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Coyote Springs Riparian Stream Habitat Restoration

AARK Stream Restorations, LLC

We strive for excellence in every project, small or large, in order to make every stream the best that it can be.

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List of Abbreviations

AARK - Abdullatif, Alex, Rachel, and Kyle
LLC - Limited Liability Corporation
HWY - Highway
ADOT - Arizona Department of Transportation
USDA - United States Department of Agriculture
SENG - Senior Engineer
ENG - Engineer
EIT - Engineer in Training
INT - Intern

Acknowledgements

The AARK Stream Restoration, LLC team would like to express our profound gratitude to our client, Cindy Perin, from the Coyote Springs Homeowners Association. Without her this project would not be possible.

Thank you to Professor and Chair of Civil and Environmental Engineering, Bridget Bero, PhD, PE, for providing regular and useful suggestions to improve upon this important process for our academic careers.

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Many thanks to those who helped our team directly or indirectly in completion of this project report. We are successful because of you.

1.0 Introduction

A riparian habitat lies between the Coyote Springs property area and HWY 180 in Flagstaff, Arizona. The purpose of this project is to assess the Coyote Springs stream reach, to provide proper analysis of the function of the channel and culverts, enhance riparian habitat through the establishment of native vegetation, and increase the aesthetic appearance. There is a final suggested design to alter part of the existing stream while being naturally and aesthetically pleasing.

The objectives of this project include:

1. Field Evaluation
2. Manning's Roughness Coefficient
3. Watershed Delineation
4. Rosgen Stream Classification
5. Culvert Analysis
6. Channel Analysis
7. Existing HEC-RAS Model
8. Proposed HEC-RAS Model
9. Cost of Alternatives

1.1 Background

The Coyote Springs stream restoration project is located approximately 2.6 miles Northwest of Flagstaff City Hall, shown in Appendix A Figure 1. There is a well house where the stream begins, built by the late Dr. Harold S. Colton, one of the founding members of the Museum of Northern Arizona. The stream runs perpendicular to the highway initially, then flows adjacent to the Flagstaff Urban Trail System footpath for the remaining reach until crossing under the highway. Figure 2 below shows the start and end points of the Coyote Springs stream reach.

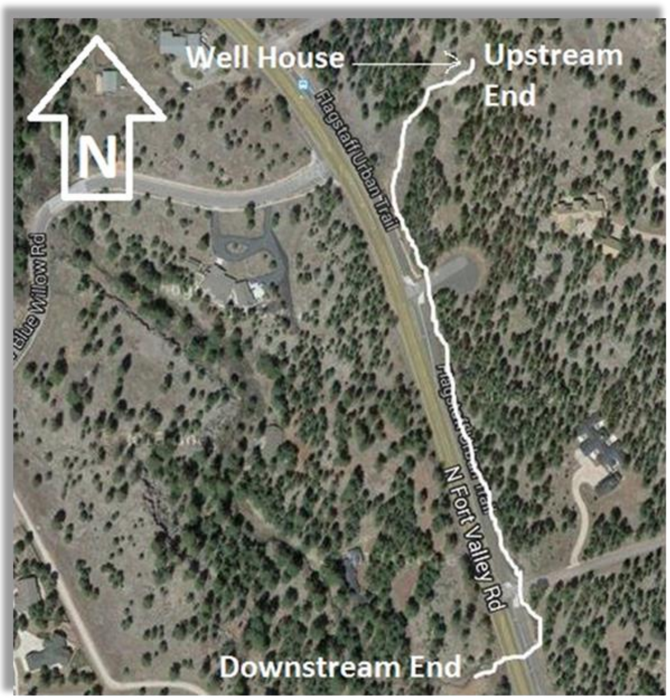

Figure 2: Coyote Springs Stream Reach, image taken from Google Maps

The Coyote Range, also known as the Colton House, is on the National Register of Historic Places list in Arizona; construction on the property and adjacent footpath and highway must consider the Arizona Historic Preservation Act of 1966 to refrain from encroaching on the historic area [1]. Vegetation along the stream is overgrown in the built up sediment, clogging culverts in some areas and filling the pond area at the entrance of Coyote Springs. The pooled area in front of the Coyote Springs sign contains large, overgrown plant species, which poses a visual safety hazard for cars and pedestrians, as shown in Appendix B Figure 3. A section downstream, between the entrance sign and culvert 3 leading under the highway, has embankment mats to stabilize the side slopes of the stream, Appendix B Figure 4. This turf reinforcement netting placed by ADOT is unnatural and not aesthetically pleasing, leading to the alternative design suggestion by the AARK Stream Restorations team.

1.2 Organization

Our major tasks and subtasks can be referred to in Appendix C. The AARK team coordinated a schedule for the whole year to stay on track with due dates and deliverables. Please see the original Gantt chart in Appendix D Figure 5. During the second semester, the project scope was changed from designing a stream to analyzing the existing stream, causing the Gantt chart to be updated as necessary, Appendix D Figure 6. The original hours predicted, as shown in Appendix E Table 1, ended up being reduced as the scope changed. The final hours that the AARK team worked on this project was significantly lower by approximately 175 hours, shown in Appendix E Table 2.

2.0 Methods

This section addresses watershed hydrology and methods that were used to analyze the Coyote Springs stream, channel and culvert conditions. These processes allowed for the conclusion of the proper steps to take to improve the stream reach and surrounding areas. Sediment buildup can be problematic and difficult to predict the source accurately; sediment can come from natural channels, heavy rainfalls, and other miscellaneous disturbances. When channels and culverts are not properly sized, shaped or at the correct slope, the channels and culverts will fill with sediment. The consequences of improper sediment transportation will result in reduction of flood capacity in undesired locations as well as rapid vegetation growth.

2.1 Field Evaluation

The site conditions have been monitored and evaluated by the team throughout the past year to observe the vegetation and topography. The initial observation of the area concluded there were artificial rocks, slope stabilization netting that looked unnatural, overgrown vegetation, and a trickling stream; the stream had water throughout the year. Following the field evaluation, the team concluded further analysis regarding the stream's characteristics, using surveying equipment and computer software to determine existing channel conditions, is to be completed.

2.2 Manning's Roughness Coefficient

The Manning's roughness coefficient represents the roughness or friction caused by the channel materials that affect the flow of the channel. The Manning's coefficient, n, can be determined using the *Manning's N for Channels* (Chow, 1959) table [2]. After visiting the site and determining the channel conditions, Manning's n = 1.00 was chosen for the existing channel.

The n value was chosen because of the weedy reaches, pooling area and profoundly vegetated flood plains. This n value will be used in the culvert analysis as well as the channel analysis and HEC-RAS.

2.3 Watershed Delineation

The watershed delineation was performed in order to determine the discharge to analyze the culvert and channels to determine if the existing features were originally designed correctly and if they could convey the discharge properly. The discharge is also used in HEC-RAS for modeling and determining the streamflow characteristics.

The area for the watershed was determined from using existing lidar data from Northern Arizona University. This lidar data was imported into ArcGIS to obtain contour interval lines and then imported again into AutoCAD. Once in the AutoCAD software, the concentration point was found at the furthest downstream point of our stream reach and a polyline was created beginning at the concentration point. The line was drawn perpendicular to the topographic contour lines, ending at the original concentration point to acquire an area. Sub-basins were then created inside the main watershed area to determine the discharge to important areas, in this case for the culverts, channels, and impervious areas. Each individual sub-basin areas, runoff coefficients, rainfall intensities, and precipitation factors were found using the *Flagstaff Design Drainage Manual Section 3.1* and the *Coconino County Drainage Design Manual Section 3.1* [3,4]. These values were then used to calculate the discharge using the Rational Method for each sub-basin for a discharge of 25 years.

Rational Method Equation: $Q = C_f C I A$ **(Equation 1)**

Where:
- Q = maximum rate of runoff, cfs
- C_f = antecedent precipitation factor
- C = runoff coefficient
- I = rainfall intensity, in/hr
- A = drainage area tributary to the design location, acres

The Rational formula is one of the most commonly used simplified methods in estimating peak discharges for a small uniform drainage areas. This method is typically used to size drainage structures for the peak discharge of a given return period. The following assumptions are inherent when using the Rational Equation:

1. The total drainage area must be less than or equal to 20 acres.
2. The time of concentration cannot be less than 5 minutes or greater than 60 minutes.
3. The land of the contribution watershed must be fairly consistent over the entire drainage area and uniform throughout the area. That is, the contributing area should not consist of a large percentage of two or more land uses.
4. The contributing watershed cannot have drainage structures or facilities which would require flood routing to estimate the discharge at the point of interest.
5. All the land uses within a drainage area are uniformly distributed throughout the area.

2.4 Software

2.3.1 HEC-RAS

To develop an existing HEC-RAS model the following aspects of the Coyote springs stream will be considered: Manning's roughness coefficient, AutoCAD survey data, cross-sections, thalweg (low point along the stream), culverts, and steady flow analysis. To find this information for the HEC-RAS model the surveying data is put into AutoCAD Civil 3D. When the data is in AutoCAD the thalweg and cross-sections can be determined. Then the thalweg and cross-sections are imported to HEC-RAS, and the flow from the watershed delineation along with the manning's roughness coefficient is inputted. With these parameters, a well-represented flow of the Coyote Springs stream will be created.

2.3.2 Bentley CulvertMaster

To conduct culvert analysis for existing culverts, certain information about the culvert must be gathered. The information needed are, surveying points to determine the elevation of the inlet and outlet invert of the culvert, and the maximum allowable head of water which is the elevation of the roadway above the culvert. Also, the length, the diameter, and the material of the culvert, as well as the channel flow and slope. The flow of the culvert well be determined using watershed delineation. According to the *City of Flagstaff Stormwater Management Design Manual*, the culvert will be designed for 25-year flow and will be checked for 100-year flow [3]. After inputting all information needed in Bentley CulvertMaster, a report will be created for each culvert showing the culverts capability of conveying water.

2.3.3 Bentley FlowMaster

To conduct flow analysis for existing channel, certain information about the channel must be gathered. The information needed are the surveyed points to create cross sections throughout the channel, and the floodplains and channel conditions to choose the Manning's coefficient. Also, the channel slope and the designed discharge is necessary to complete the analysis. Each cross section will be analyzed for normal depth and full flow capacity. For the normal depth, the data from watershed delineation will be used to choose the discharge corresponding to the location of the cross section. The full flow capacity is the maximum flow that the channel can handle before water floods to overbanks. The full flow capacity values will be compared to the flows in the watershed delineation for 25-yr and 100-yr flow. The analysis will be conducted using Bentley FlowMaster, where a table for the normal depth and a table for full flow capacity will be created and discussed later in this report.

2.5 Rosgen Level 2 Classification

In order to complete a stream restoration for the Coyote Springs stream, the stream's type needed to be determined. The *Rosgen Classification Approach* was used to classify the stream in coyote springs. The Rosgen Approach takes into account several stream characteristics such as bankfull width, bankfull depth, stream length, valley length, and channel slope.

Technical Supplement 3E of the USDA National Engineering Handbook 654 describes the data requirements for classifying streams using this approach [5]. The main characteristics are single-threaded or multiple-threaded channels, entrenchment ratio, width-to-depth ratio, sinuosity, slope, and material type. For the purpose of this report, the parameters that will be evaluated are the entrenchment ratio, width-to-depth ratio, sinuosity, and slope. The equations used to calculate them are provided below.

Entrenchment Ratio: $$\frac{\textbf{Flood prone area width (ft)}}{\textbf{Bankfull channel width (ft)}}$$ **(Equation 2)** [5]

Width to Depth Ratio: $$\frac{\textbf{Bankfull channel width (ft)}}{\textbf{Bankfull mean depth (ft)}}$$ **(Equation 3)** [5]

Channel Sinuosity: $$\frac{\textbf{Stream Length (ft)}}{\textbf{Valley Length (ft)}}$$ **(Equation 4)** [5]

Slope: $$\frac{\textbf{Elevation Change (ft)}}{\textbf{Stream Length (ft)}}$$ **(Equation 5)** [5]

These calculations will be used for the Coyote Springs stream as well as our reference reach explained in Section 2.6 below.

2.6 Reference Reach

The team will analyze a known stream reach with similar characteristics to Coyote Springs to compare features. This will help determine how Coyote Springs stream should operate. This analysis is just to reference from and will not be the exact answer to what is occurring in the Coyote Springs stream reach. The reference reach is a portion of Sinclair Wash that is located on NAU campus between Hilltop Townhomes and the football practice fields, map and tables are located in Appendix F Figure 7. Since this portion of Sinclair wash is able to convey water without much sediment build-up, it is a good starting point. Both streams will be analyzed using Rosgen level 2 comparatively.

2.7 Vegetation

Plants along the stream and in the surrounding floodplains were researched to determine their speciation. The native and non-native species were identified to determine their effect on the stream and surrounding wildlife. A list of the species along with their respective pictures can be found in Appendix G. The species of most concern are the overgrown Common Cattails, Scouler's Willow, and Creeping Bentgrass. Although native to the area, Common Cattails and Scouler's Willow are haphazardly grown along the length of the stream as well as collectively in the ponding area. The invasive species of concern is the Creeping Bentgrass, which is overgrown and obstructing the upstream end and the floodplains, Appendix G Figure 8. Although elk and wildlife meander through the area, they do not frequent it enough to restrain the plant growth. In the downstream area, the mesh netting has not permitted native species to grow along the slopes; the final design will promote native plants in the area for erosion management and better aesthetics.

3.0 Analysis Results

3.1 Rosgen

By using the equations in 2.3 and the survey data obtained by the team these parameters were evaluated which were used to determine the classification of Coyote Springs stream. The channel sinuosity was determined by using the stream length (1360.82 ft) divided by the valley length (1346.68 ft) and was determined to be 1.01ft/ft. The slope of the stream was then determined by dividing the change in elevation from the upstream point to the downstream point (53 ft) by the stream's length (1360.82) which came out to be 0.0389 ft/ft. Next the width to depth ratio was calculated using the average bankfull channel width (2.42 ft) divided by the bankfull mean depth (0.1 ft) and the width to depth ratio is 24.78 ft/ft. Finally, the entrenchment ratio was calculated by dividing the flood prone area (4.38 ft) by the bankfull channel width (2.42 ft) to get 1.81 ft/ft. Along with this information the tables of this data is located in Appendix D Table 5.

To summarize, Coyote Springs stream has the following characteristics:

- Entrenchment Ratio = 1.81 ft/ft
- Width to Depth Ratio = 24.78 ft/ft
- Channel Sinuosity = 1.01 ft/ft
- Slope = 0.0389 ft/ft

The same process was used in order to classify our reference reach of Sinclair Wash.

A summary of the results of the reach of Sinclair Wash are as follows:

- Entrenchment Ratio = 1.87 ft/ft
- Width to Depth Ratio = 10.63 ft/ft
- Channel Sinuosity = 1.06 ft/ft
- Slope = 0.0065 ft/ft

3.1.1 Coyote Springs Stream

Following the flowchart in Figure 22 below, this sub-reach appears to represent a B stream. First, using the entrenchment ratio 1.81 ft/ft the stream is *moderately entrenched*. Its width to depth ratio of 24.78 ft/ft the stream has a *moderate width to depth ratio.* The channel sinuosity is 1.01 ft/ft, which is below the cutoff of 1.2 for *moderately sinuosity*. However, this sub-reach is close enough to be classified as *moderately sinuous.* Finally, by using the slope of 0.0389 ft/ft and the fact that mostly silts and clays compose the streambed, the sub-reach fits under Rosgen classification B6.

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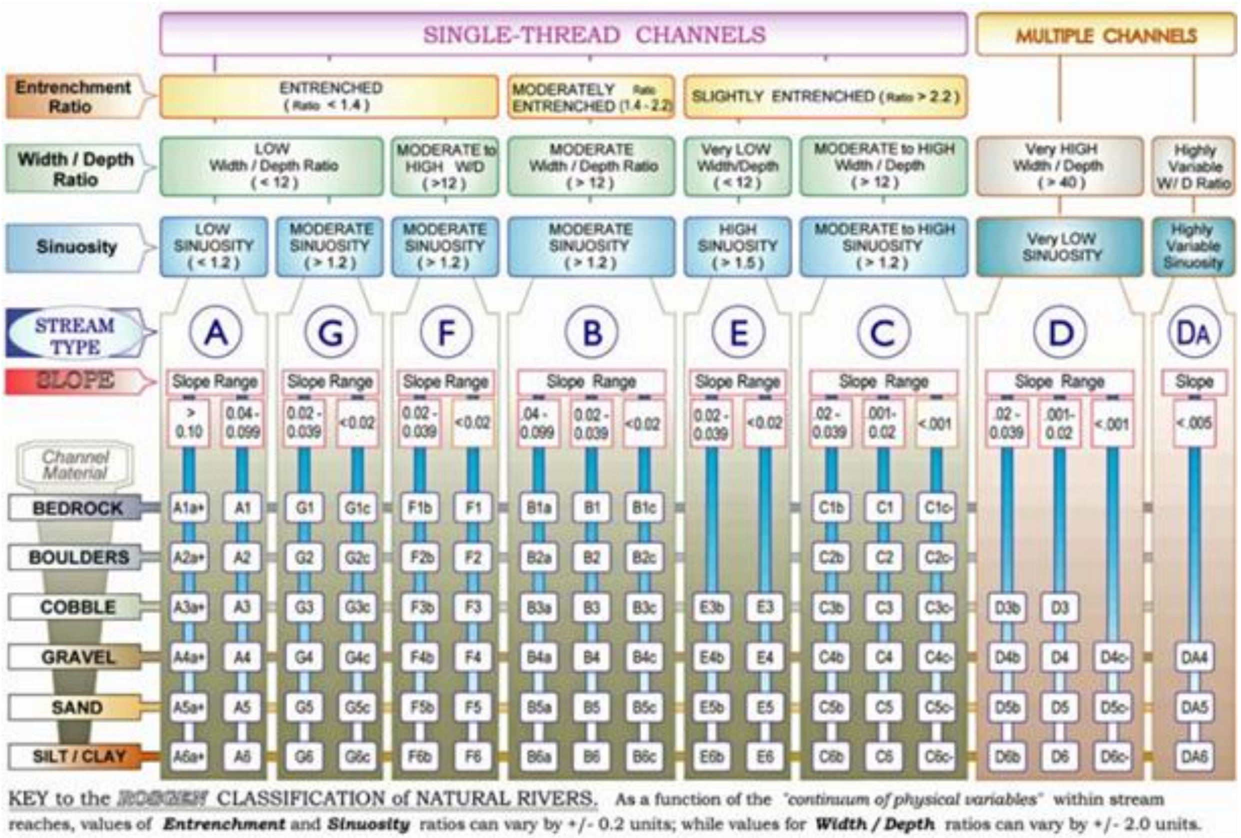

Figure 22: Rosgen Classification Level 2 Flowchart

3.1.2 Sinclair Wash Reference Reach

From the same flowchart, this reach appears to represent a B stream as well. First, using the entrenchment ratio 1.87ft/ft the stream is *moderately entrenched*. Its width to depth ratio of 10.63 ft/ft is under the cut off but still resembles a *moderate width to depth ratio.* The channel sinuosity is 1.06 ft/ft, once again below the cut off for *moderately sinuosity*. However, this reach could still be classified as *moderately sinuous* similar to Coyote Springs. Finally, by using the slope of 0.0065 ft/ft and the fact that mostly silts and clays compose the streambed, the reach fits under Rosgen classification B6a.

From this information we found that the Coyote Springs stream is very similar to our reference reach in Sinclair Wash. This helps us determine that only minor alterations need to be done for this stream to convey water with less build up along with some occasional maintenance.

3.2 Hydrology

Watershed delineation for the entire area was found to be 24.35 Acre which technically does not satisfy the 20 acre requirement to use the rational method for Coconino County. For this project since our watershed delineation was very close to the 20 acre requirement we decided that the representation of the rational method was suitable and so did our technical advisors. The watershed delineation can be seen in with each sub-basin in Appendix H.

The existing Coyote Stream discharge could then be calculated by finding the velocity and the cross sectional area of the channel three separate times and then taking the average to ensure accurate results. Coyote Springs has a discharge of 0.040 cfs shown in Table 8.

Table 8: Perennial Stream Flow

Perennial Stream Flow, Q				
Test No	**Time, sec**	**Distance, ft**	**Velocity, ft/s**	**Q, cfs**
1	6.8	3	0.441	**0.040**
2	5.3	3	0.566	
3	6.8	3	0.441	
		Avg	0.483	
Channel Area, ft^2		0.08333		

The final discharges for each sub-basin can be seen in Table 9 and were calculated for a 25 year frequently at 10 minute duration per the Flagstaff Drainage Design Manual. Rainfall intensity for a 10 minute duration was found in the *Coconino County Drainage Design Manual* [4] to be 5.34 in/hr. A precipitation factor of 1.1 and varying runoff coefficients depending on sub-basin conditions. The total of all the sub-basin discharges was calculated to be 22.05 cfs.

Table 9: Sub-Basin Discharges

Sub-Basin Discharges							
Sub Basin	**Area (Sf)**	**Area (Acre)**	**Runoff Coefficient, C**	**Duration (min)**	**Rainfall Intensity (in/hr)**	**Precip Factor, Cf**	**Q (cfs) 25-yr**
SB1	126,566	2.91	0.15	10	5.34	1.1	2.56
SB2	502,116	11.53	0.15	10	5.34	1.1	10.16
SB3	401,354	9.21	0.10	10	5.34	1.1	5.41
SB4	30,594	0.70	0.95	10	5.34	1.1	3.92
Total	**1,060,630**	**24.35**					**22.05**

All watershed analysis and hydrology was also checked with the City of *Flagstaff Stormwater Management Design Manual* to ensure that it met the requirements since Coyote Springs is inside of Flagstaff City Limits [5].

3.3 Hydraulics

3.3.1 HEC-RAS

A HEC-RAS model was created using the thalweg and the cross sections made in AutoCAD, along with the flow from the watershed delineation for 25 year flood, and the information retrieved from the Rosgen analysis. The flow was determined to be 22.05 cubic feet per second based on the 25 year flood scenario. The pertinent information from Rosgen that is used includes the slope and average bankfull depth, which are 0.0389 ft/ft and 0.1 ft respectively. This information plugged into HEC-RAS the program will run a steady flow analysis.

Once the Existing stream is compiled in HEC-RAS the steady flow analysis can be run. With this the program shows that the stream is functioning to an ok level with only a few problem areas. These problem areas include; one section of the stream at the downstream end near highway 180, the culverts being clogged, and before and after the culverts having some buildup. With this the existing stream has an average velocity of 3.46 ft/s with a few outliers near 5.5 ft/s shown in Appendix I Table 10.

3.3.2 Culvert Master

The table below shows the culverts dimensions and material. It also shows the inlet and outlet status, which are the conditions around the culverts. Table 11 also shows the control issue, which is whether the inlet or the outlet can convey water, as well as how much the culverts are filled with sedimentation.

Table 11: Culvert Analysis

Culvert Dimensions, Status, and Control							
Culvert	**Length, ft**	**Material**	**Diameter, in**	**Inlet**	**Outlet**	**Control**	**Outlet Clearance, in**
Culvert 1	90	Corrugated	24	Some Vegetation	Sedimentation	Outlet	2
Culvert 2	50	Corrugated	24	Pooling Area	Vegetation	Outlet	12
Culvert 3	100	Corrugated	24	Some Rocks	Vegetation	Outlet	23

3.3.3 Flow Master – Normal Depth

The table below shows the normal depths and the flow type throughout the channel. The data is from Bentley FlowMaster.

Table 12: Normal Depth Analysis

Normal Depth Analysis				
Cross Section	**Normal Depth, ft**	**Velocity, ft/s**	**Discharge, ft3/s**	**Flow Type**
1 (Well House)	0.56	1.71	12.72	Subcritical
2	0.5	1.65	12.72	Subcritical
3	0.7	1.63	12.72	Subcritical
4	0.48	1.21	12.72	Subcritical
5	0.68	1.56	12.72	Subcritical
6	0.63	1.73	12.72	Subcritical
Culvert 1				
7	1.01	2.12	22.05	Subcritical
8	1.45	2.68	22.05	Subcritical
9	0.69	1.76	22.05	Subcritical
10 (Pooling Area)	0.95	2.12	22.05	Subcritical
Culvert 2				
11	1.96	2.87	22.05	Subcritical
12	1.79	2.9	22.05	Subcritical
Culvert 3				

3.3.4 Flow Master – Full Flow Capacity

Table 13 below shows the current capacity of the channel. Cross sections 4 through 12 are adjacent to HYW 180. The cross sections capacity of the channel are compared to the discharge for the 25-yr and 100-yr flow. Cross sections 1, 9 and 3 cannot handle the 25-yr flow, which means in the event of 25-yr storm, the water will not flood into HYW 180, except at the locations of cross sections 9 and 12, and for cross section 1 the water will flood in the woods surrounding the channel. For 100-yr flow, the channel fail in cross sections 1, 3, 7, 9 and 12. Cross sections 1 and 3 are not adjacent to HYW 180, so the water will flood in the woods surrounding the channel. Cross sections 7, 9 and 12, which are adjacent to HYW 180, cannot handle the 100-yr flow, reasons for such failures will be discussed later in the report.

Table 13: Full Flow Capacity Comparison with 25-yr and 100-yr Flow

Flow from FlowMaster Compared to 25-yr and 100-yr Flow					
Cross Section	Discharge, ft^3/s	25-year		100-year	
		Discharge, ft^3/s	Pass?	Discharge, ft^3/s	Pass?
1 (Well House)	5.98	12.72	NO	18.02	NO
2	53.39	12.72	YES	18.02	YES
3	16.25	12.72	YES	18.02	NO
4	29.24	12.72	YES	18.02	YES
5	314.37	12.72	YES	18.02	YES
6	198	12.72	YES	18.02	YES
Culvert 1					
7	25.83	22.05	YES	31.25	NO
8	75.23	22.05	YES	31.25	YES
9	13.34	22.05	NO	31.25	NO
10 (Pooling Area)	44.98	22.05	YES	31.25	YES
Culvert 2					
11	33.93	22.05	YES	31.25	YES
12	16.23	22.05	NO	31.25	NO
Culvert 3					

4.0 Discussion

4.1 Hydrology and Hydraulics

The proposed design for the stream is similar to the existing with changes only in the problem areas and changing the Manning's number from 1 to 0.45 since the proposed design is used with a cleaned out channel area. The downstream area next to highway 180 near culvert 3 existing is shown in Figure 25. The proposed cross section will be spread out a little on the sides for less steep banks shown in Figure 26. With this change the stream has a less varying velocity which will cause less erosion throughout the stream. The velocity tables for the existing and proposed downstream cross sections are shown in Appendix I.

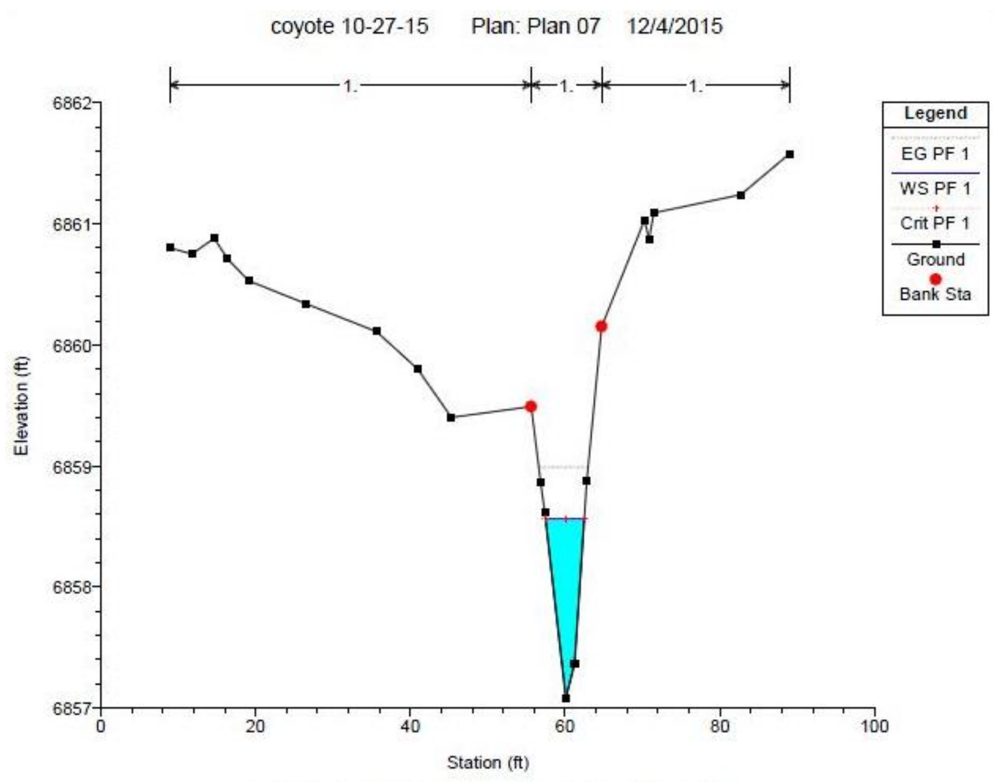

Figure 25: Existing Downstream Cross Section

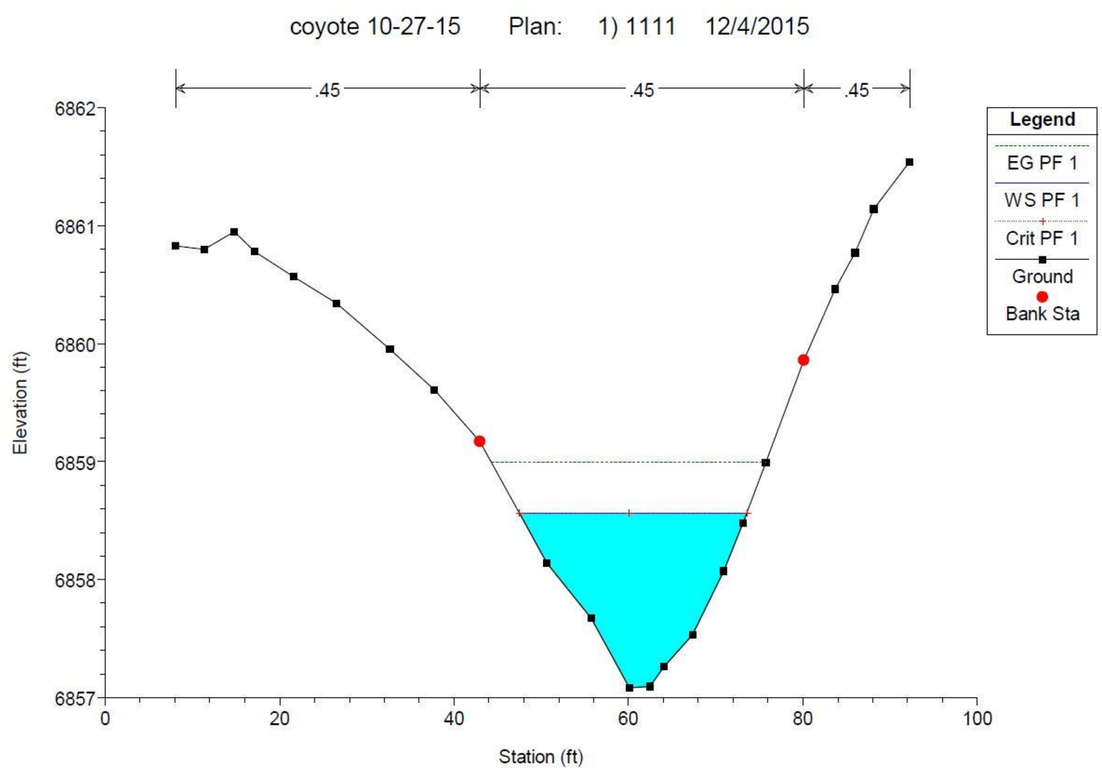

Figure 26: Proposed Downstream Cross Section

Along with this change and the maintenance of the streams culverts and plants the stream is able to flow at stable rate and possibly less problems in the future. Example images of the existing and cleaned culverts with the flow represented are shown below in Figure 27 and Figure 28 respectively.

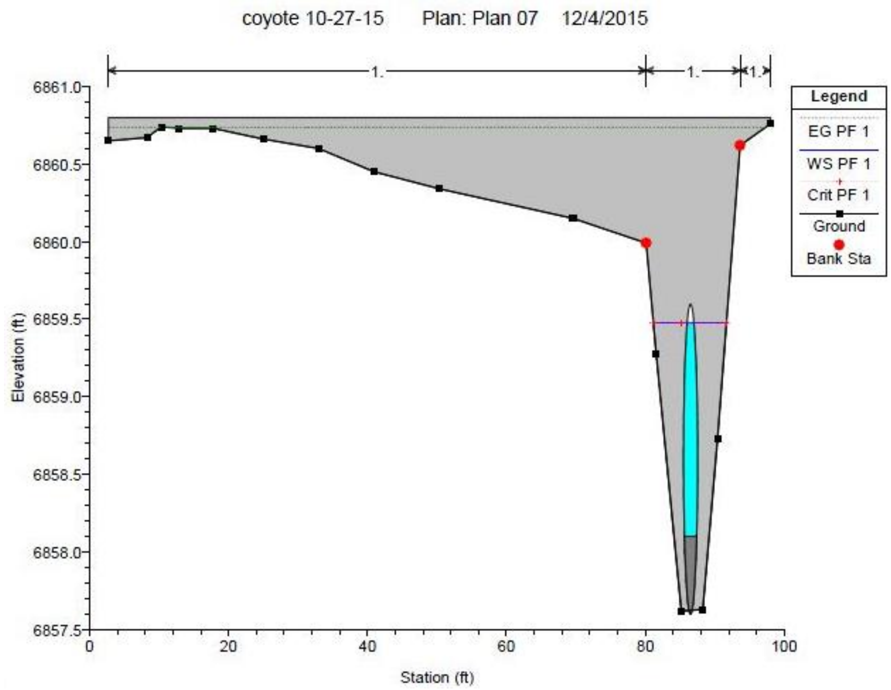

Figure 27: Existing Stream CLogged Culvert 3 Example

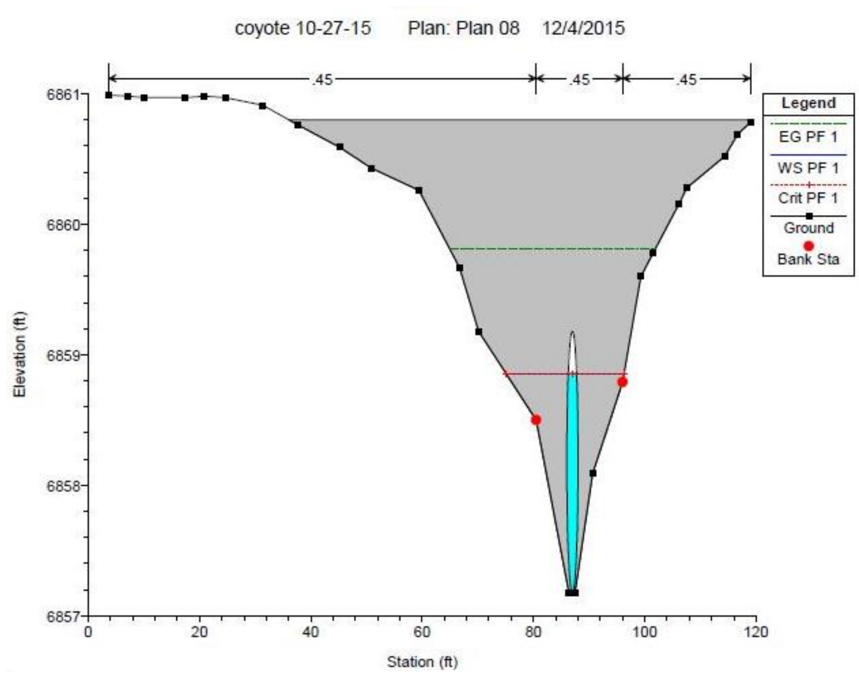

Figure28: Proposed Stream Cleaned Out Culvert 3 Example

4.2 Operation & Maintenance Plan

The AARK Stream Restorations team proposes to subcontract the tasks for cleaning and maintaining the Coyote Springs area. The Museum of Northern Arizona maintains the Colton House property itself, but not the well house and stream area. There are local botanical businesses that are available for hire to work in the area with the City of Flagstaff's approval. The first step is to provide an estimate and consultation by the local company to consider the existing plant species and additional native species, if necessary. There will be a revision in the downstream slopes, which will need native plant additions to stabilize the slope and for aesthetic considerations. The City of Flagstaff in accordance with the Coyote Springs HOA will need to alter the stream slopes during this phase with the proper equipment. The sedimentation will be cleaned out of the culverts during this phase using a subcontracted company with the proper tools necessary for the three culverts.

The second phase will consist of the removal of weeds and revegetation with native seeds. The stream's perennial flow will water the plants but a bi-annual schedule for maintenance will be set. It is recommended to have a representative examine the reach during the Spring and Fall for plant growth; removal will occur if necessary. Any trash located in the stream or along the footpath will be removed as well. Refer to section 5.1 for the total cost if subcontracted.

This symbiotic system will mostly sustain its geography once altered; as the sediment is cleared, the plants will not take root in the streambed, and the energy of the stream will improve. In the event that the HOA would like to involve the community, an education program and volunteer opportunities will be necessary, while decreasing the total cost for maintenance and removal of invasive species.

4.3 Exclusions

There are utilities present in the area adjacent to the stream reach but are not included in the scope of this project. The ponding area on the west side of HWY 180 will be considered with respect to the culvert, however, due to the stream flowing onto private property, that part of the stream will be excluded from the scope. Utility locations and the relocation of utilities is not within the scope due to time constraints. For additional exclusions, refer to Appendix J, Qualifications and Exclusions.

5.0 Cost of Implementing Design

5.1 Operation & Maintenance Plan

The team suggests subcontracting for the cleaning and maintenance portion of this project. Figure 29 below shoes the price allocations for generalized costs.

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Project	Location	Architect	Total Area	Cost Per SF	Estimated By	Checked By	Project Duration	
Coyote Springs	Flagstaff, AZ 86001		13,600 SF	$ 51.39	AJC	KWD	76 Days	

DIV	Description	Materials	Labor	Equipment	Subcontract	Line Total	Cost/SF	% Total
1	General Requirments	$ 6,000.00	$ 28,348.50	$ 4,800.00	$ -	$ 39,148.50	$ 28.79	56.02%
2	Site Work					$ -	$ -	0.00%
3	Concrete					$ -	$ -	0.00%
4	Masonry					$ -	$ -	0.00%
5	Excavation	$ -	$ -	$ -	$ 5,336.00	$ 5,336.00	$ 3.92	7.64%
6	Pumping					$ -	$ -	0.00%
7	Moisture & Thermal Protection					$ -	$ -	0.00%
8	Maintanence	$ -	$ -	$ -	$ 600.00	$ 600.00	$ 0.44	0.86%
9	Finishes					$ -	$ -	0.00%
10	Specialties					$ -	$ -	0.00%
11	Equipment					$ -	$ -	0.00%
12	Special Cleaning	$ -	$ -	$ -	$ 10,300.00	$ 10,300.00	$ 7.57	14.74%
Sub Totals		$ 6,000.00	$ 28,348.50	$ 4,800.00	$ 16,236.00	$ 55,384.50	$ 40.72	
Sales Tax	4.95%	$ 297.00	$ 1,403.25	$ 237.60	$ 803.68	$ 2,741.53	$ 2.02	3.92%
Contingency	20.00%	$ 1,200.00	$ -	$ 960.00	$ 3,247.20	$ 5,407.20	$ 8.14	7.74%
Sub Totals		$ 7,497.00	$ 29,751.75	$ 5,997.60	$ 20,286.88	$ 63,533.23	$ 50.88	
Profit	10.00%	$ 749.70	$ 2,975.18	$ 599.76	$ 2,028.69	$ 6,353.32	$ 5.09	9.09%
Totals		$ 8,246.70	$ 32,726.93	$ 6,597.36	$ 22,315.57	$ 69,886.56	$ 55.97	100.00%
This is a estimate on the goods named, subject to the conditions noted below:					Check	69,886.56	51.39	100.00%

Figure 29: Cost Estimate for Total Project

The alternative that we suggest is to alter the downstream area; the cost in Figure 29 is associated with this alteration. This will include excavation of the channel and slopes, special cleaning involving culvert flushing, as well as maintenance and weed removal. In the event that Coyote Springs Homeowners Association would like to reduce costs, they may choose to involve volunteers and the community members. If the client and the Homeowners Association chooses to not alter the downstream area and just include special cleaning of culverts and maintenance, the cost would be reduced significantly, however, there is a higher probability for the stream to fill with sediment due to the unstable energy throughout the stream. An additional cost for culvert flushing will be added to the cost when the culverts fill with six inches of sediment. Future maintenance will be approximately $450 per every 6 months if the Coyote Springs Homeowners Association chooses to subcontract for labor. The City of Flagstaff bid tabulations will be taken into consideration for hiring subcontractors; mobilization of the crew, the equipment, and an hourly rate will be considered. The rate is dependent on the amount and type of debris in the culverts as well.

6.0 Conclusion

In conclusion the AARK team determined the Coyote Springs Stream to have a few problem areas that needed to be focused on. These areas include the pooling area near Creekside Drive, the downstream channel after Creekside Drive next to Highway 180, and the three culverts that are clogged by sediment along the stream. With these areas the team determined that the pooling area will be left alone and just have maintenance done on it to keep the vegetation controllable. The culverts are to be cleaned out by subcontracting a company to flush them as needed. As for the downstream section of the stream, there are choices to be made whether to change it or not. We recommend that the downstream section is changed to our specifications as this will allow the energy in the stream to stabilize and thus having less sediment moving around in the stream. With less sediment movement the culvert can be flushed out less saving money in the long run. The price for the proposed design that we recommend is $22,315.57 with taxes and fees of work to be done. The grand total of the overall project for analysis and work to be done with taxes and fees comes to $95,490.53 a further breakdown is located in Appendix J.

7.0 References

[1] Garrison, J. *National Register of Historcial Places, Arizona*. Retrieved from http://www.nationalregisterofhistoricplaces.com/az/coconino/state.html

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Appendix A: Site Map

Figure 1: Site Overview and Location of Coyote Springs

Appendix B: Problematic Areas

Figure 3: Pooling Area Overgrown with Vegetation at Creekside Drive and HWY 180

Figure 4: Turf Reinforcement Netting at Downstream End Looking Northwest

Appendix C: Tasks

Task 1.0 - Field Evaluation

This task involves visiting the site to collect existing data and familiarize all parties with the area, vegetation, and topography.

1.1 - Spring

The spring is to be evaluated, to determine its flow and where the water comes from. A well house currently surrounds the spring. The staff working on this project will determine who is responsible for the well house to better view the site, and get access for testing purposes.

1.2 - Stream

The extents and reach, as well as the flow will be evaluated. The vegetation surrounding the stream will also be taken into account and analyzed.

1.3 - Culverts

The culvert infrastructures will be observed and surveyed to determine the effectiveness on site.

1.4 - Surveying/General Site Constraints

The surveying will start at the upstream end of the stream at the well house, and end downstream at the end of the culvert crossing HWY 180. Both the industrial and environmental elements surrounding the stream will be surveyed and analyzed. This will allow the staff working on this project to determine what needs to be fixed and what doesn't need to be fixed.

Task 2.0 - Permitting, Standards, Codes

2.1 - Construction Requirements

ADOT and the City of Flagstaff regulation documents must be utilized in order for legal standards to be adhered to and approved for the project.

2.2 - Property Standards

Coyote Springs HOA standards will be inspected as well as landscape parameters in order to make sure the stream does not cross property lines or violate any of HOA standards.

2.3 - Hydrologic

AARK Restorations, LLC will follow proper design standards to comply with all regulations for the City of Flagstaff and the state of Arizona.

2.4 - Hydraulic

AARK Restorations, LLC will follow proper design standards to comply with all regulations for the City of Flagstaff and the state of Arizona.

2.5 - Arizona Department of Environmental Quality

There are laws, policies, rules, and permits that need to be examined and possibly obtained in the event that the stream reach and surrounding environment will be altered.

2.6 - Arizona Department of Water Resources

Flagstaff is under the area of the Eastern Plateau according to the ADWR. The ADWR must be researched to ensure the stream flow is not extremely altered or the possible geographical change will impact the groundwater aquifer.

Task 3.0 - Hydrologic Analysis

3.1 - Rainfall and Snowfall

Annual precipitation and snowfall as well as snowmelt runoff will be analyzed to design around. This will add to the discharge of the stream.

3.2 - Spring and Stream Discharge

The spring's discharge will contribute to the stream reach being analyzed. This flow rate will be identified to understand the amount of perennial flow the stream has. The source of the spring will be researched in order to determine contributing surface area. The overall discharge from the stream will be a sum of the rainfall and snowfall, the spring's source of water, and the surrounding watershed runoff.

3.3 - Watershed

Delineation needs to be complete to determine what encompasses the stream and affects the flow regime. This will be completed using online resources.

Task 4.0 - Hydraulic Analysis

4.1 - Culvert

The culvert sizing will be analyzed to determine if they are the correct sizes and materials for the areas as well as the flow rates they will convey so there is no overbanking of water onto the streets using Bentley CulvertMaster.

4.2 - Channel

The channels sinuosity and slope will be analyzed to determine if the conveyance is low or high for this stream. This will help determine if the stream will have any aggradation or degradation in the future. The analysis of the data for the channel will be done using HEC-RAS

Task 5.0 - Site Analysis

5.1 - Geological Report

Geologic reports will show soil properties and characteristics of the surrounding area. These reports will be obtained from previous construction.

5.2 - Plant Classification

Plants in the area, both native and non-native, will be researched to determine their speciation and possible effects in the riparian habitat.

Task 6.0 - Hydrologic Design

If necessary, the Coyote Springs stream reach will be designed to accommodate high and low flow storm events determined from the watershed delineation and past storm events.

Task 7.0 - Hydraulic Design

If necessary, the stream slope and sinuosity will be designed so the water flows without pooling in certain areas, and causing minimal aggradation or degradation. The survey data will be in put into HEC-RAS in order to develop 3D models of the stream, and analyze all the flow scenarios.

Task 8.0 - Final Concepts

The team will conclude their findings from assessing and analyzing the site, along with the research conducted for the existing reach. If necessary, the AARK Restorations team will deduce multiple solutions and formulate the most sustainable, eco-friendly solution. The broader impacts of the proposed solutions will be evaluated to ensure the participation of the public for educational purposes, further research opportunity possibilities, and directly enhancing the habitat for perpetuating the wildlife. Depending on the findings, the team will then present the progress and plan to move forward and begin the alterations of the reach if necessary.

Task 9.0 - Project Management

9.1 - Schedule

The proposed schedule must be planned to determine the start and end dates of the project, the tasks and subtasks, the durations of the tasks, task dependencies, and task milestones. The Gantt chart for this project is located in Appendix B.

9.2 - 50% report

The 50% report allows for both the client and team to determine if they are on task according to the proposed schedule. This report may include technical analyses, cost analyses, and any other information started or finished by the half way point of the project time frame. This report is due on October 22, 2015.

9.3 - Final Report

The final report will conclude all analyses, due on December 4, 2015.

9.4 - Final Presentation

AARK Restorations, LLC will propose the final design to the client on December 4, 2015.

9.5 - Website

The website will include: a homepage which include the title of the project and a description, the client contact info, the team contact info, the technical advisor contact info and link to other pages. It will also include a project information's page which include project constraint, alternative design and final design, HEC-RAS model, photo gallery and Gantt chart and internal team budgeting. It will also include a document page which include the final report and the presentation in PDF form. The final website will be available to the public on Wednesday, December 16, 2015.

Appendix D: Gantt Charts

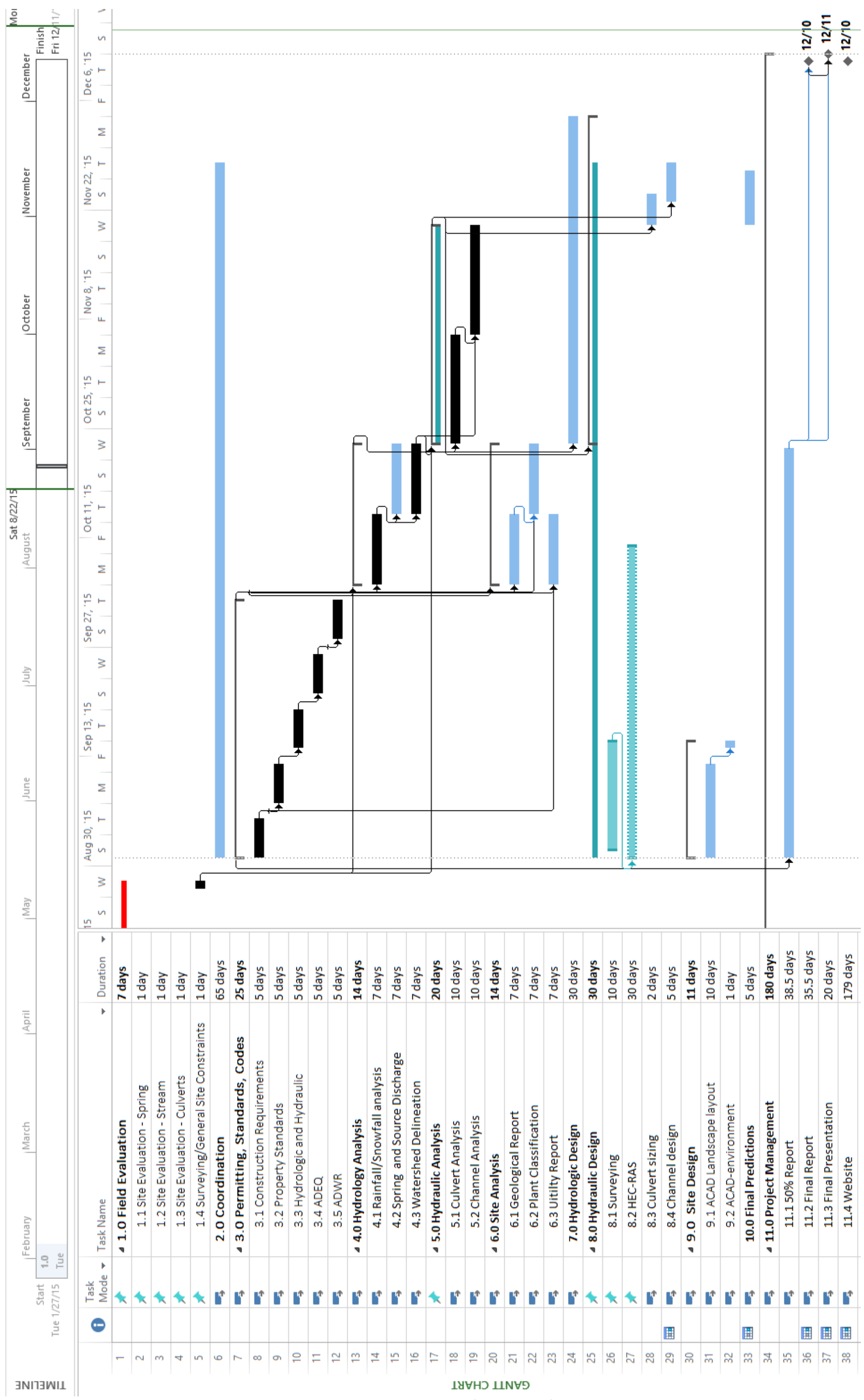


Figure 5: Original Gantt Chart

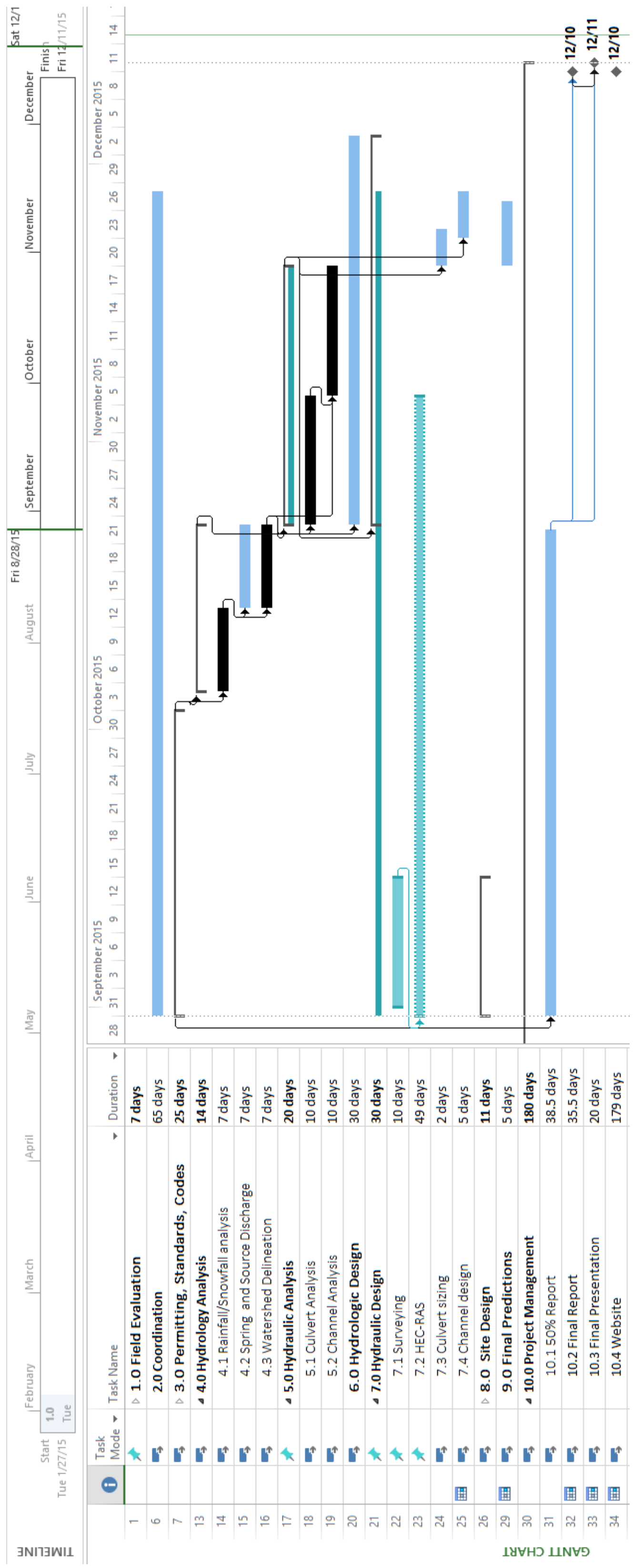


Figure 6: Updated Gantt Chart per Updated Scope

Appendix E: AARK Team Hours

Table 4: Hours Approximated for AARK Stream Restorations Team

Approximated Hours for AARK Team	SENG Hours	ENG Hours	EIT Hours	INT Hours
Subtotal	38	312	176	75
Total (Hours)				601

Table 5: Actual Hours Completed by AARK Stream Restorations Team

Actual Hours for AARK Team	SENG Hours	ENG Hours	EIT Hours	INT Hours
Subtotal	75	159.5	205	38
Total (Hours)				477.5

Appendix F: Reference Reach

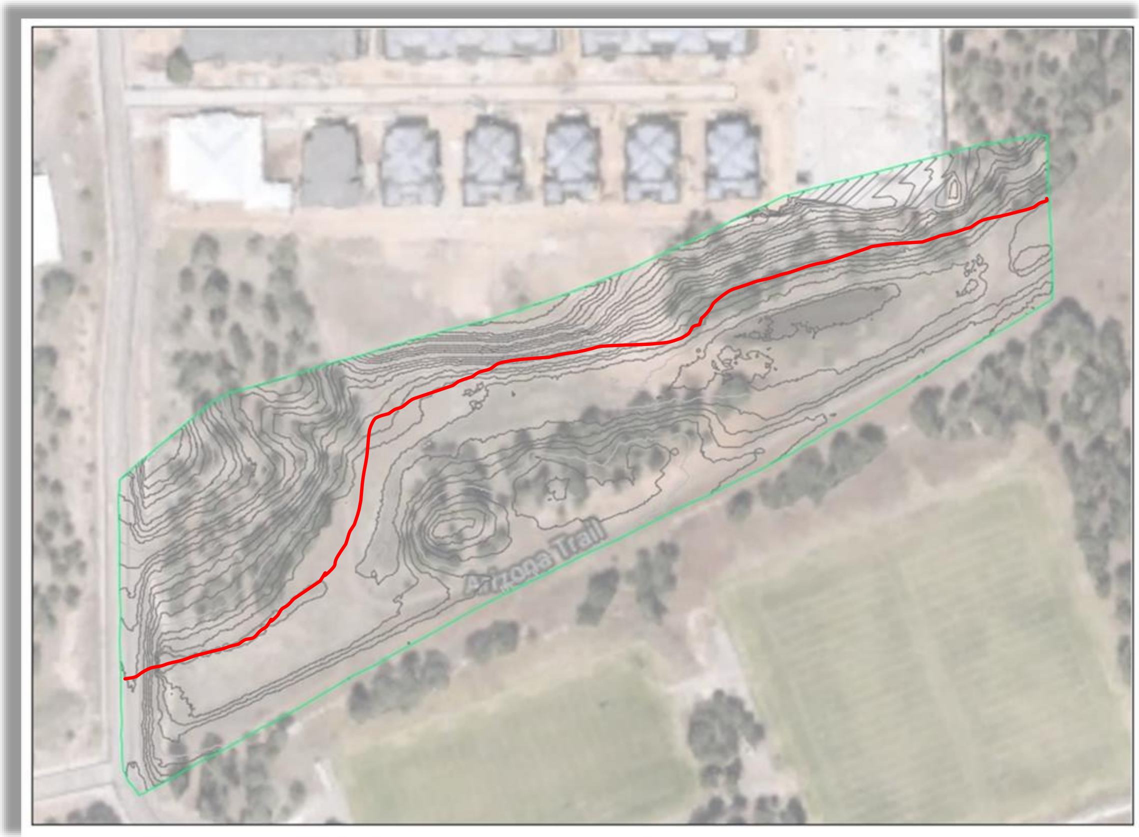


Figure 7: Sinclair Wash Near Practice Fields and Hilltop Townhomes from AutoCAD

Table 6: Sinclair Wash Dimensions

XS	Bankfull Width, ft	Bankfull Depth, ft	Flood Prone, ft
1	15	1.5	24
2	12	0.8	25
3	18	2	26
4	10	2	28
5	14	5	30
6	19	105	32
Avg	14.67	1.38	27.5

Table 7: Sinclair Wash Classification Summary

Stream Length, ft	854.7
Valley Length, ft	809.3
Change in Elevation, ft	5.64
Average Bankfull Width, ft	14.67
Average Bankfull Depth, ft	1.38
Average Flood Prone Width,	27.5
Entrenchment Ratio, ft/ft	1.87
Width to Depth Ratio, ft/ft	10.63
Channel Sinuousity, ft/ft	1.06
Stream Slope, ft/ft	0.01

Table 8: Coyote Springs Summary from Rosgen

Coyote Springs Stream Classification	
Stream Length, ft	1360.82
Valley Length, ft	1346.68
Change in Elevation, ft	53.00
Entrenchment Ratio, ft/ft	1.81
Width to Depth Ratio, ft/ft	24.78
Channel Sinuousity, ft/ft	1.01
Stream Slope, ft/ft	0.04

Appendix G: Plant Species in Coyote Springs

Figure 8:Agrostis stolonifera (creeping bentgrass): invasive

Figure 9: Ambrosia psilostachya (cuman ragweed): native

Figure 10: Argemone munita (prickly poppies): native

Figure 11: Deschampsia cespitosa (tufted hairgrass): invasive

Figure 12: Helianthus annuus (common sunflower): invasive

Figure 13: Potentilla recta (sulfur cinquefoil): invasive

Figure 14: Ribes cereum (wax currant): native

Figure 15: Ratibida pinnata (grayhead prairie coneflower): invasive

Figure 16: Salix scouleriana (scouler's willow): native

Figure 17: Schoenocrambe linearifolia (slimleaf plainsmustard): native

Figure 18: Sisymbrium irio (London rocket): invasive

Figure 19: Typha latifolia (common cattail): native

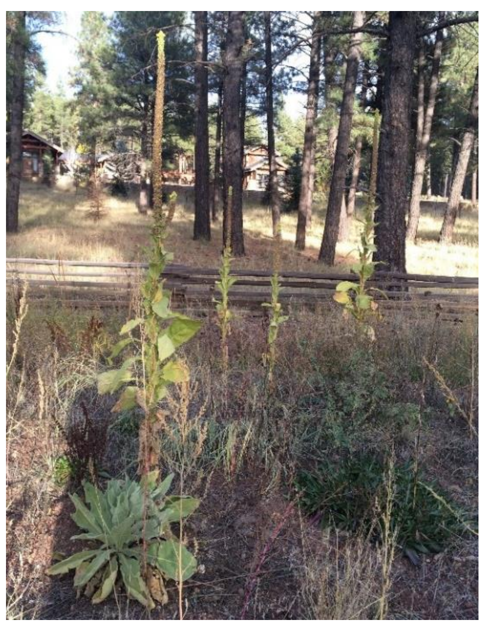


Figure 10: Verbascum Thapsus (great mullein): invasive

Figure 11: Vicia pulchella (sweetclover vetch): invasive

Table 9: Plant Species at Coyote Springs

Scientific Name	Common Name	Invasive?
Agrostis stolonifera	Creeping bentgrass	Invasive
Ambrosia psilostachya	Cuman ragweed	Non-Invasive
Argemone munita	Prickling poppies	Non-Invasive
Deschampsia cespitosa	Tufted hairgrass	Invasive
Helianthus annuus	Common sunflower	Invasive
Potentilla recta	Sulfur cinquefoil	Invasive
Ribes cereum	Wax currant	Non-Invasive
Ratibida pinnata	Grayhead prairie coneflower	Invasive
Salix scouleriana	Scouler's willow	Non-Invasive
Schoenocrambe linearifolia	Slimleaf plainsmustard	Non-Invasive
Sisymbrium irio	London rocket	Invasive
Typha latifolia	Common cattail	Non-Invasive
Verbascum thapsus	Great mullein	Invasive
Vicia pulchella	Sweetclover vetch	Invasive

Appendix H: Watershed Delineation

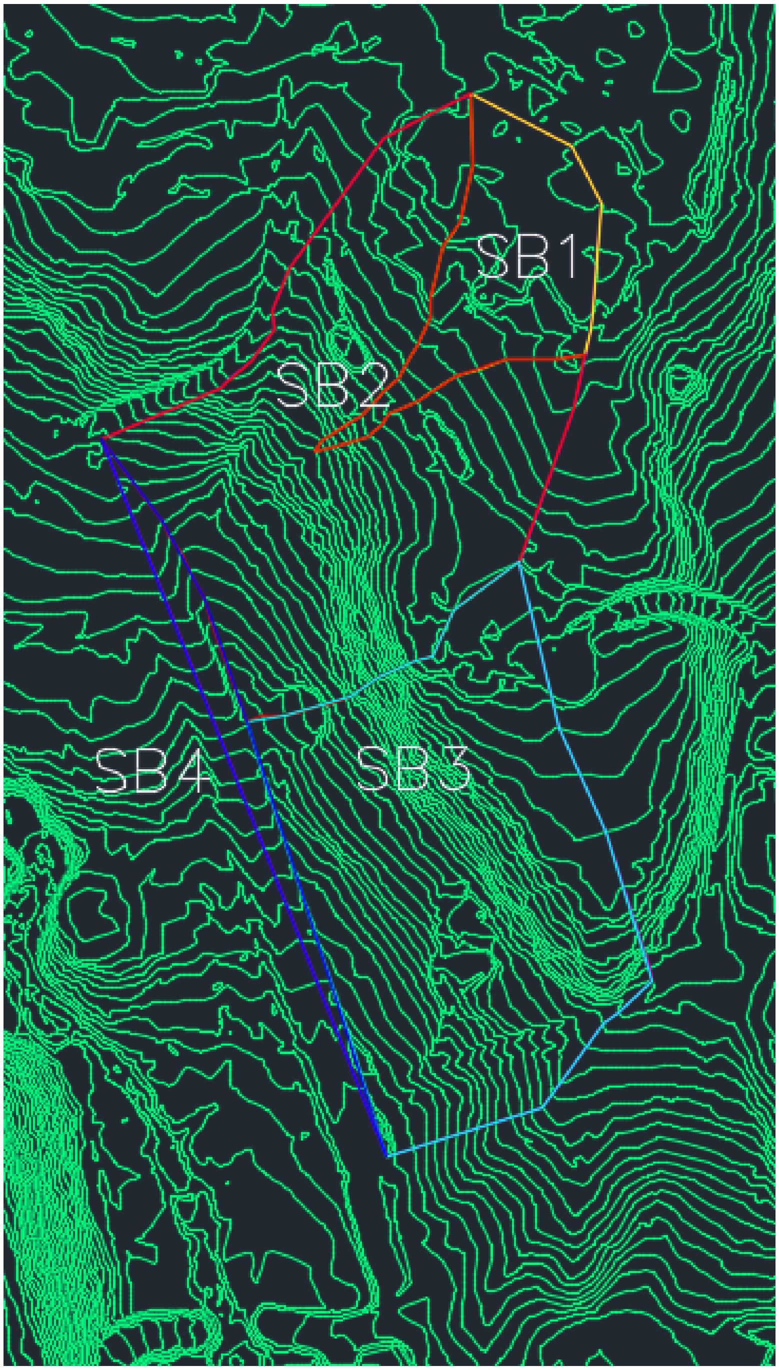


Figure23: AutoCAD Contours

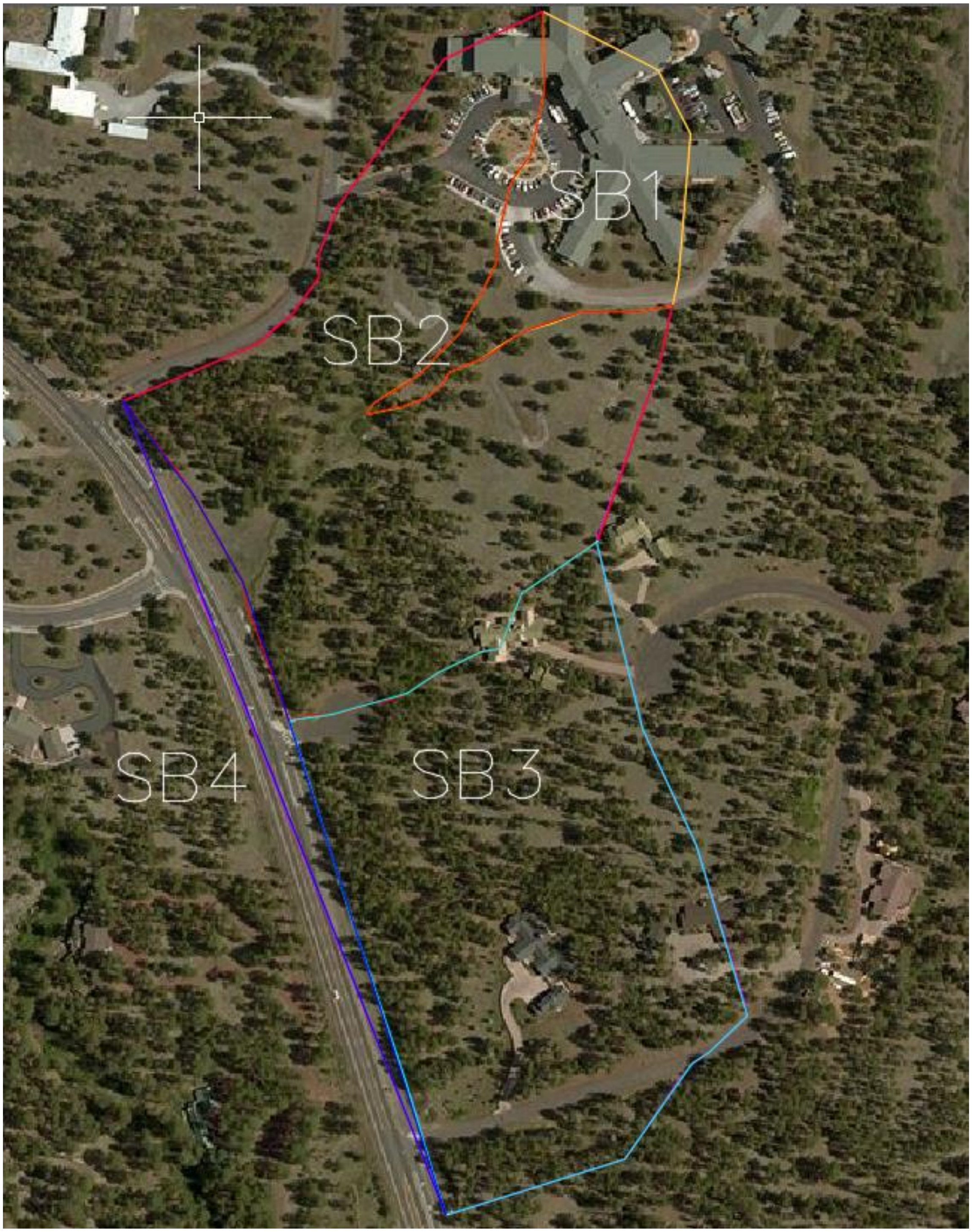


Figure24: Watershed Sub-Basins

Appendix I: Existing HEC-RAS Information

Table 10: HEC-RAS for Existing Stream Output

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)	
coyote reverse f	1352.14	PF 1	22.05	6909.91	6910.52	6910.52	6910.71	20.262670	3.51	6.28	16.39	1.00
coyote reverse f	1338.22	PF 1	22.05	6907.52	6908.01	6908.01	6908.15	21.856870	3.07	7.19	24.50	1.00
coyote reverse f	1288.81	PF 1	22.05	6899.90	6900.76	6900.76	6900.94	20.822550	3.43	6.43	17.74	1.00
coyote reverse f	1239.11	PF 1	22.05	6896.40	6897.16	6897.16	6897.31	20.892820	3.18	6.94	21.53	0.99
coyote reverse f	1198.97	PF 1	22.05	6894.04	6894.53	6894.53	6894.67	22.169170	3.06	7.19	24.79	1.00
coyote reverse f	1138.07	PF 1	22.05	6890.86	6891.35	6891.35	6891.48	22.993800	2.98	7.40	27.25	1.01
coyote reverse f	1088.32	PF 1	22.05	6888.23	6888.75	6888.75	6888.87	25.852270	2.70	8.17	38.20	1.03
coyote reverse f	1019.67	PF 1	22.05	6884.91	6885.48	6885.48	6885.60	25.041710	2.74	8.04	35.83	1.02
coyote reverse f	938.56	PF 1	22.05	6880.78	6881.50	6881.50	6881.67	22.598380	3.31	6.67	20.67	1.03
coyote reverse f	888.83	PF 1	22.05	6878.69	6879.54	6879.54	6879.72	20.615580	3.40	6.48	17.91	1.00
coyote reverse f	838.55	PF 1	22.05	6876.40	6876.98	6876.98	6877.22	18.955790	3.86	5.71	12.23	1.00
coyote reverse f	838		Culvert									
coyote reverse f	788.68	PF 1	22.05	6874.17	6874.82	6874.82	6875.07	18.784880	3.94	5.60	11.57	1.00
coyote reverse f	738.18	PF 1	22.05	6873.05	6873.95	6873.95	6874.19	19.167310	3.97	5.55	11.48	1.01
coyote reverse f	688.28	PF 1	22.05	6871.90	6872.84	6872.84	6873.12	19.832370	4.25	5.19	9.76	1.03
coyote reverse f	639.13	PF 1	22.05	6869.65	6871.22	6871.22	6871.63	19.916830	5.12	4.31	5.39	1.01
coyote reverse f	589.04	PF 1	22.05	6868.97	6870.13	6870.13	6870.39	19.634880	4.10	5.38	10.65	1.02
coyote reverse f	538.95	PF 1	22.05	6867.44	6868.44	6868.44	6868.62	20.008620	3.37	6.55	17.98	0.98
coyote reverse f	488.27	PF 1	22.05	6866.22	6866.99	6866.99	6867.20	19.953860	3.73	5.91	13.95	1.01
coyote reverse f	439.05	PF 1	22.05	6865.29	6865.96	6865.96	6866.11	22.839040	3.14	7.03	23.86	1.02
coyote reverse f	389.36	PF 1	22.05	6864.34	6864.92	6864.92	6865.06	23.219280	3.02	7.30	26.61	1.02
coyote reverse f	338.77	PF 1	22.05	6862.29	6863.04	6863.04	6863.25	20.120840	3.63	6.07	14.99	1.01
coyote reverse f	288.27	PF 1	22.05	6860.40	6861.30	6861.30	6861.53	19.542890	3.89	5.67	12.29	1.01
coyote reverse f	229.3	PF 1	22.05	6858.50	6859.07	6859.07	6859.23	20.873380	3.24	6.80	20.49	0.99
coyote reverse f	139		Culvert									
coyote reverse f	138.33	PF 1	22.05	6857.08	6858.56	6858.56	6858.99	19.592000	5.24	4.21	5.02	1.01
coyote reverse f	106.39	PF 1	22.05	6857.62	6858.56	6858.56	6858.90	18.460930	4.72	4.68	6.94	1.01
coyote reverse f	27		Culvert									
coyote reverse f	26.48	PF 1	22.05	6856.64	6857.06	6857.06	6857.20	24.039520	3.01	7.34	27.64	1.03

Appendix J: Cost Breakdown

AARK Stream Restoration, LLC
NAU Capstone

AARK Stream Restoration, LLC

We strive for excellence in every project, small or large, in order to make every stream the best that it can be.

Estimate

Date:	12/16/2015
Estimate #:	2015-132
Customer ID:	WONAUCAP
Expiration Date:	1/16/2016
Sheet #:	1

To: Cindy Perin
Coyote Springs HOA
Northern Arizona University Capstone
Flagstaff, AZ 86001

Project	Location	Architect	Total Area	Cost Per SF	Estimated By	Checked By	Project Duration
Coyote Springs	Flagstaff, AZ 86001		13,600 SF	$ 70.21	AJC	KWD	76 Days

DIV	Description	Materials	Labor	Equipment	Subcontract	Line Total	Cost/SF	% Total
1	General Requirments	$ 6,000.00	$ 50,527.00	$ 4,800.00	$ -	$ 61,327.00	$ 45.09	64.22%
2	Site Work					$ -	$ -	0.00%
3	Concrete					$ -	$ -	0.00%
4	Masonry					$ -	$ -	0.00%
5	Excavation	$ -	$ -	$ -	$ 5,336.00	$ 5,336.00	$ 3.92	5.59%
6	Pumping					$ -	$ -	0.00%
7	Moisture & Thermal Protection					$ -	$ -	0.00%
8	Maintanence	$ -	$ -	$ -	$ 600.00	$ 600.00	$ 0.44	0.63%
9	Finishes					$ -	$ -	0.00%
10	Specialties					$ -	$ -	0.00%
11	Equipment					$ -	$ -	0.00%
12	Special Cleaning	$ -	$ -	$ -	$ 10,300.00	$ 10,300.00	$ 7.57	10.79%
Sub Totals		**$ 6,000.00**	**$ 50,527.00**	**$ 4,800.00**	**$ 16,236.00**	**$ 77,563.00**	**$ 57.03**	
Sales Tax	4.95%	$ 297.00	$ 2,501.09	$ 237.60	$ 803.68	$ 3,839.37	$ 2.82	4.02%
Contingency	20.00%	$ 1,200.00	$ -	$ 960.00	$ 3,247.20	$ 5,407.20	$ 11.41	5.66%
Sub Totals		**$ 7,497.00**	**$ 53,028.09**	**$ 5,997.60**	**$ 20,286.88**	**$ 86,809.57**	**$ 71.26**	
Profit	10.00%	$ 749.70	$ 5,302.81	$ 599.76	$ 2,028.69	$ 8,680.96	$ 7.13	9.09%
Totals		**$ 8,246.70**	**$ 58,330.90**	**$ 6,597.36**	**$ 22,315.57**	**$ 95,490.53**	**$ 78.39**	**100.00%**
					Check	95,490.53	70.21	100.00%

This is a estimate on the goods named, subject to the conditions noted below:
As is.

To accept this quotation, sign here and return: ____________________

Thank you for your business!

1030 San Fransisco, Flagstaff, AZ 86001 (805)450-6980 AARKRestoration@gmail.com

AARK Stream Restoration, LLC

NAU Capstone

General Conditions

AARK Stream Restoration, LLC

We strive for excellence in every project, small or large, in order to make every stream the best that it can be.

Date:	12/16/2015
Estimate #:	2015-132
Customer ID:	WONAUCAP
Expiration Date	1/16/2016
Sheet #:	2

To: Cindy Perin
Coyote Springs HOA
Northern Arizona University Capstone
Flagstaff, AZ 86001

CSI / Means	Item	Qty	Unit	Material Unit	Material Total	Labor Unit	Labor Total	Equipment Unit	Equipment Total	Subcontractor Total	Line Total
	Project Personnel										
	Senior Engineer	38	Hr	$ -	$ -	$ 130.00	$ 4,940.00	$ -	$ -	$ -	$ 4,940.00
	Engineer	312	Hr	$ -	$ -	$ 97.00	$ 30,264.00	$ -	$ -	$ -	$ 30,264.00
	Engineer in Training	176	Hr	$ -	$ -	$ 73.00	$ 12,848.00	$ -	$ -	$ -	$ 12,848.00
	Interns	75	Hr	$ -	$ -	$ 33.00	$ 2,475.00	$ -	$ -	$ -	$ 2,475.00
	Overhead	1	LS	$ 6,000.00	$ 6,000.00	$ -	$ -	$ 4,800.00	$ 4,800.00	$ -	$ 10,800.00
Sub Totals					**$6,000.00**		**$ 50,527.00**		**$ 4,800.00**	**$ -**	**$ 61,327.00**
										Check	61,327.00

Thank you for your business!

1030 San Fransisco, Flagstaff, AZ 86001 (805)450-6980 AARKRestoration@gmail.com

AARK Stream Restoration, LLC

NAU Capstone

Excavation Conditions

AARK Stream Restoration, LLC

We strive for excellence in every project, small or large, in order to make every stream the best that it can be.

Date:	12/16/2015
Estimate #:	2015-132
Customer ID:	WONAUCAP
Expiration Date	1/16/2016
Sheet #:	3

To: Cindy Perin
Coyote Springs HOA
Northern Arizona University Capstone
Flagstaff, AZ 86001

CSI / Means	Item	Qty	Unit	Material Unit	Material Total	Labor Unit	Labor Total	Equipment Unit	Equipment Total	Subcontractor Total	Line Total
	Project Personnel										
	Labor	56	Hr	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,576.00	$ 2,576.00
	Debris Disposal	40	CY	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,360.00	$ 1,360.00
	Equipment	7	Day	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,400.00	$ 1,400.00
Sub Totals					**$ -**		**$ -**		**$ -**	**$ 5,336.00**	**$ 5,336.00**
										Check	5,336.00

Thank you for your business!

1030 San Fransisco, Flagstaff, AZ 86001 (805)450-6980 AARKRestoration@gmail.com

AARK Stream Restoration, LLC
NAU Capstone

Maintenance Conditions

AARK Stream Restoration, LLC

We strive for excellence in every project, small or large, in order to make every stream the best that it can be.

Date:	12/16/2015
Estimate #:	2015-132
Customer ID:	WONAUCAP
Expiration Date	1/16/2016
Sheet #:	4
Subcontractor:	Native Plant/Seed

To: Cindy Perin
Coyote Springs HOA
Northern Arizona University Capstone
Flagstaff, AZ 86001

CSI / Means	Item	Qty	Unit	Material Unit	Material Total	Labor Unit	Labor Total	Equipment Unit	Equipment Total	Subcontractor Total	Line Total
	Landscaping										
	Labor	16	Hr	$ -	$ -	$ -	$ -	$ -	$ -	$ 560.00	$ 560.00
	Supplies	5	EA	$ -	$ -	$ -	$ -	$ -	$ -	$ 40.00	$ 40.00
Sub Totals					$ -		$ -		$ -	$ 600.00	$ 600.00
										Check	600.00

Thank you for your business!

1030 San Fransisco, Flagstaff, AZ 86001 (805)450-6980 AARKRestoration@gmail.com

AARK Stream Restoration, LLC
NAU Capstone

Special Cleaning Conditions

AARK Stream Restoration, LLC

We strive for excellence in every project, small or large, in order to make every stream the best that it can be.

Date:	12/16/2015
Estimate #:	2015-132
Customer ID:	WONAUCAP
Expiration Date	1/16/2016
Sheet #:	5
Subcontractor:	Riley Industrial

To: Cindy Perin
Coyote Springs HOA
Northern Arizona University Capstone
Flagstaff, AZ 86001

CSI / Means	Item	Qty	Unit	Material Unit	Material Total	Labor Unit	Labor Total	Equipment Unit	Equipment Total	Subcontractor Total	Line Total
	Culvert Cleaning										
	Initial Mobilize/Demobilize	1	LS	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,600.00	$ 1,600.00
	Culvert Cleaning	30	Hr	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,220.00	$ 8,220.00
	Per Diem (Motels/Meals)	3	Night	$ -	$ -	$ -	$ -	$ -	$ -	$ 480.00	$ 480.00
Sub Totals					$ -		$ -		$ -	$10,300.00	$ 10,300.00
										Check	10,300.00

Thank you for your business!

1030 San Fransisco, Flagstaff, AZ 86001 (805)450-6980 AARKRestoration@gmail.com

AARK Stream Restoration, LLC
NAU Capstone

Qualifications & Exclusions

AARK Stream Restoration, LLC
We strive for excellence in every project, small or large,
in order to make every stream the best that it can be.

Date: 12/16/2015
Estimate #: 2015-132
Customer ID: WONAUCAP
Expiration Date: 1/16/2016
Sheet #: 6

To: Cindy Perin
Coyote Springs HOA
Northern Arizona University Capstone
Flagstaff, AZ 86001

Qualifications

General:
We assume to work during designated time frame, during normal business hours 8am to 5pm
Our price is void after one month from origination date
The price we have provided is accurate for specified work only
We have included 2 days in our estimate for time lost to weather
Excavation:
Based on Arizona's average work costs
Information from http://www.homewyse.com/services/cost_to_excavate_land.html
Maintenance:
This price is for the initial clean up of the streams channels and banks
Supply cost is for 5, 8 pound bags of native seed
For landscape costs and 2 men working 1, 8 hour day
This price is subject to change with time, for future maintenance by subcontractor
Special Cleaning:
This price is subject to change with time, for future maintenance by subcontractor

Exclusions

General:
We exclude all insurance cost that may come from other parties injuries
We exclude loss of property while working
We exclude lost or stolen tool costs
We exclude all overtime costs
We exclude costs associated with schedule acceleration due to other trades
We exclude the costs of any permits or bonds
We exclude any liabilty of damage or injury caused by all subcontractors work
We exclude all utility related work in the vasinity of the job site
Excavation:
We exclude the accuracy of these prices, prices are subject to change
Maintenance:
We exclude the cost of extra bags of native seed if needed
We exclude the cost of overtime if needed
Special Cleaning:
We exclude overtime costs due to weather delays

Thank you for your business!

1030 San Fransisco, Flagstaff, AZ 86001 (805)450-6980 AARKRestoration@gmail.com

Appendix K: Surveyed Points

Point Number	Northing	Easting	Elevation	Point Name
1	10326.89651	5041.66051	6911.040183	SS1a
2	10330.40964	5038.16474	6911.269877	SS1b
3	10333.31973	5038.290727	6910.984804	2a
4	10318.71352	5013.708568	6908.233109	SS3a
5	10310.6175	5036.13636	6907.771549	SS4a
6	10275.86665	5015.644781	6902.912241	ss5
7	10275.72522	5013.68966	6902.494689	ss6
8	10276.04431	5011.21117	6902.663507	ss7
9	10261.7458	5021.033961	6900.255121	ss8
10	10261.5843	5019.547414	6900.245677	ss8
11	10261.81035	5018.018087	6899.78249	ss9
12	10260.41909	5015.991844	6900.229046	ss10
13	10260.20845	5012.245572	6900.786228	ss11
14	10244.39972	5027.411606	6898.283065	ss12
15	10245.48491	5022.954827	6898.236079	ss13
16	10245.46764	5020.776965	6897.611235	ss14
17	10244.49249	5018.23525	6898.612816	ss15
18	10244.37854	5014.253792	6899.358049	ss16
19	10233.20491	5038.628224	6897.656487	ss17
20	10232.70263	5032.480728	6897.346686	ss18
21	10232.19987	5030.280826	6896.818152	ss18
22	10231.84871	5028.30344	6897.625041	ss19
23	10231.62158	5024.363841	6897.842968	ss20
24	10211.27912	5044.61406	6896.581257	ss21
25	10210.78018	5040.864311	6896.502076	ss21
26	10210.80689	5038.913395	6896.131878	ss22
27	10210.34306	5036.753835	6896.631885	ss23
28	10209.71154	5031.573965	6896.864324	ss24
29	10190.67838	5045.670138	6895.647802	ss25
30	10191.48061	5040.513142	6895.484744	ss26
31	10191.98745	5038.873541	6894.861828	ss27
32	10191.75408	5037.769797	6895.691588	ss28
33	10191.91147	5030.650587	6895.825475	ss29
34	10166.14784	5038.740195	6893.849517	ss30
35	10167.37585	5033.490043	6893.996366	ss31
36	10167.59321	5031.349448	6893.773002	ss32
37	10167.90376	5029.526125	6894.189692	ss33
38	10167.57704	5022.665545	6894.020955	ss34

39	10152.52001	5042.210519	6892.779978	ss35
40	10153.04718	5036.111198	6892.994529	ss36
41	10153.14773	5033.343719	6892.666335	ss37
42	10152.60402	5031.477276	6893.192957	ss38
43	10153.01551	5025.816364	6893.08466	ss39
44	10133.4695	5037.967656	6891.701459	ss40
45	10133.82262	5032.510961	6891.958132	ss41
46	10133.86788	5030.614203	6891.282485	ss42
47	10133.54925	5028.858266	6891.884461	ss43
48	10133.14272	5021.082806	6892.135939	ss44
49	10116.05152	5043.374683	6890.88849	ss45
50	10116.15383	5037.993296	6891.216189	ss46
51	10115.60551	5035.996884	6890.72094	ss47
52	10115.31456	5033.836774	6891.304079	ss48
53	10114.42724	5025.798938	6891.265852	ss49
54	10107.14916	5048.338582	6890.387924	ss50
55	10106.11379	5044.041039	6890.813046	ss51
56	10106.12032	5042.658137	6890.343371	ss52
57	10105.48891	5041.213864	6891.093876	ss53
58	10104.97358	5027.922511	6890.926207	ss54
59	10100.62055	5047.389908	6890.23367	ss55
60	10098.4736	5043.307531	6890.509758	ss56
61	10097.97168	5041.948496	6890.084384	ss57
62	10097.48934	5040.577262	6890.622604	ss58
63	10096.78659	5033.852688	6890.580643	ss59
64	10096.10639	5062.04284	6889.707626	ss60
65	10091.47166	5058.037839	6889.568748	ss61
66	10090.39807	5057.094469	6889.158348	ss62
67	10088.9155	5055.568375	6889.75102	ss63
68	10085.05553	5047.987808	6889.580517	ss64
69	10039.71823	5082.978816	6886.485797	ss65
70	10038.74916	5074.298625	6886.950515	ss66
71	10037.98166	5072.770098	6886.482599	ss67
72	10037.18106	5070.664071	6886.991944	ss68
73	10034.34091	5065.899262	6886.710701	ss69
74	10031.76893	5084.44621	6886.193245	ss70
75	10025.86205	5073.97955	6885.978724	ss71
76	10024.33921	5072.867709	6885.414598	ss72
77	10023.44696	5071.504389	6886.009526	ss73
78	10018.9868	5065.020316	6885.932737	ss74
79	10015.85682	5097.750085	6885.251953	ss75

80	10009.81006	5090.444594	6884.786468	ss76
81	10008.90057	5089.594163	6884.528234	ss77
82	10007.46986	5087.341629	6885.086595	ss78
83	10006.43189	5080.22194	6885.453628	ss79
84	9997.885492	5116.104824	6883.662813	ss80
85	9993.726726	5113.805934	6883.512141	ss801
86	9991.76814	5112.779876	6883.325788	ss82
87	9989.094689	5110.657793	6883.804831	ss83
88	9984.497725	5106.275771	6883.979675	ss84
89	9970.738321	5097.587984	6887.428564	ss85
90	9968.979178	5158.848769	6880.878877	ss86
91	9963.659031	5156.23883	6880.900704	ss87
92	9961.192815	5155.083576	6880.490705	ss87
93	9957.490756	5153.330165	6881.424151	ss88
94	9954.581094	5151.275049	6883.204545	ss89
95	9947.353439	5147.477587	6885.141131	ss90
96	9937.241702	5142.608094	6885.197294	ss91
97	9943.179999	5219.032211	6878.46902	ss92
98	9939.483428	5216.208101	6878.317307	ss93
99	9936.74228	5215.392108	6877.904721	ss94
100	9934.285367	5215.206792	6878.242067	ss94
101	9931.145627	5214.154525	6878.26377	ss95
102	9926.755149	5212.168218	6881.411986	ss96
103	9919.089408	5207.239551	6882.380134	ss97
104	9908.905454	5202.096982	6882.465064	ss98
105	9914.914456	5278.381618	6876.684636	ss99
106	9911.139224	5275.619661	6876.527239	ss100
107	9908.527321	5273.991755	6875.420591	ss101
108	9907.267782	5273.531285	6875.312857	ss102
109	9905.284069	5272.524403	6875.866805	ss103
110	9901.661404	5270.340968	6878.478666	ss104
111	9895.180542	5267.691085	6879.683087	ss105
112	9877.594951	5260.612816	6879.278649	ss106
113	9905.327865	5277.160614	6875.18399	cu1in
114	9863.317715	5363.047782	6871.861846	cu1out
115	9864.039885	5370.998444	6873.747615	ss107
116	9862.141403	5369.681087	6872.448465	ss108
117	9861.169191	5369.088511	6872.353356	ss109
118	9853.786641	5364.374411	6873.23456	ss110
119	9851.135642	5362.816831	6873.909394	ss111
120	9838.751035	5357.248902	6874.515877	ss112

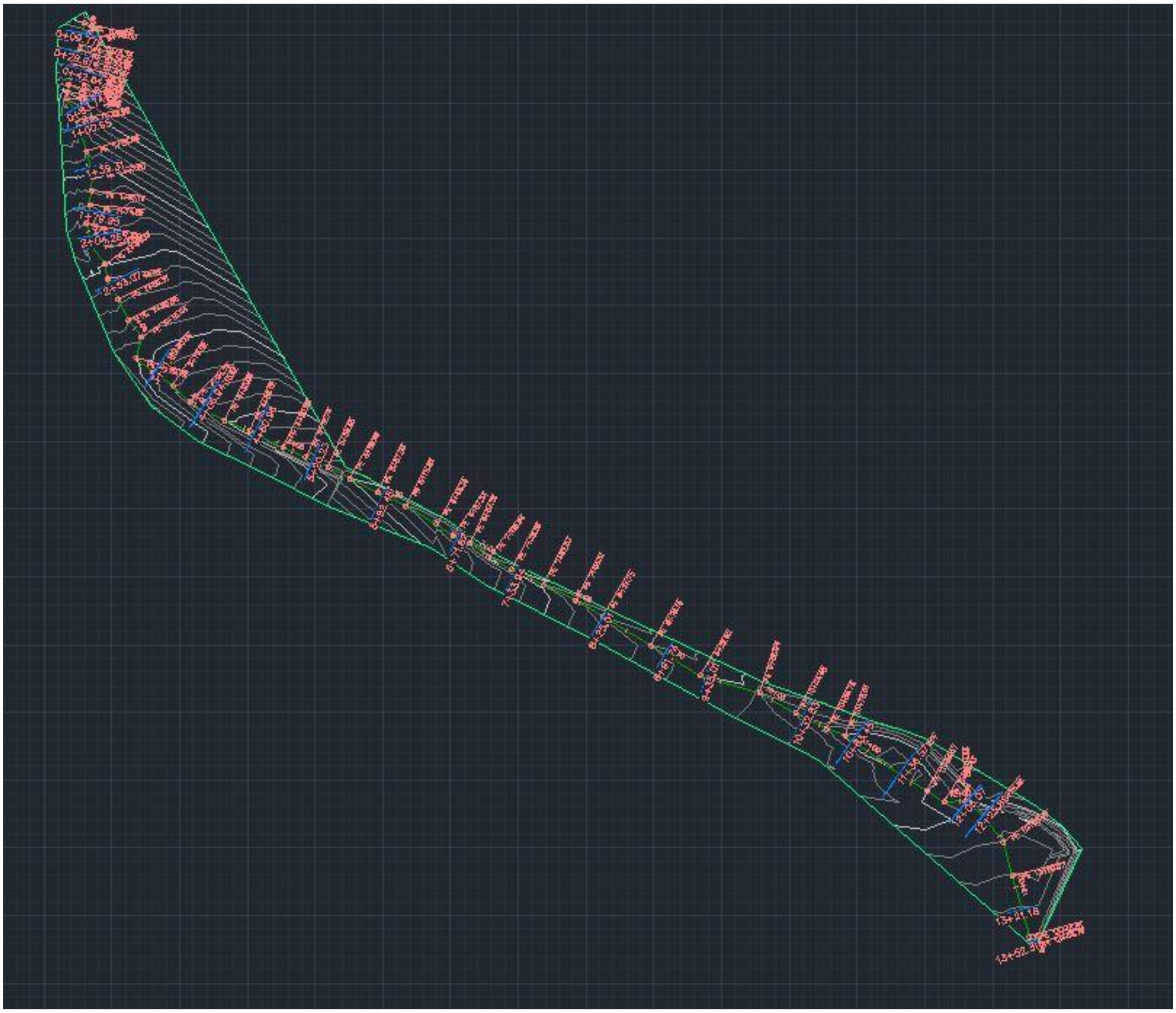
121	9830.30066	5422.260292	6871.652075	ss113
122	9827.651376	5420.112486	6871.361412	ss114
123	9826.047853	5419.253813	6870.622517	ss115
124	9825.212514	5419.014035	6870.402641	ss116
125	9824.458233	5418.257051	6869.53287	ss117
126	9823.121261	5417.549487	6871.015085	ss118
127	9819.918034	5416.059121	6872.236093	ss119
128	9805.935162	5406.865873	6872.381045	ss120
129	9783.0387	5519.3188	6867.964863	ss121
130	9780.5258	5517.0078	6867.964212	ss122
131	9778.3908	5515.8428	6867.140649	ss123
132	9775.6946	5515.4304	6866.965638	ss124
133	9775.5258	5515.0017	6867.280151	ss125
134	9769.0104	5511.6457	6868.016316	ss126
135	9754.2245	5505.4009	6868.034364	ss127
136	9715.9495	5662.7442	6864.702834	ss128
137	9712.3959	5659.9788	6864.599315	ss129
138	9706.9653	5657.7806	6863.074525	ss130
139	9706.1292	5656.8559	6864.719332	ss131
140	9693.9842	5650.4507	6863.996917	ss132
141	9679.6824	5642.9923	6863.869077	ss133
142	9680.7857	5722.4418	6862.750959	ss134
143	9672.7895	5718.5252	6861.242149	ss135
144	9670.2564	5717.9689	6860.762201	ss136
145	9668.7374	5717.4436	6861.654868	ss137
146	9661.8777	5714.1547	6862.55165	ss138
147	9647.5889	5706.2792	6862.578666	ss139
148	9678.249	5734.2443	6862.496655	ss140
149	9672.1227	5731.2141	6860.29615	ss141
150	9664.6913	5726.7797	6861.206213	ss142
151	9655.8936	5721.7309	6862.172759	ss143
152	9642.6159	5715.5633	6862.236378	ss144
153	9678.6271	5767.5037	6863.435931	ss145
154	9666.6854	5766.2092	6859.834906	ss146
155	9650.5641	5759.0791	6859.217996	ss147
156	9643.684	5754.7974	6861.244188	ss148
157	9639.4417	5752.302	6861.234942	ss149
158	9631.3878	5746.6558	6861.162844	ss150
159	9669.9932	5793.4947	6862.70596	ss151
160	9660.3275	5785.0815	6859.10276	ss152
161	9639.8848	5780.0756	6858.712679	ss153

162	9636.5755	5777.4122	6860.698876	ss154
163	9629.7593	5773.3335	6860.841645	ss155
164	9620.9509	5767.9826	6861.000728	ss156
165	9662.4145	5815.0841	6863.067029	ss157
166	9649.6551	5814.1944	6860.24367	ss158
167	9644.561	5812.1416	6859.237234	ss159
168	9632.0133	5806.5799	6861.233447	ss160
169	9619.8244	5798.4244	6860.951072	ss161
170	9603.5039	5790.2434	6860.969301	ss162
171	9645.7889	5816.6291	6858.399992	cu2in
172	9605.8338	5849.8579	6858.063228	cu2out
173	9609.8888	5863.7464	6861.126009	ss163
174	9604.7639	5861.0064	6860.1652	ss164
175	9603.0571	5860.1923	6858.857544	ss165
176	9601.1956	5859.5243	6857.75429	ss166
177	9598.8537	5858.5277	6858.85486	ss167
178	9597.5436	5857.5438	6859.742529	ss168
179	9585.3174	5849.3815	6859.738993	ss169
180	9605.2344	5890.5816	6860.715824	ss170
181	9599.5322	5888.9964	6858.253608	ss171
182	9593.4289	5886.5334	6859.911393	ss172
183	9581.0231	5878.8693	6859.063064	ss173
184	9572.8111	5874.132	6859.171508	ss174
185	9601.2059	5915.9914	6860.815572	ss175
186	9596.0571	5914.6226	6860.5883	ss176
187	9592.6527	5912.6839	6857.924386	ss177
188	9590.1039	5911.8638	6857.40807	ss178
189	9586.7243	5909.6815	6860.062577	ss179
190	9571.0053	5901.0428	6858.813324	ss180
191	9562.7677	5895.7363	6858.817935	ss181
192	9582.5085	5939.4149	6860.390873	ss182
193	9577.5728	5935.9598	6857.447435	ss183
194	9574.7538	5934.1902	6856.926449	ss184
195	9572.0162	5931.3601	6859.748133	ss185
196	9560.4195	5924.0571	6858.754112	ss186
197	9552.1191	5918.5391	6858.710885	ss187
198	9561.238	5957.283	6860.660172	ss188
199	9560.8731	5953.5765	6860.173364	ss189
200	9561.2355	5948.2849	6856.575138	ss190
201	9560.843	5946.4116	6856.460902	ss191
202	9560.6245	5940.5099	6859.41833	ss192

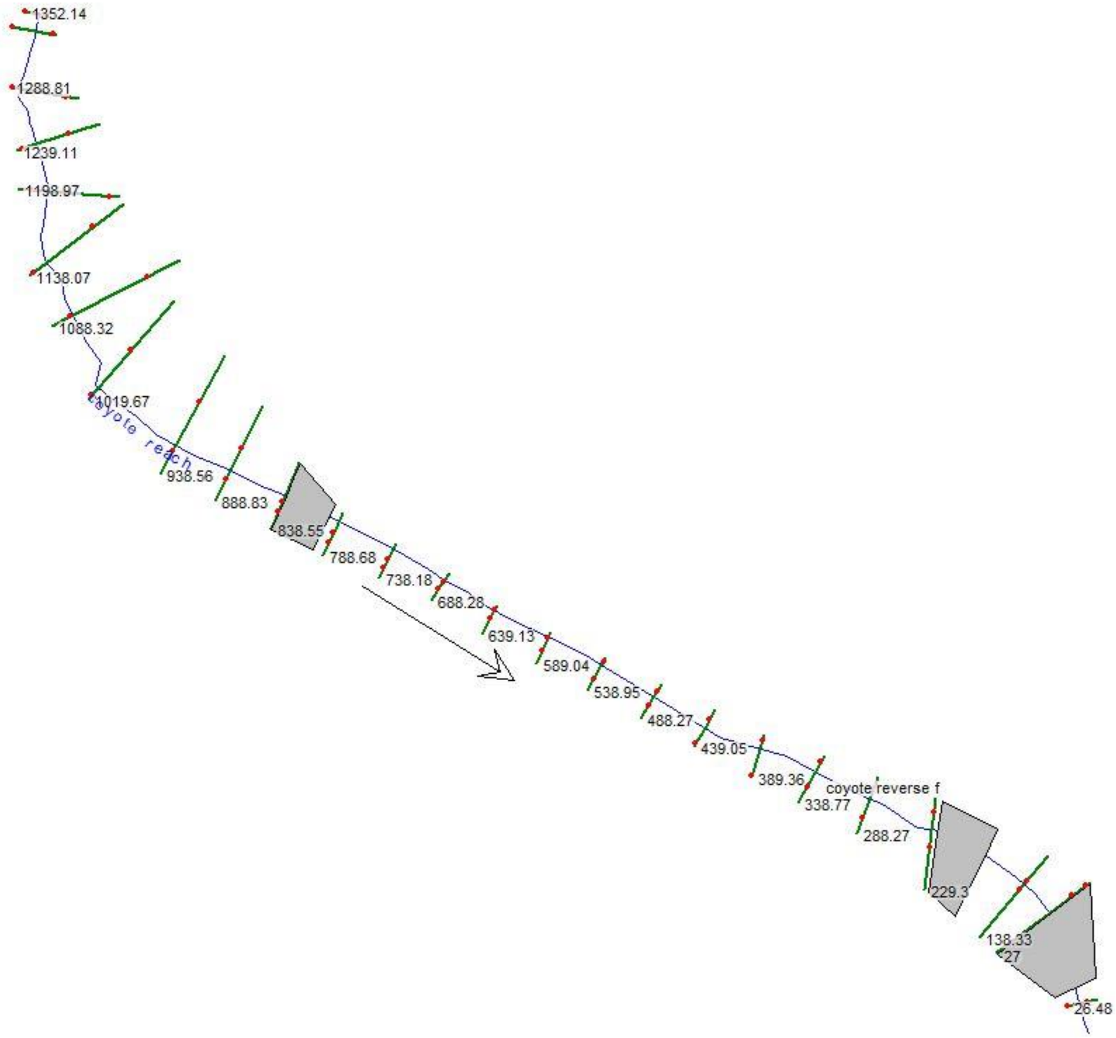
203	9553.8732	5948.0704	6855.849072	cu3in
204	9469.9055	5914.0957	6855.705155	cu3out
bs	10000	5000	6890	bs
bs2	9719.918	5316.059	6872.236	ba
oc	10000	5010	6890	occupied
oc2	9774.419	5467.6482	6869	occupied

Table) Raw Survey Data Points

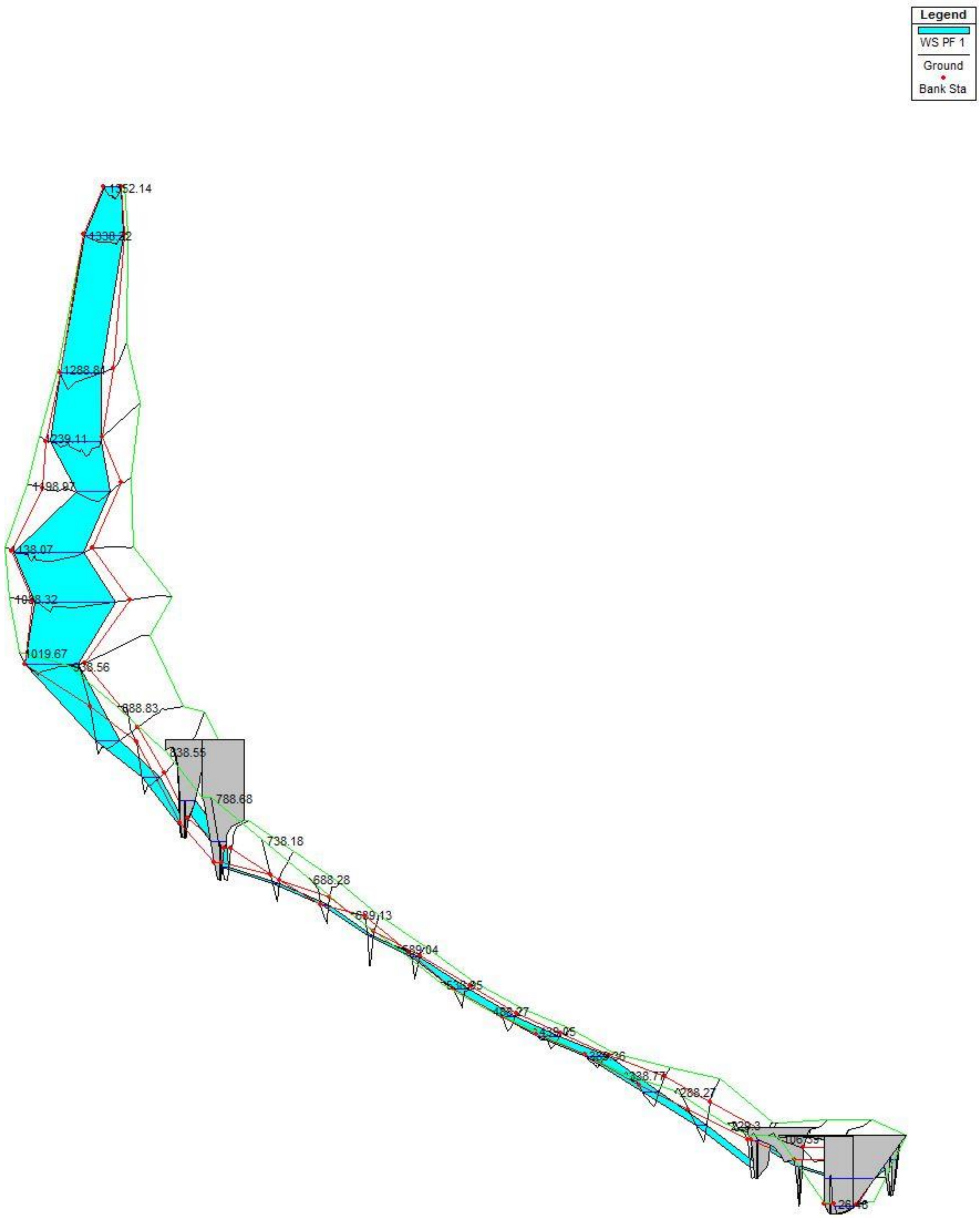
Appendix L: Surveyed Points in AutoCAD with Cross Sections



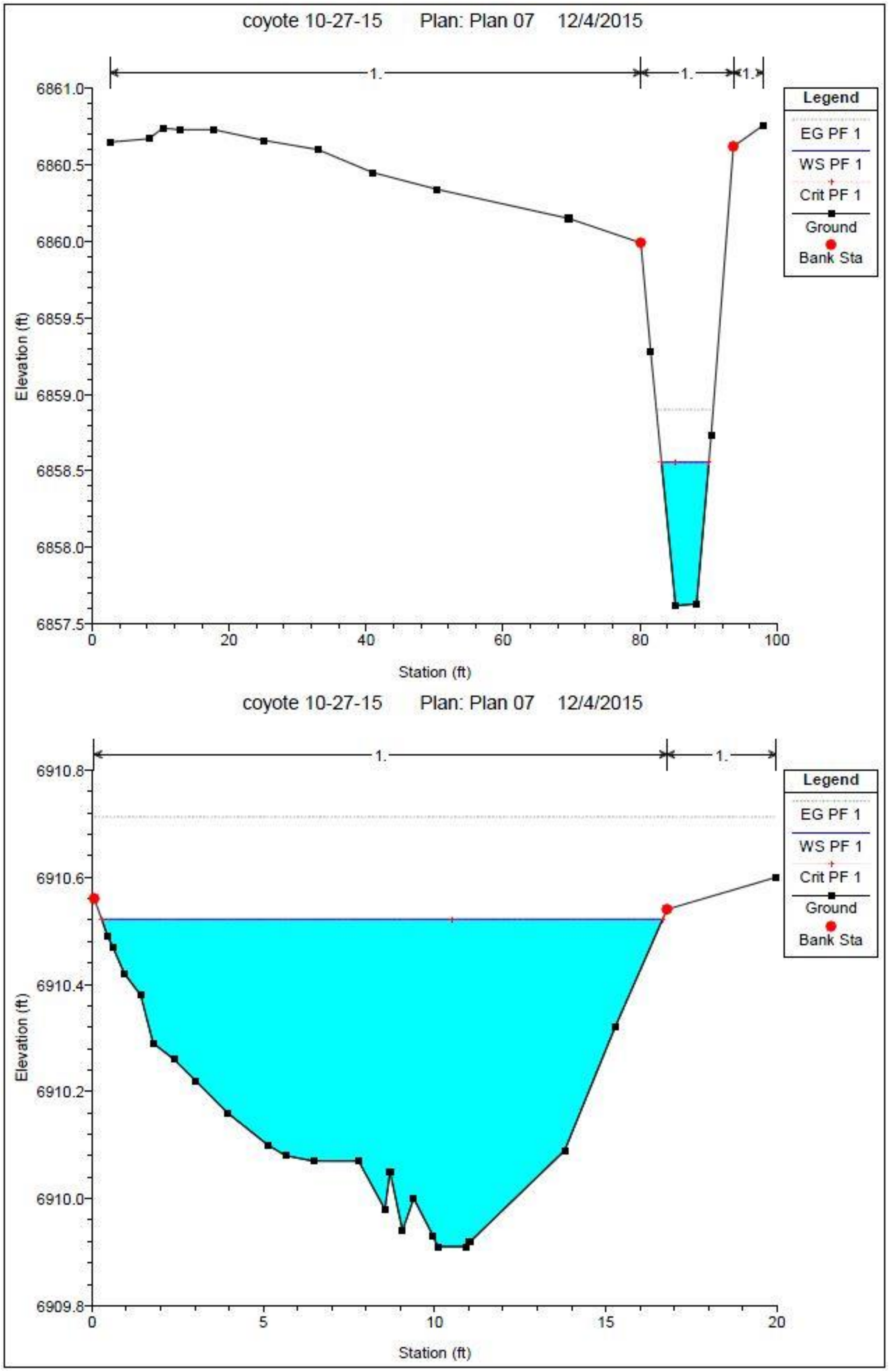
Appendix M: Existing HEC-RAS Model



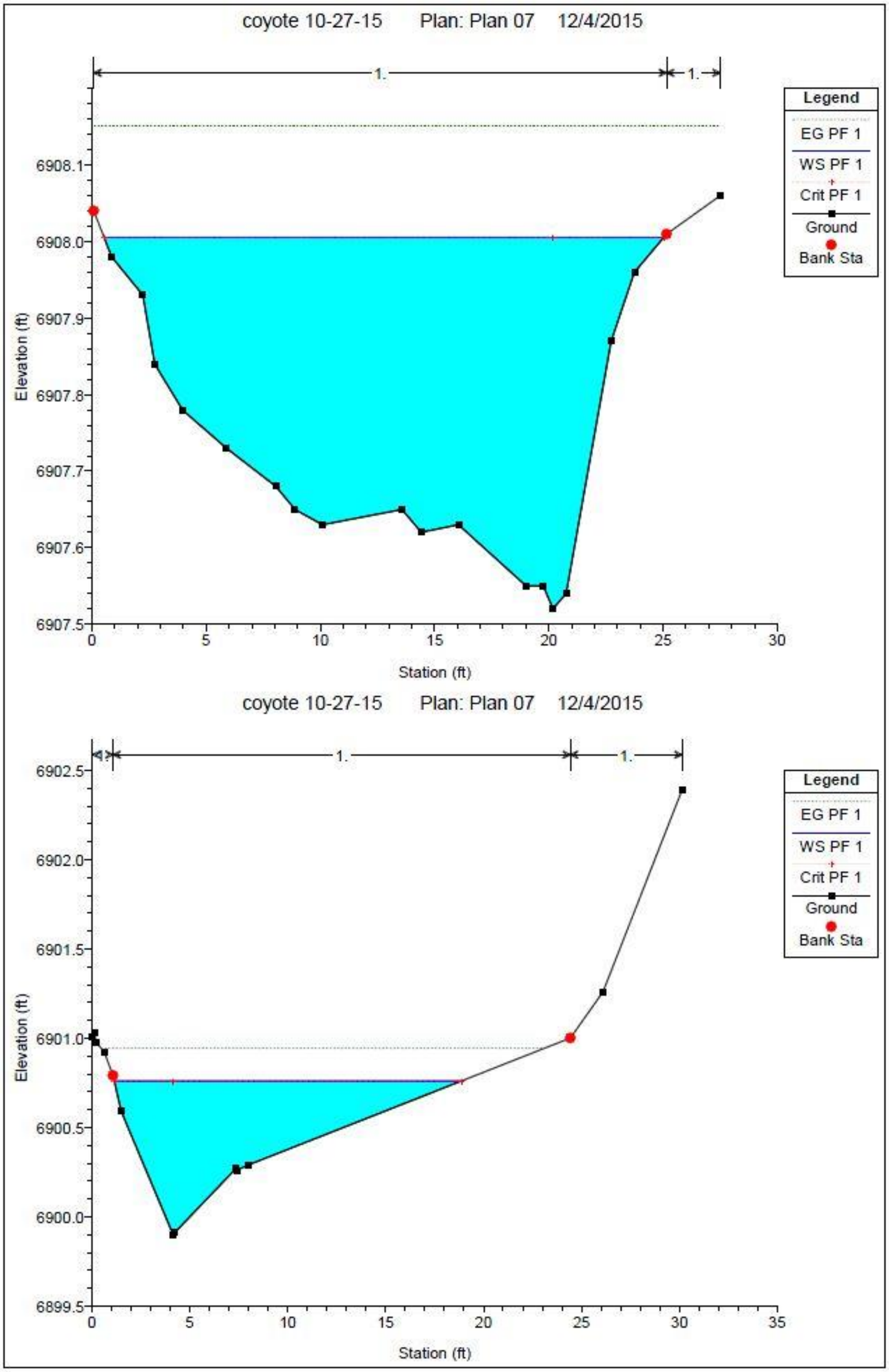
Cross Sections in HEC-RAS Model



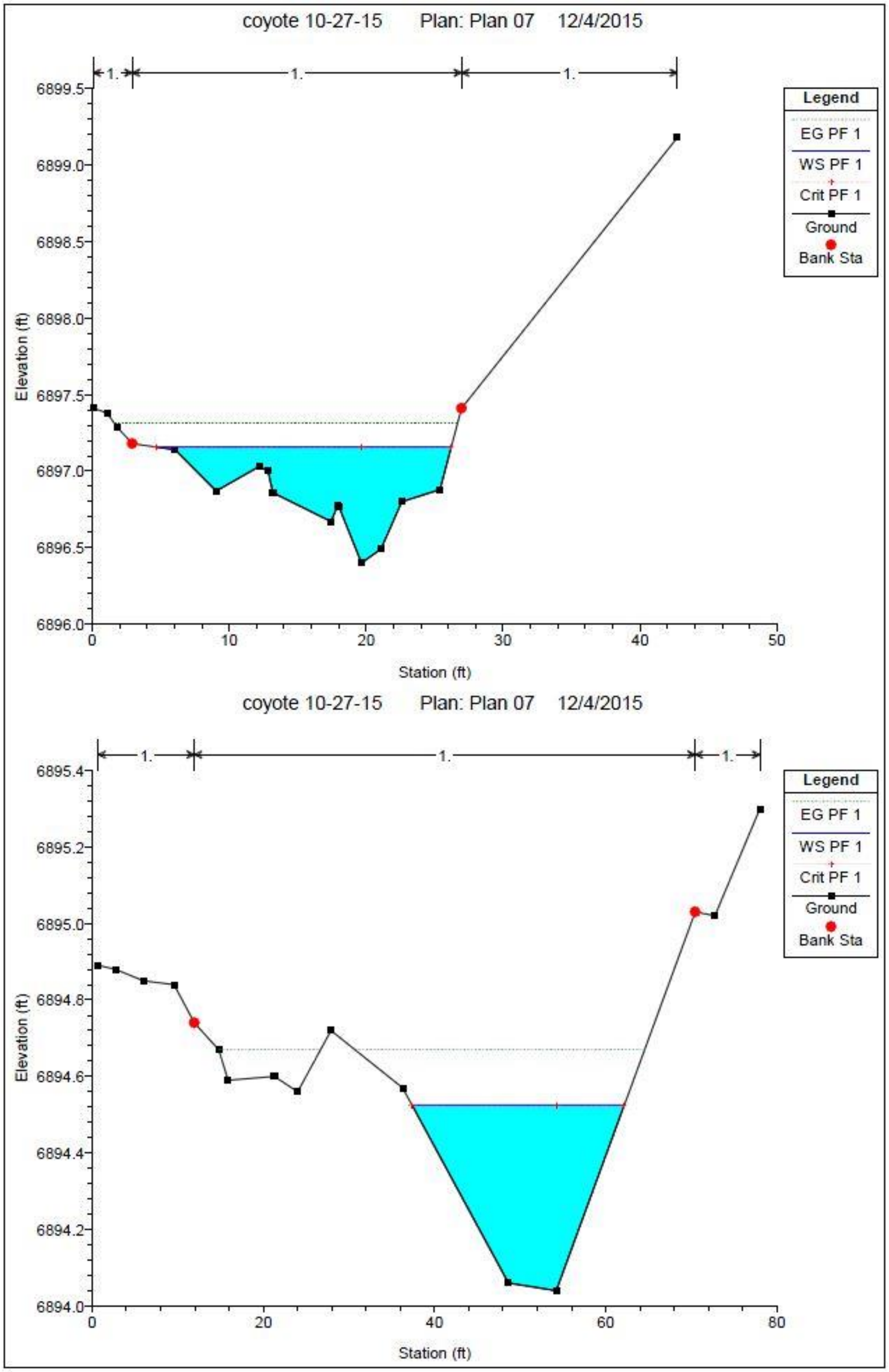
Existing Stream Prospective Plot



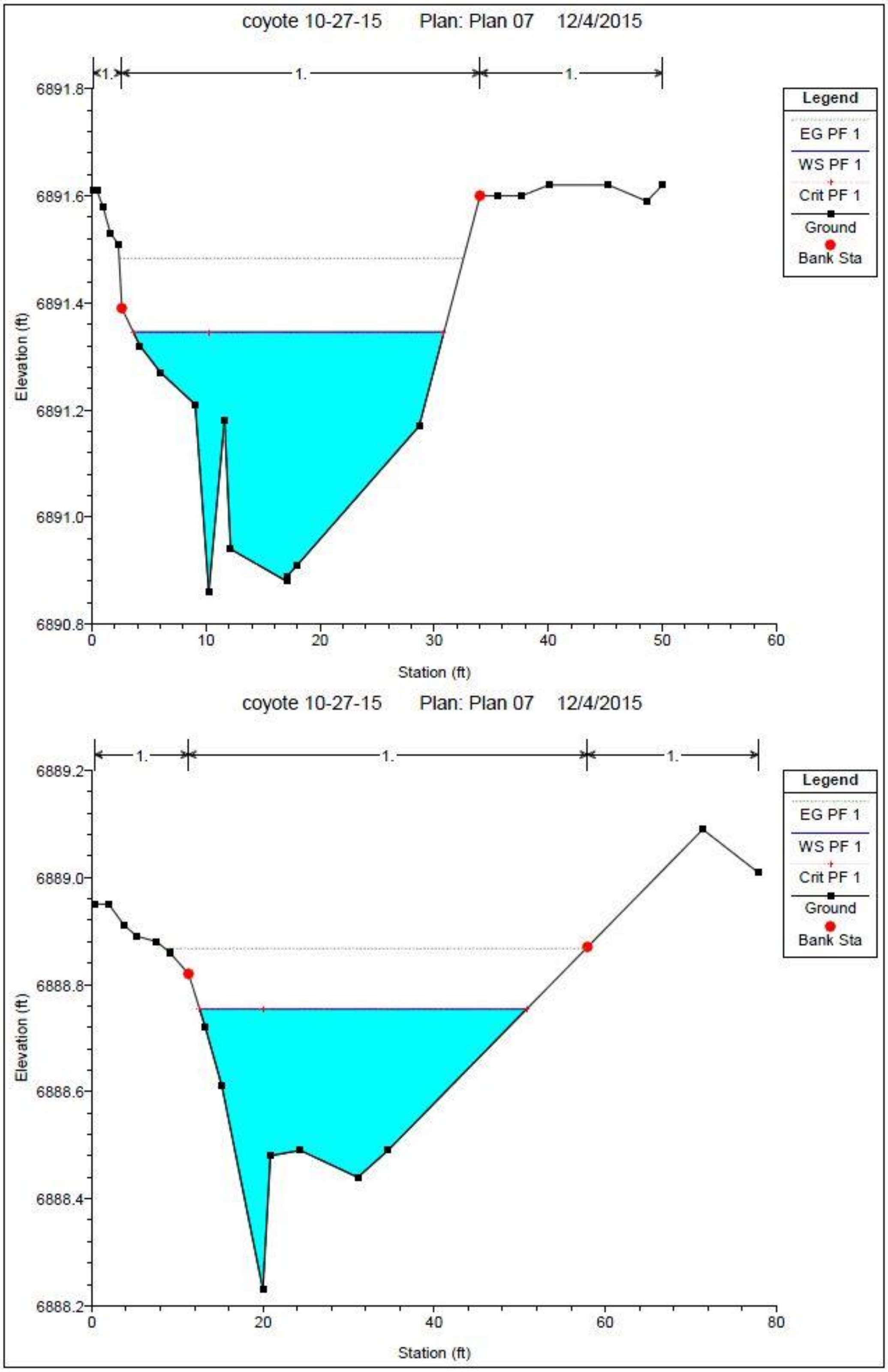
Existing Stream Cross Sections With 25 Year Flow



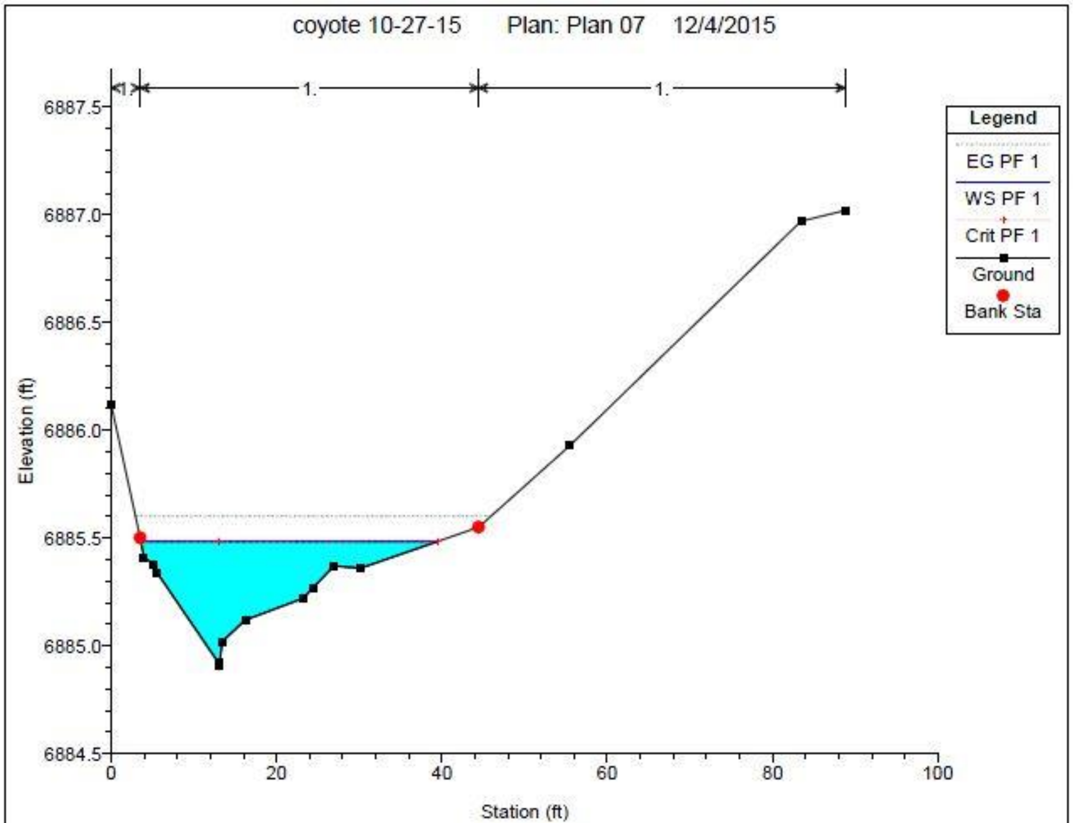
Existing Stream Cross Sections With 25 Year Flow

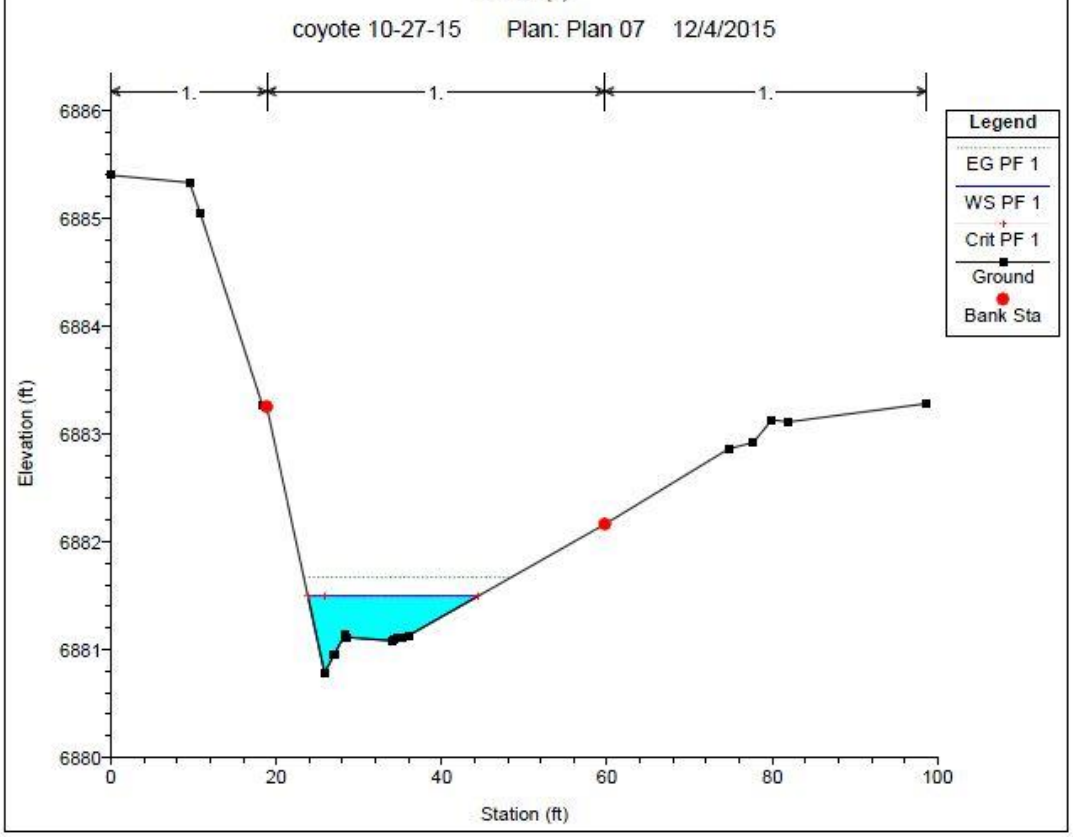


Existing Stream Cross Sections With 25 Year Flow

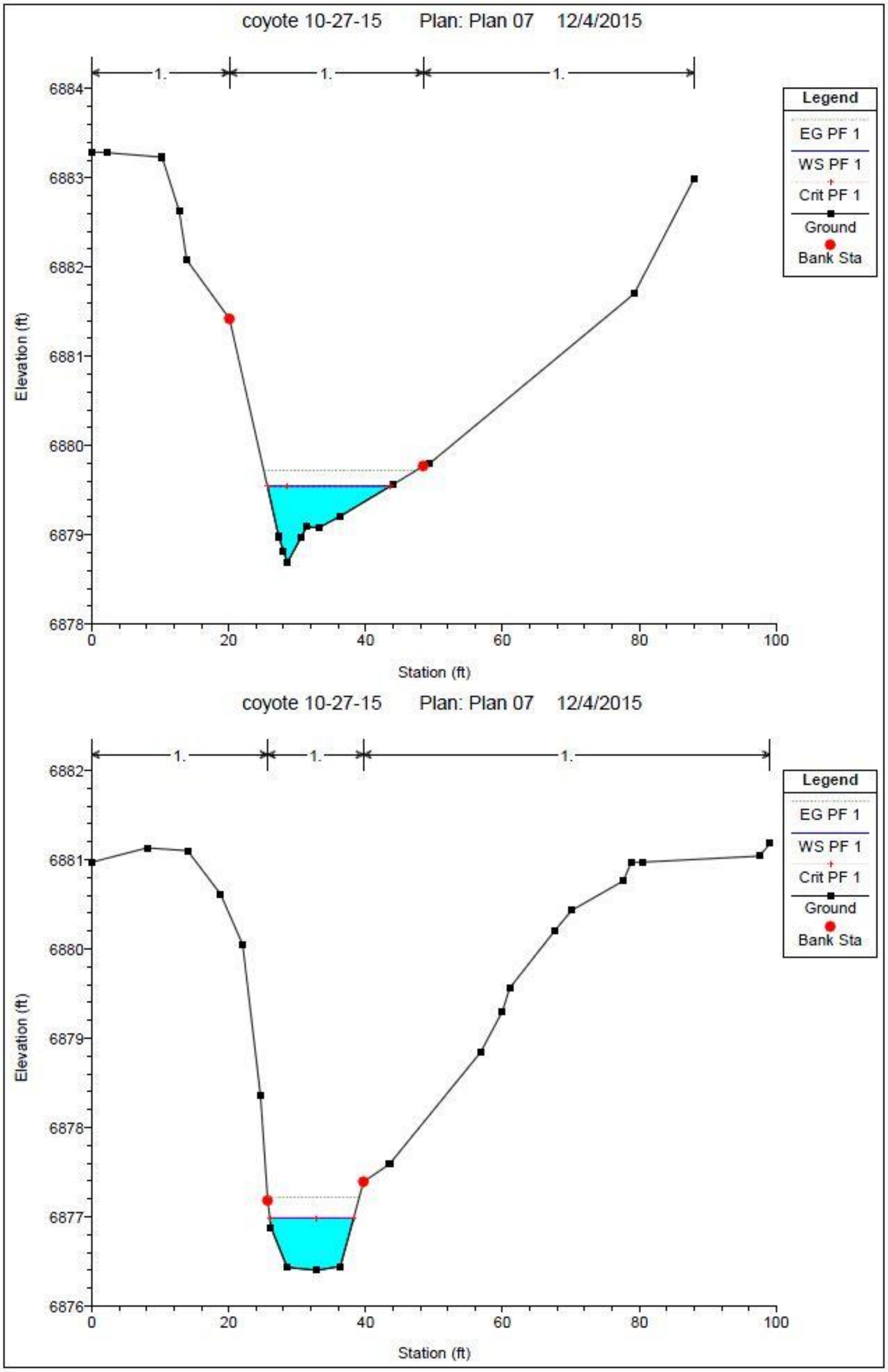


Existing Stream Cross Sections With 25 Year Flow

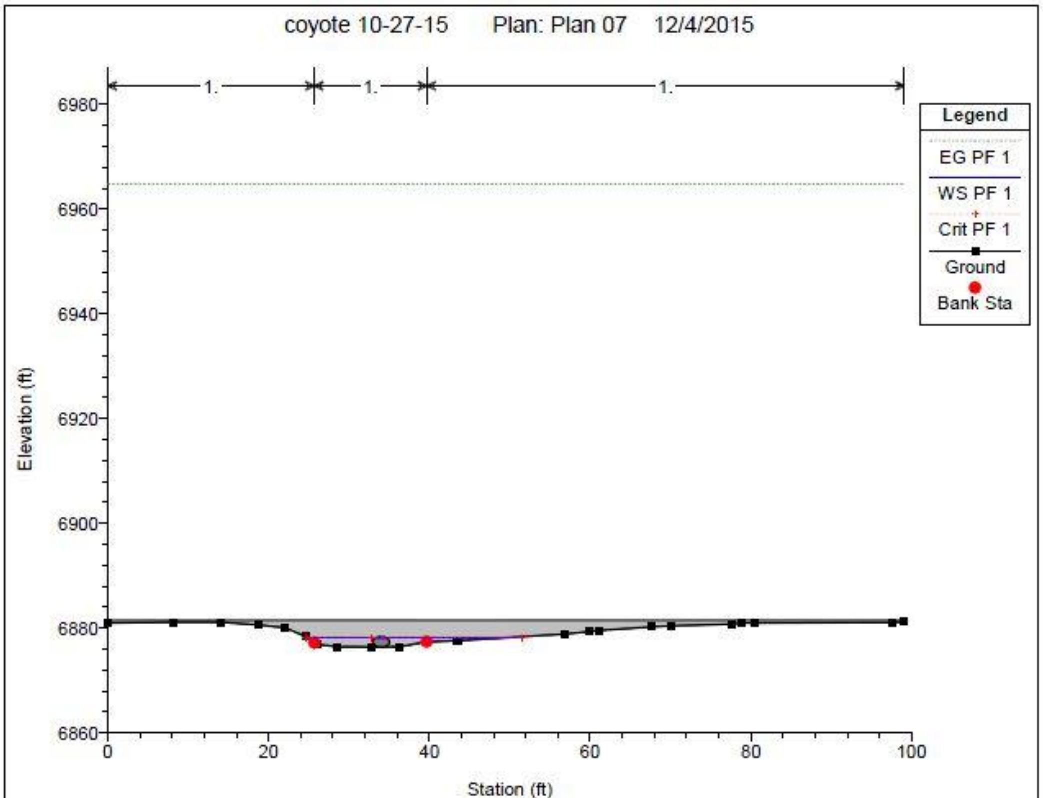


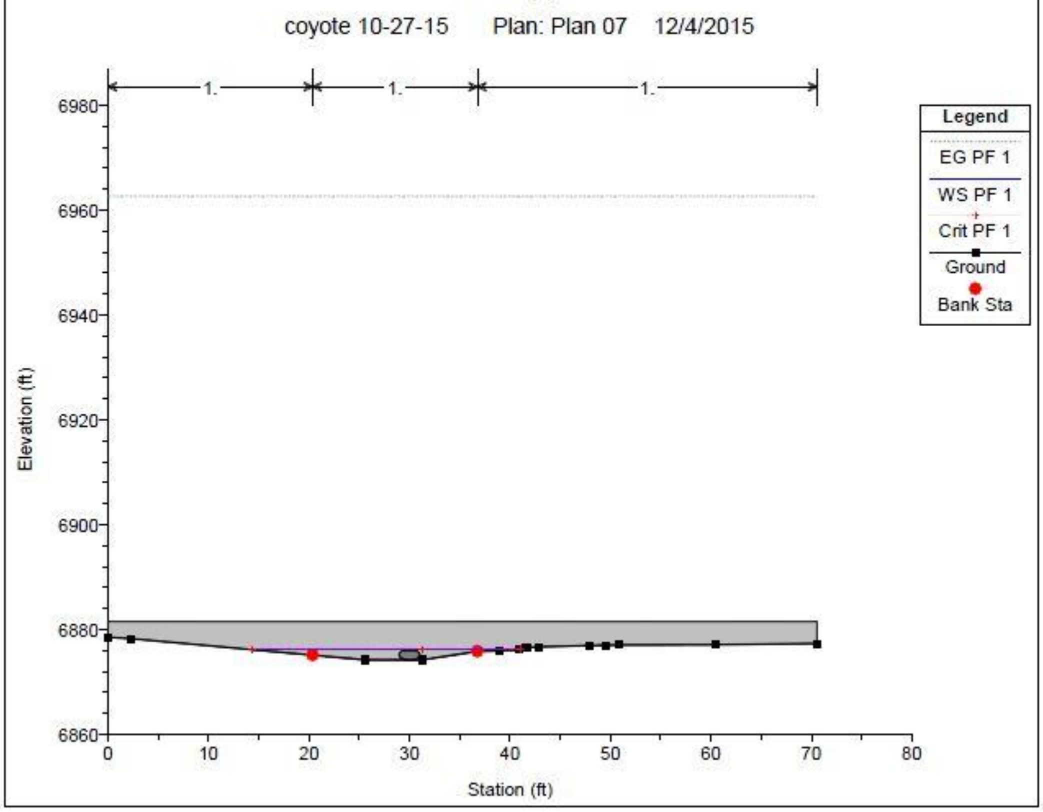


Existing Stream Cross Sections With 25 Year Flow

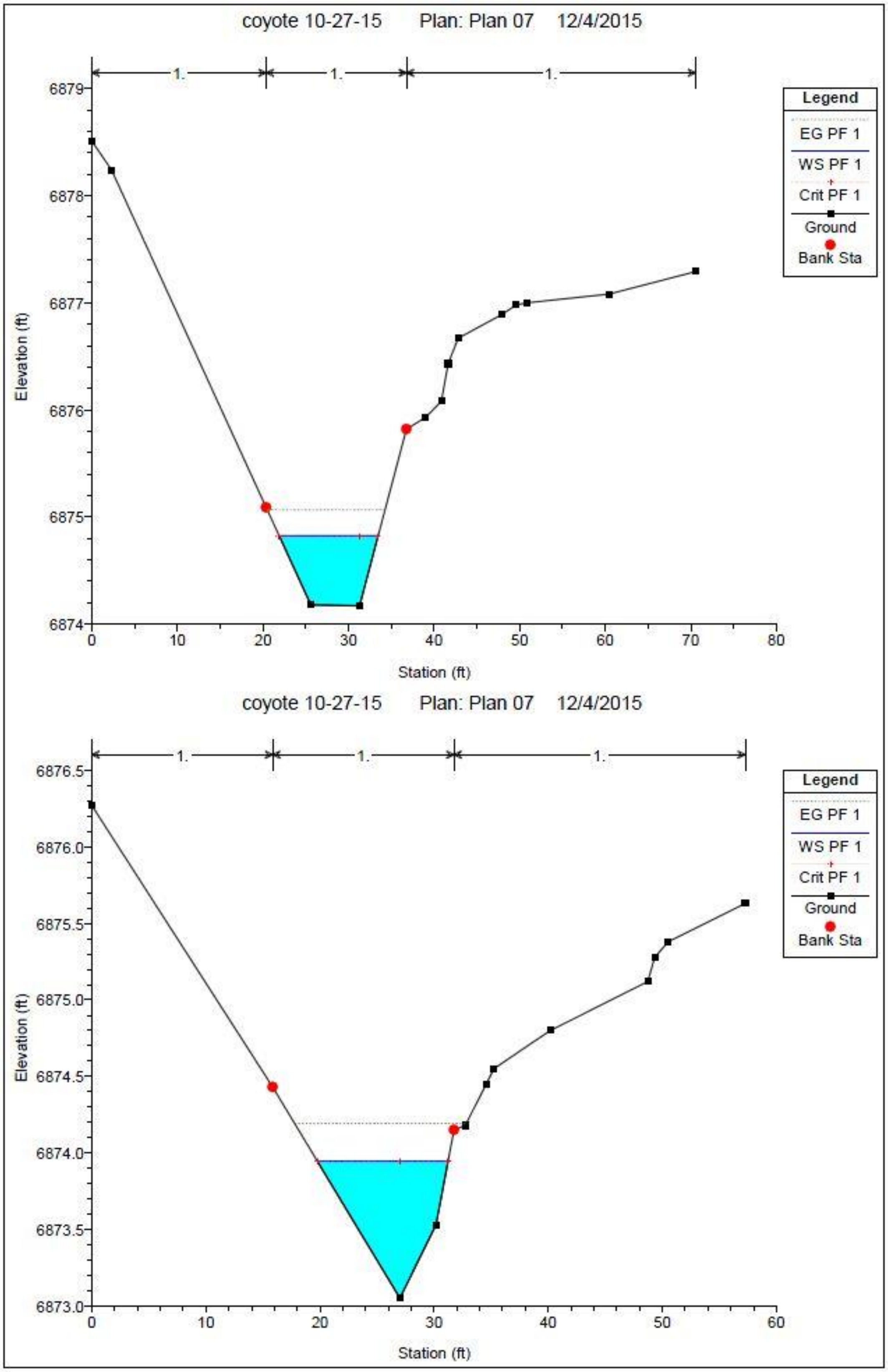


Existing Stream Cross Sections With 25 Year Flow

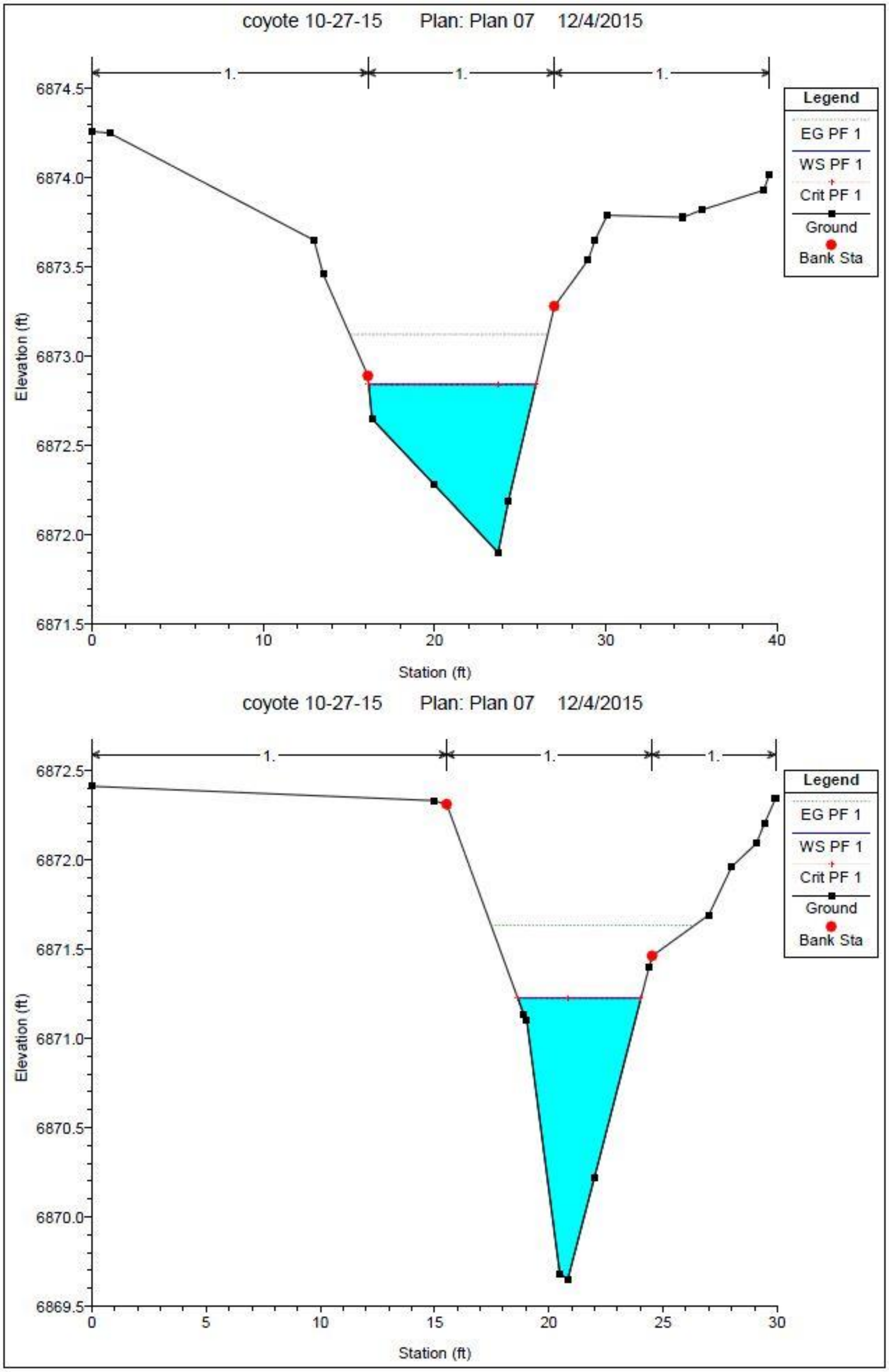




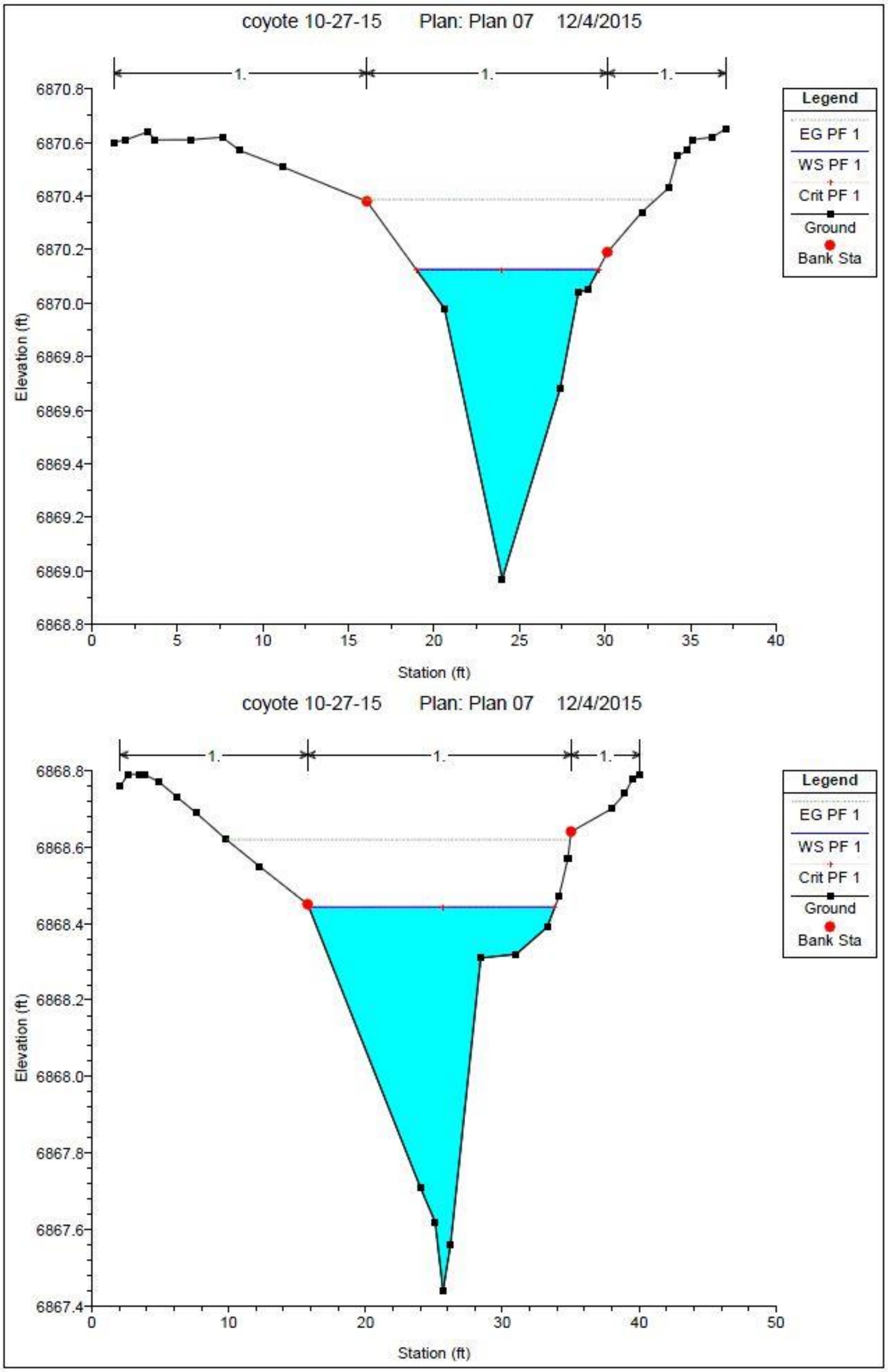
Existing Stream Cross Sections With 25 Year Flow



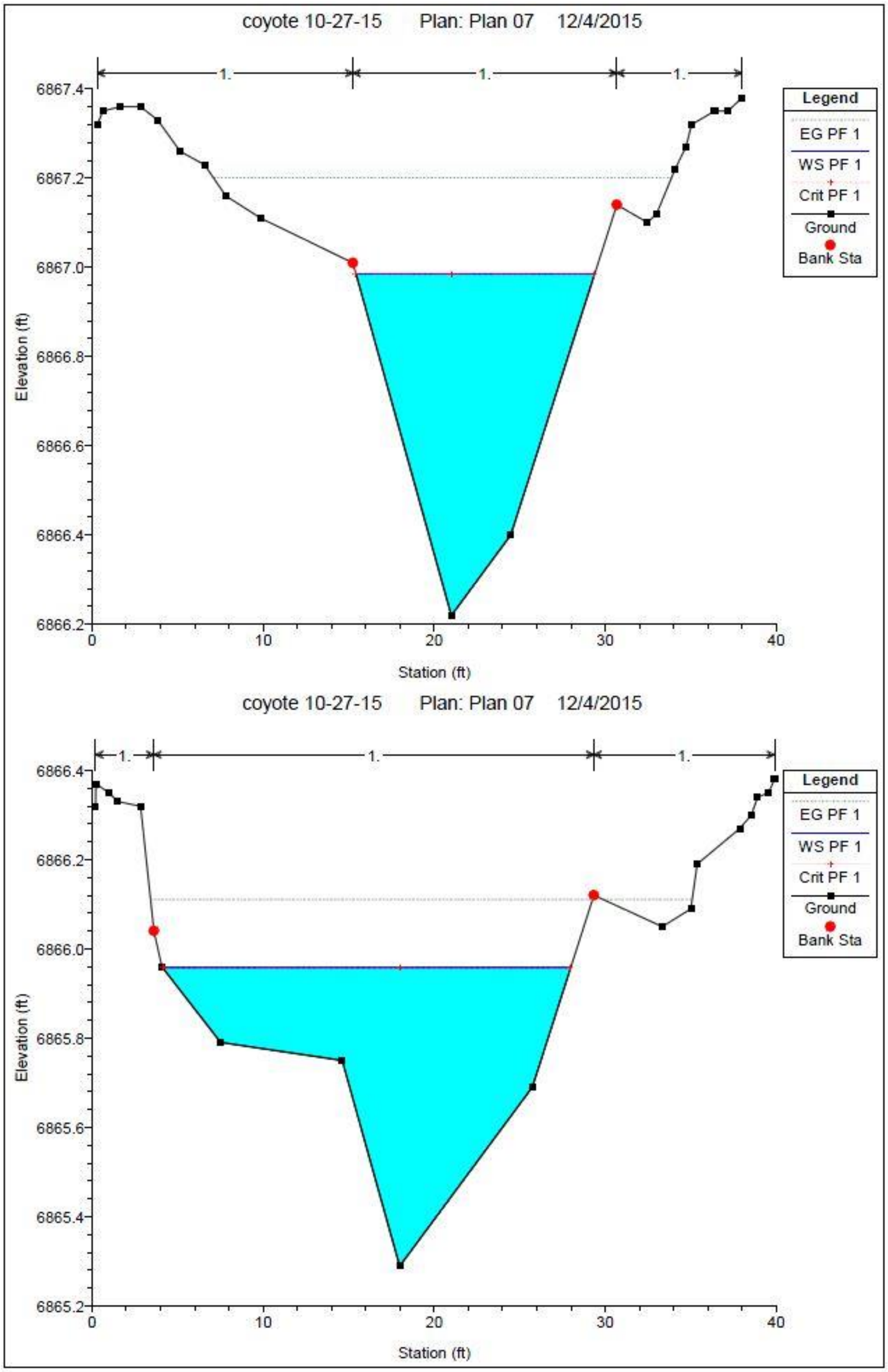
Existing Stream Cross Sections With 25 Year Flow



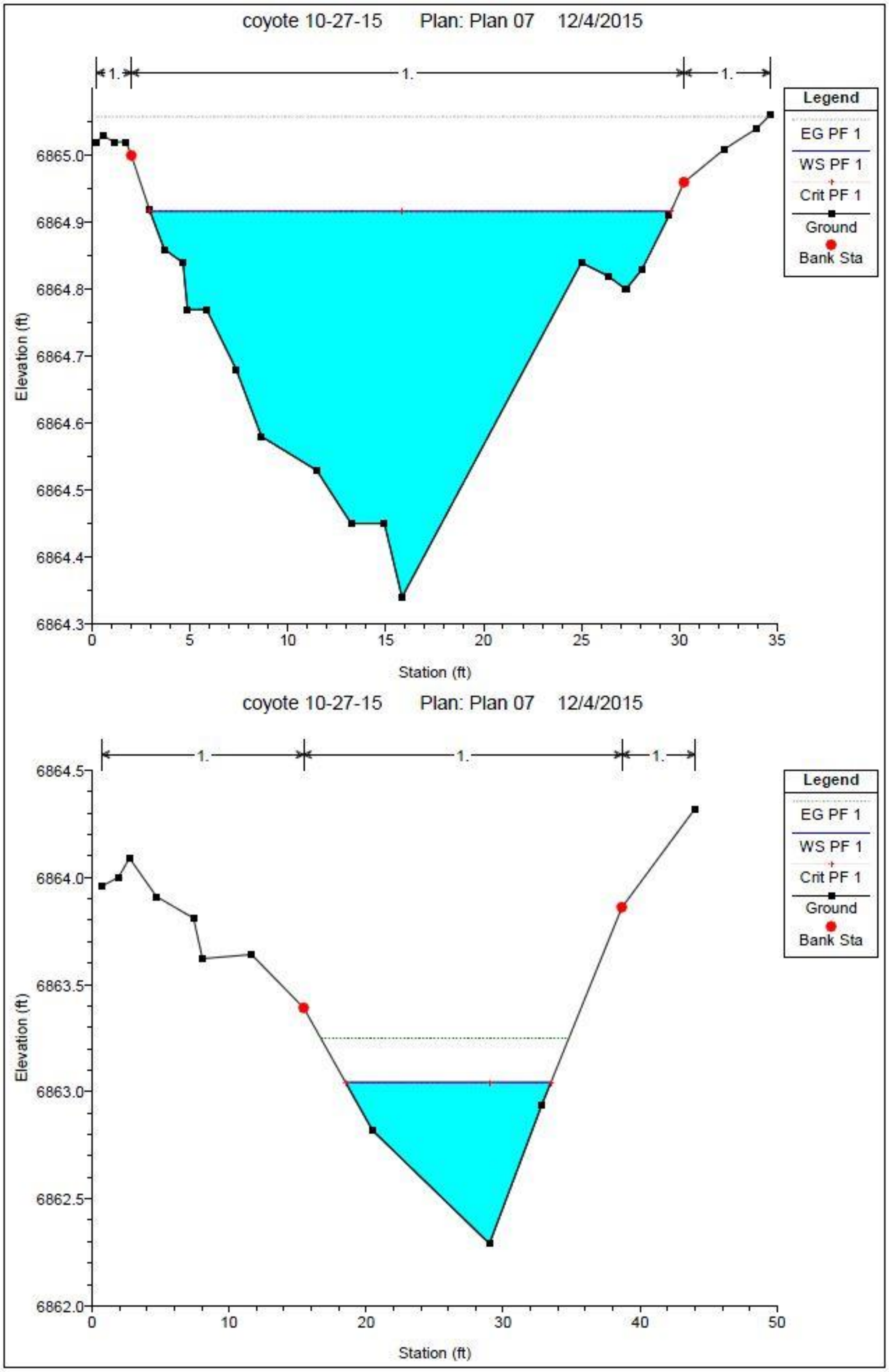
Existing Stream Cross Sections With 25 Year Flow



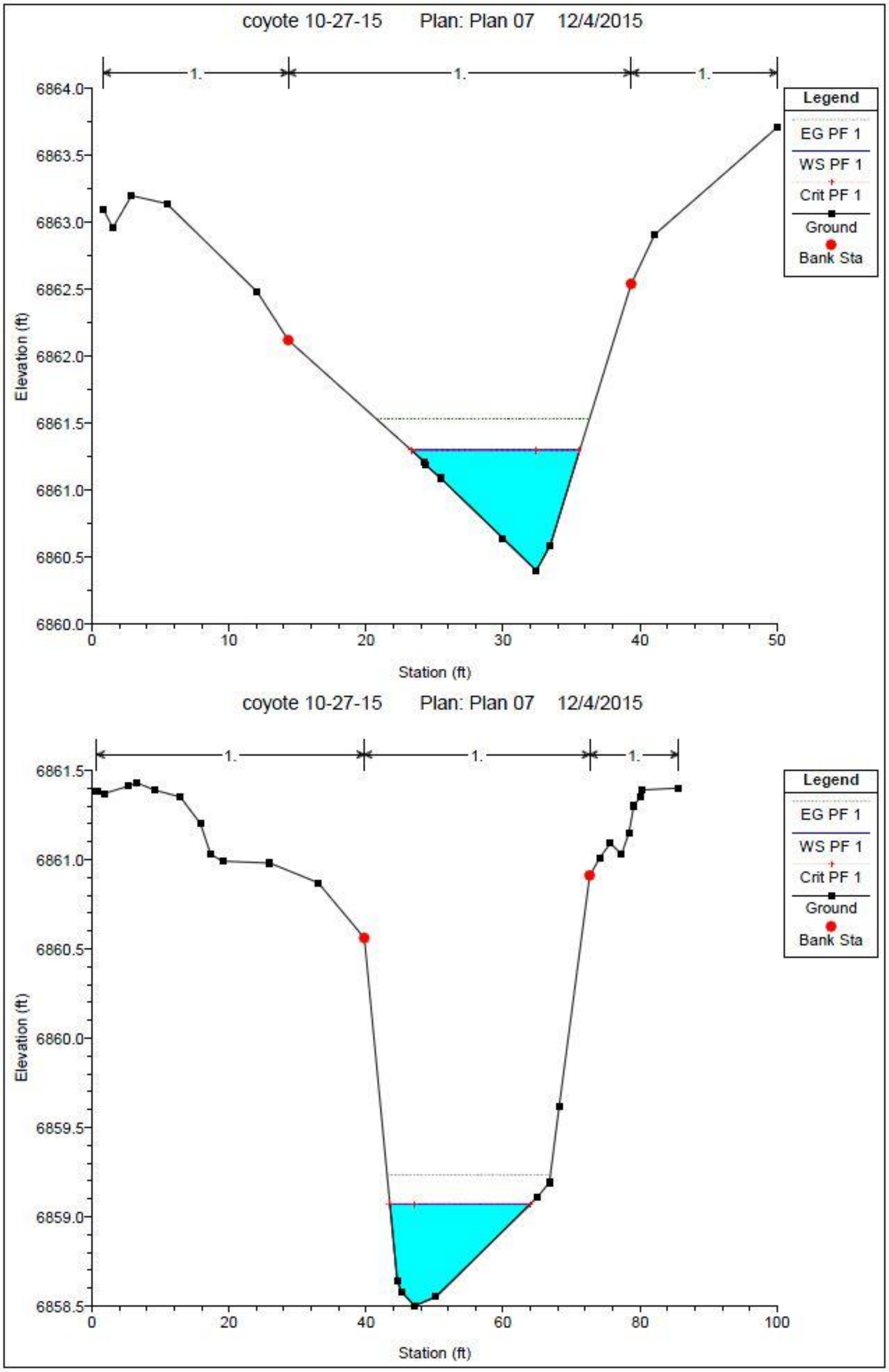
Existing Stream Cross Sections With 25 Year Flow



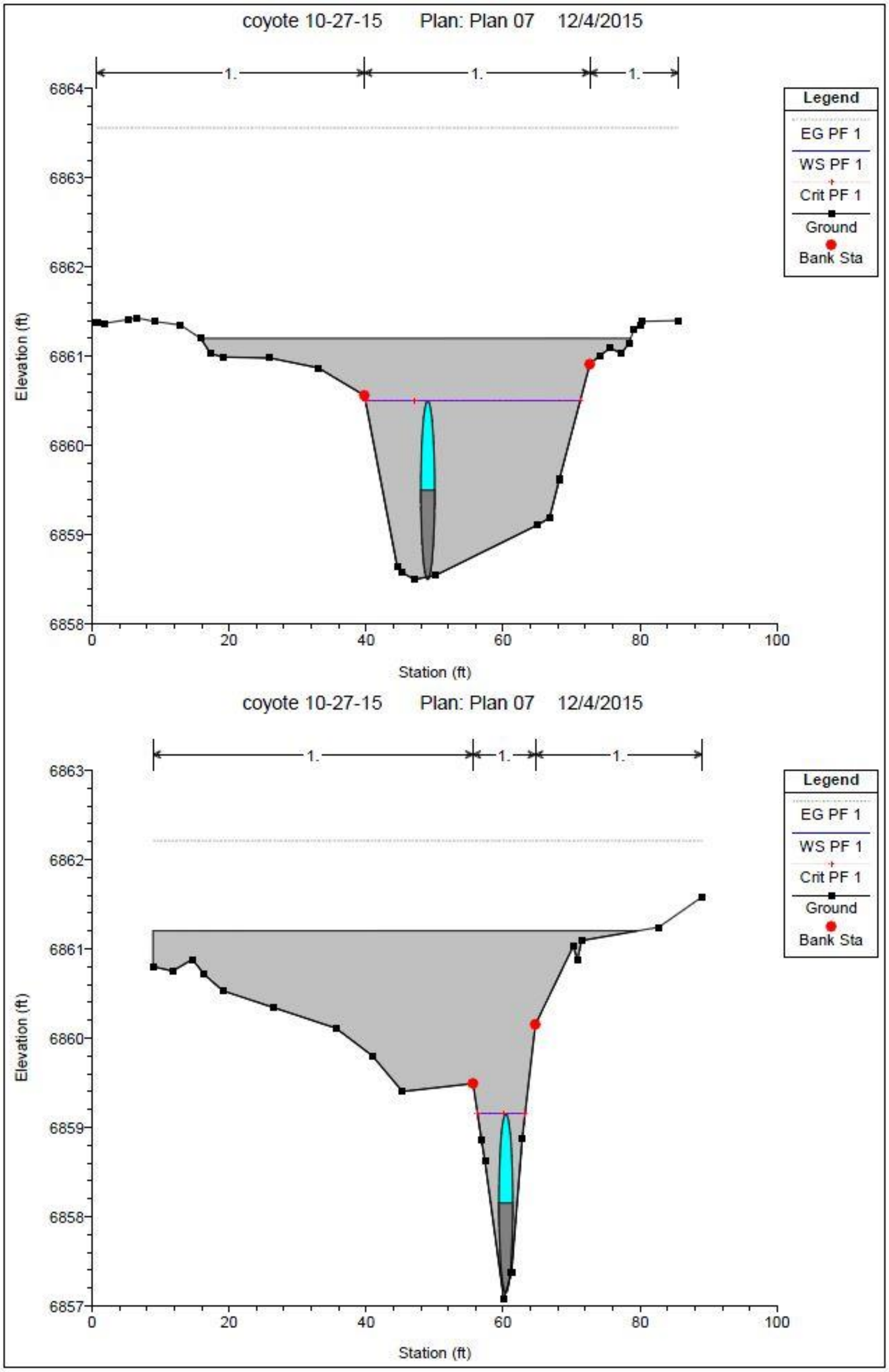
Existing Stream Cross Sections With 25 Year Flow



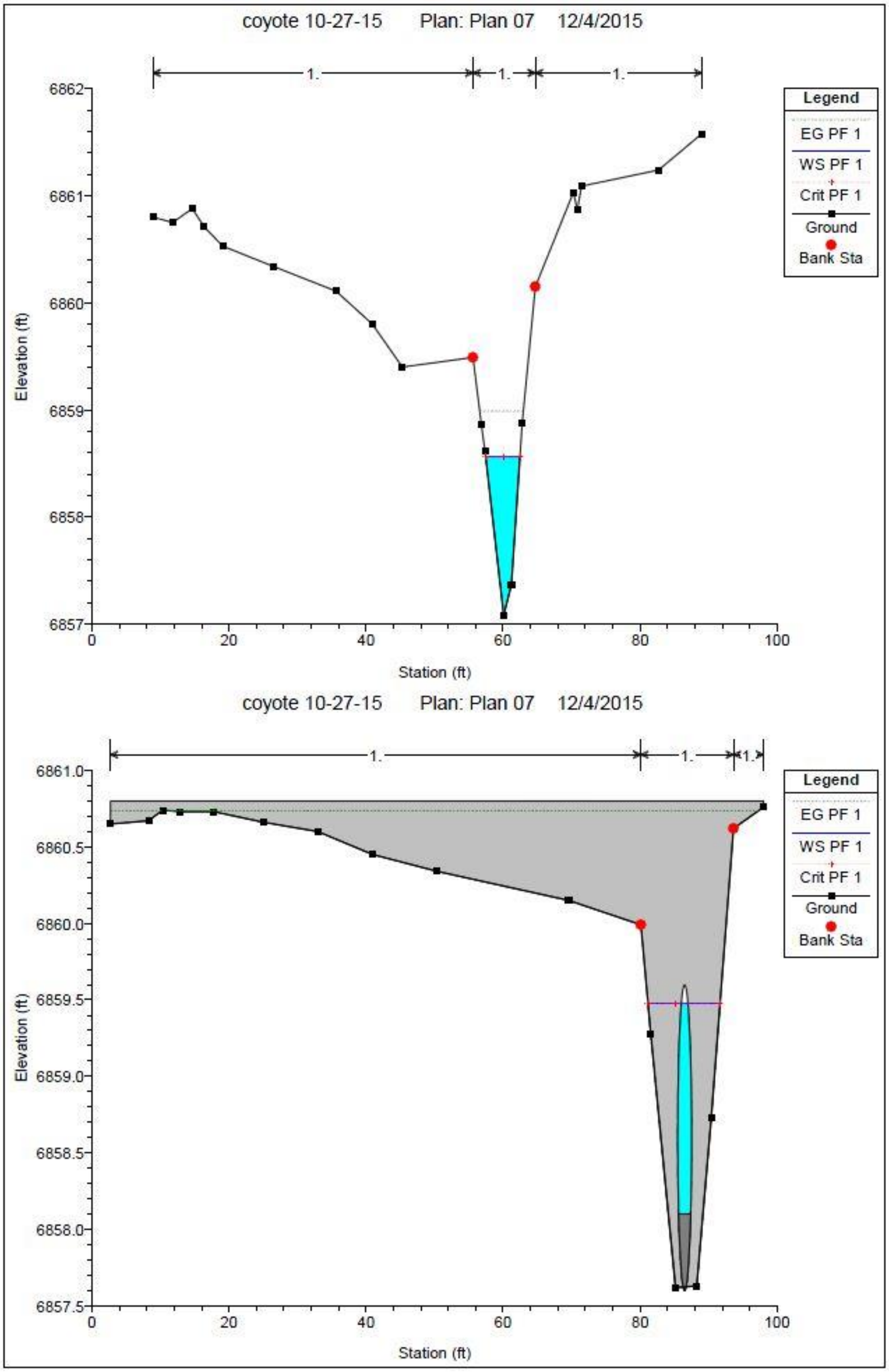
Existing Stream Cross Sections With 25 Year Flow



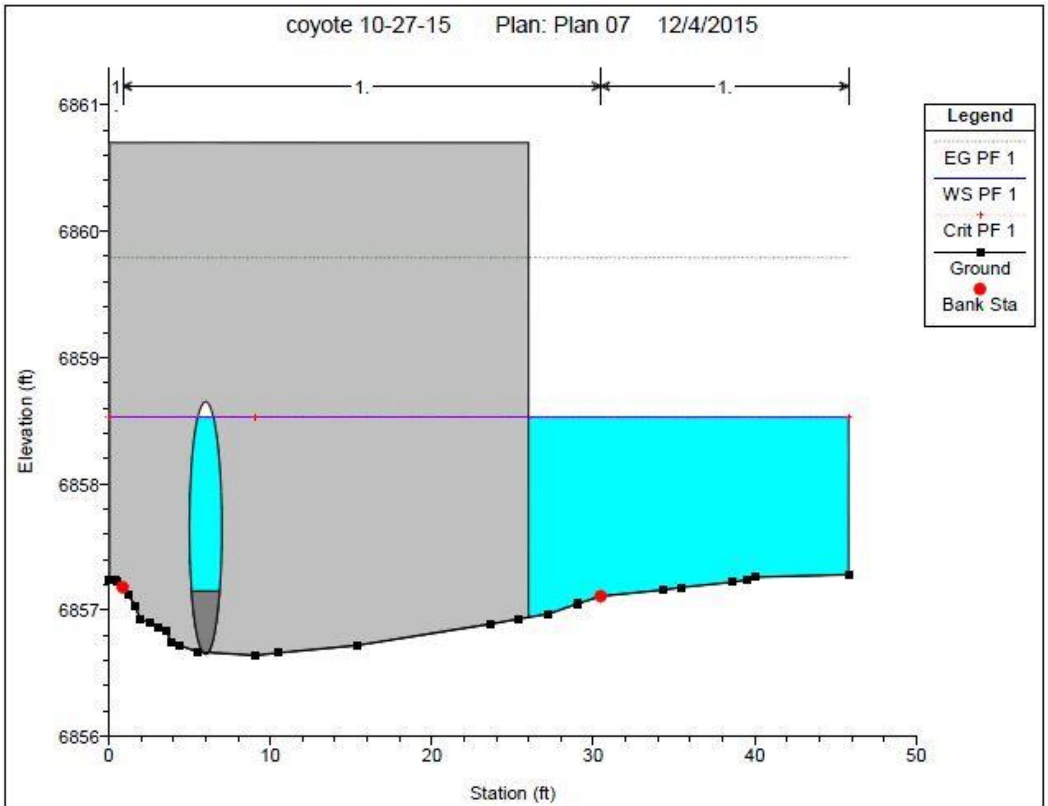
Existing Stream Cross Sections With 25 Year Flow

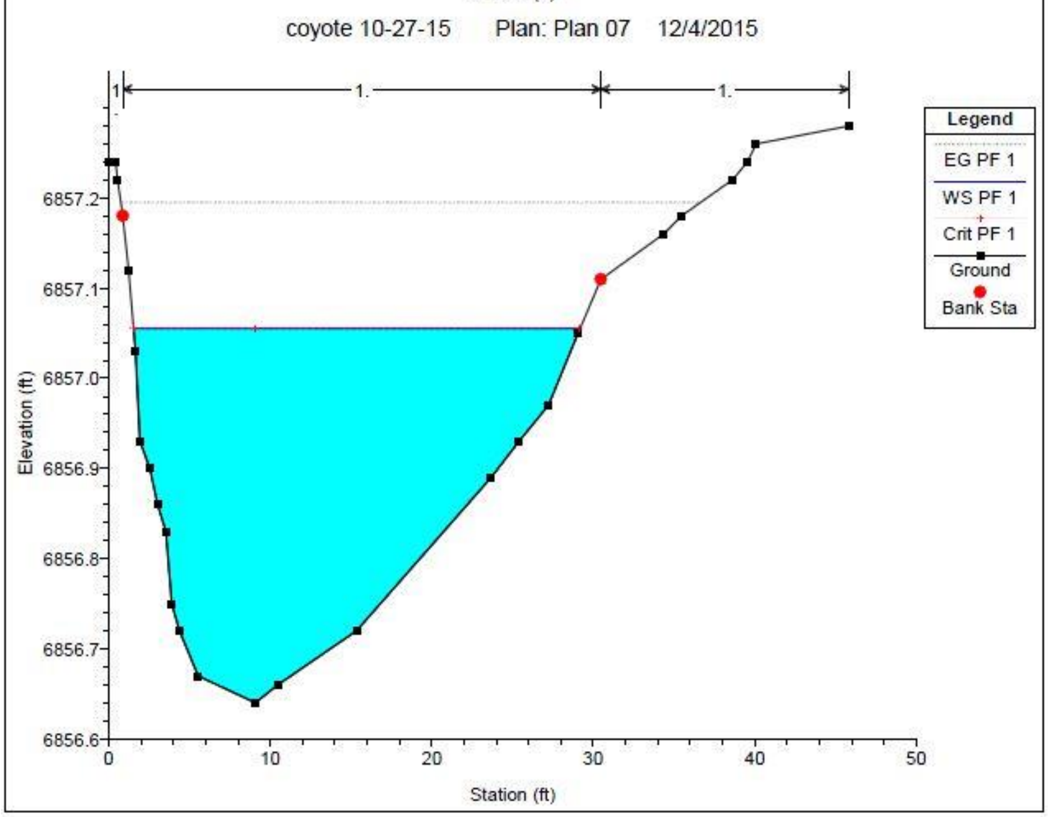


Existing Stream Cross Sections With 25 Year Flow



Existing Stream Cross Sections With 25 Year Flow





Existing Stream Cross Sections With 25 Year Flow

Plan: 1111 coyote reach coyote reverse f RS: 138.33 Profile: PF 1

E.G. Elev (ft)	6858.99	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.43	Wt. n-Val.		1.000	
W.S. Elev (ft)	6858.56	Reach Len. (ft)	31.94	31.94	31.94
Crit W.S. (ft)	6858.56	Flow Area (sq ft)		4.21	
E.G. Slope (ft/ft)	19.592000	Area (sq ft)		4.21	
Q Total (cfs)	22.05	Flow (cfs)		22.05	
Top Width (ft)	5.02	Top Width (ft)		5.02	
Vel Total (ft/s)	5.24	Avg. Vel. (ft/s)		5.24	
Max Chl Dpth (ft)	1.48	Hydr. Depth (ft)		0.84	
Conv. Total (cfs)	5.0	Conv. (cfs)		5.0	
Length Wtd. (ft)	31.94	Wetted Per. (ft)		5.92	
Min Ch El (ft)	6857.08	Shear (lb/sq ft)		869.55	
Alpha	1.00	Stream Power (lb/ft s)	89.00	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)		0.01	
C & E Loss (ft)		Cum SA (acres)		0.04	

Errors, Warnings and Notes

Existing Downstream Cross Section Output

File Type Options Help

River: coyote reach Profile: PF 1

Reach: coyote reverse f RS: 788.68 Plan: 1111

Plan: 1111 coyote reach coyote reverse f RS: 788.68 Profile: PF 1

E.G. Elev (ft)	6875.07	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.24	Wt. n-Val.		1.000	
W.S. Elev (ft)	6874.82	Reach Len. (ft)	50.50	50.50	50.50
Crit W.S. (ft)	6874.82	Flow Area (sq ft)		5.60	
E.G. Slope (ft/ft)	18.784880	Area (sq ft)		5.60	
Q Total (cfs)	22.05	Flow (cfs)		22.05	
Top Width (ft)	11.57	Top Width (ft)		11.57	
Vel Total (ft/s)	3.94	Avg. Vel. (ft/s)		3.94	
Max Chl Dpth (ft)	0.65	Hydr. Depth (ft)		0.48	
Conv. Total (cfs)	5.1	Conv. (cfs)		5.1	
Length Wtd. (ft)	50.50	Wetted Per. (ft)		11.72	
Min Ch El (ft)	6874.17	Shear (lb/sq ft)		560.44	
Alpha	1.00	Stream Power (lb/ft s)	70.55	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)		0.09	
C & E Loss (ft)		Cum SA (acres)		0.25	

Errors, Warnings and Notes

Existing Mid-Stream Cross Section Output

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)	
coyote reverse f	1352.14	PF 1	22.05	6909.91	6910.52	6910.52	6910.71	20.262670	3.51	6.28	16.39	1.00
coyote reverse f	1338.22	PF 1	22.05	6907.52	6908.01	6908.01	6908.15	21.856870	3.07	7.19	24.50	1.00
coyote reverse f	1288.81	PF 1	22.05	6899.90	6900.76	6900.76	6900.94	20.822550	3.43	6.43	17.74	1.00
coyote reverse f	1239.11	PF 1	22.05	6896.40	6897.16	6897.16	6897.31	20.892820	3.18	6.94	21.53	0.99
coyote reverse f	1198.97	PF 1	22.05	6894.04	6894.53	6894.53	6894.67	22.169170	3.06	7.19	24.79	1.00
coyote reverse f	1138.07	PF 1	22.05	6890.86	6891.35	6891.35	6891.48	22.993800	2.98	7.40	27.25	1.01
coyote reverse f	1088.32	PF 1	22.05	6888.23	6888.75	6888.75	6888.87	25.852270	2.70	8.17	38.20	1.03
coyote reverse f	1019.67	PF 1	22.05	6884.91	6885.48	6885.48	6885.60	25.041710	2.74	8.04	35.83	1.02
coyote reverse f	938.56	PF 1	22.05	6880.78	6881.50	6881.50	6881.67	22.598380	3.31	6.67	20.67	1.03
coyote reverse f	888.83	PF 1	22.05	6878.69	6879.54	6879.54	6879.72	20.615580	3.40	6.48	17.91	1.00
coyote reverse f	838.55	PF 1	22.05	6876.40	6876.98	6876.98	6877.22	18.955790	3.86	5.71	12.23	1.00
coyote reverse f	838		Culvert									
coyote reverse f	788.68	PF 1	22.05	6874.17	6874.82	6874.82	6875.07	18.784880	3.94	5.60	11.57	1.00
coyote reverse f	738.18	PF 1	22.05	6873.05	6873.95	6873.95	6874.19	19.167310	3.97	5.55	11.48	1.01
coyote reverse f	688.28	PF 1	22.05	6871.90	6872.84	6872.84	6873.12	19.832370	4.25	5.19	9.76	1.03
coyote reverse f	639.13	PF 1	22.05	6869.65	6871.22	6871.22	6871.63	19.916830	5.12	4.31	5.39	1.01
coyote reverse f	589.04	PF 1	22.05	6868.97	6870.13	6870.13	6870.39	19.634880	4.10	5.38	10.65	1.02
coyote reverse f	538.95	PF 1	22.05	6867.44	6868.44	6868.44	6868.62	20.008620	3.37	6.55	17.98	0.98
coyote reverse f	488.27	PF 1	22.05	6866.22	6866.99	6866.99	6867.20	19.953860	3.73	5.91	13.95	1.01
coyote reverse f	439.05	PF 1	22.05	6865.29	6865.96	6865.96	6866.11	22.839040	3.14	7.03	23.86	1.02
coyote reverse f	389.36	PF 1	22.05	6864.34	6864.92	6864.92	6865.06	23.219280	3.02	7.30	26.61	1.02
coyote reverse f	338.77	PF 1	22.05	6862.29	6863.04	6863.04	6863.25	20.120840	3.63	6.07	14.99	1.01
coyote reverse f	288.27	PF 1	22.05	6860.40	6861.30	6861.30	6861.53	19.542890	3.89	5.67	12.29	1.01
coyote reverse f	229.3	PF 1	22.05	6858.50	6859.07	6859.07	6859.23	20.873380	3.24	6.80	20.49	0.99
coyote reverse f	139		Culvert									
coyote reverse f	138.33	PF 1	22.05	6857.08	6858.56	6858.56	6858.99	19.592000	5.24	4.21	5.02	1.01
coyote reverse f	106.39	PF 1	22.05	6857.62	6858.56	6858.56	6858.90	18.460930	4.72	4.68	6.94	1.01
coyote reverse f	27		Culvert									
coyote reverse f	26.48	PF 1	22.05	6856.64	6857.06	6857.06	6857.20	24.039520	3.01	7.34	27.64	1.03

Existing Stream Output

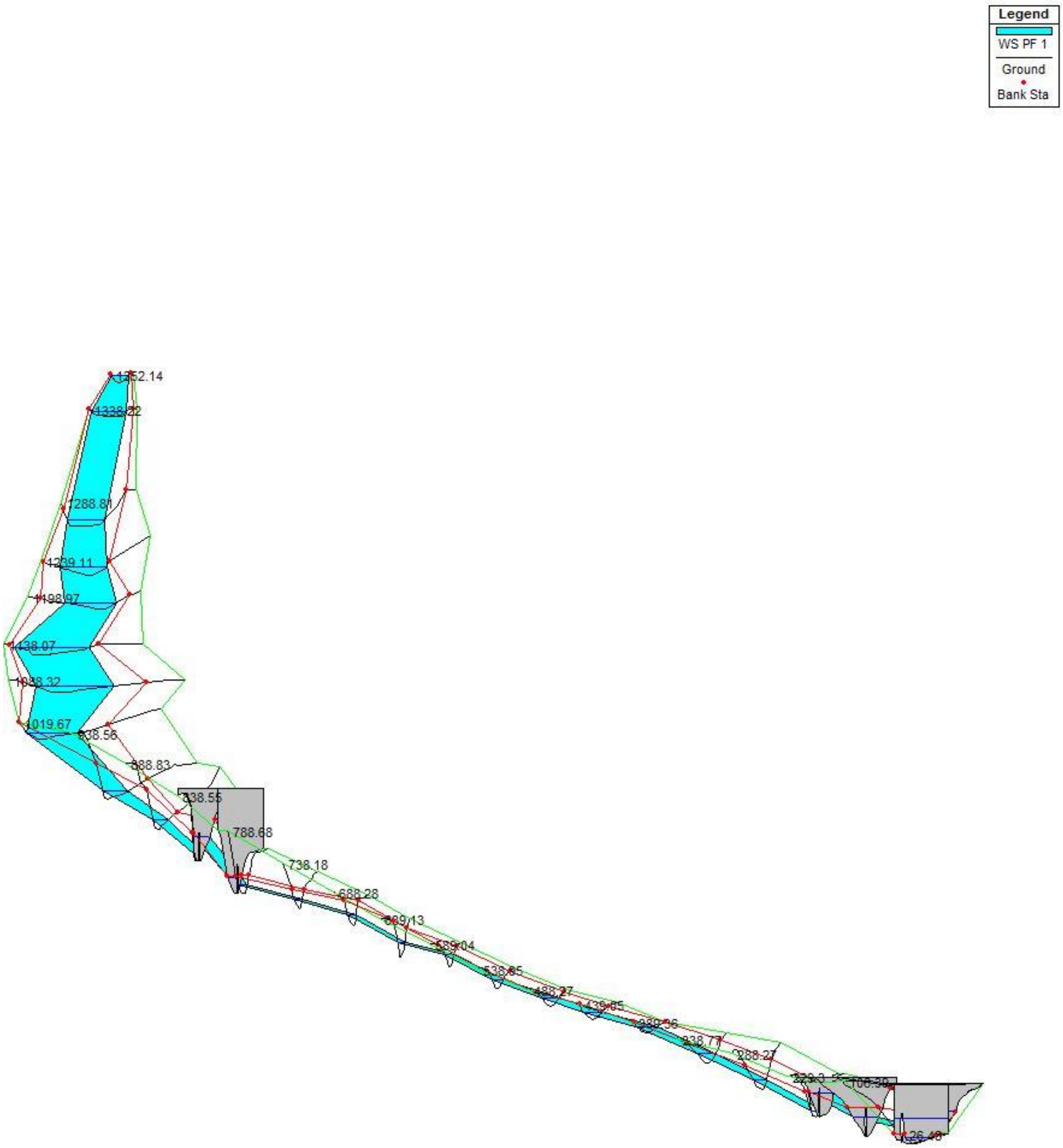
Location: River: coyote reach Reach: coyote reverse f RS: 1352.14 Profile: PF 1
Warning: Slope too shallow for slope area to converge during supercritical flow calculations (normal depth is above critical depth). Water surface set to critical depth.
Location: River: coyote reach Reach: coyote reverse f RS: 1338.22 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1288.81 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1239.11 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1198.97 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1138.07 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1088.32 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1019.67 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 938.56 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 888.83 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 838.55 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 838 Profile: PF 1 Culv: Culvert #1
Warning: During the supercritical analysis, the program could not converge on a supercritical answer in the downstream cross section. The program used the solution with the least error.
Warning: During the supercritical analysis, there was not enough energy for supercritical flow going into the culvert. The program assumed critical depth at the inlet.
Warning: During supercritical calculations, the culvert inlet depth is at or above critical depth and the culvert slope is mild. The outlet depth has defaulted to critical depth. For best results, this profile should be run in a mixed flow regime.
Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

Existing Stream HEC-RAS Errors

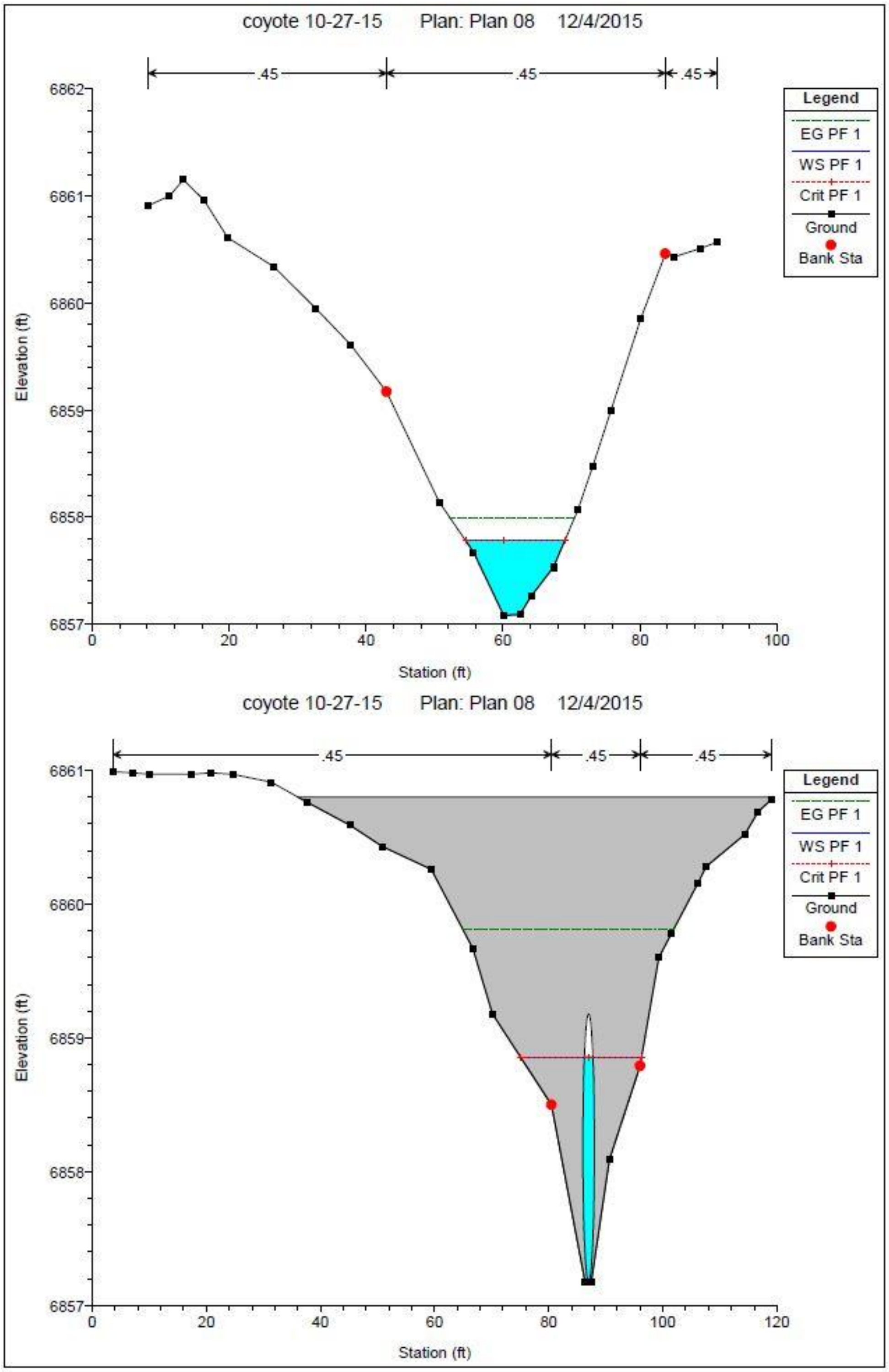
Note: Culvert critical depth exceeds the height of the culvert.
Location: River: coyote reach Reach: coyote reverse f RS: 738.18 Profile: PF 1
Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Location: River: coyote reach Reach: coyote reverse f RS: 688.28 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 639.13 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 589.04 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 538.95 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 488.27 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 439.05 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 389.36 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 338.77 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 288.27 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 229.3 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 139 Profile: PF 1 Culv: Culvert #2
Warning: During the supercritical analysis, the program could not converge on a supercritical answer in the downstream cross section. The program used the solution with the least error.
Warning: During the supercritical analysis, there was not enough energy for supercritical flow going into the culvert. The program assumed critical depth at the inlet.
Warning: During supercritical calculations, the culvert inlet depth is at or above critical depth and the culvert slope is mild. The outlet depth has defaulted to critical depth. For best results, this profile should be run in a mixed flow regime.
Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.
Note: Culvert critical depth exceeds the height of the culvert.
Location: River: coyote reach Reach: coyote reverse f RS: 106.39 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.
Location: River: coyote reach Reach: coyote reverse f RS: 27 Profile: PF 1 Culv: Culvert #1
Warning: During the supercritical analysis, the program could not converge on a supercritical answer in the downstream cross section. The program used the solution with the least error.
Warning: During the supercritical analysis, there was not enough energy for supercritical flow going into the culvert. The program assumed critical depth at the inlet.
Warning: During supercritical calculations, the culvert inlet depth is at or above critical depth and the culvert slope is mild. The outlet depth has defaulted to critical depth. For best results, this profile should be run in a mixed flow regime.
Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

Existing Stream HEC-RAS Errors Continued

Appendix N: Proposed HEC-RAS Model



Proposed HEC-RAS Prospective Plot



Proposed Downstream Cross Section

Plan: 1111 coyote reach coyote reverse f RS: 138.33 Profile: PF 1					
E.G. Elev (ft)	6858.00	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.21	Wt. n-Val.		0.450	
W.S. Elev (ft)	6857.78	Reach Len. (ft)	31.94	31.94	31.94
Crit W.S. (ft)	6857.78	Flow Area (sq ft)		5.97	
E.G. Slope (ft/ft)	4.116838	Area (sq ft)		5.97	
Q Total (cfs)	22.05	Flow (cfs)		22.05	
Top Width (ft)	14.52	Top Width (ft)		14.52	
Vel Total (ft/s)	3.69	Avg. Vel. (ft/s)		3.69	
Max Chl Dpth (ft)	0.70	Hydr. Depth (ft)		0.41	
Conv. Total (cfs)	10.9	Conv. (cfs)		10.9	
Length Wtd. (ft)	31.94	Wetted Per. (ft)		14.61	
Min Ch El (ft)	6857.08	Shear (lb/sq ft)		105.10	
Alpha	1.00	Stream Power (lb/ft s)	91.27	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)		0.01	
C & E Loss (ft)		Cum SA (acres)		0.04	

Errors, Warnings and Notes

Proposed Downstream Cross Section Output

Plan: 1111 coyote reach coyote reverse f RS: 788.68 Profile: PF 1					
E.G. Elev (ft)	6874.96	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.20	Wt. n-Val.		0.450	
W.S. Elev (ft)	6874.75	Reach Len. (ft)	50.50	50.50	50.50
Crit W.S. (ft)	6874.75	Flow Area (sq ft)		6.14	
E.G. Slope (ft/ft)	4.012260	Area (sq ft)		6.14	
Q Total (cfs)	22.05	Flow (cfs)		22.05	
Top Width (ft)	15.24	Top Width (ft)		15.24	
Vel Total (ft/s)	3.59	Avg. Vel. (ft/s)		3.59	
Max Chl Dpth (ft)	0.58	Hydr. Depth (ft)		0.40	
Conv. Total (cfs)	11.0	Conv. (cfs)		11.0	
Length Wtd. (ft)	50.50	Wetted Per. (ft)		15.32	
Min Ch El (ft)	6874.17	Shear (lb/sq ft)		100.33	
Alpha	1.00	Stream Power (lb/ft s)	70.55	0.00	0.00
Frctn Loss (ft)		Cum Volume (acre-ft)		0.09	
C & E Loss (ft)		Cum SA (acres)		0.28	

Errors, Warnings and Notes

Proposed Mid-Stream Cross Section Output

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)	
coyote reverse f	1352.14	PF 1	22.05	6909.91	6910.39	6910.39	6910.55	4.324919	3.25	6.78	20.74	1.00
coyote reverse f	1338.22	PF 1	22.05	6907.52	6907.92	6907.92	6908.08	4.445572	3.21	6.87	21.89	1.01
coyote reverse f	1288.81	PF 1	22.05	6899.90	6900.32	6900.32	6900.51	4.218102	3.46	6.37	17.38	1.01
coyote reverse f	1239.11	PF 1	22.05	6896.37	6896.99	6896.99	6897.17	4.262333	3.43	6.43	17.99	1.01
coyote reverse f	1198.97	PF 1	22.05	6894.04	6894.46	6894.46	6894.58	4.971703	2.77	7.97	34.57	1.02
coyote reverse f	1138.07	PF 1	22.05	6890.85	6891.33	6891.33	6891.46	4.528545	2.99	7.38	26.51	1.00
coyote reverse f	1088.32	PF 1	22.05	6888.23	6888.64	6888.64	6888.76	4.981652	2.77	7.97	34.65	1.02
coyote reverse f	1019.67	PF 1	22.05	6884.90	6885.39	6885.39	6885.52	4.662752	2.81	7.85	31.76	1.00
coyote reverse f	938.56	PF 1	22.05	6880.70	6881.30	6881.30	6881.47	4.292765	3.34	6.60	19.22	1.01
coyote reverse f	888.83	PF 1	22.05	6878.58	6879.30	6879.30	6879.51	4.044426	3.69	5.98	14.33	1.01
coyote reverse f	838.55	PF 1	22.05	6876.40	6876.95	6876.95	6877.16	4.099717	3.63	6.07	15.08	1.01
coyote reverse f	838		Culvert									
coyote reverse f	788.68	PF 1	22.05	6874.17	6874.75	6874.75	6874.96	4.012260	3.59	6.14	15.24	1.00
coyote reverse f	738.18	PF 1	22.05	6873.05	6873.76	6873.76	6873.98	4.114156	3.82	5.77	13.30	1.02
coyote reverse f	688.28	PF 1	22.05	6871.90	6872.66	6872.66	6872.91	3.910921	4.01	5.50	11.28	1.01
coyote reverse f	639.13	PF 1	22.05	6869.65	6870.67	6870.67	6871.00	3.652812	4.61	4.78	7.28	1.00
coyote reverse f	589.04	PF 1	22.05	6868.98	6869.80	6869.80	6870.06	3.938031	4.06	5.43	10.96	1.02
coyote reverse f	538.95	PF 1	22.05	6867.44	6868.11	6868.11	6868.31	4.008750	3.62	6.10	15.02	1.00
coyote reverse f	488.27	PF 1	22.05	6866.22	6866.82	6866.82	6867.01	4.186255	3.51	6.29	16.77	1.01
coyote reverse f	439.05	PF 1	22.05	6865.29	6865.81	6865.81	6865.96	4.511361	3.12	7.07	23.84	1.01
coyote reverse f	389.36	PF 1	22.05	6864.34	6864.82	6864.82	6864.98	4.772320	3.14	7.02	24.41	1.03
coyote reverse f	338.77	PF 1	22.05	6862.29	6862.89	6862.89	6863.09	4.083806	3.59	6.15	15.53	1.00
coyote reverse f	288.27	PF 1	22.05	6860.40	6861.04	6861.04	6861.27	3.964671	3.80	5.80	13.06	1.01
coyote reverse f	229.3	PF 1	22.05	6858.48	6858.92	6858.92	6859.07	4.257289	3.10	7.11	23.14	0.99
coyote reverse f	139		Culvert									
coyote reverse f	138.33	PF 1	22.05	6857.08	6857.78	6857.78	6858.00	4.116838	3.69	5.97	14.52	1.01
coyote reverse f	106.39	PF 1	22.05	6857.18	6858.19	6858.19	6858.47	3.841705	4.24	5.20	9.57	1.01
coyote reverse f	27		Culvert									
coyote reverse f	26.48	PF 1	22.05	6856.62	6857.05	6857.05	6857.18	4.516761	2.94	7.49	27.57	0.99

Proposed Stream Output

Location: River: coyote reach Reach: coyote reverse f RS: 1352.14 Profile: PF 1
Warning: Slope too shallow for slope area to converge during supercritical flow calculations (normal depth is above critical depth). Water surface set to critical depth.
Location: River: coyote reach Reach: coyote reverse f RS: 1338.22 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1288.81 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1239.11 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1198.97 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1138.07 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1088.32 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 1019.67 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 938.56 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 888.83 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 838.55 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 838 Profile: PF 1 Culv: Culvert #1
Warning: During the supercritical analysis, the program could not converge on a supercritical answer in the downstream cross section. The program used the solution with the least error.
Warning: During the supercritical analysis, there was not enough energy for supercritical flow going into the culvert. The program assumed critical depth at the inlet.
Location: River: coyote reach Reach: coyote reverse f RS: 738.18 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.
Location: River: coyote reach Reach: coyote reverse f RS: 688.28 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 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.

Proposed Stream HEC-RAS Errors

Location: River: coyote reach Reach: coyote reverse f RS: 639.13 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 589.04 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.
Location: River: coyote reach Reach: coyote reverse f RS: 538.95 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 488.27 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 439.05 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 389.36 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.
Location: River: coyote reach Reach: coyote reverse f RS: 338.77 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 288.27 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 229.3 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 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.
Location: River: coyote reach Reach: coyote reverse f RS: 139 Profile: PF 1 Culv: Culvert #2
Warning: During the supercritical analysis, the program could not converge on a supercritical answer in the downstream cross section. The program used the solution with the least error.
Warning: During the supercritical analysis, there was not enough energy for supercritical flow going into the culvert. The program assumed critical depth at the inlet.
Location: River: coyote reach Reach: coyote reverse f RS: 106.39 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.
Location: River: coyote reach Reach: coyote reverse f RS: 27 Profile: PF 1 Culv: Culvert #1
Warning: During the supercritical analysis, the program could not converge on a supercritical answer in the downstream cross section. The program used the solution with the least error.
Warning: During the supercritical analysis, there was not enough energy for supercritical flow going into the culvert. The program assumed critical depth at the inlet.
Warning: During supercritical calculations, the culvert inlet depth is at or above critical depth and the culvert slope is mild. The outlet depth has defaulted to critical depth. For best results, this profile should be run in a mixed flow regime.
Note: The normal depth exceeds the height of the culvert. The program assumes that the normal depth is equal to the height of the culvert.

Proposed Stream HEC-RAS Errors Continued

Appendix O: Bentley CulvertMaster and FlowMaster Reports

Culvert 1

Peak Discharge Method: Rational			
Design Return Period	25 year	Check Return Period	25 year
Design Peak Discharge	31.54 cfs	Check Peak Discharge	31.54 cfs
Total Area	24.35 acres	Time of Concentration	0.00 min
Rational Coefficient	0.15	Intensity	8.34 in/hr

Subwatershed	Area (acres)	C
1	2.91	0.15
2	11.53	0.15
3	9.21	0.10
4	0.70	0.95

Grades Model: Inverts			
Invert Upstream	6,875.18 ft	Invert Downstream	6,871.86 ft
Length	90.00 ft	Slope	0.036913 ft/ft
Drop	3.32 ft		

Headwater Model: Maximum Allowable HW	
Headwater Elevation	6,879.46 ft

Tailwater properties: Irregular Channel

Tailwater conditions for Design Storm.			
Discharge	31.54 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

Tailwater conditions for Check Storm.			
Discharge	31.54 cfs	Actual Depth	0.00 ft
Velocity	0.00 ft/s		

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-24 inch Circular	31.54 cfs	6,879.81 ft	10.28 ft/s

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,879.46	ft	Storm Event	Design	
Computed Headwater Elevation	6,879.81	ft	Discharge	31.54	cfs
Headwater Depth/Height	2.31		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	6,879.57	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	6,879.81	ft			

Grades					
Upstream Invert	6,875.18	ft	Downstream Invert	6,871.86	ft
Length	90.00	ft	Constructed Slope	0.036913	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	1.88	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.88	ft
Velocity Downstream	10.28	ft/s	Critical Slope	0.039777	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.020	
Section Material	Corrugated HDPE 18-24 inch (Corrugated Interior)		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,879.81	ft	Upstream Velocity Head	1.57	ft
Ke	0.20		Entrance Loss	0.31	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,879.57	ft	Flow Control	N/A	
Inlet Type	Groove end w/headwall		Area Full	3.1	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	

Inlet Control Properties	
Y	0.74000

Culvert 2

Peak Discharge Method: Rational					
Design Return Period	25	year	Check Return Period	25	year
Design Peak Discharge	31.54	cfs	Check Peak Discharge	31.54	cfs
Total Area	24.35	acres	Time of Concentration	0.00	min
Rational Coefficient	0.15		Intensity	8.34	in/hr

Subwatershed	Area (acres)	C
1	2.91	0.15
2	11.53	0.15
3	9.21	0.10
4	0.70	0.95

Grades Model: Inverts					
Invert Upstream	6,858.40	ft	Invert Downstream	6,858.06	ft
Length	50.00	ft	Slope	0.006735	ft/ft
Drop	0.34	ft			

Headwater Model: Maximum Allowable HW		
Headwater Elevation	6,858.75	ft

Tailwater properties:
Irregular Channel

Tailwater conditions for Design Storm.					
Discharge	31.54	cfs	Actual Depth	0.00	ft
Velocity	0.00	ft/s			

Tailwater conditions for Check Storm.					
Discharge	31.54	cfs	Actual Depth	0.00	ft
Velocity	0.00	ft/s			

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-24 inch Circular	31.54 cfs	6,864.20 ft	10.28 ft/s

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,858.75	ft	Storm Event	Design	
Computed Headwater Elevation	6,864.20	ft	Discharge	31.54	cfs
Headwater Depth/Height	2.90		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	6,862.82	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	6,864.20	ft			

Grades					
Upstream Invert	6,858.40	ft	Downstream Invert	6,858.06	ft
Length	50.00	ft	Constructed Slope	0.006735	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	1.88	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.88	ft
Velocity Downstream	10.28	ft/s	Critical Slope	0.039777	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.020	
Section Material	Corrugated HDPE 18-24 inch (Corrugated Interior)		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,864.20	ft	Upstream Velocity Head	1.57	ft
Ke	0.20		Entrance Loss	0.31	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,862.82	ft	Flow Control	N/A	
Inlet Type	Groove end w/headwall		Area Full	3.1	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	

Inlet Control Properties	
Y	0.74000

Culvert 3

Peak Discharge Method: Rational					
Design Return Period	25	year	Check Return Period	25	year
Design Peak Discharge	31.54	cfs	Check Peak Discharge	31.54	cfs
Total Area	24.35	acres	Time of Concentration	0.00	min
Rational Coefficient	0.15		Intensity	8.34	in/hr

Subwatershed	Area (acres)	C
1	2.91	0.15
2	11.53	0.15
3	9.21	0.10
4	0.70	0.95

Grades Model: Inverts					
Invert Upstream	6,855.85	ft	Invert Downstream	6,855.71	ft
Length	100.00	ft	Slope	0.001439	ft/ft
Drop	0.14	ft			

Headwater Model: Maximum Allowable HW		
Headwater Elevation	6,857.63	ft

Tailwater properties:
Irregular Channel

Tailwater conditions for Design Storm.					
Discharge	31.54	cfs	Actual Depth	0.00	ft
Velocity	0.00	ft/s			

Tailwater conditions for Check Storm.					
Discharge	31.54	cfs	Actual Depth	0.00	ft
Velocity	0.00	ft/s			

	Name	Description	Discharge	HW Elev.	Velocity
x	Trial-1	1-24 inch Circular	31.54 cfs	6,864.14 ft	10.28 ft/s

Design:Trial-1

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	6,857.63	ft	Storm Event	Design	
Computed Headwater Elevation	6,864.14	ft	Discharge	31.54	cfs
Headwater Depth/Height	4.15		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	6,860.27	ft	Control Type	Outlet Control	
Outlet Control HW Elev.	6,864.14	ft			

Grades					
Upstream Invert	6,855.85	ft	Downstream Invert	6,855.71	ft
Length	100.00	ft	Constructed Slope	0.001439	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	1.88	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.88	ft
Velocity Downstream	10.28	ft/s	Critical Slope	0.039777	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.020	
Section Material	Corrugated HDPE 18-24 inch (Corrugated Interior)		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,864.14	ft	Upstream Velocity Head	1.57	ft
Ke	0.20		Entrance Loss	0.31	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,860.27	ft	Flow Control	N/A	
Inlet Type	Groove end w/headwall		Area Full	3.1	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	

Inlet Control Properties	
Y	0.74000

Flow Master

Coyote Springs Report

Label	Solve For	Friction Method	Roughness Coefficient
Flow Capacity CS 1	Discharge	Manning Formula	0.100
Flow Capacity CS 2	Discharge	Manning Formula	0.100
Flow Capacity CS 3	Discharge	Manning Formula	0.100
Flow Capacity CS 4	Discharge	Manning Formula	0.100
Flow Capacity CS 5	Discharge	Manning Formula	0.100
Flow Capacity CS 6	Discharge	Manning Formula	0.100
Flow Capacity CS 7	Discharge	Manning Formula	0.100
Flow Capacity CS 8	Discharge	Manning Formula	0.100
Flow Capacity CS 9	Discharge	Manning Formula	0.100
Flow Capacity CS 10	Discharge	Manning Formula	0.100
Flow Capacity CS 11	Discharge	Manning Formula	0.100
Flow Capacity CS 12	Discharge	Manning Formula	0.100
Normal Depth CS 1	Normal Depth	Manning Formula	0.100
Normal Depth CS 2	Normal Depth	Manning Formula	0.100
Normal Depth CS 3	Normal Depth	Manning Formula	0.100
Normal Depth CS 4	Normal Depth	Manning Formula	0.100
Normal Depth CS 5	Normal Depth	Manning Formula	0.100
Normal Depth CS 6	Normal Depth	Manning Formula	0.100
Normal Depth CS 7	Normal Depth	Manning Formula	0.100
Normal Depth CS 8	Normal Depth	Manning Formula	0.100
Normal Depth CS 9	Normal Depth	Manning Formula	0.100
Normal Depth CS 10	Normal Depth	Manning Formula	0.100
Normal Depth CS 11	Normal Depth	Manning Formula	0.100
Normal Depth CS 12	Normal Depth	Manning Formula	0.100

Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft^3/s)
0.03890	6910.30	6909.91 to 6910.30 ft	5.98
0.03890	6901.00	6899.90 to 6901.00 ft	53.39

Coyote Springs Report

Channel Slope (ft/ft)	Water Surface Elevation (ft)	Elevation Range	Discharge (ft³/s)
0.03890	6897.14	6896.37 to 6897.14 ft	36.10
0.03890	6888.90	6888.23 to 6888.90 ft	64.98
0.03890	6883.25	6880.70 to 6883.25 ft	698.60
0.03890	6878.84	6876.40 to 6878.84 ft	440.01
0.03890	6874.13	6873.05 to 6874.13 ft	57.39
0.03890	6872.19	6869.65 to 6872.19 ft	167.19
0.03890	6864.91	6864.34 to 6864.91 ft	29.65
0.03890	6861.71	6860.40 to 6861.71 ft	99.95
0.03890	6860.15	6857.76 to 6860.15 ft	75.40
0.03890	6859.29	6857.74 to 6859.29 ft	36.06
0.03890	6910.47	6909.91 to 6910.30 ft	12.72
0.03890	6900.40	6899.90 to 6901.00 ft	12.72
0.03890	6897.07	6896.37 to 6897.14 ft	12.72
0.03890	6888.71	6888.23 to 6888.90 ft	12.72
0.03890	6881.38	6880.70 to 6883.25 ft	12.72
0.03890	6877.03	6876.40 to 6878.84 ft	12.72
0.03890	6874.06	6873.05 to 6874.13 ft	22.05
0.03890	6871.10	6869.65 to 6872.19 ft	22.05
0.03890	6865.03	6864.34 to 6864.91 ft	22.05
0.03890	6861.35	6860.40 to 6861.71 ft	22.05
0.03890	6859.72	6857.76 to 6860.15 ft	22.05
0.03890	6859.53	6857.74 to 6859.29 ft	22.05

Flow Area (ft²)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Top Width (ft)
4.68	16.27	0.29	16.03
19.94	22.84	0.87	22.22
9.20	19.65	0.47	19.34
19.26	51.62	0.37	51.47

Coyote Springs Report

Flow Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Top Width (ft)
74.04	42.46	1.74	40.91
50.75	33.04	1.54	31.11
11.56	17.38	0.67	17.12
20.53	14.68	1.40	13.24
9.26	26.84	0.34	26.76
16.93	19.61	0.86	19.16
10.55	9.19	1.15	7.00
6.16	7.23	0.85	6.00
7.43	16.61	0.45	16.03
7.70	18.16	0.42	18.04
7.79	18.74	0.42	18.51
10.52	39.71	0.26	39.69
8.16	21.02	0.39	20.90
7.35	16.18	0.45	16.07
10.41	16.96	0.61	16.77
8.24	9.44	0.87	8.82
12.56	27.09	0.46	26.76
10.38	16.83	0.62	16.66
7.70	7.96	0.97	6.32
7.60	7.71	0.99	6.00

Normal Depth (ft)	Critical Depth (ft)	Critical Slope (ft/ft)	Velocity (ft/s)
0.39	0.37	0.04602	2.84
1.10	1.16	0.03126	5.95
0.77	0.77	0.03859	3.93
0.67	0.66	0.04128	3.37
2.55	2.83	0.02469	9.44
2.44	2.65	0.02654	8.67

Coyote Springs Report

Normal Depth (ft)	Critical Depth (ft)	Critical Slope (ft/ft)	Velocity (ft/s)
1.08	1.11	0.03399	4.96
2.54	2.69	0.02914	8.14
0.57	0.56	0.04247	3.20
1.31	1.37	0.03126	5.90
2.39	2.42	0.03704	7.14
1.55	1.56	0.03752	5.85
0.56	0.37	0.22907	1.71
0.50	0.30	0.22778	1.65
0.70	0.50	0.22649	1.63
0.48	0.33	0.25673	1.21
0.68	0.47	0.22858	1.56
0.63	0.41	0.21728	1.73
1.01	0.71	0.19397	2.12
1.45	1.02	0.17947	2.68
0.69	0.49	0.21991	1.76
0.95	0.64	0.19290	2.12
1.96	1.39	0.19243	2.87
1.79	1.25	0.18961	2.90

Velocity Head (ft)	Specific Energy (ft)	Froude Number	Flow Type
0.13	0.52	0.93	Subcritical
0.55	1.65	1.11	Supercritical
0.24	1.01	1.00	Supercritical
0.18	0.85	0.97	Subcritical
1.38	3.93	1.24	Supercritical
1.17	3.61	1.20	Supercritical
0.38	1.46	1.06	Supercritical
1.03	3.57	1.15	Supercritical

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Velocity Head (ft)	Specific Energy (ft)	Froude Number	Flow Type
0.16	0.73	0.96	Subcritical
0.54	1.85	1.11	Supercritical
0.79	3.18	1.03	Supercritical
0.53	2.08	1.02	Supercritical
0.05	0.61	0.44	Subcritical
0.04	0.54	0.45	Subcritical
0.04	0.74	0.44	Subcritical
0.02	0.50	0.41	Subcritical
0.04	0.72	0.44	Subcritical
0.05	0.68	0.45	Subcritical
0.07	1.08	0.47	Subcritical
0.11	1.56	0.49	Subcritical
0.05	0.74	0.45	Subcritical
0.07	1.02	0.47	Subcritical
0.13	2.09	0.46	Subcritical
0.13	1.92	0.45	Subcritical

Notes	Messages
Well House	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180 Pound area/	

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Notes	Messages
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Well House	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	
Pound area/ Adjacent HYW 180	
Adjacent HYW 180	
Adjacent HYW 180	

Bentley Systems, Inc. Haestad Methods Solution Center
Bentley FlowMaster V8i (SELECTseries 1) [08.11.01.03]