Camp Verde Community Park Entry Road

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CENE – 486

Fall 2013

Table of Contents

Introduction………………………………………………………………………………………………………..

1.0 Existing Site Observations
1.1 Existing Roads……………………………………………………………………………………..
1.2 Review Client's Given Materials………………………………………………………..

2.0 Design Controls & Criteria……………………………………………………………………………..

3.0 Horizontal Alignment
3.1 Center Line Stations, Bearing, & Elevations………………………………………………
3.2 Sight Distances……………………………………………………………………………………..
3.3 Left-Turn Lane Design…………………………………………………………………………..

4.0 Vertical Alignment
4.1 Vertical Curves………………………………………………………………………………
4.2 Maximum Cut & Fill………………………………………………………………………..

5.0 Cross-Sections
5.1 Typical Cross-Sections…………………………………………………………………………..

6.0 Drainage Design Systems
6.1 Hydrology…………………………………………………………………………..
6.2 Culvert Hydraulic Design…………………………………………………………………………..

List of Figures

1.0 Google Map's Top View of the Site…………………………………………………………………..
1.1 Proposed Park Entry Road & ADOT Basin Locations…………………………………………..
1.2 Posted Signs of the Existing Paved Roadway…………………………………………………
1.3 Existing Culvert (flow entrance) with Road Overtopping View……………………………..
1.4 Pipes Exit with some Scour Forming…………………………………………………………..
1.5 Existing Dirt Road Conditions: Drainage on side of Road…………………………………..

2.0 MCDOT Pavement Marking Manual's Typical Cross-Section………………………………..

3.0 Wild Animal Trough at the EOP………………………………………………………………
3.1Enlarged Wild Animal Trough…………………………………………………………………..
3.2 A Magnified Road Plan View Section……
3.3 ADOT PGP……………………………………………………………………..
3.4 A Magnified Section of the Left Turn Lane……………………………………………………..

4.0 Types of Vertical Curves………………………………………………………………………..

5.0 Typical Cross-Section…………………………………………………………………..
5.1 Suggested Clear Zone Distances………………………………………………………………...

6.0 NMV's Top View of Culvert Locations (Not Drawn to Scale)……………………..
6.1 Culvert #1 Profile…………………………………………………………………...
6.2 Culvert #1 Profile Information…………………………………………………………………...
6.3 Plan View of Culverts, Wingwalls, Headwalls, & Fill Lines (dotted light blue)
6.4 NOAA's Rainfall Intensity (i) Value
6.5 Culvert #2 Profile
6.6 Culvert #2 Profile Information

List of Tables

3.0 Existing & Proposed Stations, Elevations, & Bearing………………………………………
3.1 ADOT PGP Gap Lengths Table…………………………………………………………………..
3.2 ADOT PGP Braking Distance Table……………………………………………………………

Appendices

Appendix A	Basic Plan
Appendix B	Master Conceptual Architectural Plans
Appendix C	AutoCAD Drawing as Given By the Cilent
Appendix D	MAG Thickened Edge (Type A)
Appendix E	Proposed Road's Plan View
Appendix F	Horizontal Alignment: Stations & Elevations
Appendix G	Sight Stopping Distance Calculations
Appendix H	Decision Sight & Braking Distance Calculations
Appendix I	Left-Turn Lane Design Calculations
Appendix J	Vertical Alignment: Curve #1 Calculations
Appendix K	Vertical Alignment: Curve #2 Calculations
Appendix L	Vertical Alignment: Curve #3 Calculations
Appendix M	Vertical Alignment: Curve #4 Calculations
Appendix N	Vertical Curves' Table
Appendix O	Road Profile
Appendix P	Max. Fill & Cut Calculations
Appendix Q	Typical Cross-Section with Pavement Detail
Appendix R	Road Plan View with Culverts' Locations
Appendix S	Culvert #1 Profile
Appendix T	Culvert #2 Profile
Appendix U1	Culvert #1's Watershed Delineations
Appendix U2	NSS Program's Peak Flow
Appendix U3	Culvert #1's Skew Angle Calculations
Appendix U4	Culvert #1's Hydraflow Report: Inlet Control
Appendix U5	Culvert #1's Hydraflow Report: Outlet Control
Appendix U6	ADOT's Concrete Box Culvert's Wingwall Detail Drawings
Appendix U7	ADOT's CMP Headwall Detail Drawings
Appendix V1	Culvert #2's Watershed Delineation
Appendix V2	Culvert #2's Peak Flow Calculations
Appendix V3	Culvert #2's Skew Angle Calculations
Appendix V4	Culvert #2's Hydraflow Report: Inlet Control
Appendix V5	Culvert #2's Hydraflow Report: Outlet Control

Introduction:

The proposed entry road to the community park will have a new paved road section approximately 1,134.07 feet long, which is off of State Route (SR) 260. This proposed road is going to follow the existing alignments of a paved and dirt road (See Figure 1.0). A new road will not only be redesigned to accommodate both the park and sanitary treatment plant's future average daily traffic volume, but also because several sections on the existing road experience overtopping floods each year. The new roadway will contain the following design parameters: existing site observations, design controls and criteria, horizontal and vertical alignment subtasks, cross sections, and drainage systems. All subtasks will comply with the American Association of State Highway and Transportation Officials (AASHTO), Arizona Department of Transportation (ADOT), United States Department of Transportation's (USDOT) Federal Highway Administration's (FHWA) Hydraulic Design of Highway Culverts (HDHDC), Maricopa Association of Governments (MAG), Highway Capacity Manual (HCM), and Maricopa County Department of Transportation (MCDOT) regulations/requirements.

1.0 Existing Site Observations:

1.1 Existing Roads:

Two existing roads make up the proposed road entrance to the park. Approximately 600 feet comes from Camp Verde's Sanitary District paved road and the remaining 534.07 feet from an existing dirt road (See Figures 1.0 & 1.1). The paved sanitary district road has a posted speed of 15 miles per hour (mph), has no current traffic information, and contains four corrugated culvert pipes that serve as the only point of drainage along the pipe (See Figure 1.2 for the posted speed limit sign & Figure 1.3 for culvert pipes). Figure 1.3 also shows that the current placement of the culvert pipes does not convey the total recurring annual peak flows that overtop the road. As seen in the figure, a large volume of flow overtops the road at a further distance from the existing pipes. In addition, the pipes' exit exhibits signs of scour ("Erosion of streambed due to flowing water," (HDHC, 2012)) as seen in Figure 1.4. As seen in Figure 1.5, the dirt road has several minor water crossings that may pose drainage problems for the entry road. Future park traffic will need to use the SR260 road to enter the park's entry road; the SR260 road has a total of five lanes (four traveled way lanes & one center lane). SR260 has functional classification as a minor arterial (ADOT Map Book, Page #8) and the site is located in the Yavapai County (ADOT Map Book, Page #5) on the Transportation Board District #6 (ADOT Map Book, Page #10). The overall terrain of the site is considered rolling, because there are several slope changes, but a majority of the road can be viewed from beginning to end.

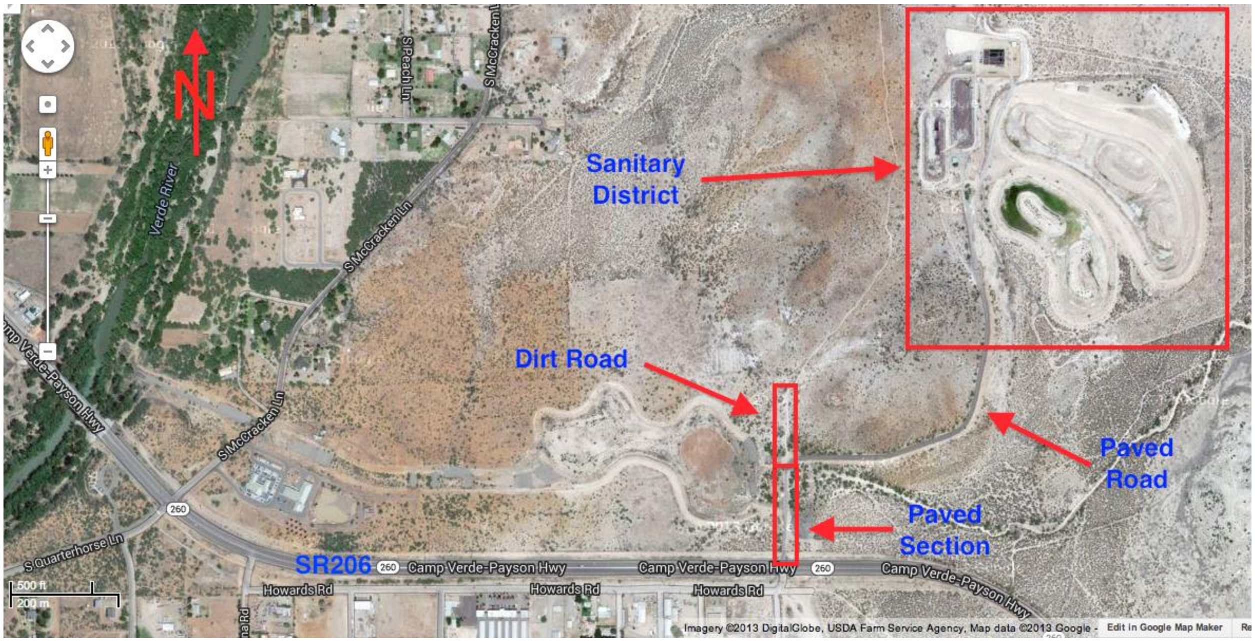


Figure 1.0: Google Maps' Top View of the Site.

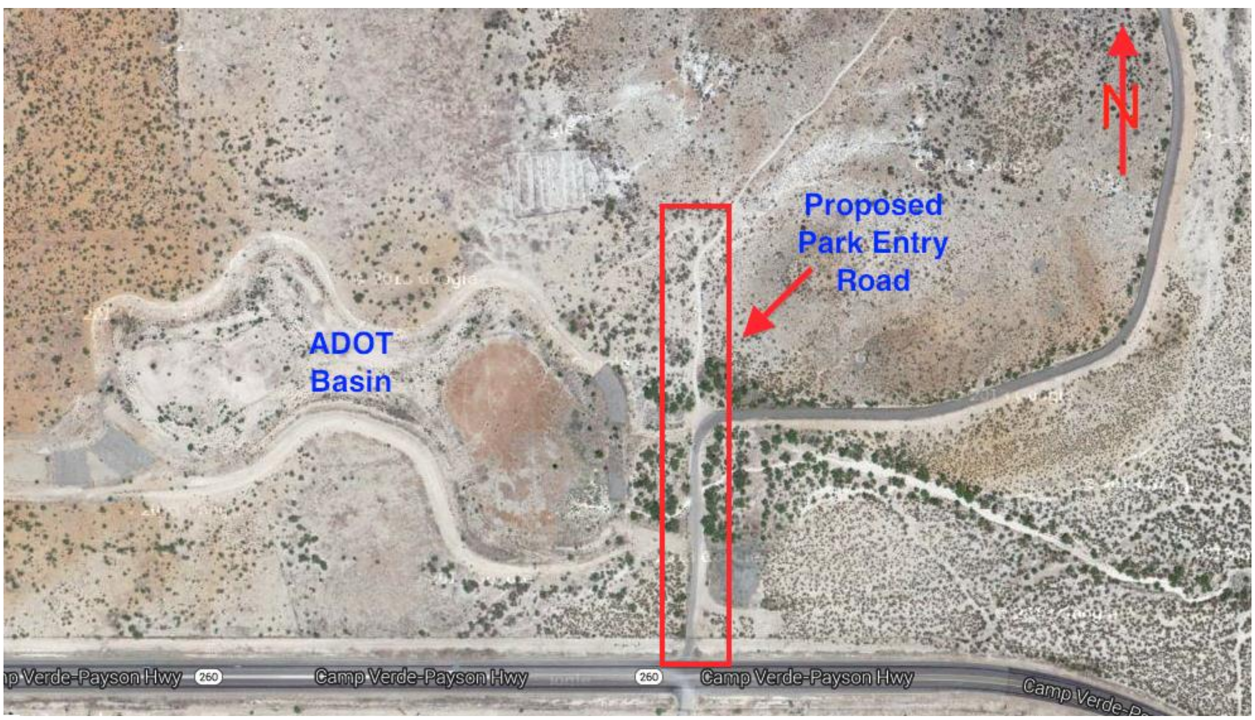


Figure 1.1: Proposed Park Entry Road & ADOT Basin Locations

Figure 1.2: Posted Signs of the Existing Paved Roadway

Figure 1.3: Existing Culvert (flow entrance) with Road Overtopping View

Figure 1.4: Pipes Exit with some scour forming

Figure 1.5: Existing Dirt Road Conditions: Drainage on side of road

1.2 Review of the Client's Given Materials:

The client has given the team a basic site plan showing the park and city boundaries, the proposed town access easement dimensions, ADOT's drainage basin, etc. (See Appendix A), two conceptual architectural plans where future site road and facility locations (See Appendix B), and an AutoCAD drawing of the entire existing site that shows the community park area, entrance road, site topography (contour lines), and property boundaries, etc. (See Appendix C). Keep in mind that the proposed road shown in Appendices A&B is the first park access suggestion, but due to frequent overtopping floods as seen in Figure 1.3, the latest proposal can be seen in Figures 1.1 & 1.2.

2.0 <u>Design Controls & Criteria:</u>

The up coming park entry road of 1,134.07 feet in length will need to accommodate the 2012 Camp Verde population of approximately 10,925 with a population change since the year 2000 of +15.6% (City-Data.com, Camp Verde, Arizona, accessed on 8/25/13). Therefore, the proposed road's traffic projections will be based on a 20-year design period (AASHTO's *A Policy on Geometric Design of Highways and Streets, 2001*, Page #424 & ADOT's *Roadway Design Guidelines, 2012,* Page #100-4), which will be designed for the year 2033. According to Institute of Transportation Engineers (ITE) Trip Generation Manual, the park's future average daily traffic (ADT) was estimated to be approximately 400 vehicles per day for the year 2033. Since the present speed is 15 mph, the design speed (V) will also be 15 mph. The following list provides the client's requirements for the proposed entry road:

- Lane width: 12 feet (ft)
- Number of lanes: 2
- Shoulder widths:
    - As entering the park (North direction):
        - Right side shoulder: 4 ft (for roadside safety stops)
        - Left side shoulder: 8 ft (where the majority of pedestrians & bicyclists will travel on)
- Shoulders are to have a thickened edge design (See Appendix D) to slow erosion
- Total Right-of-way (ROW): 100ft
- Provide a left turn lane for traffic exiting the park onto SR260
- A right turn lane will not be required to design for adding an extra lane to the existing SR260 is out of the site location. The client will take care of the SR260's right turn lane into the park entry road with ADOT
- Design entry: approximately 20 ft. from property fence line
- Provide box culvert designs where the existing road experiences overtop flooding as seen in Figure 1.3

After reviewing the client's design requirements, the road's functional classification was chosen to be a "rural minor collector," because the road will be serving a purpose of moving traffic between a arterial road (SR260) and the park's local streets to access the community park's facilities. Also the typical road cross-section is similar to that of MCDOT's

Pavement Marking Manual, 2005's "rural minor collector" standard drawing (See Figure 2.0). With the functional classification, the roadway capacity is to be designed for a level of service (LOS) C, which provides "acceptable operating service for facility users" on the rural minor collector road (HCM, 2000, Page 2-3 & AASHTO's *A Policy on Geometric Design of Highways and Streets, 2001*, Page #426 & ADOT's *Roadway Design Guidelines, 2012,* Page #100-6 Table 103.2A). "LOS is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience (HCM, 2000, Page #2-2)." By selecting the functional classification of the proposed entry road, the rural minor collector road section of AAHTO's *A Policy on Geometric Design of Highways & Streets, 2001* & *Roadside Design Guide, 2002* can be utilized in obtaining design requirements such crown slopes, foreslopes and backslopes, etc.

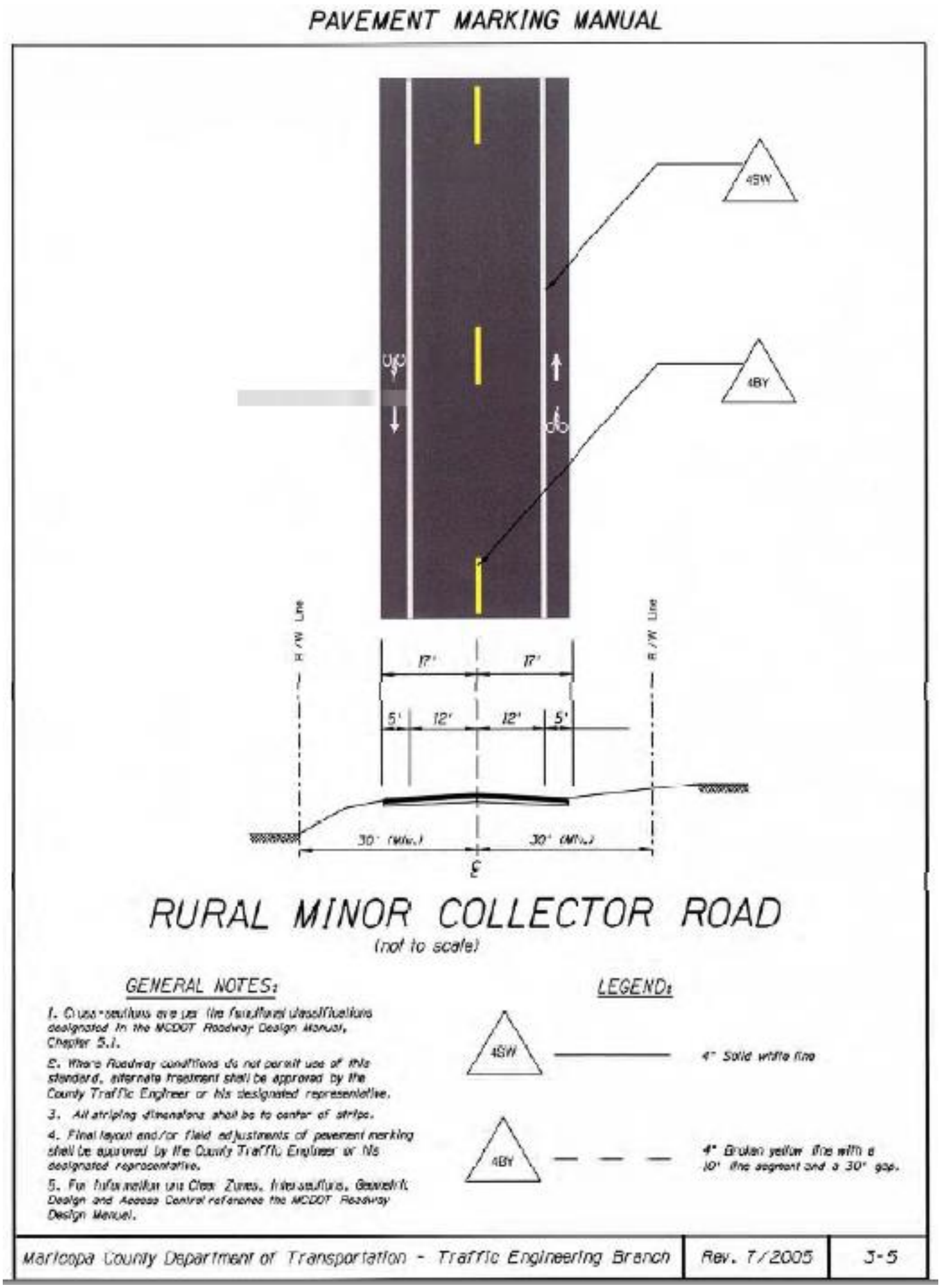


Figure 2.0: MCDOT Pavement Marking Manual's Typical Cross Section

3.0 Horizontal Alignment:

3.1 Center Line Stations, Bearing, & Elevations:

The new road's center-line (CL) will be redesigned on top of the existing paved and dirt road sections. The AutoCAD drawing provided by the client was used in developing both the existing and proposed road CL's stations (every 50 ft. including major drainage facilities), one bearing (proposed), and elevations of each station points. Since the new roadway's beginning of project (BOP) is at the intersection of SR260 and the end of project (EOP) is where a wild animal trough is located on the dirt road (See Figure 3.0 & 3.1), there is no need for horizontal curves for the proposed CL is straight. Therefore, only one bearing is listed and can be seen in Appendix E. This S 00° 00' 35" E bearing does not need to be calculated for it is in the same direction as the boundary line to the right of the road's CL. Figure 3.2 is a closer picture of the road's plan view to better see the different colors that associate the CL (white line dotted line with a X at the center of the line to specify stations & elevations), property fenced line (white line with a square at the center of the line), boundary line (white), edge of the shoulder (blue), and traveled way (TW) in red. Elevations of every 50-foot stations (including major drainage facilities) of the CL were estimated and calculated using the slope-intercept formula $y=mx+b$ and a printed contour map (See Table 3.0 for the existing & proposed road's stations, elevations, & bearing). Calculations of using the slope-intercept formula to find the elevations of each station can be found in Appendix F.

Figure 3.0: Wild Animal Trough at the EOP

Figure 3.1: Enlarged Wild Animal Trough

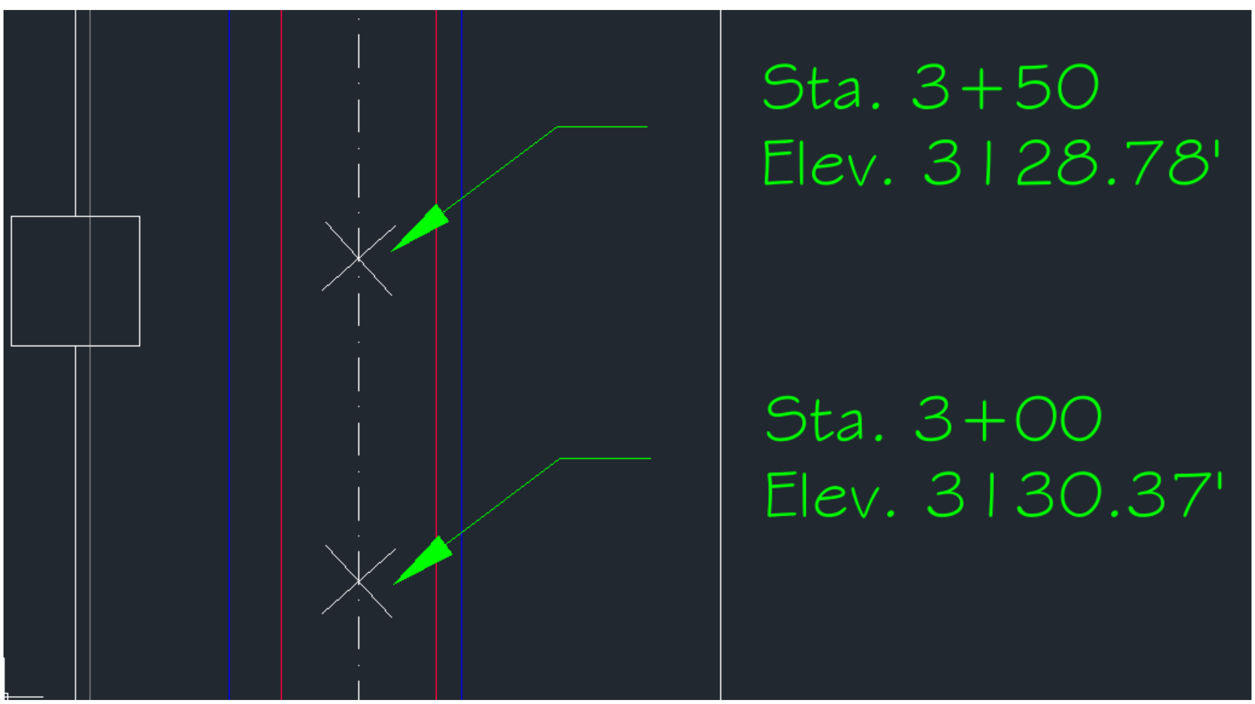


Figure 3.2: A Magnified Road Plan View Section

Stations	Proposed Elevations	Existing Elevations
00+00	3122.09	3122.09
00+25.79	3124.23	3123.24
00+50.00	3125.06	3124.48
00+65.50	3126.05	3125.03
01+00	3126.28	3125.89
01+50	3127.58	3126.58
02+00	3129.38	3128.65
02+50	3130.07	3129.49
03+00	3130.37	3130.12
03+50	3128.78	3128.65
04+00	3130.38	3129.21
04+36.50	3129.75	3128.95
04+50	3129.74	3128.77
05+00	3128	3127.3
05+50	3127.76	3127.43
05+75	3127.57	3127.57
06+00	3127.75	3127.78
06+50	3127.97	3127.86
07+00	3128.37	3127.9
07+50	3129.31	3128.82
08+00	3129.95	3129.77
08+50	3131.51	3131.51
09+00	3134.63	3134.61
09+50	3137.75	3135.95
10+00	3141.29	3138
10+50	3141.86	3141.85
11+00	3141	3141
11+34.07	3144.25	
BOP to EOP Bearing: S 00° 00' 35" E		

Table 3.0: Existing & Proposed Stations, Elevations, & Bearing

3.2 Sight Distances:

First, the stopping sight distance (SSD) is calculated (See Appendix G), and the decision sight distance (DSD) is also computed (See Appendix H) to assure roadway safety. SSD is the required distance that is needed to stop when the driver sees a person or object on the travelled way and the instant the brakes are applied plus the distance that the vehicle comes to a complete stop. DSD is the distance the driver needs to make when approached with complex decision maneuvering tasks. The future road will not have much difficulty when it comes to making a complete stop or maneuver decisions for the design speed is a low 15 mph on an intermediate terrain (between leveled & rolling) where the entire roadway can be seen at any point without vegetation or different road grade sight blockages.

3.3 Left-Turn Lane:

Since there will be more traffic using the entry road in the future, a left turn lane needs to be designed at the new road intersection with SR260. ADOT *Traffic Engineering Policies, Guidelines, and Procedures Section 400 – Pavement Markings, 2000* (PGP) provided guidelines in designing a left-turn lane. A left-turn lane consists of a taper, gap, and storage lengths as seen in Figure 3.3 with design calculations in Appendix I. Taper lengths are comprised of the design speed (15 mph) and width of the lane added (12ft.); the gap length is given in Table 3.1 to be 60 ft. (PGP, 2000, Page 430-2); and the storage length is the braking distance (20 ft. from Table 3.2) plus the queue length, where the queue length should provide space for two passenger cars at 25 ft. each when the truck percentage is less than 10% (ADOT PGP, 2000, Page 430-5). Figure 3.4 shows a closer top view of the left turn lane, which was taken from the road's plan.

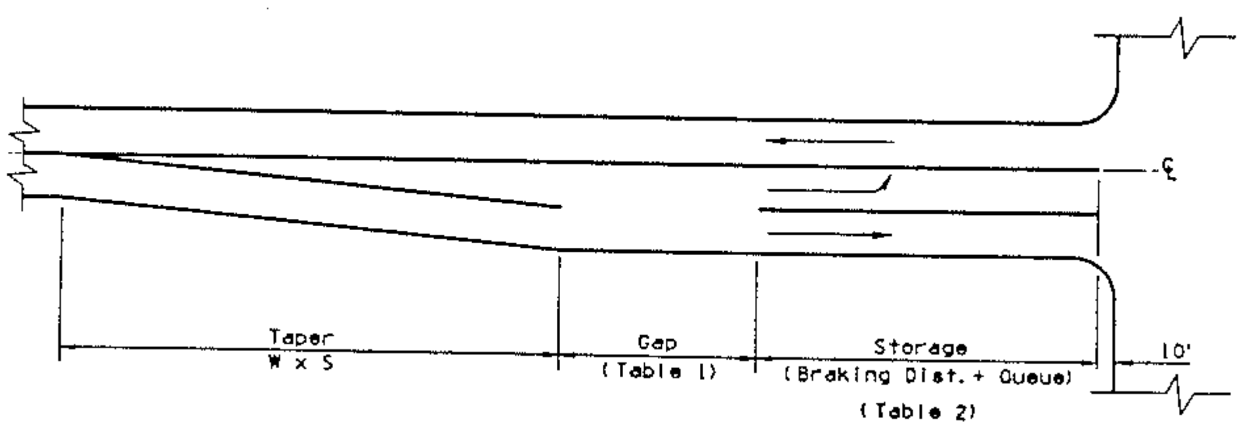


Figure 3.3: ADOT PGP, 2000, Page 430-1; Left-Turn Lane

POSTED or DESIGN SPEED (mph)	GAP (feet)
< 40	60
40 - 50	90
> 50	140

Table 3.1: ADOT PGP Gap Lengths Table

POSTED or DESIGN SPEED (mph)	DESIRABLE		MINIMUM		
	BRAKING SPEED (mph)	BRAKING DISTANCE (feet)	ENTERING SPEED (mph)	BRAKING SPEED (mph)	BRAKING DISTANCE (feet)
30	29	80	20	20	20
35	34	115	25	25	40
40	38	150	30	29	50
45	43	200	35	34	85
50	47	245	40	38	120
55	52	300	45	42	145
60	56	360	50	47	200
65	60	415	55	52	265
70	64	490	60	56	315
75	70	585	65	61	400

Table 3.2: ADOT PGP Braking Distance Table

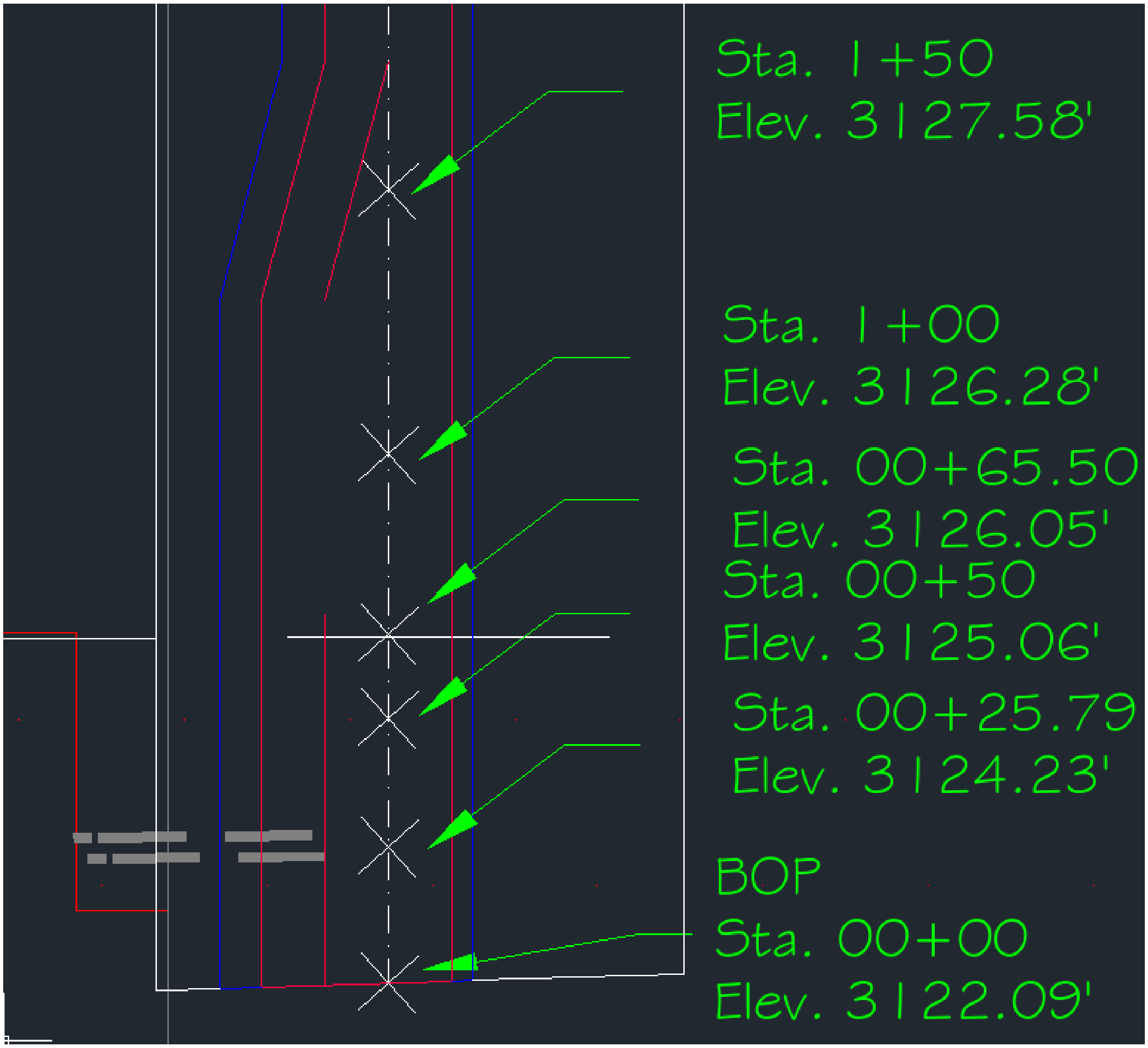


Figure 3.4: A Magnified Section of the Left Turn Lane

4.0 <u>Vertical Alignment:</u>

4.1 Vertical Curves:

First, an elevation vs. stations was plotted to create a vertical profile of the road's existing (in blue) and proposed road's centerlines (in red) using the Excel software (See Appendix O for profile). From the profile, straight lines were drawn closer to the existing road's CL (in green). Having the vertical alignment closer to the existing CL leads to a reduced need for compaction, cut, and fill during construction. After the straight lines were drawn (a total of 5 lines), the Point of Vertical Intersections (PVI –where each straight line intersects) could now be used to calculate the stations and elevations of each Point of Vertical Curves (PVC –where the curve starts) and Point of Vertical Tangencies (PVT – where the curve ends) (See Appendices J, K, L, & M for vertical curve calculations). A table shown in Appendix N displays the vertical alignments' curves, grades in percentages (G), stations, elevations in feet, the absolute values of grade differences (A in percent), length of vertical curves (L – the distance between PVC & PVT), and the rate of vertical curvatures (K). By looking at the profile, there are a total of four vertical curves (VC) where Curve#1 is a Type II Crest VC (AASHTO, 2001, Exhibit 3-73, Page #269), Curve#2 is a Type II Crest VC (AASHTO, 2001, Exhibit 3-73, Page #269), Curve#3 is a Type I Crest VC (AASHTO, 2001, Exhibit 3-73, Page #269), and Curve#4 is a Type III Sag VC (AASHTO, 2001, Exhibit 3-73, Page #269). In Figure 4.0 from AASHTO, 2001, Exhibit 3-73, Page #269 shows the different types of VC's. The designer also made sure that while choosing the placements of the vertical alignment, there will be enough room for a concrete box culvert with a minimum rise of 3 feet tall to be installed with a minimum freeboard of two feet (ADOT 2012, Page 600-20).

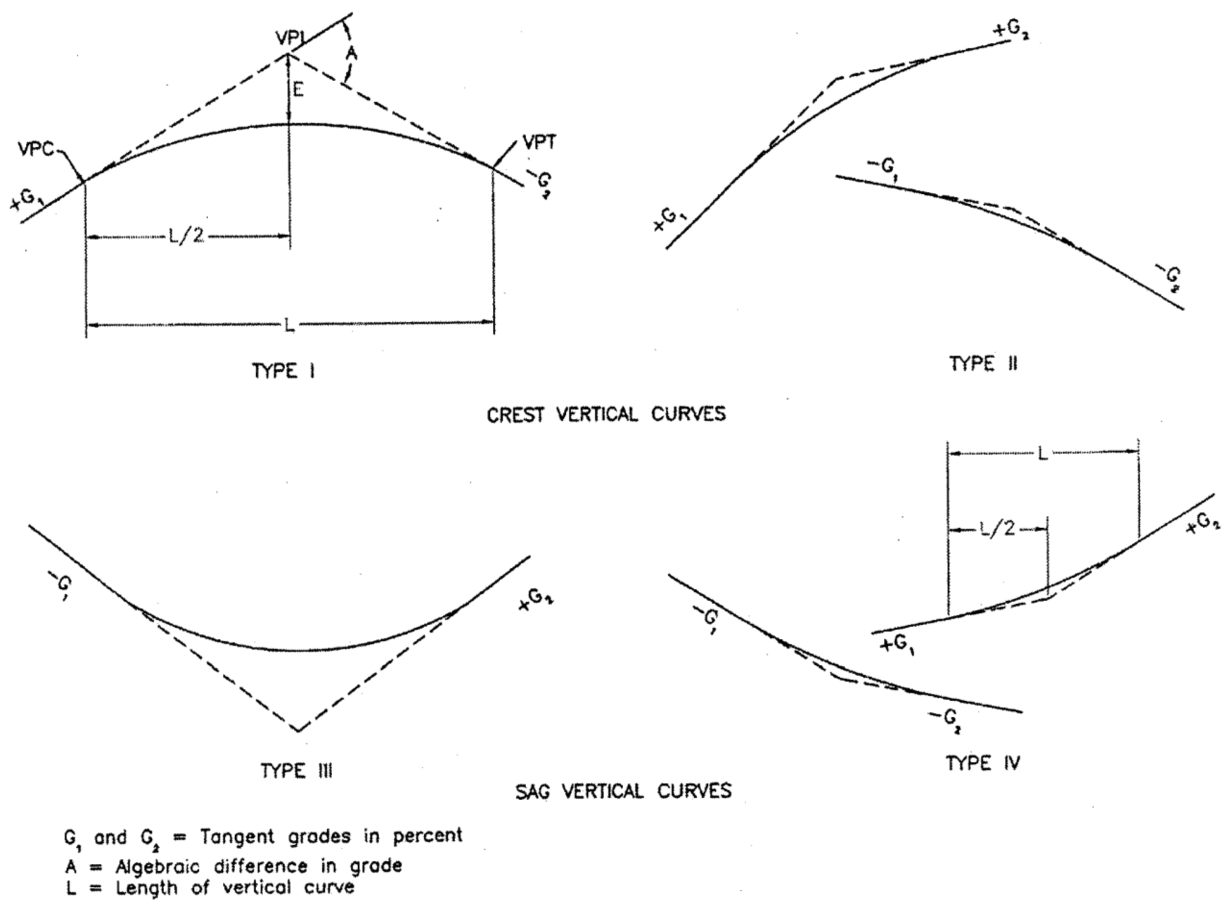


Figure 4.0: Types of Vertical Curves

4.2 Maximum Cut & Fill Locations:

The max fill and cut depths are determined by looking at the road profile in Appendix O. The farthest depth from the road's vertical alignment (in green) to the existing roads' (current & proposed) elevations helps specify where the max fill and cuts are located. From the road profile, Station 5+75 shows the maximum fill location with a depth of 5.274 feet (See Appendix P for Max. Fill calculations). Also from Appendix O, Station 10+00 displays the maximum cut location with a cut height of 2.59 feet (See Appendix P for Max. Cut calculations). By specifying the location and depth of the max fill, one can also speculate that 5.274 feet is enough height and width (From Stations 5+00 to 6+50 is where the majority of the roadway experiences overtop flooding) for a concrete box culvert with a rise of 3 feet to be installed during the drainage design of roadway, which is discussed in Section 6.0 of the report.

5.0 <u>Cross Sections:</u>

5.1 Typical Cross-Sections:

A typical road cross-section was designed according to ADOT's 2012 Roadway Design Guidelines, AASHTO's *Geometric Design of Highways & Streets, 2001* and the *Roadside Design Guide, 2002*. Shown in Figure 5.0, the road lanes, in red, will have a width of 12 feet, a total of two lanes, the left shoulder, in blue, will be 8 feet wide, and the right shoulder will have a width of 4 feet as requested by the client (Also See Appendix Q for a Typical Cross-Section with scale bars). The left shoulder is wider than the right shoulder, due to pedestrian, bicyclist, and vehicle emergency stops, driver comfort and confidence. Vehicle emergency stops, driver comfort and confidence are the main purpose for the right shoulder width. Also requested by the client is to have a thickened edge design (See Appendix D for MAG's Thickened Edge Type A Detail) for the shoulders to slow down erosion. To double-check the client's requests, a 12-foot lane (ADOT 2012, Page 300-2), two lanes (AASHTO 2001, Page 428), and a minimum of 4 foot shoulders (AASHTO 2001, Page 318-319) are all desirable or accepted values according to regulations. Given in Appendix Q is also a detail drawing of the TW's pavement. This pavement detail shows 3 inches of Asphalt Concrete (AC) and 6 inches of Aggregate Base (BC), but these values may change to better suit the soil conditions of the roadway.

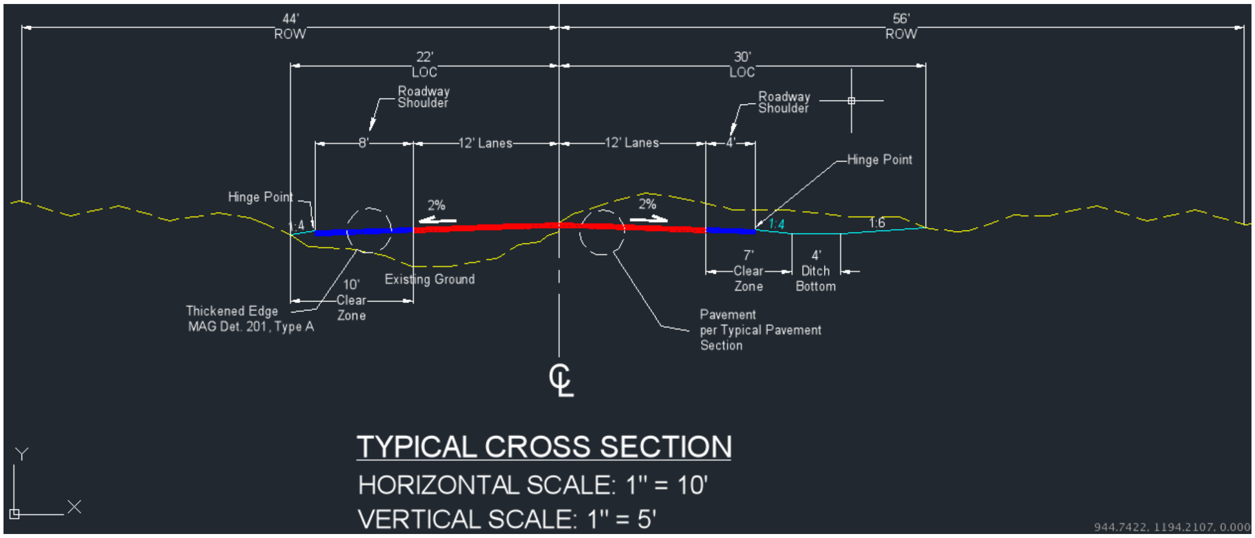


Figure 5.0: Typical Cross-Section

As shown in Figure 5.0, the crown will have a 2% slope (ADOT 2012, Page 300-1) for drainage, 1Vertcial:4Horizontal foreslopes (AASHTO 2001, Page 429), a 4 foot wide ditch bottom (AASHTO 2002, Page 3-12), 1V:6H backslopes for cut areas (AASHTO 2001, Page 331), and clear zone distances of 10 and 7 feet (AASHTO 2002, Page 3-6) for out-of-control vehicles to recover and reenter the TW safely. Figure 5.1 shows the suggested clear zone distances by using the designed ADT, forslopes, and backslopes. The values of the Limit of Construction (LOC – where construction will take place), ROW (area reserved for transportation purposed), and the location of the hinge points are shown in Figure 5.0 or in Appendix Q.

[U.S. Customary Units]

DESIGN SPEED	DESIGN ADT	FORESLOPES			BACKSLOPES		
		1V:6H or flatter	1V:5H TO 1V:4H	1V:3H	1V:3H	1V:5H TO 1V:4H	1V:6H or flatter
40 mph or less	UNDER 750	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10
	750 – 1500	10 – 12	12 – 14	**	10 – 12	10 – 12	10 – 12
	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14
	OVER 6000	14 – 16	16 – 18	**	14 – 16	14 – 16	14 – 16

Figure 5.1: Suggested Clear Zone Distances

6.0 Drainage systems:

6.1 Introduction:

The following hydrology and hydraulic analysis follows ADOT's *2012 Roadway Design Guidelines* and ADOT's *Drainage Structures' details* (ADOT.com, Drainage Structures), and FHWA's *2012 Hydraulic Design of Highway Culverts*. The proposed road will have a total of two newly installed culverts (Culvert #1 & Culvert #2), which can be seen in Appendix R along with the existing culverts (kept in final design; extension of culvert length required). Stations 5+66.02 and

6+30.37 are where Culverts #1 & #2 will be located. By looking at Appendix R, the existing culvert near the SR260 intersection has two pipe diameters of 18 inches and the other existing culvert near Station 4+36.50 have four pipe diameters of 20 inches. New culverts will be designed for the 100-year flood event as requested by the client. Figure 6.0, shows the locations of Culvert#1 & #2, the existing culvert #2, and the direction of flow.

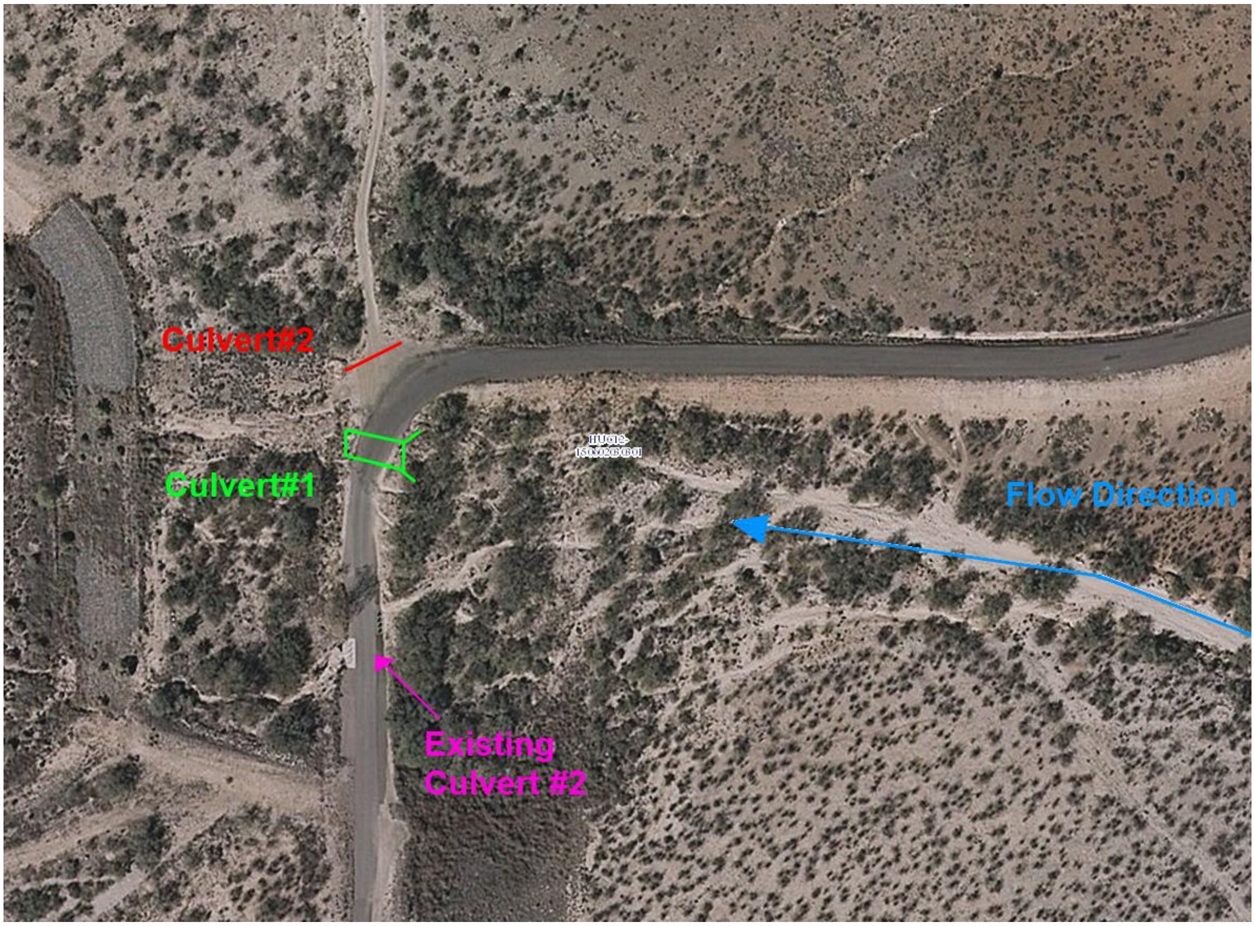


Figure 6.0: NMV's Top View of Culvert Locations (Not Drawn to Scale)

6.2 Culvert #1:

6.2.1 Hydrology:

First, a watershed delineation (See Appendix U1) was completed using the U.S. Geological Survey's USGS) National Map Viewer (NMV) to obtain a drainage area (A) of 2.556 sq. miles (1,635.84 acres). Since the drainage area was found to be greater than 160 acres (ADOT 2012, Page 600-10), the Rational Method for calculating the 100-year peak flow cannot be utilized. Instead, the National Streamflow Statistics (NSS) Program (See Appendix U2) was used. Values such as the Analysis Type (Peak), Rural location (Ungauged Site), Basin Drainage Area (A=2.556 sq. miles), Mean Basin Elevation (3,130 feet), and Crippen & Bue Region (16) were inputted into the NSS Program to obtain a 100-year Peak Flow of 2920 cubic feet per second (cfs). Next, the stream's slope (S = 3.05%) was determined from upstream and downstream elevations by using the typical LOC values.

6.2.2 Hydraulics Design:

By examining Figure 6.0, the main channel (wash) that drains into the ADOT basin widens before reaching the existing culvert #2, causing some (not all) of the flow to drain through the existing culvert #2 and a majority of the flood overtops approximately 150 feet of the existing road's length (From Stations 4+25 to 5+75). Therefore, the location of Culvert#1 was chosen by examining Figures 1.3, 1.4, 6.0 and also by reviewing the vertical alignment (road profile) of the road to verify that a concrete box culvert (See Figures 6.1 & 6.2 for Culvert #1 Profile drawn at skewed and Information) will be able to pass a flow of 2920 cfs without overtopping the road. A culvert with a rise of 3 feet and a span of 4 feet was selected, because the vertical alignment of the road at Culvert #1's location will allow a freeboard (top of culvert to hinge point) of about 2.25 feet (See Appendix S for a scaled drawing of Culvert #1's Profile).

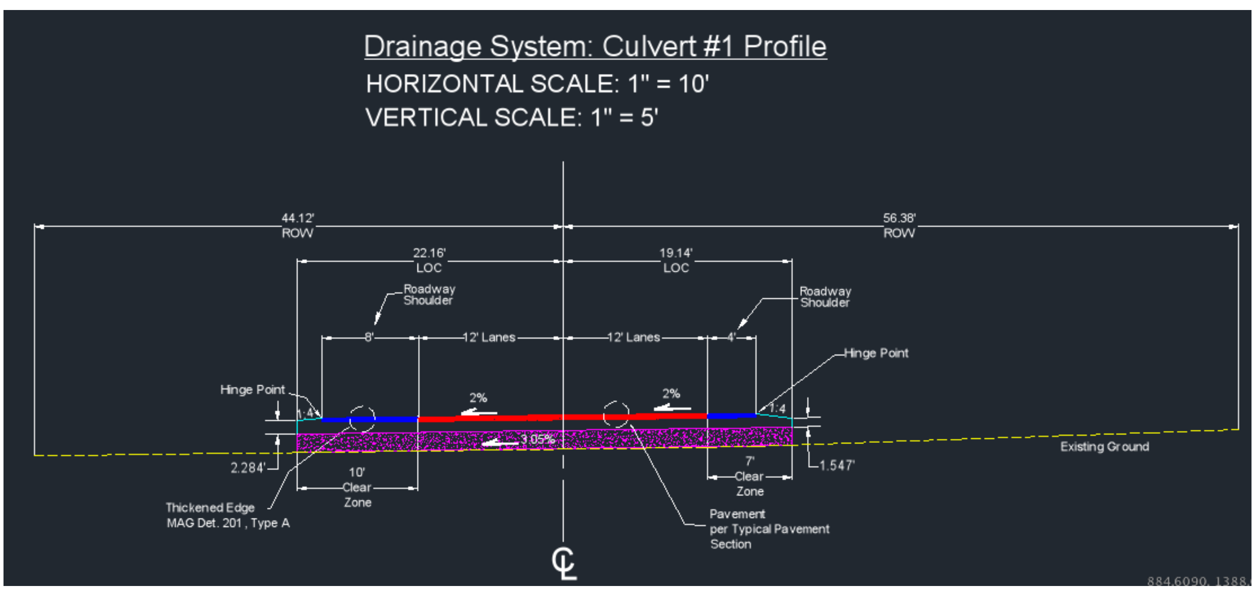


Figure 6.1: Culvert #1 Profile

Culvert #1 Profile

Station: 5+66.02
Bearing: S 00° 00' 35" E
Right Skew Angle: 7° 4' 48"
Type: Concrete Box Culvert
Rise: 3 ft. or 36 in.
Span: 4 ft. or 48 in.
Length of Culvert: 41.32 ft.
No. of Barrels: 6
Fill Depth to Hinge Pt.: 5.22 ft.

Figure 6.2: Culvert #1 Profile Information

Civil 3D's Hydraflow Express was used to determine the number of barrels needed to pass a peak flow of 2920 cfs without overtopping the roadway as requested by the client. The maximum number of barrels that could be entered into the software was four, the flow was divided by half (2920cfs/2=1460 cfs) and inputted, which allowed three barrels to pass the flow (1460 cfs) through without flooding the road. Now, since the flow was divided by half and three barrels were checked under both Inlet (See Appendix U4 for Hydraflow: Inlet Control) and Outlet Control (See Appendix U5 for Hydraflow: Outlet Control), the total number of barrels needed for a peak 100-year flow of 2920 cfs will be a total of six barrels. As shown in the Hydraflow reports in the appendices, the concrete box culverts will have a 30° to 75° flared wingwalls (See Appendix U6 for ADOT's Wingwall Detail Drawings). 30° flared wingwalls were chosen for the design of Culvert #1.

The skewed angle was calculated to be 7.08° (7°4'48" as seen in Appendix U3), which is used in selecting the correct wingwall lengths. Shown in Appendix U6 is ADOT's *Reinforced Concrete Box Culverts Inlet Wings - Skew 0° to 20°* to help obtain wingwall lengths of 7 and 8 feet from provided tables. The calculated skew angle was rounded up to 10°, a culvert height of 6 feet, and the foreslope (1V:4H) of the road are required to use the table shown in Appendix U6. A culvert height of 6 feet was used instead of the designed 3 feet, because the structure detail drawing only provides values for a culvert height from 5 to 7 feet, therefore the culvert lengths from the table were divided by half to match the height of the designed 3 foot high box culvert (See Figure 6.3 for a Plan View of Culvert#1 and the flared wingwalls).

The existing culvert shown in Figure 6.3 was extended to help Culvert #1 along with a fill boundary denoted as a dotted line (in light blue connecting Culvert #1's bottom wingwall to the existing culverts' headwall) to prevent flooding to enter the sides of the roadway, which may cause the road's embankment to erode. Headwall lengths were obtained also from ADOT's *Pipe Culvert Headwalls Inlet and Outlet 18" to 42"* structure detail drawing (See Appendix U7). 20 inches is the diameter of the four existing corrugated metal pipes; the diameter is needed to interpolate values from the table in Appendix U7 to get a length (L) of 10.2 feet. This 10.2 feet was then added to another value (E = 7.5 feet), which was interpolated from the table to get a total of 18 feet wide headwall (See Appendix U7 Plan View to define L & E values).

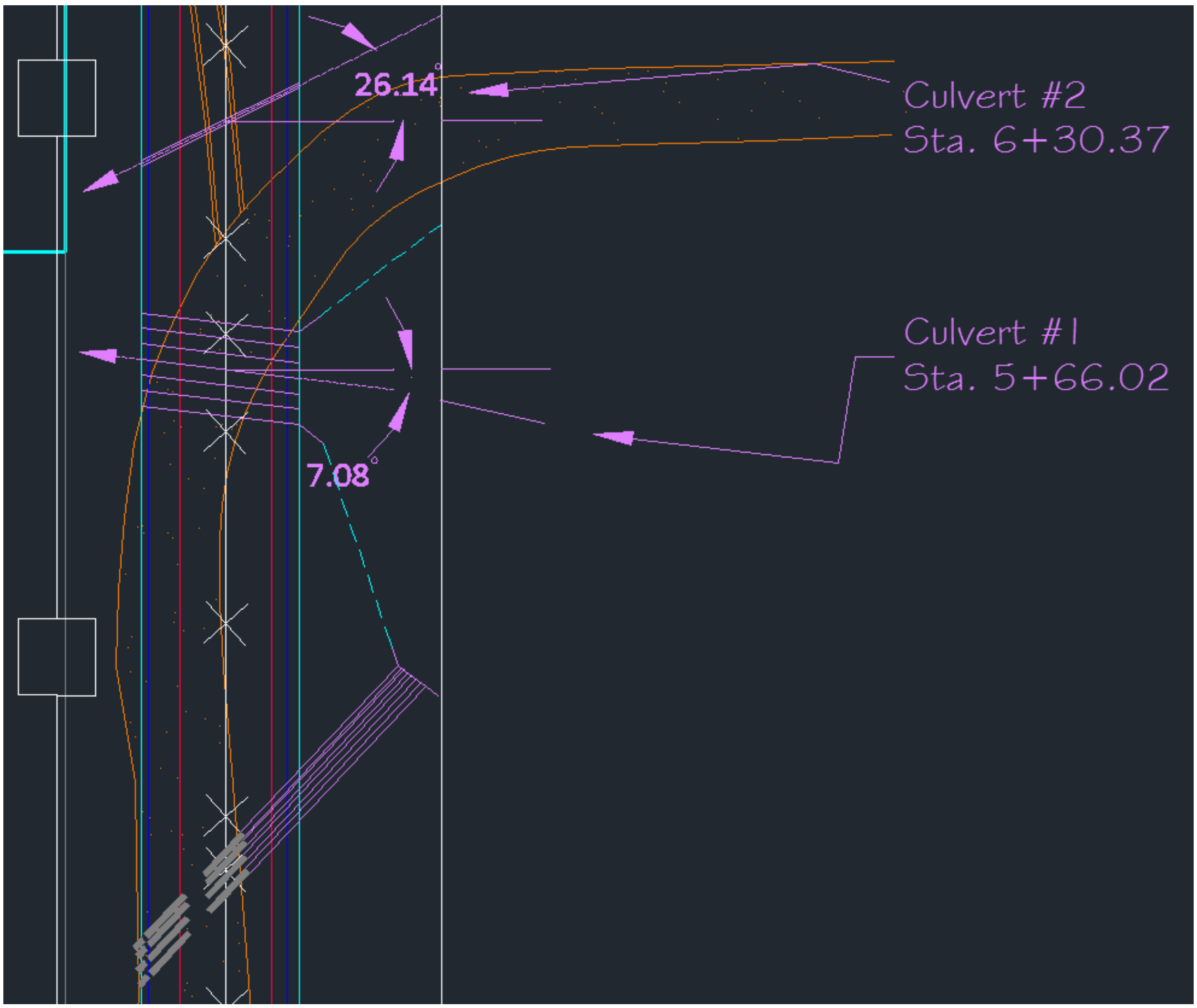


Figure 6.3: Plan View of Culverts, Wingwalls, Headwalls, & Fill lines (dotted light blue)

6.3 Culvert #2:

6.3.1 Hydrology:

A watershed delineation (See Appendix V1) was completed using USGS's NMV to acquire a drainage area (A) of 30.08 acres, which is less than 160 acres. Since A≤160 acres, the Rational Method was used to get the 100-year peak discharge (Q_{100}). The equation consists of the rational method runoff coefficient (C=0.20 from Highway Engineering, PH Wright, 1996, Table 11-2), rainfall intensity (i=0.167 inches/hour or 4 inches/day), and the drainage area (A=30.08 acres). Before computing the Q_{100}, the client's given rainfall intensity was verified using the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service (See Figure 6.4). NOAA's rainfall intensity came to be 0.164 inches per hour, which is very close to the value the client provided. The team used the client's rainfall intensity to evaluate the Q_{100} of 1.005 cfs (See Appendix V2 for Q_{100} calculations). Then, the stream flow's slope (S=3.02%) was determined in a similar manner as described for Culvert #1.

PF tabular | PF graphical | Supplementary information | Print Page

AMS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Annual exceedance probability (1/years)								
	1/2	1/5	1/10	1/25	1/50	1/100	1/200	1/500	1/1000
5-min	2.75 (2.33-3.23)	4.03 (3.42-4.74)	5.00 (4.21-5.86)	6.35 (5.29-7.40)	7.46 (6.16-8.69)	8.70 (7.09-10.2)	10.0 (8.04-11.7)	11.9 (9.36-14.0)	13.5 (10.4-15.9)
10-min	2.09 (1.78-2.45)	3.07 (2.60-3.61)	3.81 (3.21-4.46)	4.83 (4.03-5.64)	5.68 (4.69-6.61)	6.62 (5.39-7.72)	7.62 (6.12-8.90)	9.06 (7.12-10.6)	10.2 (7.93-12.1)
15-min	1.73 (1.46-2.03)	2.54 (2.15-2.98)	3.15 (2.65-3.68)	3.99 (3.33-4.66)	4.69 (3.87-5.47)	5.47 (4.46-6.38)	6.30 (5.06-7.35)	7.48 (5.88-8.79)	8.47 (6.56-9.99)
30-min	1.16 (0.988-1.37)	1.71 (1.45-2.01)	2.12 (1.79-2.48)	2.69 (2.24-3.14)	3.16 (2.61-3.68)	3.68 (3.00-4.29)	4.24 (3.40-4.95)	5.04 (3.96-5.92)	5.70 (4.41-6.72)
60-min	0.719 (0.611-0.845)	1.06 (0.897-1.24)	1.31 (1.10-1.54)	1.66 (1.39-1.94)	1.96 (1.61-2.28)	2.28 (1.86-2.66)	2.62 (2.11-3.06)	3.12 (2.45-3.66)	3.53 (2.73-4.16)
2-hr	0.432 (0.375-0.500)	0.619 (0.536-0.715)	0.758 (0.652-0.872)	0.955 (0.812-1.10)	1.12 (0.938-1.28)	1.30 (1.07-1.49)	1.49 (1.22-1.72)	1.77 (1.42-2.05)	2.00 (1.57-2.32)
3-hr	0.311 (0.275-0.356)	0.436 (0.385-0.498)	0.527 (0.463-0.601)	0.654 (0.569-0.745)	0.759 (0.653-0.862)	0.876 (0.744-0.997)	1.00 (0.838-1.15)	1.19 (0.971-1.38)	1.34 (1.07-1.56)
6-hr	0.188 (0.167-0.212)	0.254 (0.226-0.287)	0.303 (0.268-0.341)	0.371 (0.325-0.418)	0.425 (0.369-0.477)	0.485 (0.416-0.546)	0.547 (0.463-0.619)	0.638 (0.530-0.726)	0.715 (0.582-0.818)
12-hr	0.110 (0.099-0.124)	0.147 (0.131-0.164)	0.172 (0.153-0.192)	0.204 (0.181-0.228)	0.229 (0.202-0.256)	0.256 (0.224-0.286)	0.282 (0.244-0.316)	0.321 (0.274-0.363)	0.357 (0.299-0.411)
24-hr	0.068 (0.061-0.076)	0.092 (0.083-0.103)	0.109 (0.097-0.121)	0.130 (0.116-0.144)	0.147 (0.130-0.163)	0.164 (0.145-0.182)	0.182 (0.159-0.201)	0.205 (0.178-0.228)	0.223 (0.192-0.249)
2-day	0.037 (0.033-0.041)	0.050 (0.044-0.056)	0.059 (0.052-0.066)	0.070 (0.062-0.079)	0.079 (0.070-0.089)	0.089 (0.077-0.100)	0.098 (0.085-0.110)	0.111 (0.095-0.125)	0.121 (0.103-0.136)

Figure 6.4: NOAA's Rainfall Intensity (i) Value

6.3.2 Hydraulics Design:

Culvert #2's location was determined by examining Figure 6.0 and reviewing the vertical alignment to make sure that the culvert is properly alignment with the stream's flow direction. Once the alignment of the culvert was set, the skew angle (See Appendix V3 for Skew Angle calculations) of the culvert was computed to be 26.14° at which Culvert #2's Profile was drawn at (See Figure 6.5, 6.6 and Appendix T for Culvert drawings and information). Then, a diameter of 16 inches was chosen to carry the peak 100-year flow (Q_{100} = 1.005 cfs) through one corrugated metal pipe with a low chance of having debris clogging up the barrel. By looking at the profile, a 3.5 feet free board will be provided and the culvert was designed to not overtop the roadway as seen from the Hydraflow reports shown in Appendix V4 (under Inlet Control) and V5 (under Outlet Control).

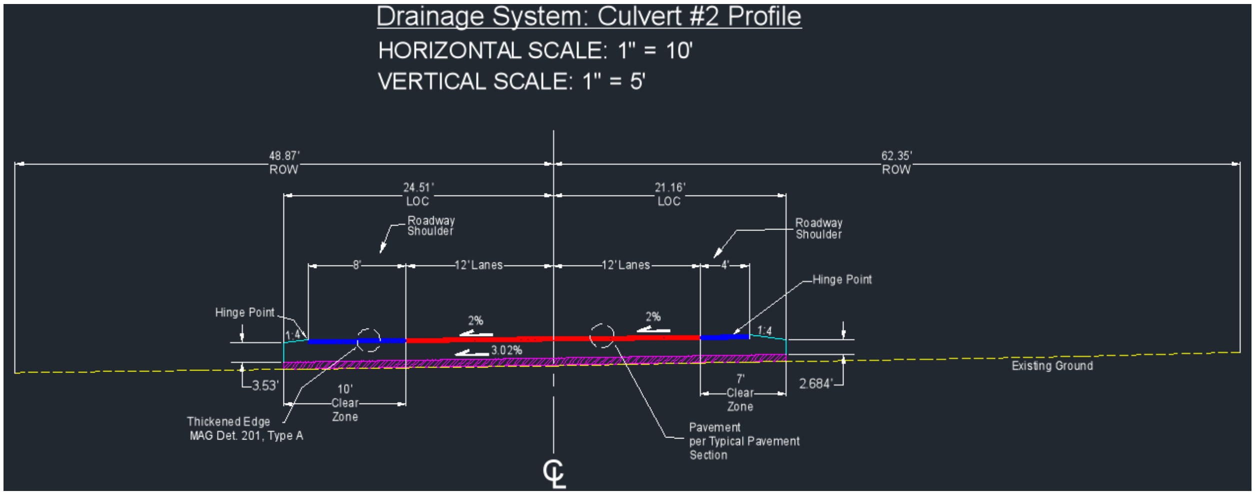


Figure 6.5: Culvert #2 Profile

Culvert #2 Profile

Station: 6+30.37

Bearing: S 00° 00' 35" E

Right Skew Angle: 26° 8' 24"

Type: CM Pipe

Diameter: 16 in.

Length of Culvert: 45.67 ft.

No. of Barrels: 1

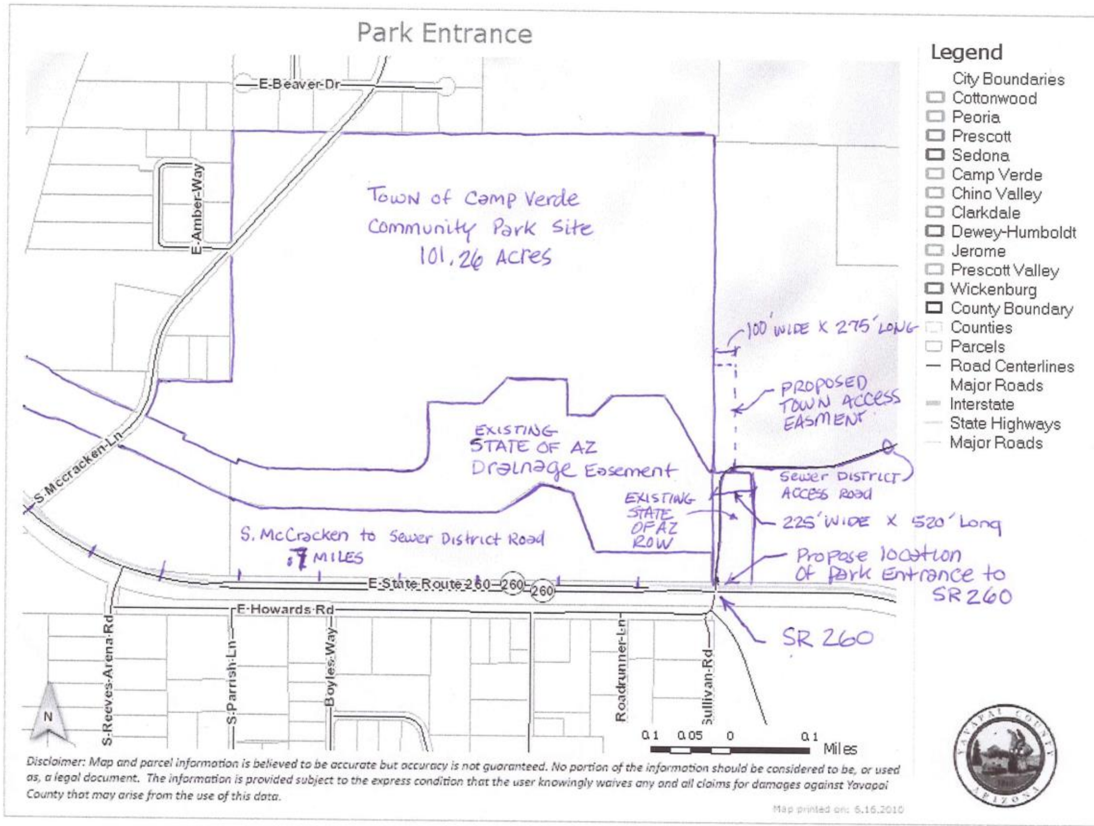
Fill Depth to Hinge Pt.: 4.79 ft.

Figure 6.6: Culvert#2 Information

6.3.3 Culvert Maintenance:

Finally, yearly maintenance of the new and current culverts is required to attain their highest performances. Maintenance consists of culvert performance, erosion, and debris blockages to best achieve the designed culverts' performances. A concrete slab should be installed at the downward stream of existing culvert #2 to stop the erosion (scouring – See Figure 1.4) and maybe considered for all other culverts after yearly check ups.

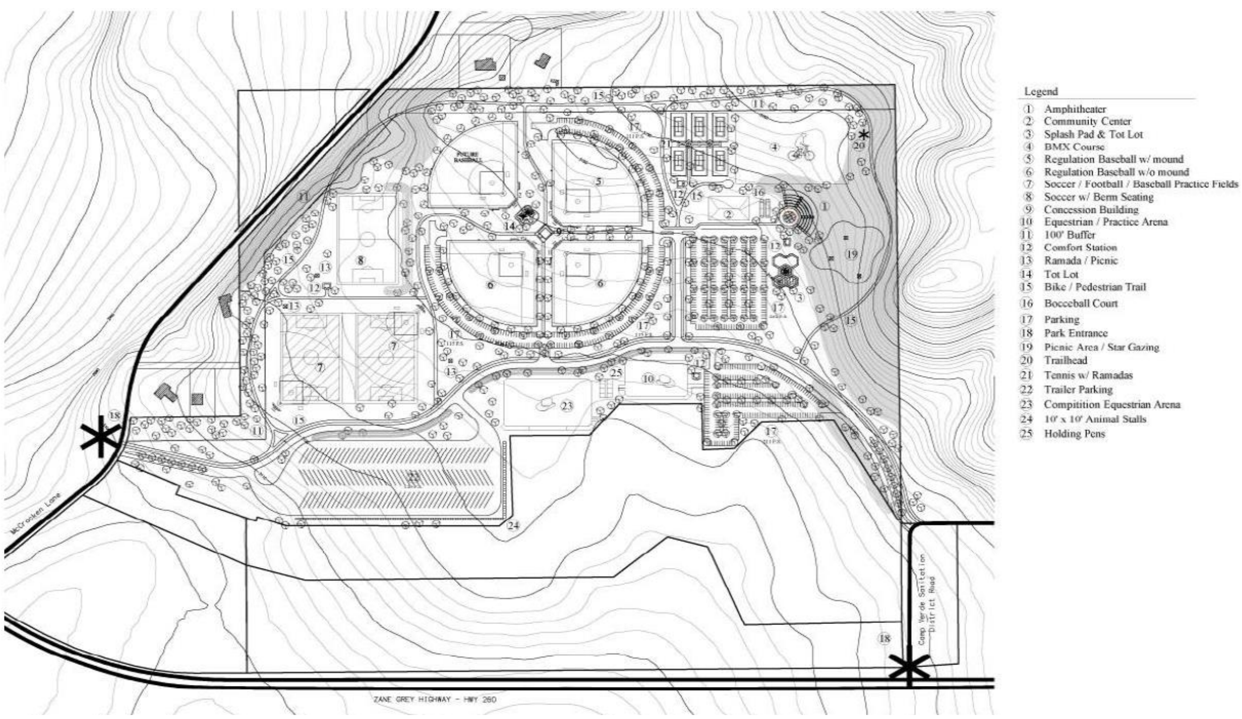
Appendix F



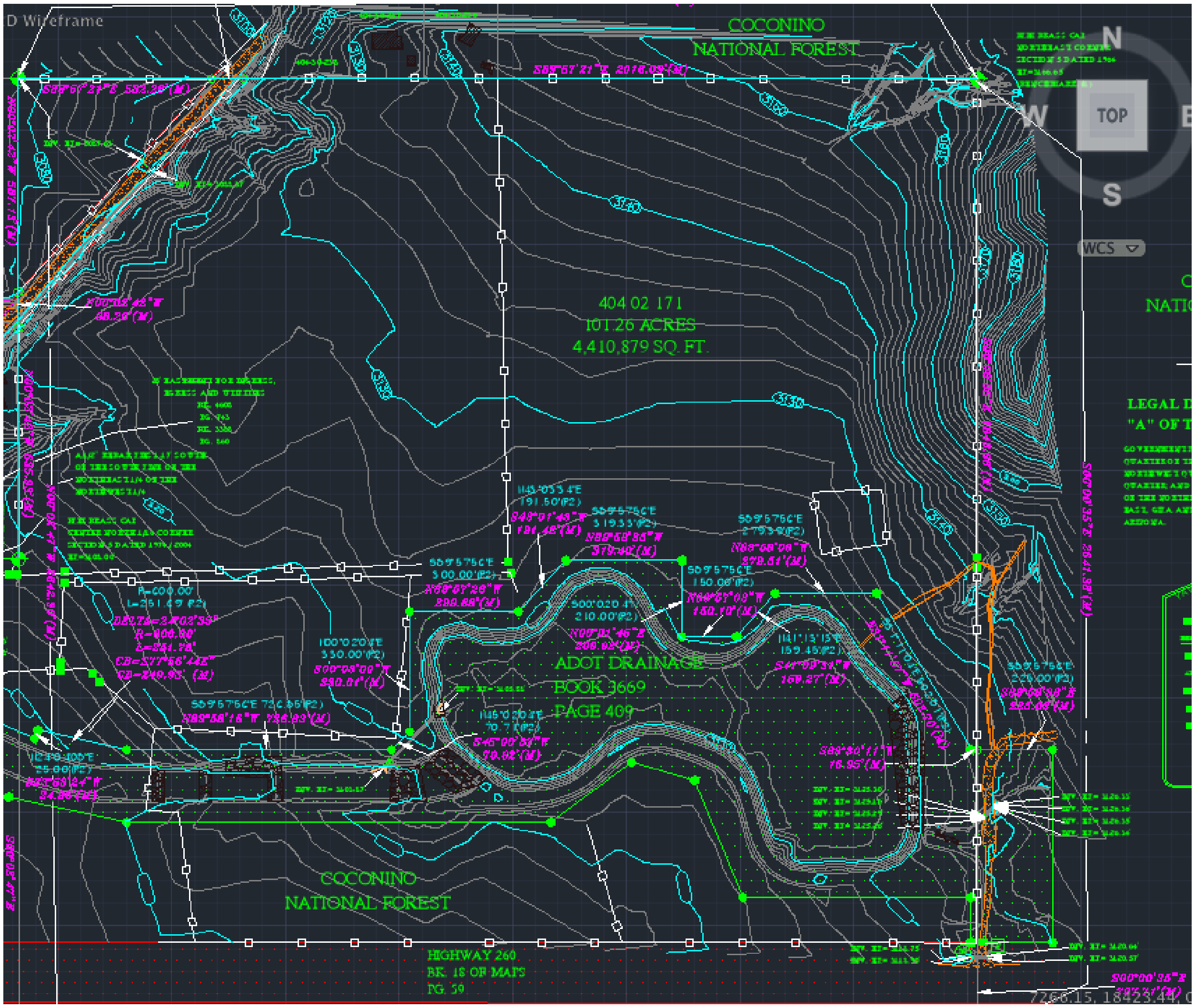
Park Entrance
Legend
City Boundaries
Cottonwood
Peoria
Prescott
Sedona
Camp Verde
Chino Valley
Clarkdale
Dewey-Humboldt
Jerome
Prescott Valley
Wickenburg
County Boundary
Counties
Parcels
Road Centerlines
Major Roads
Interstate
State Highways
Major Roads
E-Beaver-Dr
E-Amber-Way
S-Mccracken-Ln
E-State-Route-260
260
E-Howards-Rd
S-Reeves-Arena-Rd
S-Parrish-Ln
Boyles-Way
Roadrunner-Ln
Sullivan-Rd
N
0.1 0.05 0 0.1 Miles
Town of Camp Verde Community Park Site 101.26 Acres
100' WIDE X 275' LONG
PROPOSED TOWN ACCESS EASMENT
EXISTING STATE OF AZ Drainage Easement
Sewer DISTRICT ACCESS Road
EXISTING STATE OF AZ ROW
225' WIDE X 520' Long
S. McCracken to Sewer District Road
MILES
Propose location Of Park Entrance to SR260
SR 260
Disclaimer: Map and parcel information is believed to be accurate but accuracy is not guaranteed. No portion of the information should be considered to be, or used as, a legal document. The information is provided subject to the express condition that the user knowingly waives any and all claims for damages against Yavapai County that may arise from the use of this data.
Map printed on: 6.16.2010

Appendix G

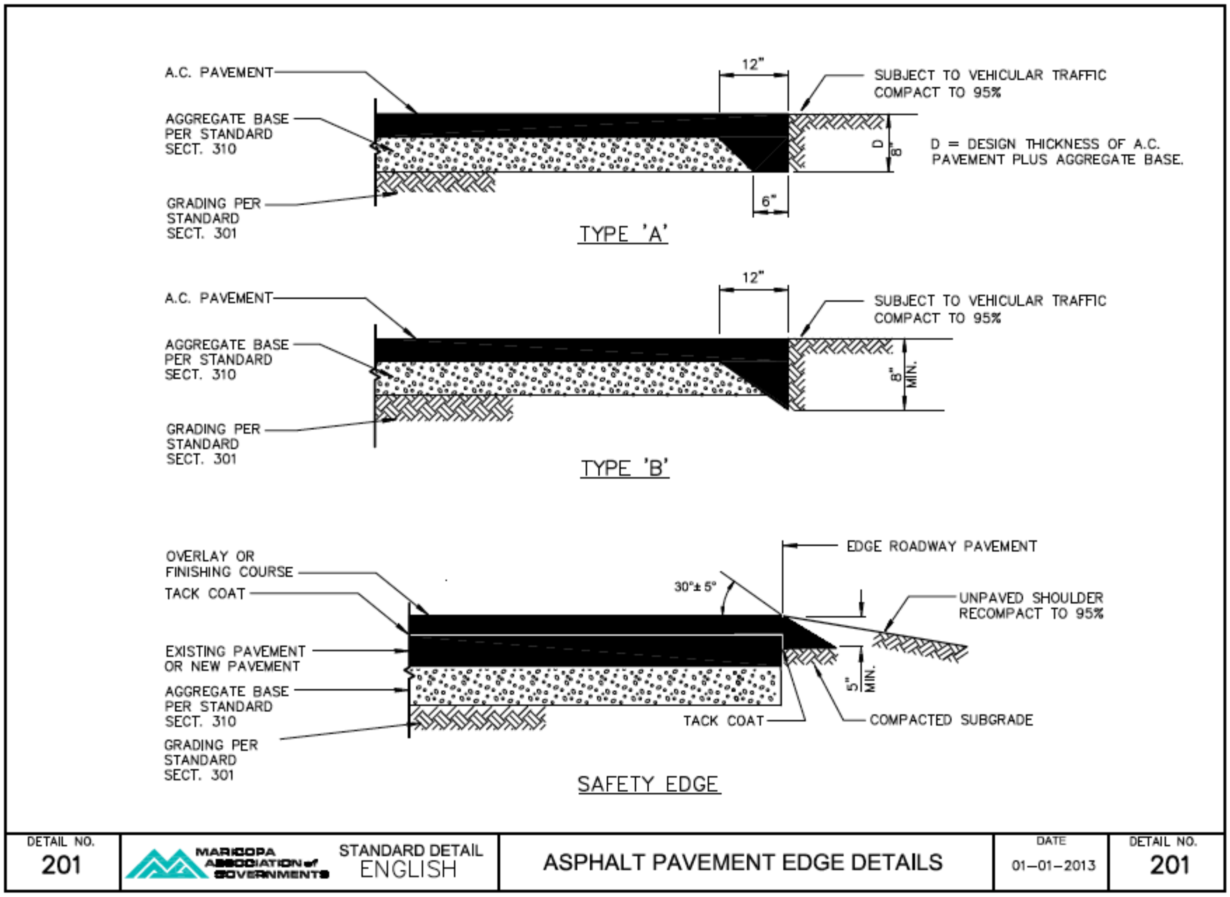

Camp Verde
Community Park
Masterplan
McCracken Lane
HWY 260
Legend
1 Amphitheater
2 Community Center
3 Splash Pad & Tot Lot
4 BMX Course
5 Regulation Baseball w/ mound
6 Regulation Baseball w/o mound
7 Soccer / Football
8 Soccer / Practice Baseball Field
9 Concession Building
10 Rodeo / Practice Arena
11 100' Buffer
12 Comfort Station
13 Ramada / Picnic
14 Tot Lot
15 Bike / Pedestrian Trail
16 Bocceball Court
17 Parking
18 Park Entrance
19 Picnic Area / Star Gazing
20 Trailhead
21 Tennis w/ Ramadas
22 Trailer Parking
RBF


McCracken Lane
ZANE GREY HIGHWAY - HWY 260
Camp Verde Sanitation District Road
Legend
1 Amphitheater
2 Community Center
3 Splash Pad & Tot Lot
4 BMX Course
5 Regulation Baseball w/ mound
6 Regulation Baseball w/o mound
7 Soccer / Football / Baseball Practice Fields
8 Soccer w/ Berm Seating
9 Concession Building
10 Equestrian / Practice Arena
11 100' Buffer
12 Comfort Station
13 Ramada / Picnic
14 Tot Lot
15 Bike / Pedestrian Trail
16 Bocceball Court
17 Parking
18 Park Entrance
19 Picnic Area / Star Gazing
20 Trailhead
21 Tennis w/ Ramadas
22 Trailer Parking
23 Compitition Equestrian Arena
24 10' x 10' Animal Stalls
25 Holding Pens

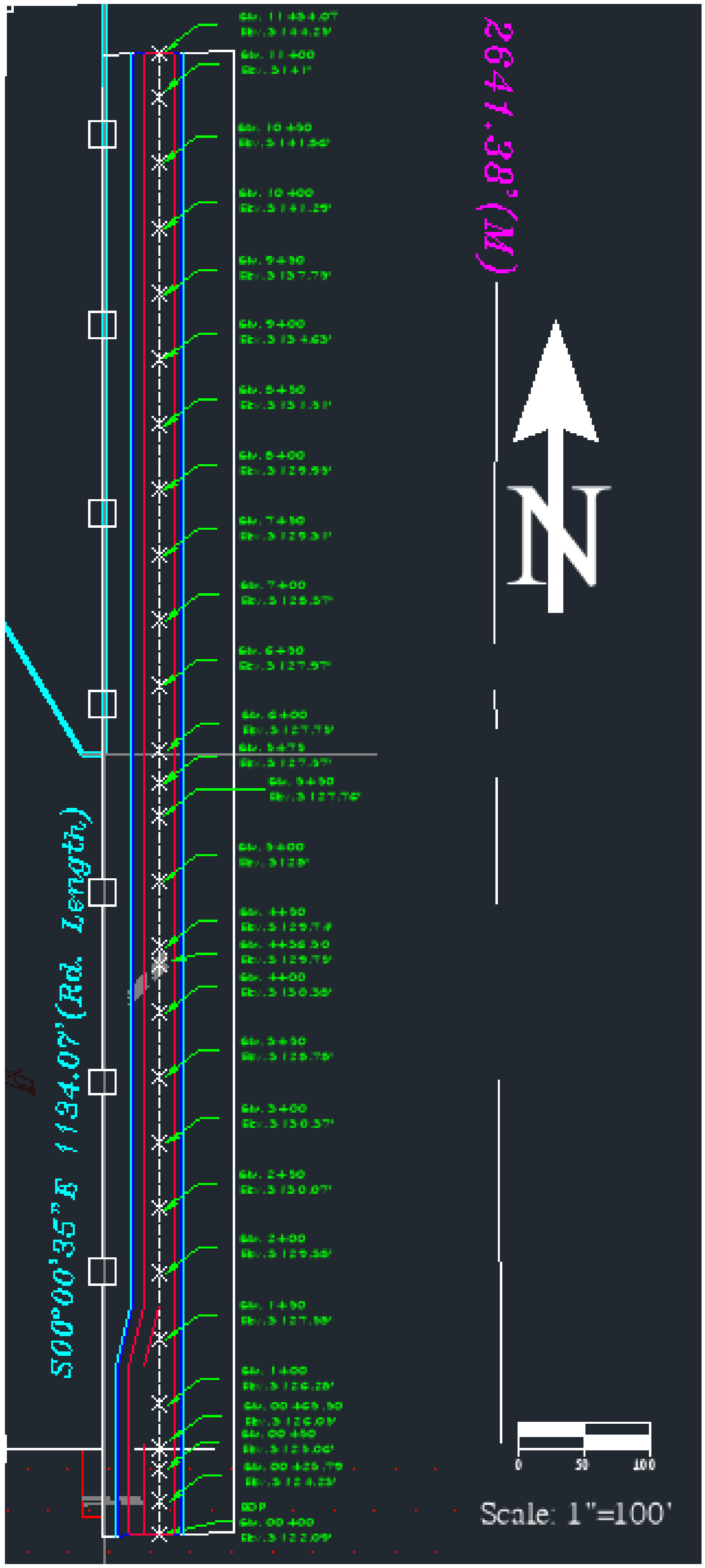
Appendix H

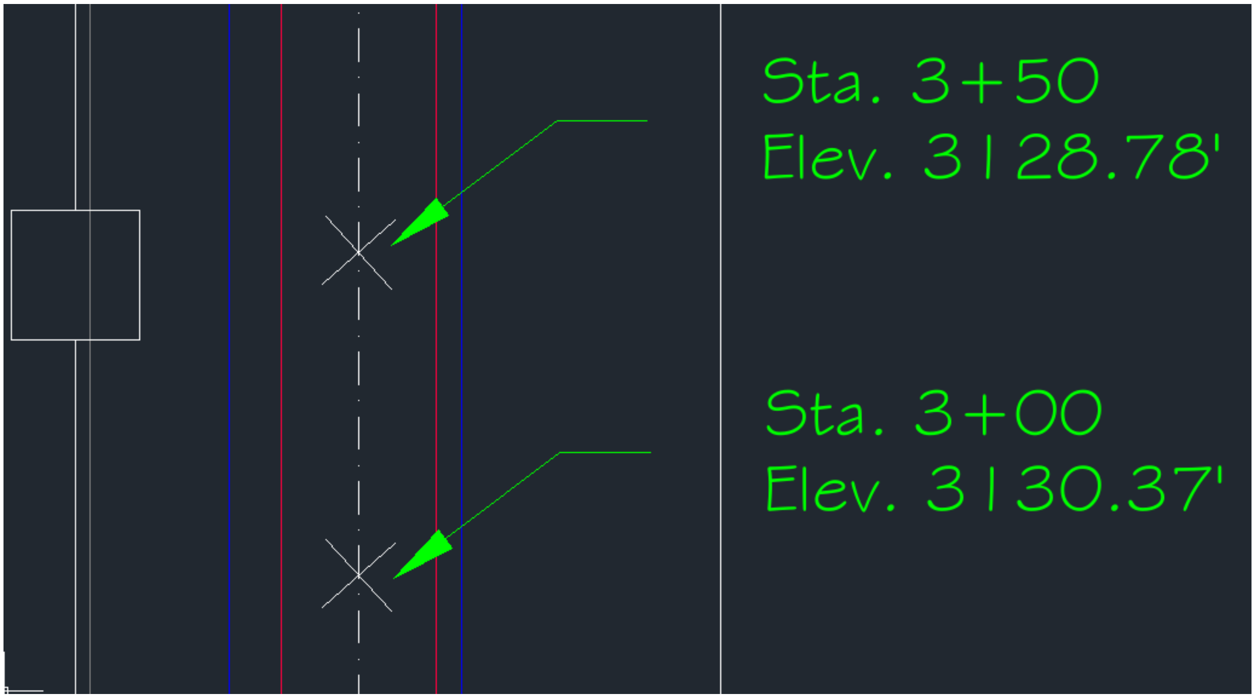

COCONINO
NATIONAL FOREST
404 02 171
101.26 ACRES
4,410,879 SQ. FT.
ADOT DRAINAGE
BOOK 3669
PAGE 409
COCONINO
NATIONAL FOREST
HIGHWAY 260
BK. 18 OF MAPS
PG. 59

Appendix I


A.C. PAVEMENT
AGGREGATE BASE PER STANDARD SECT. 310
GRADING PER STANDARD SECT. 301
12"
6"
SUBJECT TO VEHICULAR TRAFFIC COMPACT TO 95%
D = DESIGN THICKNESS OF A.C. PAVEMENT PLUS AGGREGATE BASE.
TYPE 'A'
A.C. PAVEMENT
AGGREGATE BASE PER STANDARD SECT. 310
GRADING PER STANDARD SECT. 301
12"
SUBJECT TO VEHICULAR TRAFFIC COMPACT TO 95%
8" MIN.
TYPE 'B'
OVERLAY OR FINISHING COURSE
TACK COAT
EXISTING PAVEMENT OR NEW PAVEMENT
AGGREGATE BASE PER STANDARD SECT. 310
GRADING PER STANDARD SECT. 301
30°± 5°
EDGE ROADWAY PAVEMENT
UNPAVED SHOULDER RECOMPACT TO 95%
5" MIN.
TACK COAT
COMPACTED SUBGRADE
SAFETY EDGE
DETAIL NO. 201
MARICOPA ASSOCIATION of GOVERNMENTS
STANDARD DETAIL ENGLISH
ASPHALT PAVEMENT EDGE DETAILS
DATE 01-01-2013
DETAIL NO. 201

Appendix J




Sta. 3+50
Elev. 3128.78'
Sta. 3+00
Elev. 3130.37'

Appendix K

Horizontal Alignment

℄ Stations	Proposed ℄ Elevations	Existing ℄ Elevations
BOP 00+00	3122.09'	3122.09'
00+25.79	3124.23'	(2/31.5) 19.5 + 3122 = 3123.24'
00+50	(2/17) 9 + 3124' = 3125.06'	(2/52) 12.5 + 3124 = 3124.48'
00+65.50	(2/84) 2 + 3126' = 3126.05'	(2/62) 32 + 3124 = 3125.03'
1+00	(2/61) 8.5 + 3126' = 3126.28'	(2/79) 74.5 + 3124 = 3125.89'
1+50	(2/38) 30 + 3126 = 3127.58'	(2/36) 10.5 + 3126 = 3126.58'
2+00	(2/29) 20 + 3128 = 3129.38'	(2/27.5) 9 + 3128 = 3128.65'
2+50	(2/60) 2 + 3130 = 3130.07'	(2/21.5) 16 + 3128 = 3129.49'
3+00	(2/60) 11 + 3130 = 3130.37'	(2/59.5) 3.5 + 3130 = 3130.12'
3+50	(2/66.5) 26 + 3128 = 3128.78'	(2/64.5) 21 + 3128 = 3128.65'
4+00	(2/24) 4.5 + 3130 = 3130.38'	(2/14) 8.5 + 3128 = 3129.21'
4+36.50	(2/20) 17.5 + 3128 = 3129.75'	(2/20) 9.5 + 3128 = 3128.95'
4+50	(2/19.5) 17 + 3128 = 3129.74'	(2/19.5) 7.5 + 3128 = 3128.77'
5+00	= 3128.00'	(2/46) 30 + 3126 = 3127.30'
5+50	(2/67) 59 + 3126 = 3127.76'	(2/68) 48.5 + 3126 = 3127.43'
5+75	(2/83) 65 + 3126 = 3127.57'	3127.57'
6+00	(2/80.5) 70.5 + 3126.00 = 3127.75'	(2/81.5) 72.5 + 3126 = 3127.78'
6+50	(2/71.6) 69.9 + 3126 = 3127.97'	(2/71) 66 + 3126 = 3127.86'
7+00	(2/41) 7.5 + 3128 = 3128.37'	(2/62.5) 59.5 + 3126 = 3127.90'
7+50	(2/49.5) 32.5 + 3128 = 3129.31'	(2/53.5) 22 + 3128 = 3128.82'
8+00	(2/66.5) 65 + 3128 = 3129.95'	(2/68.5) 60.5 + 3128 = 3129.77'
8+50	(2/39.5) 29 + 3130 = 3131.51'	3131.51'
9+00	(2/24) 7.5 + 3134 = 3134.63'	(2/21) 7 + 3134 = 3134.61'
9+50	(2/4) 3.5 + 3136 = 3137.75'	(2/60.5) 59 + 3134 = 3135.95'
10+00	(2/7) 4.5 + 3140 = 3141.29'	3138'
10+50	(2/37) 34.5 + 3140 = 3141.86'	(2/20.5) 19 + 3140 = 3141.85'
11+00	3141.0'	3140.0'
EOP 11+34.07	(2/8) 1.5 + 3144 = 3144.25'	0

★ Grade from BOP to EOP

• $\text{Grade} = \left(\frac{\text{Rise}}{\text{Run}}\right) * 100$

$= \left(\frac{3146.38' - 3123.25'}{1134.07' - 0}\right) \times 100$

$= 2.03956\%$

★ Bearing from BOP to EOP:

S 00°00'35" E

Appendix L

★ **Sight Distance:**

① **SSD**

- Design Speed = 15 mph
- Brake reaction distance = 55.1 ft
- Braking distance on level = 21.6 ft
- SSD for calculated = 76.7 ft
- SSD for Design = 80 ft

(AASHTO 2001 pg # 112 Ex 3-1)

or

$$d = 1.47\,Vt + 1.075\left(\frac{V^2}{a}\right)$$

$$= 1.47(15\text{mph})(2.5\text{ sec}) + 1.075\left(\frac{15\text{mph}^2}{11.2\text{ ft/s}}\right)$$

$$= 76.721\text{ ft}$$

AASHTO 2001 Ch3 pg 113 (3-2)

- d - SSD in (ft)
- V - design speed (mph)
- t - brake reaction time (2.5 seconds) ← AASHT 2001 Ch3 pg. 111
- a - deceleration rate, ($11.2\ ft/s^2$) ← AASHTO 2001 Ch3 pg 111

Appendix M

★ **DSD:**

- The decision sight distances for avoidance maneuvers C, D, & E are:

AASHTO 2001 Ch3 pg 117

$d = 1.47Vt$ } (3-5)

$= 1.47(15\,mph)(11.2\,sec)$

$= \underline{246.96\ ft}$

AASHTO 2001 Ch3 pg 116 Ex. 3-3

d - DSD for LOS C
V - design speed (mph)
t - total pre-maneuver & maneuver time, s } LOS C (10.2s - 11.2s)

★ **Braking Distance**

$d = 1.075\left(\frac{V^2}{a}\right)$ } (3-1) AASHTO 2001 Ch3 pg 111

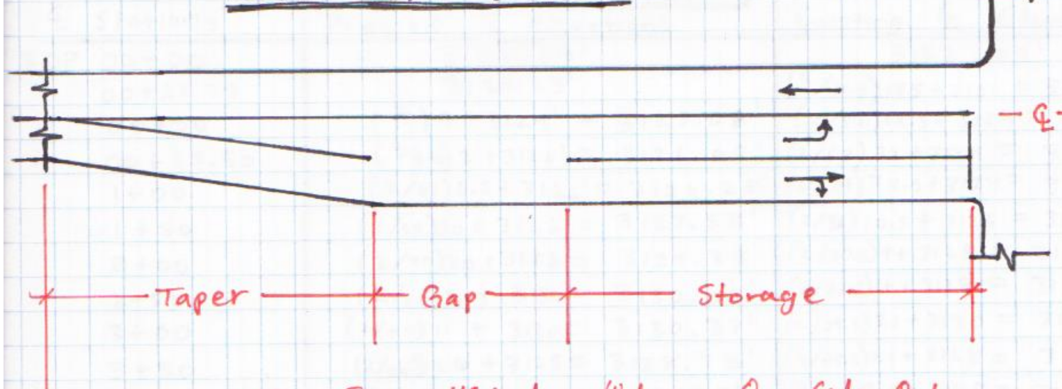
$= 1.075\left(\frac{15\,mph^2}{11.2\,ft/s^2}\right)$

$= \underline{21.596\ ft}$

Appendix N

Left Turn Lanes: ADOT PGP 2000

9/29/13



PGP: Figure 430-A – Widening One Side Only

T = length of taper (ft)
W = width of the added lane (ft)
S = posted speed for existing roadways, or design speed for new or reconstructed roadways (mph)

★ $T = \frac{S^2 \times W}{60}$ for speeds under 45 mph

$= \frac{(15\,mph)^2 \times (12\,ft)}{60} = \underline{45\ ft}$ but Client wants 200 ft

★ Gap Length:

- Table 430-1 – Gap Lengths
  - ↳ Gap length = 60 ft for < 40 mph design speed

★ Storage Length:

- Storage length = braking distance + queue length
  - ↳ Braking distance = 20 feet ← Table 430-2, PGP
  - ↳ Queue: should provide space for two passenger cars @ 25 ft each < 10% truck %.

(PGP pg 430-5)

$\approx 2 \times (25') = \underline{50\,ft}$

- Storage length = 20 ft + 50 ft = 70 ft

Appendix O

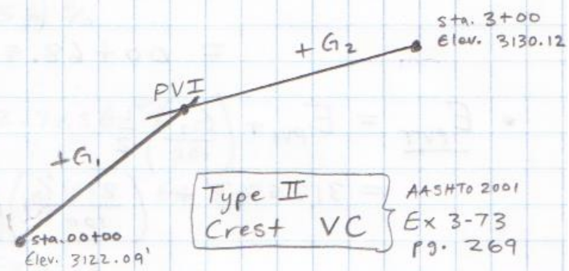
Vertical Alignment

- Roadway Functional Classification:
  Rural Collector

- Maximum Grade

  - Max. Grade for Rural Collectors
    → Level : 15 mph ≈ 9%
    → Rolling : 15 mph ≈ 12%
    } AASHTO pg 427 Ex 6-4

- Vertical Curves:



Type II Crest VC } AASHTO 2001 Ex 3-73 pg. 269

  - PVI #1
    → Sta. 00+65.5
    → Elevation : 3125.03'

    - $+G_1 = \left(\frac{3125.03' - 3122.09'}{65.5' - 0.0}\right) \times 100\%$
      $= 4.49\%$

    - $+G_2 = \left(\frac{3130.12' - 3125.03'}{300' - 65.5'}\right) \times 100\% = 2.17\%$

    - A (Algebraic diff. in grade) $= G_2 - G_1 = 2.17\% - 4.49\% = -2.32\%$

    - S (sight stopping dist.) = 80 ft for 15 mph ← AASHTO 2001 pg 274 Ex 3-76

    - K (rate of vertical curvature) = 3 ← AASHTO 2001 Ex 3-76 pg 274

    - $L = KA = (3)(2.32) = $ **6.96 ft = L**

    - S < L :
      $L_{min} = \frac{AS^2}{2158}$ } AASHTO 2001 pg 272 (3-45) & ADOT 2012 pg 200-28
      $= \left(\frac{-2.32\%(80)^2}{2158}\right)$
      $= 6.88$ ft

→ • PVC₁ Station

$$PVC_1 \text{ Station} = PVI \text{ Sta.} - \frac{L}{2} = 65.5' - \left(\frac{6.96'}{2}\right) = 00+62.02$$

$$E_{PVC} = E_{PVI} - \left(\frac{G_1}{100}\right)\frac{L}{2} = 3125.03' - \left(\frac{4.49\%}{100}\right)\frac{6.96'}{2} = 3124.87'$$

→ • PVT₁ Station

$$PVT_1 \text{ Station} = PVI \text{ Sta.} + \frac{L}{2} = 65.5' + \left(\frac{6.96'}{2}\right) = 00+68.98$$

$$E_{PVT} = E_{PVI} + \left(\frac{G_2}{100}\right)\frac{L}{2} = 3125.03' + \left(\frac{2.17\%}{100}\right)\left(\frac{6.96'}{2}\right) = 3125.11'$$

• Elevation of curve @ PVI = 3125.01

$$X_m = \left|\frac{G_1 * L}{G_2 - G_1}\right| = 1.06466 \text{ ft}$$

• high pt. sta.

$$\text{high pt. sta.} = PVC \text{ Sta.} + X_m = 62.02' + 1.06466' = 63.085 = 00+63.09$$

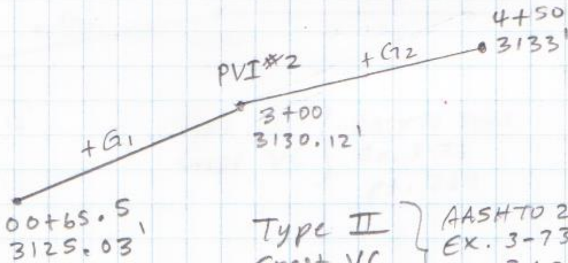
• high pt. elev.

$$\text{high pt. elev.} \Rightarrow E_x = E_{PVC} + \left(\frac{G_1}{100}\right)X_m = 3124.87' + \left(\frac{4.49\%}{100}\right)1.06466' = 3124.92'$$

Appendix P

★ Vertical Alignment:

- Vertical Curve #2



Type II Crest VC } AASHTO 2001 Ex. 3-73 pg. 269

↳ PVI #2
- → Station: 3+00
- → Elevation: 3130.12'

- $+G_1 = \frac{(3130.12' - 3125.03')}{(300' - 65.5')} \times 100\%$

$= +2.171\%$

- $+G_2 = \frac{(3133' - 3130.12')}{(450 - 300)} \times 100\% = +1.92\%$

- $A = G_2 - G_1 = |1.92\% - 2.17\%| = 0.251\%$

- $S = 80$ ft for 15 mph ← AASHTO 2001 pg. 274 Ex. 3-76

- $K = 3$ ← AASHTO 2001 Ex 3-76 pg 274

- $L = KA = (3)(0.251\%) = \boxed{0.752 \text{ ft}}$

- PVC Sta. $=$ PVI sta. $- \frac{L}{2} = 300' - \frac{0.752'}{2} = 2+99.624$

- $E_{PVC} = E_{PVI} - \left(\frac{G_1}{100}\right)\frac{L}{2} = 3130.12' - \left(\frac{2.171\%}{100}\right)\frac{0.752'}{2} = 3130.11'$

- PVT Sta. $=$ PVI sta. $+ \frac{L}{2} = 300' + \frac{0.752'}{2} = 3+00.376$

- $E_{PVT} = E_{PVI} + \left(\frac{G_2}{100}\right)\frac{L}{2} = 3130.12' + \left(\frac{1.92\%}{100}\right)\frac{0.752'}{2} = 3130.13'$

- $X_m = \left|\frac{G_1 * L}{G_2 - G_1}\right| = \left|\frac{2.171\% * 0.752'}{1.92\% - 2.171\%}\right| = 6.504'$

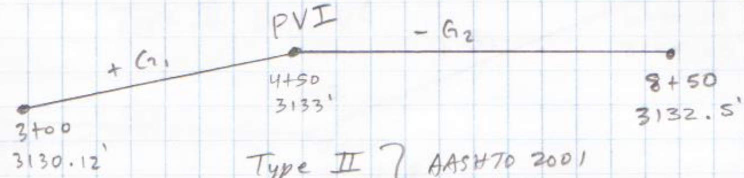
- Sta. of highest pt. on VC $=$ PVC Sta. $+ X_m = 2+99.624 + 6.504'$
  $= 3+06.128$

- Elev. of highest pt. on VC $= E_{PVC} + \left(\frac{G_1}{100}\right)X_m + \frac{(G_2 - G_1)X_m^2}{200L}$
  $= 3130.11' + \left(\frac{2.17\%}{100}\right)6.504' + \frac{(1.92\% - 2.17\%)\,6.504'^2}{200 \cdot 0.752'}$
  $= 3130.18'$

Appendix Q

★ Vertical Curve #3

PVI #3
→ Station: 4+50
→ Elevation: 3133'



Type II Crest VC } AASHTO 2001 Ex. 3-73 pg. 269

- $+G_1 = \frac{(3133' - 3130.12')}{(450' - 300')} \times 100\% = 1.92\%$
- $-G_2 = \frac{(3132.5' - 3133')}{(850' - 450')} \times 100\% = -0.125\%$
- $A = |G_2 - G_1| = 2.045\%$
- $S = SSD = 80\,ft$ ← AASHTO 2001, Ex 3-76, pg 274
- $K = 3$
- $L = KA = 3(2.045\%) = \boxed{6.135'}$
- PVC Sta. $= \text{PVI Sta.} - \frac{L}{2} = 450 - \frac{6.135'}{2} = 4+46.933$
- $E_{PVC} = E_{PVI} - \left(\frac{G_1}{100}\right)\frac{L}{2} = 3133' - \left(\frac{1.92\%}{100}\right)\frac{6.135'}{2} = 3132.94'$
- PVT Sta. $= \text{PVI sta.} + \frac{L}{2} = 450 + \frac{6.135'}{2} = 4+53.068$
- $E_{PVT} = E_{PVI} + \left(\frac{G_2}{100}\right)\frac{L}{2} = 3133' + \left(\frac{-0.125\%}{100}\right)\frac{6.135'}{2} = 3133'$
- $X_m = \left|\frac{G_1 * L}{G_2 - G_1}\right| = \left|\frac{1.92\% \cdot 6.135'}{-0.125\% - 1.92\%}\right| = 5.76'$
- Sta. of high pt. on VC $= \text{PVC Sta.} + X_m = 4+46.933 + 5.76'$
  $= 4+52.693$
- Elev. of high pt. on VC $= E_x = E_{PVC} + \left(\frac{G_1}{100}\right)X_m + \frac{(G_2 - G_1)X_m^2}{200L}$

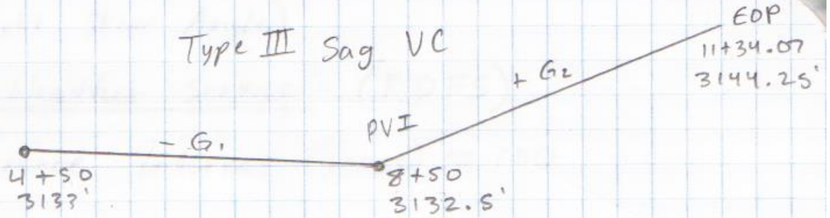
$$= 3132.94' + \left(\frac{1.92\%}{100}\right)5.76' + \frac{(-0.125\% - 1.92\%)\,5.76'^2}{200(6.135')}$$

$$= 3133'$$

Appendix R

* **Vertical Curve \# 4**

Type III Sag VC



PVI:

→ Station: 8+50

→ Elevation: 3132.5'

- $-G_1 = \left(\dfrac{3132.5' - 3133'}{850 - 450}\right) \times 100 = -0.125\%$

- $+G_2 = \left(\dfrac{3144.25' - 3132.5'}{1134.07' - 850'}\right) \times 100 = 4.1363\%$

- $A = |G_2 - G_1| = |4.1363\% - -0.125\%| = 4.2613\%$

- $K = 10$ ← AASHTO 2001, pg 280, Ex 3-79

- $L = KA = (10)(4.2613\%) = \boxed{42.613'}$

- PVC Sta. $=$ PVI Sta. $- \dfrac{L}{2} = 850 - \dfrac{42.613'}{2} = 8+28.694$

- $E_{PVC} = E_{PVI} - \left(\dfrac{G_1}{100}\right)\dfrac{L}{2} = 3132.5' - \left(\dfrac{-0.125\%}{100}\right)\left(\dfrac{42.613'}{2}\right) = 3132.53'$

- PVT Sta. $=$ PVI Sta. $+ \dfrac{L}{2} = 850 + \left(\dfrac{42.613'}{2}\right) = 8+71.307$

- $E_{PVT} = E_{PVI} + \left(\dfrac{G_2}{100}\right)\dfrac{L}{2} = 3132.5' + \left(\dfrac{4.1363\%}{100}\right)\left(\dfrac{42.613'}{2}\right) = 3133.38'$

- $X_m = \left|\dfrac{G_1 L}{G_2 - G_1}\right| = \left|\dfrac{-0.125\%(42.613')}{4.2613\% - (-0.125\%)}\right| = 1.21438'$

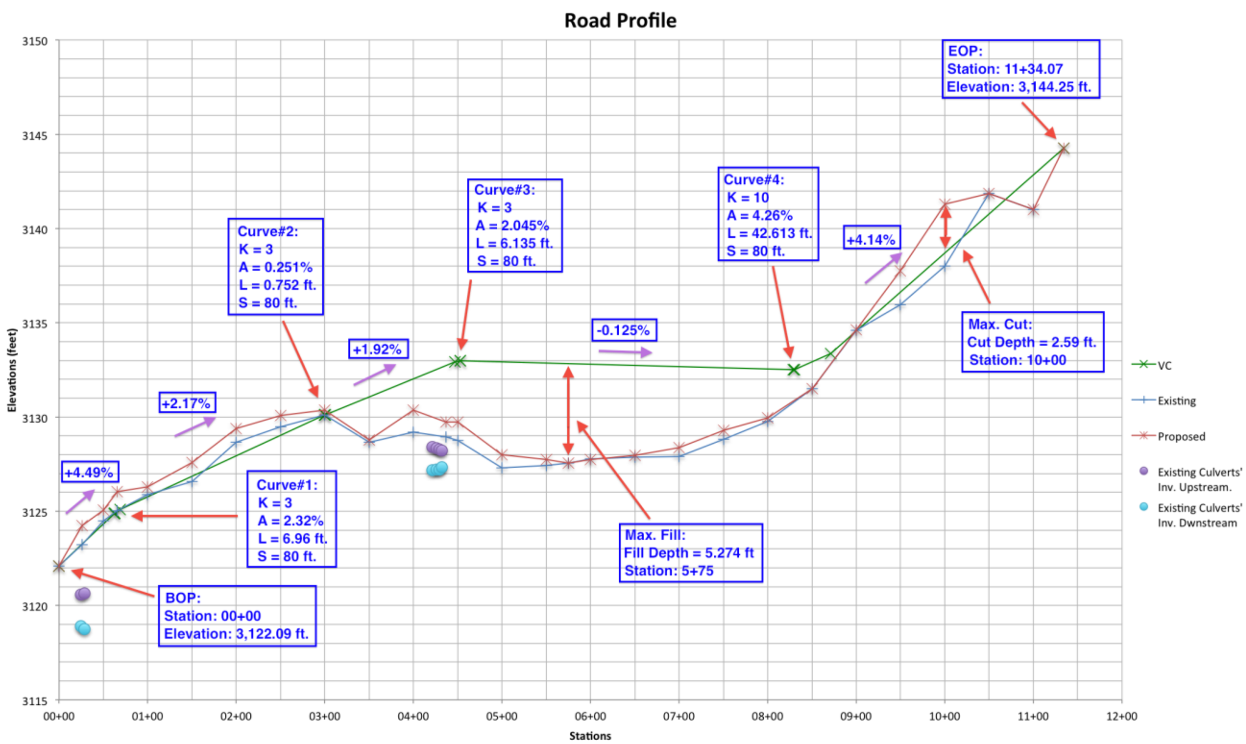
- Low pt. Sta. on VC $=$ PVC Sta. $+ X_m = 828.694 + 1.21438'$
  $= 829.91$
  $= 8+29.91$

- Low pt. Elev. on VC $\Rightarrow E_x = E_{PVC} - \left(\dfrac{G_1}{100}\right)X_m$
  $= 3132.53' - \left(-\dfrac{0.125\%}{100}\right)1.21438'$
  $= 3132.53'$

Appendix T

Vertical Curves		Stations	Elevations (ft)	A (%)	K	L (ft.)=K*A	Critical Station	Critical Elevation (ft	Grades (%)
Curve #1	PVI1	00+65.50	3125.03						G1 = 4.49
Crest	PVC1	00+62.02	3124.87	2.32	3	6.69	00+63.09	3124.92	G2 = 2.17058
	PVT1	00+68.98	3125.11						G3 = 1.92
									G4 = -0.125
Curve #2	PVI2	03+00.00	3130.12						G5 = 4.1363
Crest	PVC2	02+99.62	3130.11	0.251	3	0.752	03+00.00	3130.12	
	PVT2	03+00.38	3130.13						
Curve #3	PVI3	04+50.00	3133						
Crest	PVC3	04+46.93	3132.94	2.045	3	6.135	04+52.69	3133	
	PVT3	04+53.07	3133						
Curve #4	PVI4	08+50.00	3132.5						
Sag	PVC4	08+28.69	3132.53	4.2613	10	42.613	08+29.91	3132.53	
	PVT4	08+71.31	3133.38						

Appendix U

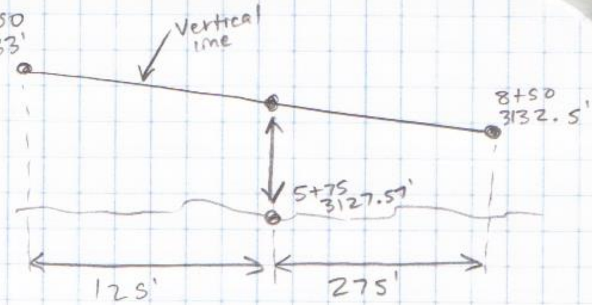


Appendix V

★ **Max. Fill:**

- [Existing Ground] ⇒ Station: 5+75.00; Elevation: 3127.57'

- [Vertical line] ⇒ Station: 5+75; Elevation: 3132.84'



- $y = mx + b$

$$= \left| \left(\frac{3132.5' - 3133'}{850' - 450'} \right) (275') - (3132.5') \right| = 3132.84'$$

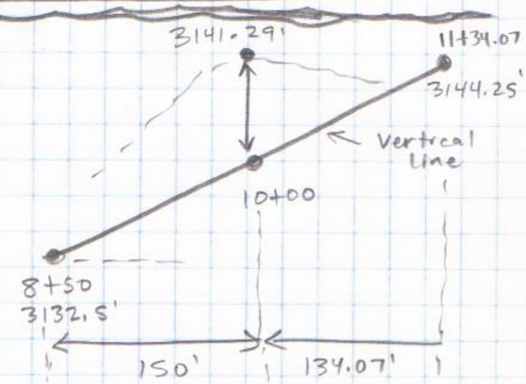
- Max. Fill Depth = 3132.84' − 3127.57'

= **5.274 ft @ Station 5+75**

★ **Max. Cut**

- [Proposed Ground] ⇒ Station: 10+00; Elevation: 3141.29'

- [Vertical line] ⇒ Station: 10+00; Elevation: 3138.7'



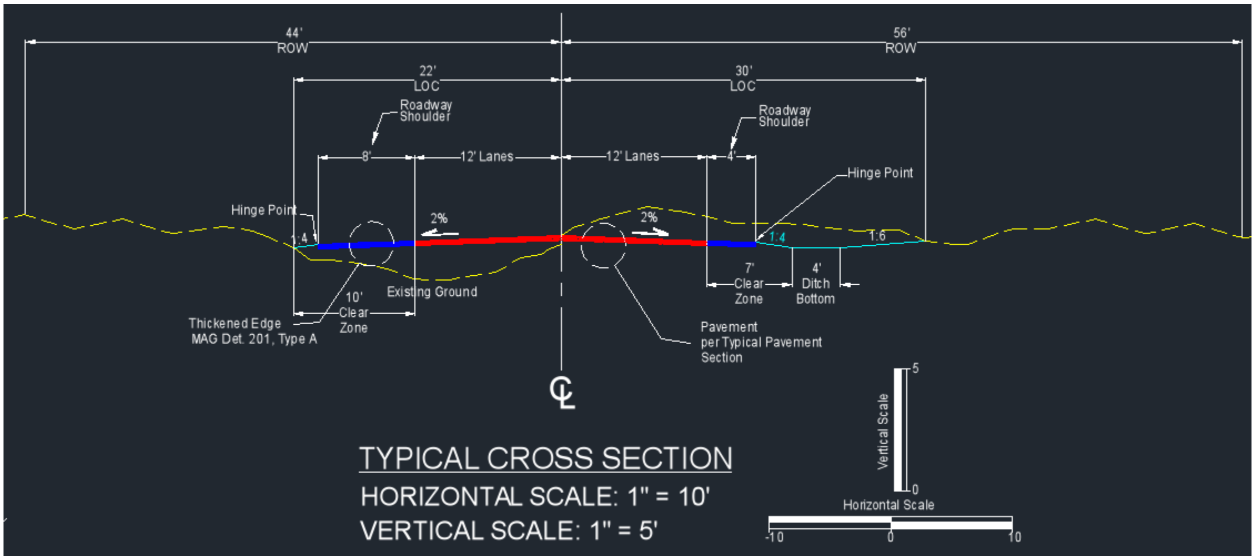
- $y = mx + b$

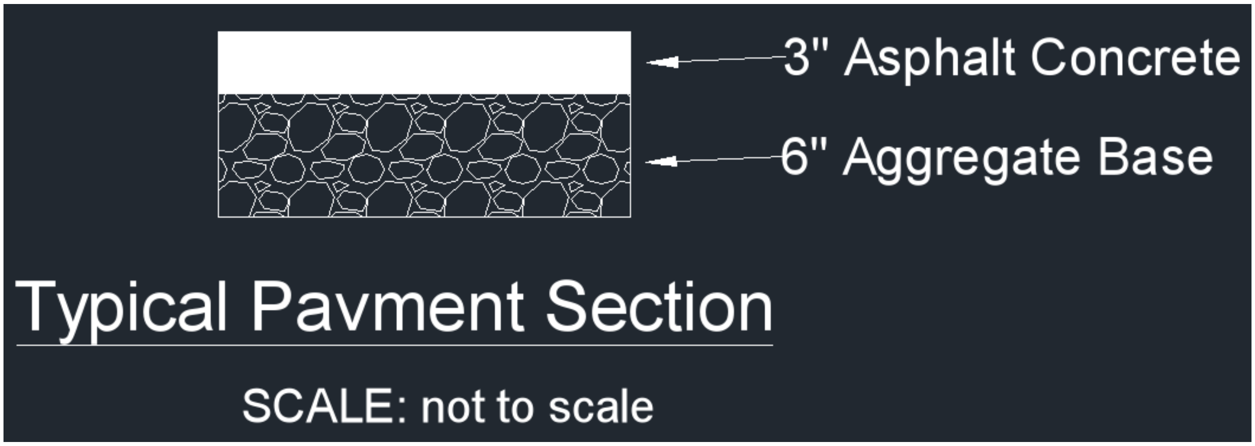
$$= \left| \left(\frac{3144.25' - 3132.5'}{1134.07' - 850'} \right) (150') + 3132.5' \right| = 3138.7'$$

- Max. Cut Depth = 3141.29' − 3138.7'

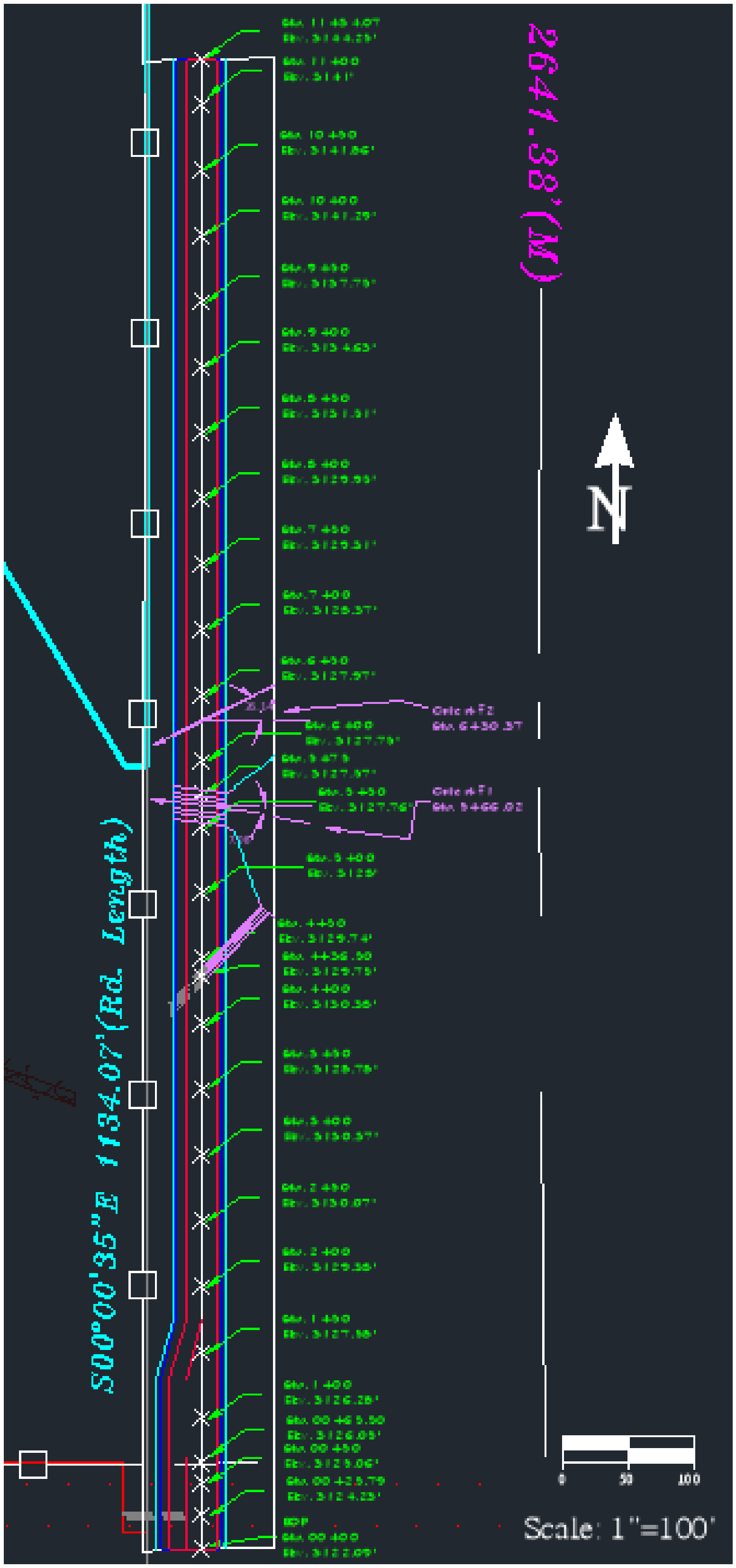
= **2.59 feet @ Station 10+00**

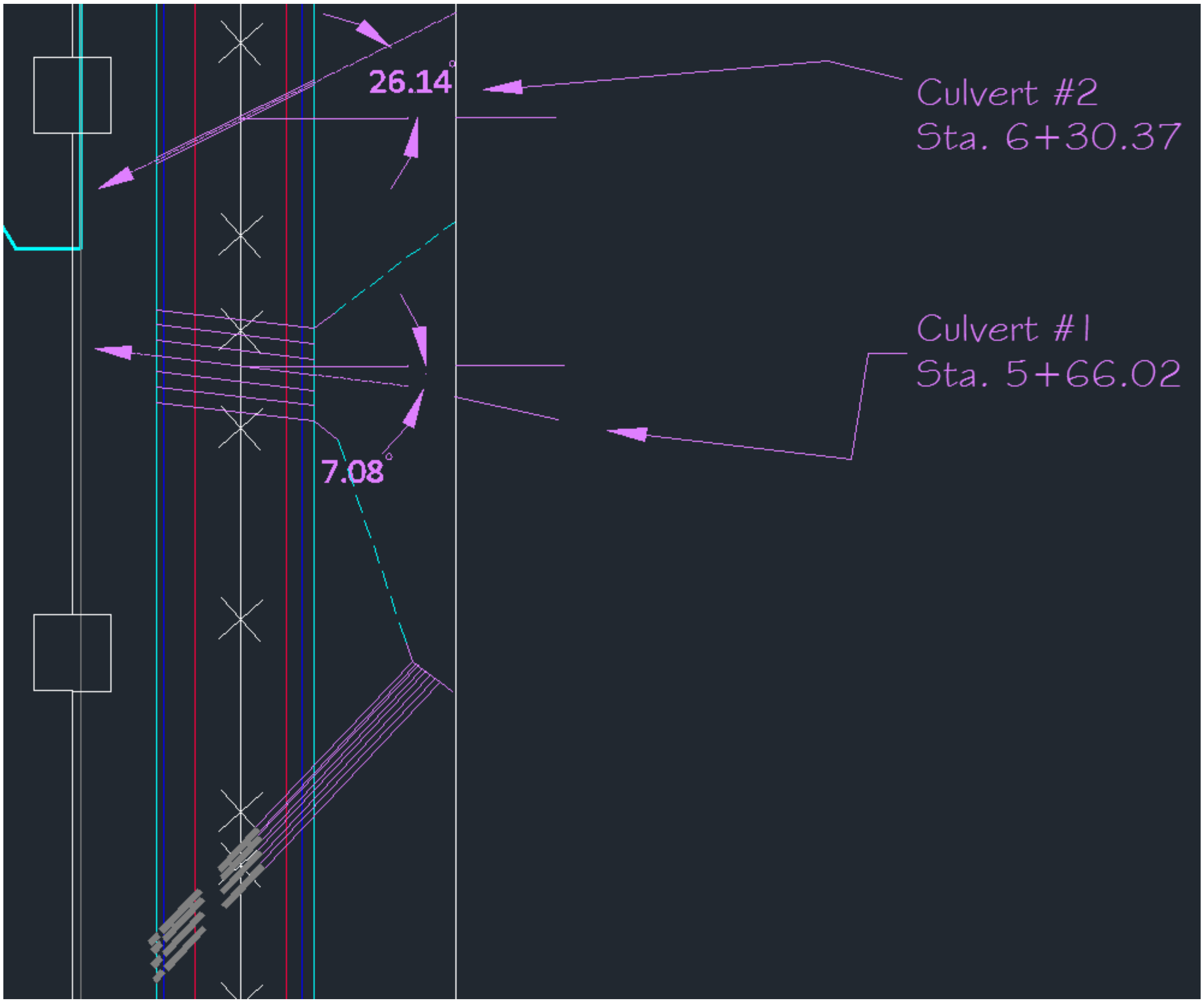
Appendix W


44'
ROW
56'
ROW
22'
LOC
30'
LOC
Roadway Shoulder
Roadway Shoulder
8'
12' Lanes
12' Lanes
4'
Hinge Point
Hinge Point
2%
2%
1:4
1:4
1:6
Existing Ground
10'
Clear Zone
7'
Clear Zone
4'
Ditch Bottom
Thickened Edge
MAG Det. 201, Type A
Pavement
per Typical Pavement Section
CL
TYPICAL CROSS SECTION
HORIZONTAL SCALE: 1" = 10'
VERTICAL SCALE: 1" = 5'
Vertical Scale
5
0
Horizontal Scale
-10
0
10

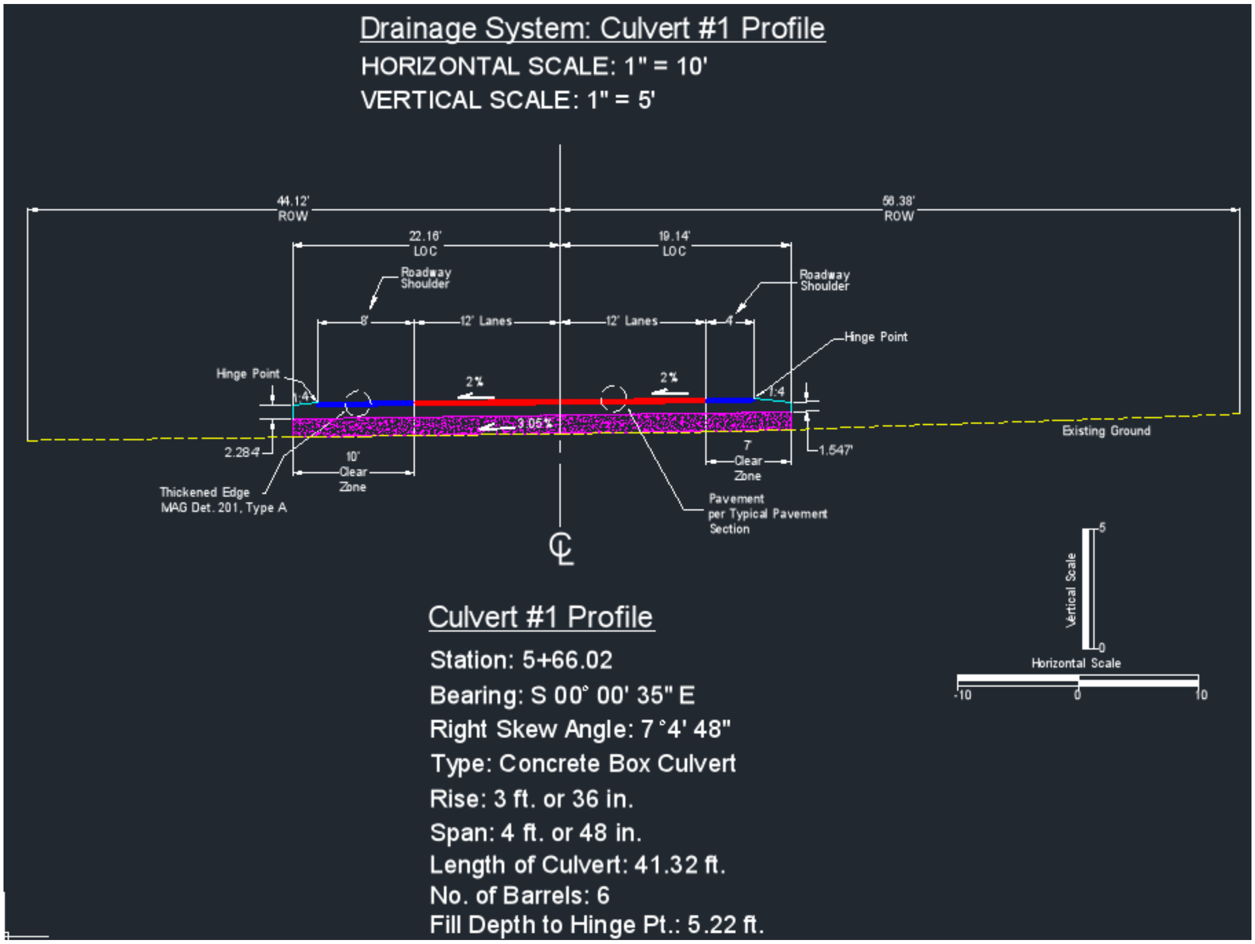

3" Asphalt Concrete
6" Aggregate Base
Typical Pavment Section
SCALE: not to scale

Appendix X



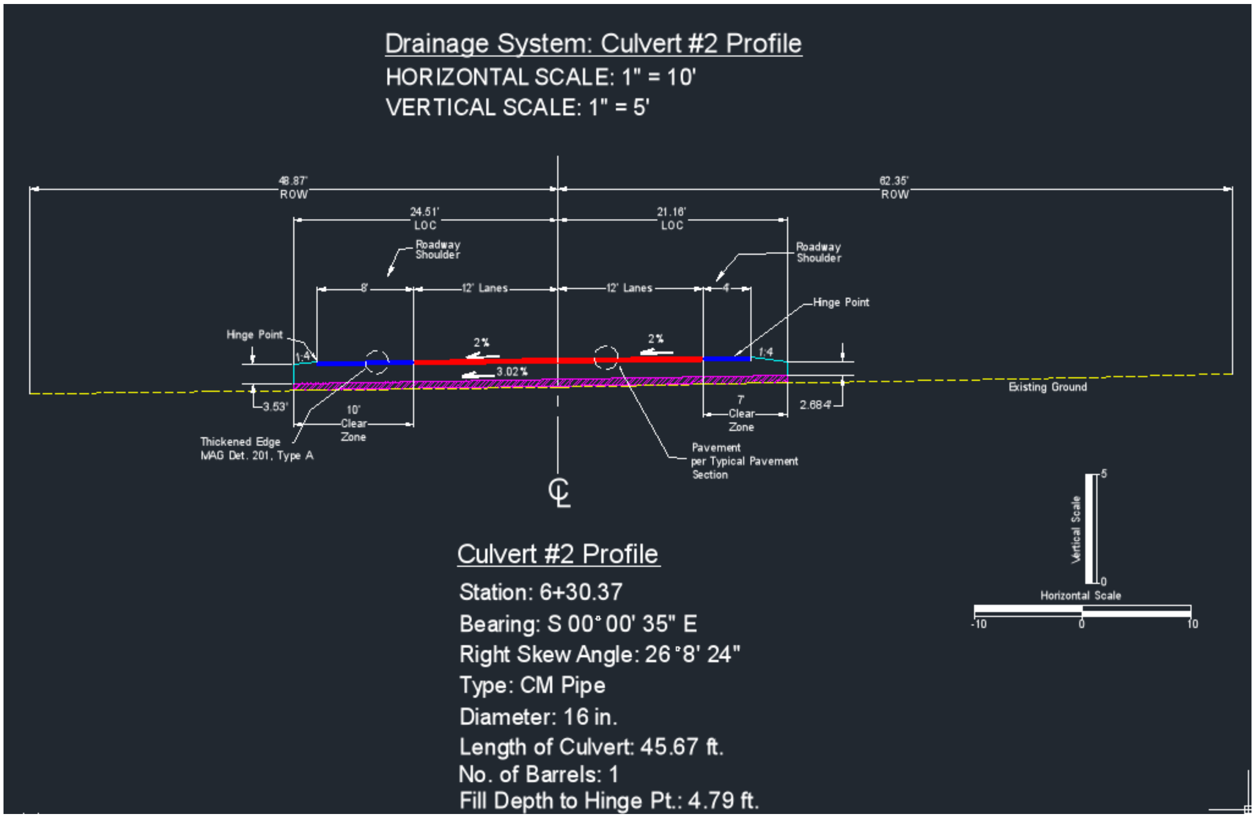

26.14°
Culvert #2
Sta. 6+30.37
Culvert #1
Sta. 5+66.02
7.08°

Appendix Y

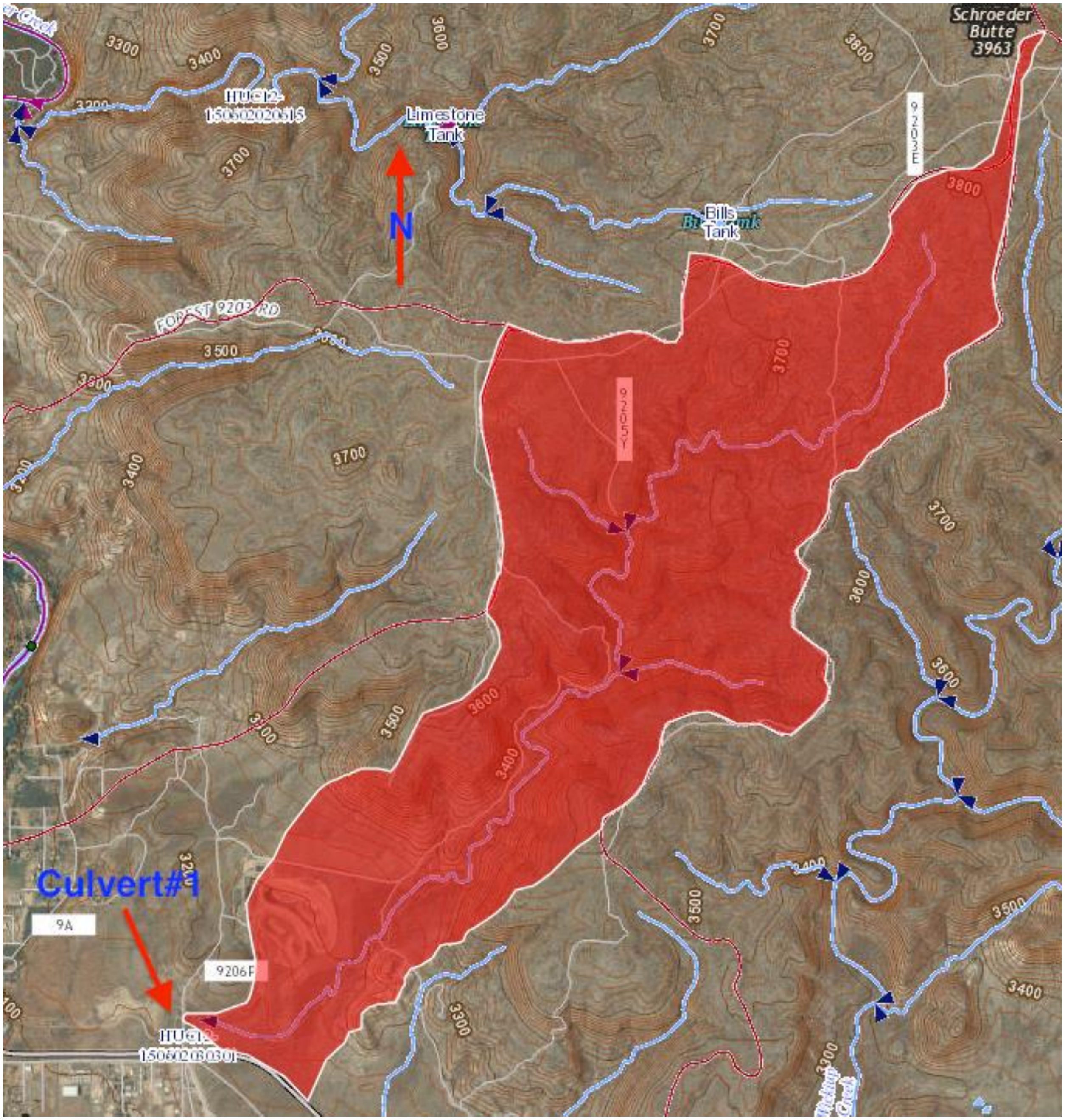


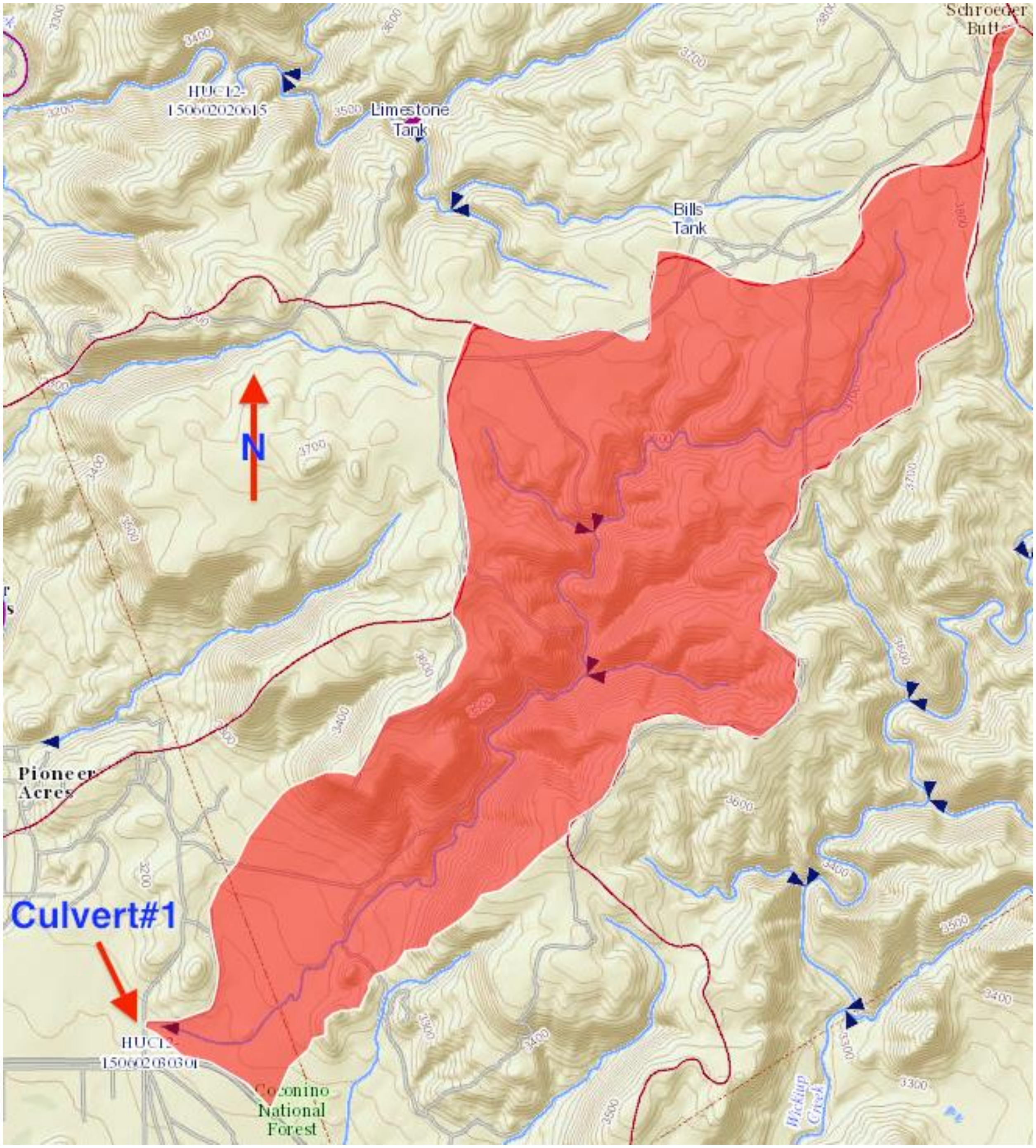
Drainage System: Culvert #1 Profile
HORIZONTAL SCALE: 1" = 10'
VERTICAL SCALE: 1" = 5'
44.12' ROW
56.38' ROW
22.16' LOC
19.14' LOC
Roadway Shoulder
Roadway Shoulder
8'
12' Lanes
12' Lanes
4'
Hinge Point
Hinge Point
1:4
1:4
2%
2%
3.05%
2.284'
1.547'
10' Clear Zone
7' Clear Zone
Existing Ground
Thickened Edge MAG Det. 201, Type A
Pavement per Typical Pavement Section
CL
Vertical Scale
5
0
Horizontal Scale
-10
0
10
Culvert #1 Profile
Station: 5+66.02
Bearing: S 00° 00' 35" E
Right Skew Angle: 7°4' 48"
Type: Concrete Box Culvert
Rise: 3 ft. or 36 in.
Span: 4 ft. or 48 in.
Length of Culvert: 41.32 ft.
No. of Barrels: 6
Fill Depth to Hinge Pt.: 5.22 ft.

Appendix Z


Drainage System: Culvert #2 Profile
HORIZONTAL SCALE: 1" = 10'
VERTICAL SCALE: 1" = 5'
48.87' ROW
62.35' ROW
24.51' LOC
21.16' LOC
Roadway Shoulder
Roadway Shoulder
8'
12' Lanes
12' Lanes
4'
Hinge Point
Hinge Point
1:4
1:4
2%
2%
3.02%
3.53'
2.684'
10' Clear Zone
7' Clear Zone
Existing Ground
Thickened Edge MAG Det. 201, Type A
Pavement per Typical Pavement Section
Vertical Scale
Horizontal Scale
Culvert #2 Profile
Station: 6+30.37
Bearing: S 00° 00' 35" E
Right Skew Angle: 26°8' 24"
Type: CM Pipe
Diameter: 16 in.
Length of Culvert: 45.67 ft.
No. of Barrels: 1
Fill Depth to Hinge Pt.: 4.79 ft.

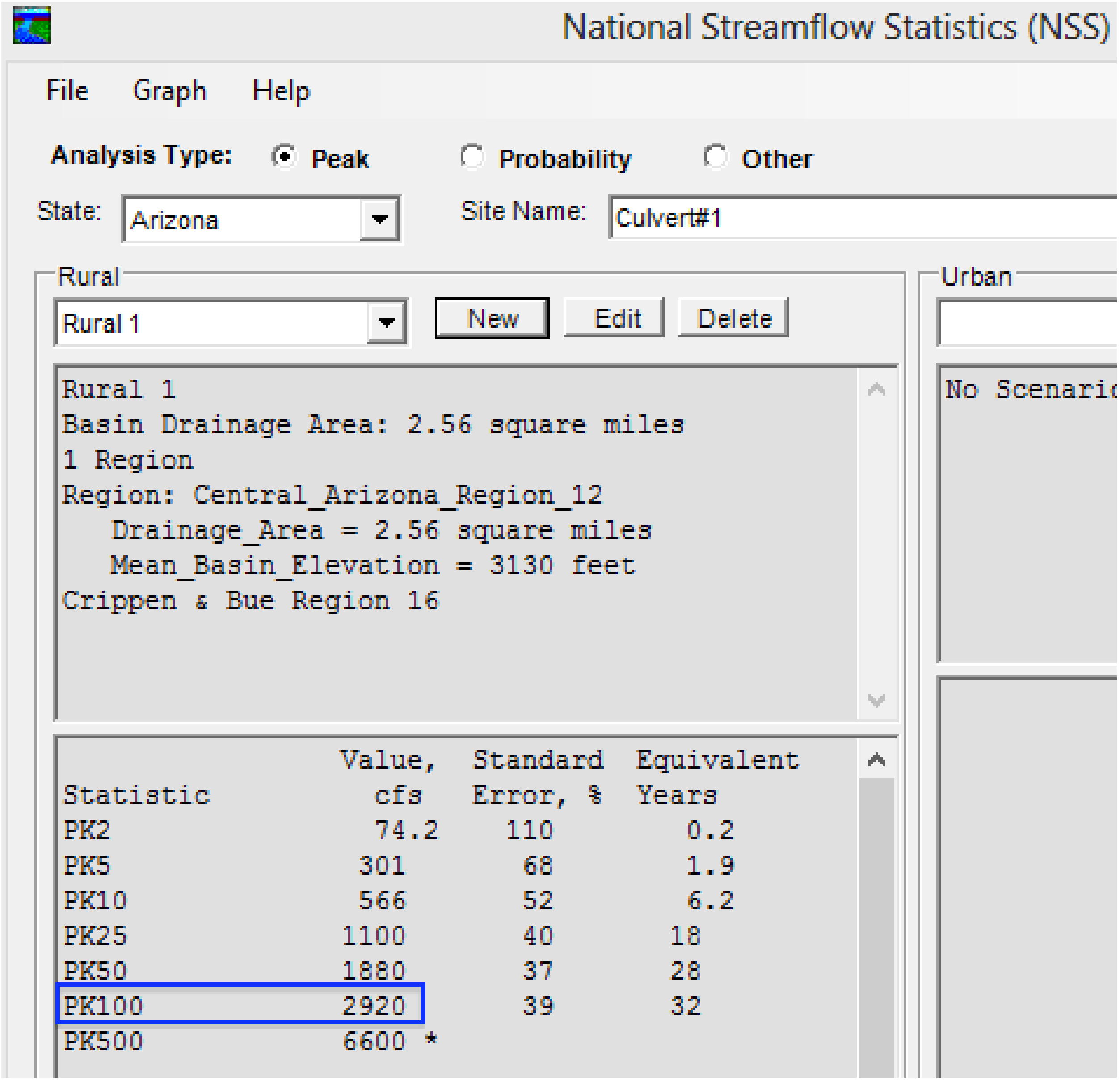
Appendix AA1





Schroeder Butte
HUC12-
150602020615
Limestone Tank
Bills Tank
N
Pioneer Acres
Culvert#1
HUC12-
150602030301
Coconino National Forest
Wickiup Creek

Appendix AA2

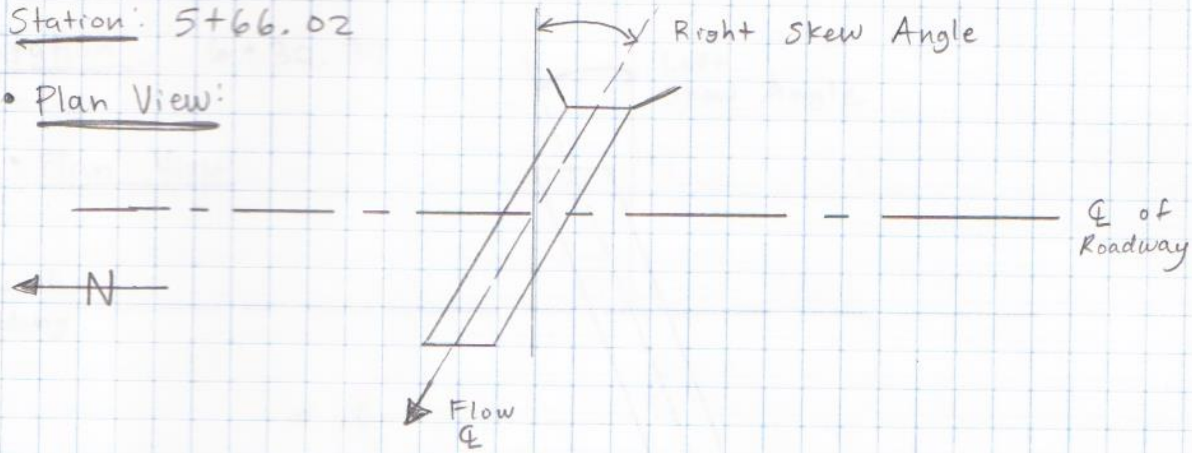


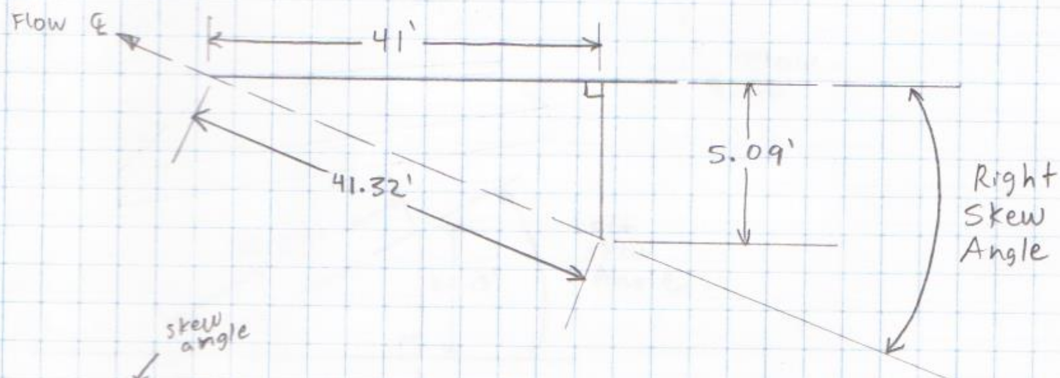
Appendix AA3

★ **Culvert #1: Skew Angle Calculations**

Station: 5+66.02

- Plan View:





skew angle

- $\sin\theta$ = opposite / hypotenuse

$$\sin\theta = \left(\frac{5.09'}{41.32'}\right)$$

$$\theta = \sin^{-1}\left(\frac{5.09'}{41.32'}\right)$$

$$= \boxed{7.08^\circ = \text{Right Skew Angle}}$$

or

$$\boxed{7^\circ\, 4'\, 48''}$$

Appendix AA4

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Wednesday, Nov 27 2013

Culvert #1

Invert Elev Dn (ft)	=	3127.05
Pipe Length (ft)	=	41.32
Slope (%)	=	3.05
Invert Elev Up (ft)	=	3128.31
Rise (in)	=	36.0
Shape	=	Box
Span (in)	=	48.0
No. Barrels	=	3
n-Value	=	0.012
Culvert Type	=	Flared Wingwalls
Culvert Entrance	=	30D to 75D wingwall flares
Coeff. K,M,c,Y,k	=	0.026, 1, 0.0347, 0.81, 0.4

Embankment

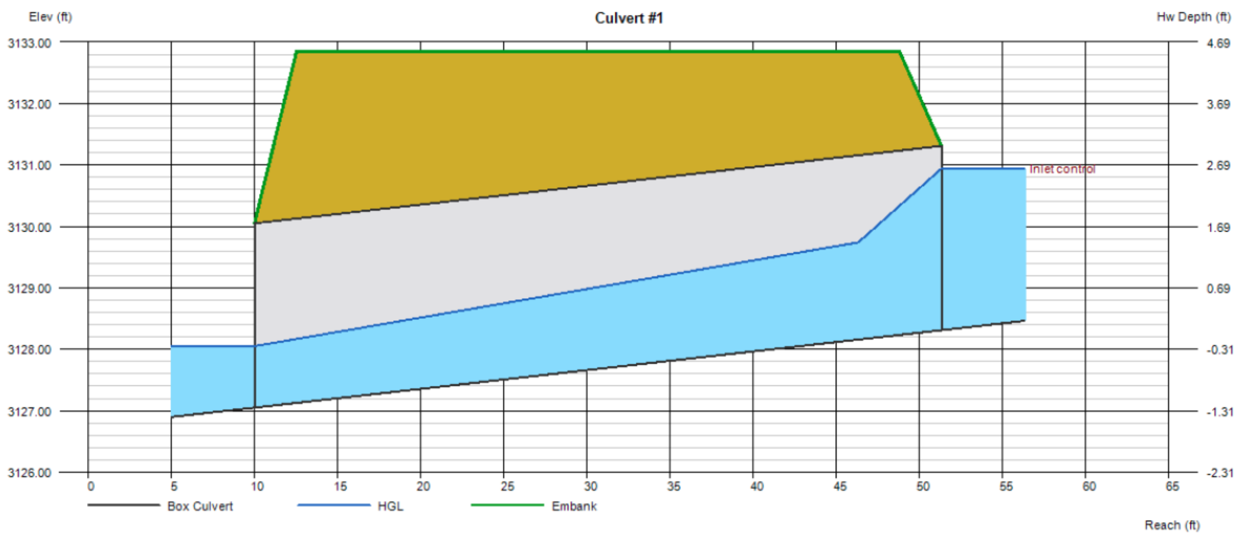
Top Elevation (ft)	=	3132.85
Top Width (ft)	=	36.26
Crest Width (ft)	=	41.32

Calculations

Qmin (cfs)	=	0.00
Qmax (cfs)	=	1460.00
Tailwater Elev (ft)	=	0.00

Highlighted

Qtotal (cfs)	=	146.00
Qpipe (cfs)	=	146.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	12.17
Veloc Up (ft/s)	=	7.32
HGL Dn (ft)	=	3128.05
HGL Up (ft)	=	3129.97
Hw Elev (ft)	=	3130.94
Hw/D (ft)	=	0.88
Flow Regime	=	Inlet Control



Appendix AA5

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Wednesday, Nov 27 2013

Culvert #1

Invert Elev Dn (ft)	=	3127.05
Pipe Length (ft)	=	41.32
Slope (%)	=	3.05
Invert Elev Up (ft)	=	3128.31
Rise (in)	=	36.0
Shape	=	Box
Span (in)	=	48.0
No. Barrels	=	3
n-Value	=	0.012
Culvert Type	=	Flared Wingwalls
Culvert Entrance	=	30D to 75D wingwall flares
Coeff. K,M,c,Y,k	=	0.026, 1, 0.0347, 0.81, 0.4

Embankment

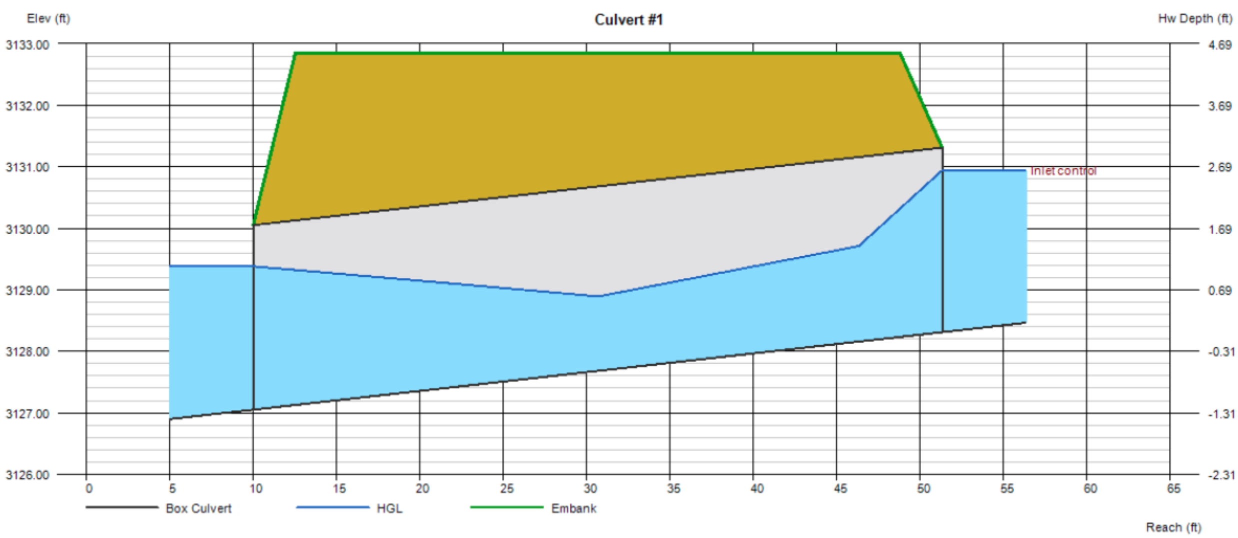
Top Elevation (ft)	=	3132.85
Top Width (ft)	=	36.26
Crest Width (ft)	=	41.32

Calculations

Qmin (cfs)	=	0.00
Qmax (cfs)	=	1460.00
Tailwater Elev (ft)	=	(dc+D)/2

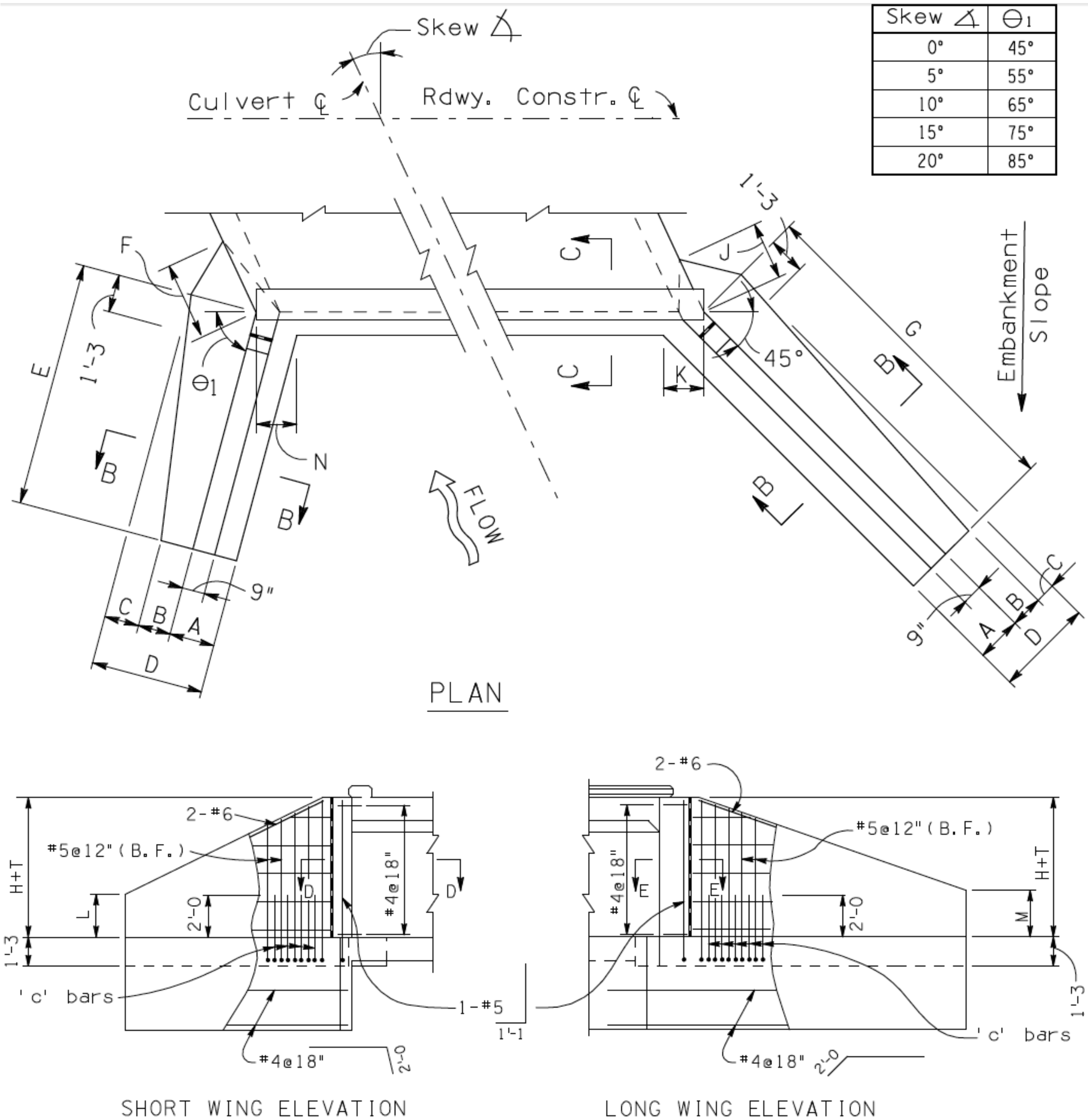
Highlighted

Qtotal (cfs)	=	146.00
Qpipe (cfs)	=	146.00
Qovertop (cfs)	=	0.00
Veloc Dn (ft/s)	=	5.22
Veloc Up (ft/s)	=	7.32
HGL Dn (ft)	=	3129.38
HGL Up (ft)	=	3129.97
Hw Elev (ft)	=	3130.94
Hw/D (ft)	=	0.88
Flow Regime	=	Inlet Control



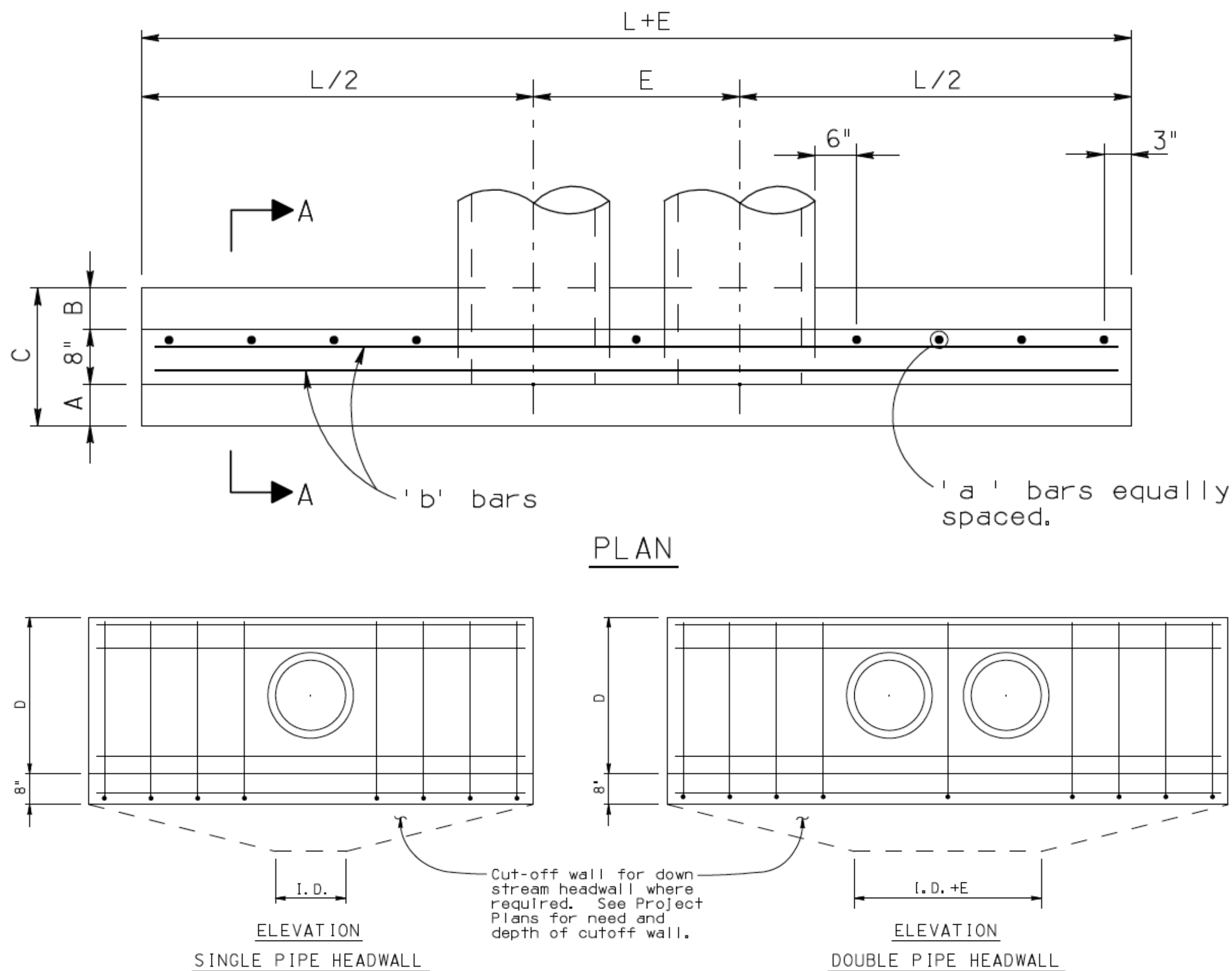
Appendix AA6

Skew ∡	Θ_1
0°	45°
5°	55°
10°	65°
15°	75°
20°	85°



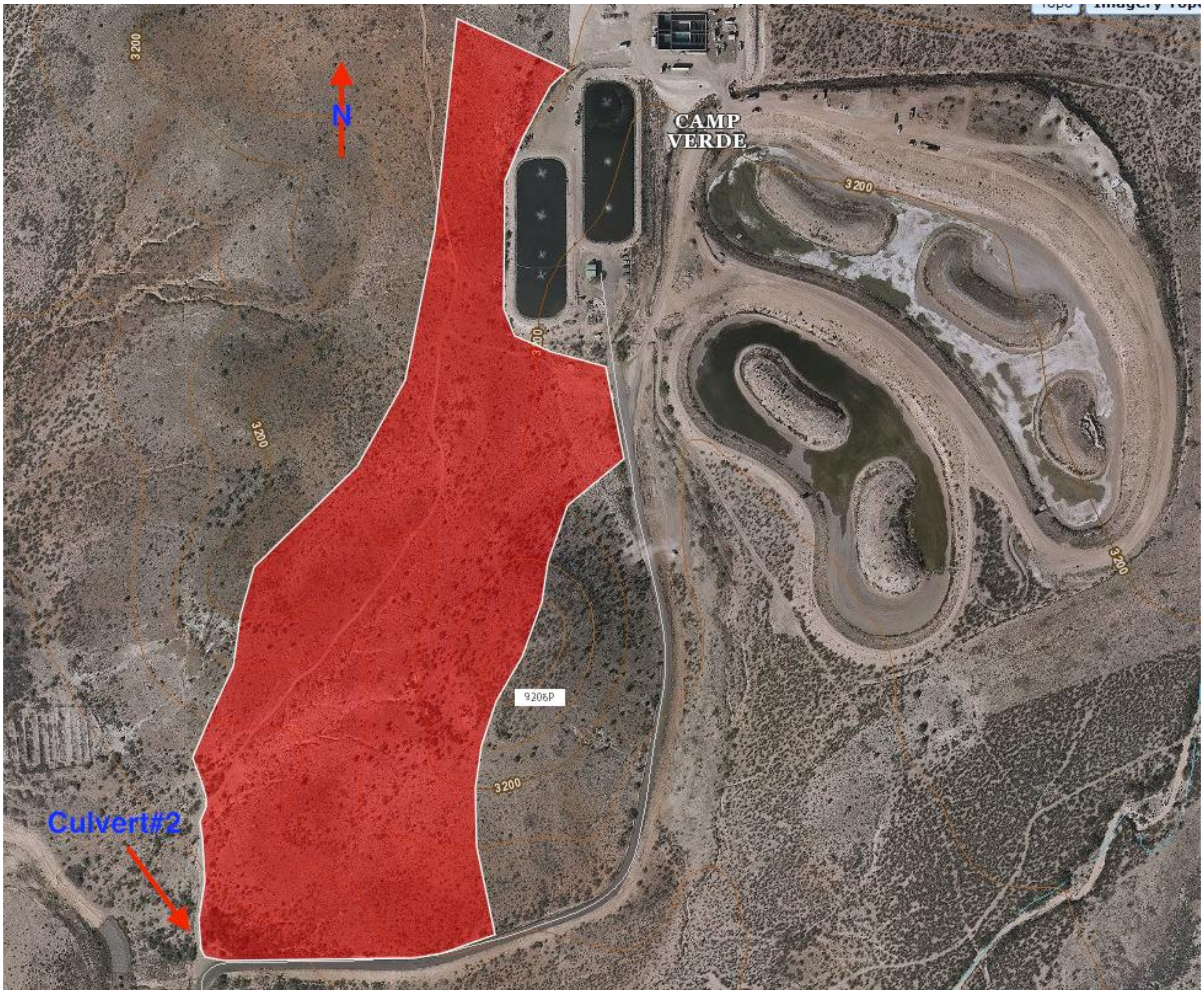
4 : 1 Slope	Skew ∡	0°			5°			10°			15°			20°		
	Height H	5'	6'	7'	5'	6'	7'	5'	6'	7'	5'	6'	7'	5'	6'	7'
Dimensions	A	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6	1'-6
	B	1'-1	1'-4	1'-8	1'-1	1'-3	1'-7	1'-1	1'-2	1'-6	1'-1	1'-2	1'-5	1'-1	1'-2	1'-3
	C	1'-0	1'-3	1'-5	1'-0	1'-4	1'-6	1'-0	1'-5	1'-7	1'-0	1'-5	1'-8	1'-0	1'-5	1'-10
	D	3'-7	4'-1	4'-7	3'-7	4'-1	4'-7	3'-7	4'-1	4'-7	3'-7	4'-1	4'-7	3'-7	4'-1	4'-7
	E	11'-6	13'-6	15'-6	11'-6	13'-6	15'-6	12'-0	14'-0	16'-0	12'-6	14'-6	16'-6	13'-6	15'-6	17'-6
	F	2'-8	3'-4	4'-1	2'-7	3'-4	4'-0	2'-7	3'-3	4'-0	2'-6	3'-3	3'-11	2'-5	3'-1	3'-9
	G	11'-6	13'-6	15'-6	12'-6	14'-6	16'-6	13'-0	15'-6	17'-6	14'-6	16'-6	19'-0	15'-6	18'-6	21'-0
	J	2'-8	3'-4	4'-1	2'-7	3'-4	4'-0	2'-7	3'-3	4'-0	2'-6	3'-3	3'-11	2'-5	3'-1	3'-9
	K	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½	1'-4½
	L	4'-0	4'-8	5'-4	3'-8	4'-4	4'-11	3'-4	3'-11	4'-5	3'-1	3'-7	4'-1	2'-8	3'-2	3'-8
	M	4'-0	4'-8	5'-4	3'-10	4'-6	5'-2	3'-9	4'-4	5'-0	3'-6	4'-2	4'-8	3'-4	3'-10	4'-4
	N	1'-4½	1'-4½	1'-4½	1'-3⅝	1'-3⅝	1'-3⅝	1'-3⅝	1'-3⅝	1'-3⅝	1'-4¼	1'-4¼	1'-4¼	1'-5¼	1'-5¼	1'-5¼

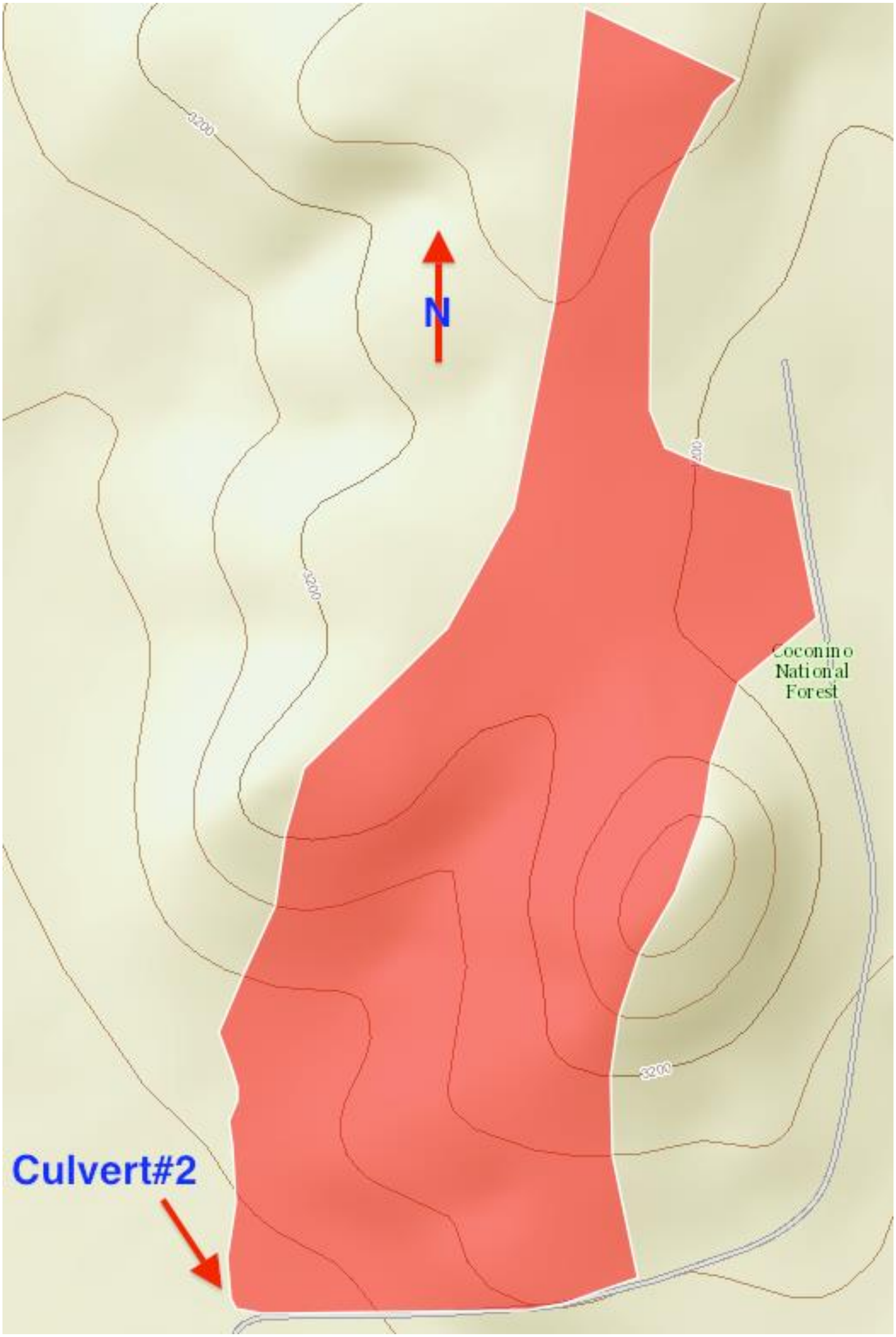
Appendix AA7



Dimensions									
I.D.	A	B	C	D	E	F	G	L	L+E
18"	6"	10"	2'-0	3'-2	2'-6	1'-7	4'-6	9'-6	12'-0
24"	8"	1'-0	2'-4	3'-8	3'-0	2'-1	5'-6	11'-6	14'-6
30"	10"	1'-2	2'-8	4'-2	3'-9	2'-7	6'-6	13'-6	17'-3
36"	1'-0	1'-4	3'-0	4'-8	4'-6	3'-1	7'-6	15'-6	20'-0
42"	1'-2	1'-6	3'-4	5'-2	5'-3	3'-7	8'-6	17'-6	22'-9

Appendix BB1




3200
N
3200
Coconino
National
Forest
3200
Culvert#2

Appendix BB2

★ **Culvert #2:**

• NOAA: PDS – based Precipitation Frequency Esitmates with 90% confidence intervals (in inches/hour)

↳ Average Recurrence interval (years) = 100

↳ Duration = 24 hours

↳ i (rainfall intensity) = 3.94 inches / 24 hours } NOAA'S Data
= 0.164 in/hr

↳ i (rainfall intensity) = 4 inches / 24 hours } Given by client
= **0.167 in/hr**

• USGS (National Map Viewer): Watershed Delineation

Drainage Area (A) = $0.047\ mi^2$
= **30.08 acres**

• Rational Method: $A \leq 160$ acres

$Q = CiA$

Q – Peak discharge (cfs)
C – Rational Method runoff coefficient
i – rainfall intensity (in./hr.)
A – drainage area (acre)

C – 0.20 ← (Table 11-2, Highway Engineering, PH Wright, 1996)

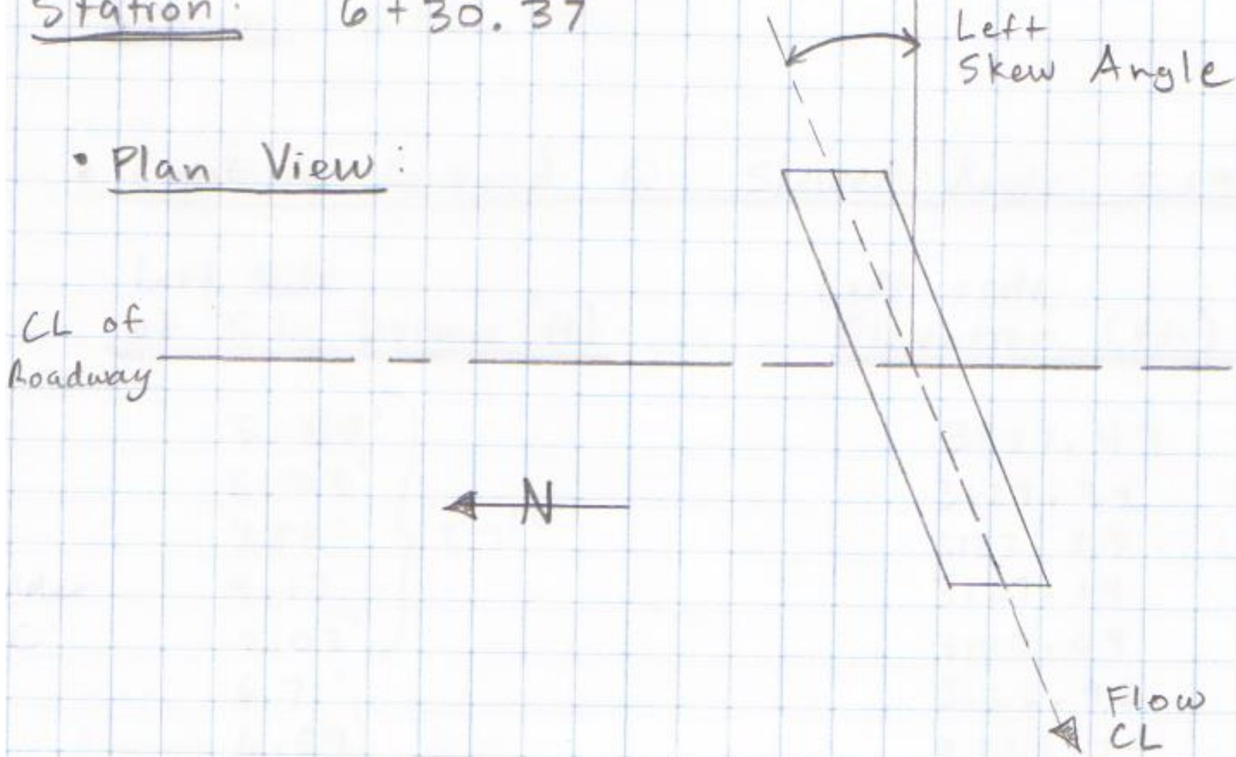
$Q_{100} = (0.20)(0.167\ in/hr)(30.08\ acres)$
$= \boxed{1.005\ cfs}$

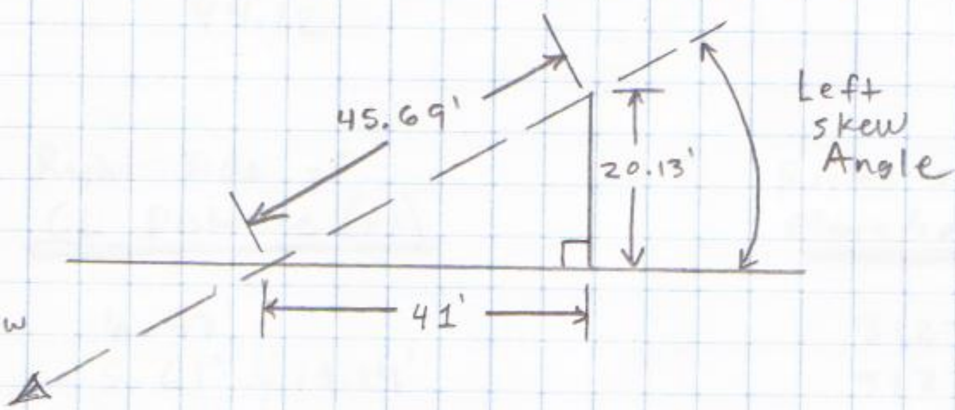
Appendix BB3

Culvert # 2 : Skew Angle Calculatrons

Statron: 6 + 30.37

- Plan View:





- $\sin\theta = (\text{opposite} / \text{hypotenuse})$ ← skew angle

$$\theta = \sin^{-1}\left(\frac{20.13'}{45.69'}\right)$$

$$= \boxed{26.14^\circ = \text{Left Skew Angle}}$$

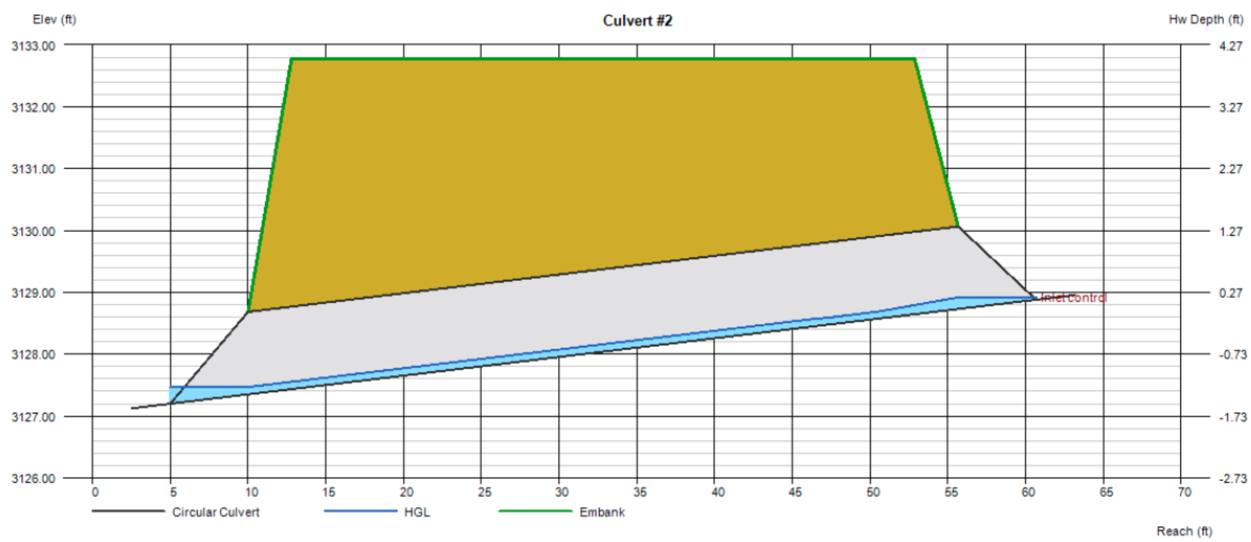
Appendix BB4

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Wednesday, Nov 27 2013

Culvert #2

Invert Elev Dn (ft)	= 3127.35	**Calculations**	
Pipe Length (ft)	= 45.67	Qmin (cfs)	= 0.00
Slope (%)	= 3.02	Qmax (cfs)	= 1.01
Invert Elev Up (ft)	= 3128.73	Tailwater Elev (ft)	= 0.00
Rise (in)	= 16.0		
Shape	= Circular	**Highlighted**	
Span (in)	= 16.0	Qtotal (cfs)	= 0.10
No. Barrels	= 1	Qpipe (cfs)	= 0.10
n-Value	= 0.024	Qovertop (cfs)	= 0.00
Culvert Type	= Circular Corrugate Metal Pipe	Veloc Dn (ft/s)	= 1.62
Culvert Entrance	= Mitered to slope (C)	Veloc Up (ft/s)	= 1.62
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7	HGL Dn (ft)	= 3127.47
		HGL Up (ft)	= 3128.85
Embankment		Hw Elev (ft)	= 3128.92
Top Elevation (ft)	= 3132.77	Hw/D (ft)	= 0.14
Top Width (ft)	= 40.08	Flow Regime	= Inlet Control
Crest Width (ft)	= 45.67		



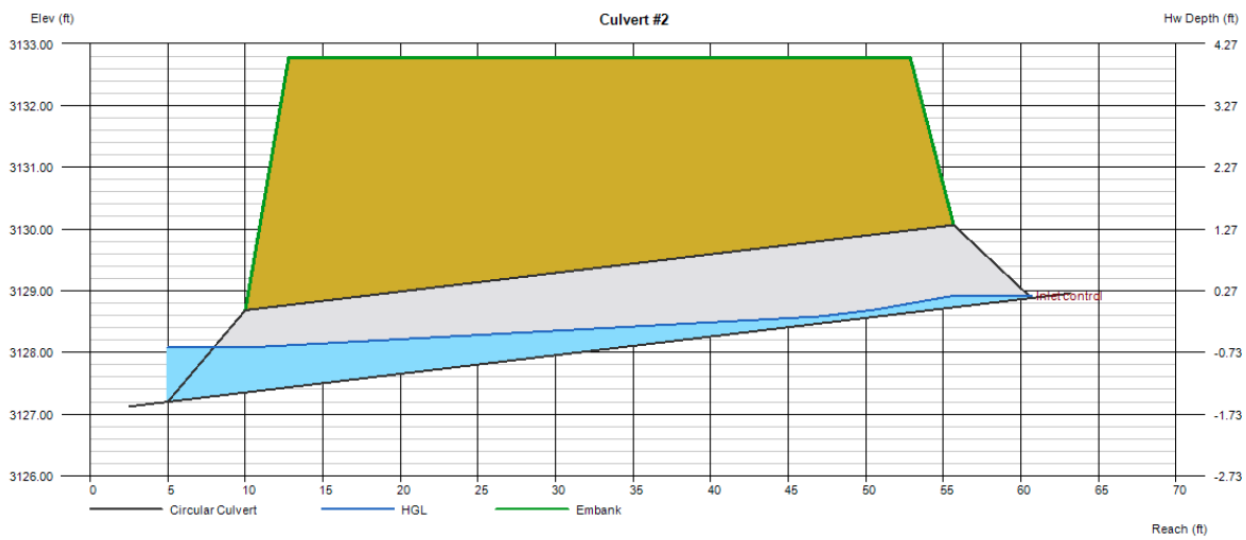
Appendix BB5

Culvert Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. — Wednesday, Nov 27 2013

Culvert #2

Invert Elev Dn (ft)	= 3127.35	**Calculations**	
Pipe Length (ft)	= 45.67	Qmin (cfs)	= 0.00
Slope (%)	= 3.02	Qmax (cfs)	= 1.01
Invert Elev Up (ft)	= 3128.73	Tailwater Elev (ft)	= (dc+D)/2
Rise (in)	= 16.0		
Shape	= Circular	**Highlighted**	
Span (in)	= 16.0	Qtotal (cfs)	= 0.10
No. Barrels	= 1	Qpipe (cfs)	= 0.10
n-Value	= 0.024	Qovertop (cfs)	= 0.00
Culvert Type	= Circular Corrugate Metal Pipe	Veloc Dn (ft/s)	= 0.13
Culvert Entrance	= Mitered to slope (C)	Veloc Up (ft/s)	= 1.62
Coeff. K,M,c,Y,k	= 0.021, 1.33, 0.0463, 0.75, 0.7	HGL Dn (ft)	= 3128.08
		HGL Up (ft)	= 3128.85
Embankment		Hw Elev (ft)	= 3128.92
Top Elevation (ft)	= 3132.77	Hw/D (ft)	= 0.14
Top Width (ft)	= 40.08	Flow Regime	= Inlet Control
Crest Width (ft)	= 45.67		



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