KUAE Consulting Engineers Final Report

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Spring 2017

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1.0 PROJECT DESCRIPTION

1.1 PROJECT BACKGROUND

The following report is to provide the client with the Project Report. Sinclair Wash is one of the largest streams in Northern Arizona. It serves as a storm water conveyer and transport the storm water to the Rio De Flag in Flagstaff, Arizona. Sinclair Wash runs through rural parts of the city as well as in the city limits. It also runs through the campus of Northern Arizona University. Along some reaches of the Sinclair Wash, there are trails that are a part of the Flagstaff Urban Trail System (FUT). The trails serve as a recreational opportunity for the users of the community. The purpose of this project is to evaluate the current condition of the chosen reach and enhance the reach condition in different aspects. The main aspect are the hydraulics of the reach, and propose a new low water crossing design.

1.2 PROJECT REACH LOCATION

The reach is within the campus of Northern Arizona University and the city of Flagstaff limits. It is located at the intersection of East McConnell Drive and the State Highway, I-17. The reach total length is 814 ft. Figure 1 shows the location of the chosen reach within the city limit. Figure 2 below shows the detailed aerial photo of the reach.

Figure 1: Reach Location Within The city of Flagstaff

Figure 2: Aerial Image of the Reach

2.0 REACH ASSESSMENT

The team-conducted a field visit to the selected reach to identify the infrastructures, utilities and to have an overall understanding about the reach conditions. Comments about the reach conditions and concerns were reported prior to surveying work. The team also set a surveying plan that includes equipment borrow times, number and location of control points, as well as other surveying concerns.

2.1 CURRENT CONDITIONS OF THE REACH

The overall condition of the reach is in a decreasing manner. This is due to its location that is within the campus of Northern Arizona University, which make the reach under a lot of urban development changes and modifications leading to the reach losing its natural health. The reach shows signs of flooding during storms events, which create a hazard on the life of FUT user. It has several infrastructure utilities including culverts and valve boxes. Conditions of the culverts are acceptable overall but some culverts need maintenance such as the one shown in Figure 2. Figure 3 shows an example of the open valve boxes that also need to be closed on maintained due to safety concerns. Furthermore the team noticed a 1.5 feet deep scour pool located downstream of the Flagstaff Urban Trail system trail. Figure 4 shows the scour pool.

Figure 3: FUT Culvert

Figure 4: open Valve Box

Figure 5: Deep Scour Pool

2.2 WILD LIFE AND VEGETATION

Because of the verity in Sinclair wash, the wildlife and vegetation vary from on section of the wash to another. Some reaches nearby NAU campus tend to have less wildlife habitat because of the heavy use by students all the year but there is still a wildlife and a vegetation in those sections of the wash. Moving to the rural sections of the wash, there is a variety of wildlife and vegetation because of the low human access to these areas. The wildlife along the wash includes some species of animals like squirrels, elks, birds and other species like bats. The vegetation in the wash varies from ponderosa pine to small flowers. The overall condition of the wildlife and vegetation in wash is fair in some reaches, and in some other reaches it needs improvements.

2.3 GEOMORPHOLOGY

2.3.1 STREAM CLASSIFICATION

2.3.1.1 Rosgen Method

The team started the stream classification to increase the knowledge about the stream. Different classifications methods were available for the reach classification. The team decided to choose Rosgen classification method, which requires to be familiar with the stream morphology. The reason for choosing Rosgen method is because it is the most widely used classification method in US. Furthermore, the method is easy to apply and it saves money, and no expensive materials are required for the method. Rosgen method can be used to collect the raw data for predicting channel stability, channel enlargement, erosion risks, and hydraulic relations. Rosgen method consists of four main levels which are geomorphic characterization, morphological description, stream condition, and validation level. The process for our stream start with single thread channel then the entrenchment ratio which is 0.14 then the width and depth ratio which is about 14.06 and finally the sinuosity that is bigger than 1.2. The result of the classification shows that the stream is type F which can be described as the classic entrenchment channel, morphologically unstable, and actively down cutting. The stream classification will help the team to get a better understanding and increase the knowledge about the reach, and it plays an important role in stream restoration for the project. For Full Reach Classification Results Refer to Appendix A.

2.4 REACH SURVEYING

The team surveyed the assigned reach using Total Station. First, the team set a benchmark in a 1000N, 1000E and 1000Z coordinates. The benchmark is connected with the control points. The team set the total station to the benchmark then take a backsight in a north direction using campus. After that, the team chose four control points and backsight each control point five times and take the average. The reason to have four control point is some part of the reach can't be surveyed in one location. Then the team survey around 500 points these points are used to create a topographic map using Civil 3D. The purpose of the topographic map is to show the existing condition of the reach. See figure for more clarification. For full Surveying Results and data refer to Appendix B.

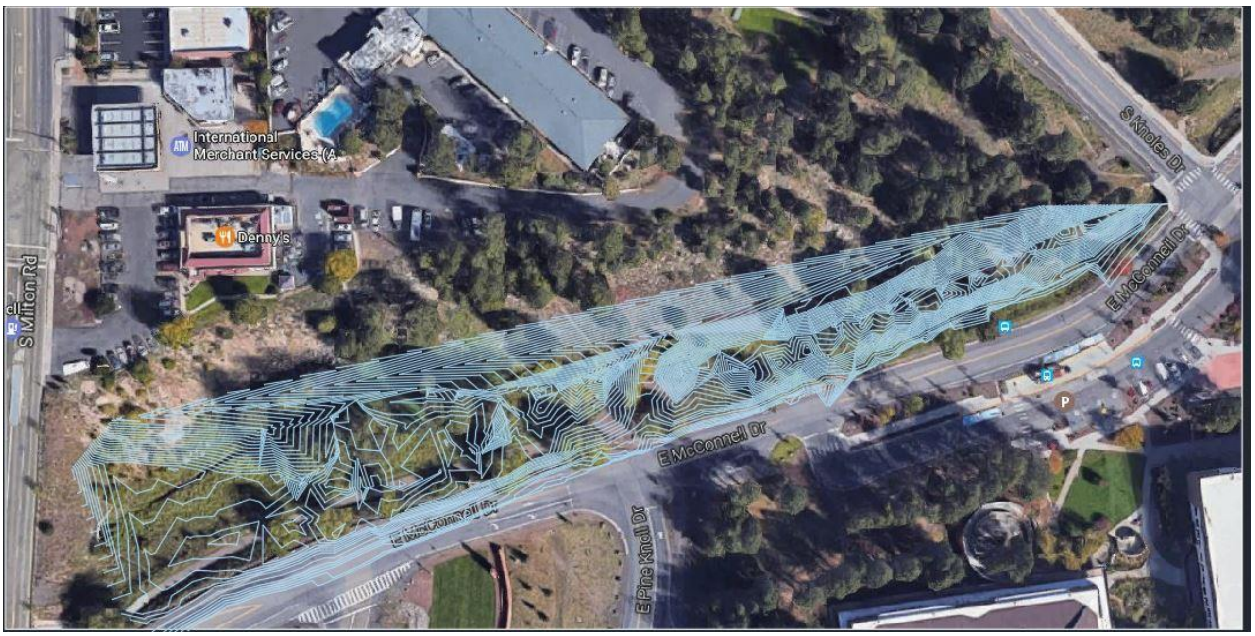

Figure 6: Reach Topographic Map

2.4.1 Surveying challenges

The main challenge that the team faced is surveying. After the team surveyed the reach and created the first topo map. The topo map was not complete, so the team decided to survey the remaining points but based on weather condition and failure of equipment we were delayed for two weeks to create the final topo map.

3.0 HYDRAULIC ANALYSIS

The hydraulic analysis was conducted on the selected reach for both the existing condition model and the proposed condition model. The hydraulic analysis conducted using the Hydraulic Engineering Center River Analysis System (HEC-RAS). The analysis was based on the surveying data the team collected. The hydraulics analysis is used to determine the velocity, the water surface elevation and other hydraulics characteristics. The discharge values used in the hydraulics model were the 2-year, 10-year, 50-year and the 100-year storm event. The flow rate for the storm events used were obtained from the Flood insurance study [1] and the National Stream Flow Statistics Software [2]. Table 1 shows the storm event and the flow rate for Sinclair wash.

Table 1 Flow Rates at Sinclair Wash.

Storm Event	2–year	10-year	50-year	100-year
Flow Rate (CFS)	130	350	670	890

3.1 EXISTING CONDETION MODEL

3.1.1 Reach Stabilization Analysis

To analyze the existing condition of reach better the stabilization factors of the reach were determined. The stabilization velocity of the reach was determined based on the bed material in the reach. The reach is divided into two section, upstream of FUT culvert and downstream of the FUT culvert. Each section has a different bed material leading to a different stabilization velocity in the section. Table 2 shows the material type of each section and the allowable velocity of the section.

Table 2 Stabilization Analysis Results

	Bed Material	Allowable Velocity (ft/s)
Upstream	Native Grass Mixture	4.0
Downstream	Silt Loam (non-colloidal)	2.5

3.1.2 Reach Cross-Section Analysis

To model the existing model using HEC-RAS several cross-section in the reach were identified. Appendix C shows the Cross-section used in the HEC-RAS Model.

3.1.3 HEC-RAS Model Results

Using the topographic map from the surveying data the existing condition model was developed using HEC-RAS. Figure 7 shows the 100-year profile of the existing condition model.

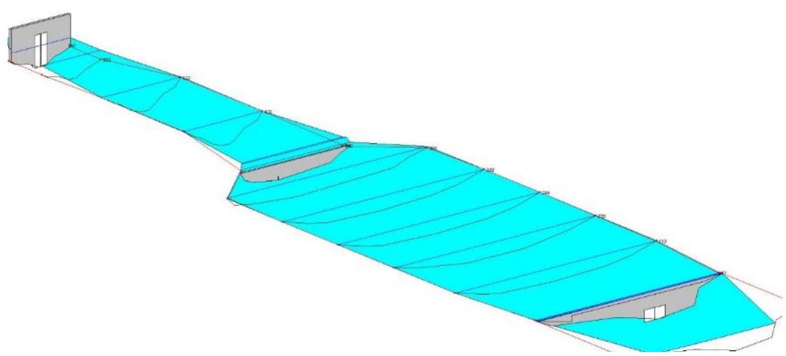

Figure 7: Profile view of 100-year storm Existing Condition Model.

The results were the section downstream of FUT culvert in the unhealthy section of the reach. Three cross-section at this section had higher velocities than the allowable velocity in 100-year storm and two cross-sections in the remaining storm events. Furthermore, the exit velocity of the FUT culvert exceed the allowable velocity causing the scour pool downstream of the culvert in all storm event. For Full Results of HEC-RAS Existing Condition Model refer to Appendix C.

4.0 FINAL DESIGN

The proposed design solution is to set modification to the affected cross-sections with the high velocities and to propose a new low water crossing design.

4.1 AFFECTED SECTION MODIFECATION

The proposed solution to the unhealthy section is to modify the affected cross-sections with high velocities. In order to modify these sections, a healthy reference reach was selected to apply the healthy reach characteristics to the affected unhealthy section.

4.1.1 Healthy Reference reach

The healthy reference was needed to be within the Sinclair Wash network for the ease of access to the reach. The healthy reference was the reach at the intersection of San Francisco & S Lone tree. Previous NAU capstone teams worked on the reach. The bankfull location in the healthy reach was identified to define the bankfull depth, length and bankfull cross-section area. The bankfull characteristics was applied to the affected cross-section to match the bankfull depth and bankfull cross-section area. For full bankfull analysis of the healthy reference reach refer to Appendix D.

4.2 LOW WATER CROSSING DESIGN

The team came up with a design that match with the bankfull characteristics and can hold the bankfull cross section area, which is equal to 44 square feet. USDA Low-Water Crossing manual was used to choose the low water crossing type, material, thickness, and roughness coefficient. [4].

There are different types of low water crossing, each type is appropriate for certain kind of conditions. In this project's case where there is no vehicle access or fish passage, the "Unvented Ford" type the best type to use. The material was chosen to be concrete and the thickness was 6 inches. Roughness coefficient was obtained from the manual as 0.016. Table 8 summarizes the low water crossing data.

Table 3

Low Water Crossing Type	Low Crossing Material	Concrete Slab Thickness (inch)	Roughness Coefficient (n)
Unvented Ford	Concrete	6	0.016

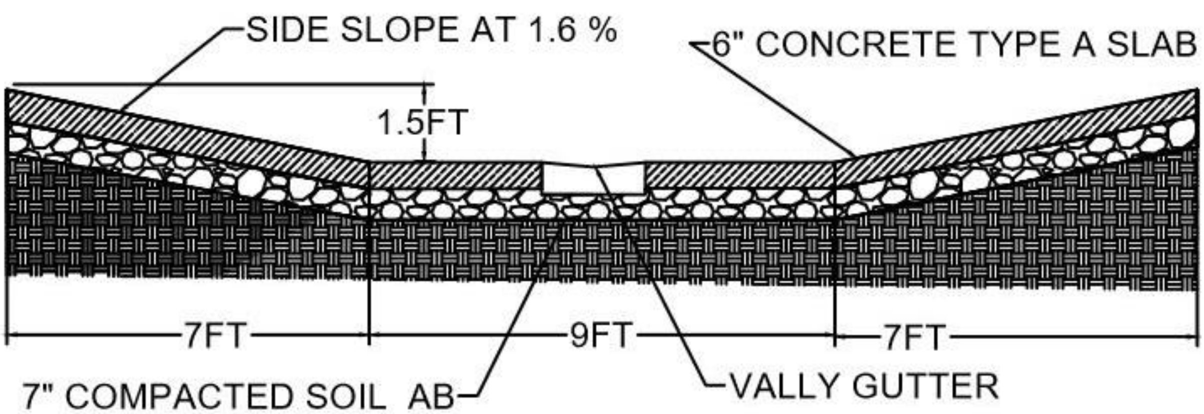

Figure 8: Design

4.2.1 CONCRETE SLAB

Team could not find all design standards for the City of Flagstaff specifically, so both Coconino County and Maricopa County standards were used to determine the design standards. The slab has a thickness of 6 inches and a depth of 1.5 ft. The side slope is 1.6%. A 7” compacted soil AB is to be placed under the slab. These specifications are based on the design manuals used by the City of Flagstaff such as the Highway Drainage Design Manual. Figure 15 shows the low water crossing design created by the team.

4.2.2 VALLEY GUTTER

The purpose of the valley gutter is to move sedimentation that may exist. The design of the valley gutter is with accordance of City of Flagstaff sidewalk standards. The material type of the valley gutter was selected to be concrete type “AA”.

4.2.3 RIPRAP

Since the concrete is smooth, high velocities may occur. In order to solve this problem, the team provided the solution of “riprap”. “Riprap” describes the wall of stones that are thrown along or inside the channel. The Coconino County Storm Water Drainage Manual was used to determine the riprap requirements. Riprap type was selected to be “Rock”. D50 of the rock, which is also known as the average diameter, was calculated to be 6 inches. D_min value is 3 inches and D_max is 12 inches. Based on the manual, the riprap needs to be extended 3 ft downstream (D_min * D_max). Table 9 below shows the riprap type, values for D_min, D50, D_max, riprap extension, riprap volume, and the roughness coefficient.

Table 4: Riprap Design Results

Riprap Type	D min (inch)	D 50 (inch)	D max (inch)	Riprap Extend (ft)	Riprap Volume (ft^3)	Roughness Coefficient (n)
Rock	3	6	12	3	115	0.035

Figure 9 shows a section view of low water crossing design. It can be seen that the riprap has a 6” diameter and is to be extended 3 ft downstream. A wall is to be added to protect the riprap. The wall has a height of 12 inches on the right side close to the concrete slab and a height of 6 inches on the left side. Figure 10 shows plan view of the proposed low water crossing design with the riprap downstream of the crossing to add protection to the crossing.

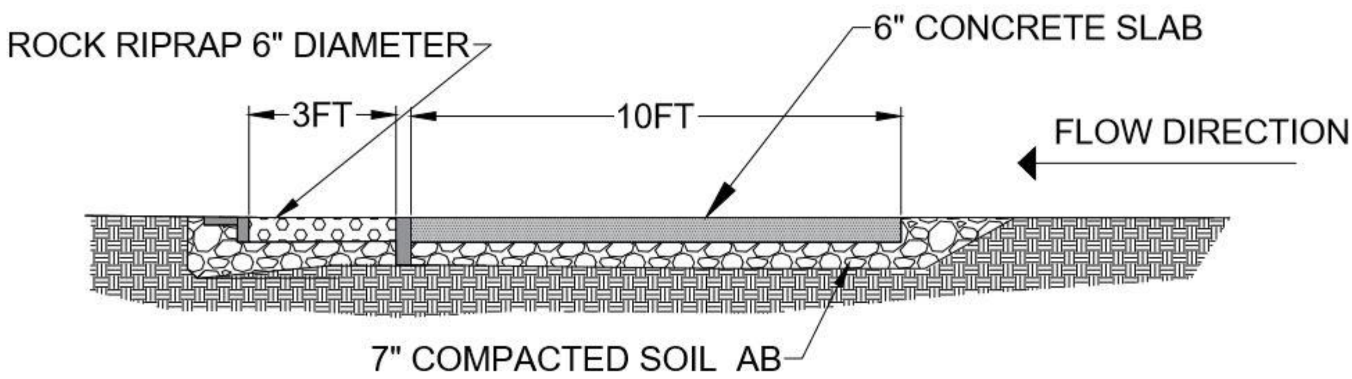

Figure 9: Section View of the Proposed Design.

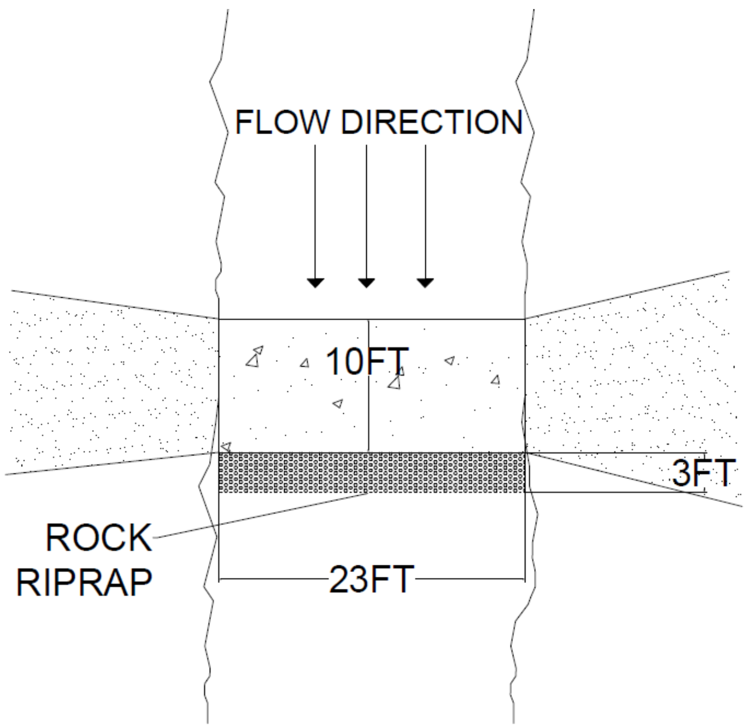

Figure 10: Plan View of the LWC Design.

5.0 PROJECT SCHEDULE

Table 5 below shows the project schedule that compares the expected and the actual task. The task that is highlighted yellow delayed based on the surveying issues, which pushes back the data analysis, and design alternative for two weeks. For site visit and the project management were finished as expected.

Table 4: Expected Project Schedule vs Actual Project Schedule

Task	Expected	Actual
1.0 Site Visit	11/21/2016	11/21/2016
1.1 Filed Assessment	11/7/2016	11/7/2016
1.2 Sinclair Wash Document	11/14/2016	11/14/2016
1.3 Infrastructure Assessment	11/21/2016	11/21/2016
2.0 Data Collection	12/2/2016	1/2/2017
2.1 Surveying	11/26/2016	1/2/2017
3.0 Data Analysis	2/20/2017	2/25/2017
3.1 Geomorphic Assessment	2/10/2017	2/12/2017
3.2 Hydraulic Assessment	2/17/2017	2/20/2017
3.2.1 Existing condition Model	2/17/2017	2/20/2017
3.2.2 Proposed Condition Model	2/19/2017	2/22/2017
4.0 Design Alternative	3/20/2017	4/10/2017
4.1 Low Water Crossing	3/27/2017	4/1/2017
5.0 Project Management	5/9/2017	5/9/2017
5.1 50% Report	3/2/2017	3/2/2017
5.2 Final Presentation	4/28/2017	4/28/2017
5.3 Final Report	5/9/2017	5/9/2017

6.0 PROJECT COST

6.1 Cost of Services

The cost of the project consist of five main items which are the project manager, project engineer, lab technician, engineer in training and interns. Each one of the five main items has it is own rate, so project manager has a rate of 145$ per hour, project engineer is 85 $ per hour, lab technician is 65 $ per hour, engineer in training is 70 $ per hour and intern is 17 $ per hour. In addition, the surveying equipment is added to the project cost, and it has a rate of 130 $ per hour. Table 2 show the predicted cost of the project which is 56,845 $, but the actual cost of the project is 60,555 $ as seen in table 3. The difference in cost is because of surveying issues like weather condition and equipment failure that was a challenge for the team, and that led to increase the project cost.

Table 5: Predicted Project Cost.

Personnel	Classification	Hours	Rate ($/hr.)	Cost ($)
	Project Manger	80	145	11,600
	Project Engineer	130	85	11,050
	Lab Technician	190	65	14,300
	Engineer in Training	220	70	13,300
	Intern	235	17	3,995
Surveying Equipment		20	130	2,600
Total			**56,845**	

Table 6: Actual Project Cost

Personnel	Classification	Hours	Rate ($/hr.)	Cost ($)
	Project Manger	83	145	12,035
	Project Engineer	138	85	11,730
	Lab Technician	193	65	12,545
	Engineer in Training	241	70	16,870
	Intern	235	17	3,995
Surveying Equipment		26	130	3,380
Total		**60,555**		

6.2 Cost of Implementation

A research was conducted by the team to estimate the total value of project implementation. As can be seen in table 4, the cost of implementation consist of earth work, culvert removal, concrete slab and riprap. The design cost listed in table 4 were used from the Arizona of Transportation Historical Bid unit price lookup. The earth work cost 8 $ per yard, culvert removal is 16 $ per square feet, concrete slab is 92 $ per square feet and the Riprap cost 40 $ per yard, so the total cost of implementation came out to 22,568 $.

Table 7: Design Implantation Cost.

Item	**Unit**	**Quantity**	**Unit Cost**	**Total**
Earth Work	40 (yard)	1	8 $ per yard	320 $
Culvert Removal	18 (Square feet)	3	16 $ per square feet	288 $
Concrete Slab	230 (Square feet)	1	92 $ per square feet	21160 $
Riprap	20 (Square yard)	1	40 $ per square yard	800 $
Total Cost	22568 $			

7.0 IMPACT ANALYSIS

7.1 ECONOMIC IMPACTS

One of the problems that the project design solves is the problem of the old non-sufficient culverts. Since the design consist of removing the culverts and implementing the new low water crossing design, no culvert maintenance will be needed, which saves budget. Another problem that the design solves is that some weak points of the wash are subject to be flooded. Improving the conditions of the wash and solving this problem will also save money that would have been spent for fixing flood damages.

7.2 SOCIAL IMPACTS

Selected design improves the wash and makes it more attractive for users. Since no flooding problems will occur after implementing the design, lives of people living nearby the reach will be safer.

7.3. ENVIRONMENTAL IMPACTS

Improving the wash conditions means improving the wildlife and vegetation in the wash. More animals will be able to live within this area, and more plants will exist.

8.0 REFERENCES

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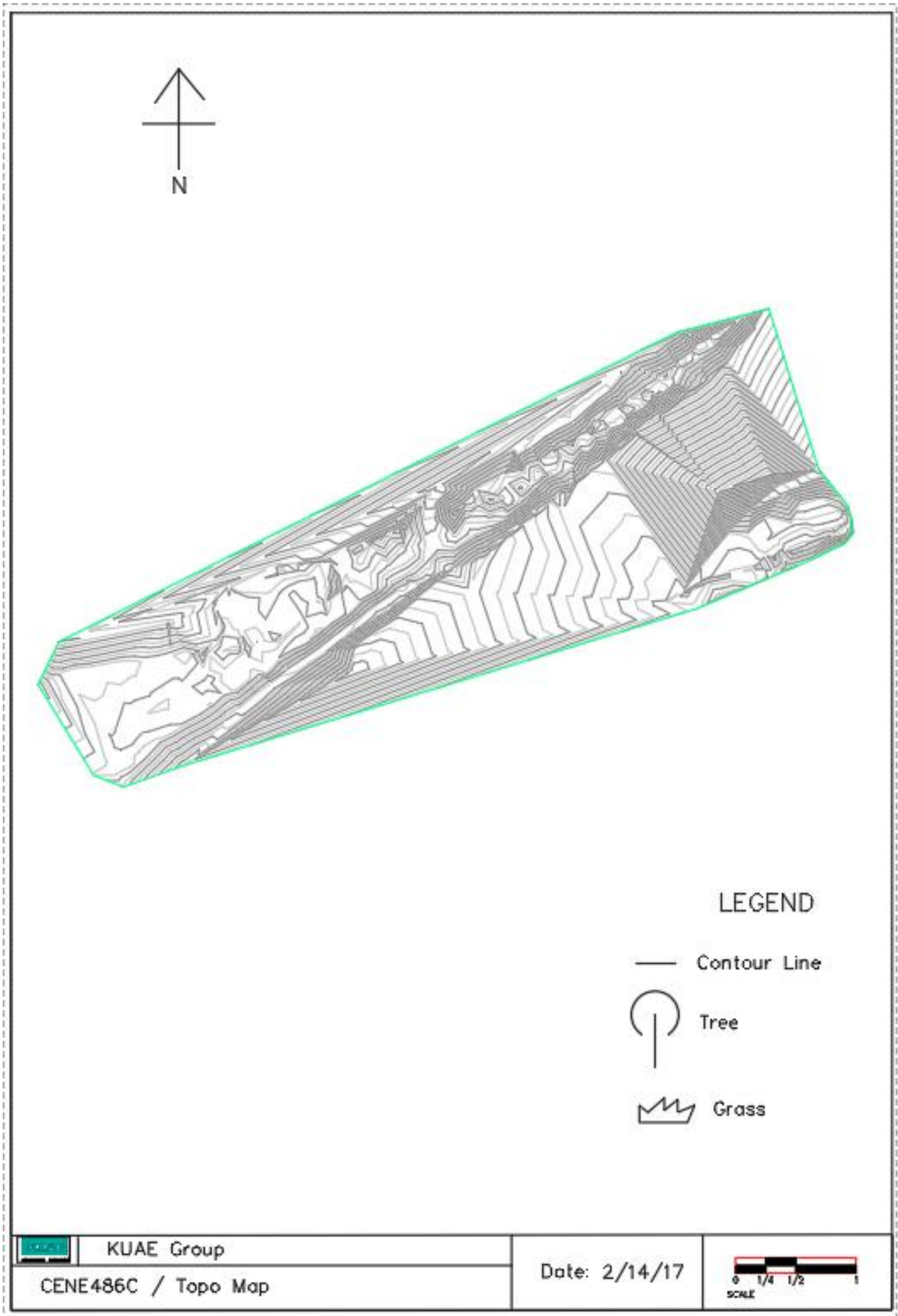
9.0 APPENDECIES

Appendix A

Surveying Results

Data collection	Definition
Benchmark	Occupation Point
CP	Control Point
leftB	Left bank
MC	Main Channel
rightB	Right Bank
GR	Grass
TR	Trail
UT	Utility
CL	Culvert upstream left
CR	Culvert upstream right
CM	Culvert upstream middle
FL	Flood plain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LEGEND
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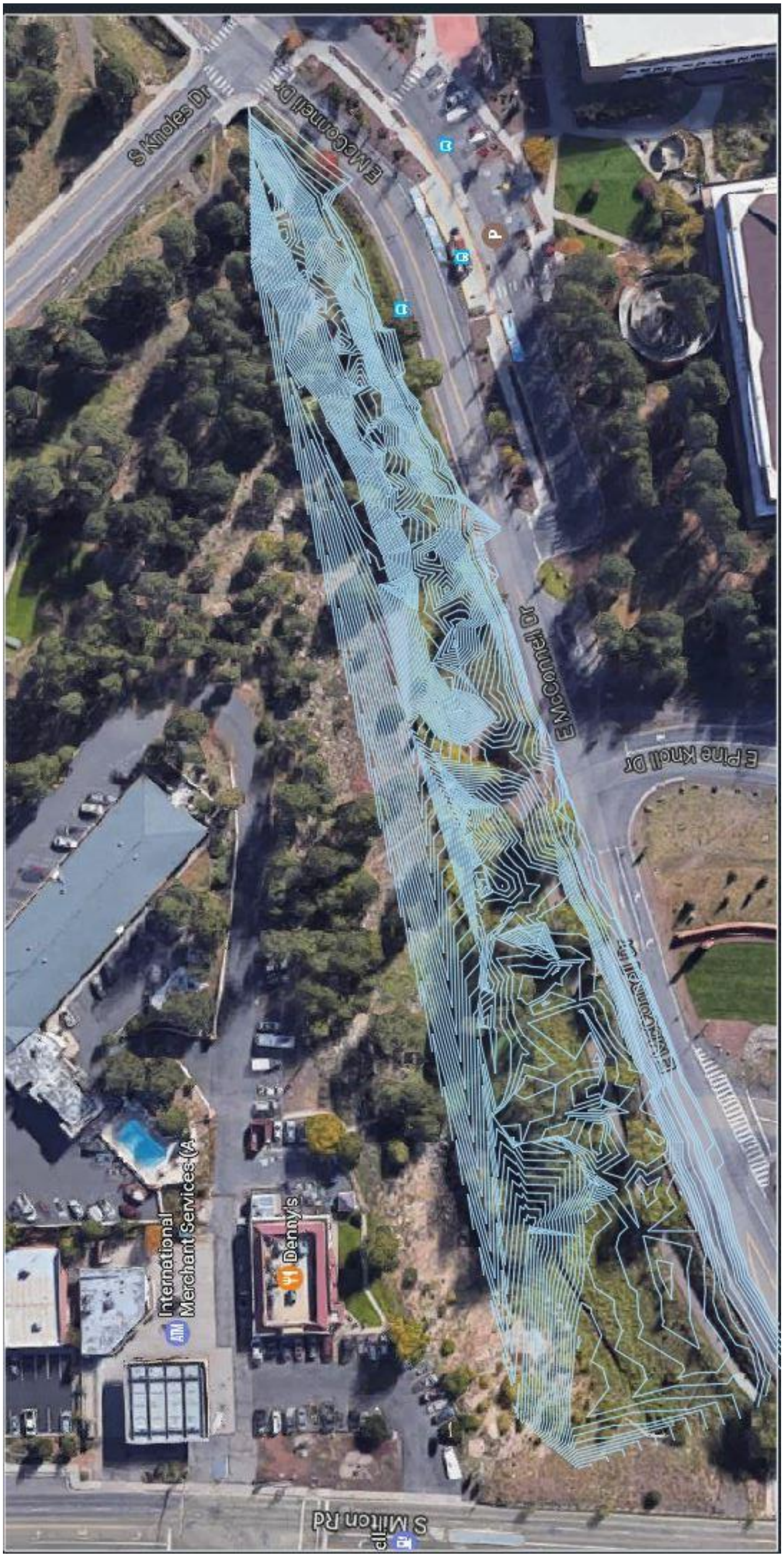
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Merchant Services
Denny's
S Milton Rd

Appendix B

Reach Geomorphology Results

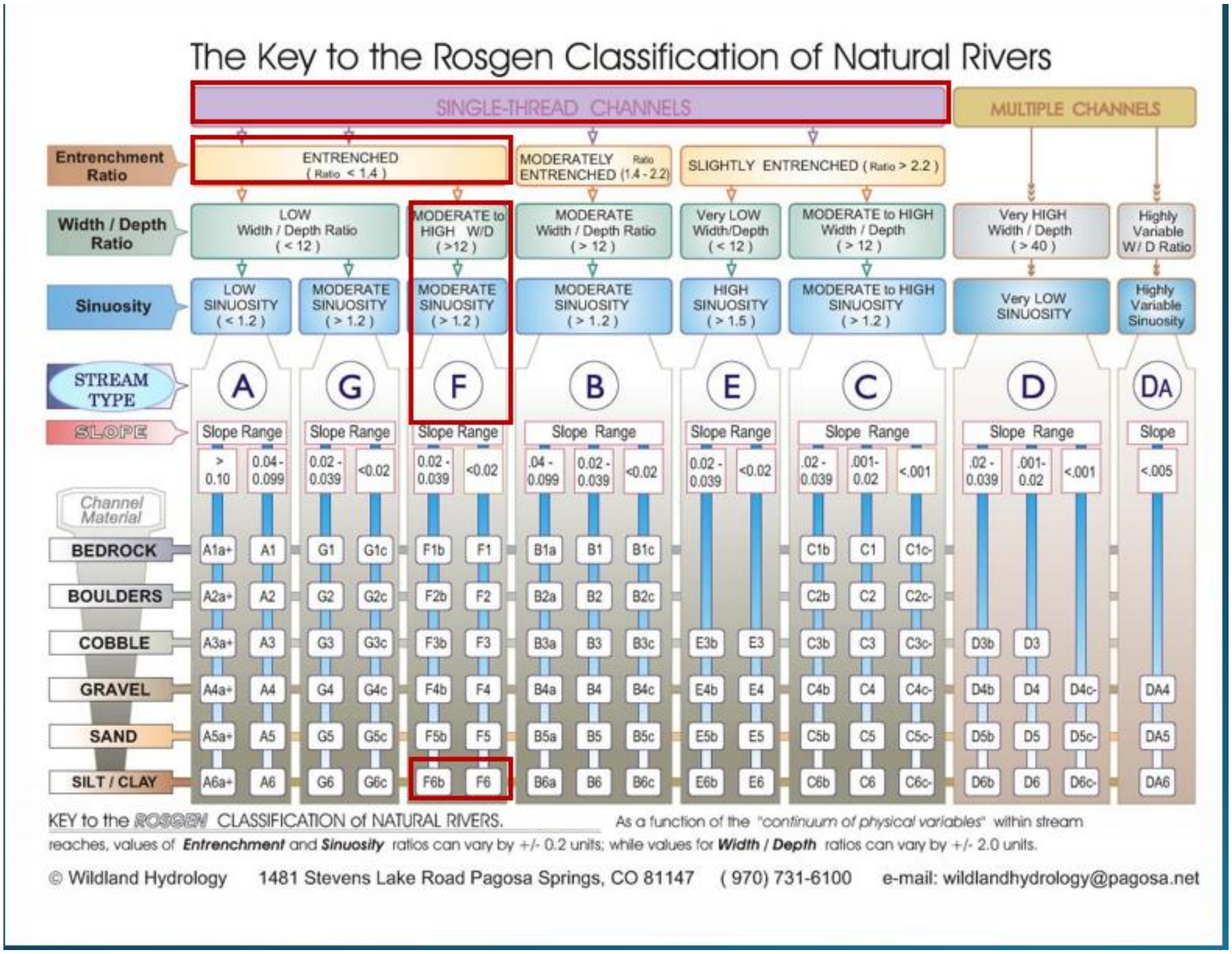


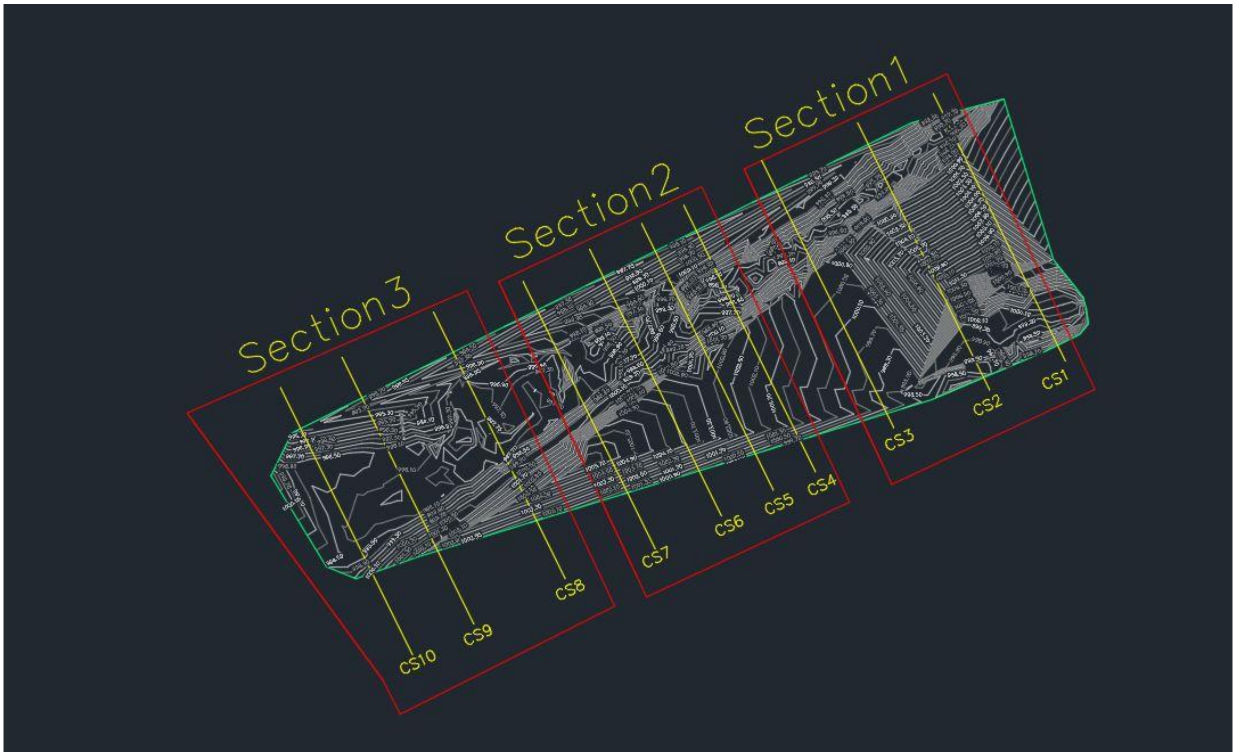
Figure 11 Rosgen Method

Table 8 Rosgen Method Results

Location	I-17 East McConnell Drive
Bankfull WIDTH (ft)	73.79
Channel Bottom Width (ft)	18.00
Bankfull DEPTH (ft)	5.25
Bankfull X-Section AREA (ft^2)	240.95
Width/Depth Ratio	14.06
Maximum DEPTH (ft)	5.33
WIDTH of Flood-Prone Area (ft)	10.67
Entrenchment Ratio	0.14
Channel Material Size (mm)	3.00
Water Surface Slope	0.01
Channel Sinuosity	1.3
Stream Classification	F

Appendix C

Cross-Section for Existing Condition Model



Appendix D

HEC-RAS Existing Condition Model Results

2-year model results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	130.00	997.00	1000.71	998.33	1000.72	0.000212	0.83	156.88	67.48	0.10
1	695		Culvert									
1	650	PF 1	130.00	997.00	1000.56		1000.57	0.000263	0.89	146.67	67.48	0.11
1	532	PF 1	130.00	996.00	1000.54		1000.55	0.000128	0.68	189.85	75.78	0.08
1	430	PF 1	130.00	996.00	1000.53		1000.54	0.000057	0.69	189.12	75.69	0.08
1	380	PF 1	130.00	996.00	1000.53	997.26	1000.54	0.000020	0.42	306.95	114.70	0.05
1	340		Culvert									
1	301	PF 1	130.00	996.00	997.68		997.69	0.000161	0.66	196.42	181.65	0.11
1	300	PF 1	130.00	996.50	997.64		997.66	0.000699	1.10	117.79	152.24	0.22
1	299	PF 1	130.00	996.50	997.58		997.60	0.000918	1.21	107.59	148.86	0.25
1	220	PF 1	130.00	996.46	997.49		997.52	0.001132	1.39	93.73	123.46	0.28
1	118	PF 1	130.00	996.50	997.08	997.08	997.25	0.019699	3.26	39.86	124.04	1.01
1	77	PF 1	130.00	993.00	996.84	994.42	996.85	0.000194	0.92	141.97	92.08	0.13
1	3		Culvert									
1	0	PF 1	130.00	993.00	994.76	994.05	994.81	0.002428	1.72	75.54	69.11	0.29

10-year model results

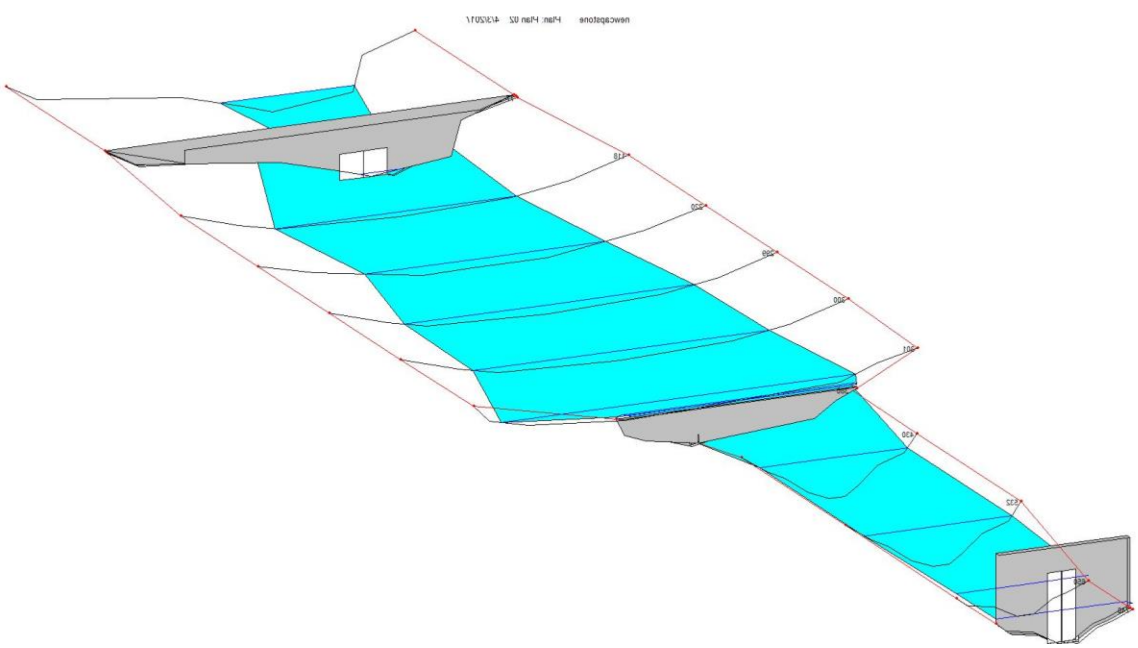
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	350.00	997.00	1001.98	999.16	1002.01	0.000377	1.44	242.58	67.48	0.13
1	695		Culvert									
1	650	PF 1	350.00	997.00	1001.17		1001.23	0.000850	1.86	188.30	67.48	0.20
1	532	PF 1	350.00	996.00	1001.12		1001.16	0.000498	1.49	235.51	81.44	0.15
1	430	PF 1	350.00	996.00	1001.08		1001.12	0.000230	1.51	232.33	81.06	0.16
1	380	PF 1	350.00	996.00	1001.09	997.92	1001.10	0.000078	0.94	370.45	114.70	0.09
1	340		Culvert									
1	301	PF 1	350.00	996.00	998.56		998.57	0.000168	0.96	365.52	200.58	0.13
1	300	PF 1	350.00	996.50	998.53		998.55	0.000424	1.30	268.43	185.76	0.19
1	299	PF 1	350.00	996.50	998.49		998.52	0.000459	1.34	261.61	184.65	0.20
1	220	PF 1	350.00	996.46	998.44		998.47	0.000591	1.47	237.51	175.38	0.22
1	118	PF 1	350.00	996.50	998.39		998.42	0.000568	1.44	243.76	181.73	0.22
1	77	PF 1	350.00	993.00	998.37	995.22	998.39	0.000156	1.01	347.68	166.93	0.12
1	3		Culvert									
1	0	PF 1	350.00	993.00	995.70	994.57	995.79	0.002481	2.36	148.13	85.33	0.32

50-year model results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	670.00	997.00	1003.98	999.81	1004.03	0.000339	1.77	377.93	67.48	0.13
1	695		Culvert									
1	650	PF 1	670.00	997.00	1001.80		1001.93	0.001630	2.91	230.32	67.48	0.28
1	532	PF 1	670.00	996.00	1001.70		1001.78	0.001072	2.36	283.84	87.04	0.23
1	430	PF 1	670.00	996.00	1001.61		1001.70	0.000516	2.43	276.08	86.16	0.24
1	380	PF 1	670.00	996.00	1001.62	998.60	1001.65	0.000175	1.55	431.34	114.70	0.14
1	340		Culvert									
1	301	PF 1	670.00	996.00	999.07		999.11	0.000284	1.42	471.50	211.78	0.17
1	300	PF 1	670.00	996.50	999.02		999.07	0.000626	1.84	363.62	200.54	0.24
1	299	PF 1	670.00	996.50	998.96		999.02	0.000688	1.90	352.34	198.85	0.25
1	220	PF 1	670.00	996.46	998.89		998.95	0.000908	2.10	318.99	190.96	0.29
1	118	PF 1	670.00	996.50	998.81		998.87	0.000900	2.08	322.03	194.22	0.28
1	77	PF 1	670.00	993.00	998.77	996.11	998.81	0.000341	1.61	416.17	177.47	0.19
1	3		Culvert									
1	0	PF 1	670.00	993.00	996.86	995.11	996.96	0.002102	2.51	266.47	123.39	0.30

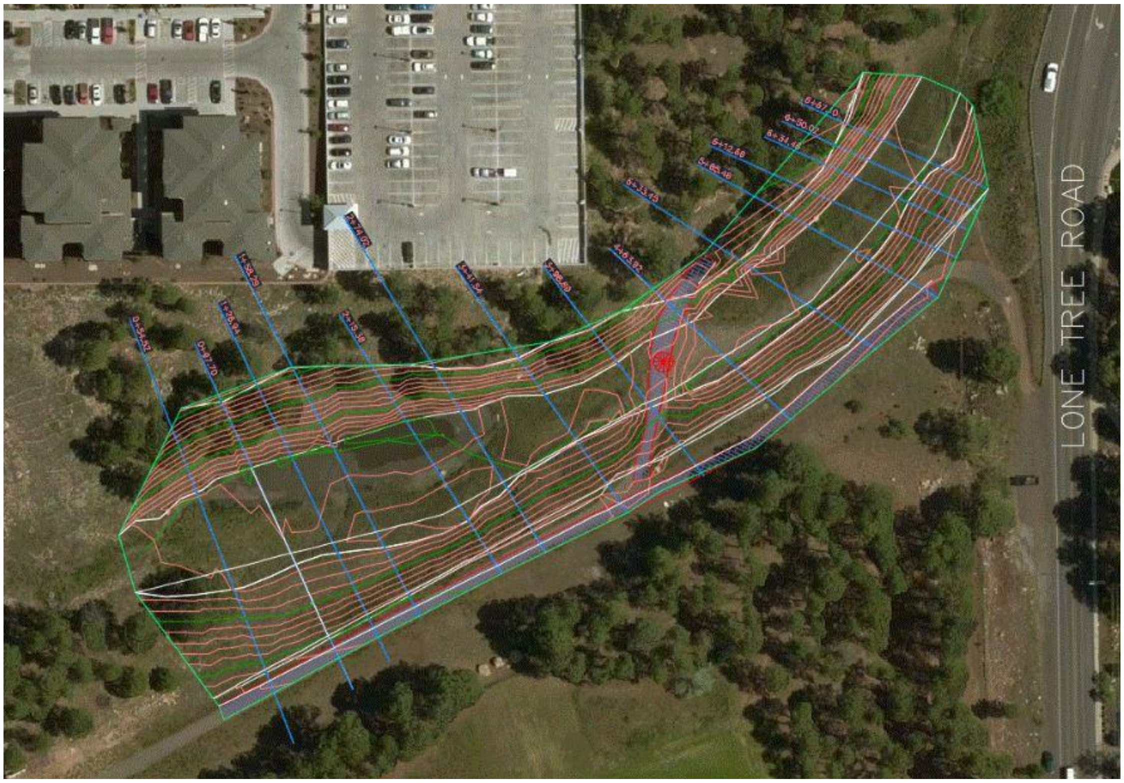
100-year model results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	890.00	997.00	1005.38	1000.14	1005.43	0.000299	1.89	472.04	67.48	0.13
1	695		Culvert									
1	650	PF 1	890.00	997.00	1002.21		1002.39	0.001998	3.45	258.09	67.48	0.31
1	532	PF 1	890.00	996.00	1002.09		1002.21	0.001348	2.79	318.75	90.00	0.26
1	430	PF 1	890.00	996.00	1001.97		1002.10	0.000665	2.89	308.25	89.73	0.27
1	380	PF 1	890.00	996.00	1001.99	998.89	1002.04	0.000228	1.88	474.00	114.70	0.16
1	340		Culvert									
1	301	PF 1	890.00	996.00	1000.05		1000.08	0.000156	1.29	689.36	228.00	0.13
1	300	PF 1	890.00	996.50	1000.03		1000.06	0.000278	1.53	581.05	230.00	0.17
1	299	PF 1	890.00	996.50	1000.00		1000.04	0.000287	1.55	575.67	230.00	0.17
1	220	PF 1	890.00	996.46	999.97		1000.02	0.000337	1.63	547.60	229.08	0.19
1	118	PF 1	890.00	996.50	999.95		999.99	0.000306	1.58	562.93	228.42	0.18
1	77	PF 1	890.00	993.00	999.93	996.65	999.96	0.000178	1.39	639.33	208.14	0.14
1	3		Culvert									
1	0	PF 1	890.00	993.00	997.26	995.42	997.38	0.002383	2.79	318.89	138.70	0.32



Appendix E

Bankfull Information



BANKFULL LOCATION	BANKFULL X-SECTION AREA (FT)	BANKFULL WIDTH (FT)	BANKFULL DEPTH (FT)
S FRANSISCO & S LONE TREE	44	23	1.5

Appendix F

HEC-RAS Proposed Condition Model Results

2-year model results

HEC-RAS Plan: 2-yr-after River: Sinclair Wash Reach: 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	130.00	997.00	999.35	998.33	999.40	0.002590	1.90	68.60	57.00	0.30
1	695		Culvert									
1	650	PF 1	130.00	997.00	998.69		998.89	0.013515	3.65	35.65	38.28	0.67
1	532	PF 1	130.00	996.00	998.24		998.32	0.002867	2.26	57.61	39.62	0.33
1	430	PF 1	130.00	996.00	997.80		997.95	0.003256	3.15	41.25	34.78	0.51
1	380	PF 1	130.00	995.98	997.54		997.64	0.002674	2.48	52.40	54.77	0.45
1	301	PF 1	130.00	995.98	997.58		997.60	0.000160	1.09	119.80	134.70	0.20
1	300	PF 1	130.00	996.51	997.54		997.58	0.000409	1.49	87.28	123.51	0.31
1	299	PF 1	130.00	996.19	997.53		997.55	0.000219	1.24	104.52	121.37	0.24
1	220	PF 1	130.00	996.45	997.45		997.50	0.002573	1.94	67.09	99.01	0.42
1	118	PF 1	130.00	996.15	996.79	996.79	997.02	0.017306	3.83	33.91	75.14	1.01
1	77	PF 1	130.00	993.00	996.84	994.42	996.85	0.000194	0.92	141.97	92.08	0.13
1	3		Culvert									
1	0	PF 1	130.00	993.00	994.76	994.05	994.81	0.002428	1.72	75.54	69.11	0.29

10-year model results

HEC-RAS Plan: 100-after River: Sinclair Wash Reach: 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	350.00	997.00	1001.50	999.17	1001.55	0.000592	1.66	210.64	67.48	0.17
1	695		Culvert									
1	650	PF 1	350.00	997.00	999.82		1000.02	0.006894	3.59	97.43	64.62	0.52
1	532	PF 1	350.00	996.00	999.33		999.50	0.003976	3.23	108.32	55.53	0.41
1	430	PF 1	350.00	996.00	998.63		998.98	0.004572	4.72	74.21	43.98	0.64
1	380	PF 1	350.00	995.98	998.45		998.60	0.002415	3.04	115.21	82.36	0.45
1	301	PF 1	350.00	995.98	998.52		998.55	0.000109	1.26	278.04	188.44	0.18
1	300	PF 1	350.00	996.51	998.50		998.53	0.000179	1.51	231.07	171.58	0.23
1	299	PF 1	350.00	996.19	998.49		998.52	0.000141	1.42	246.88	169.50	0.21
1	220	PF 1	350.00	996.45	998.45		998.49	0.000959	1.76	198.64	161.23	0.28
1	118	PF 1	350.00	996.15	998.39		998.43	0.000605	1.54	227.43	160.15	0.23
1	77	PF 1	350.00	993.00	998.37	995.22	998.39	0.000156	1.01	347.68	166.93	0.12
1	3		Culvert									
1	0	PF 1	350.00	993.00	995.70	994.57	995.79	0.002481	2.36	148.13	85.33	0.32

50-year model results

HEC-RAS Plan: 100-after River: Sinclair Wash Reach: 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	670.00	997.00	1003.93	999.79	1003.98	0.000348	1.79	374.53	67.48	0.13
1	695		Culvert									
1	650	PF 1	670.00	997.00	1000.79		1001.06	0.005003	4.12	162.65	67.48	0.47
1	532	PF 1	670.00	996.00	1000.36		1000.59	0.004214	3.80	176.29	74.01	0.43
1	430	PF 1	670.00	996.00	999.13	998.91	999.86	0.008244	6.89	97.30	50.87	0.88
1	380	PF 1	670.00	995.98	998.86		999.17	0.004144	4.45	150.63	91.12	0.61
1	301	PF 1	670.00	995.98	999.02		999.07	0.000164	1.78	375.66	204.60	0.23
1	300	PF 1	670.00	996.51	998.98		999.05	0.000259	2.10	318.37	190.34	0.29
1	299	PF 1	670.00	996.19	998.96		999.03	0.000222	2.02	332.25	188.58	0.27
1	220	PF 1	670.00	996.45	998.90		998.99	0.001372	2.43	275.95	181.20	0.35
1	118	PF 1	670.00	996.15	998.80		998.88	0.001044	2.25	297.49	178.10	0.31
1	77	PF 1	670.00	993.00	998.77	996.11	998.81	0.000341	1.61	416.17	177.47	0.19
1	3		Culvert									
1	0	PF 1	670.00	993.00	996.86	995.11	996.96	0.002102	2.51	266.47	123.39	0.30

100-year model results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	740	PF 1	890.00	997.00	1005.37	1000.14	1005.43	0.000299	1.89	471.82	67.48	0.13
1	695		Culvert									
1	650	PF 1	890.00	997.00	1001.27		1001.59	0.004931	4.57	194.75	67.48	0.47
1	532	PF 1	890.00	996.00	1000.85		1001.12	0.004272	4.17	213.48	78.76	0.45
1	430	PF 1	890.00	996.00	999.92		1000.51	0.005776	6.15	144.69	68.70	0.75
1	380	PF 1	890.00	995.98	999.93		1000.11	0.001583	3.42	260.14	113.28	0.40
1	301	PF 1	890.00	995.98	1000.03		1000.06	0.000072	1.49	596.82	228.00	0.16
1	300	PF 1	890.00	996.51	1000.01		1000.05	0.000104	1.66	534.79	230.00	0.19
1	299	PF 1	890.00	996.19	1000.00		1000.04	0.000095	1.62	549.46	230.00	0.18
1	220	PF 1	890.00	996.45	999.98		1000.03	0.000464	1.79	497.64	229.03	0.21
1	118	PF 1	890.00	996.15	999.95		999.99	0.000374	1.68	529.47	227.66	0.19
1	77	PF 1	890.00	993.00	999.93	996.65	999.96	0.000178	1.39	639.33	208.14	0.14
1	3		Culvert									
1	0	PF 1	890.00	993.00	997.26	995.42	997.38	0.002383	2.79	318.89	138.70	0.32