Fanning Wash and Soliere Ave Low Water Crossing Design Report

Prepared for:

City of Flagstaff

Edward Schenk

Tuesday, December 07, 2021

Submitted By:

AAMP Engineering Inc.

CENE 486C

Final Report

Abdalla Alatar, Austin Simmons, Muhammad Muhammad, Preston Meek

Table of Contents

List of Tables

List of Figures

List of Equations

List of Appendices

List of Abbreviations

AOI- (Area of Interest)

CLOMR - (Conditional Letter of Map Revision)

CMP - (Corrugated Metal Pipe)

FEMA - (Federal Emergency Management Agency)

FIS - (Flood Insurance Study)

GIS - (Geographic information system)

GPS - (Global Positioning System)

NRCS - (Natural Resources Conservation Service)

USDA - (United States Department of Agriculture)

WSE - (Water Surface Elevations)

Acknowledgement

We want to thank our grading instructor Dr. Bero for her guidance and feedback throughout each step of this process so that we may succeed. We would also like to thank our Technical Advisor Mr. Schenk, (City of Flagstaff Stormwater Division Project Manager) for providing us with reference materials, similar plan-sets, and his professional guidance. Additionally, thank you to Professor Lamer for providing us with the necessary equipment to conduct the collection of survey data of the existing site features.

1 Introduction:

The goal of this project is to improve the Low-Water Crossing at the intersection of Fanning Wash and Soliere Avenue South of the I-40 in East Flagstaff, AZ. Soliere Avenue provides the connection from the residential area made up of multiple apartment complexes and neighborhoods to businesses such as grocery stores, banks, and more. The low water crossing at this intersection poses a public safety risk for vehicles, bicycles, and pedestrians. Existing conditions at the crossing allow stormwater runoff from upstream to flow into Fanning Wash and through the box culverts beneath the I-40E and I-40W, causing flooding across the highly trafficked Soliere road.

To mitigate this flooding, a culvert was designed to allow the runoff to flow under Soliere road and into the Rio de Flag basin on the south side. Research of local hydrology, physical properties of the site, and hydraulic calculations were performed to create a design that can withhold peak flooding at the 50-year flood interval and safely transport water to the other side of the road.

1.1 Project Location

This project is on the eastern side of the City of Flagstaff on East Soliere Avenue just south of the I-40, at coordinates (35.214828, -111.5864986). Figure 1.1 below illustrates the location of the project in reference to the rest of Flagstaff.

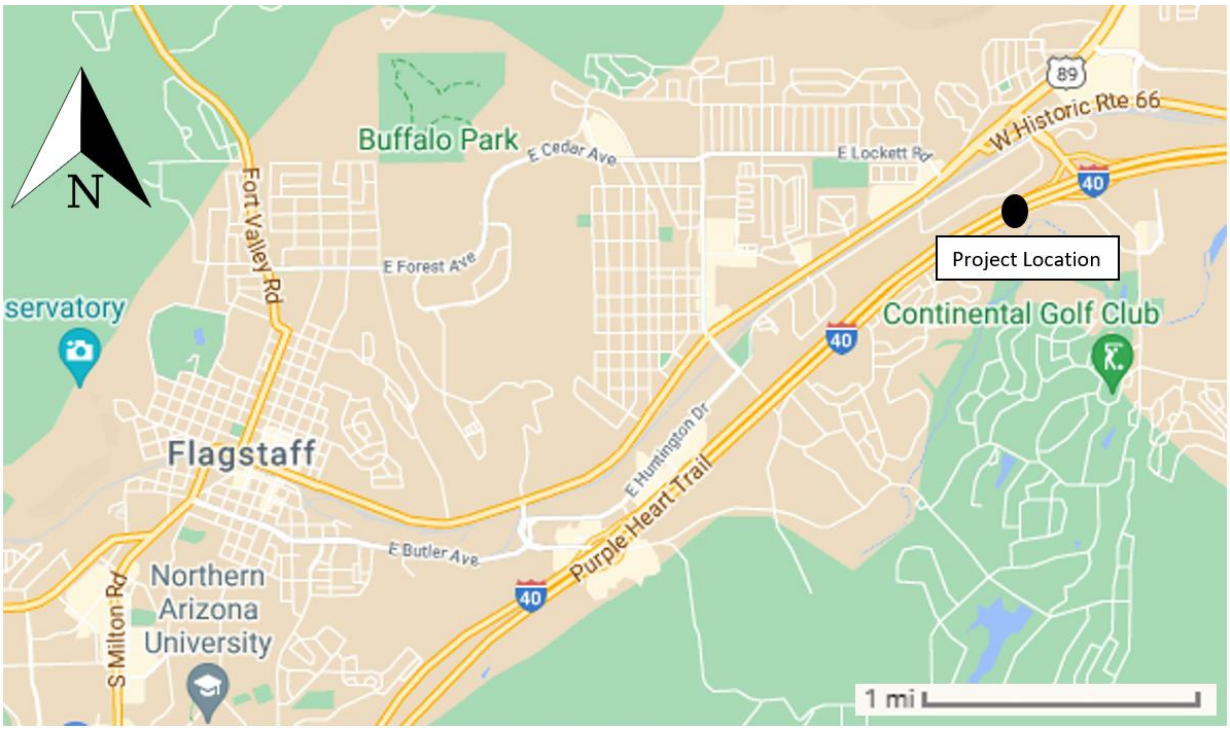


Figure 1.1: General Project Location Map.

Figure 1.2 shows the entirety of Fanning Wash and its relation to the relevant portion of the Rio de Flag, with the project location identified at the black arrow.

Figure 1.2: Fanning Wash/Rio de Flag Location Map

.

Figure 1.3 shows the existing I-40 culvert upgradient of the crossing.

Figure 1.3: Project location with I-40

Figure 1.4 shows the exit conditions of the I-40E box culvert which is also the beginning of the site being considered in this project. The figure also shows the erosion of the concrete and deposition of sediment between the exit of the culvert and Soliere Rd.

Figure 1.4: Existing I-40 Culvert

Figure 1.5 shows a pavement pull out on Soliere Rd at the culvert, a sheet of concrete is adjacent that is cemented down into the Rio de Flag wash. More erosion and deposition can also be seen here.

Figure 1.5: Erosion of Concrete above Rio de Flag

Figure 1.6 shows the exit conditions into the wash of Rio de Flag in which all flood waters flow into.

Figure 1.6: Exit Conditions into Rio de Flag.

1.2 Exclusions

The following items were excluded from the scope of work for the project: Roadway design, Construction, identification of conditions related to unforeseen site conditions, Conditional Letter of Map Revision (CLOMR), and permitting.

2.0 Preliminary Research

Plan sets of a similar site about a mile upstream from the site at Industrial Dr. were provided by the client and reviewed to assist with the creation of plan sets for this site.

The standards and codes applicable to this project were researched to ensure that the designed culvert meets all applicable codes. The main documents consulted were the Coconino Drainage Design Manual's Title 13 code specified by the City of Flagstaff and the City of Flagstaff Stormwater Management Design Manual. As refred to in Appendix A, the Title 13 code ***13-08-001-0001*** specified that the design be held to the code standards in the Stormwater Management Design Manual. Using this codes from section ***5.0 Culvert and Bridges*** was primarily used due correlating directly to this project. As mentioned, the exact codes utilized may be found in Appendix A.

3.0 Site Investigation

A preliminary site investigation was made on 8/31/21 in which the team visited the site to develop a plan of how the site would be surveyed and what data would be collected to create an accurate hydraulic model. An existing culvert overrun by sediment was found under soliere Rd; this culvert was not functional. The team identified an area approximately 30 feet wide and 160 feet long from the exit of the I-40E culvert across Soliere Rd and into the Rio De Flag that was to be surveyed.

A GPS base and GPS rover were used to survey the area. Since no existing data was found in the area a new control point had to be found using the base from which all shots locations and elevations were in reference to. An additional control point was shot and marked using a 60D nail in the chance that additional surveying was needed, and an established control point was set up on. One hundred and twenty-five more shots were collected across the site as needed to collect topographic data and locations of various land features/structures to later be compiled into one topographic map and one site map as seen below in Figures 3.1 and 3.2.

Figure 3.1 depicts an aerial view of the sites with topographic information plotted. This includes major and minor contours as well as flow paths denoted by varying lines of different colors. Figure 3.2 is provided to illustrate the general layout of the site and locations of important features within it. As seen in the figure the I-40E culvert outlet is located just below the highway and has two bevels located on either side to direct the flow at the culvert outlet. Other important features on the site map include the locations of the existing clogged culvert, Soliere Avenue, rip rap and the Rio de Flag. A legend has been provided to distinguish between the features at the site.

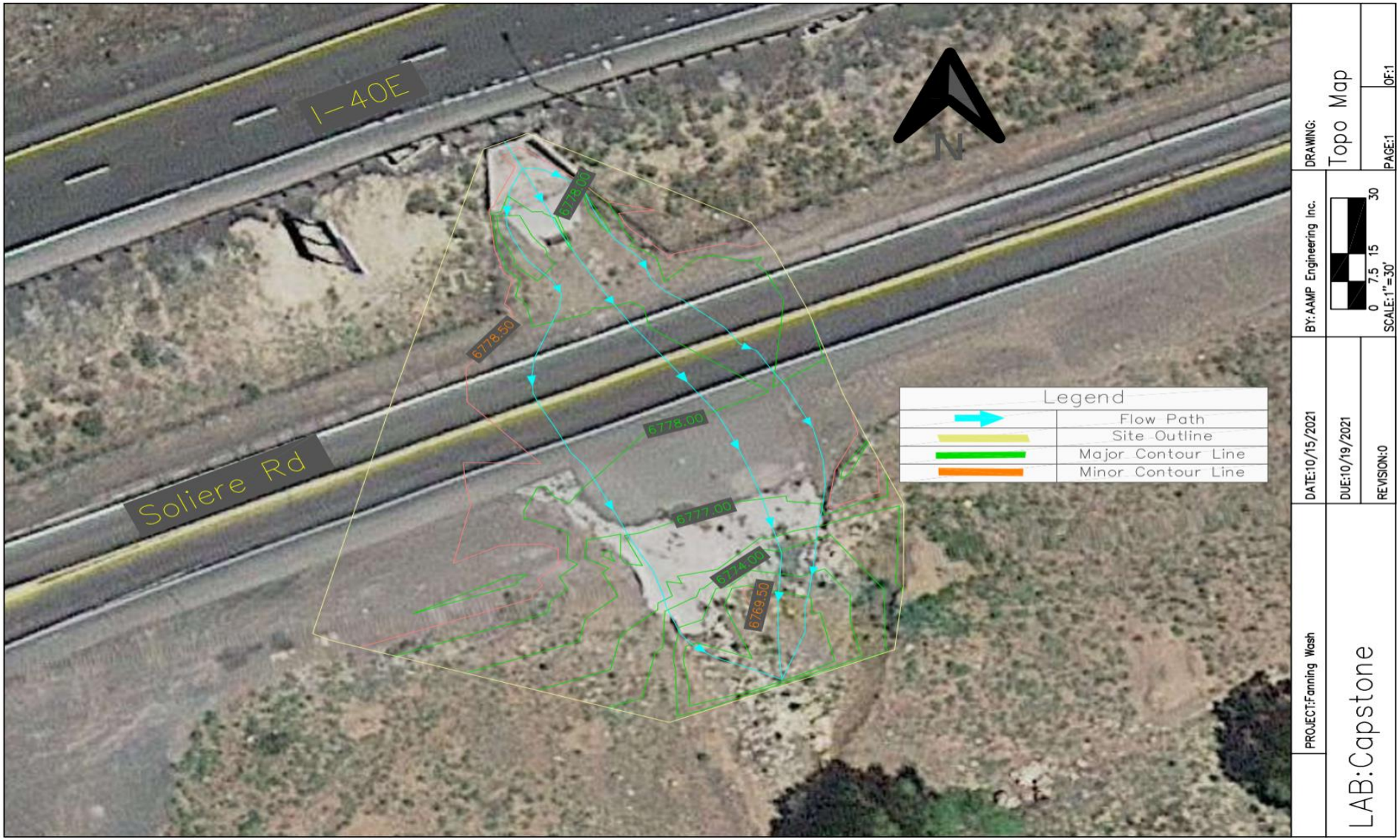


Figure 0.1: Topo Map

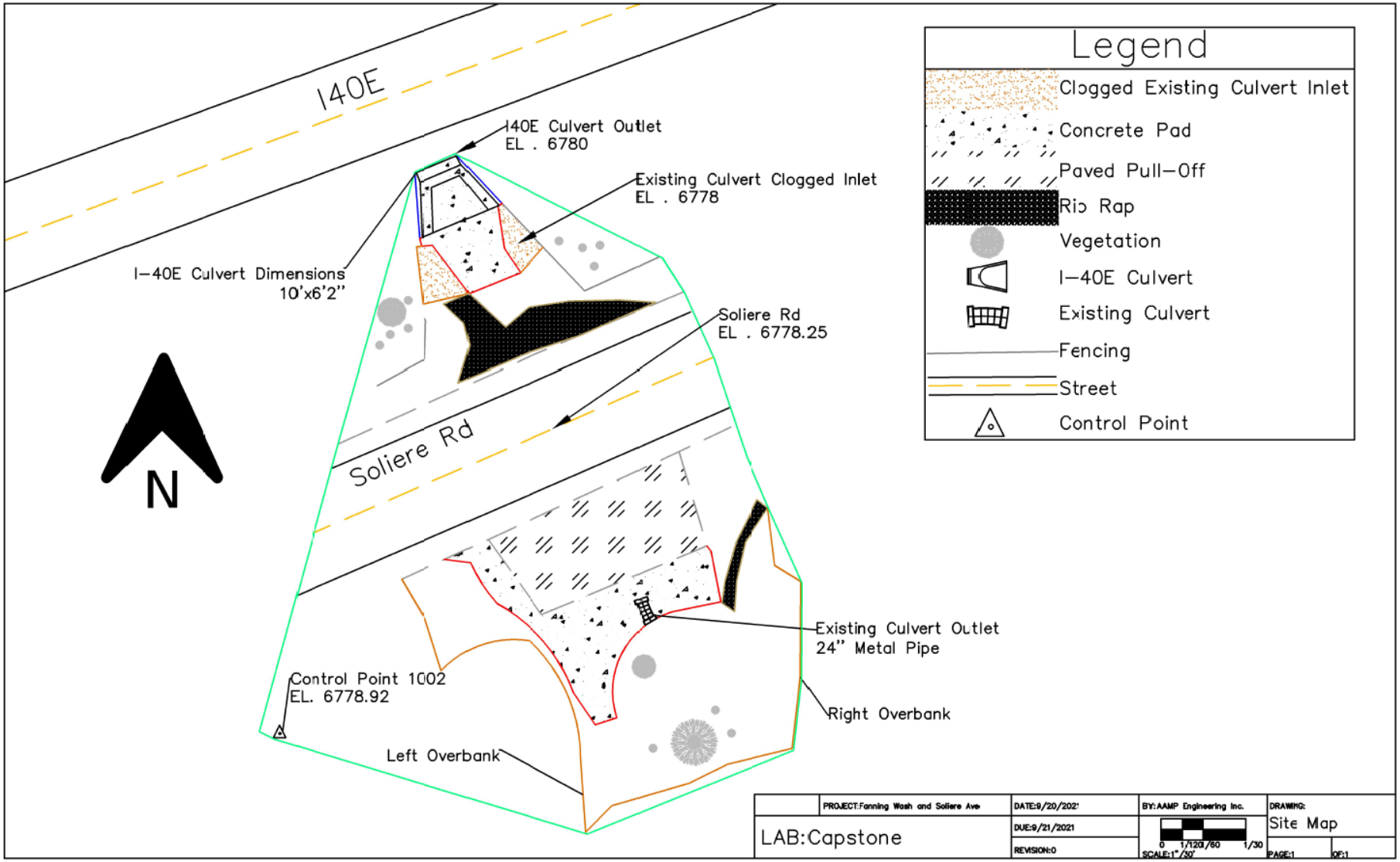


Figure 0.2: Site map

4.0 Geotechnical Analysis

After consulting with client and technical advisor Ed Schenk, it was concluded no testing of soils was needed due to the assumption that the project will only deal with asphalt and compacted soil, and soil characteristics will not affect the design. Alternatively, the soil was classified using the USDA Web Survey Soil GIS maps [1] which provided what types of soil are estimated to be in the project area (Area of Interest, AOI). Lynx Loam, a fine clayey soil, is formed in mixed alluvium and typically found in flood plains or alluvial fans and was the predominant soil type at the site. This soil is also known to drain water well and have low runoff. Refer to Appendix A for the geotechnical AOI and soil report. The AOI includes a large portion of land around the site due to a larger scale needed for the report to be valid. Additionally, different soil types were present in the AOI; however, the area "13" (Lynx Loam) surrounds the project location.

5.0 Hydraulic Analysis

A model of the existing site was created using HEC-RAS to show the current flow conditions through the area. The existing culvert at the site was not included in the model due to it being clogged with sediment and not functioning sufficiently to reduce flooding. To obtain station and elevation information of each cross section the Station Interval Method was performed. This was done in AutoCAD by placing 11 additional cross sections along the area where there was a change in geometry or material. For each of these cross sections, circles having a radius of 2' were placed along the cross-section lines and at the circles' intersections (2' from one another), elevations were recorded. For areas where elevation change was small (such as the roadway), 5' diameter circles were used. An image to illustrate this process is seen below. Figure 5.1 shows these results. The tabulated results of each cross section can be seen in Appendix D.

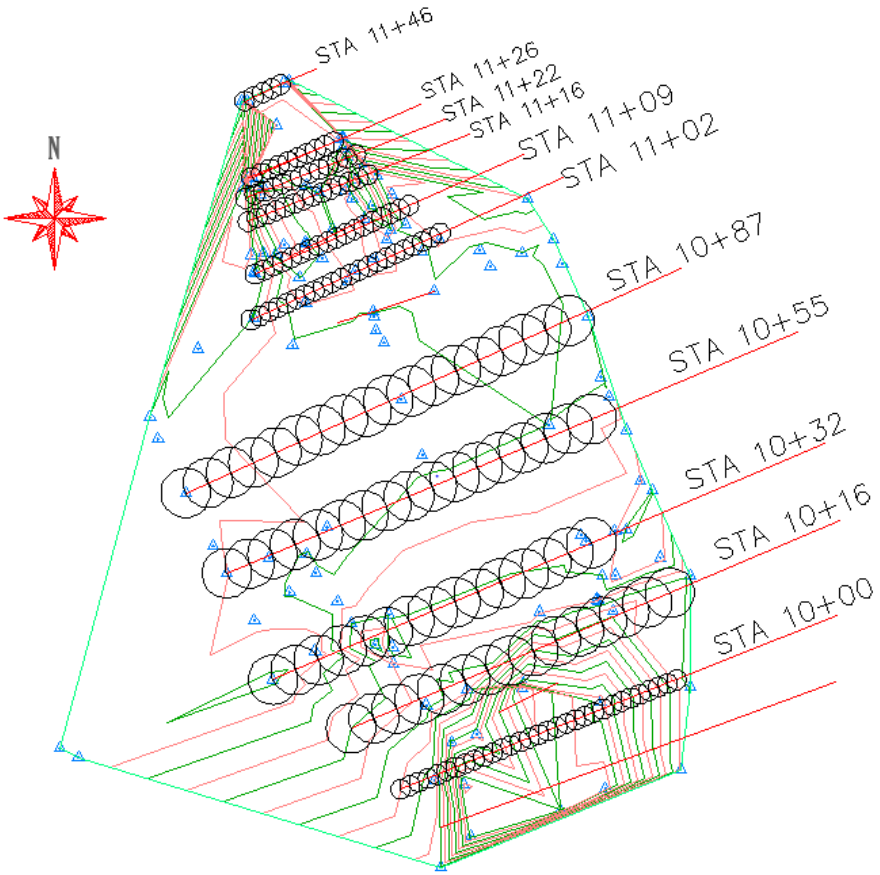


Figure 5.1: Cross section map

Using the data generated, each of these cross-section's stations were created in HEC RAS to model the existing flow that illustrates the flooding issues at the site. The discharge for the 50yr and 100yr flood interval at the confluence of Fanning Wash and Rio de Flag was found from the Flood Emergency Management Agencies (FEMA) Flood Insurance Study (FIS). Discharges of 570cfs and 730cfs were used for the two flow profiles to create and run the model. A 3D view of the existing HEC RAS model for the 50-year flood depicting the cross-section stations is shown in Figure 5.2 below. The blue denotes the Water Surface Elevation (WSE) flowing across the cross sections. On the left the water exits the I40 Box Culvert and has a high elevation which slowly decreases due to the bevels withholding the water on either side. It then floods across the road at a depth of 3’ for the 50-year flood and discharges down into the Rio de Flag on the right side.

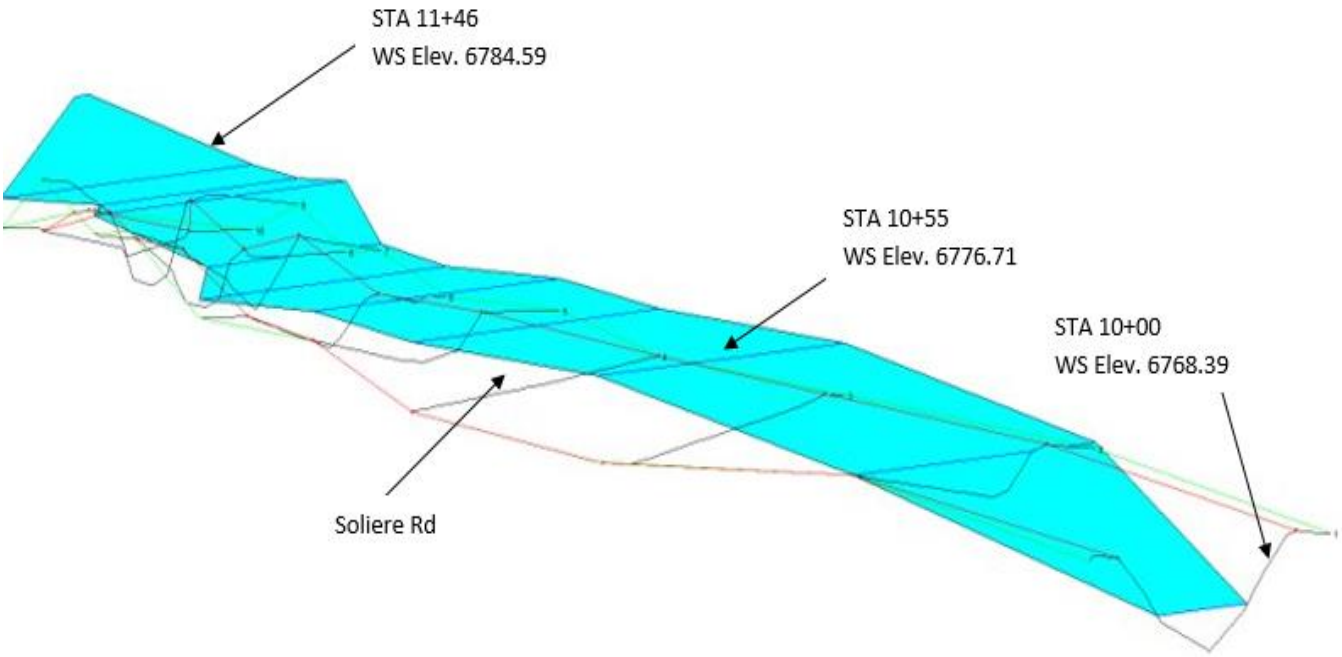


Figure 5.2: HEC-RAS Existing Condition at 50-year Flood

The HEC-RAS model results provides velocities, flow types, water surface elevations (WSE), and hydraulic depth. Significant flooding was found, and the flow was primarily supercritical indicating a very fast flow. The results for the 50yr and 100yr storms are shown in Table 5.1.

Table 5.1: Tabulated HEC-RAS Results 50 and 100 yr storm

River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area
		(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)
11+46	100 YR	730	6778	6785.77	6789.58	0.006709	15.66	46.6
11+46	50 YR	570	6778	6784.59	6787.82	0.006069	14.42	39.52
11+26	100 YR	730	6772.7	6780.29	6780.37	0.000085	2.45	321.11
11+26	50 YR	570	6772.7	6779.63	6779.71	0.000103	2.38	253.11
11+22	100 YR	730	6774.7	6779.1	6780.26	0.437214	6.36	101.03
11+22	50 YR	570	6774.7	6778.9	6779.64	0.38909	5.88	90.62
11+16	100 YR	730	6774.1	6778.22	6779.01	0.021566	1.28	177.18
11+16	50 YR	570	6774.1	6778.03	6778.61	0.018415	1.15	161.39
11+09	100 YR	730	6774.48	6777.33	6778.25	0.04833	1.92	170.02
11+09	50 YR	570	6774.48	6777.01	6777.83	0.065516	2.03	140.44
11+02	100 YR	730	6773.6	6777.14	6777.42	0.004105	4.64	177.75
11+02	50 YR	570	6773.6	6776.45	6776.95	0.010931	5.94	108.17
10+87	100 YR	730	6773.88	6777.27	6777.34	0.000131	2.19	328.26
10+87	50 YR	570	6773.88	6776.73	6776.8	0.000145	2.04	273.18
10+55	100 YR	730	6773.6	6777.25	6777.33	0.000135	2.34	312.38
10+55	50 YR	570	6773.6	6776.71	6776.78	0.000155	2.22	257.2
10+32	100 YR	730	6771	6777.18	6777.29	0.005721	1.12	515.56
10+33	50 YR	570	6771	6776.65	6776.74	0.00503	0.97	462.17
10+16	100 YR	730	6771.7	6774.28	6774.91	1.321229	6.45	117.5
10+16	50 YR	570	6771.7	6774.03	6774.61	1.421334	6.16	94.14
10+00	100 YR	730	6766	6768.66	6771.11	0.008422	12.56	58.1
10+00	50 YR	570	6766	6768.39	6770.58	0.008995	11.87	48.01

Faster flows were found at the outlet of the I40 culvert down to the end of the bevels which are two concrete walls designed to direct the flow path coming out of the I-40E culvert. After that water was able to disperse to a wider area between the bevels and Soilere Avenue and to the cross sections downstream below Soliere Avenue into the Rio de Flag. A full HEC RAS Report can be found in Appendix E.

6.0 Development and Screening of Alternatives and Selection of Final Design

6.1 Develop Alternatives

Four different potential solutions were considered and are shown in Table 6.1. This variety of culverts was considered based on different shapes, sizes and materials that are typical in other culverts around the City of Flagstaff. Sizes of each were selected based upon obtaining reasonable velocities and ensuring no overtopping occurs as per CulvertMaster and HEC-RAS models.

Table 6.1: Design Alternatives

Potential Design:				
Description:	Three 6’ Diameter Corrugated Metal Pipes	Three 6’ Diameter Concrete Pipes	Two 12’x 7’ Box Culverts	Two 5.9’ x 4.5’ Arched Culvert

6.2 Site Preparation

Before the analysis of the alternatives, the geometry of the site had to be altered so that the purposed culverts could fit under the road. Based on the geometry and extension of the bevels from the existing I-40 culvert, a channel cross section was created. From the end of the bevels the channel extends to where the existing rip rap is approximately 2’ north of Soliere Avenue. The channel was modeled to gradually slope down 6’ over 35’ from the end of the bevels to the Soliere culvert inlet. The channel will also contract from 20.5’ wide at the bevels to 15’ at the Soliere inlet where the new culverts will be placed. 10’ of soil needs to be dug out to account for the proposed culvert inlet and cover. A total excavation volume of 2216.6ft^3 is needed for this channel and will be discussed in section 7 below.

6.3 Preliminary Hydraulic Models

Each of the four alternatives were modeled using HEC-RAS to determine the proposed conditions with new culverts and channel in place. An additional model using CulvertMaster was

also created to compare to the HEC-RAS results. However, HEC-RAS is more accurate due accounting for all obstructions whereas CulvertMaster does not. The results of the two models are tabulated below in Tables 6.2 (100 year) and Table 6.3 (50 year). Figures 6.1 through 6.4 show the HEC-RAS 3D models for each propsed design alternatives. For each of the figures the proposed culvert may be seen beneath Soliere Avenue, paved pullout and concrete pad. Additionally, the blue depicts the WSE and the red line with dots provides the bank stations.

Figure 6.1 illustrates the thee 6ft diameter CMP.

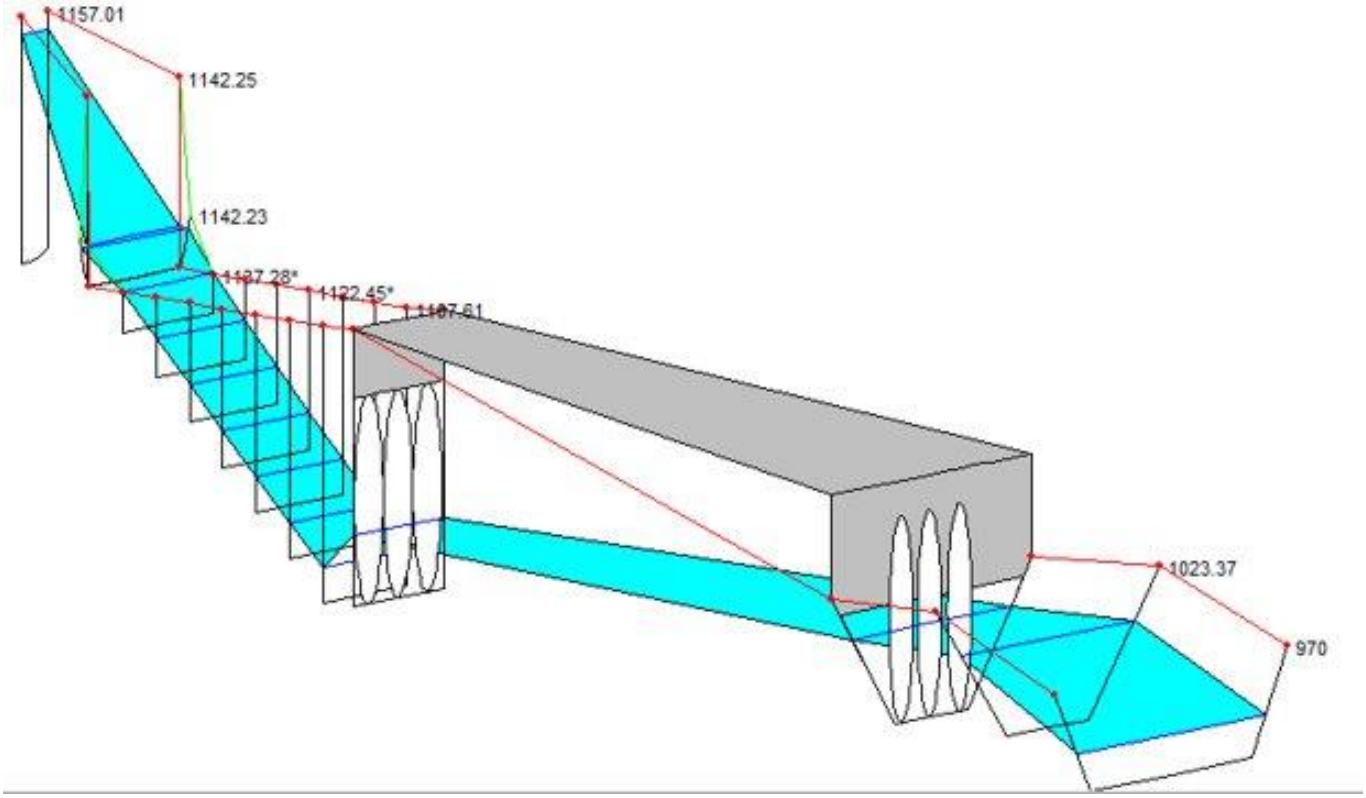


Figure 6.2: Triple Barrel Corrugated Metal Pipes

Figure 6.2 depicts the three 6’ diameter concrete pipes.

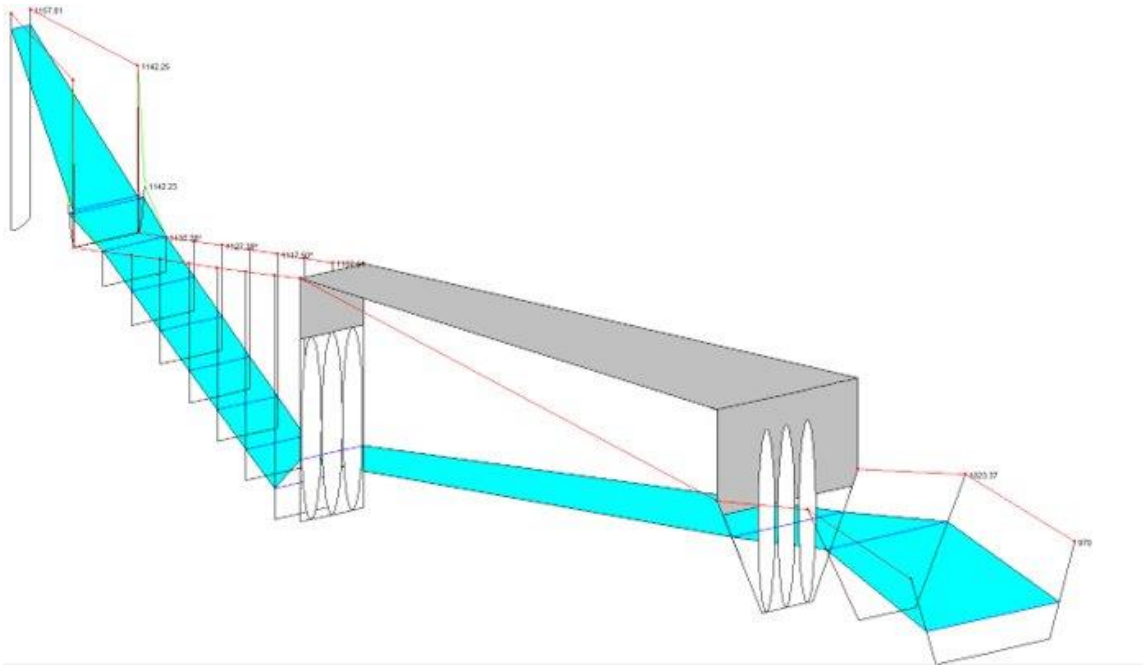


Figure 6.2: Triple Barrel Concrete Pipes

Figure 6.3 depicts the two 12ft x 7ft box culverts.

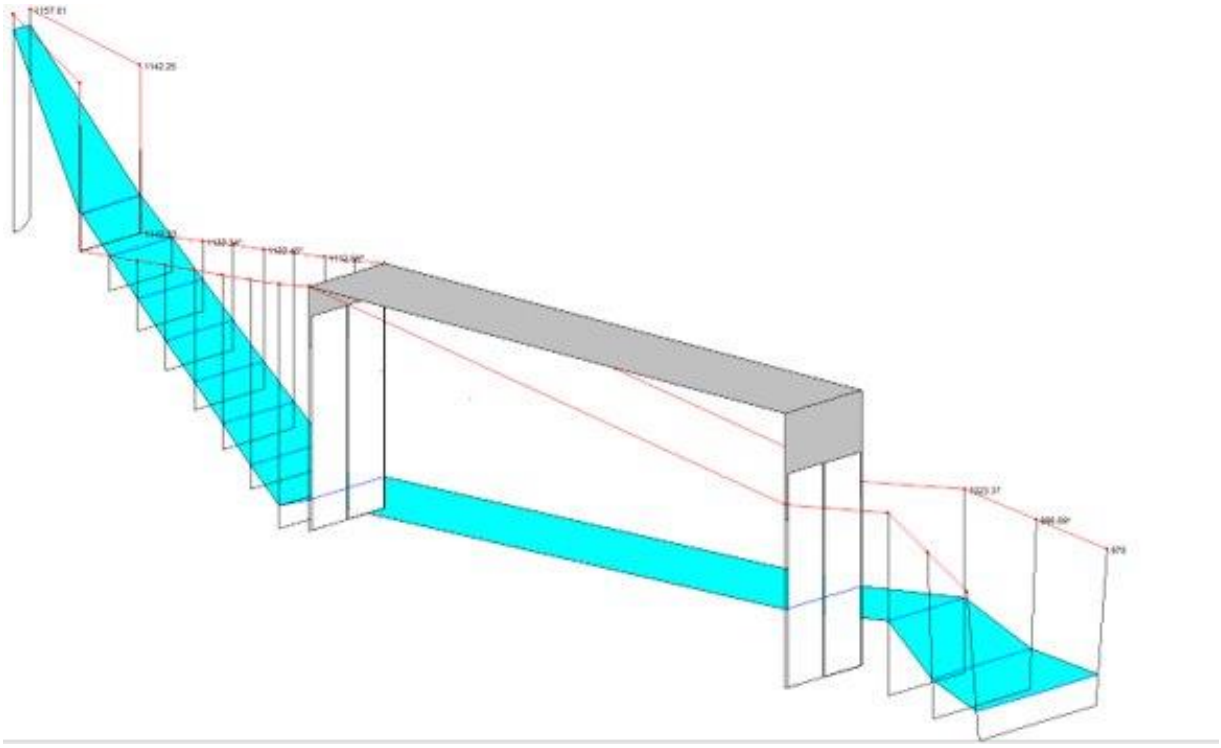


Figure 6.3: Double Box Culverts

Figure 6.4 depicts the 5.9ft x 4.5ft double pipe arch culverts.

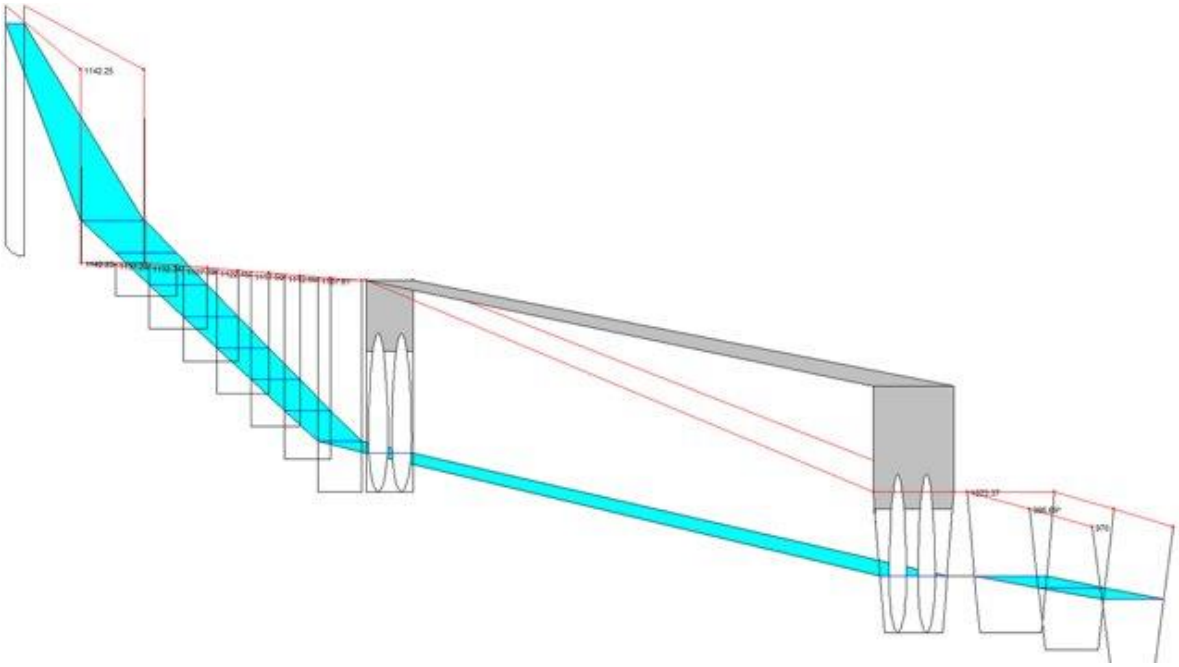


Figure 6.4: Double Pipe Arch Culvert

Table 6.2: Flow Conditions under the 100-yr Flood.

100-year flood (730 cfs)						
Analysis	Culvert	Exit Velocity(ft/s)	WSE (ft)	HW/D	Normal Depth(ft)	Flow Regime
HEC-RAS	5.9' x 4.5' Double Pipe Arch	17.02	6773.74	0.44	2.0	Supercritical
CulvertMaster	5.9' x 4.5' DoublePipe Arch	10.71	6775.75	1.13	1.68	Supercritical
HEC-RAS	12' x 7' Double Box	9.93	6770.91	0.85	5.92	Supercritical
CulvertMaster	12' x 7' Double Box	19.46	6772.36	0.77	1.22	Supercritical
HEC-RAS	6' Triple Barrel CMP	16.77	6772.35	0.61	3.67	Supercritical
CulvertMaster	6' Triple Barrel CMP	16.74	6775.98	0.99	2.96	Supercritical
HEC-RAS	6' Triple BarrelConcrete	22.85	6772.35	0.42	2.54	Supercritical
CulvertMaster	6' Triple BarrelConcrete	20.21	6773.62	0.95	2.12	Supercritical

Table 6.3: Flow Conditions under the 50-yr Flood.

50-year flood (570 cfs)						
Analysis	Culvert	Exit Velocity(ft/s)	WSE (ft)	HW/D	Normal Depth(ft)	Flow Regime
HEC-RAS	5.9' x 4.5' DoublePipe Arch	6.40	6773.43	0.37	1.7	Subcritical
Culvert Master	5.9' x 4.5' DoublePipe Arch	8.37	6775.69	0.95	1.47	Supercritical
HEC-RAS	12' x 7' DoubleBox	9.14	6770.76	0.70	2.60	Supercritical
Culvert Master	12' x 7' DoubleBox	18.53	6773.55	0.65	1.04	Supercritical
HEC-RAS	6' Triple BarrelCMP	15.32	6772.04	0.523	3.14	Supercritical
Culvert Master	6' Triple BarrelCMP	9.49	6773.5	1.08	2.57	Supercritical
HEC-RAS	6' Triple BarrelConcrete	21.45	6772.04	0.37	2.22	Supercritical
Culvert Master	6' Triple BarrelConcrete	9.77	6702.72	0.82	1.86	Supercritical

Tables 6.2 and 6.3 show a comparison of the data between HEC-RAS and CulvertMaster. The criteria being compared at the top was pulled straight for the drainage design manual. No major differences in results were found between CulvertMaster and HEC-RAS as well as between the results of the culvert models except for the exit velocity. This was considered the most important criteria of this project to mitigate flooding and protect the area downstream of the project. Highlighted in orange in the two tables is the exit velocity which was analyzed the most to select best design.

In Tables 6.4 and 6.5 below the design alternatives were compared again but now with criteria for the decision matrix. The results used were provided by HEC-RAS and the cost provides is the premade culverts costs which were estimated using RS means construction cost estimator.

Table 6.4 results of the 100-year design storm.

100 Year Flood (730 cfs) CHECK STORM					
Potential Solution	Control	Outlet Velocity(ft/s)	Overtopping	Meets COFRequirements	Material Cost Estimate ($)
Double Pipe Arch 5.9' x 4.5'	Inlet	17.02	No	Yes	25,500
12' x 7' DoubleBox	Outlet	9.93	No	Yes	38,000
3 – 6' CMP	Outlet	16.77	No	Yes	30,500
3 – 6' Concrete	Outlet	22.85	No	No	51,000

Table 6.5 results of the 50-year design storm.

50 Year Flood (570 cfs) DESIGN STORM					
Potential Solution	Control	Outlet Velocity(ft/s)	Overtopping	Meets COFRequirements	Material Cost Estimate ($)
Double PipeArch 5.9' x 4.5'	Inlet	6.4	No	Yes	25,500
12' x 7' DoubleBox	Inlet	9.14	No	Yes	38,000
3 – 6' CMP	Outlet	15.32	No	Yes	30,500
3 – 6' Concrete	Inlet	21.45	No	No	51,000

6.4 Decision Matrix

Decision criteria were created. The criteria used criteria of outlet velocity, construction time, and cost. The outlet velocity was included due to the need of the culverts to not only convey water across Soliere Avenue but also reduce its energy at the outlet to protect from erosion and scouring. This was weighed at 0.5 due to being considered the most important feature of the design. Construction duration was considered due to the site being on a vital access road to residential areas as well as to reduce complicated design culvert. This was weighed at 0.25. These durations were developed using estimated quote times provided by contractors in the area. Lastly, cost was included to find the most cost-effective design. This criterion was also weighted with a 0.25. Each design was rated in each of the categories assigning points one through three. By then multiplying the rating by the weight and summing each score, the total score for that design was determined. Table 6.6 shows rating criteria and how each was quantified.

Table 6.6: Rating Criteria

Rating	Outlet Velocity, ft/s	Construction Duration, months	Cost, $
3 - Highest Rating	10 and below	< 2	<30000
2 - Average Rating	10 - 20	2-4	30000- 40000
1 - Lowest Rating	20 and above	> 4	>40000

6.5 Final Design Selection

Table 6.7 below illustrates the ratings and scores of each design. The Double Pipe Arch highlighted in green was selectced as the final design.

Table 6.7: Decision Matrix

Fanning Wash Culvert Decision Matrix									
	Weight	Double Pipe Arch 5.9' x 4.5'		12' x 7' Double Box		3 - 6' CMP		3 - 6' Concrete	
		Score	WT Score	Score	WT score	Score	WT score	Score	WT score
Outlet Velocity	0.5	3	1.50	2	1.00	2	1.00	1	0.50
Constructability	0.25	2	0.50	2	0.50	2	0.50	2	0.50
Cost	0.25	3	0.75	2	0.50	2	0.50	1	0.25
Sum			2.75		2.00		2.00		1.25

6.6 Select Final Design

As shown above the 5.9'x4.5' Double Pipe Arch design proved to be the best alternative and will be selected for the final design. This alternative proved to stand out significantly from the other in terms of outlet velocity. Due to geometry of the culvert a full pipe flow is experienced at the beginning and then a hydraulic jump due to the friction occurring between the water and pipe material results in energy dissipation with lowered velocities and WSE. Additionally, this was the only design to experience subcritical flow at the outlet. The design is feasible for construction due to only requiring a concrete pad in the bottom and CMP arch.

Although all solutions were designed to meet the COF design requirements this solution had little alterations needed to surpass the requirements. It is hydraulically efficient and will require no maintenance with little risk of getting clogged due to its wide passage. No overtopping potential for either storm was found when analyzed in both HEC-RAS and CulvertMaster. The full HEC-RAS report for the purposed conditions may be found in Appendix F and a full CulvertMaster report can be found in Appendix G.

7.0: Final Design

The construction plans for the new channel and culvert will depict the design of the Soliere Avenue low water crossing based on restrictions put in place by the COF Drainage Design Manual. The design will consider all data presented in previous sections.

7.1 Cut Volume

To calcuate the cut volume for the proposed channel, the dimensions of the channel used in the purposed HEC-RAS model were used. Using the equations below the total cut volume of the channel was able to be found. To begin, the channel was split into three section separating the middle from the two sides which would now make three triangular prisms with known dimensions. By using Equation 7.1 the volume of center was found. Looking at it from a side profile view the area of the triangle was then multiplied by the distance across the center.

$$V_{center} = \frac{1}{2} * (w) * (h) * (l)$$

Equation 7.1: Volume (Cut at Center of Channel)

To solve for the area of the two sides the volume formula for a triangular prism was used as shown below in Equation 7.2.

$$V_{side} = \frac{1}{4} * (h) * [-a^4 + 2(a * b)^2 + 2(a * c)^2 - (h)^4 + 2(b * c)^2 - c^4]$$

Equation 7.2: Volume (Cut at Side of Channel))

The volume of the sides was then multiplied by two to account for either side.

$$V_{Both\ Sides} = 2 * V_{side}$$

Equation 7.3: Volume (Both Sides of Channel)

Finally, the volumes were summed together to determine the total volume.

$$V_{channel\ (Total)} = V_{center} + V_{side}$$

Equation 7.4: Volume (Total of Entire Channel)

Hand calculations and drawings of this process may be found in Appendix H.

7.2 Purposed Site Map

Figure 7.1 shows the updated site map that includes the proposed channel, culverts, guard rails and rip rap apron at the exit of the culvert.

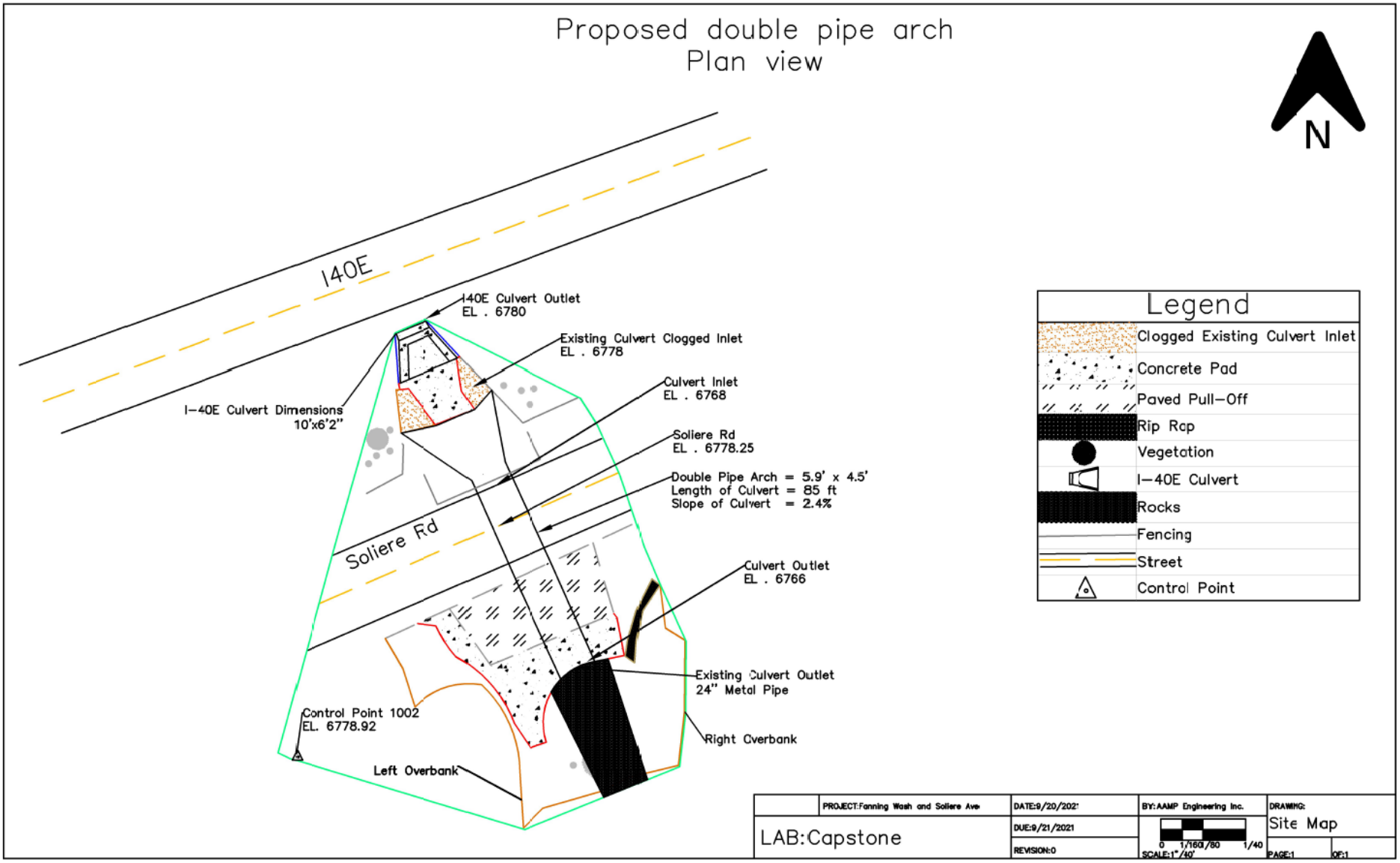


Figure 7.1: Proposed culvert design

7.2 Purposed Channel Modification and Cross Sections

Both upstream and downstream cross sections have been modified leading to the inlet of the culverts and to allow for the water to flow beneath the road into the culverts as mentioned previously. Additionally, cross sections at the outlet were modified to ensure channel stabilization measures have also been taken by altering cross section geometry and providing a rip apron. With these modifications in place, it makes sure no erosion, scouring or sediment is trapped occur while providing a controlled outlet so no additional downstream modifications in the Rio de Flag are needed. Further details of the cross-sectional views may be found in Appendix G.

7.3 Channel Design Details

Figure 7.2 shows the new proposed culvert design. Each of the 5.9' x 4.5' arches will be made of CMP and the bottom will be made of a concrete pad. Above the culverts 1.5' of concrete cover was used to allow ponding with no overtopping at the inlet. This amount of cover was also used to meet codes specified by the drainage design manual. Additionally, the two 3' x 1.5' concrete blocks seen were put in place on either side to confine water to one flow path across Soliere Avenue in the chance overtopping does occur. This was a feature of this design requested by the client.

Figure 7.2: Double Pipe Arch Design

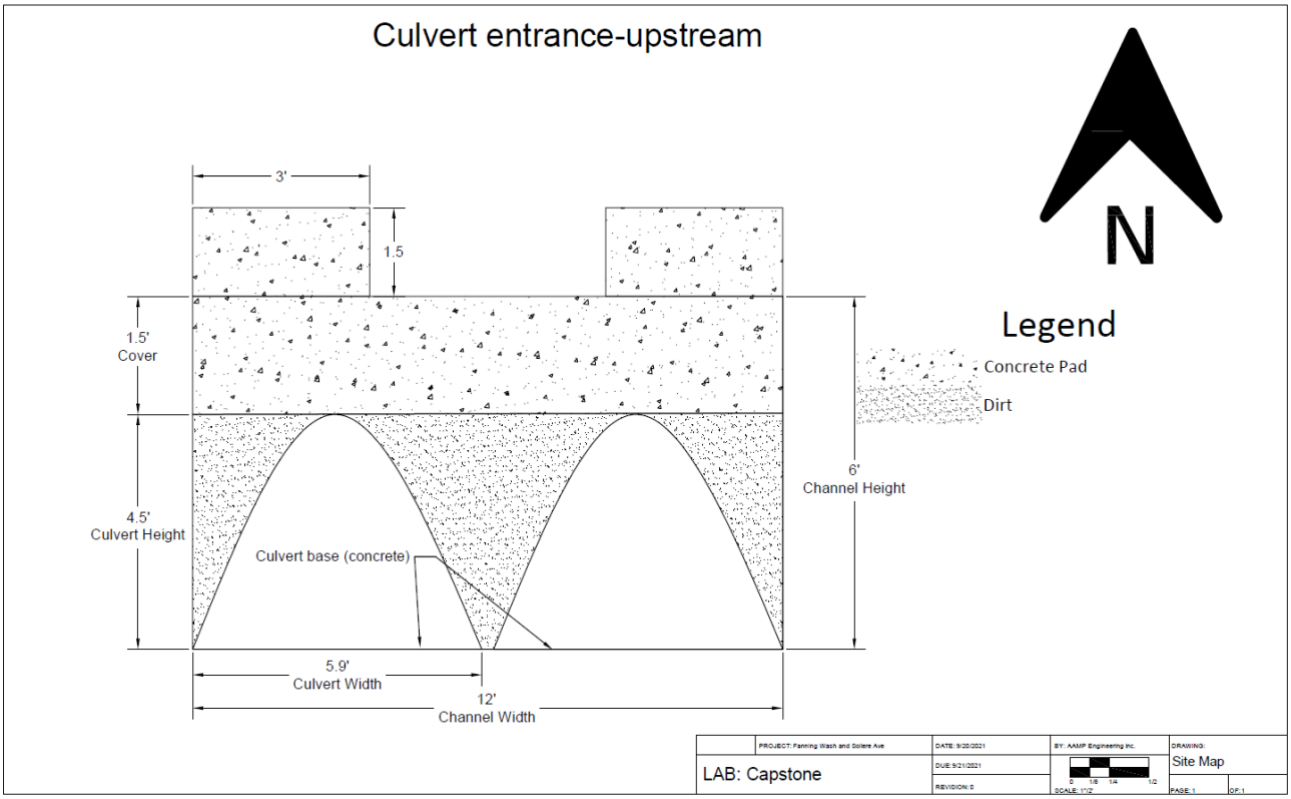


Figure 7.3 shows a plan view with the blocks in the purposed site map.

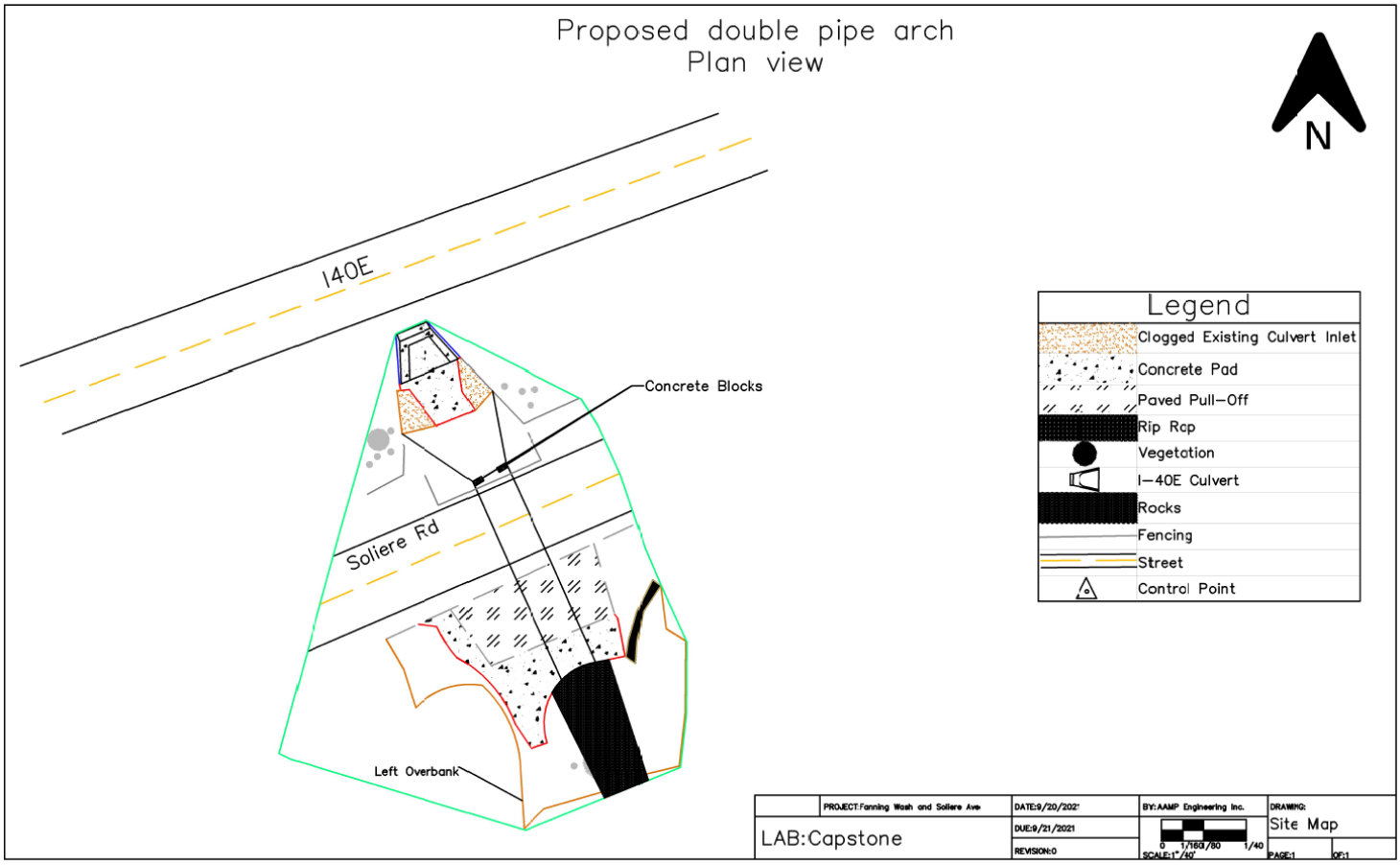


Figure 7.3: Double Pipe Arch Plan View

8.0 Construction Cost Estimate

The total estimated cost of construction is $198,627.23. The construction cost estimate is shown in Table 8.1. The table has been split into three stages of the project. The first stage includes all excavation needed. This includes the removal and disposal of the pavement on Soliere Avenue as well as the paved pullout on the South side of the road, the removal and disposal of the concrete pad further south of the paved pullout and is the required deepening of the channel to accommodate the new culvert.

The second stage includes installation of the channel and culvert. The process begins by prepping the ground for the culvert and channel. The preparation is priced by the square yard. The channel walls and bedding and culvert bedding are then implemented and are priced by the square foot of the surface area. The culvert is then installed, the rip rap is put in place, and the fill is compacted for the roadway construction to begin. The guard rail is constructed, and the roadway is paved.

Table 8.1: Construction Cost Estimate

Construction Costs						
	Item	Description	Plan QTY	Unit	Unit Price ($)	Amount ($)
Excavation	1	Removal & Dispose of Asphalt	616	SF	15.00	9,240.00
	2	Removal of Existing Culvert	85	LF	25.00	2,125.00
	3	Remove & Disposal of Soil	490	CY	125.00	61,250.00
	4	Remove & Disposal of Concrete	154	SF	14.00	2,156.00
Installation	5	Subgrade Preparation	173.90	SF	6.00	1,043.40
	6	Concrete Channel Walls	659.82	SF	35.00	23,093.70
	7	Concrete Blocks	13.5	SF	30.00	405.00
	8	Channel Bottom Concrete	396.95	SF	7.50	2,977.13
	9 (a)	Premade Arch CMP 5.9' x 4.5'	85	LF	300.00	25,500.00
	9 (b)	Premade Arch CMP 5.9' x 4.5'	85	LF	300.00	25,500.00
	10	Culvert Concrete Pad	850	SF	8.50	7,225.00
	11	Structural Fill	88.75	CY	120.00	10,650.00
	12	Riprap (Dumped)	75	CY	200.00	15,000.00
RoadwayStructures	13	Paving	350	SY	31.00	10,850.00
	14	Safety Rail (3'x6' height)	26	LF	62.00	1,612.00
					Total Cost	198,627.23

9.0: Impacts

9.1 Short-Term

9.1.1 Social

Construction of the culvert will require a road closure, requiring travelers to detour, possibly increasing travel time. Also, construction will produce noise that may disturb the residential areas near the construction site. However, the construction will be confined during the hours of 7 AM until 5 PM which will help reduce noise impacts. Also, it is helpful to complete all the construction at one time to reduce the time of construction.

9.1.2 Economic

The cost estimate for this project is approximately $200,000 which is about 3.96 % of the total Flagstaff annual stormwater budget of approximately $5,049,000. This project cost is relatively low.

9.1.3 Environmental

The construction noise and personnel present may disturb the local wildlife during the construction time period. However, the animals will likely return soon to this area soon after project completion.

9.2 Long-Term

9.2.1 Social

Over time, the general public's faith in City planning will grow as positive impacts of the proposed culvert are seen, as travel time is decreased, and the road no longer floods. The new culvert will allow for better access to nearby areas. Therefore, it will help create a safer environment for the nearby residential homes, and for cars driving in the area in the long-term due to mitgted flooding chance.

9.2.2 Economic

Maintenance costs will be reduced because the culvert is a wide & flat Arched CMP model. Due to the nature of CMP building materials, the culvert will be self-cleaning since the base is smooth concrete while the rest is CMP which dramatically lowers maintenance needed.

In the long term, increases in nearby land value as well as property value may be seen. This is due mainly to the fact that the new culvert will mitigate possible flooding or events where nearby residential/commercial areas are affected. The concept of increasing property values over time is a common standard within many industries where construction occurs with the end goal being a new and improved site. Furthermore, the decrease in the probability of flooding will save money for residents affected.

9.2.3 Environmental

Reduced soil erosion will be seen after the new culvert is built both upstream of the culvert and downstream, as well as in the Rio de Flag.

10.0: FEMA Analysis and Summary of Engineering Work

The FEMA (Federal Emergency Management Agency) flood map shows that the project area is in an urban floodplain area. Urban floodplains are in urbanized areas where the flows have been altered from their natural locations [7]. Urban floodplains can be altered to minimize erosion and flooding concerns following the Flagstaff Stormwater regulations [7]. Any altering of a flow path within the flood plain requires that a FEMA analysis must be performed. This is done through creating a Letter of Map Revision (LOMR) that allows for the modification of the Flood Insurance Rate Map. In doing so, this may alter the Flood Insurance Rates of nearby residents within the flood zone area. A full analysis is outside of the scope of this project; however, the client has requested a brief discussion of the modifications.

The flow path across Soliere Avenue has been proposed to be rerouted beneath Soliere Avenue and into the Rio de Flag using two pipe arch culverts. Through implementing the new culvert design, the WSE across Soliere Avenue has been lowered from 3’ during the 50yr storm interval to 0’ since no overtopping will occur. Upstream and downstream modifications are not needed therefore the project area beginning from the channel to the end of the rip rap will be the only alterations to the floodway.

11. Summary of Engineering costs

The proposed cost of engineering work is shown in Table 11.1

Table 11.1: Purposed Cost of Engineering Work

Purposed Cost of Work				
	Classification	**Hours**	**Rate, $/hr**	**Cost**
Personnel	CEN	115	190	$21,850
	PEN	149	120	$17,880
	INT	191	75	$14,325
	TEC	180	60	$10,800
Personnel Total				$64,855
Supplies	Surveying Equipment Rental	24	2,400 per day	$2,400
	Geotechnical Equipment	N/A	Flat Rate	$200
Supplies Total				$2,600
Cost of Engineering Services Total				$67,455

Table 11.2: Final Cost of Engineering Work

Final Cost of Work				
	Classification	**Hours**	**Rate, $/hr**	**Cost**
Personnel	CEN	145	190	$27,550
	PEN	108.8	120	$13,056
	INT	95	75	$7,125
	TEC	101.5	60	$6,090
Personnel Total				$53,821
Supplies	Surveying Equipment Rental	24	2,400 per day	$2,400
Supplies Subtotal				$2400
Cost of Engineering Services Total				$56,421

The final project cost totaled $56,421. Most of the cost is due to personnel, which resulted in being less than proposed. Geotechnical work was not needed. The project was $11,034 under budget which is found in Table 11.1.

References

[1] "Web Soil Survey", *Websoilsurvey.sc.egov.usda.gov*, 2021. [Online]. Available: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx. [Accessed: 20- Sep- 2021].

[2] "Soil Data Explorer | California Soil Resource Lab", *Casoilresource.lawr.ucdavis.edu*, 2021. [Online]. Available: https://casoilresource.lawr.ucdavis.edu/sde/?series=LYNX. [Accessed: 20- Sep- 2021].

[3] “Title 13: Engineering Design Standards and Specifications for New Infrastructure,” Flagstaff Municipal Code. [Online]. Available: https://www.codepublishing.com/AZ/Flagstaff/. [Accessed: Sep-2021].

[4] “City of Flagstaff Stormwater Management Design Manual,” Stormwater Management Design Manual. [PDF]. Available: https://www.flagstaff.az.gov/DocumentCenter/View/58133/SWMgmtDesignManual-3-09?bidId=. [Accessed: Sep-2021].

[5] “Hy8:inlet configurations,” HY8:Inlet Configurations - XMS Wiki. [Online]. Available: https://www.xmswiki.com/wiki/HY8:Inlet_Configurations. [Accessed: 18-Oct-2021].

[6] “Construction Cost Estimation Tool,” Gordian. [Online]. Available: https://www.rsmeansonline.com/ManageEstimate. [Accessed: 02-Dec-2021].

[7] Northern Arizona University, “COF Example Construction Cost .” NAU, Flagstaff, 01-Oct-2021.

[8] “What is a decision matrix?,” Decision Matrix . [Online]. Available: https://asq.org/quality-resources/decision-matrix. [Accessed: Nov-2021].

Appendix A Codes and Requirements

COF Drainage Design Manual Codes

(All sections of CODES come from City of Flagstaff Stormwater Management Design Manual) [4]

5.2.1. Design Storm Criteria

Roadway culverts shall be designed to convey the following frequency flows without roadway overtopping

Collector/Arterial Streets…… 50-year

5.2.3.1. Allowable Headwater

The allowable headwater (HW) is the depth of water that can be ponded at the upstream end of a culvert and shall be limited to one or more of the following parameters:

1. No damage or inundation to upstream property; 2. No greater than the low point in the road grade; 3. Equal to the elevation where flow diverts around the culvert.

5.2.3.2. Tailwater Relationship

A submerged outlet occurs where the tailwater elevation is higher than the crown of the culvert. For design purposes, downstream conditions which result in high tailwater should be avoided if possible. A free outlet has a tailwater equal to or lower than critical depth. For culverts having free outlets, lowering the tailwater has no effect on the discharge or the backwater profile upstream of the tailwater. The tailwater depth may be computed as the highest value of the following criteria:

1. The normal depth in the downstream channel for subcritical flow regimes; 2. The critical depth and equivalent hydraulic grade line if the outlet is operating with a free outfall; 3. The high water elevation that has the same design frequency if outlet is a detention basin, channel, or other body of water; or 4. The quantity (dc + D)/2; where dc = critical depth (ft.), and D = pipe diameter (ft.)

5.2.4.3. Outlets

The maximum velocity at the culvert outlet shall be consistent with the velocity in the natural channel. Appropriate protection shall be considered when outlet velocities are between 4.0 and 15 ft/sec. Recommended outlet treatments are shown in Table 5-2

4 to 10 fps Dumped rock riprap apron

5.2.4.4. Riprap Apron Design Procedure

Typical riprap aprons, as illustrated in Figure 5-3, are suitable for use with outlet velocities not exceeding ten (10) feet per second.

La = (3Q / D1.5) + 7D for TW > 0.5D

Wa = 3D + 0.4La for TW > 0.5D

D50 = [0.02 (Q)4/3] / [TW (D)]

5.2.4.5. Safety Considerations

During design and construction, culvert entrances may require safety precautions to protect life, health, traffic, and adjacent property. This may include the use of safety measures such as fencing, handrails, guard rails, warning signs, and safety/trash racks to limit or deter access by the public.

c. Shielded with a guard rail if the culvert is very large, cannot be extended, has a channel which cannot be safely traversed by a vehicle, has significant flooding hazard with a grate, or has headwalls which protrude 6" or higher above driving surface within the "clear zone"

5.2.5.1. Material Selection

The material selected for culverts should be based on service life, durability, structural strength, hydraulic efficiency, bedding conditions, abrasion and corrosion resistance, and joint tightness. Acceptable materials for culverts intended to be public are:

• Corrugated Metal Pipe (CMP). • Helical Corrugated or Spiral Rib Metal Pipe per MAG Section 760.3. • Rubber Gasket Reinforced Concrete Pipe (RGRCP) - bell or groove and spigot or tongue. 5-14 • Reinforced Concrete Box Culvert (RCBC) per Section 5.2.5.2

5.2.5.3. Culvert Sizes and Shape

Circular cross-sections are preferred, however, the use of arch or oval shapes is permitted only if dictated by hydraulic limitations, site characteristics, structural criteria, or environmental concerns.

5.2.5.4. Cover Requirements

The minimum allowable cover for culverts 18 to 36 inches in diameter shall be one (1) foot from top of pipe to top of subgade or top of finish grade if no subgrade is present. For culverts greater than 36 inches in diameter, minimum cover should be 30% of the culvert diameter, if possible. The top of any culvert should never extend above the roadway subgrade into the roadway street section.

Flagstaff Municipal Code

13-08-001-0001 Stormwater Management

The design and construction of all public and private stormwater management facilities shall be in accordance with these regulations and with the City of Flagstaff Stormwater Management Design Manual and these standards. In the event of a conflict, the more stringent regulation shall apply. (Ord. 2017-22, Rep&ReEn, 07/05/2017

Appendix B Geotechnical AOI and Soil Report

Oak Creek-San Francisco Peaks Area, Arizona, Part of Coconino County (AZ693)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Jacques clay loam, 0 to 2 percent slopes	0.2	0.2%
3A	Baldy stony loam, 8 to 15 percent slopes	2.3	2.1%
13	Lynx loam, 0 to 2 percent slopes	68.0	63.2%
14	Daze fine sandy loam, 0 to 8 percent slopes	30.9	28.7%
15A	Tortugas-Daze complex, 0 to 15 percent slopes	6.3	5.8%
Totals for Area of Interest		**107.6**	**100.0%**

Appendix C Station Interval Method Results

Station 11				
STA	0+00		LOB	ROB
0	6779		0	0
2	6778.8			
4	6778.7			
6	6778.7			

Station 10				
STA	00+16.44		LOB	ROB
0	6778.6		15.46	17.73
2	6778.2			
4	6777.94			
6	6778.05			
8	6778.08			
10	6778.16			
12	6778.23			
14	6778.32			
16	6778.47			
18	6778.6			

Station 9				
STA	00+19.79		LOB	ROB
0	6779.5		19.64	21.82
2	6777.38			

4	6776.8			
6	6777.6			
8	6778.02			
10	6778.06			
12	6778.13			
14	6778.15			
16	6778.05			
18	6777.5			
20	6776.1			
22	6778.59			
24	6781.3			

Station 8				
STA	00+24.55			
0	6779.51		LOB	ROB
2	6777.55		24.41	21.76
4	6776.42			
6	6776.83			
8	6777.25			
10	6777.61			
12	6777.83			
14	6777.99			
16	6777.85			
18	6777.41			
20	6776.64			
22	6777.07			
24	6778.73			

Station 7				
STA	00+24.55		LOB	ROB
0	6779.5		35.51	36.15
2	6778.68			
4	6777.88			
6	6776.57			
8	6776.86			
10	6776.95			
12	6777.23			
14	67777.58			
16	6777.96			
18	6777.81			
20	6777.61			
22	6777.41			
24	6777.23			
26	6776.36			
28	6777.75			
30	6778.46			
32	6778.73			
34	6778.81			

Station 6				
STA	41.29		LOB	ROB
0	6778.99		44.18	44.56
2	6778.77			
4	6778.45			
6	6778.16			
8	6777.86			

10	6777.56			
12	6777.38			
14	6777.31			
16	6777.3			
18	6777.27			
20	6777.28			
22	6777.57			
24	6777.73			
26	6777.52			
28	6777.37			
30	6777.43			
32	6777.53			
34	6777.65			
36	6777.81			
38	6778.05			
40	6778.48			
42	6778.69			
44	6778.76			

Station 5				
STA	00+67.56		LOB	ROB
0	6778.73		80.02	77.32
5	6778.65			
10	6778.56			
15	6778.48			
20	6778.4			
25	6778.32			
30	6778.27			

35	6778.25			
40	6778.24			
45	6778.19			
50	6778.11			
55	6778.02			
60	6777.93			
65	6777.89			
70	6777.89			
75	6777.96			
80	6778.02			

Station 4				
STA	86.98		LOB	ROB
			95.78	93.64
0	6778.51			
5	6778.33			
10	6778.22			
15	6778.31			
20	6778.35			
25	6778.34			
30	6778.2			
35	6778.06			
40	6777.92			
45	6777.89			
50	6777.92			
55	6777.93			
60	6777.93			
65	6777.93			

70	6777.82			
75	6777.7			
80	6777.73			

Station 3				
STA	00+86.76		LOB	ROB
0	6779.09		116.97	112.7
5	6778.77			
10	6778.48			
15	6777.67			
20	6776.31			
25	6776.86			
30	6776.89			
35	6776.95			
40	6776.95			
45	6776.96			
50	6776.97			
55	6776.99			
60	6777.05			
65	6777.1			
70	6777.28			
75	6777.35			

Station 2				
STA	01+25.39		LOB	ROB
0	6776.99		128.44	130.45
5	6776.82			
10	6776.64			

15	6776.31			
20	6775.96			
25	6775.84			
30	6775.74			
35	6774.72			
40	6773.97			
45	6774.84			
50	6774.97			
55	6774.99			
60	6775.39			
65	6775.61			
70	6776.9			

Station 1				
STA	1+41.6		LOB	ROB
0	6775.49		142.84	144.89
2	6775.31			
4	6775.11			
6	6774.91			
8	6774.44			
10	6772.85			
12	6771.37			
14	6770.95			
16	6771.15			
18	6771.56			
20	6771.96			
22	6771.71			
24	6771.13			

26	6770.56			
28	6769.98			
30	6769.57			
32	6769.81			
34	6770.06			
36	6770.31			
38	6770.55			
40	6770.79			
42	6771.04			
44	6771.31			
46	6771.88			
48	6772.37			
50	6772.88			
52	6773.42			
54	6773.99			
56	6774.58			
58	6775.15			
60	6766.04			

Appendix D HEC RAS Existing Model Report

```
                HEC-RAS HEC-RAS 6.0.0 Beta 3 Dec 2020
                  U.S. Army Corps of Engineers
                 Hydrologic Engineering Center
                       609 Second Street
                       Davis, California

 X     X  XXXXXXX    XXXX         XXXX        XX       XXXX
 X     X  X         X    X       X    X      X  X     X
 X     X  X         X            X    X     X    X    X
 XXXXXXX  XXXX      X       XXX  XXXX      XXXXXX     XXXX
 X     X  X         X            X  X      X    X        X
 X     X  X         X    X       X   X     X    X        X
 X     X  XXXXXXX    XXXX        X    X    X    X   XXXXX

PROJECT DATA
Project Title: Fanning Wash Pre Model
Project File : FanningWashPreMo.prj
Run Date and Time: 11/29/2021 6:45:31 PM

Project in English units


PLAN DATA

Plan Title: Plan 02
Plan File : Z:\Documents\FanningWashPreMo.p02

          Geometry Title: Fanning Wash Geometry Data Pre Model
          Geometry File : Z:\Documents\FanningWashPreMo.g02

          Flow Title    : Flow 01
          Flow File     : Z:\Documents\FanningWashPreMo.f01

Plan Summary Information:
Number of:  Cross Sections =   11    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    0    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001
```

```
Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Mixed Flow



FLOW DATA

Flow Title: Flow 01
Flow File : Z:\Documents\FanningWashPreMo.f01

Flow Data (cfs)

  River           Reach           RS                  PF 1            PF 2
  Fanning Wash    1               11                   730             570


Boundary Conditions


  River           Reach           Profile                       Upstream
    Downstream


  Fanning Wash    1               PF 1                            Critical
      Critical
  Fanning Wash    1               PF 2                            Critical
      Critical




GEOMETRY DATA

Geometry Title: Fanning Wash Geometry Data Pre Model
Geometry File : Z:\Documents\FanningWashPreMo.g02

CROSS SECTION


RIVER: Fanning Wash
REACH: 1                 RS: 11

INPUT
Description: Exit of I40 Culvert
```

Station Elevation Data num= 4

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6779	2	6778.8	4	6778.7	6	6778.7

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.013	0	.013	6	.013

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	6	.5	.5	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6790.36	Element	Left OB	Channel
Vel Head (ft)	3.82	Wt. n-Val.		0.013
W.S. Elev (ft)	6786.54	Reach Len. (ft)	0.50	0.50
Crit W.S. (ft)	6786.54	Flow Area (sq ft)		46.55
E.G. Slope (ft/ft)	0.006678	Area (sq ft)		46.55
Q Total (cfs)	730.00	Flow (cfs)		730.00
Top Width (ft)	6.00	Top Width (ft)		6.00
Vel Total (ft/s)	15.68	Avg. Vel. (ft/s)		15.68
Max Chl Dpth (ft)	7.84	Hydr. Depth (ft)		7.76
Conv. Total (cfs)	8932.8	Conv. (cfs)		8932.8
Length Wtd. (ft)	0.50	Wetted Per. (ft)		21.39
Min Ch El (ft)	6778.70	Shear (lb/sq ft)		0.91
Alpha	1.00	Stream Power (lb/ft s)		14.23
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)		3.10
C & E Loss (ft)	1.03	Cum SA (acres)		0.75

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical
depth for the water surface and continued on with the calculations.

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
program defaulted to critical depth.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6788.60	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.24	Wt. n-Val.		0.013	
W.S. Elev (ft)	6785.36	Reach Len. (ft)	0.50	0.50	0.50
Crit W.S. (ft)	6785.36	Flow Area (sq ft)		39.47	
E.G. Slope (ft/ft)	0.006037	Area (sq ft)		39.47	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	6.00	Top Width (ft)		6.00	
Vel Total (ft/s)	14.44	Avg. Vel. (ft/s)		14.44	
Max Chl Dpth (ft)	6.66	Hydr. Depth (ft)		6.58	
Conv. Total (cfs)	7336.0	Conv. (cfs)		7336.0	
Length Wtd. (ft)	0.50	Wetted Per. (ft)		19.04	
Min Ch El (ft)	6778.70	Shear (lb/sq ft)		0.78	
Alpha	1.00	Stream Power (lb/ft s)		11.29	

Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	2.68
C & E Loss (ft)	0.88	Cum SA (acres)	0.74

```
Warning: The energy equation could not be balanced within the specified number of
iterations.  The program used critical
         depth for the water surface and continued on with the calculations.
Warning: The cross-section end points had to be extended vertically for the computed
water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than
         1.4.  This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth
calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and
previous cross section.  This may indicate
         the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set
equal to critical depth, the calculated
         water surface came back below critical depth.  This indicates that there is
not a valid subcritical answer.  The
         program defaulted to critical depth.
Warning: The parabolic search method failed to converge on critical depth.  The
program will try the cross section slice/secant
         method to find critical depth.

CROSS SECTION


RIVER: Fanning Wash
REACH: 1                 RS: 10

INPUT
Description: Conc out of I40 Culv
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  6778.6       2  6778.2       4 6777.94       6 6778.05       8 6778.08
      10 6778.16      12 6778.23      14 6778.32      16 6778.47      18  6778.6

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .013       0    .013      18    .013
```

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	18	15.46	16.44	17.73	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6786.79	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.38	Wt. n-Val.		0.013	
W.S. Elev (ft)	6786.41	Reach Len. (ft)	15.46	16.44	17.73
Crit W.S. (ft)	6781.97	Flow Area (sq ft)		147.26	
E.G. Slope (ft/ft)	0.000263	Area (sq ft)		147.26	
Q Total (cfs)	730.00	Flow (cfs)		730.00	
Top Width (ft)	18.00	Top Width (ft)		18.00	
Vel Total (ft/s)	4.96	Avg. Vel. (ft/s)		4.96	
Max Chl Dpth (ft)	8.47	Hydr. Depth (ft)		8.18	
Conv. Total (cfs)	44994.4	Conv. (cfs)		44994.4	
Length Wtd. (ft)	16.44	Wetted Per. (ft)		33.69	
Min Ch El (ft)	6777.94	Shear (lb/sq ft)		0.07	
Alpha	1.00	Stream Power (lb/ft s)		0.36	
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)		3.10	
C & E Loss (ft)	0.06	Cum SA (acres)		0.75	

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Note: Hydraulic jump has occurred between this cross section and the previous upstream section.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6785.66	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.31	Wt. n-Val.		0.013	
W.S. Elev (ft)	6785.35	Reach Len. (ft)	15.46	16.44	17.73
Crit W.S. (ft)	6781.39	Flow Area (sq ft)		128.17	
E.G. Slope (ft/ft)	0.000234	Area (sq ft)		128.17	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	18.00	Top Width (ft)		18.00	
Vel Total (ft/s)	4.45	Avg. Vel. (ft/s)		4.45	
Max Chl Dpth (ft)	7.41	Hydr. Depth (ft)		7.12	
Conv. Total (cfs)	37284.4	Conv. (cfs)		37284.4	
Length Wtd. (ft)	16.44	Wetted Per. (ft)		31.57	
Min Ch El (ft)	6777.94	Shear (lb/sq ft)		0.06	
Alpha	1.00	Stream Power (lb/ft s)		0.26	
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)		2.68	
C & E Loss (ft)	0.05	Cum SA (acres)		0.74	

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Note: Hydraulic jump has occurred between this cross section and the previous upstream section.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 9

INPUT
Description: Culvert Inlet
Culvert

```
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  6779.5       2 6777.38       4  6776.8       6  6777.6       8 6778.02
      10 6778.06      12 6778.13      14 6778.15      16 6778.05      18  6777.5
      20  6776.1      22 6778.59      24  6781.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0     .04       0      .3      24     .04

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      24            19.64   19.79   21.82              .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6786.72    Element                   Left OB    Channel
Right OB
  Vel Head (ft)               0.19    Wt. n-Val.                            0.300

  W.S. Elev (ft)           6786.53    Reach Len. (ft)            19.64      19.79
  21.82
  Crit W.S. (ft)                      Flow Area (sq ft)                     207.04

  E.G. Slope (ft/ft)      0.057593    Area (sq ft)                          207.04

  Q Total (cfs)             730.00    Flow (cfs)                            730.00

  Top Width (ft)             24.00    Top Width (ft)                         24.00

  Vel Total (ft/s)            3.53    Avg. Vel. (ft/s)                       3.53

  Max Chl Dpth (ft)          10.42    Hydr. Depth (ft)                       8.63

  Conv. Total (cfs)         3041.9    Conv. (cfs)                           3041.9

  Length Wtd. (ft)           19.79    Wetted Per. (ft)                       40.53

  Min Ch El (ft)           6776.10    Shear (lb/sq ft)                       18.37

  Alpha                       1.00    Stream Power (lb/ft s)                 64.77

  Frctn Loss (ft)             1.32    Cum Volume (acre-ft)                    3.04

  C & E Loss (ft)             0.01    Cum SA (acres)                          0.74



Warning: The cross-section end points had to be extended vertically for the computed
```

water surface.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
         the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6785.60	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.15	Wt. n-Val.		0.300	
W.S. Elev (ft)	6785.44	Reach Len. (ft)	19.64	19.79	21.82
Crit W.S. (ft)		Flow Area (sq ft)		181.06	
E.G. Slope (ft/ft)	0.051026	Area (sq ft)		181.06	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	24.00	Top Width (ft)		24.00	
Vel Total (ft/s)	3.15	Avg. Vel. (ft/s)		3.15	
Max Chl Dpth (ft)	9.34	Hydr. Depth (ft)		7.54	
Conv. Total (cfs)	2523.4	Conv. (cfs)		2523.4	
Length Wtd. (ft)	19.79	Wetted Per. (ft)		38.36	
Min Ch El (ft)	6776.10	Shear (lb/sq ft)		15.04	
Alpha	1.00	Stream Power (lb/ft s)		47.33	
Frctn Loss (ft)	1.16	Cum Volume (acre-ft)		2.62	
C & E Loss (ft)	0.00	Cum SA (acres)		0.73	

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
         the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 8

INPUT
Description: Culvert Inlet
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6779.51	2	6777.55	4	6776.42	6	6776.83	8	6777.25
10	6777.61	12	6777.83	14	6777.99	16	6777.85	18	6777.41
20	6776.64	22	6777.07	24	6778.73				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.04	0	.3	24	.04

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	24	24.41	24.55	21.76	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6785.40	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.24	Wt. n-Val.		0.300
W.S. Elev (ft)	6785.15	Reach Len. (ft)	24.41	24.55
21.76				
Crit W.S. (ft)		Flow Area (sq ft)		184.49
E.G. Slope (ft/ft)	0.078000	Area (sq ft)		184.49
Q Total (cfs)	730.00	Flow (cfs)		730.00
Top Width (ft)	24.00	Top Width (ft)		24.00
Vel Total (ft/s)	3.96	Avg. Vel. (ft/s)		3.96
Max Chl Dpth (ft)	8.73	Hydr. Depth (ft)		7.69
Conv. Total (cfs)	2613.8	Conv. (cfs)		2613.8
Length Wtd. (ft)	24.55	Wetted Per. (ft)		38.14
Min Ch El (ft)	6776.42	Shear (lb/sq ft)		23.56
Alpha	1.00	Stream Power (lb/ft s)		93.21
Frctn Loss (ft)	2.12	Cum Volume (acre-ft)		2.95
C & E Loss (ft)	0.00	Cum SA (acres)		0.73

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
         the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6784.44	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.19	Wt. n-Val.		0.300	
W.S. Elev (ft)	6784.24	Reach Len. (ft)	24.41	24.55	21.76
Crit W.S. (ft)		Flow Area (sq ft)		162.72	
E.G. Slope (ft/ft)	0.067729	Area (sq ft)		162.72	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	24.00	Top Width (ft)		24.00	
Vel Total (ft/s)	3.50	Avg. Vel. (ft/s)		3.50	
Max Chl Dpth (ft)	7.82	Hydr. Depth (ft)		6.78	
Conv. Total (cfs)	2190.2	Conv. (cfs)		2190.2	
Length Wtd. (ft)	24.55	Wetted Per. (ft)		36.32	
Min Ch El (ft)	6776.42	Shear (lb/sq ft)		18.94	
Alpha	1.00	Stream Power (lb/ft s)		66.35	
Frctn Loss (ft)	1.89	Cum Volume (acre-ft)		2.54	
C & E Loss (ft)	0.00	Cum SA (acres)		0.72	

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate

the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 7

INPUT
Description: Culvert Inlet
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6779.5	2	6778.68	4	6777.88	6	6776.57	8	6776.86
10	6776.95	12	6777.23	14	6777.58	16	6777.96	18	6777.81
20	6777.61	22	6777.41	24	6777.23	26	6776.36	28	6777.75
30	6778.46	32	6778.73	34	6778.81				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.04	0	.3	34	.04

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	34	35.51	35.01	36.15	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6783.27	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.25	Wt. n-Val.		0.300	
W.S. Elev (ft)	6783.02	Reach Len. (ft)	35.51	35.01	36.15
Crit W.S. (ft)		Flow Area (sq ft)		182.21	
E.G. Slope (ft/ft)	0.096404	Area (sq ft)		182.21	
Q Total (cfs)	730.00	Flow (cfs)		730.00	
Top Width (ft)	34.00	Top Width (ft)		34.00	
Vel Total (ft/s)	4.01	Avg. Vel. (ft/s)		4.01	
Max Chl Dpth (ft)	6.66	Hydr. Depth (ft)		5.36	
Conv. Total (cfs)	2351.1	Conv. (cfs)		2351.1	
Length Wtd. (ft)	35.01	Wetted Per. (ft)		43.34	
Min Ch El (ft)	6776.36	Shear (lb/sq ft)		25.31	

Alpha	1.00	Stream Power (lb/ft s)	101.38
Frctn Loss (ft)	0.10	Cum Volume (acre-ft)	2.84
C & E Loss (ft)	0.03	Cum SA (acres)	0.72

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6782.54	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.20	Wt. n-Val.		0.300
W.S. Elev (ft)	6782.34	Reach Len. (ft)	35.51	35.01
36.15				
Crit W.S. (ft)		Flow Area (sq ft)		159.11
E.G. Slope (ft/ft)	0.088527	Area (sq ft)		159.11
Q Total (cfs)	570.00	Flow (cfs)		570.00
Top Width (ft)	34.00	Top Width (ft)		34.00
Vel Total (ft/s)	3.58	Avg. Vel. (ft/s)		3.58
Max Chl Dpth (ft)	5.98	Hydr. Depth (ft)		4.68
Conv. Total (cfs)	1915.7	Conv. (cfs)		1915.7
Length Wtd. (ft)	35.01	Wetted Per. (ft)		41.98
Min Ch El (ft)	6776.36	Shear (lb/sq ft)		20.95
Alpha	1.00	Stream Power (lb/ft s)		75.05
Frctn Loss (ft)	0.09	Cum Volume (acre-ft)		2.45
C & E Loss (ft)	0.02	Cum SA (acres)		0.70

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 6

INPUT
Description: Rip Rap
Station Elevation Data num= 23

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6778.99	2	6778.77	4	6778.45	6	6778.16	8	6777.86
10	6777.56	12	6777.38	14	6777.31	16	6777.3	18	6777.27
20	6777.28	22	6777.57	24	6777.73	26	6777.52	28	6777.37
30	6777.43	32	6777.53	34	6777.65	36	6777.81	38	6778.05
40	6778.48	42	6778.69	44	6778.76				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	0	.035	44	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	44	44.18	41.29	44.56	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6783.15	Element	Left OB	Channel
Right OB				
Vel Head (ft)	0.16	Wt. n-Val.		0.035
W.S. Elev (ft)	6782.99	Reach Len. (ft)	44.18	41.29
44.56				
Crit W.S. (ft)		Flow Area (sq ft)		227.37
E.G. Slope (ft/ft)	0.000809	Area (sq ft)		227.37
Q Total (cfs)	730.00	Flow (cfs)		730.00
Top Width (ft)	44.00	Top Width (ft)		44.00
Vel Total (ft/s)	3.21	Avg. Vel. (ft/s)		3.21

Max Chl Dpth (ft)	5.72	Hydr. Depth (ft)	5.17
Conv. Total (cfs)	25658.6	Conv. (cfs)	25658.6
Length Wtd. (ft)	41.29	Wetted Per. (ft)	52.47
Min Ch El (ft)	6777.27	Shear (lb/sq ft)	0.22
Alpha	1.00	Stream Power (lb/ft s)	0.70
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	2.68
C & E Loss (ft)	0.03	Cum SA (acres)	0.69

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6782.43	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.13	Wt. n-Val.		0.035	
W.S. Elev (ft)	6782.30	Reach Len. (ft)	44.18	41.29	44.56
Crit W.S. (ft)		Flow Area (sq ft)		197.04	
E.G. Slope (ft/ft)	0.000768	Area (sq ft)		197.04	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	44.00	Top Width (ft)		44.00	
Vel Total (ft/s)	2.89	Avg. Vel. (ft/s)		2.89	
Max Chl Dpth (ft)	5.03	Hydr. Depth (ft)		4.48	
Conv. Total (cfs)	20572.8	Conv. (cfs)		20572.8	
Length Wtd. (ft)	41.29	Wetted Per. (ft)		51.09	
Min Ch El (ft)	6777.27	Shear (lb/sq ft)		0.18	

Alpha	1.00	Stream Power (lb/ft s)	0.53
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	2.31
C & E Loss (ft)	0.03	Cum SA (acres)	0.67

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 5

INPUT
Description: Road
Station Elevation Data num= 17

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6778.73	5	6778.65	10	6778.56	15	6778.48	20	6778.4
25	6778.32	30	6778.27	35	6778.25	40	6778.24	45	6778.19
50	6778.11	55	6778.02	60	6777.93	65	6777.89	70	6777.89
75	6777.96	80	6778.02						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.016	0	.016	80	.016

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	80	80.02	67.56	77.32	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6783.11	Element	Left OB Channel Right OB
Vel Head (ft)	0.06	Wt. n-Val.	0.016
W.S. Elev (ft)	6783.06	Reach Len. (ft)	80.02 67.56 77.32
Crit W.S. (ft)		Flow Area (sq ft)	386.74
E.G. Slope (ft/ft)	0.000059	Area (sq ft)	386.74

Q Total (cfs)	730.00	Flow (cfs)	730.00
Top Width (ft)	80.00	Top Width (ft)	80.00
Vel Total (ft/s)	1.89	Avg. Vel. (ft/s)	1.89
Max Chl Dpth (ft)	5.17	Hydr. Depth (ft)	4.83
Conv. Total (cfs)	95378.6	Conv. (cfs)	95378.6
Length Wtd. (ft)	67.56	Wetted Per. (ft)	89.37
Min Ch El (ft)	6777.89	Shear (lb/sq ft)	0.02
Alpha	1.00	Stream Power (lb/ft s)	0.03
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	2.39
C & E Loss (ft)	0.00	Cum SA (acres)	0.63

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6782.40	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.05	Wt. n-Val.		0.016	
W.S. Elev (ft)	6782.35	Reach Len. (ft)	80.02	67.56	77.32
Crit W.S. (ft)		Flow Area (sq ft)		330.37	
E.G. Slope (ft/ft)	0.000059	Area (sq ft)		330.37	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	80.00	Top Width (ft)		80.00	
Vel Total (ft/s)	1.73	Avg. Vel. (ft/s)		1.73	
Max Chl Dpth (ft)	4.46	Hydr. Depth (ft)		4.13	
Conv. Total (cfs)	74135.7	Conv. (cfs)		74135.7	
Length Wtd. (ft)	67.56	Wetted Per. (ft)		87.96	

Min Ch El (ft)	6777.89	Shear (lb/sq ft)	0.01
Alpha	1.00	Stream Power (lb/ft s)	0.02
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	2.06
C & E Loss (ft)	0.00	Cum SA (acres)	0.61

Warning: The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 4

INPUT
Description: Conc above Culvert Outlet
Paved Pullout
Station Elevation Data num= 17

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6778.51	5	6778.33	10	6778.22	15	6778.31	20	6778.35
25	6778.34	30	6778.2	35	6778.06	40	6777.92	45	6777.89
50	6777.92	55	6777.93	60	6777.93	65	6777.93	70	6777.82
75	6777.7	80	6777.73						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.015	0	.015	80	.015

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	80	95.78	86.98	93.64	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6783.11	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.05	Wt. n-Val.		0.015	
W.S. Elev (ft)	6783.05	Reach Len. (ft)	95.78	86.98	93.64
Crit W.S. (ft)		Flow Area (sq ft)		399.48	
E.G. Slope (ft/ft)	0.000047	Area (sq ft)		399.48	

Q Total (cfs)	730.00	Flow (cfs)	730.00
Top Width (ft)	80.00	Top Width (ft)	80.00
Vel Total (ft/s)	1.83	Avg. Vel. (ft/s)	1.83
Max Chl Dpth (ft)	5.35	Hydr. Depth (ft)	4.99
Conv. Total (cfs)	106974.5	Conv. (cfs)	106974.5
Length Wtd. (ft)	86.98	Wetted Per. (ft)	89.88
Min Ch El (ft)	6777.70	Shear (lb/sq ft)	0.01
Alpha	1.00	Stream Power (lb/ft s)	0.02
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	1.78
C & E Loss (ft)	0.00	Cum SA (acres)	0.50

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6782.39	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.04	Wt. n-Val.		0.015	
W.S. Elev (ft)	6782.35	Reach Len. (ft)	95.78	86.98	93.64
Crit W.S. (ft)		Flow Area (sq ft)		343.11	
E.G. Slope (ft/ft)	0.000046	Area (sq ft)		343.11	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	80.00	Top Width (ft)		80.00	
Vel Total (ft/s)	1.66	Avg. Vel. (ft/s)		1.66	
Max Chl Dpth (ft)	4.65	Hydr. Depth (ft)		4.29	

Conv. Total (cfs)	83899.4	Conv. (cfs)	83899.4
Length Wtd. (ft)	86.98	Wetted Per. (ft)	88.47
Min Ch El (ft)	6777.70	Shear (lb/sq ft)	0.01
Alpha	1.00	Stream Power (lb/ft s)	0.02
Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	1.54
C & E Loss (ft)	0.00	Cum SA (acres)	0.49

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 3

INPUT
Description: Conc above culvert outlet
Station Elevation Data num= 16

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6779.09	5	6778.77	10	6778.48	15	6777.67	20	6776.31
25	6776.86	30	6776.89	35	6776.95	40	6776.95	45	6776.96
50	6776.97	55	6776.99	60	6777.05	65	6777.1	70	6777.28
75	6777.35								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.04	0	.3	75	.04

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	75	116.97	115.43	112.7	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6783.09	Element	Left OB Channel Right OB
Vel Head (ft)	0.04	Wt. n-Val.	0.300

W.S. Elev (ft)	6783.05	Reach Len. (ft)	116.97	115.43	112.70
Crit W.S. (ft)		Flow Area (sq ft)		431.12	
E.G. Slope (ft/ft)	0.013401	Area (sq ft)		431.12	
Q Total (cfs)	730.00	Flow (cfs)		730.00	
Top Width (ft)	75.00	Top Width (ft)		75.00	
Vel Total (ft/s)	1.69	Avg. Vel. (ft/s)		1.69	
Max Chl Dpth (ft)	6.73	Hydr. Depth (ft)		5.75	
Conv. Total (cfs)	6306.0	Conv. (cfs)		6306.0	
Length Wtd. (ft)	115.43	Wetted Per. (ft)		84.95	
Min Ch El (ft)	6776.31	Shear (lb/sq ft)		4.25	
Alpha	1.00	Stream Power (lb/ft s)		7.19	
Frctn Loss (ft)	5.14	Cum Volume (acre-ft)		0.95	
C & E Loss (ft)	0.07	Cum SA (acres)		0.35	

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6782.38	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.04	Wt. n-Val.		0.300	
W.S. Elev (ft)	6782.34	Reach Len. (ft)	116.97	115.43	

112.70

Crit W.S. (ft)		Flow Area (sq ft)	378.31
E.G. Slope (ft/ft)	0.012351	Area (sq ft)	378.31
Q Total (cfs)	570.00	Flow (cfs)	570.00
Top Width (ft)	75.00	Top Width (ft)	75.00
Vel Total (ft/s)	1.51	Avg. Vel. (ft/s)	1.51
Max Chl Dpth (ft)	6.03	Hydr. Depth (ft)	5.04
Conv. Total (cfs)	5128.8	Conv. (cfs)	5128.8
Length Wtd. (ft)	115.43	Wetted Per. (ft)	83.54
Min Ch El (ft)	6776.31	Shear (lb/sq ft)	3.49
Alpha	1.00	Stream Power (lb/ft s)	5.26
Frctn Loss (ft)	4.79	Cum Volume (acre-ft)	0.82
C & E Loss (ft)	0.06	Cum SA (acres)	0.34

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 2

INPUT
Description: Concrete directly above Culvert
Concrete above Culvert Outlet
Station Elevation Data num= 15

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6776.99	5	6776.82	10	6776.64	15	6776.31	20	6775.96
25	6775.84	30	6775.74	35	6774.72	40	6773.97	45	6774.84
50	6774.97	55	6774.99	60	6775.39	65	6775.61	70	6776.9

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.4	0	.33	70	.4

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	70	128.44	125.39	130.45	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6777.88	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.76	Wt. n-Val.		0.330	
W.S. Elev (ft)	6777.12	Reach Len. (ft)	128.44	125.39	130.45
Crit W.S. (ft)	6777.12	Flow Area (sq ft)		104.47	
E.G. Slope (ft/ft)	1.433300	Area (sq ft)		104.47	
Q Total (cfs)	730.00	Flow (cfs)		730.00	
Top Width (ft)	70.00	Top Width (ft)		70.00	
Vel Total (ft/s)	6.99	Avg. Vel. (ft/s)		6.99	
Max Chl Dpth (ft)	3.15	Hydr. Depth (ft)		1.49	
Conv. Total (cfs)	609.8	Conv. (cfs)		609.8	
Length Wtd. (ft)	125.39	Wetted Per. (ft)		70.80	
Min Ch El (ft)	6773.97	Shear (lb/sq ft)		132.05	
Alpha	1.00	Stream Power (lb/ft s)		922.66	
Frctn Loss (ft)	2.98	Cum Volume (acre-ft)		0.24	
C & E Loss (ft)	0.14	Cum SA (acres)		0.16	

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical

depth for the water surface and continued on with the calculations.
Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
program defaulted to critical depth.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6777.53	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.66	Wt. n-Val.		0.330	
W.S. Elev (ft)	6776.87	Reach Len. (ft)	128.44	125.39	130.45
Crit W.S. (ft)	6776.87	Flow Area (sq ft)		87.26	
E.G. Slope (ft/ft)	1.471911	Area (sq ft)		87.26	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	66.30	Top Width (ft)		66.30	
Vel Total (ft/s)	6.53	Avg. Vel. (ft/s)		6.53	
Max Chl Dpth (ft)	2.90	Hydr. Depth (ft)		1.32	
Conv. Total (cfs)	469.8	Conv. (cfs)		469.8	
Length Wtd. (ft)	125.39	Wetted Per. (ft)		66.74	
Min Ch El (ft)	6773.97	Shear (lb/sq ft)		120.15	
Alpha	1.00	Stream Power (lb/ft s)		784.79	
Frctn Loss (ft)	3.18	Cum Volume (acre-ft)		0.20	

```
  C & E Loss (ft)            0.12    Cum SA (acres)                      0.15


Warning: The energy equation could not be balanced within the specified number of
iterations.  The program used critical
         depth for the water surface and continued on with the calculations.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than
         1.4.  This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and
previous cross section.  This may indicate
         the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set
equal to critical depth, the calculated
         water surface came back below critical depth.  This indicates that there is
not a valid subcritical answer.  The
         program defaulted to critical depth.

CROSS SECTION


RIVER: Fanning Wash
REACH: 1                 RS: 1

INPUT
Description: Rio de Flag
Station Elevation Data    num=      31
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 6775.49       2 6775.31       4 6775.11       6 6774.91       8 6774.44
      10 6772.85      12 6771.37      14 6770.95      16 6771.15      18 6771.56
      20 6771.96      22 6771.71      24 6771.13      26 6770.56      28 6769.98
      30 6769.57      32 6769.81      34 6770.06      36 6770.31      38 6770.55
      40 6770.79      42 6771.04      44 6771.31      46 6771.88      48 6772.37
      50 6772.88      52 6773.42      54 6773.99      56 6774.58      58 6775.15
      60 6776.04

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .014       0    .014      60    .014

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      60           142.84   141.6  144.89             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6774.75    Element                  Left OB    Channel
```

Right OB			
Vel Head (ft)	2.16	Wt. n-Val.	0.014
W.S. Elev (ft)	6772.59	Reach Len. (ft)	
Crit W.S. (ft)	6773.25	Flow Area (sq ft)	61.95
E.G. Slope (ft/ft)	0.006791	Area (sq ft)	61.95
Q Total (cfs)	730.00	Flow (cfs)	730.00
Top Width (ft)	38.51	Top Width (ft)	38.51
Vel Total (ft/s)	11.78	Avg. Vel. (ft/s)	11.78
Max Chl Dpth (ft)	3.02	Hydr. Depth (ft)	1.61
Conv. Total (cfs)	8858.4	Conv. (cfs)	8858.4
Length Wtd. (ft)		Wetted Per. (ft)	39.62
Min Ch El (ft)	6769.57	Shear (lb/sq ft)	0.66
Alpha	1.00	Stream Power (lb/ft s)	7.81
Frctn Loss (ft)		Cum Volume (acre-ft)	
C & E Loss (ft)		Cum SA (acres)	

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.
Note: Program found supercritical flow starting at this cross section.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6774.22	Element	Left OB	Channel
Right OB				
Vel Head (ft)	1.91	Wt. n-Val.		0.014
W.S. Elev (ft)	6772.31	Reach Len. (ft)		
Crit W.S. (ft)	6772.88	Flow Area (sq ft)		51.48
E.G. Slope (ft/ft)	0.007268	Area (sq ft)		51.48
Q Total (cfs)	570.00	Flow (cfs)		570.00
Top Width (ft)	37.04	Top Width (ft)		37.04
Vel Total (ft/s)	11.07	Avg. Vel. (ft/s)		11.07
Max Chl Dpth (ft)	2.74	Hydr. Depth (ft)		1.39
Conv. Total (cfs)	6686.1	Conv. (cfs)		6686.1
Length Wtd. (ft)		Wetted Per. (ft)		38.03
Min Ch El (ft)	6769.57	Shear (lb/sq ft)		0.61
Alpha	1.00	Stream Power (lb/ft s)		6.80
Frctn Loss (ft)		Cum Volume (acre-ft)		
C & E Loss (ft)		Cum SA (acres)		

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Note: Program found supercritical flow starting at this cross section.

SUMMARY OF MANNING'S N VALUES

River:Fanning Wash

Reach	River Sta.	n1	n2	n3
1	11	.013	.013	.013
1	10	.013	.013	.013
1	9	.04	.3	.04
1	8	.04	.3	.04
1	7	.04	.3	.04
1	6	.035	.035	.035
1	5	.016	.016	.016
1	4	.015	.015	.015
1	3	.04	.3	.04
1	2	.4	.33	.4
1	1	.014	.014	.014

SUMMARY OF REACH LENGTHS

River: Fanning Wash

Reach	River Sta.	Left	Channel	Right
1	11	.5	.5	.5
1	10	15.46	16.44	17.73
1	9	19.64	19.79	21.82
1	8	24.41	24.55	21.76
1	7	35.51	35.01	36.15
1	6	44.18	41.29	44.56
1	5	80.02	67.56	77.32
1	4	95.78	86.98	93.64
1	3	116.97	115.43	112.7
1	2	128.44	125.39	130.45
1	1	142.84	141.6	144.89

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Fanning Wash

Reach	River Sta.	Contr.	Expan.
1	11	.1	.3
1	10	.1	.3
1	9	.1	.3
1	8	.1	.3
1	7	.1	.3

1	6	.1	.3
1	5	.1	.3
1	4	.1	.3
1	3	.1	.3
1	2	.1	.3
1	1	.1	.3

Profile Output Table - Standard Table 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.
E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	
			(cfs)	(ft)	(ft)	(ft)
(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		
1	11	PF 1	730.00	6778.70	6786.54	6786.54
6790.36	0.006678	15.68	46.55	6.00	0.99	
1	11	PF 2	570.00	6778.70	6785.36	6785.36
6788.60	0.006037	14.44	39.47	6.00	0.99	
1	10	PF 1	730.00	6777.94	6786.41	6781.97
6786.79	0.000263	4.96	147.26	18.00	0.31	
1	10	PF 2	570.00	6777.94	6785.35	6781.39
6785.66	0.000234	4.45	128.17	18.00	0.29	
1	9	PF 1	730.00	6776.10	6786.53	
6786.72	0.057593	3.53	207.04	24.00	0.21	
1	9	PF 2	570.00	6776.10	6785.44	
6785.60	0.051026	3.15	181.06	24.00	0.20	
1	8	PF 1	730.00	6776.42	6785.15	
6785.40	0.078000	3.96	184.49	24.00	0.25	
1	8	PF 2	570.00	6776.42	6784.24	
6784.44	0.067729	3.50	162.72	24.00	0.24	
1	7	PF 1	730.00	6776.36	6783.02	
6783.27	0.096404	4.01	182.21	34.00	0.31	
1	7	PF 2	570.00	6776.36	6782.34	
6782.54	0.088527	3.58	159.11	34.00	0.29	
1	6	PF 1	730.00	6777.27	6782.99	
6783.15	0.000809	3.21	227.37	44.00	0.25	
1	6	PF 2	570.00	6777.27	6782.30	

6782.43	0.000768	2.89	197.04	44.00	0.24	
1	5	PF 1	730.00	6777.89	6783.06	
6783.11	0.000059	1.89	386.74	80.00	0.15	
1	5	PF 2	570.00	6777.89	6782.35	
6782.40	0.000059	1.73	330.37	80.00	0.15	
1	4	PF 1	730.00	6777.70	6783.05	
6783.11	0.000047	1.83	399.48	80.00	0.14	
1	4	PF 2	570.00	6777.70	6782.35	
6782.39	0.000046	1.66	343.11	80.00	0.14	
1	3	PF 1	730.00	6776.31	6783.05	
6783.09	0.013401	1.69	431.12	75.00	0.12	
1	3	PF 2	570.00	6776.31	6782.34	
6782.38	0.012351	1.51	378.31	75.00	0.12	
1	2	PF 1	730.00	6773.97	6777.12	6777.12
6777.88	1.433300	6.99	104.47	70.00	1.01	
1	2	PF 2	570.00	6773.97	6776.87	6776.87
6777.53	1.471911	6.53	87.26	66.30	1.00	
1	1	PF 1	730.00	6769.57	6772.59	6773.25
6774.75	0.006791	11.78	61.95	38.51	1.64	
1	1	PF 2	570.00	6769.57	6772.31	6772.88
6774.22	0.007268	11.07	51.48	37.04	1.66	

Profile Output Table - Standard Table 2

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
1	11	PF 1	6790.36	6786.54	3.82	0.00	1.03		730.00		6.00
1	11	PF 2	6788.60	6785.36	3.24	0.00	0.88		570.00		6.00
1	10	PF 1	6786.79	6786.41	0.38						

```
0.02        0.06              730.00                18.00
  1           10            PF 2        6785.66     6785.35       0.31
0.01        0.05              570.00                18.00


  1            9            PF 1        6786.72     6786.53       0.19
1.32        0.01              730.00                24.00
  1            9            PF 2        6785.60     6785.44       0.15
1.16        0.00              570.00                24.00


  1            8            PF 1        6785.40     6785.15       0.24
2.12        0.00              730.00                24.00
  1            8            PF 2        6784.44     6784.24       0.19
1.89        0.00              570.00                24.00


  1            7            PF 1        6783.27     6783.02       0.25
0.10        0.03              730.00                34.00
  1            7            PF 2        6782.54     6782.34       0.20
0.09        0.02              570.00                34.00


  1            6            PF 1        6783.15     6782.99       0.16
0.01        0.03              730.00                44.00
  1            6            PF 2        6782.43     6782.30       0.13
0.01        0.03              570.00                44.00


  1            5            PF 1        6783.11     6783.06       0.06
0.00        0.00              730.00                80.00
  1            5            PF 2        6782.40     6782.35       0.05
0.00        0.00              570.00                80.00


  1            4            PF 1        6783.11     6783.05       0.05
0.01        0.00              730.00                80.00
  1            4            PF 2        6782.39     6782.35       0.04
0.01        0.00              570.00                80.00


  1            3            PF 1        6783.09     6783.05       0.04
5.14        0.07              730.00                75.00
  1            3            PF 2        6782.38     6782.34       0.04
4.79        0.06              570.00                75.00


  1            2            PF 1        6777.88     6777.12       0.76
2.98        0.14              730.00                70.00
  1            2            PF 2        6777.53     6776.87       0.66
```

```
3.18         0.12               570.00                66.30


  1            1            PF 1        6774.75     6772.59       2.16
                           730.00                  38.51
  1            1            PF 2        6774.22     6772.31       1.91
                           570.00                  37.04
```

ERRORS WARNINGS AND NOTES
Errors Warnings and Notes for Plan : Plan 02

River: Fanning Wash Reach: 1   RS: 11   Profile: PF 1
     Warning:The energy equation could not be balanced within the specified number of iterations. The program used critical depth
             for the water surface and continued on with the calculations.
     Warning:The cross-section end points had to be extended vertically for the computed water surface.
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
     Warning:The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The cross section had to be extended vertically during the critical depth calculations.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate
             the need for additional cross sections.
     Warning:During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated
             water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
             program defaulted to critical depth.
     Warning:The parabolic search method failed to converge on critical depth. The program will try the cross section
             slice/secant method to find critical depth.
River: Fanning Wash Reach: 1   RS: 11   Profile: PF 2
     Warning:The energy equation could not be balanced within the specified number of iterations. The program used critical depth
             for the water surface and continued on with the calculations.
     Warning:The cross-section end points had to be extended vertically for the computed water surface.
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
     Warning:The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.

```
     Warning:The cross section had to be extended vertically during the critical
depth calculations.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
     Warning:During the standard step iterations, when the assumed water surface was
set equal to critical depth, the calculated
             water surface came back below critical depth.  This indicates that
there is not a valid subcritical answer.  The
             program defaulted to critical depth.
     Warning:The parabolic search method failed to converge on critical depth.  The
program will try the cross section
             slice/secant method to find critical depth.
River: Fanning Wash  Reach: 1     RS: 10     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Note:   Hydraulic jump has occurred between this cross section and the previous
upstream section.
River: Fanning Wash  Reach: 1     RS: 10     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Note:   Hydraulic jump has occurred between this cross section and the previous
upstream section.
River: Fanning Wash  Reach: 1     RS: 9     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 9     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 8     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 8     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
```

```
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 7     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 7     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 6     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 6     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 5     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
River: Fanning Wash  Reach: 1     RS: 5     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
River: Fanning Wash  Reach: 1     RS: 4     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 4     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 3     Profile: PF 1
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross sections.
```

```
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 3     Profile: PF 2
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross sections.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
River: Fanning Wash  Reach: 1     RS: 2     Profile: PF 1
     Warning:The energy equation could not be balanced within the specified number
of iterations.  The program used critical depth
             for the water surface and continued on with the calculations.
     Warning:The cross-section end points had to be extended vertically for the
computed water surface.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The cross section had to be extended vertically during the critical
depth calculations.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
     Warning:During the standard step iterations, when the assumed water surface was
set equal to critical depth, the calculated
             water surface came back below critical depth.  This indicates that
there is not a valid subcritical answer.  The
             program defaulted to critical depth.
     Warning:The parabolic search method failed to converge on critical depth.  The
program will try the cross section
             slice/secant method to find critical depth.
River: Fanning Wash  Reach: 1     RS: 2     Profile: PF 2
     Warning:The energy equation could not be balanced within the specified number
of iterations.  The program used critical depth
             for the water surface and continued on with the calculations.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
     Warning:During the standard step iterations, when the assumed water surface was
```

```
set equal to critical depth, the calculated
             water surface came back below critical depth.  This indicates that
there is not a valid subcritical answer.  The
             program defaulted to critical depth.
River: Fanning Wash  Reach: 1     RS: 1     Profile: PF 1
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross sections.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The cross section had to be extended vertically during the critical
depth calculations.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
     Warning:The parabolic search method failed to converge on critical depth.  The
program will try the cross section
             slice/secant method to find critical depth.
     Note:   Program found supercritical flow starting at this cross section.
River: Fanning Wash  Reach: 1     RS: 1     Profile: PF 2
     Warning:The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross sections.
     Warning:The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than 1.4.
             This may indicate the need for additional cross sections.
     Warning:The energy loss was greater than 1.0 ft (0.3 m). between the current
and previous cross section.  This may indicate
             the need for additional cross sections.
     Note:   Program found supercritical flow starting at this cross section.
```

Appendix E Final Design HEC-RAS Report

```
                    HEC-RAS HEC-RAS 6.0.0 Beta 3 Dec 2020
                      U.S. Army Corps of Engineers
                     Hydrologic Engineering Center
                           609 Second Street
                           Davis, California


          X     X  XXXXXX    XXXX        XXXX       XX      XXXX
          X     X  X        X    X       X   X     X  X    X
          X     X  X        X            X   X    X    X   X
          XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
          X     X  X        X            X  X     X    X        X
          X     X  X        X    X       X   X    X    X        X
          X     X  XXXXXX    XXXX        X    X   X    X   XXXXX


PROJECT DATA
Project Title: Fanning Wash Post Model
Project File : FanningWashPostM.prj
Run Date and Time: 11/30/2021 1:01:05 PM

Project in English units



PLAN DATA

Plan Title: Plan 02
Plan File : Z:\Documents\FanningWashPostM.p02

           Geometry Title: Fanning Wash Post Geometry 2
           Geometry File : Z:\Documents\FanningWashPostM.g02

           Flow Title    : Flow 01
           Flow File     : Z:\Documents\FanningWashPostM.f01

Plan Summary Information:
Number of:  Cross Sections =   12    Multiple Openings  =    0
            Culverts       =    1    Inline Structures  =    0
            Bridges        =    0    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001
```

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method: Average Conveyance
    Computational Flow Regime: Mixed Flow

FLOW DATA

Flow Title: Flow 01
Flow File : Z:\Documents\FanningWashPostM.f01

Flow Data (cfs)

River	Reach	RS	PF 1	PF 2	PF 3
Fanning Wash	1	1157.01	730	570	290

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Fanning Wash	1	PF 1	Critical	Critical

GEOMETRY DATA

Geometry Title: Fanning Wash Post Geometry 2
Geometry File : Z:\Documents\FanningWashPostM.g02

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 1157.01

```
INPUT
Description: I40 Culvert Exit
Station Elevation Data    num=       6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 6785.82       0    6779       2  6778.8       4  6778.7       6  6778.7
       6 6785.82

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .013       0    .013       6    .013

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0       6             16.3   14.84    16.3             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6790.36    Element                  Left OB    Channel
Right OB
  Vel Head (ft)               3.88    Wt. n-Val.                           0.013

  W.S. Elev (ft)           6786.48    Reach Len. (ft)           16.30      14.84
  16.30
  Crit W.S. (ft)           6786.48    Flow Area (sq ft)                    46.18

  E.G. Slope (ft/ft)      0.006803    Area (sq ft)                         46.18

  Q Total (cfs)             730.00    Flow (cfs)                          730.00

  Top Width (ft)              6.00    Top Width (ft)                       6.00

  Vel Total (ft/s)           15.81    Avg. Vel. (ft/s)                     15.81

  Max Chl Dpth (ft)           7.78    Hydr. Depth (ft)                     7.70

  Conv. Total (cfs)         8850.4    Conv. (cfs)                         8850.4

  Length Wtd. (ft)           14.84    Wetted Per. (ft)                     21.27

  Min Ch El (ft)           6778.70    Shear (lb/sq ft)                     0.92

  Alpha                       1.00    Stream Power (lb/ft s)               14.57

  Frctn Loss (ft)             0.19    Cum Volume (acre-ft)                 0.12
   0.00
  C & E Loss (ft)             0.58    Cum SA (acres)                       0.06
   0.00
```

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6788.60	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.29	Wt. n-Val.		0.013	
W.S. Elev (ft)	6785.31	Reach Len. (ft)	16.30	14.84	16.30
Crit W.S. (ft)	6785.31	Flow Area (sq ft)		39.16	
E.G. Slope (ft/ft)	0.006154	Area (sq ft)		39.16	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	6.00	Top Width (ft)		6.00	
Vel Total (ft/s)	14.56	Avg. Vel. (ft/s)		14.56	
Max Chl Dpth (ft)	6.61	Hydr. Depth (ft)		6.53	
Conv. Total (cfs)	7265.8	Conv. (cfs)		7265.8	
Length Wtd. (ft)	14.84	Wetted Per. (ft)		18.93	
Min Ch El (ft)	6778.70	Shear (lb/sq ft)		0.79	
Alpha	1.00	Stream Power (lb/ft s)		11.57	
Frctn Loss (ft)	0.18	Cum Volume (acre-ft)		0.11	0.00
C & E Loss (ft)	0.49	Cum SA (acres)		0.06	0.00

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated

water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The
program defaulted to critical depth.

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6785.04	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.10	Wt. n-Val.		0.013	
W.S. Elev (ft)	6782.94	Reach Len. (ft)	16.30	14.84	16.30
Crit W.S. (ft)	6782.94	Flow Area (sq ft)		24.96	
E.G. Slope (ft/ft)	0.004872	Area (sq ft)		24.96	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	6.00	Top Width (ft)		6.00	
Vel Total (ft/s)	11.62	Avg. Vel. (ft/s)		11.62	
Max Chl Dpth (ft)	4.24	Hydr. Depth (ft)		4.16	
Conv. Total (cfs)	4154.8	Conv. (cfs)		4154.8	
Length Wtd. (ft)	14.84	Wetted Per. (ft)		14.20	
Min Ch El (ft)	6778.70	Shear (lb/sq ft)		0.53	
Alpha	1.00	Stream Power (lb/ft s)		6.21	
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)		0.07	0.00
C & E Loss (ft)	0.32	Cum SA (acres)		0.06	0.00

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 1142.23

INPUT
Description: Top of Channel/ End of I40 Bevel
Station Elevation Data num= 2

Sta	Elev	Sta	Elev

```
       0  6778.5    20.5  6778.5

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .013       0    .013    20.5    .013

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0    20.5             17.6    17.5    17.6             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6789.59    Element                   Left OB    Channel
Right OB
  Vel Head (ft)               9.66    Wt. n-Val.                            0.013

  W.S. Elev (ft)           6779.93    Reach Len. (ft)            17.60      17.50
  17.60
  Crit W.S. (ft)           6781.91    Flow Area (sq ft)                     29.28

  E.G. Slope (ft/ft)      0.035203    Area (sq ft)                          29.28

  Q Total (cfs)             730.00    Flow (cfs)                           730.00

  Top Width (ft)             20.50    Top Width (ft)                        20.50

  Vel Total (ft/s)           24.93    Avg. Vel. (ft/s)                      24.93

  Max Chl Dpth (ft)           1.43    Hydr. Depth (ft)                       1.43

  Conv. Total (cfs)         3890.7    Conv. (cfs)                          3890.7

  Length Wtd. (ft)           17.50    Wetted Per. (ft)                      23.36

  Min Ch El (ft)           6778.50    Shear (lb/sq ft)                       2.75

  Alpha                       1.00    Stream Power (lb/ft s)                68.69

  Frctn Loss (ft)             0.57    Cum Volume (acre-ft)                   0.11
   0.00
  C & E Loss (ft)             0.27    Cum SA (acres)                         0.06
   0.00


Warning: The cross-section end points had to be extended vertically for the computed
water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.
```

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6787.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.21	Wt. n-Val.		0.013	
W.S. Elev (ft)	6779.71	Reach Len. (ft)	17.60	17.50	17.60
Crit W.S. (ft)	6781.41	Flow Area (sq ft)		24.79	
E.G. Slope (ft/ft)	0.036425	Area (sq ft)		24.79	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	20.50	Top Width (ft)		20.50	
Vel Total (ft/s)	22.99	Avg. Vel. (ft/s)		22.99	
Max Chl Dpth (ft)	1.21	Hydr. Depth (ft)		1.21	
Conv. Total (cfs)	2986.6	Conv. (cfs)		2986.6	
Length Wtd. (ft)	17.50	Wetted Per. (ft)		22.92	
Min Ch El (ft)	6778.50	Shear (lb/sq ft)		2.46	
Alpha	1.00	Stream Power (lb/ft s)		56.56	
Frctn Loss (ft)	0.58	Cum Volume (acre-ft)		0.10	0.00
C & E Loss (ft)	0.28	Cum SA (acres)		0.06	0.00

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6784.56	Element	Left OB	Channel	Right OB
Vel Head (ft)	5.29	Wt. n-Val.		0.013	
W.S. Elev (ft)	6779.27	Reach Len. (ft)	17.60	17.50	17.60
Crit W.S. (ft)	6780.34	Flow Area (sq ft)		15.72	
E.G. Slope (ft/ft)	0.040899	Area (sq ft)		15.72	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	20.50	Top Width (ft)		20.50	
Vel Total (ft/s)	18.45	Avg. Vel. (ft/s)		18.45	
Max Chl Dpth (ft)	0.77	Hydr. Depth (ft)		0.77	
Conv. Total (cfs)	1434.0	Conv. (cfs)		1434.0	
Length Wtd. (ft)	17.50	Wetted Per. (ft)		22.03	
Min Ch El (ft)	6778.50	Shear (lb/sq ft)		1.82	
Alpha	1.00	Stream Power (lb/ft s)		33.61	
Frctn Loss (ft)	0.60	Cum Volume (acre-ft)		0.07	0.00
C & E Loss (ft)	0.29	Cum SA (acres)		0.06	0.00

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.

Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
         1.4. This may indicate the need for additional cross sections.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
         method to find critical depth.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1   RS: 1142.22

INPUT
Description: Just after bevel
Station Elevation Data   num=   2
     Sta   Elev   Sta   Elev
       0 6778.5   20.5 6778.5

Manning's n Values   num=   3
     Sta   n Val   Sta   n Val   Sta   n Val
       0   .013   0   .013   20.5   .013

Bank Sta: Left   Right   Lengths: Left Channel   Right   Coeff Contr.   Expan.
             0   20.5   5.14   4.99   5.14   .1   .3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6788.75	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.75	Wt. n-Val.		0.013	
W.S. Elev (ft)	6780.00	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6781.91	Flow Area (sq ft)		30.77	
E.G. Slope (ft/ft)	0.030078	Area (sq ft)		30.77	
Q Total (cfs)	730.00	Flow (cfs)		730.00	
Top Width (ft)	20.50	Top Width (ft)		20.50	
Vel Total (ft/s)	23.72	Avg. Vel. (ft/s)		23.72	
Max Chl Dpth (ft)	1.50	Hydr. Depth (ft)		1.50	
Conv. Total (cfs)	4209.2	Conv. (cfs)		4209.2	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		23.50	

Min Ch El (ft)	6778.50	Shear (lb/sq ft)	2.46
Alpha	1.00	Stream Power (lb/ft s)	58.33
Frctn Loss (ft)	0.15	Cum Volume (acre-ft)	0.10
0.00			
C & E Loss (ft)	0.07	Cum SA (acres)	0.05
0.00			

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6787.06	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.28	Wt. n-Val.		0.013	
W.S. Elev (ft)	6779.79	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6781.41	Flow Area (sq ft)		26.34	
E.G. Slope (ft/ft)	0.030052	Area (sq ft)		26.34	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	20.50	Top Width (ft)		20.50	
Vel Total (ft/s)	21.64	Avg. Vel. (ft/s)		21.64	
Max Chl Dpth (ft)	1.28	Hydr. Depth (ft)		1.28	
Conv. Total (cfs)	3288.0	Conv. (cfs)		3288.0	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		23.07	
Min Ch El (ft)	6778.50	Shear (lb/sq ft)		2.14	

Alpha	1.00	Stream Power (lb/ft s)	46.36
Frctn Loss (ft)	0.15	Cum Volume (acre-ft)	0.09
0.00			
C & E Loss (ft)	0.07	Cum SA (acres)	0.05
0.00			

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6783.66	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.31	Wt. n-Val.		0.013	
W.S. Elev (ft)	6779.35	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6780.34	Flow Area (sq ft)		17.41	
E.G. Slope (ft/ft)	0.029379	Area (sq ft)		17.41	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	20.50	Top Width (ft)		20.50	
Vel Total (ft/s)	16.66	Avg. Vel. (ft/s)		16.66	
Max Chl Dpth (ft)	0.85	Hydr. Depth (ft)		0.85	
Conv. Total (cfs)	1691.9	Conv. (cfs)		1691.9	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		22.20	
Min Ch El (ft)	6778.50	Shear (lb/sq ft)		1.44	
Alpha	1.00	Stream Power (lb/ft s)		23.96	
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)		0.06	

```
   0.00
  C & E Loss (ft)            0.07    Cum SA (acres)                        0.05
   0.00


Warning: The cross-section end points had to be extended vertically for the computed
water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.
Warning: The parabolic search method failed to converge on critical depth.  The
program will try the cross section slice/secant
         method to find critical depth.

CROSS SECTION


RIVER: Fanning Wash
REACH: 1                  RS: 1137.28*

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 6778.43       0 6777.57      19 6777.57      19 6778.43

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0    .013      19    .013

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      19             5.14    4.99    5.14             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6788.53    Element                  Left OB    Channel
Right OB
  Vel Head (ft)               9.40    Wt. n-Val.                           0.013

  W.S. Elev (ft)           6779.13    Reach Len. (ft)            5.14       4.99
   5.14
  Crit W.S. (ft)           6781.11    Flow Area (sq ft)                    29.68

  E.G. Slope (ft/ft)      0.031302    Area (sq ft)                         29.68

  Q Total (cfs)             730.00    Flow (cfs)                          730.00

  Top Width (ft)             19.00    Top Width (ft)                       19.00
```

Vel Total (ft/s)	24.60	Avg. Vel. (ft/s)	24.60
Max Chl Dpth (ft)	1.56	Hydr. Depth (ft)	1.56
Conv. Total (cfs)	4126.1	Conv. (cfs)	4126.1
Length Wtd. (ft)	4.99	Wetted Per. (ft)	22.12
Min Ch El (ft)	6777.57	Shear (lb/sq ft)	2.62
Alpha	1.00	Stream Power (lb/ft s)	64.48
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)	0.10
0.00			
C & E Loss (ft)	0.06	Cum SA (acres)	0.05
0.00			

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6786.84	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.95	Wt. n-Val.		0.013	
W.S. Elev (ft)	6778.90	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6780.61	Flow Area (sq ft)		25.21	
E.G. Slope (ft/ft)	0.031962	Area (sq ft)		25.21	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	19.00	Top Width (ft)		19.00	
Vel Total (ft/s)	22.61	Avg. Vel. (ft/s)		22.61	

Max Chl Dpth (ft)	1.33	Hydr. Depth (ft)	1.33
Conv. Total (cfs)	3188.3	Conv. (cfs)	3188.3
Length Wtd. (ft)	4.99	Wetted Per. (ft)	21.65
Min Ch El (ft)	6777.57	Shear (lb/sq ft)	2.32
Alpha	1.00	Stream Power (lb/ft s)	52.53
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)	0.09
0.00			
C & E Loss (ft)	0.06	Cum SA (acres)	0.05
0.00			

Warning: The cross-section end points had to be extended vertically for the computed water surface.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant
method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6783.43	Element	Left OB	Channel	Right OB
Vel Head (ft)	5.01	Wt. n-Val.		0.013	
W.S. Elev (ft)	6778.42	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6779.50	Flow Area (sq ft)		16.15	
E.G. Slope (ft/ft)	0.034349	Area (sq ft)		16.15	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	19.00	Top Width (ft)		19.00	
Vel Total (ft/s)	17.95	Avg. Vel. (ft/s)		17.95	
Max Chl Dpth (ft)	0.85	Hydr. Depth (ft)		0.85	
Conv. Total (cfs)	1564.7	Conv. (cfs)		1564.7	

```
  Length Wtd. (ft)           4.99    Wetted Per. (ft)                    20.70

  Min Ch El (ft)          6777.57    Shear (lb/sq ft)                     1.67

  Alpha                      1.00    Stream Power (lb/ft s)              30.04

  Frctn Loss (ft)            0.18    Cum Volume (acre-ft)                 0.06
   0.00
  C & E Loss (ft)            0.07    Cum SA (acres)                       0.04
   0.00


Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.

CROSS SECTION


RIVER: Fanning Wash
REACH: 1                 RS: 1132.33*

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 6778.36       0 6776.64    17.5 6776.64    17.5 6778.36

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0    .013    17.5    .013

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0    17.5             5.14    4.99    5.14             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6788.31    Element                  Left OB    Channel
Right OB
  Vel Head (ft)              10.03    Wt. n-Val.                           0.013

  W.S. Elev (ft)           6778.28    Reach Len. (ft)            5.14       4.99
   5.14
  Crit W.S. (ft)           6780.43    Flow Area (sq ft)                    28.74

  E.G. Slope (ft/ft)      0.032068    Area (sq ft)                         28.74
```

Q Total (cfs)	730.00	Flow (cfs)	730.00
Top Width (ft)	17.50	Top Width (ft)	17.50
Vel Total (ft/s)	25.40	Avg. Vel. (ft/s)	25.40
Max Chl Dpth (ft)	1.64	Hydr. Depth (ft)	1.64
Conv. Total (cfs)	4076.5	Conv. (cfs)	4076.5
Length Wtd. (ft)	4.99	Wetted Per. (ft)	20.78
Min Ch El (ft)	6776.64	Shear (lb/sq ft)	2.77
Alpha	1.00	Stream Power (lb/ft s)	70.32
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)	0.09
0.00			
C & E Loss (ft)	0.06	Cum SA (acres)	0.05
0.00			

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The cross section had to be extended vertically during the critical depth calculations.
Warning: The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6786.61	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.59	Wt. n-Val.		0.013	
W.S. Elev (ft)	6778.03	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6779.84	Flow Area (sq ft)		24.25	
E.G. Slope (ft/ft)	0.033299	Area (sq ft)		24.25	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	17.50	Top Width (ft)		17.50	
Vel Total (ft/s)	23.50	Avg. Vel. (ft/s)		23.50	

Max Chl Dpth (ft)	1.39	Hydr. Depth (ft)	1.39
Conv. Total (cfs)	3123.7	Conv. (cfs)	3123.7
Length Wtd. (ft)	4.99	Wetted Per. (ft)	20.27
Min Ch El (ft)	6776.64	Shear (lb/sq ft)	2.49
Alpha	1.00	Stream Power (lb/ft s)	58.45
Frctn Loss (ft)	0.17	Cum Volume (acre-ft)	0.08
0.00			
C & E Loss (ft)	0.06	Cum SA (acres)	0.05
0.00			

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6783.18	Element	Left OB	Channel	Right OB
Vel Head (ft)	5.67	Wt. n-Val.		0.013	
W.S. Elev (ft)	6777.51	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6778.68	Flow Area (sq ft)		15.18	
E.G. Slope (ft/ft)	0.038338	Area (sq ft)		15.18	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	17.50	Top Width (ft)		17.50	
Vel Total (ft/s)	19.11	Avg. Vel. (ft/s)		19.11	
Max Chl Dpth (ft)	0.87	Hydr. Depth (ft)		0.87	
Conv. Total (cfs)	1481.1	Conv. (cfs)		1481.1	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		19.23	
Min Ch El (ft)	6776.64	Shear (lb/sq ft)		1.89	
Alpha	1.00	Stream Power (lb/ft s)		36.09	

```
  Frctn Loss (ft)            0.20    Cum Volume (acre-ft)                  0.06
   0.00
  C & E Loss (ft)            0.06    Cum SA (acres)                        0.04
   0.00


Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.

CROSS SECTION


RIVER: Fanning Wash
REACH: 1                 RS: 1127.39*

INPUT
Description:
Station Elevation Data    num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 6778.29       0 6775.71      16 6775.71      16 6778.29

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0    .013      16    .013

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      16             5.14    4.99    5.14             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6788.09    Element                   Left OB    Channel
Right OB
  Vel Head (ft)              10.63    Wt. n-Val.                            0.013

  W.S. Elev (ft)           6777.45    Reach Len. (ft)             5.14       4.99
   5.14
  Crit W.S. (ft)           6779.71    Flow Area (sq ft)                     27.91

  E.G. Slope (ft/ft)      0.032452    Area (sq ft)                          27.91

  Q Total (cfs)              730.00    Flow (cfs)                           730.00

  Top Width (ft)             16.00    Top Width (ft)                        16.00

  Vel Total (ft/s)           26.16    Avg. Vel. (ft/s)                      26.16
```

Max Chl Dpth (ft)	1.74	Hydr. Depth (ft)	1.74
Conv. Total (cfs)	4052.3	Conv. (cfs)	4052.3
Length Wtd. (ft)	4.99	Wetted Per. (ft)	19.49
Min Ch El (ft)	6775.71	Shear (lb/sq ft)	2.90
Alpha	1.00	Stream Power (lb/ft s)	75.89
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)	0.09
0.00			
C & E Loss (ft)	0.06	Cum SA (acres)	0.04
0.00			

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 2

E.G. Elev (ft)	6786.38	Element	Left OB	Channel	Right OB
Vel Head (ft)	9.20	Wt. n-Val.		0.013	
W.S. Elev (ft)	6777.17	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6779.10	Flow Area (sq ft)		23.42	
E.G. Slope (ft/ft)	0.034122	Area (sq ft)		23.42	
Q Total (cfs)	570.00	Flow (cfs)		570.00	
Top Width (ft)	16.00	Top Width (ft)		16.00	
Vel Total (ft/s)	24.34	Avg. Vel. (ft/s)		24.34	
Max Chl Dpth (ft)	1.46	Hydr. Depth (ft)		1.46	
Conv. Total (cfs)	3085.7	Conv. (cfs)		3085.7	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		18.93	
Min Ch El (ft)	6775.71	Shear (lb/sq ft)		2.64	
Alpha	1.00	Stream Power (lb/ft s)		64.15	

Frctn Loss (ft)	0.17	Cum Volume (acre-ft)	0.08
0.00			
C & E Loss (ft)	0.06	Cum SA (acres)	0.04
0.00			

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6782.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	6.31	Wt. n-Val.		0.013	
W.S. Elev (ft)	6776.61	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6777.87	Flow Area (sq ft)		14.39	
E.G. Slope (ft/ft)	0.041268	Area (sq ft)		14.39	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	16.00	Top Width (ft)		16.00	
Vel Total (ft/s)	20.15	Avg. Vel. (ft/s)		20.15	
Max Chl Dpth (ft)	0.90	Hydr. Depth (ft)		0.90	
Conv. Total (cfs)	1427.5	Conv. (cfs)		1427.5	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		17.80	
Min Ch El (ft)	6775.71	Shear (lb/sq ft)		2.08	
Alpha	1.00	Stream Power (lb/ft s)		41.98	
Frctn Loss (ft)	0.21	Cum Volume (acre-ft)		0.06	
0.00					
C & E Loss (ft)	0.06	Cum SA (acres)		0.04	
0.00					

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 1122.44*

INPUT
Description:
Station Elevation Data num= 4

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	6778.21	0	6774.79	14.5	6774.79	14.5	6778.21

Manning's n Values num= 2

Sta	n Val	Sta	n Val
0	.013	14.5	.013

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	14.5	5.14	4.99	5.14	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	6787.87	Element	Left OB	Channel
Right OB				
Vel Head (ft)	11.20	Wt. n-Val.		0.013
W.S. Elev (ft)	6776.67	Reach Len. (ft)	5.14	4.99
5.14				
Crit W.S. (ft)	6779.07	Flow Area (sq ft)		27.19
E.G. Slope (ft/ft)	0.032434	Area (sq ft)		27.19
Q Total (cfs)	730.00	Flow (cfs)		730.00
Top Width (ft)	14.50	Top Width (ft)		14.50
Vel Total (ft/s)	26.85	Avg. Vel. (ft/s)		26.85
Max Chl Dpth (ft)	1.88	Hydr. Depth (ft)		1.88
Conv. Total (cfs)	4053.5	Conv. (cfs)		4053.5
Length Wtd. (ft)	4.99	Wetted Per. (ft)		18.25
Min Ch El (ft)	6774.79	Shear (lb/sq ft)		3.02
Alpha	1.00	Stream Power (lb/ft s)		80.99
Frctn Loss (ft)	0.16	Cum Volume (acre-ft)		0.09

```
   0.00
  C & E Loss (ft)             0.05    Cum SA (acres)                          0.04
   0.00


Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.

CROSS SECTION OUTPUT  Profile #PF 2


  E.G. Elev (ft)           6786.15    Element                   Left OB    Channel
Right OB
  Vel Head (ft)               9.79    Wt. n-Val.                           0.013

  W.S. Elev (ft)           6776.36    Reach Len. (ft)             5.14       4.99
   5.14
  Crit W.S. (ft)           6778.41    Flow Area (sq ft)                    22.71

  E.G. Slope (ft/ft)      0.034429    Area (sq ft)                         22.71

  Q Total (cfs)             570.00    Flow (cfs)                          570.00

  Top Width (ft)             14.50    Top Width (ft)                       14.50

  Vel Total (ft/s)           25.10    Avg. Vel. (ft/s)                     25.10

  Max Chl Dpth (ft)           1.57    Hydr. Depth (ft)                      1.57

  Conv. Total (cfs)         3072.0    Conv. (cfs)                         3072.0

  Length Wtd. (ft)            4.99    Wetted Per. (ft)                     17.63

  Min Ch El (ft)           6774.79    Shear (lb/sq ft)                      2.77

  Alpha                       1.00    Stream Power (lb/ft s)               69.48

  Frctn Loss (ft)             0.17    Cum Volume (acre-ft)                  0.08
   0.00
  C & E Loss (ft)             0.06    Cum SA (acres)                        0.04
   0.00


Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.
```

CROSS SECTION OUTPUT Profile #PF 3

E.G. Elev (ft)	6782.65	Element	Left OB	Channel	Right OB
Vel Head (ft)	6.91	Wt. n-Val.		0.013	
W.S. Elev (ft)	6775.74	Reach Len. (ft)	5.14	4.99	5.14
Crit W.S. (ft)	6777.10	Flow Area (sq ft)		13.75	
E.G. Slope (ft/ft)	0.043059	Area (sq ft)		13.75	
Q Total (cfs)	290.00	Flow (cfs)		290.00	
Top Width (ft)	14.50	Top Width (ft)		14.50	
Vel Total (ft/s)	21.09	Avg. Vel. (ft/s)		21.09	
Max Chl Dpth (ft)	0.95	Hydr. Depth (ft)		0.95	
Conv. Total (cfs)	1397.5	Conv. (cfs)		1397.5	
Length Wtd. (ft)	4.99	Wetted Per. (ft)		16.40	
Min Ch El (ft)	6774.79	Shear (lb/sq ft)		2.25	
Alpha	1.00	Stream Power (lb/ft s)		47.55	
Frctn Loss (ft)	0.22	Cum Volume (acre-ft)		0.05	0.00
C & E Loss (ft)	0.06	Cum SA (acres)		0.04	0.00

Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.

CROSS SECTION

RIVER: Fanning Wash
REACH: 1 RS: 1117.50*

INPUT
Description:
Station Elevation Data num= 4

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev

```
       0 6778.14       0 6773.86      13 6773.86      13 6778.14

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0    .013      13    .013

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0      13             5.14    4.99    5.14             .1       .3

CROSS SECTION OUTPUT  Profile #PF 1


  E.G. Elev (ft)           6787.65    Element                   Left OB    Channel
Right OB
  Vel Head (ft)              11.75    Wt. n-Val.                            0.013

  W.S. Elev (ft)           6775.90    Reach Len. (ft)             5.14       4.99
   5.14
  Crit W.S. (ft)           6778.46    Flow Area (sq ft)                     26.55

  E.G. Slope (ft/ft)      0.032161    Area (sq ft)                          26.55

  Q Total (cfs)              730.00    Flow (cfs)                           730.00

  Top Width (ft)             13.00    Top Width (ft)                        13.00

  Vel Total (ft/s)           27.50    Avg. Vel. (ft/s)                      27.50

  Max Chl Dpth (ft)           2.04    Hydr. Depth (ft)                       2.04

  Conv. Total (cfs)         4070.6    Conv. (cfs)                          4070.6

  Length Wtd. (ft)            4.99    Wetted Per. (ft)                      17.08

  Min Ch El (ft)           6773.86    Shear (lb/sq ft)                       3.12

  Alpha                       1.00    Stream Power (lb/ft s)                85.80

  Frctn Loss (ft)             0.16    Cum Volume (acre-ft)                   0.08
   0.00
  C & E Loss (ft)             0.05    Cum SA (acres)                         0.04
   0.00


Warning: The velocity head has changed by more than 0.5 ft (0.15 m).  This may
indicate the need for additional cross
         sections.

CROSS SECTION OUTPUT  Profile #PF 2
```

Appendix F Final Design Culvert Master Report

Culvert Analysis Report
Culvert-1

Culvert Summary					
Computed Headwater Elev	6,779.81	ft	Discharge	570.00	cfs
Inlet Control HW Elev.	6,779.81	ft	Tailwater Elevation	6,772.00	ft
Outlet Control HW Elev.	6,779.25	ft	Control Type	Inlet Control	
Headwater Depth/Height	1.74				

Grades					
Upstream Invert	6,772.00	ft	Downstream Invert	6,768.00	ft
Length	85.00	ft	Constructed Slope	0.047059	ft/ft

Hydraulic Profile					
Profile	CompositeS1S2		Depth, Downstream	2.14	ft
Slope Type	Steep		Normal Depth	1.68	ft
Flow Regime	N/A		Critical Depth	3.65	ft
Velocity Downstream	20.68	ft/s	Critical Slope	0.006066	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.013	
Section Material	Concrete		Span	7.33	ft
Section Size	88.0 x 54.0 inch		Rise	4.50	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	6,779.25	ft	Upstream Velocity Head	2.40	ft
Ke	0.50		Entrance Loss	1.20	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,779.81	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall (arch)		Area Full	51.4	ft²
K	0.00980		HDS 5 Chart	0	
M	2.00000		HDS 5 Scale	0	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Analysis Report
Culvert-1

Culvert Summary					
Computed Headwater Elev	6,782.95	ft	Discharge	730.00	cfs
Inlet Control HW Elev.	6,782.95	ft	Tailwater Elevation	6,772.00	ft
Outlet Control HW Elev.	6,781.18	ft	Control Type	Inlet Control	
Headwater Depth/Height	2.43				

Grades					
Upstream Invert	6,772.00	ft	Downstream Invert	6,768.00	ft
Length	85.00	ft	Constructed Slope	0.047059	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.55	ft
Slope Type	Steep		Normal Depth	1.95	ft
Flow Regime	Supercritical		Critical Depth	4.04	ft
Velocity Downstream	22.06	ft/s	Critical Slope	0.008961	ft/ft

Section					
Section Shape	Arch		Mannings Coefficient	0.013	
Section Material	Concrete		Span	7.33	ft
Section Size	88.0 x 54.0 inch		Rise	4.50	ft
Number Sections	2				

Outlet Control Properties					
Outlet Control HW Elev.	6,781.18	ft	Upstream Velocity Head	3.43	ft
Ke	0.50		Entrance Loss	1.71	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,782.95	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall (arch)		Area Full	51.4	ft²
K	0.00980		HDS 5 Chart	0	
M	2.00000		HDS 5 Scale	0	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Analysis Report
Culvert-1

Culvert Summary					
Computed Headwater Elev	6,782.95	ft	Discharge	730.00	cfs
Inlet Control HW Elev.	6,782.95	ft	Tailwater Elevation	6,772.00	ft
Outlet Control HW Elev.	6,781.18	ft	Control Type	Inlet Control	
Headwater Depth/Height	2.43				

Grades					
Upstream Invert	6,772.00	ft	Downstream Invert	6,768.00	ft
Length	85.00	ft	Constructed Slope	0.047059	ft/ft

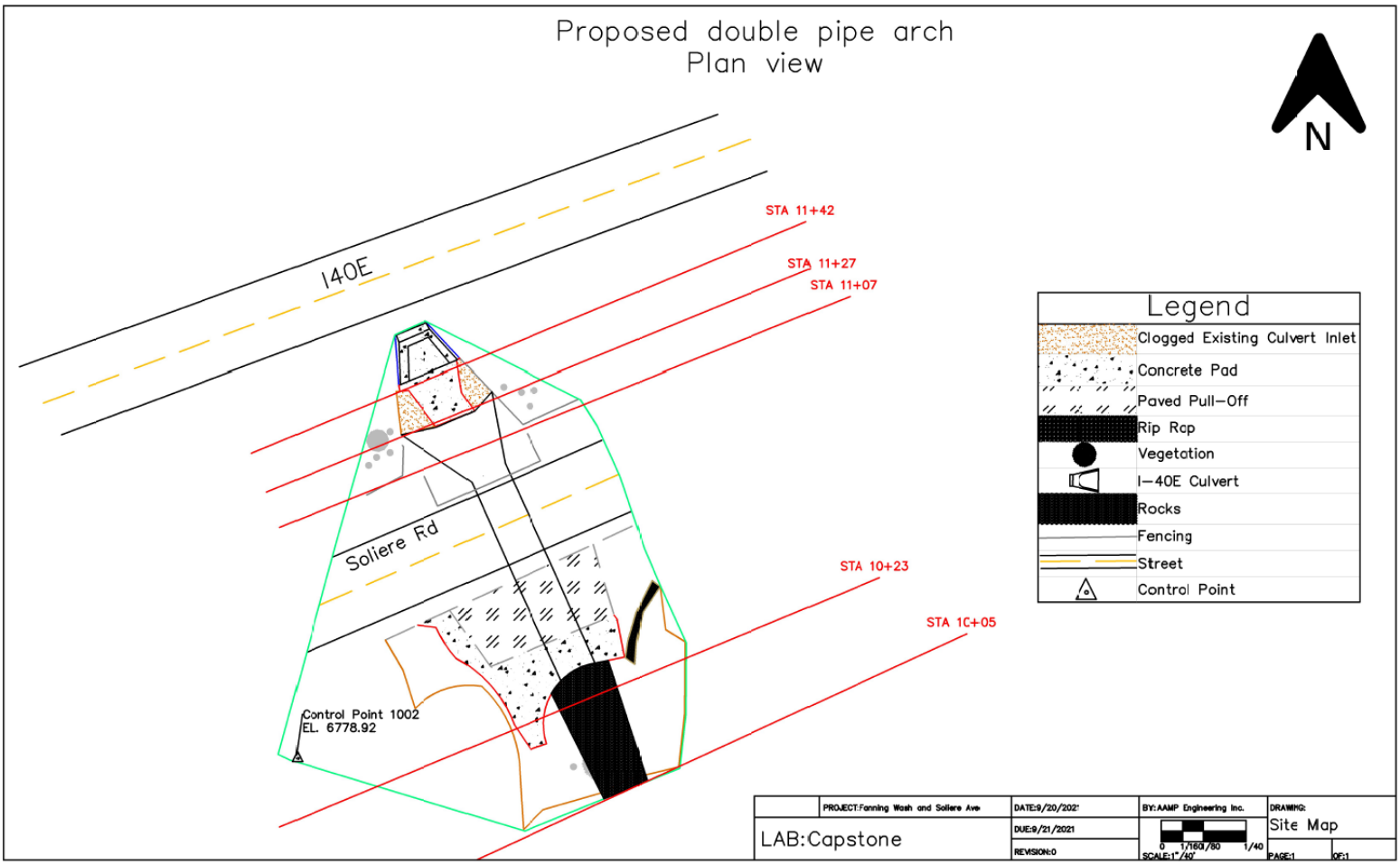
Hydraulic Profile					
Profile	S2		Depth, Downstream	2.55	ft
Slope Type	Steep		Normal Depth	1.95	ft
Flow Regime	Supercritical		Critical Depth	4.04	ft
Velocity Downstream	22.06	ft/s	Critical Slope	0.008961	ft/ft

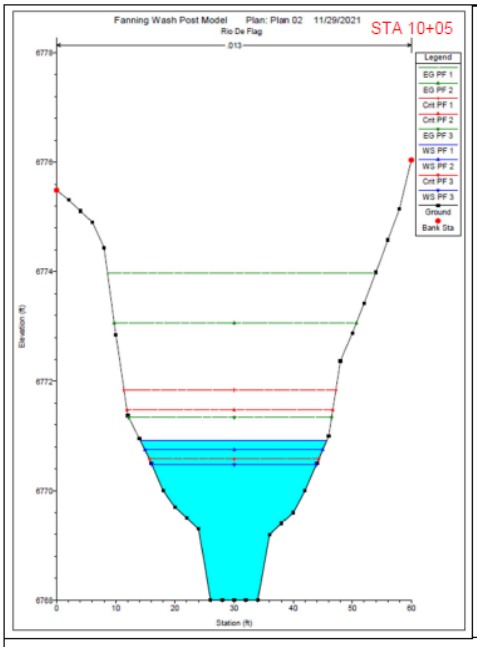
Section					
Section Shape	Arch		Mannings Coefficient	0.013	
Section Material	Concrete		Span	7.33	ft
Section Size	88.0 x 54.0 inch		Rise	4.50	ft
Number Sections	2				

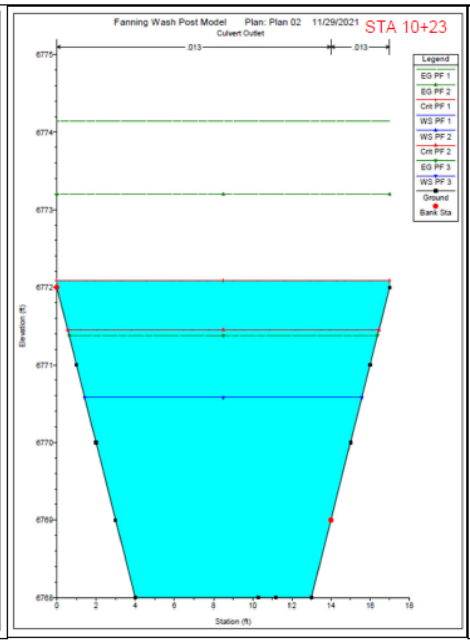
Outlet Control Properties					
Outlet Control HW Elev.	6,781.18	ft	Upstream Velocity Head	3.43	ft
Ke	0.50		Entrance Loss	1.71	ft

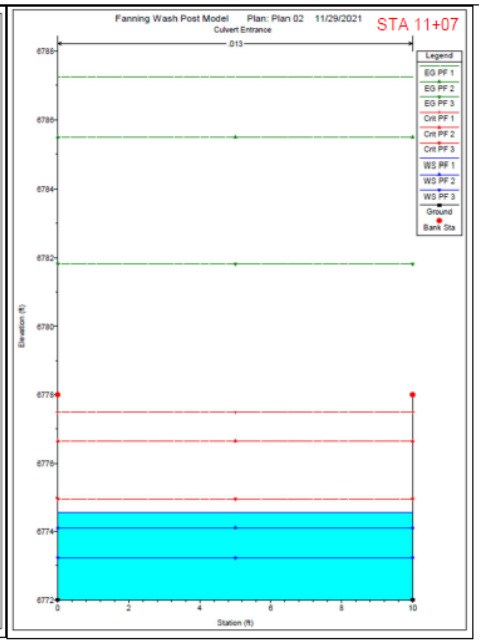
Inlet Control Properties					
Inlet Control HW Elev.	6,782.95	ft	Flow Control	Submerged	
Inlet Type	Square edge w/headwall (arch)		Area Full	51.4	ft²
K	0.00980		HDS 5 Chart	0	
M	2.00000		HDS 5 Scale	0	
C	0.03980		Equation Form	1	
Y	0.67000				

Appendix G Purposed Cross Section Modifications









DRAWING: STA Cross-Section

PAGE: 1 OF: 1

BY: AAMP Engineering Inc.

SCALE: 0

DATE: 11/28/2021

DUE: 11/30/2021

REVISION: 0

PROJECT: Fanning Wash

LAB: Capstone

Appendix H Cut Volumes