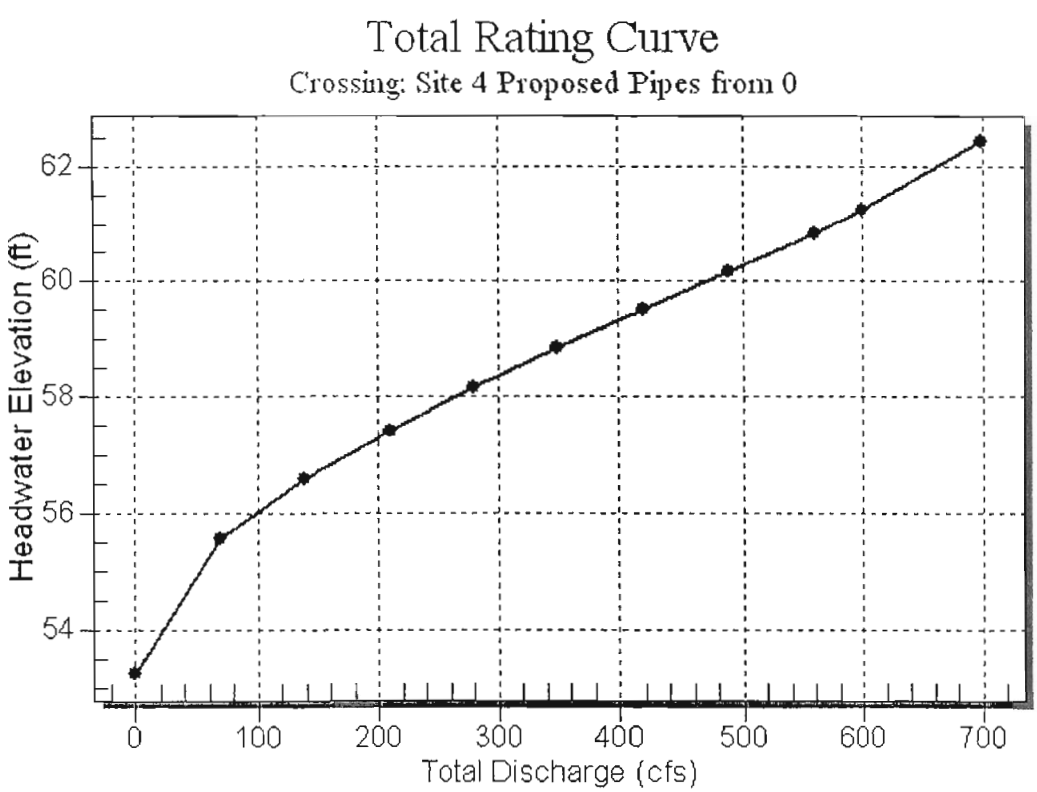


Table 2 - Culvert Summary Table: Proposed Pipes

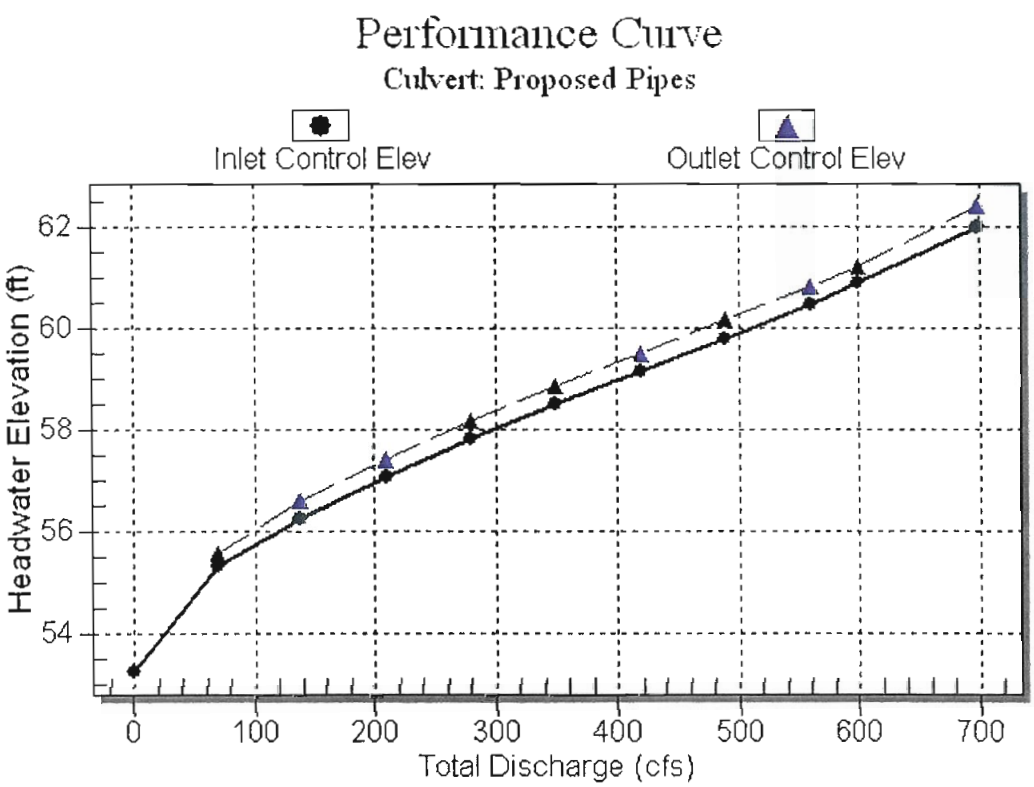
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.25	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
69.90	69.90	55.56	2.078	2.314	2-M2c	1.891	1.498	1.526	0.000	5.889	0.000
139.80	139.80	56.59	3.004	3.341	2-M2c	2.739	2.161	2.180	0.000	7.159	0.000
209.70	209.70	57.42	3.832	4.174	2-M2c	3.469	2.684	2.691	0.000	8.079	0.000
279.60	279.60	58.16	4.578	4.911	2-M2c	4.183	3.118	3.128	1.213	8.849	0.000
349.50	349.50	58.85	5.248	5.601	2-M2c	4.978	3.502	3.515	2.258	9.541	0.000
419.40	419.40	59.51	5.887	6.261	2-M2c	6.500	3.865	3.867	3.112	10.191	0.000
489.30	489.30	60.16	6.531	6.915	2-M2c	6.500	4.176	4.190	3.834	10.819	0.000
559.20	559.20	60.83	7.209	7.580	2-M2c	6.500	4.482	4.488	4.459	11.442	0.000
600.00	600.00	61.23	7.631	7.976	3-M2t	6.500	4.641	4.799	4.789	11.422	0.000
699.00	699.00	62.42	8.756	9.172	7-M2t	6.500	4.997	5.514	5.504	11.646	0.000

* theoretical depth is impractical. Depth reported is corrected.

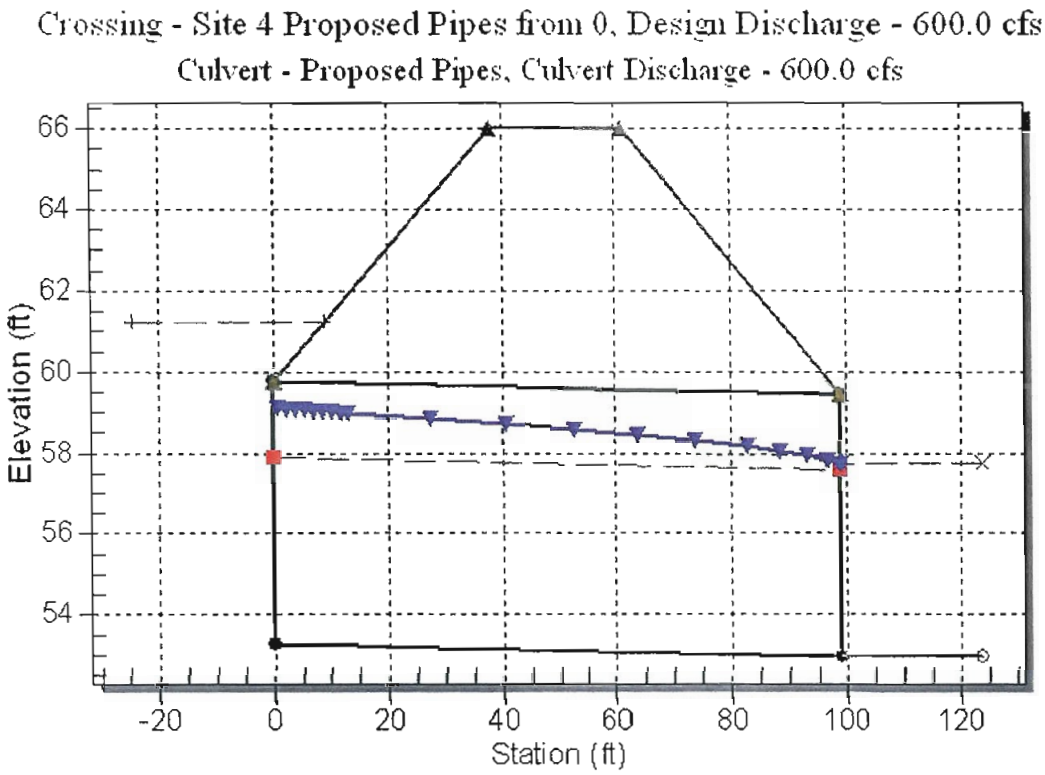
Inlet Elevation (invert): 53.25 ft, Outlet Elevation (invert): 52.95 ft

Culvert Length: 99.00 ft, Culvert Slope: 0.0030

Culvert Performance Curve Plot: Proposed Pipes



Water Surface Profile Plot for Culvert: Proposed Pipes



Site Data - Proposed Pipes

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 53.25 ft

Outlet Station: 99.00 ft

Outlet Elevation: 52.95 ft

Number of Barrels: 2

Culvert Data Summary - Proposed Pipes

Barrel Shape: Circular

Barrel Diameter: 6.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0200

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Site 4 Proposed Pipes from

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	52.96	0.00
69.90	52.96	0.00
139.80	52.96	0.00
209.70	52.96	0.00
279.60	54.17	1.21
349.50	55.22	2.26
419.40	56.07	3.11
489.30	56.79	3.83
559.20	57.42	4.46
600.00	57.75	4.79
699.00	58.46	5.50

0)

Tailwater Channel Data - Site 4 Proposed Pipes from 0

Tailwater Channel Option: Enter Rating Curve

Roadway Data for Crossing: Site 4 Proposed Pipes from 0

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 600.00 ft

Crest Elevation: 66.00 ft

Roadway Surface: Gravel

Roadway Top Width: 23.00 ft

HY-8 Culvert Analysis Report
Triple Arch Tailwater from Proposed Pipes
Flows from 0

Headwater Elevation (ft)	Total Discharge (cfs)	Triple arch Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
53.41	0.00	0.00	0.00	0.00	0
55.91	69.90	69.98	0.00	0.00	4
57.99	139.80	139.85	0.00	0.00	6
60.48	209.70	206.34	3.36	0.00	10
61.06	279.60	200.46	78.99	0.00	4
61.54	349.50	192.97	156.40	0.00	4
61.96	419.40	183.87	235.47	0.00	4
62.34	489.30	173.19	316.06	0.00	4
62.70	559.20	160.39	398.76	0.00	4
62.90	600.00	151.90	448.07	0.00	4
63.42	699.00	115.85	583.15	0.00	4
66.00	1285.00	311.89	973.11	0.00	Overtopping

Table 1 - Summary of Culvert Flows at Crossing: Triple Arch Proposed Pipes Tailwater from 0 larger weir depth

Rating Curve Plot for Crossing: Triple Arch Proposed Pipes Tailwater from 0 larger weir depth

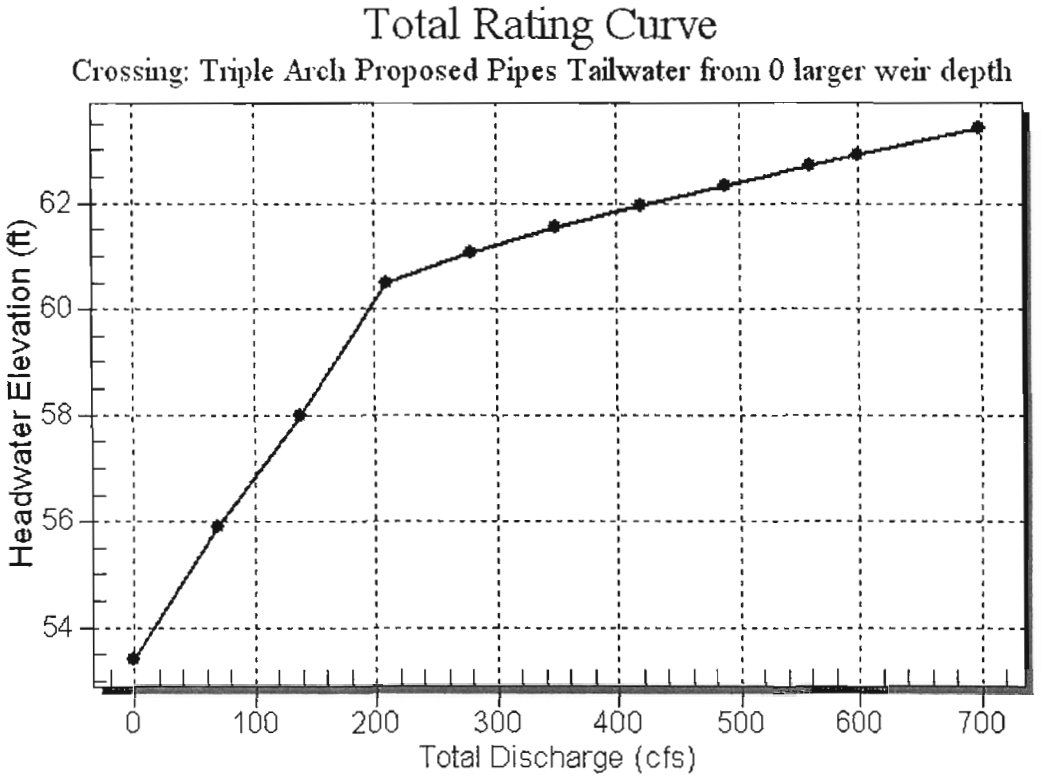


Table 2 - Culvert Summary Table: Triple arch

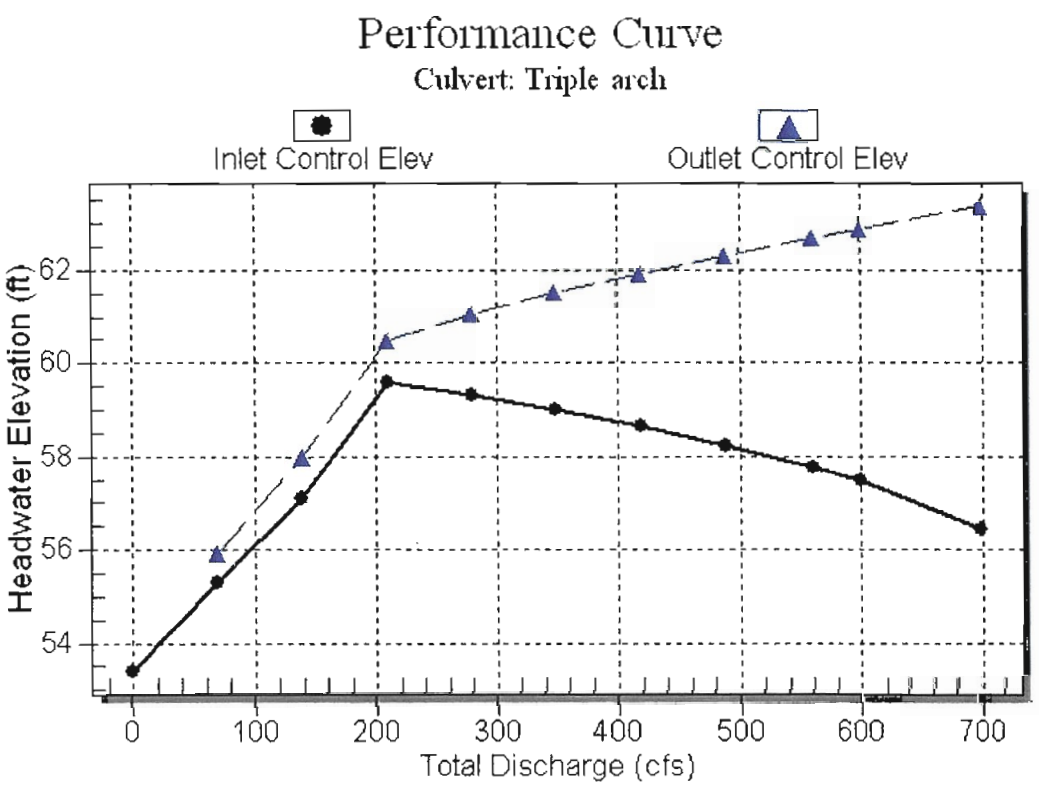
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.41	0.000	0.0*	0-NF	0.000	0.000	0.000	-0.050	0.000	0.000
69.90	69.98	55.91	1.899	2.502	4-FFf	1.121	1.188	2.218	2.260	3.708	0.000
139.80	139.85	57.99	3.695	4.584	4-FFf	2.218	1.751	2.218	3.290	7.410	0.000
209.70	206.34	60.48	6.178	7.066	4-FFf	2.218	2.078	2.218	4.120	10.932	0.000
279.60	200.46	61.06	5.919	7.634	4-FFf	2.218	2.050	2.218	4.860	10.621	0.000
349.50	192.97	61.54	5.601	8.112	4-FFf	2.218	2.014	2.218	5.550	10.224	0.000
419.40	183.87	61.96	5.232	8.526	4-FFf	2.218	1.970	2.218	6.210	9.742	0.000
489.30	173.19	62.34	4.822	8.903	4-FFf	2.218	1.919	2.218	6.860	9.176	0.000
559.20	160.39	62.70	4.364	9.266	4-FFf	2.218	1.857	2.218	7.530	8.498	0.000
600.00	151.90	62.90	4.078	9.476	4-FFf	2.218	1.816	2.218	7.930	8.048	0.000
699.00	115.85	63.42	3.007	9.973	4-FFf	1.710	1.584	2.218	9.120	6.138	0.000

* theoretical depth is impractical. Depth reported is corrected.

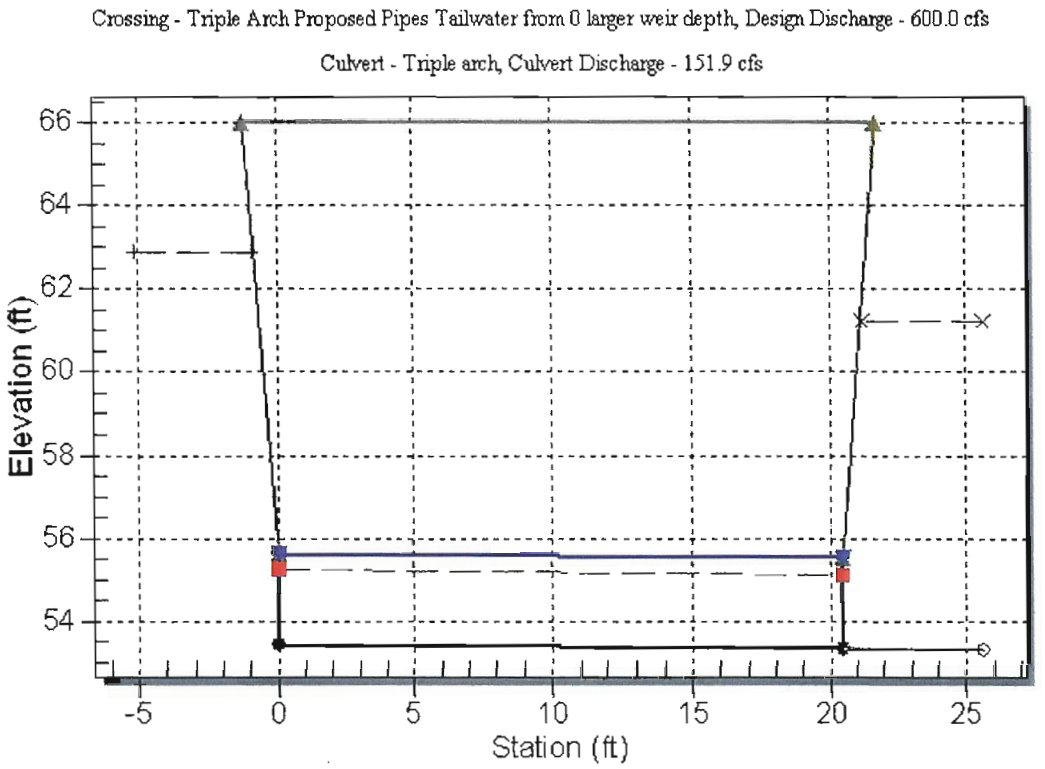
Inlet Elevation (invert): 53.41 ft, Outlet Elevation (invert): 53.32 ft

Culvert Length: 20.50 ft, Culvert Slope: 0.0044

Culvert Performance Curve Plot: Triple arch



Water Surface Profile Plot for Culvert: Triple arch



Site Data - Triple arch

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 53.41 ft

Outlet Station: 20.50 ft

Outlet Elevation: 53.32 ft

Number of Barrels: 3

Culvert Data Summary - Triple arch

Barrel Shape: Pipe Arch

Barrel Span: 43.75 in

Barrel Rise: 26.62 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 3 - Culvert Summary Table: Culvert 1

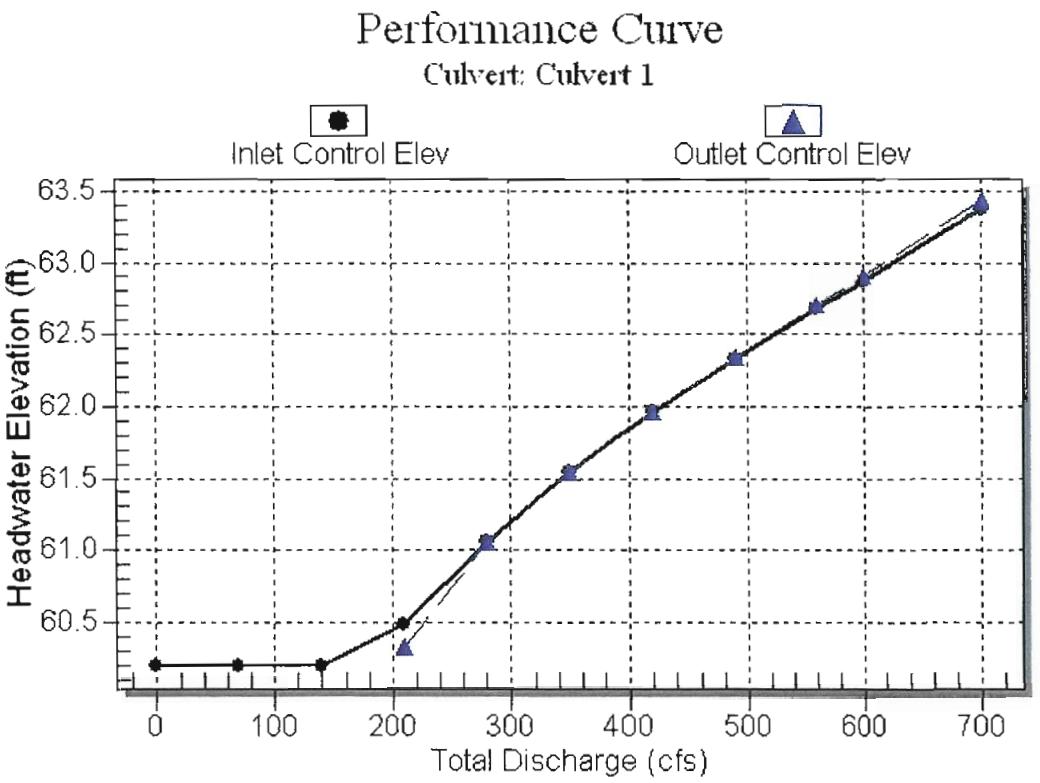
Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.41	0.000	0.0*	0-NF	0.000	0.000	0.000	-0.050	0.000	0.000
69.90	0.00	55.91	0.000	0.0*	0-NF	0.000	0.000	0.000	2.260	0.000	0.000
139.80	0.00	57.99	0.000	0.0*	0-NF	0.000	0.000	0.000	3.290	0.000	0.000
209.70	3.36	60.48	0.282	0.123	2-M2c	0.206	0.060	0.057	4.120	1.482	0.000
279.60	78.99	61.06	0.858	0.857	2-M2c	1.753	0.496	0.492	4.860	4.016	0.000
349.50	156.40	61.54	1.343	1.342	2-M2c	2.685	0.782	0.781	5.550	5.004	0.000
419.40	235.47	61.96	1.763	1.760	2-M2c	3.580	1.027	1.028	6.210	5.726	0.000
489.30	316.06	62.34	2.128	2.141	2-M2c	3.580	1.250	1.248	6.860	6.332	0.000
559.20	398.76	62.70	2.473	2.500	2-M2c	3.580	1.459	1.457	7.530	6.843	0.000
600.00	448.07	62.90	2.668	2.703	2-M2c	3.580	1.577	1.576	7.930	7.107	0.000
699.00	583.15	63.42	3.174	3.232	3-M2t	3.580	1.880	2.221	9.120	6.564	0.000

* theoretical depth is impractical. Depth reported is corrected.

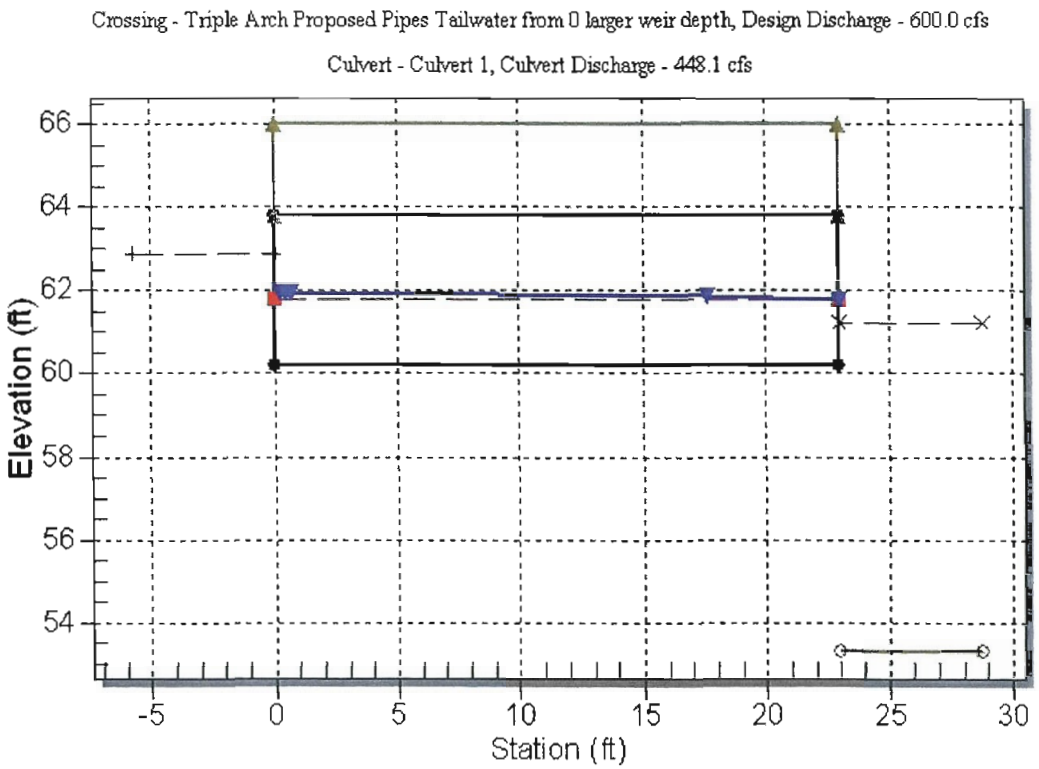
Inlet Elevation (invert): 60.20 ft, Outlet Elevation (invert): 60.20 ft

Culvert Length: 23.00 ft, Culvert Slope: 0.0000

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 60.20 ft

Outlet Station: 23.00 ft

Outlet Elevation: 60.20 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 40.00 ft

Barrel Rise: 3.58 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 4 - Downstream Channel Rating Curve (Crossing: Triple Arch Proposed Pipes

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	53.25	-0.05
69.90	55.56	2.26
139.80	56.59	3.29
209.70	57.42	4.12
279.60	58.16	4.86
349.50	58.85	5.55
419.40	59.51	6.21
489.30	60.16	6.86
559.20	60.83	7.53
600.00	61.23	7.93
699.00	62.42	9.12

Tailwater from 0 larger weir depth)

Tailwater Channel Data - Triple Arch Proposed Pipes Tailwater from 0 larger weir depth

Tailwater Channel Option: Enter Rating Curve

Roadway Data for Crossing: Triple Arch Proposed Pipes Tailwater from 0 larger weir depth

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 600.00 ft

Crest Elevation: 66.00 ft

Roadway Surface: Gravel

Roadway Top Width: 23.00 ft

Appendix C

Channel Protection Computations

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

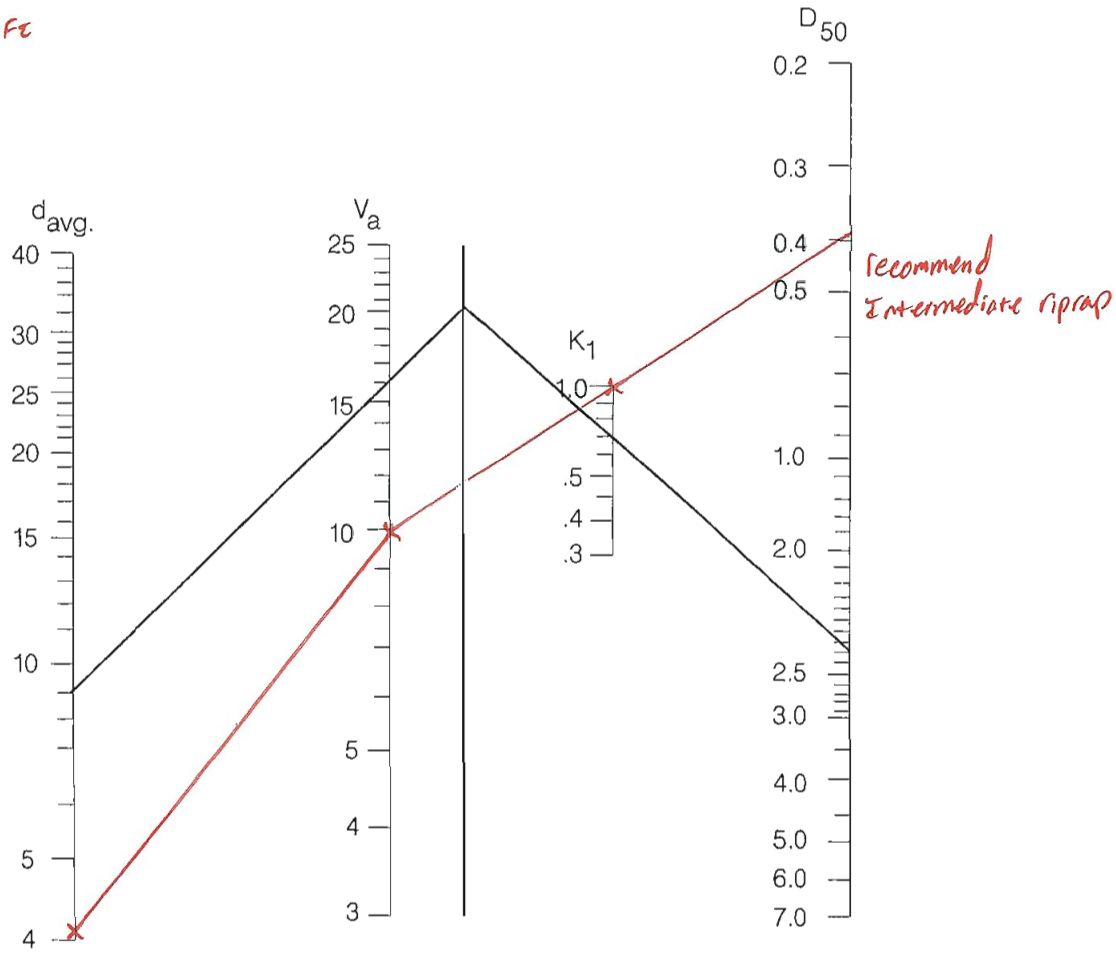
D_{50} = Median Riprap Size (ft.)
V_a = Average velocity in main channel (ft./sec)
$d_{avg.}$ = Average depth in main channel (ft.)
K_1 = Bank angle correction term

Riprap @ Outlet of Triple arch
Max outlet Velocity = 10 Fps
depth @ 10 Fps = 4.1 Ft

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

$\theta = 0.218°$
$\phi = 41°$

$K_1 = 1$



Example:

Given:	Find:	Solution:
V_a = 16 ft./sec.	D_{50}	D_{50} = 2.25
$d_{avg.}$ = 9 ft.		
k_1 = 0.72		

Figure 7-25.1 Riprap Size Relationship (English units)

GM2 Associates

Engineers • Inspectors • Surveyors

Job _____ Computed By S.W.B. Date 8/09

Description _____ Checked By MKL Date 8/15

Sheet ____ of ____

Site 4 Channel Protection – Estimation of Outlet Scour Hole Geometry

@ Station 2+00

Max outlet velocity for 100-yr event 11.6 FPS
recommend <u>standard riprap</u> for Exit velocities between 10 & 14 FPS

Determine limits of lined channel HEC-14 Ch 5
find W_s & L_s width & Length of Scour

$$\frac{W_s}{R_c}, \frac{L_s}{R_c} = C_s C_h \left(\frac{\alpha}{\sigma^{1/3}}\right)\left(\frac{Q}{\sqrt{g}\,(R_c^{2.5})}\right)^{\beta}\left(\frac{t}{316}\right)^{\theta}$$

Length

$$\frac{L_s}{R_c} = \left(\frac{17.10}{1.87^{1/3}}\right)\left(\frac{699}{5.7 \cdot 19.2}\right)^{0.47}\left(\frac{30}{316}\right)^{0.10}$$

$= 13.9 \cdot 2.4 \cdot 0.79$

$L_s = 26.3 \cdot 3.26 = 85.7$ Ft long

$$\frac{W_s}{R_c} = \left(\frac{6.94}{1.87^{1/3}}\right)\left(\frac{699}{5.7 \cdot 19.2}\right)^{0.53}\left(\frac{30}{316}\right)^{0.05}$$

$= 5.6 \cdot 2.7 \cdot 0.82$

$W_s = 40.4'$ wide

... Excessive

(for 2 barrels)

R_c = hydraulic Radius @ End of culvert
$= A/wp$ for 78" Dia Full Flow
$= \cancel{33.2}/20.42 = 1.63' \times 2 = \underline{3.26'}$

Q = Design Flow = 699 CFS

g = 32.2 Ft/s² gravity

t = time Assume 30 min

σ = SD of grain size - Assume 1.87 For Sand

$\alpha_{L_s} = 17.10$

$\beta_{L_s} = 0.47$

$\theta_{L_s} = 0.10$

$C_s = 1.00$

$C_h = 1.00$

$\alpha_{W_s} = 6.94$

$\beta_{W_s} = 0.53$

$\theta_{W_s} = 0.05$

Appendix D

Temporary Conditions Hydraulic Analysis

HY-8 Culvert Analysis Report
Temporary Conditions
Site 4 Stage 1 Construction

Headwater Elevation (ft)	Total Discharge (cfs)	Existing Discharge (cfs)	Roadway Discharge (cfs)	Iterations
53.34	0.00	0.00	0.00	1
54.51	10.00	10.00	0.00	1
55.20	20.00	20.00	0.00	1
55.79	30.00	30.00	0.00	1
56.31	40.00	40.00	0.00	1
56.79	50.00	50.00	0.00	1
57.24	60.00	60.00	0.00	1
58.03	70.00	70.00	0.00	1
58.87	80.00	80.00	0.00	1
59.72	90.00	90.00	0.00	1
60.62	100.00	100.00	0.00	1
66.00	146.83	146.83	0.00	Overtopping

Table 1 - Summary of Culvert Flows at Crossing: Site 4 stage 1 construction

Rating Curve Plot for Crossing: Site 4 stage 1 construction

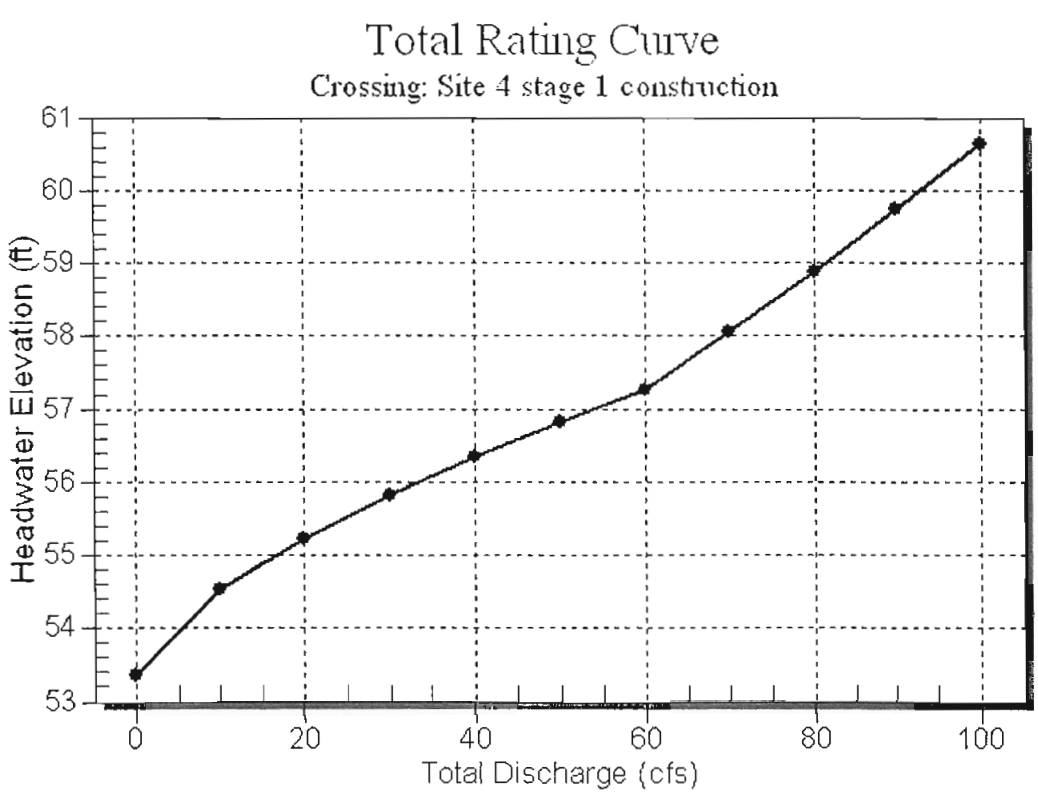


Table 2 - Culvert Summary Table: Existing

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.34	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
10.00	10.00	54.51	1.151	1.172	2-M2c	0.874	0.673	0.673	0.000	4.643	0.000
20.00	20.00	55.20	1.812	1.864	2-M2c	1.440	1.069	1.067	0.000	5.856	0.000
30.00	30.00	55.79	2.359	2.447	2-M2c	1.956	1.401	1.399	0.000	6.702	0.000
40.00	40.00	56.31	2.861	2.969	2-M2c	2.449	1.697	1.692	0.000	7.388	0.000
50.00	50.00	56.79	3.359	3.449	2-M2c	3.000	1.969	1.961	0.000	7.966	0.000
60.00	60.00	57.24	3.887	3.896	2-M2c	3.000	2.223	2.217	0.000	8.458	0.000
70.00	70.00	58.03	4.470	4.694	7-M2c	3.000	2.464	2.456	0.000	8.906	0.000
80.00	80.00	58.87	5.128	5.526	7-M2c	3.000	2.693	2.687	0.000	9.306	0.000
90.00	90.00	59.72	5.871	6.385	7-M2c	3.000	2.913	2.906	0.000	9.679	0.000
100.00	100.00	60.62	6.708	7.277	6-FFc	3.000	3.000	3.000	0.000	10.417	0.000

* theoretical depth is impractical. Depth reported is corrected.

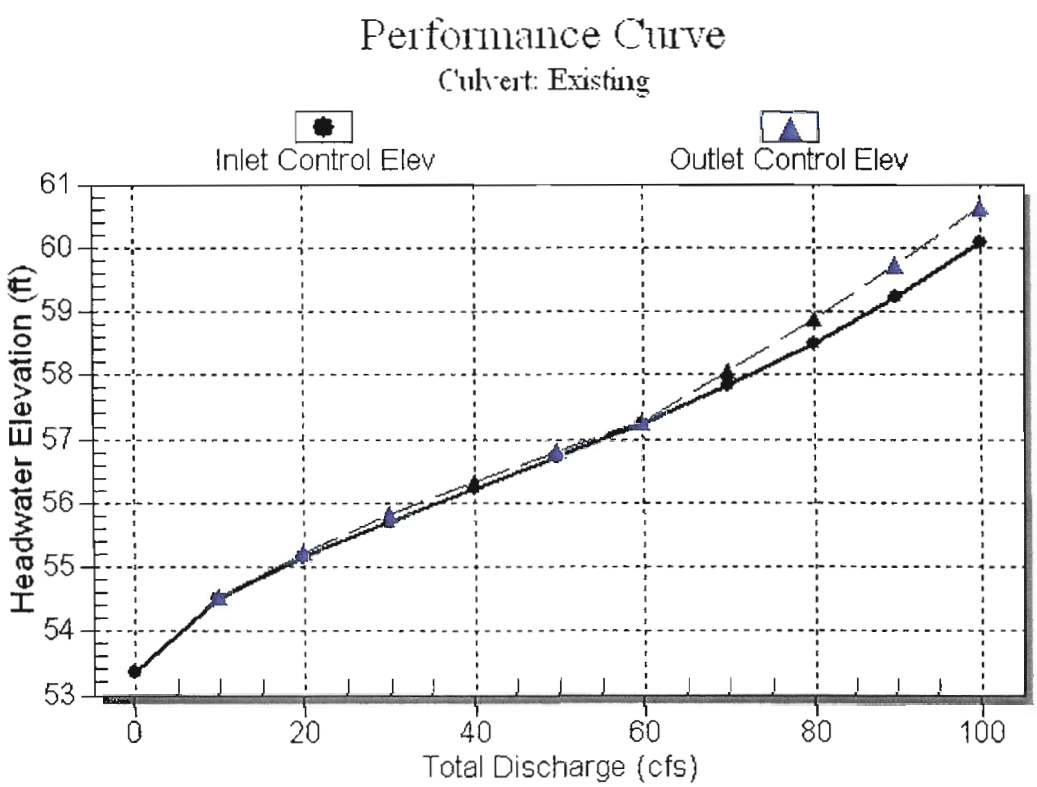
****

Inlet Elevation (invert): 53.34 ft, Outlet Elevation (invert): 52.96 ft

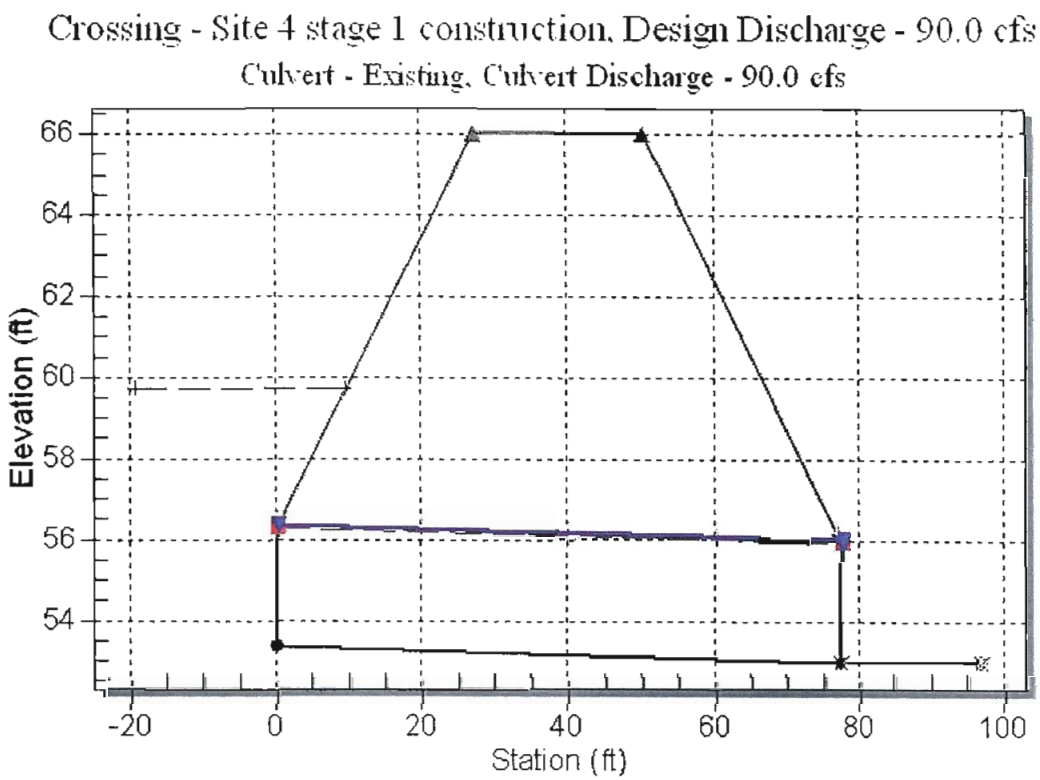
Culvert Length: 77.45 ft, Culvert Slope: 0.0049

****

Culvert Performance Curve Plot: Existing



Water Surface Profile Plot for Culvert: Existing



Site Data - Existing

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 53.34 ft

Outlet Station: 77.45 ft

Outlet Elevation: 52.96 ft

Number of Barrels: 1

Culvert Data Summary - Existing

Barrel Shape: Concrete Box

Barrel Span: 3.20 ft

Barrel Rise: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0200

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Site 4 stage 1 construction)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	52.96	0.00
10.00	52.96	0.00
20.00	52.96	0.00
30.00	52.96	0.00
40.00	52.96	0.00
50.00	52.96	0.00
60.00	52.96	0.00
70.00	52.96	0.00
80.00	52.96	0.00
90.00	52.96	0.00
100.00	52.96	0.00

Tailwater Channel Data - Site 4 stage 1 construction

Tailwater Channel Option: Enter Rating Curve

Roadway Data for Crossing: Site 4 stage 1 construction

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 600.00 ft

Crest Elevation: 66.00 ft

Roadway Surface: Gravel

Roadway Top Width: 23.00 ft

HY-8 Culvert Analysis Report
Temporary Conditions
Triple Arch Stage 1 Construction

Headwater Elevation (ft)	Total Discharge (cfs)	Triple arch Discharge (cfs)	Roadway Discharge (cfs)	Iterations
53.41	0.00	0.00	0.00	1
54.54	10.00	10.00	0.00	1
55.23	20.00	20.00	0.00	1
55.84	30.00	30.00	0.00	1
56.40	40.00	40.00	0.00	1
56.94	50.00	50.00	0.00	1
57.45	60.00	60.00	0.00	1
58.48	70.00	70.00	0.00	1
60.49	80.00	30.35	49.31	3
60.66	90.00	25.93	64.11	6
62.23	100.00	18.04	82.04	3
59.29	75.79	75.79	0.00	Overtopping

Table 1 - Summary of Culvert Flows at Crossing: Triple Arch stage 1 construction

Rating Curve Plot for Crossing: Triple Arch stage 1 construction

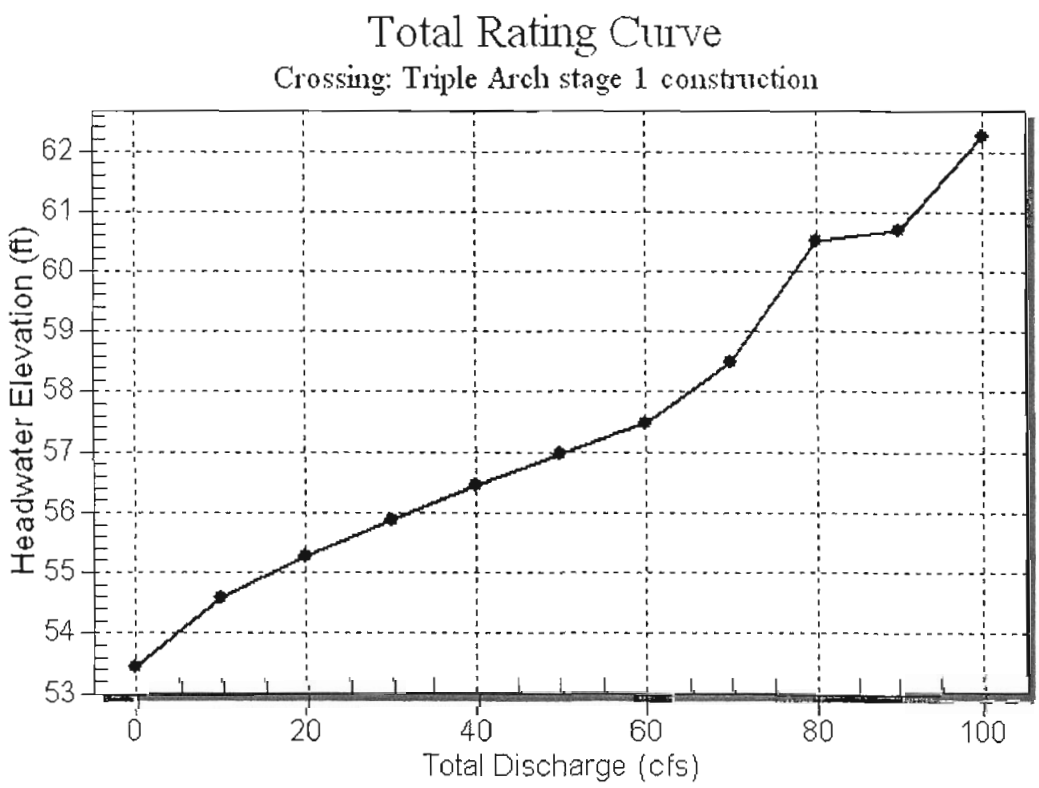


Table 2 - Culvert Summary Table: Triple arch

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	53.41	0.000	0.0*	0-NF	0.000	0.000	0.000	0.040	0.000	0.000
10.00	10.00	54.54	0.549	1.130	1-S1t	0.382	0.402	1.192	1.212	0.870	0.000
20.00	20.00	55.23	0.780	1.822	1-S1t	0.535	0.572	1.884	1.904	1.152	0.000
30.00	30.00	55.84	0.997	2.431	4-FFf	0.662	0.722	2.218	2.487	1.589	0.000
40.00	40.00	56.40	1.225	2.994	4-FFf	0.803	0.864	2.218	3.009	2.119	0.000
50.00	50.00	56.94	1.424	3.528	4-FFf	0.934	0.979	2.218	3.489	2.649	0.000
60.00	60.00	57.45	1.614	4.040	4-FFf	1.050	1.090	2.218	3.936	3.179	0.000
70.00	70.00	58.48	1.799	5.068	4-FFf	1.168	1.188	2.218	4.887	3.709	0.000
80.00	30.35	60.49	1.005	6.144	4-FFf	0.667	0.727	2.218	6.199	1.608	0.000
90.00	25.93	60.66	0.894	7.251	4-FFf	0.610	0.664	2.218	7.321	1.374	0.000
100.00	18.04	62.23	0.740	8.830	4-FFf	0.511	0.542	2.218	8.921	0.956	0.000

* theoretical depth is impractical. Depth reported is corrected.

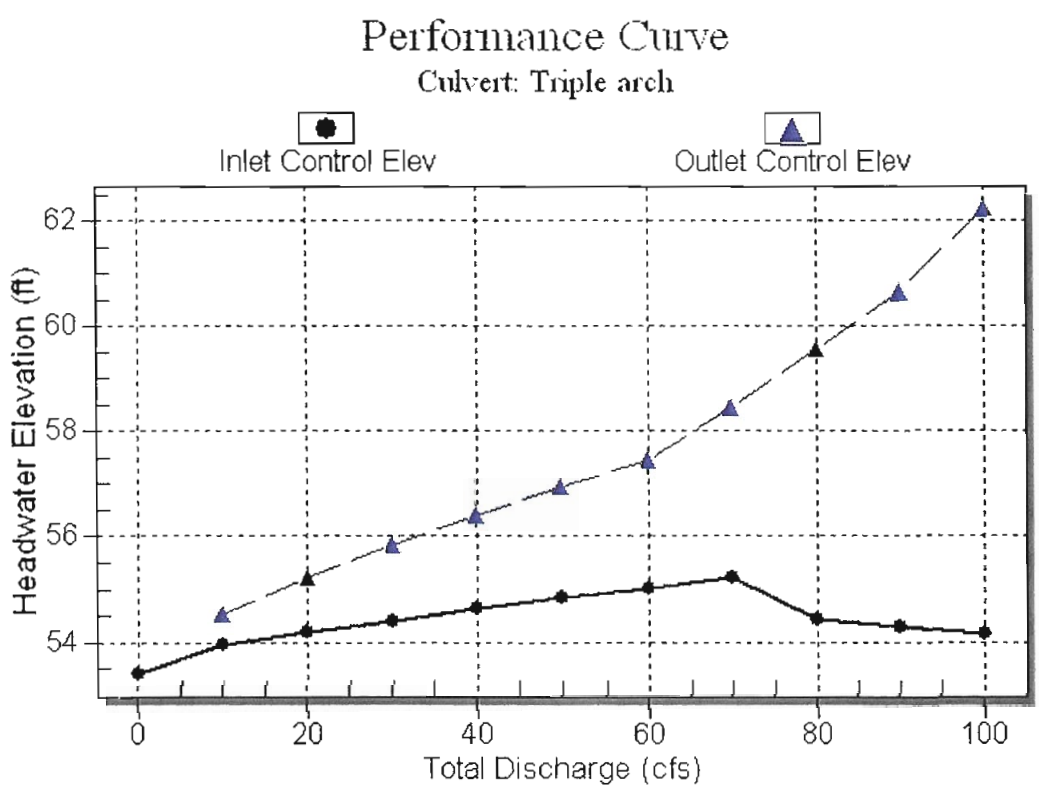
****

Inlet Elevation (invert): 53.41 ft, Outlet Elevation (invert): 53.32 ft

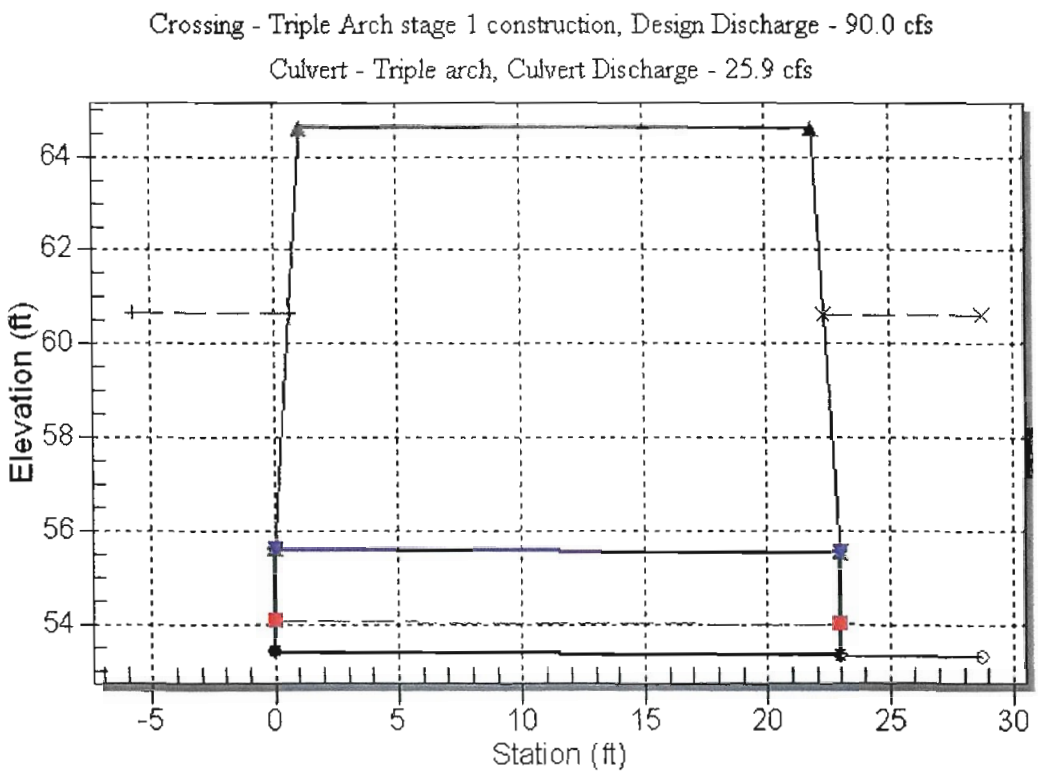
Culvert Length: 23.00 ft, Culvert Slope: 0.0039

****

Culvert Performance Curve Plot: Triple arch



Water Surface Profile Plot for Culvert: Triple arch



Site Data - Triple arch

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 53.41 ft

Outlet Station: 23.00 ft

Outlet Elevation: 53.32 ft

Number of Barrels: 3

Culvert Data Summary - Triple arch

Barrel Shape: Pipe Arch

Barrel Span: 43.75 in

Barrel Rise: 26.62 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Grooved Edge Projecting

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Triple Arch stage 1 construction)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	53.34	0.04
10.00	54.51	1.21
20.00	55.20	1.90
30.00	55.79	2.49
40.00	56.31	3.01
50.00	56.79	3.49
60.00	57.24	3.94
70.00	58.19	4.89
80.00	59.50	6.20
90.00	60.62	7.32
100.00	62.22	8.92

Tailwater Channel Data - Triple Arch stage 1 construction

Tailwater Channel Option: Enter Rating Curve

Roadway Data for Crossing: Triple Arch stage 1 construction

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
1	0.00	64.60
2	137.59	60.88
3	148.71	60.44
4	151.53	60.41
5	188.77	60.41
6	356.01	63.52
7	357.09	63.52
8	357.46	63.54
9	394.64	63.82
10	405.61	63.97
11	549.99	59.29
12	550.00	65.00
13	748.66	65.00
14	793.09	65.00
15	826.22	65.00

Coefficient of Discharge: 2.6000

Roadway Top Width: 20.70 ft

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
Feature carried: Amtrak Railroad
Quadrangle: _____

County: Hartford
Feature crossed: Tributary to Piper Brook
DEP watershed basin no.: 4402-01

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
Overall NBIS structure rating: _____

Year of reconstruction: _____
Sufficiency rating: _____

Plans available?: ☐ yes ☒ no

II. HYDROLOGIC AND HYDRAULIC INFORMATION

Watershed area: 0.54 sq. mi. 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-20	190.8	392.0	600.2	699.0	1188*
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
53.34'	66.0'		66.3	66.4	66.5	66.7

Comments: Existing Stone Box Not Adequate For Computed Design Flows

III. CULVERT DATA

Type

☐ concrete ☒ stone masonry

☐ corrugated metal
- ☐ steel
- ☐ aluminum

structural plate corrugations
- ☐ yes ☐ no
- ☐ 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	38" 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 77' 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:

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

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 Railway Ballast Material

Note the overall adequacy of this protection and note any vegetation near the culvert where root systems may damage the culvert: Embankment and ~~that~~ channel banks well Stabilized, very low amount of 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 and outlet masonry Headwalls appear to be in Fair Condition

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

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	_____	mm (in)	38" x 36"	mm (in)
mid-length	_____	mm (in)	Not Accessible	mm (in)
outlet	_____	mm (in)	38" x 36"	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

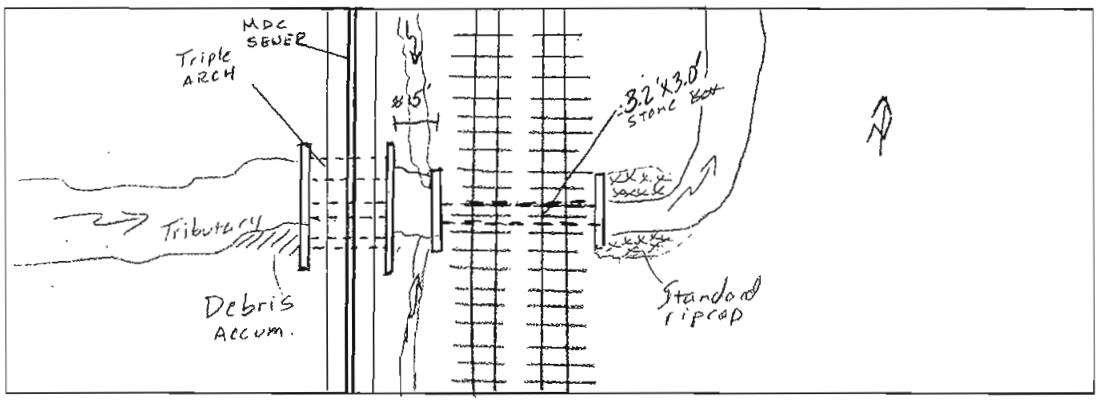
Type:	☐ modified	☐ intermediate	☒ standard	☐ slope paving
	☐ concrete	☐ other	☐ none	
Condition:	☒ good	☐ weathered	☐ slumped	☐ missing
	☐ fair	☐ poor	☐ N/A	

Comments: Standard riprap on receiving channel banks, channel invert appears to be stable or self armored.

* 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.

66.0' - Crest of Railway embankment

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.

No requirements per DEP

VII. PERIPHERAL SITE DATA

A. Hydraulic control - Note location and description.

Subject culvert operates under outlet control as a result of Tailwater from Piper Brook under coordinated flooding resulting from one flood event occurring on the two drainage areas

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

See VI - A, previous Pg.

Comments:

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

0.54 sq. mi. Comprised of residential, commercial and individual properties. Stated to be >30% urbanized.
- GARG 02/08

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.

None Recognized - flows represent no storage

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	$\leq 64.75 km^2$ (25 mi^2)
	Medium	$> 64.75 km^2$ (25 mi^2) and $\leq 259\ km^2$ (100 mi^2)
	Large	$> 259\ km^2$ (100 mi^2)
Streambed slope	Low	≤ 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 = Suburban or Farming	

B. Channel stability

Previous NBIS Item 61 rating: _____

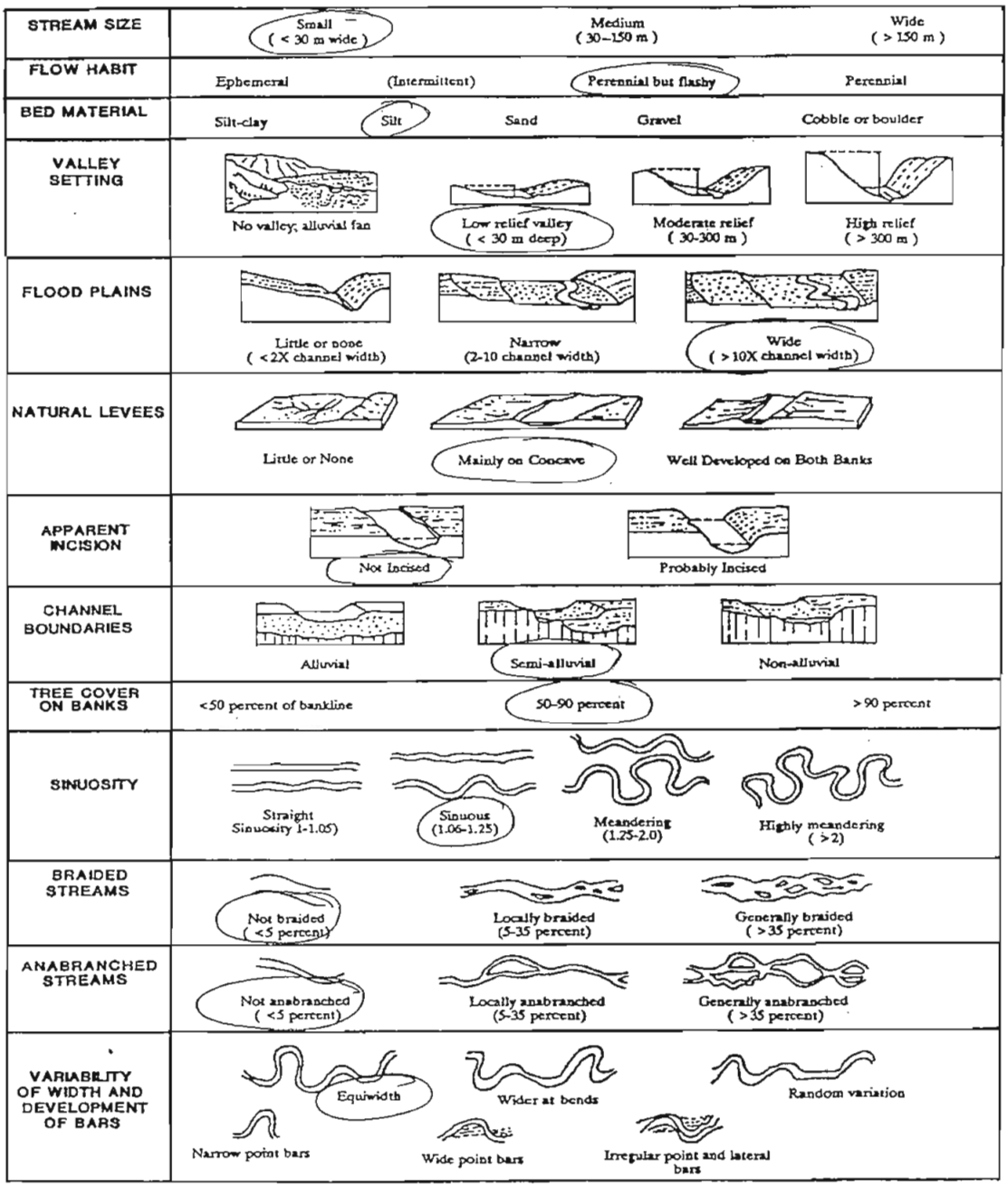
Lateral stability: ☒ stable ☐ unstable

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)



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.

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 - NOT upstream, downstream yes

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: 14 m/s (ft/s)

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
- [x] silt/clay
- [ ] gravel
- [ ] cobble
- [ ] boulders
- [ ] bedrock
- [ ] manmade

Comments: _____

Appendix G – Culvert Design Data Form

Prepared by: Eric Buckley
Date: 1/12/09
Checked:
Date:

Project No. 171-305
Town Newington
Route Amtrak Railroad
Location

1. DRAINAGE AREA

   a) Total area 0.54 sq.mi
   b) Special Considerations Following guidelines set forth by Amtrak, this crossing should be designed to manage flows generated by a 100-yr event regardless of the size of the contributing basin
   c) Existing culverts Single 3'x4' Stone Box culvert

2. DESIGN DISCHARGE 699 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 75-80 T_c (Hr.) 1.9 hrs
      Rainfall distribution: ✓ SCS Type III-24 Hr.
   c) Other _____

3. FISH PASSAGE REQUIRED? _____ Yes No No

   a) Special considerations _____

4. CULVERT HYDRAULIC DATA – Recommended Structure

   a) Size Twin 6.5' dia Type RCP
   b) Maximum permissible headwater elevation 66.0'
   c) Proposed headwater elevation 62.3'
   d) Elevation of channel bed at outlet 53.0' Inlet 53.25'
   e) Length 99' Slope 0.03 ft/ft
   f) Inlet invert elevation 53.25' Outlet 53.0 ft
   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 resulting from static tailwater of corresponding event from Piper Brook

5. MISCELLANEOUS DATA

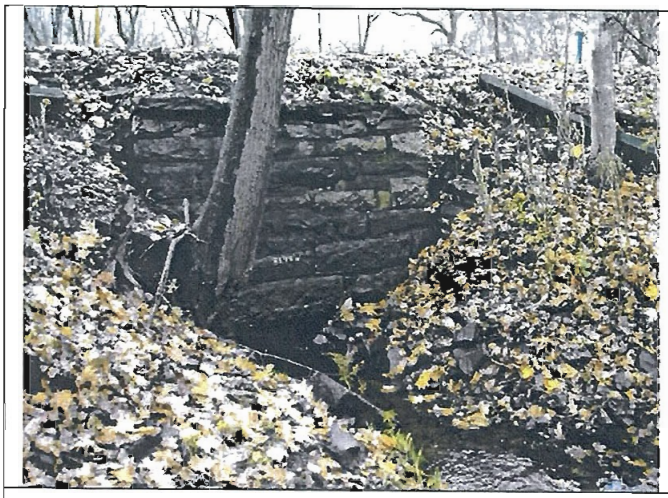
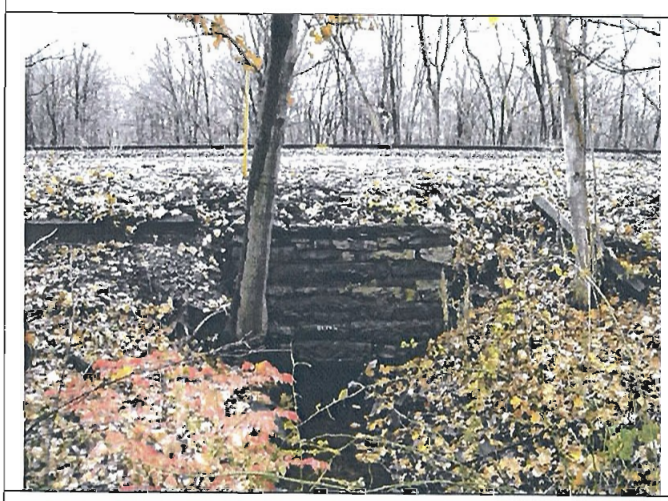
a) Height of cover 6.5' to Tracks
b) Culvert strength requirements: CMP _____ (wall or plate thickness)
RCP 5 (Class)
c) End treatment inlet - Headwall with U shape wingwalls
outlet - endWall with Flared wingwalls
d) Entrance channel Rock Riprap Apron and cutoff wall
e) Outlet channel Pre Formed Scour 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 face of triple arch carrying MDC Sewer Line Note – right cell needs clearing
	Picture 3 Downstream face of existing Triple Arch Culvert – upstream of subject culvert

	Picture 4 Upstream face of existing subject culvert
	Picture 5 Upstream face of existing subject culvert Perspective with tracks.
	Picture 6 Downstream face of existing subject culvert Perspective with tracks

	Picture 7 Outlet channel of existing subject culvert Note – riprap protection along adjacent banks
	Picture 8 Downstream reach of tributary Note – channel bend to the left. This is in contrast with the survey
	Picture 9 Downstream floodplain of tributary Note – no apparent relief channel as survey flow lines indicate

Picture 10
Reach downstream continuing along railway embankment

Picture 11
Aerial of site showing main flow lines running north along embankment then east to Piper Brook. Culvert location represented by white rectangle

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"

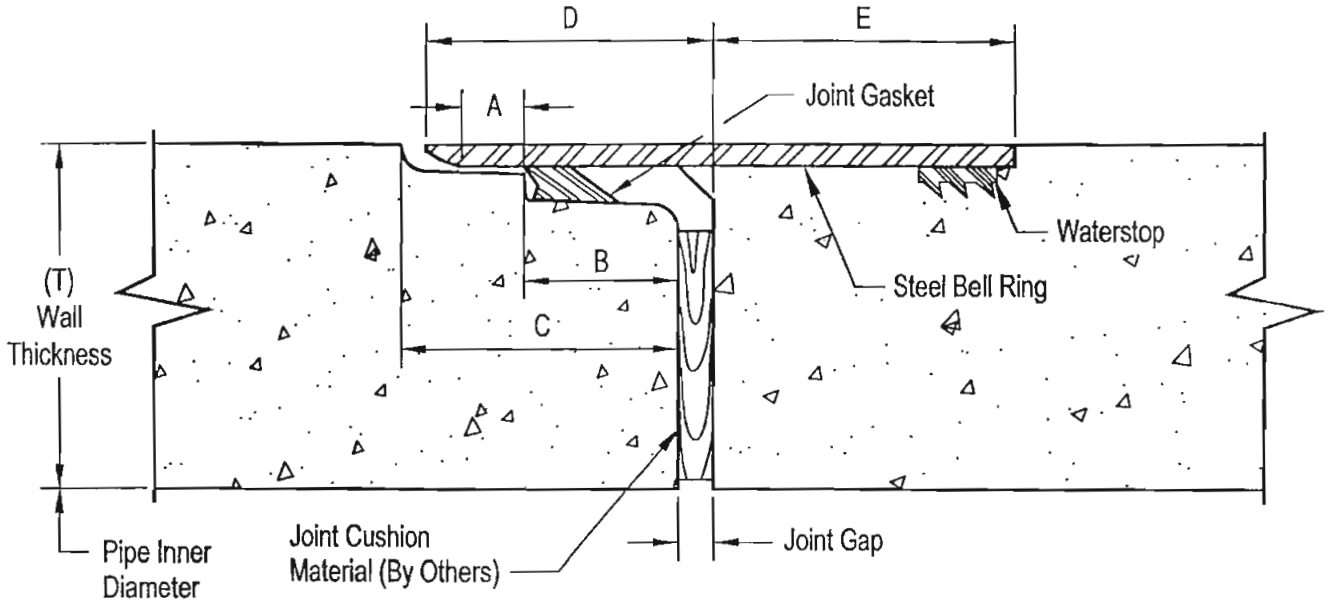
Also, no experience with elliptical in the capacity and size we are looking for. Limited experience in jacking the shape though. He said that it is difficult to keep joints lined up. He had jacked a vertical elliptical pipe through an existing culvert.

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"

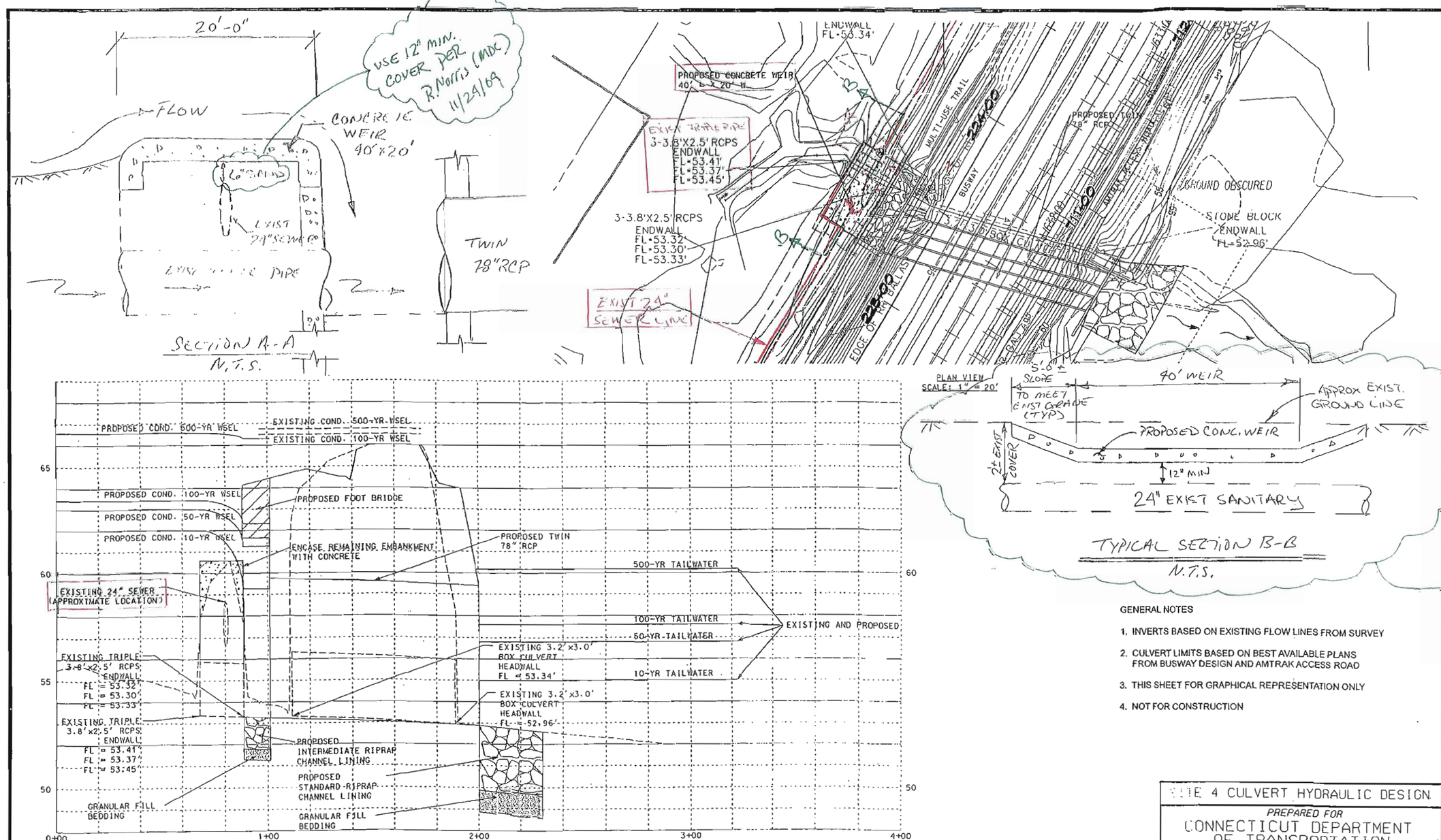
Pipe dimensions and steel joint band may vary depending upon equipment availability.

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.

Appendix H

Correspondence for Weir and Bridge Geometry



As Discussed w/R. Norris (MDC) 11/24/09

GENERAL NOTES

1. INVERTS BASED ON EXISTING FLOW LINES FROM SURVEY
2. CULVERT LIMITS BASED ON BEST AVAILABLE PLANS FROM BUSWAY DESIGN AND AMTRAK ACCESS ROAD
3. THIS SHEET FOR GRAPHICAL REPRESENTATION ONLY
4. NOT FOR CONSTRUCTION

SITE 4 CULVERT HYDRAULIC DESIGN

PREPARED FOR

CONNECTICUT DEPARTMENT OF TRANSPORTATION

NEWINGTON, CONNECTICUT

SCALE	DATE	SHEET NO.	JOB NO.
AS NOTED	SEPTEMBER 2009	__ OF __	171-305

GM2 Associates, Inc.
730 HEBRON AVENUE
GLASTONBURY, CT

REVISIONS

TO MDC 11-5-09
NOTES PER 11-24-09 PHONE CONVERSATION W/ R. Norris (MDC)

Eric W. Buckley

From: Morelli, Antonio [amorelli@mbakercorp.com]
Sent: Wednesday, January 06, 2010 4:31 PM
To: Manish K. Gupta, PhD, P.E.; Margiotta, Antonio
Cc: Eric W. Buckley
Subject: RE: Site 4 Suggested Stage Construction
Attachments: Site 4_Low Chord Elev_010610.pdf

Manish,

As we discussed over the phone, attached is the computation for the low chord elevation of the pedestrian bridge at Site 4. Even though the actual elevation is 63.2, I suggest that for the hydraulic analysis you use 63.0 (just to be safe). In the September 2009 Hydraulic Report the bottom of bridge elevation is about 61.7, thus 1.3' of additional clearance.

Tony

S.O. No.

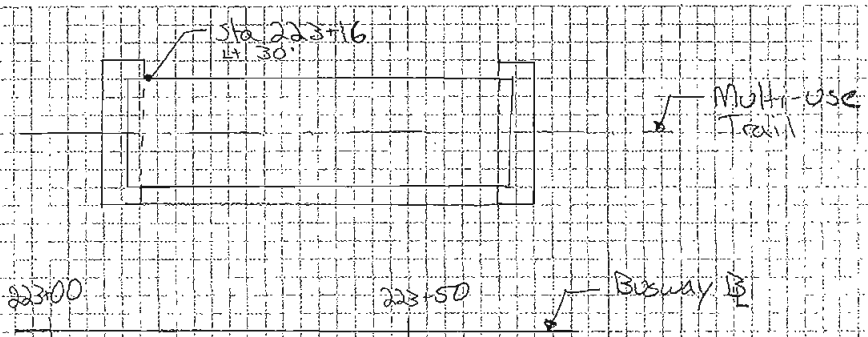
Subject: Site 4

Low Chord Elevation

Sheet No. of

Drawing No.

Computed by LSD Checked By AM 1-6-10 Date 1/6/10



Busway Elevation at 223+00 = 64.74 (H046 Dwg No PRO-3)

profile grade = 0.32% (H046 Dwg No Pro-3)

Busway Elevation at 223+16 = 64.74 + 16(0.0032) = 64.79

Busway El	Dist.	Grade	El.	Dist	Grade	El	Curb*	El	Dist	Grade	El
64.79	12'	-2%	64.55	4'	-4%	64.39	6"	64.89	14	-2%	64.61

Top of deck elevation at low chord locations = 64.61

Structure Depth = 15" voided slab

1½" overlay

16.5"

Low Chord Elevation = 64.61 - $\frac{16.5}{12}$ = 63.2

* H046 Dwg No Typ-2

Curb is 22" deep

Roadway is 16" thick, assumed 6" of curb exposed.