

City of Flagstaff Switzer Wash Regional Drainage Plan

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CENE 486 FINAL PRESENTATION

APRIL 24, 2020

Project Introduction

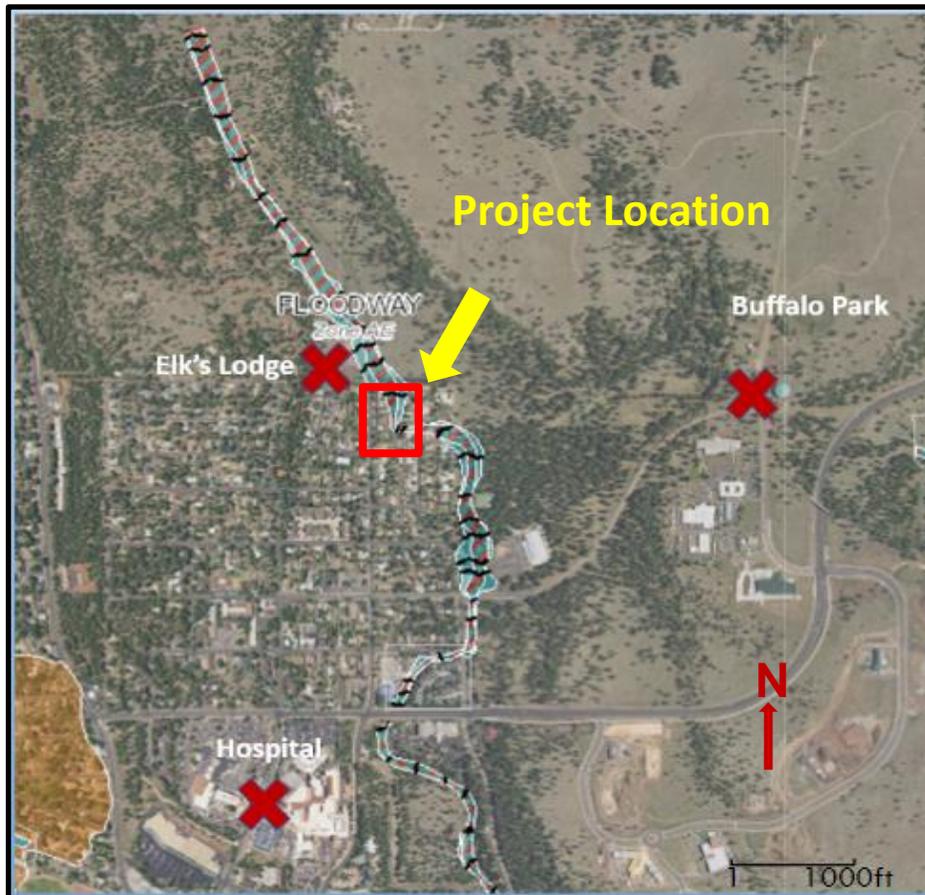


Figure 1: Aerial Map of Project Location and Floodplain [1]

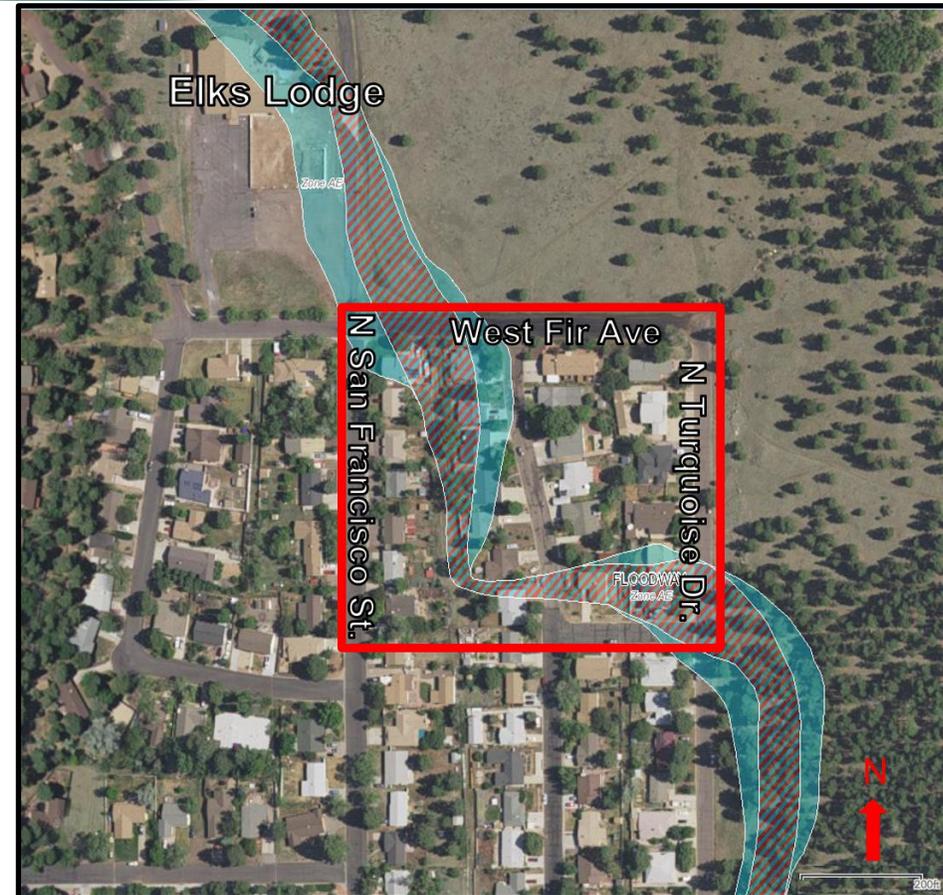


Figure 2: Aerial Map of Project Location and Area of Focus [2]

Project Introduction



Figure 3: Channel Pooling North of Elk's Lodge



Figure 4: North Fir Ave. Flooded



Figure 5: North Fir Ave. Flooded Alt.

Task 1: Site Investigation

- ▶ Performed Site Investigation
 - ▶ Stream Reach Field Inventory Forms
 - ▶ Measure Existing Culverts
- ▶ Found and Reviewed As-Builts
 - ▶ Elevations/Lengths of Culverts
 - ▶ Length/Slope of Channel of Interest
- ▶ Completed Auto Level Survey
 - ▶ Cross Sections

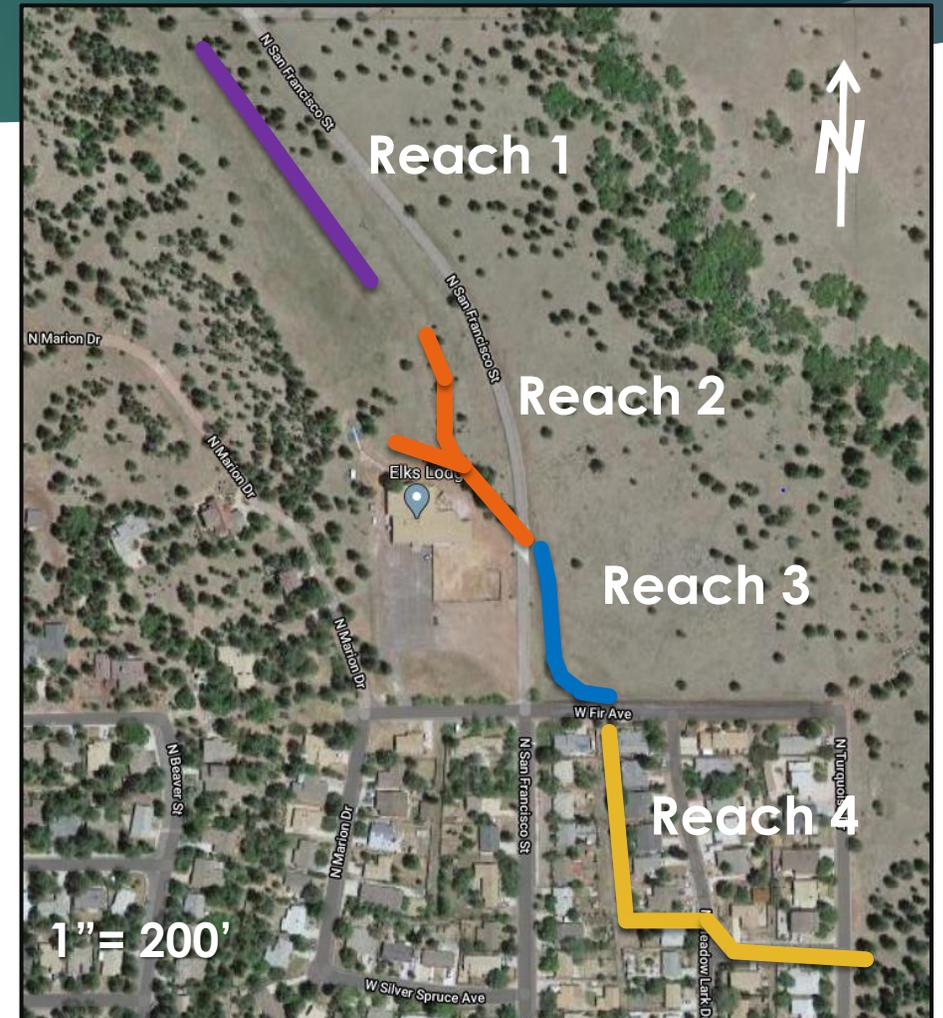


Figure 6: Aerial View of Switzer Canyon Wash with Reaches [1]

Surveying



[7]



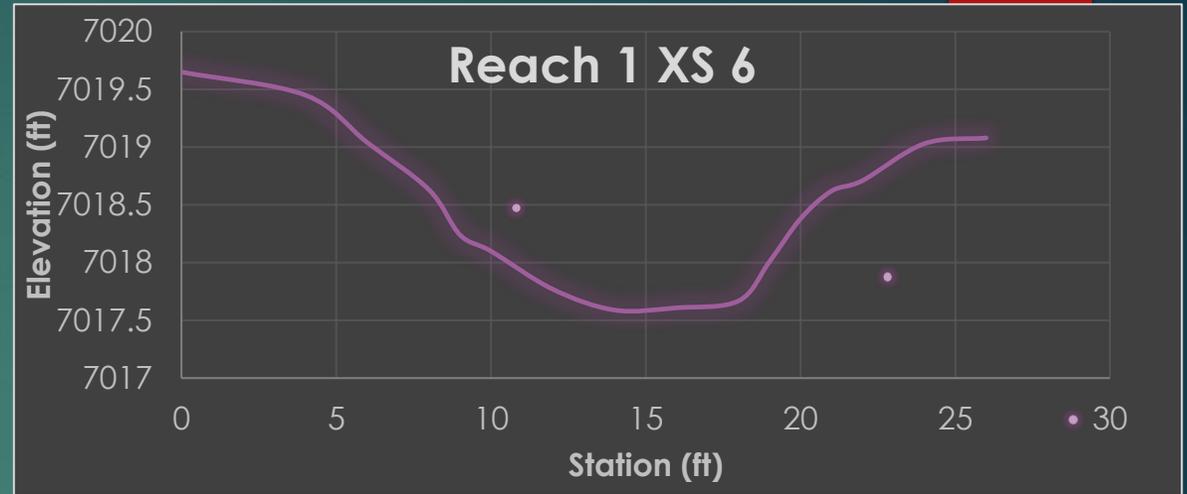
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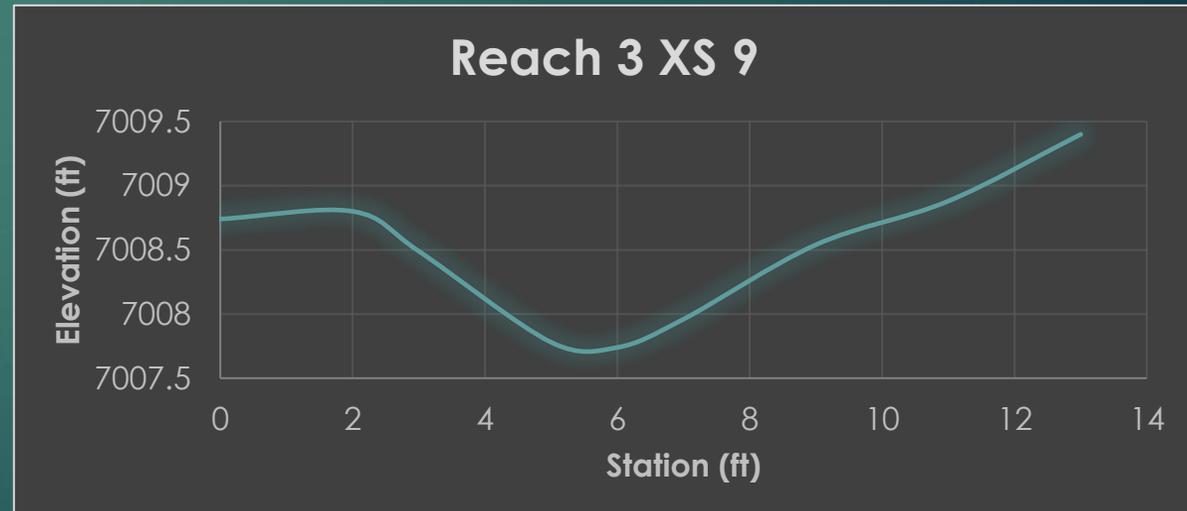
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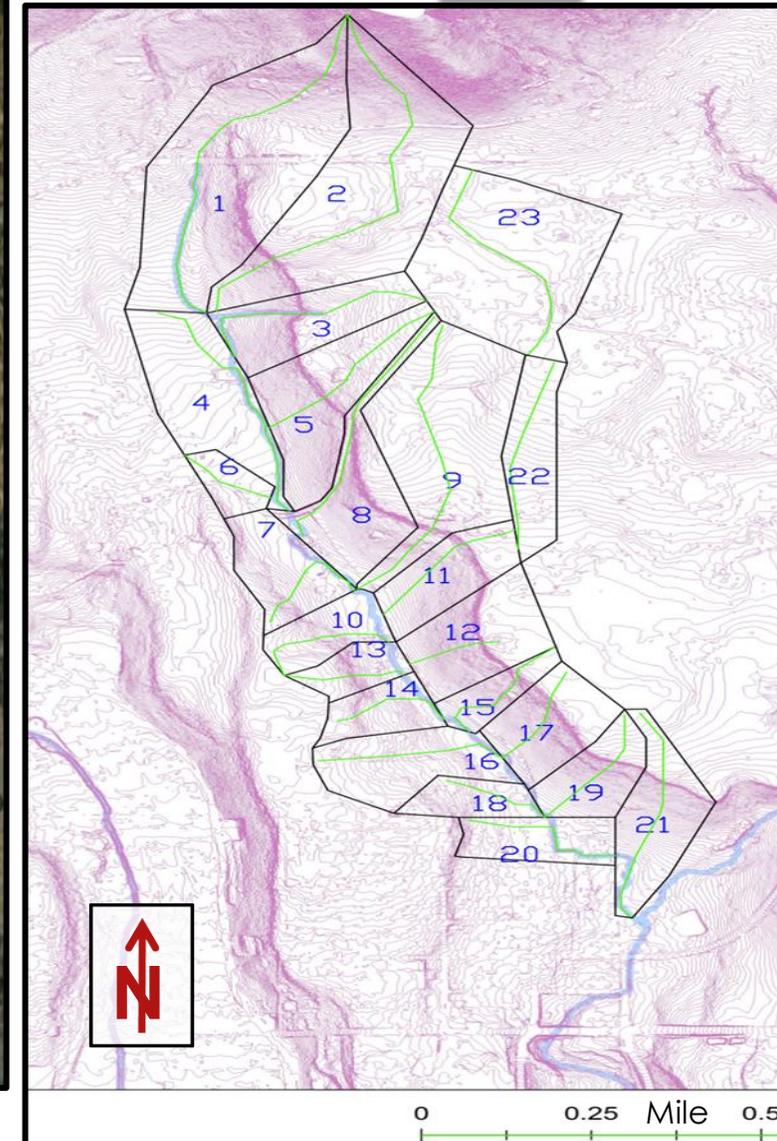
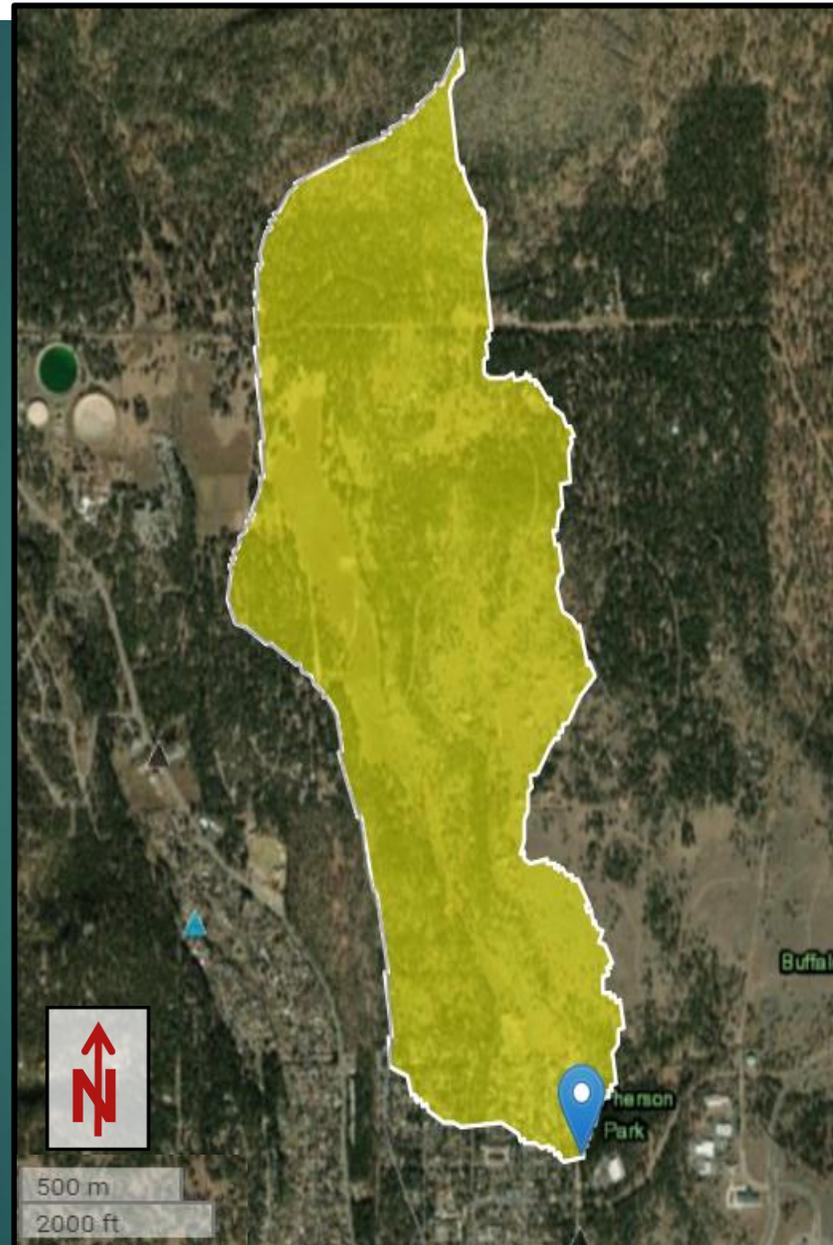
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Figures 7-10: Kara; Gindiri; Noah; Celine

Figures 11-12: Switzer Wash Existing CS Reach 1; Reach 3

Task 2: Hydrology

- ▶ Basin Delineation
 - ▶ Major Basin Delineation
 - ▶ Sub-Basin Delineation
- ▶ Time of Concentration
 - ▶ Flow Routing
 - ▶ Rainfall Intensities
- ▶ Determine Flow Rate at Concentration Points
 - ▶ Compare Found Results to FEMA results



Figures 13-14: Major Basin and Sub-Basin Outlines

Hydrology Results

- ▶ Methodology followed: Rational Method
- ▶ Weighted C found using Google Earth/Arc GIS
- ▶ Area, Weighted C, and Tc were used together to determine Flow Rate

Table 1: 100-yr Storm Output

Stream	Location	FEMA [8]	Team	Percent Error
		Q100 (cfs)	Q100 (cfs)	%
Switzer	At confluence with Silver Spruce Ave. Wash	800	829	3.60

Task 3: Conceptual Stormwater Management Approaches

- ▶ Research Approaches for Design
- ▶ Compare based on conveyance of 100-year storm event
- ▶ Select Final Design Approach
 - ▶ Decision Matrix

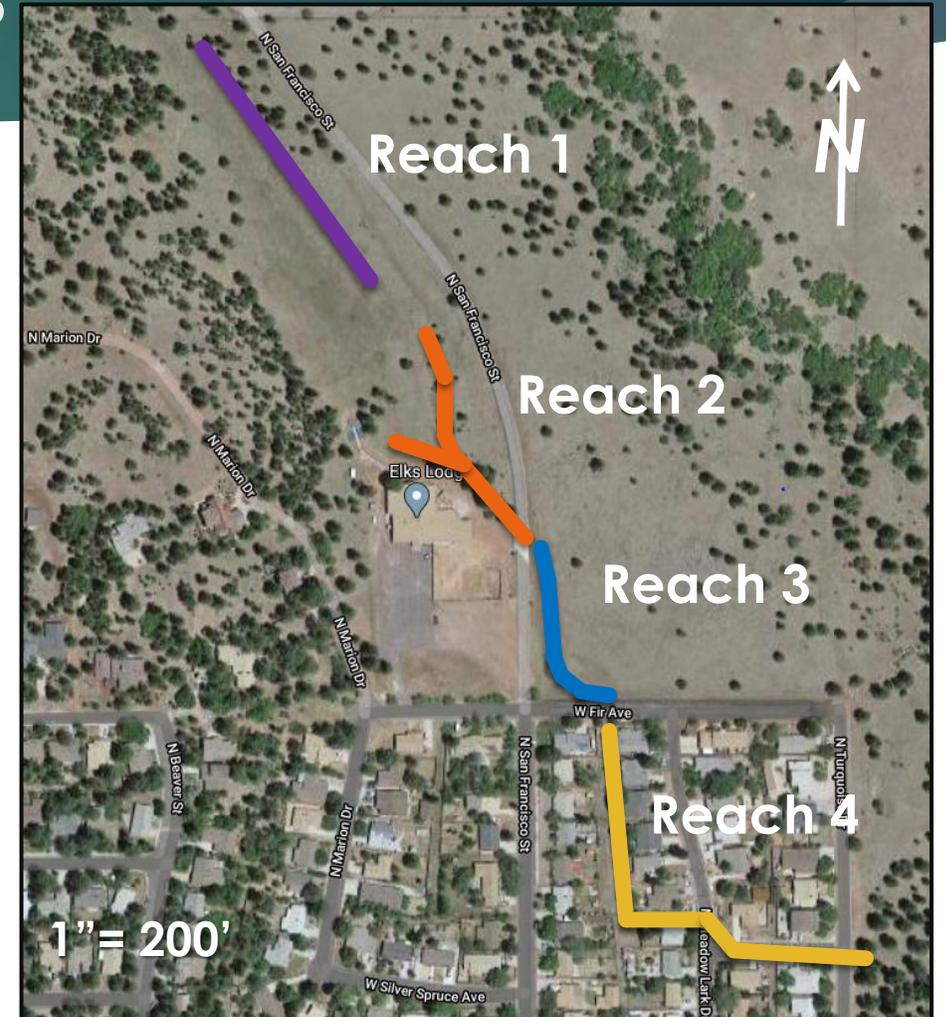


Figure 15: vSwitzer Wash with Channel Reaches [1]

Natural Channel

- ▶ Adding Missing 275 Feet (GREEN LINE)
- ▶ Modifying (Enlarging) Channel to Convey 100-yr flow
- ▶ Revegetating Reaches 1, 2, and 4



Figure 16: Switzer Wash with Natural Channel Modification [1]

Natural Channel/Culvert Bypass

- ▶ Includes 1st Natural Channel Modification
- ▶ Channel Bypass
 - ▶ Connect to Downstream Culvert



Figure 17: Switzer Wash with Natural Channel and Channel Bypass [1]

Detention/LID Basin and Extended Detention Basin

- ▶ Detention Basin north of Elk's Lodge
- ▶ Existing small pond
- ▶ Forebay: Maximum 4 acres
- ▶ Micro-Pool: Maximum 4 acres

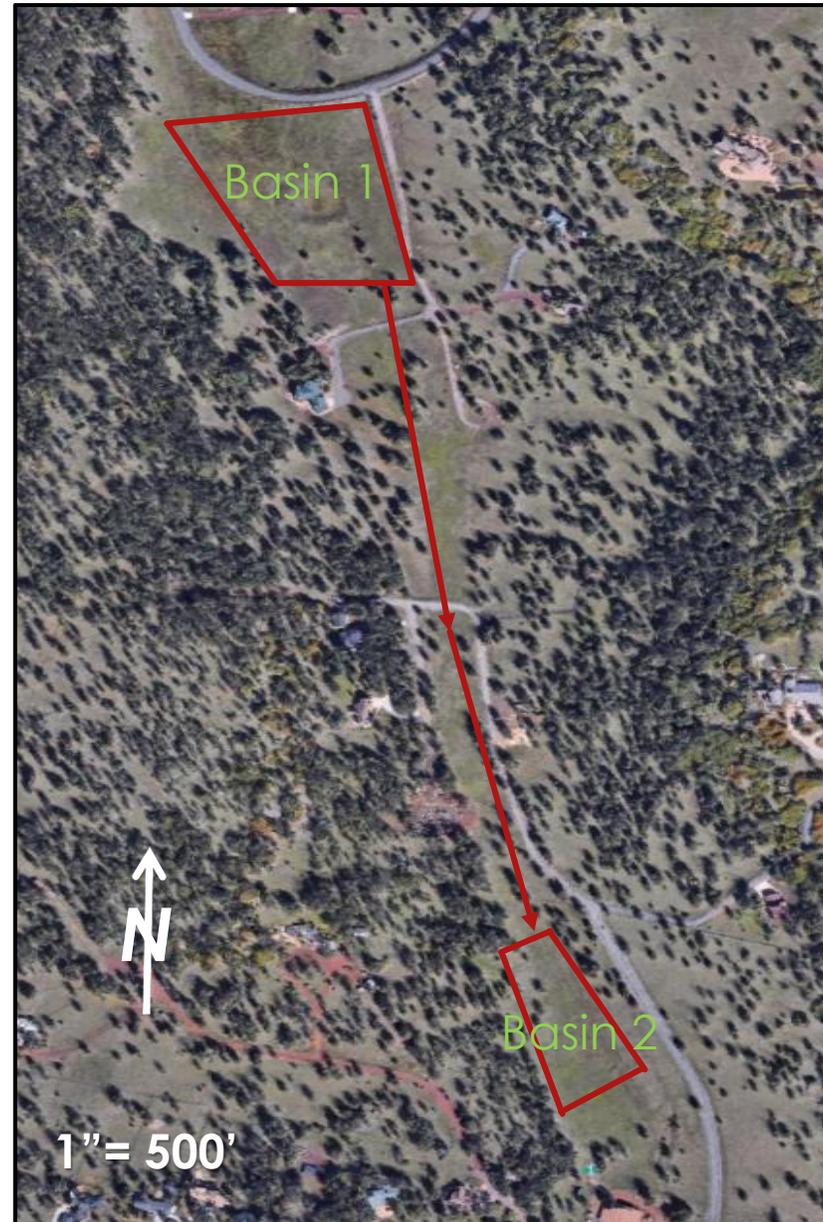


Figure 18: Switzer Wash with Detention Basins [1]

Wetlands

- ▶ Located above Elk's Lodge
- ▶ Original thought: Approx. 4 Acres
- ▶ Extend further North of area



Figure 19: Switzer Wash with Wetland [1]

Upper Basin and Natural Channel

- ▶ Upper Detention Basin located at small pond
 - ▶ Privately owned land
- ▶ Natural Channel Modification from 1st Alternative
 - ▶ Detention Basin will decrease incoming flow to channel

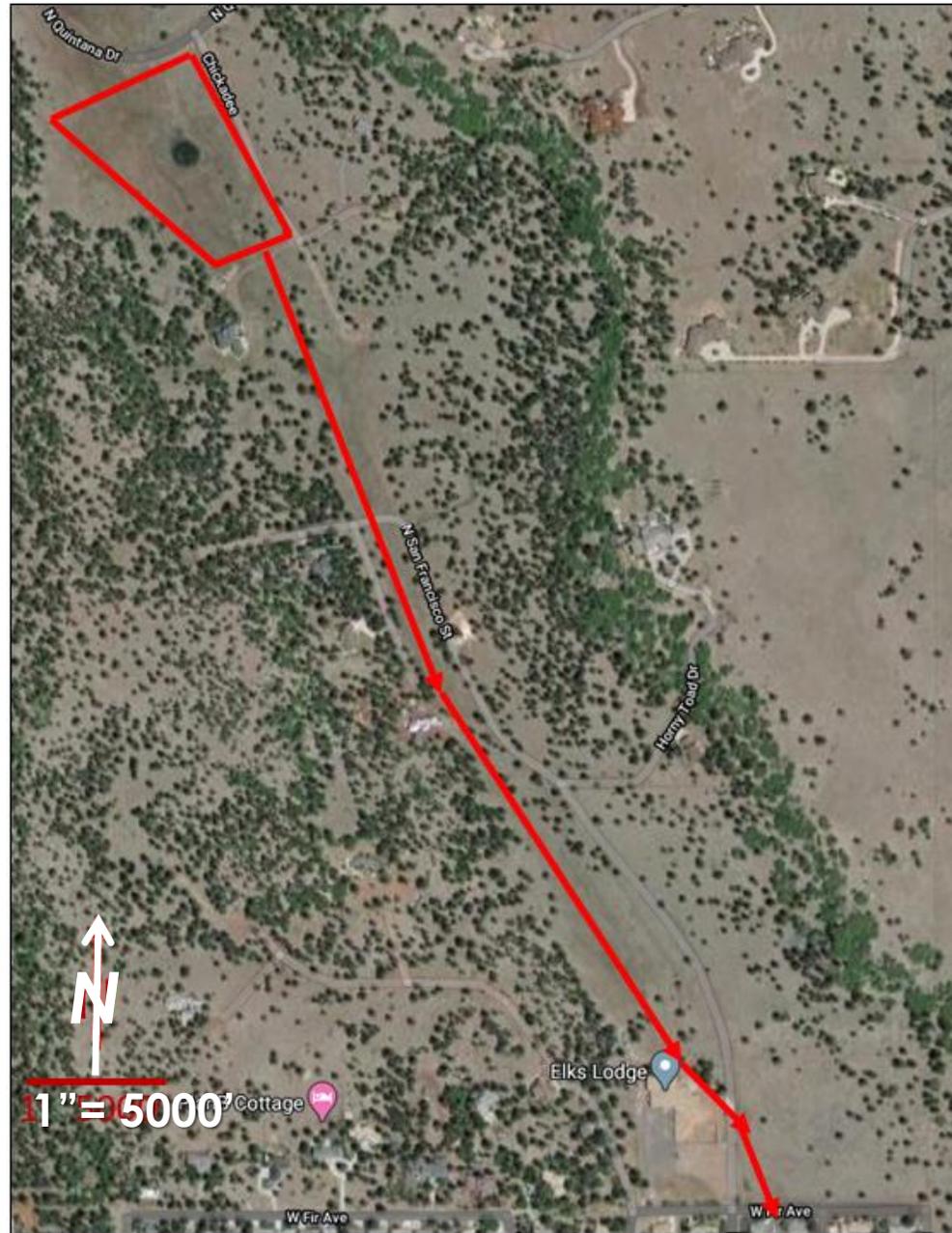


Figure 20: Switzer Wash with Upper Basin and Natural Channel [1]

Selection of Final Alternative

Table 2: Decision Matrix

	Cost/Benefit		Environmental/Social Impact		OM		Area Needed		Appeal		Total
	Weight	Score	Weight	Score	Weight	Score	Weight	Score	Weight	Score	
Natural Channel	2	0.4	4	0.8	5	1	3	0.6	3	0.6	3.4
Natural Channel/culvert bypass	4	0.8	3	0.6	4	0.8	4	0.8	4	0.8	3.8
Extended Basins	1.5	0.3	2	0.4	2	0.4	1	0.2	2	0.4	1.7
Detention Basin/LID basin	2	0.4	3	0.6	2	0.4	1	0.2	3	0.6	2.2
Wetlands	1	0.2	4	0.8	1	0.2	2	0.4	2	0.4	2
Upper Basin+ Natural Channel	4	0.8	3	0.6	3	0.6	3	0.6	4	0.8	3.4
WLB basin	3	0.6	2	0.4	3	0.6	3	0.6	0	0	2.2

Scoring Scale: 1 to 5

Task 4: Hydraulics

- ▶ Existing Open Channel Modeling
 - ▶ HEC-RAS
 - ▶ Cross Sections
 - ▶ Culvert Under Road
 - ▶ Compare 100-yr, 50-yr, 25-yr, and 10-yr flows
- ▶ Proposed Design Hydraulics
 - ▶ Channel Design
 - ▶ Culvert Design
 - ▶ Construction Costs

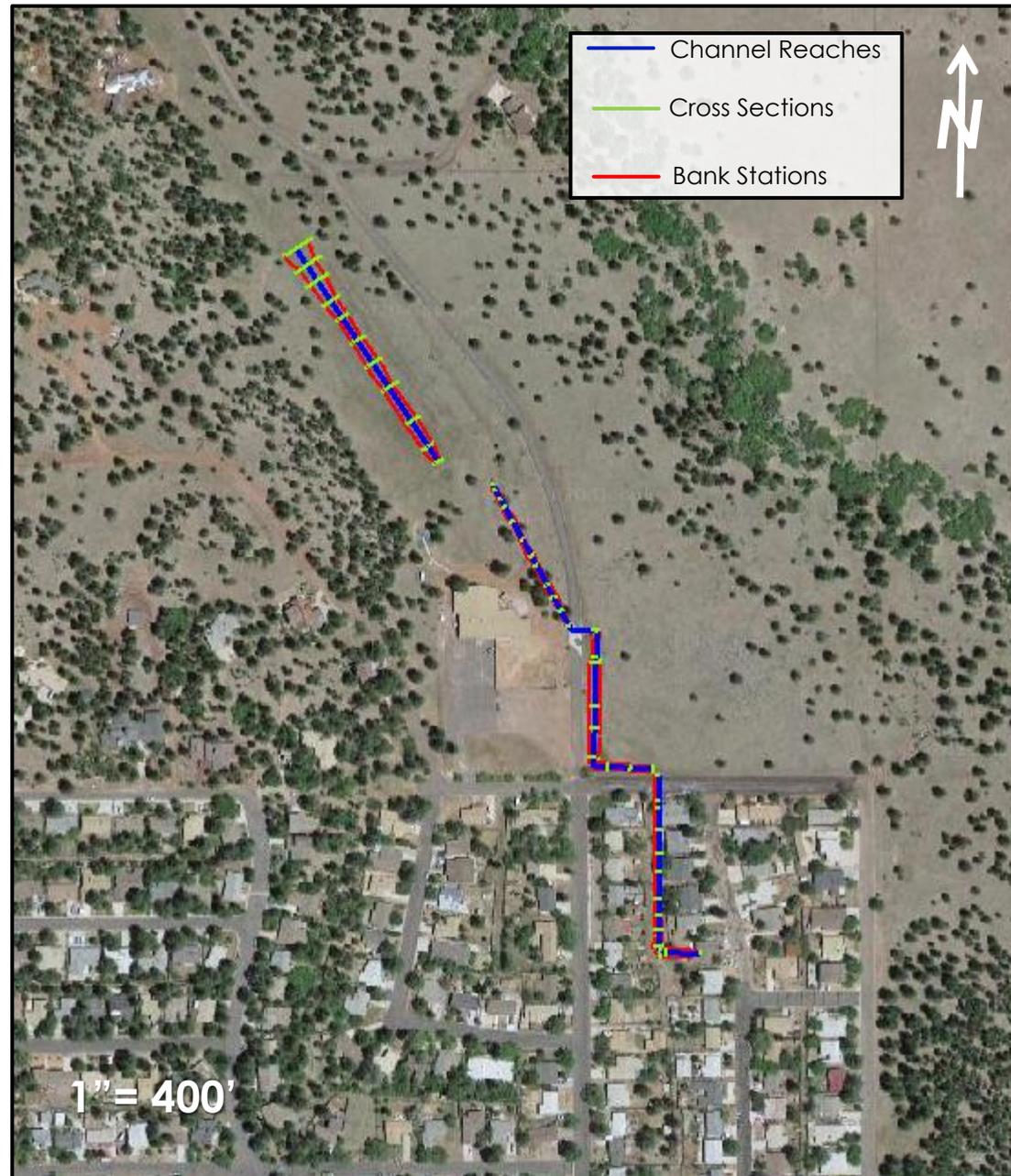
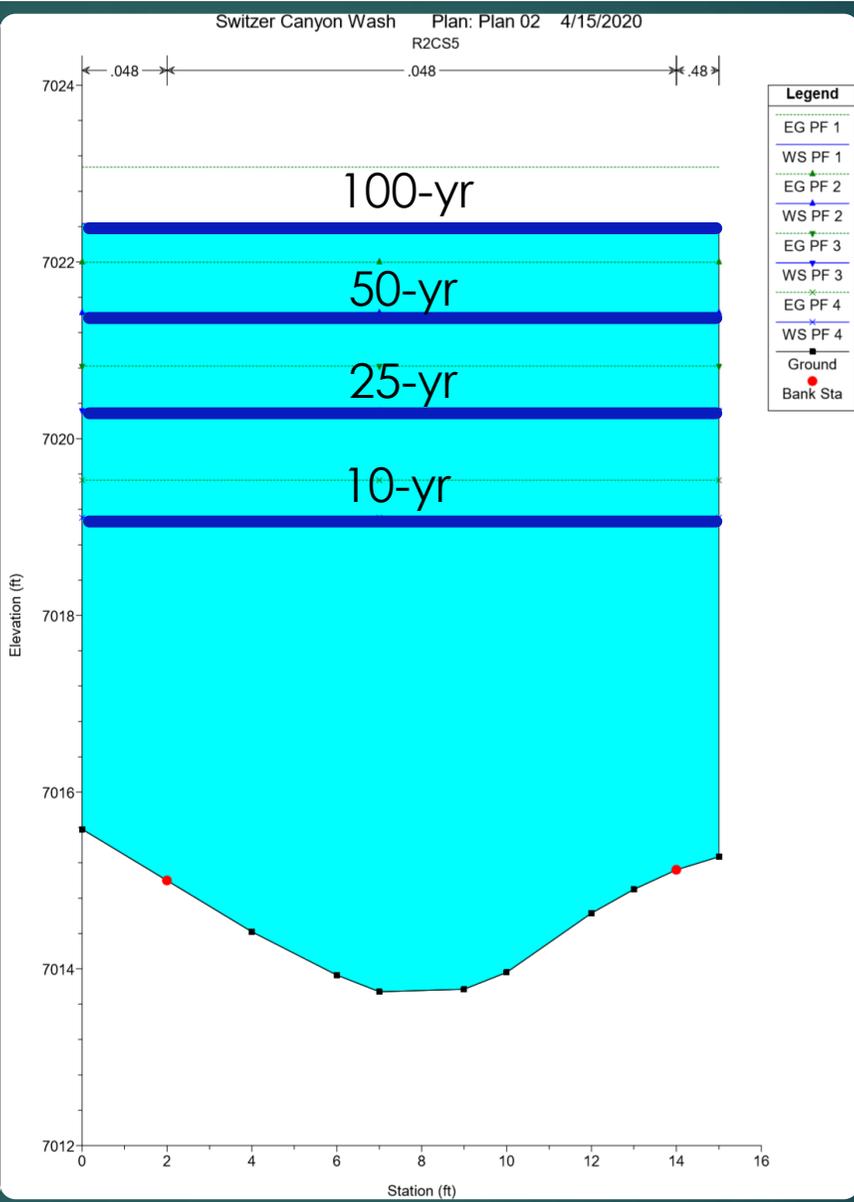
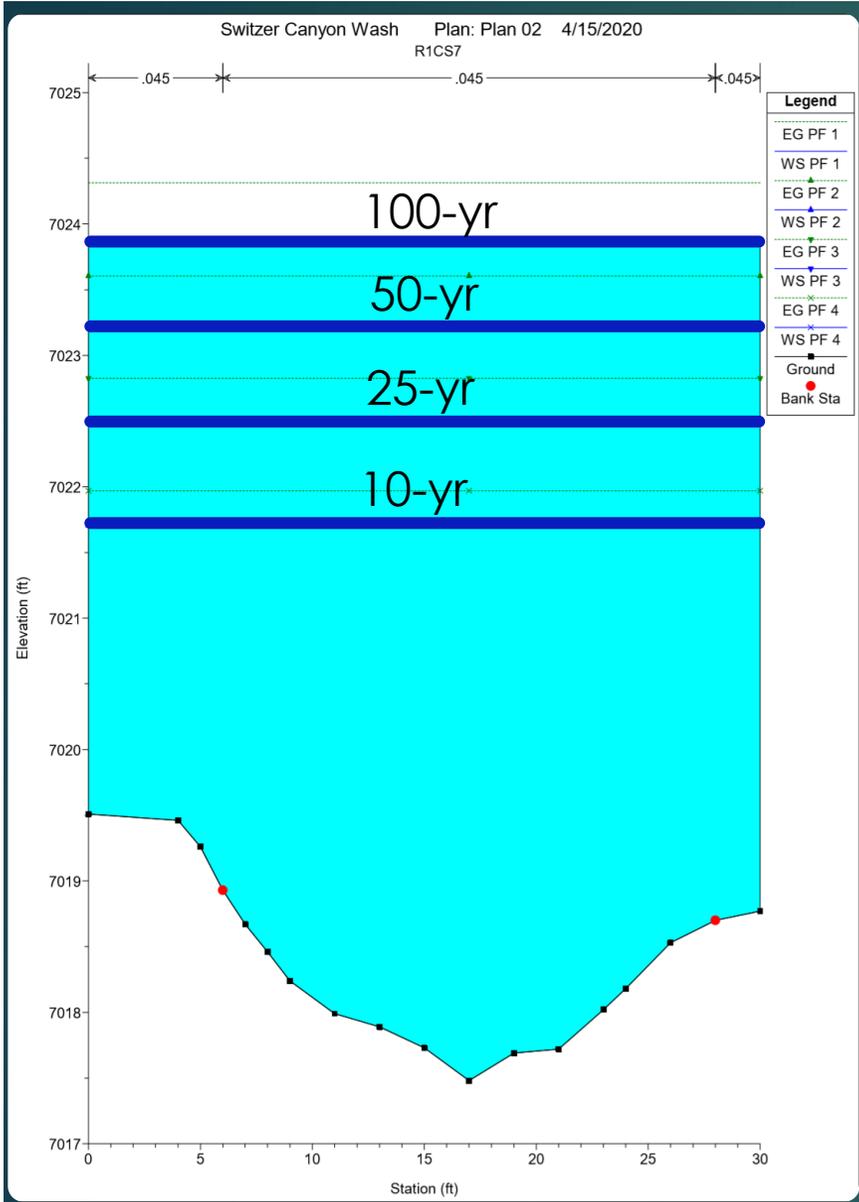


Figure 21: Switzer Wash HEC-RAS Channel



Example HEC-RAS Cross Sections

Profile 1 = 100-yr

Profile 2 = 50-yr

Profile 3 = 25-yr

Profile 4 = 10-yr

Figure 22: Switzer Wash HEC-RAS Existing CS Reach 1

Figure 23: Switzer Wash HEC-RAS Existing CS Reach 2

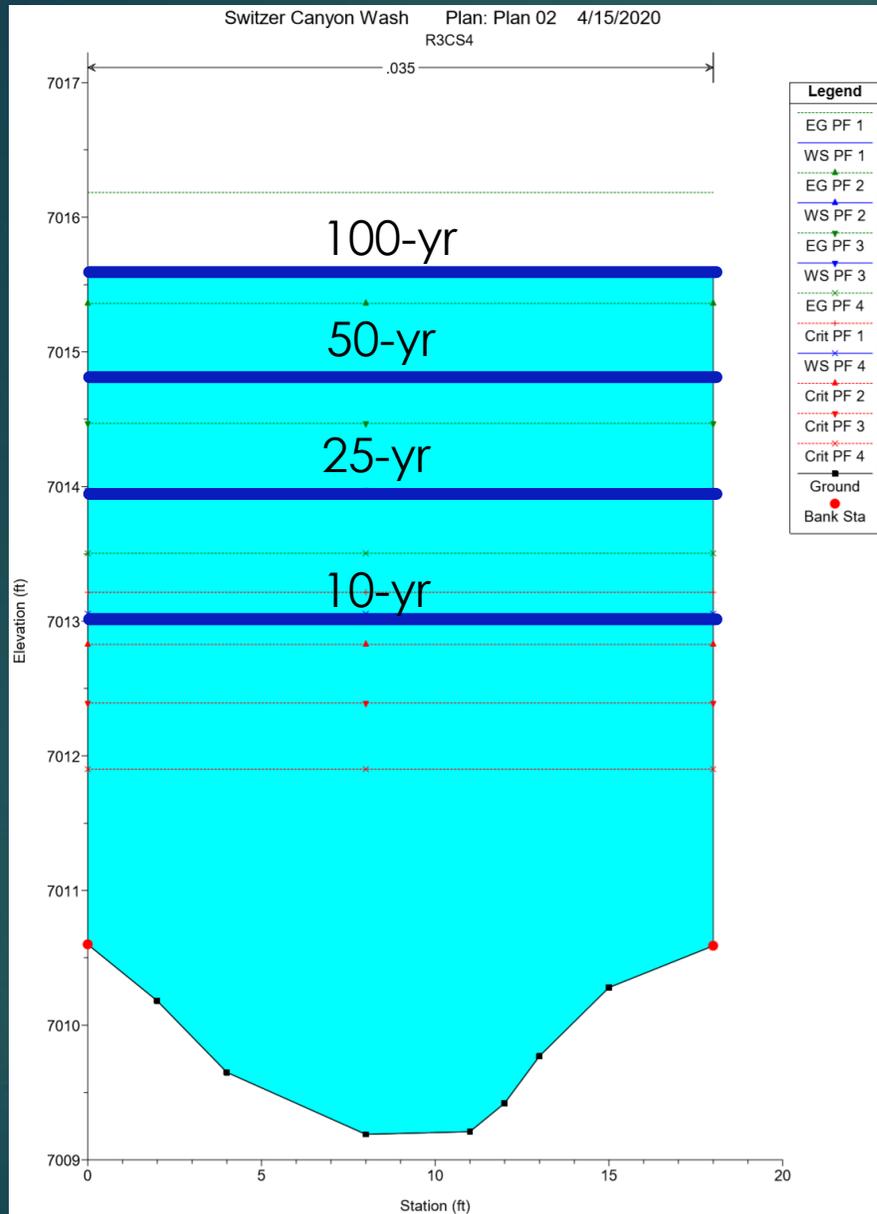


Figure 24: Switzer Wash HEC-RAS Existing CS Reach 3

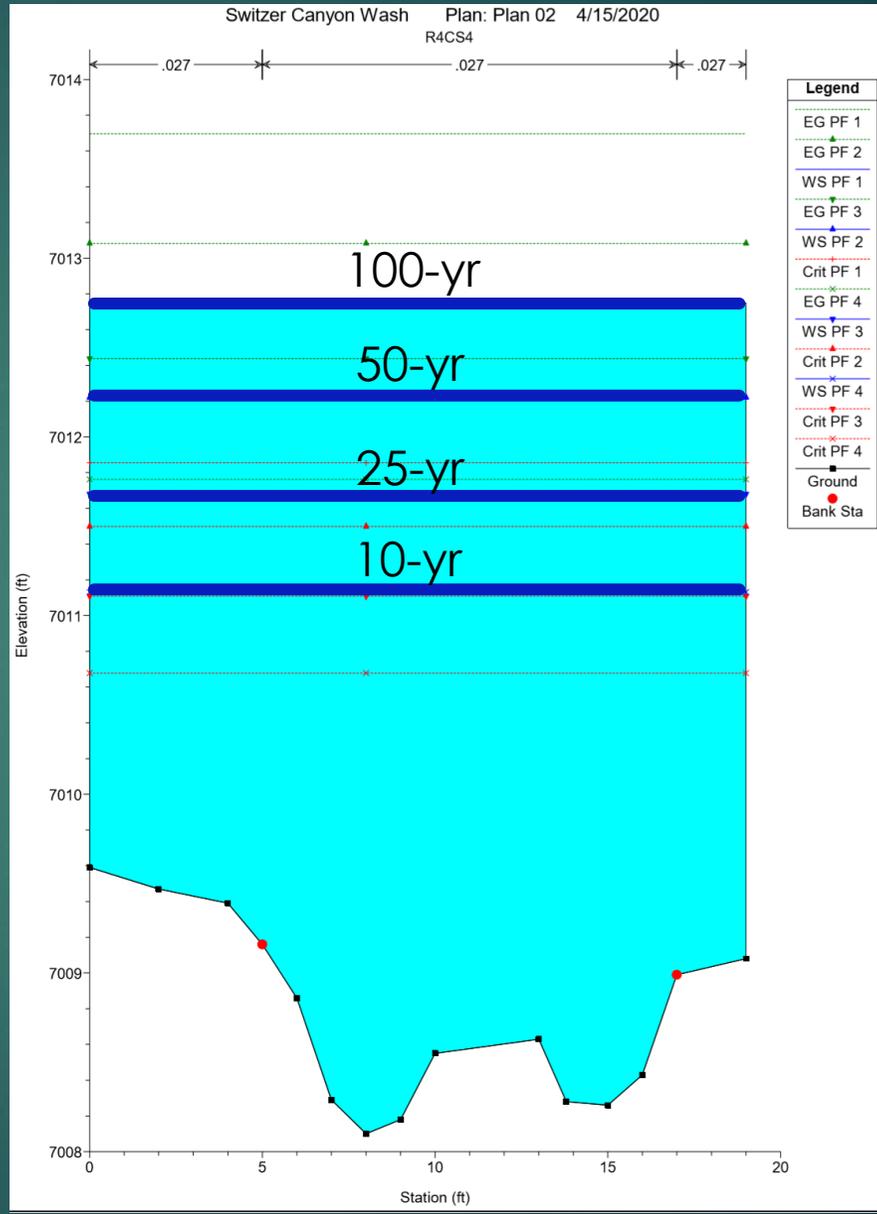


Figure 25: Switzer Wash HEC-RAS Existing CS Reach 4

Channel Design Criteria

CITY OF FLAGSTAFF STANDARDS:

- ▶ TRAPEZOIDAL SHAPE REQUIRED FOR PUBLIC OPEN CHANNELS
- ▶ MUST BE DESIGNED FOR SUBCRITICAL FLOW
- ▶ CHANNEL SLOPE $\geq 0.5\%$
- ▶ SIDE SLOPE NO STEEPER THAN 2:1

Channel Hydraulic Model and Dimensions

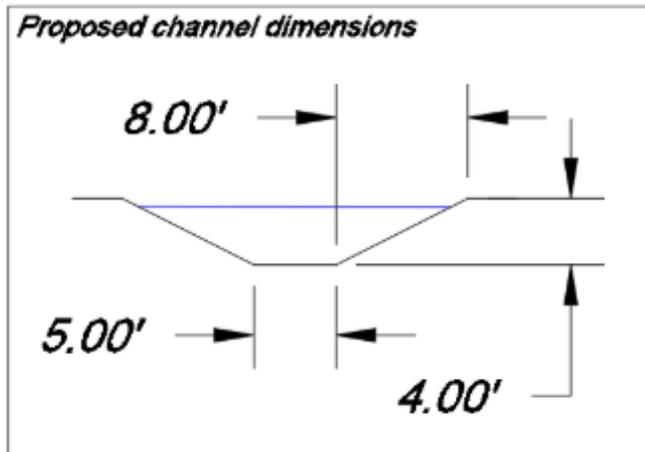


Figure 26: Switzer Wash Proposed Channel Dimensions

Table 3: Switzer Wash Proposed Channel Specs

Full flow rate (cfs):	1,028
Average channel slope (%):	0.72
Side slopes:	2:1
Roughness coefficient:	0.013
Top width (ft):	21

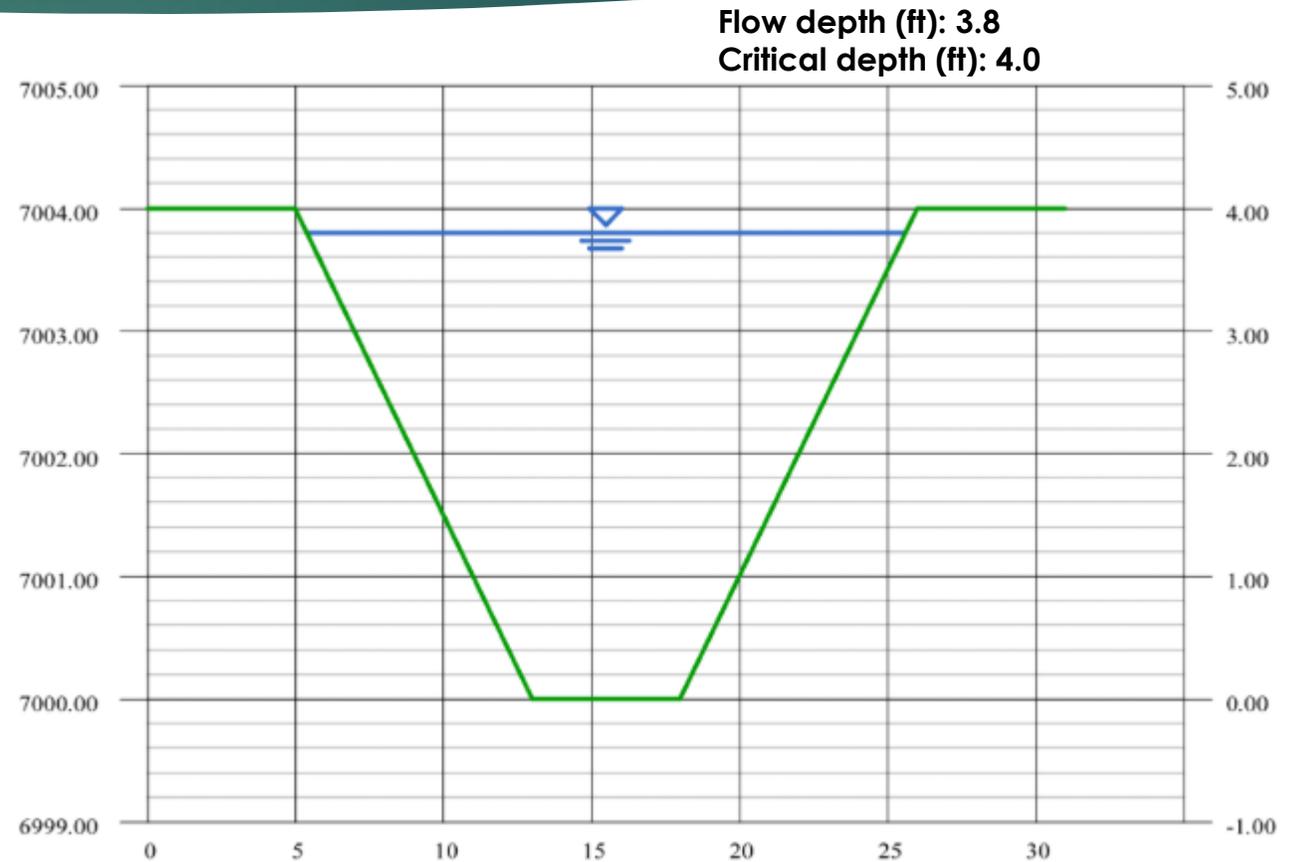


Figure 27: Switzer Wash Proposed Channel CS

Proposed Channel Cross-Sections

Profile View of Reach 1 Cross Section

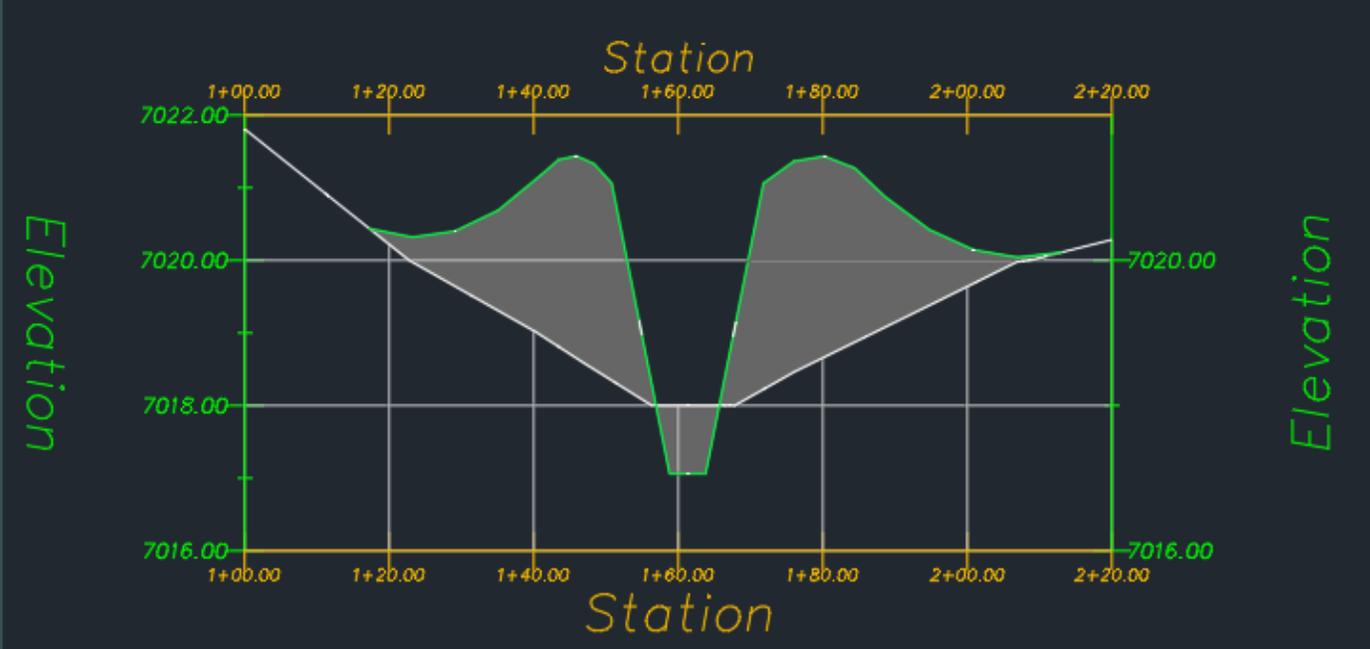


Figure 28: Example Cross-Section from Reach 1

Profile View of Entrance to Culvert

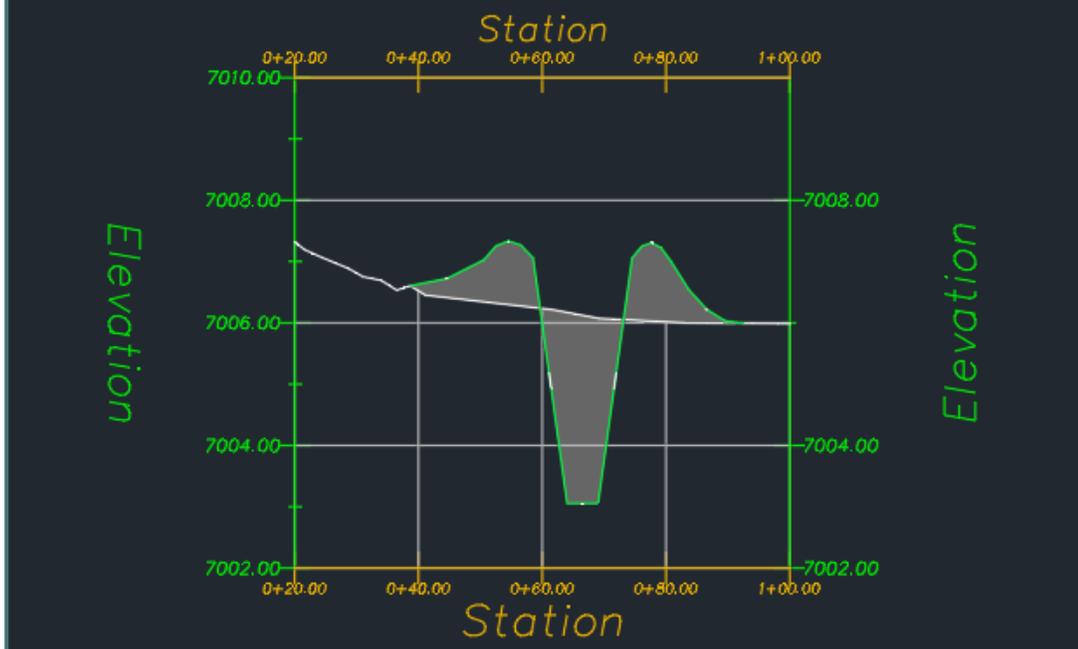


Figure 29: Example Cross-Section at the Culvert Entrance

Proposed Double Barrel Culvert

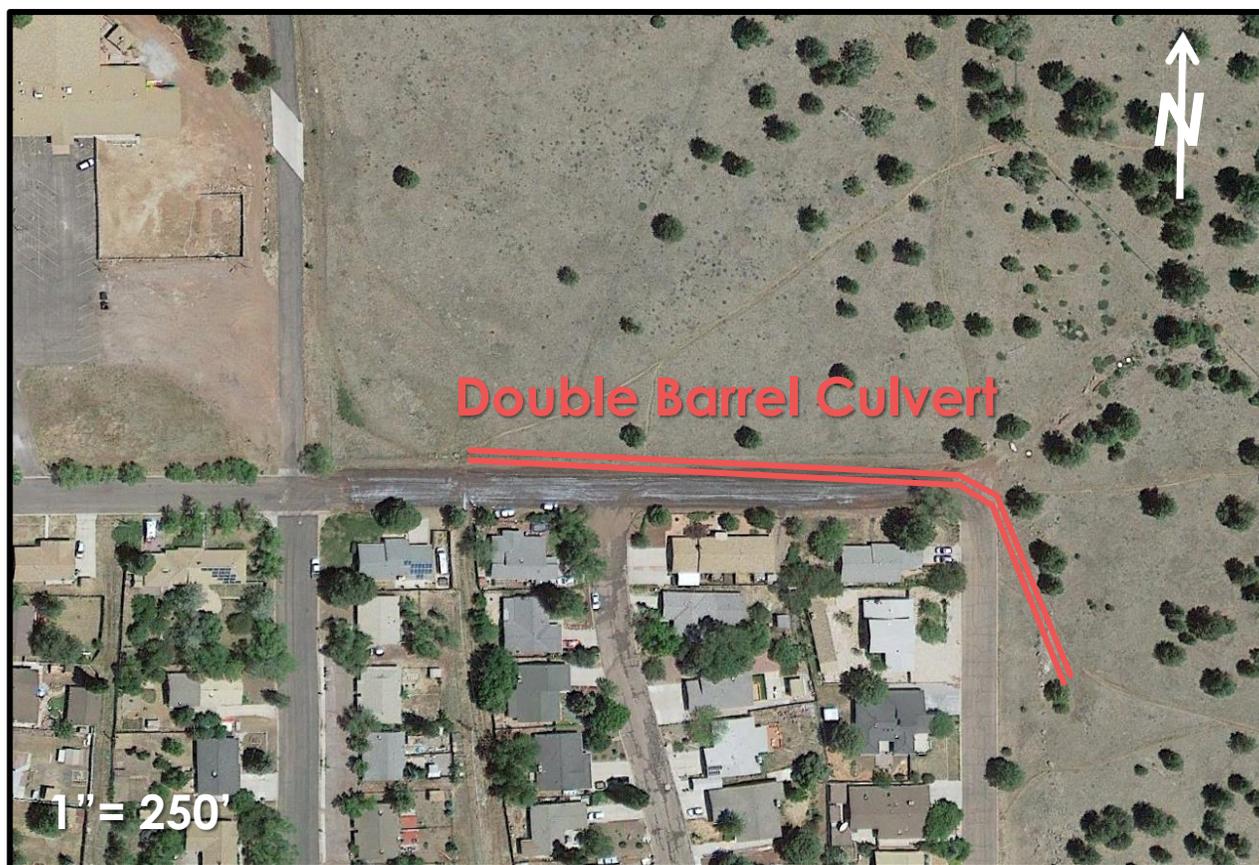


Figure 30: Switzer Wash Proposed Culvert Location

- ▶ Two 96 inch Precast Circular Concrete Pipes
- ▶ Length of each pipe: 924 feet
- ▶ Two bends in pipe: 30 degree, 60 degree
- ▶ 4 manholes placed at bends
- ▶ 24 ft of cover need at deepest point

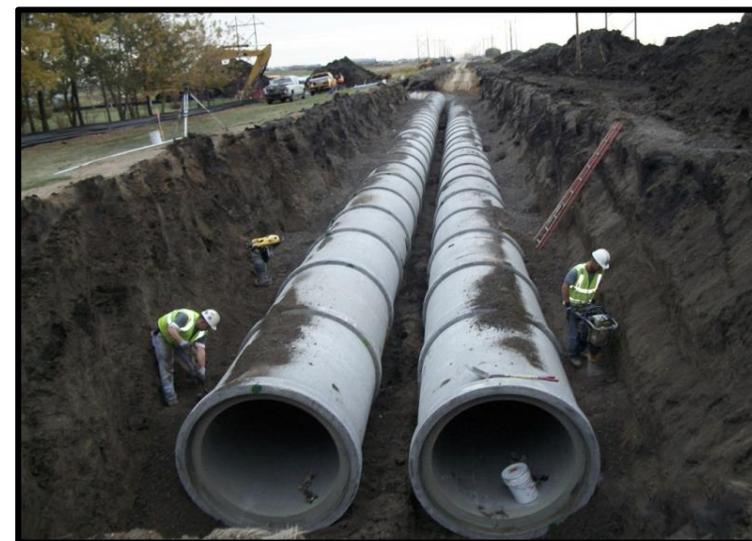


Figure 31: Proposed Culvert Example [8]

Model Results for Culvert

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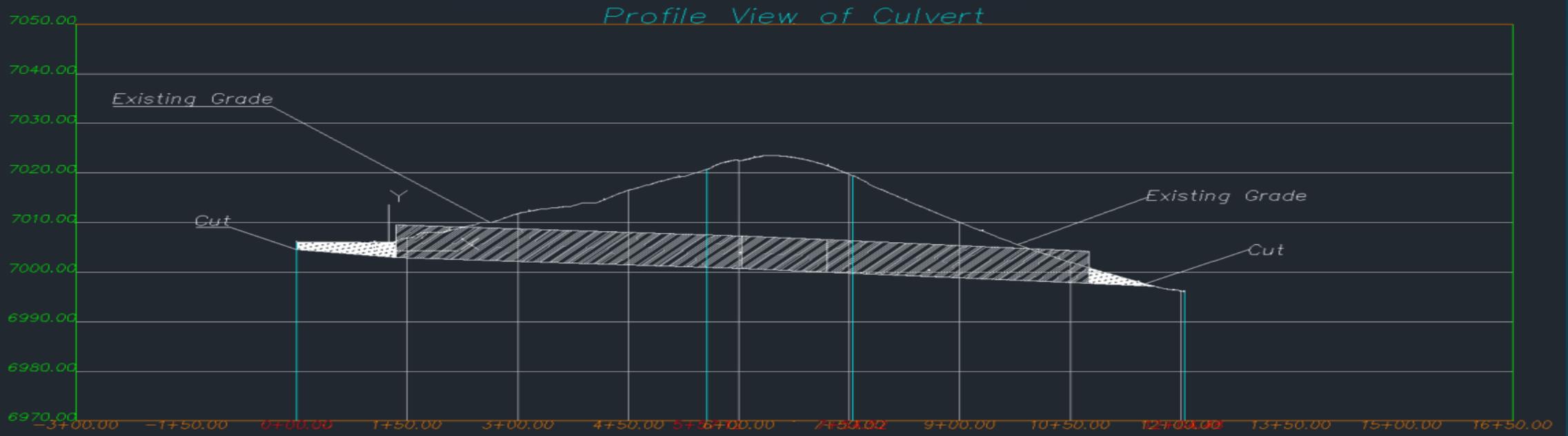


Table 4: Culvert Results for 100-yr Flow

Figure 32: Double Barrel Culvert Profile

Culvert Results for 100-year Flow	
Flow Rate	800 cfs
Up Velocity	11.88 ft/s
Dn Velocity	9 ft/s
Slope	0.78%
n	0.012
Control type	Inlet

- ▶ Inlet Protection
 - ▶ 45-degree Concrete Wing Walls
 - ▶ Steel Grate
 - ▶ 2' Dumped Rip-Rap Apron
- ▶ Outlet Protection
 - ▶ 57' Long Dumped Rip-Rap Apron

Natural Channel Construction Costs

Additional Cost per 1000 ft		
Equipment/Personnel	Hourly Rates/One Time Rate	Hours Needed
Bulldozer	37.5	350
Workers (8)	60	450
Mobilization Fees	5000	0
Inspection Fees	5000	0
Compaction Machine	25	350
Compaction Tests	2000	0
Total Cost	\$	249,875.00

Table 5: Natural Channel Equipment Costs

Channel Earth Work Cost			
Bottom Width	Top Width	Length	Height
5	20	3000	5
Volume ft ³	Cubic yards of dirt	\$ per Cubic Yard	
187500	6944	2	
Total Cost	\$	13,888.89	
Additional Cost	\$	749,625.00	

Table 6: Natural Channel Earth Work Costs

Culvert Construction Costs

Cost of Culvert Materials

Material	Unit Cost per ft/per part	# of Units
96" Round Reinforced Concrete Pipe Class 3	2000	1848
96" Manhole-Rubber Joint	435	4
96" Integral Base	624	4
96" x 1'-5' to 48" MH Reducer	1270	4
96" x 8 Manhole Base	365	4
Wing Wall	4000	1
Riprap	50	100
Total Cost	\$	3,715,776.00

Table 7: Culvert Material Costs

Cost of Culvert Earth Work

Deep (ft)	Wide (ft)	Length (ft)
24	20	924
Volume	Cubic yards of Dirt	\$ per Cubic Yard
443520	16427	2
Total Cost	\$	32,853.33

Table 8: Culvert Earth Work Costs

Totals

Total Cost of Construction Project	\$	4,762,018.22
Cubic Yards of Earth		23371.00

Table 9: Total Culvert Construction Costs

Task 5: Social Impacts

- ▶ Temporary construction congestion.
- ▶ Reduced flood risk.
- ▶ Full road access during major storms.
- ▶ Reduced property damage.

Task 5: Environmental Impacts

- ▶ Increase in sediment deposit downstream.
- ▶ Temporary vegetation loss.
- ▶ Wildlife access increases.
- ▶ Minimal landscape change.

Figure 34: Culvert Outlet at North Turquoise Dr. Sediment Build-Up Example

Task 5: Economic Impacts

- ▶ Road life expansion.
- ▶ Flood insurance reduction.
- ▶ Residence permanency.
- ▶ COF FEMA credits.

Figure 35: Neighborhood Channel Flow During Storm Event

Works Cited

- ▶ [1] Google Maps, Google, Flagstaff, AZ, 2019. [Online]. [Accessed: 1-Feb-2020]
- ▶ [2] “Switzer Canyon Floodplain”, FEMA,2019. [Online] [Accessed: 3-Feb-2020]
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Thank You

ANY QUESTIONS?