I-40/CC Westbound On-Ramp and Right-Turn Lane

CENE-486C
Final Design Presentation

Date: 04/24/2020

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Acknowledgements

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- Nate Reisner, District Development Engineer at ADOT (Client)
- Finally, to all Professors who Offered their Guidance and Support Throughout the Duration of this Project.

Project Overview

- **Client**: Arizona Department of Transportation (ADOT)
- **Location**: I-40 and Country Club Drive Traffic Interchange (Flagstaff, AZ)
- **Stakeholders**:
  - ADOT
  - City of Flagstaff
  - General Public
- **Final Product**: 30% Design Concept Report

[1]

Project Location and Vicinity Map

***Figure 1 (From Left to Right)**: Map of Arizona (NTS); Project Vicinity Map (NTS) [2][3]*

Project Milestones (Major Tasks)

- **Milestone 1**: Process Survey Data
- **Milestone 2**: Input Existing Geometry
- **Milestone 3**: Create Construction Alignments
- **Milestone 4**: Create Existing Cross Sections
- **Milestone 5**: Complete Existing Runoff Calculations
- **Milestone 6**: Create Proposed Cross-Sections
- **Milestone 7**: Final Intersection Design
- **Milestone 8**: Final On-Ramp Design
- **Milestone 9**: Final Drainage Design
- **Milestone 10**: Capacity Analysis
- **Milestone 11**: Impacts Assessment

Processing Survey Data

- Contour Data was Downloaded as a .shp File from ArcGIS, and Processed within Civil 3D
- Parcel Information was Exported from GIS into Civil 3D

Figure 2: Existing Contour Data (NTS)

Input Existing Geometry

- Project Aerial was Georeferenced into Civil 3D
- Existing Geometry was Drawn in using Aerial, within Civil 3D
- Various Layers and Line Types were used for Existing Geometry

Figure 3: Existing Geometry (NTS)

Create Construction Alignments

- Country Club Drive CL Alignment
  - Stationing began at Intersection of US89
  - Placement Involved Offsetting Existing Edge of Pavement, Half the Existing Roadway Width
- I-40 On-Ramp Edge Alignment
  - Stationing Began at Intersection of Country club Drive
  - Placement Involved Offsetting Existing Edge of Pavement, Two Feet into Existing Roadway

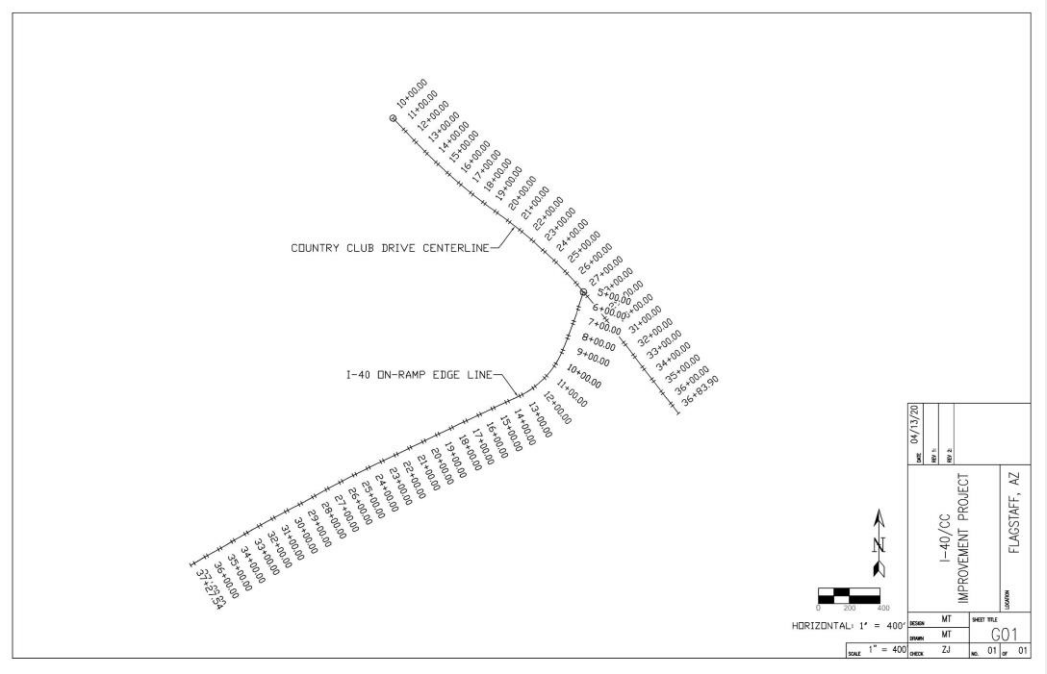


Figure 4: Alignment Geometry (NTS)

Existing Cross-Sections

- Obtained from As-Builts Provided by ADOT
- Includes
  - Pavement Structure
  - Lane Widths and Usage
  - Curb and Gutter Detail Callouts
  - Cross-Slopes
- Pavement Structure Included in Plan Set
- Existing Cross-Sectional Information was used for Proposed Cross-Sections

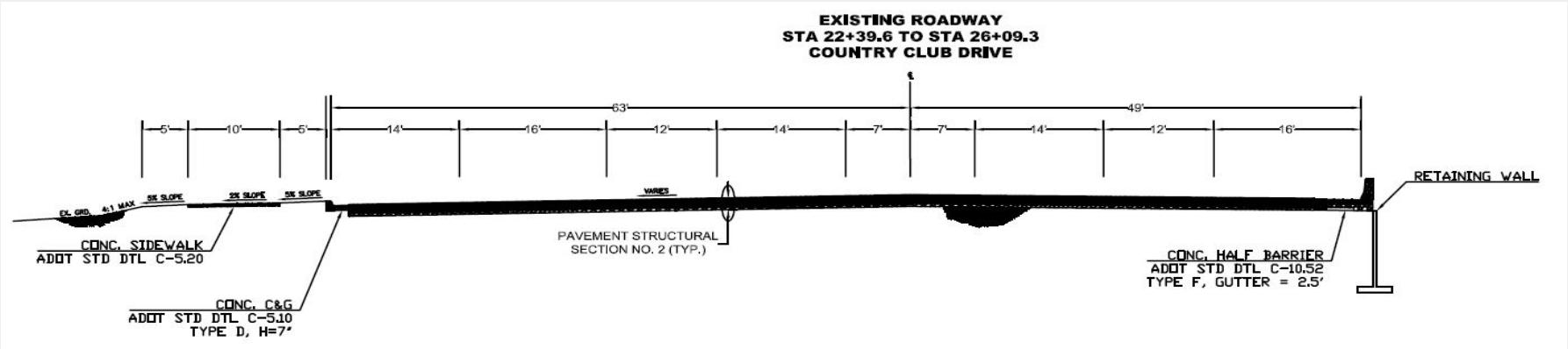


Figure 5: Country Club Drive Existing Cross-Section (NTS)

Existing Runoff Calculations

- Major Watershed was Delineated for Project Area
  - USGS Topo Maps
  - City Contour Data
  - Control Point was Box Culvert Crossing I-40 Westbound
- Peak Flows were Calculated Using National Stream Statistics (NSS)
  - Annual Precipitation (21 inches)
  - Watershed Area (2.02 square miles)
  - Region (Peak_Region_1_High_Elev_2014)
  - Peak Flow (50-yr) = 208 cfs
- Used flow from previous drainage report (more conservative flow)
  - Peak Flow (50-yr) = 1159 cfs [4]

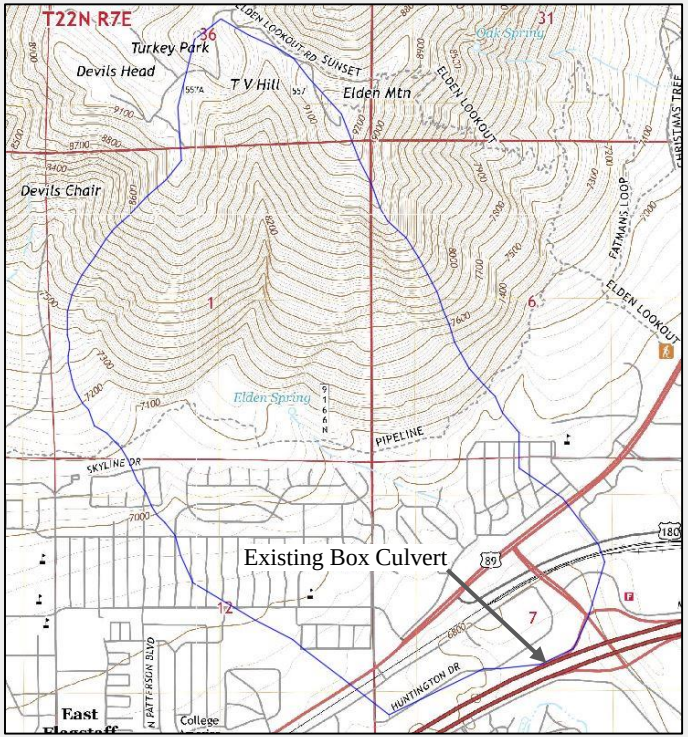


Figure 6: Project Watershed (NTS)

Existing Runoff Calculations Cont.

- Watershed was Delineated for Existing Catch Basin and 18” CMP
  - Rational Method
  - Bentley Flowmaster
  - Peak Flow (50-yr) = 33.2 cfs
- ADOT and COF Drainage Standards [5]
- Existing Infrastructure is able to Accommodate Existing Flows [6]

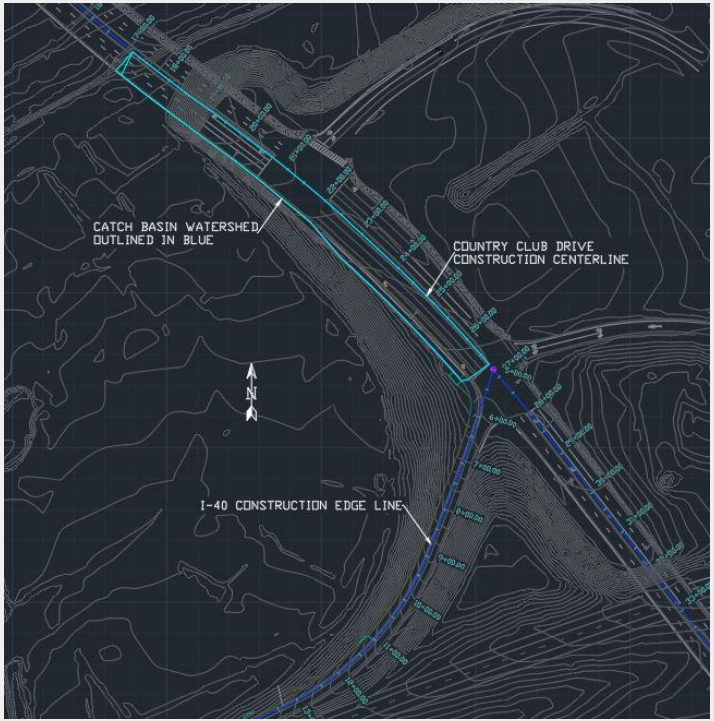


Figure 7: Catch Basin Watershed (NTS)

Create Proposed Cross-Sections

- 24” Saw Cut Offset from Existing Edge of Pavement
- Sheets TX01 - TX03
- Match Existing Infrastructure
- Pavement Structure Included in Plan Set

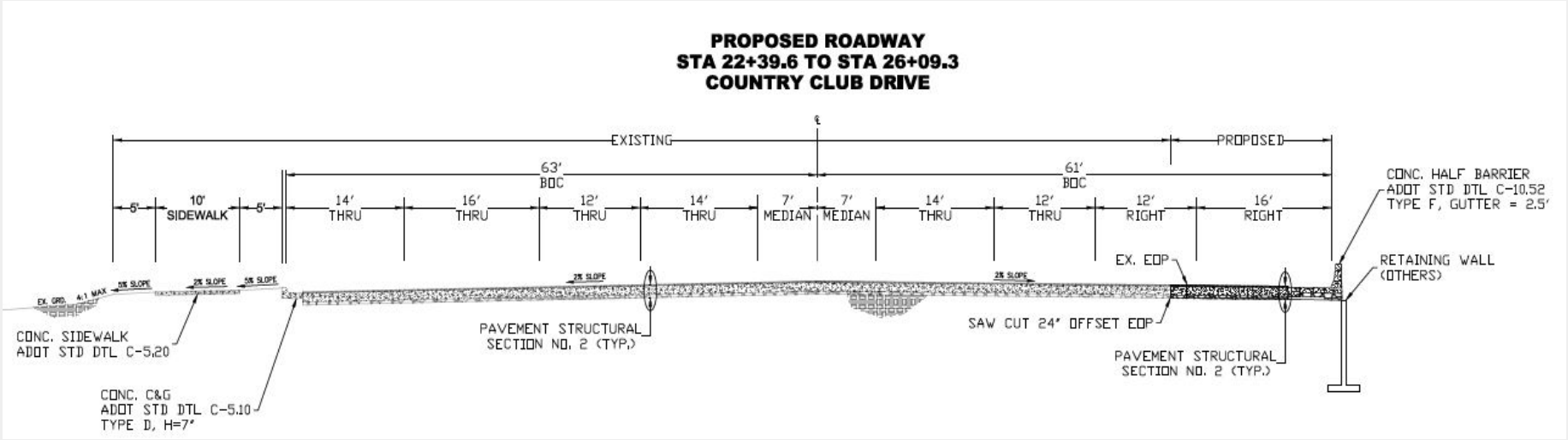
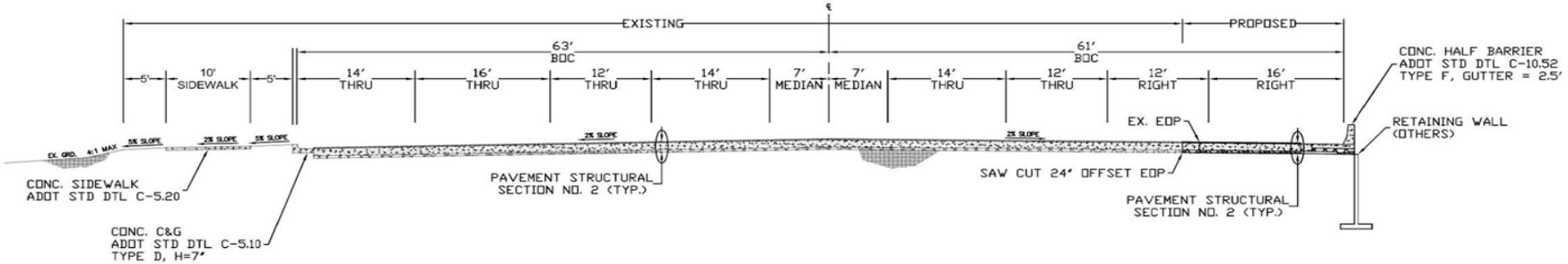
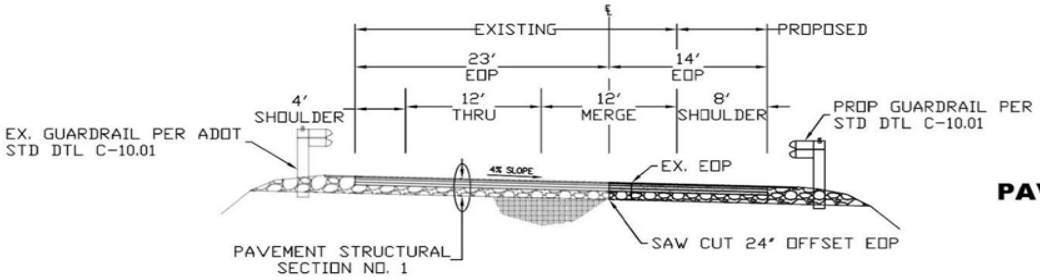


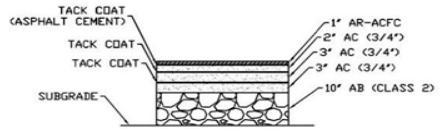
Figure 8: Proposed Cross-Sections

PROPOSED ROADWAY
STA 22+39.6 TO STA 26+09.3
COUNTRY CLUB DRIVE

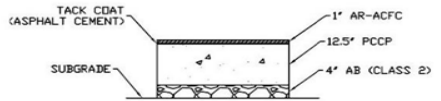


PROPOSED ROADWAY
STA 06+03.75 TO STA 11+03.44
I-40 WESTBOUND ON-RAMP





PAVEMENT STRUCTURAL SECTION NO. 1



PAVEMENT STRUCTURAL SECTION NO. 2

DATE	04/13/20		
REV 1:			
REV 2:			

I-40/CC IMPROVEMENT PROJECT

LOCATION: FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	TX01
DRAWN	MT		
CHECK	ZJ	NO. 10	OF 22

Detail Sheets

- Detail Sheets were Created for
  - Curb Types
  - Guardrail Construction
  - Concrete Barrier Construction
  - Wattle Placement for Erosion Control
  - Catch Basin Construction
- Sheets DT01-DT05 within Plan Set
  - Sheets 04-08

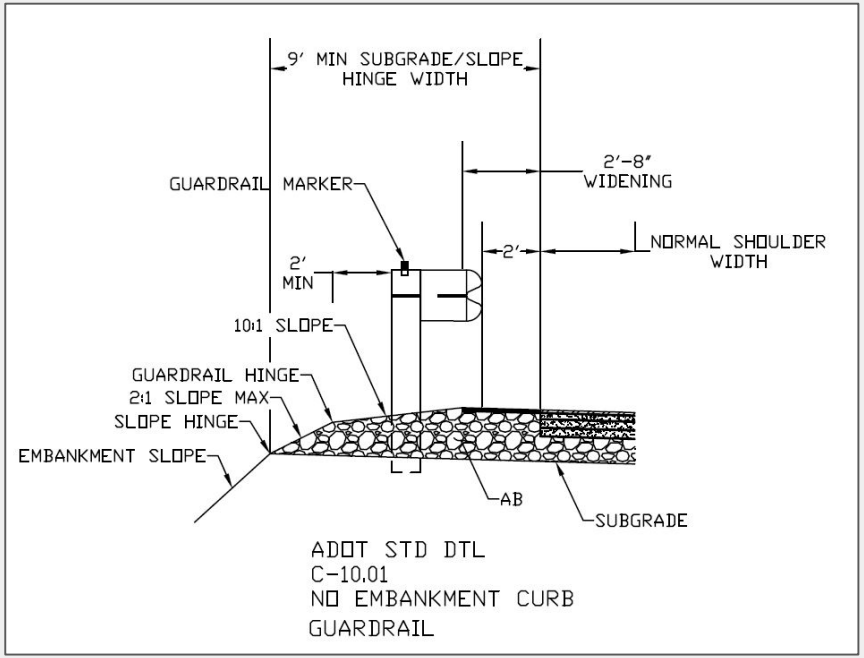
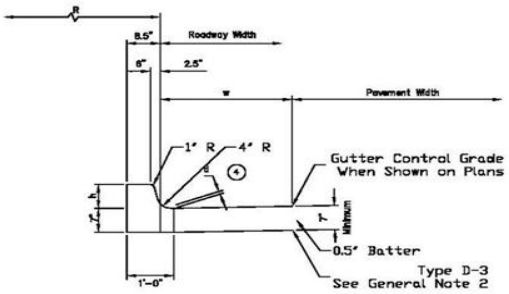
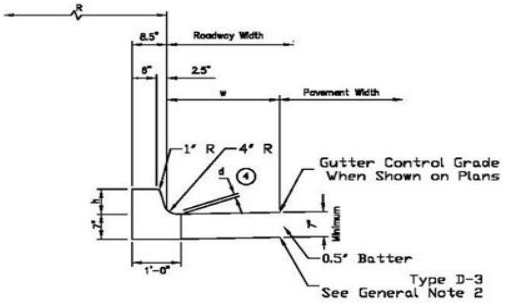


Figure 9: Example Guardrail Detail (NTS)



ADOT STD DTL C-5.10
TYPE D-1, H=7"



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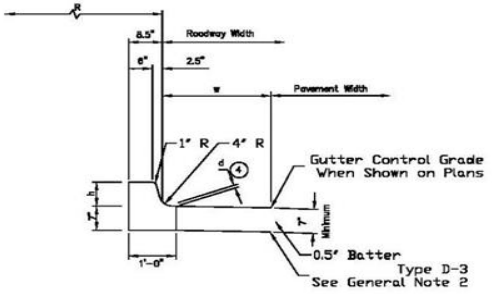
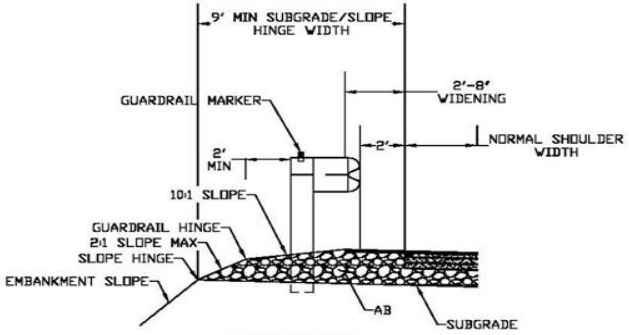
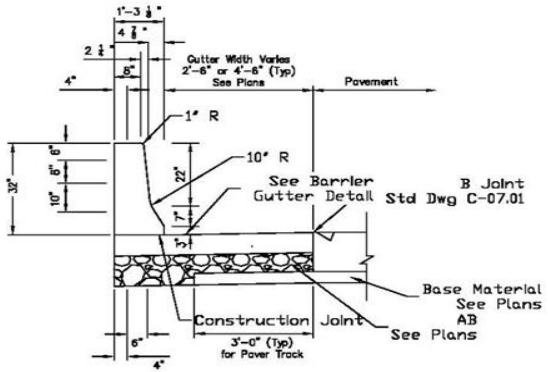
TYPE D, H=7"



ADOT STD DTL C-5.10
TYPE D-3, H=7"



ADOT STD DTL
C-10.01
NO EMBANKMENT CURB
GUARDRAIL



ADOT STD DTL C-10.52
TYPE F, GUTTER = 2.5'
CONCRETE HALF BARRIER

DATE	04/13/20		
REV 1:			
REV 2			

I-40/CC IMPROVEMENT PROJECT

LOCATION: FLAGSTAFF, AZ

DESIGN	RL	SHEET TITLE		
DRAWN	MT	DT01		
CHECK	ZJ	NO. 04	OF	22

Final Intersection Design

- FHWA Lane Taper [7] recommendations
  - Taper Length = 96’
  - Taper Slope = 8:1
- Right-Turn lane extends 512’ to Existing Bridge Structure
- 12’ Lane Width
- 4’ Shoulder Width
- Sheets PV01 - PV03

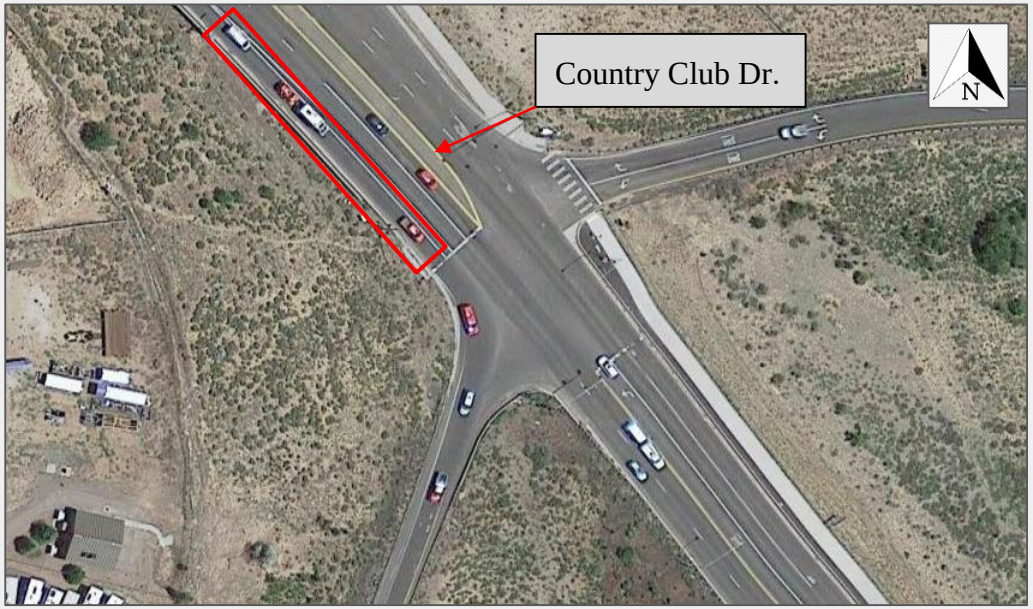
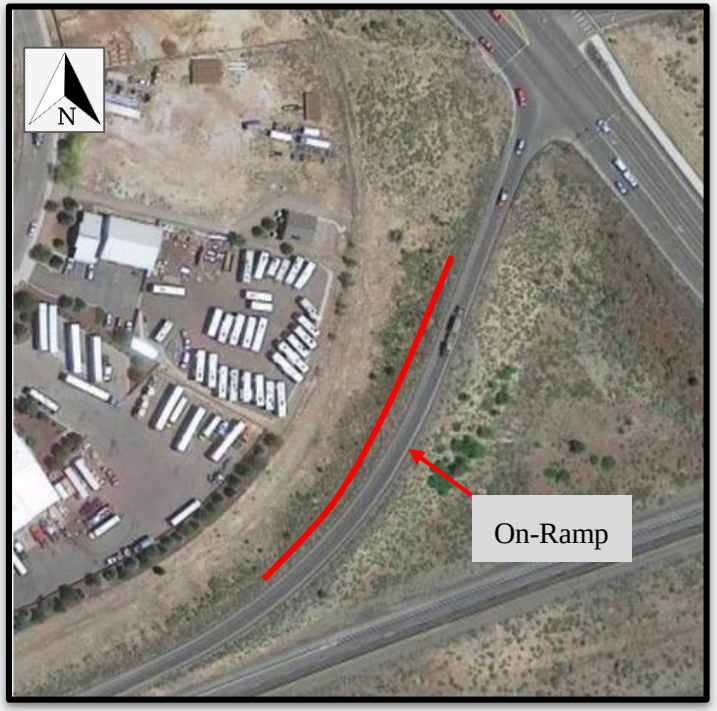


Figure 10: Intersection Plan View (NTS)

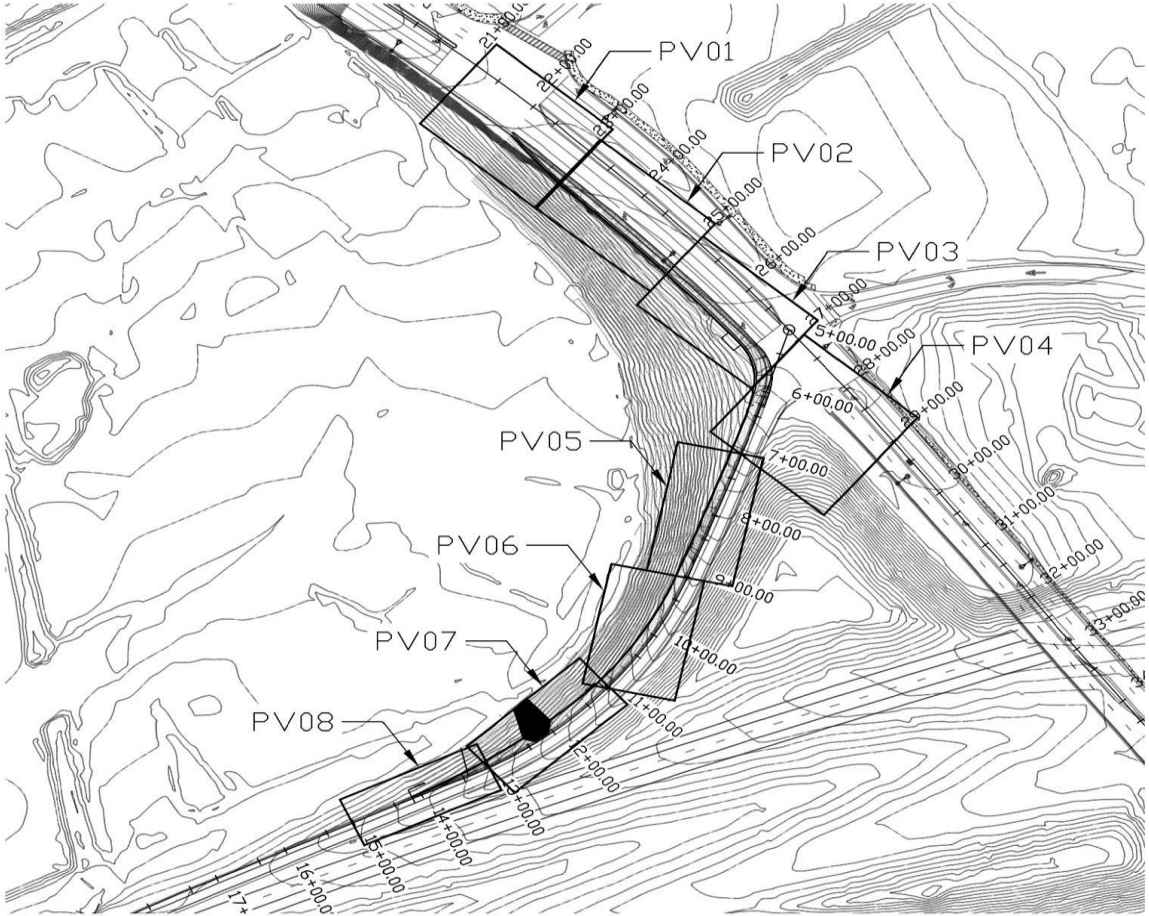
Final On-Ramp Design

- Federal Highway Administration (FHWA) Lane Taper Recommendations [7]
  - Taper Length = 300’
  - Taper Slope = 25:1
- Total Lane Length is 800’
- Match Existing Superelevation
- Guardrail Per ADOT STD DTL 10.01 [8]
- Sheets PV04 - PV08

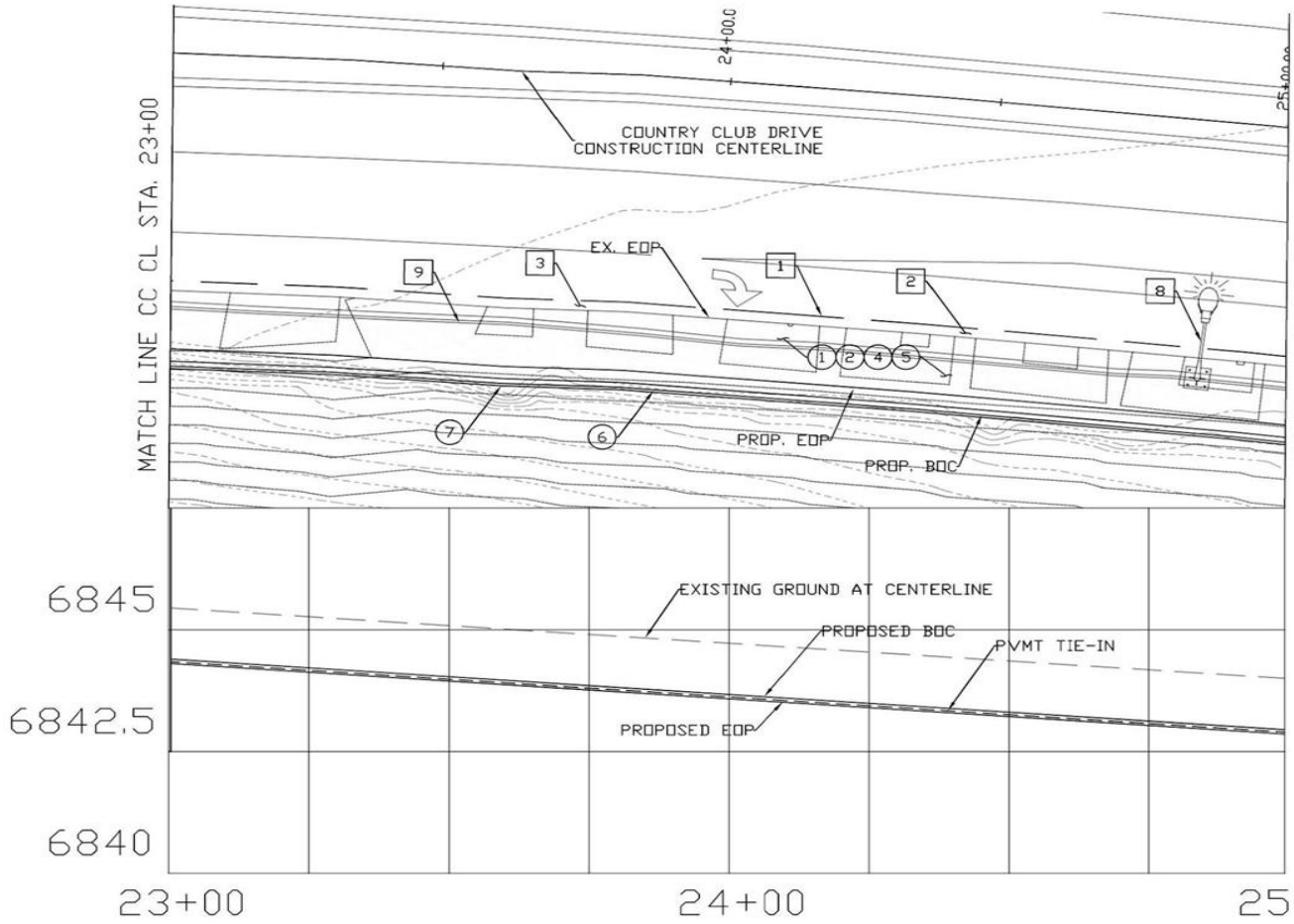


[3]

Figure 11: On-Ramp Plan View (NTS)



DATE	04/13/20		
REV 1:			
REV 2:			
I-40/CC IMPROVEMENT PROJECT		LOCATION	FLAGSTAFF, AZ
DESIGN	MT	SHEET TITLE	OV01
DRAWN	MT		
CHECK	ZJ	NO.	09 OF 22
SCALE	1" = 150		



CONSTRUCTION			
NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	52	TON
2	PORTLAND CEMENT CONCRETE PAVEMENT (12.5")	311	SY
4	BITUMINOUS TACK COAT (0.5")	7	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	13	TON
6	CONCRETE HALF BARRIER PER ADOT STD DTL C-10.52, TYPE F, GUTTER = 2.5'	200	LF
7	RETAINING WALL (OTHERS)	200	LF

REMOVAL			
NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	200	LF
2	PCCP	45	SY
3	AGGREGATE BASE	45	SY
4	ASPHALTIC PAVEMENT	45	SY
5	CONC HALF BARRIER	200	LF
8	LIGHT POST	1	EA
9	RETAINING WALL	200	LF

0 5 10 20

HORIZONTAL: 1" = 20'
VERTICAL: 1" = 2'

DATE 04/13/20
REV 1:
REV 2:

I-40/CC IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

DESIGN MT
DRAWN MT
CHECK ZJ

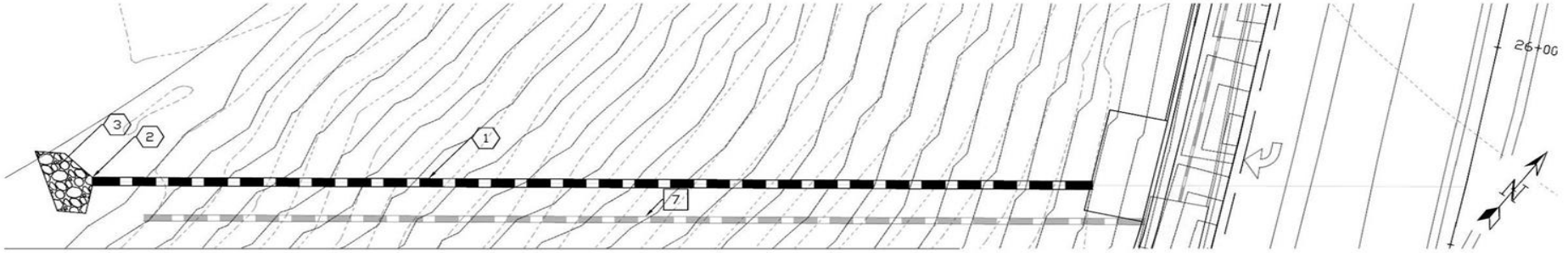
SHEET TITLE PV02

SCALE 1" = 20'

NO. 14 OF 22

Final Drainage Design

- Proposed Catch Basin Located at Intersection of I-40 Westbound On-Ramp and Country Club Dr
  - Discharge (50-yr) = 35.35 cfs
  - Efficiency = 80%
  - Intercepted Flow = 28.28 cfs
  - Bypass Flow = 7.07 cfs
  - Inlet Length = 22 ft
- Recommended Storm Pipe Up-Sizing from 18” to 24” due to Increased Runoff from Proposed Roadway [5] [6]
  - Proposed Flow (50-yr) = 29.2 cfs
  - Proposed Storm Pipe Capacity (24”) = 66.97 cfs
  - Existing Storm Pipe Capacity (18”) = 31.12 cfs
- Existing Storm Pipe must be Removed for Grading
- Storm Pipe Up-Sizing Recommended for Future Development

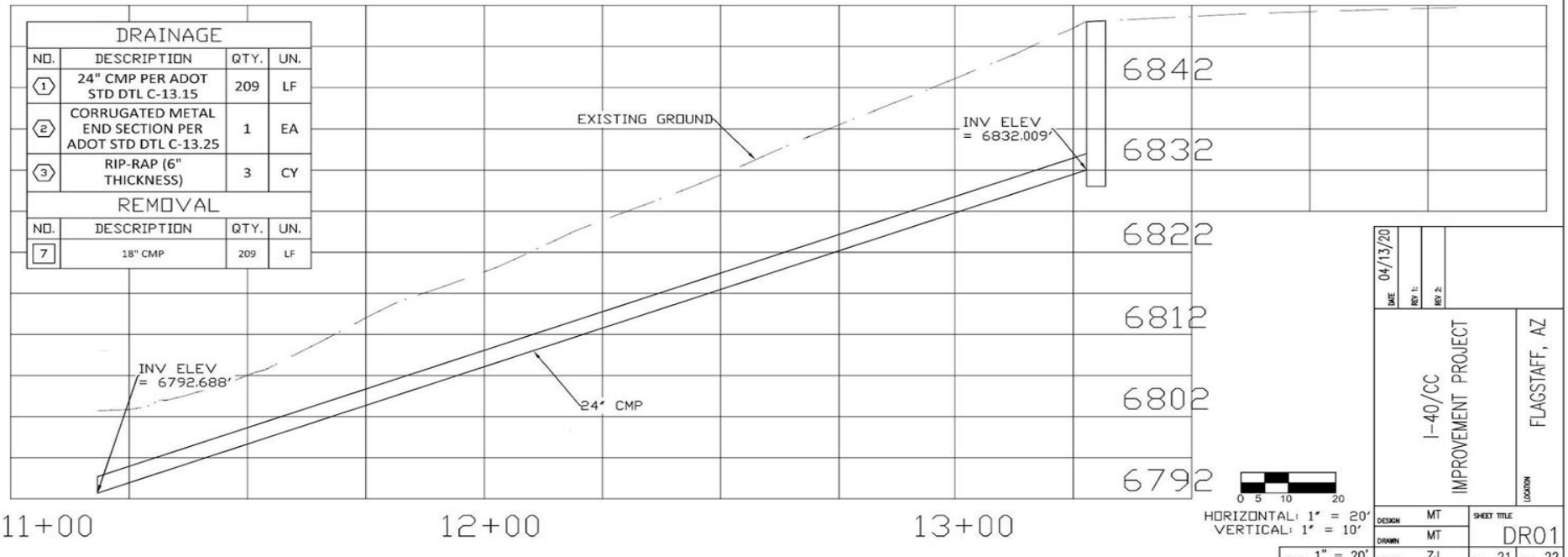


DRAINAGE

NO.	DESCRIPTION	QTY.	UN.
1	24" CMP PER ADOT STD DTL C-13.15	209	LF
2	CORRUGATED METAL END SECTION PER ADOT STD DTL C-13.25	1	EA
3	RIP-RAP (6" THICKNESS)	3	CY

REMOVAL

NO.	DESCRIPTION	QTY.	UN.
7	18" CMP	209	LF



0 5 10 20

HORIZONTAL: 1" = 20'
VERTICAL: 1" = 10'

DATE 04/13/20
REV 1:
REV 2:

I-40/CC IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

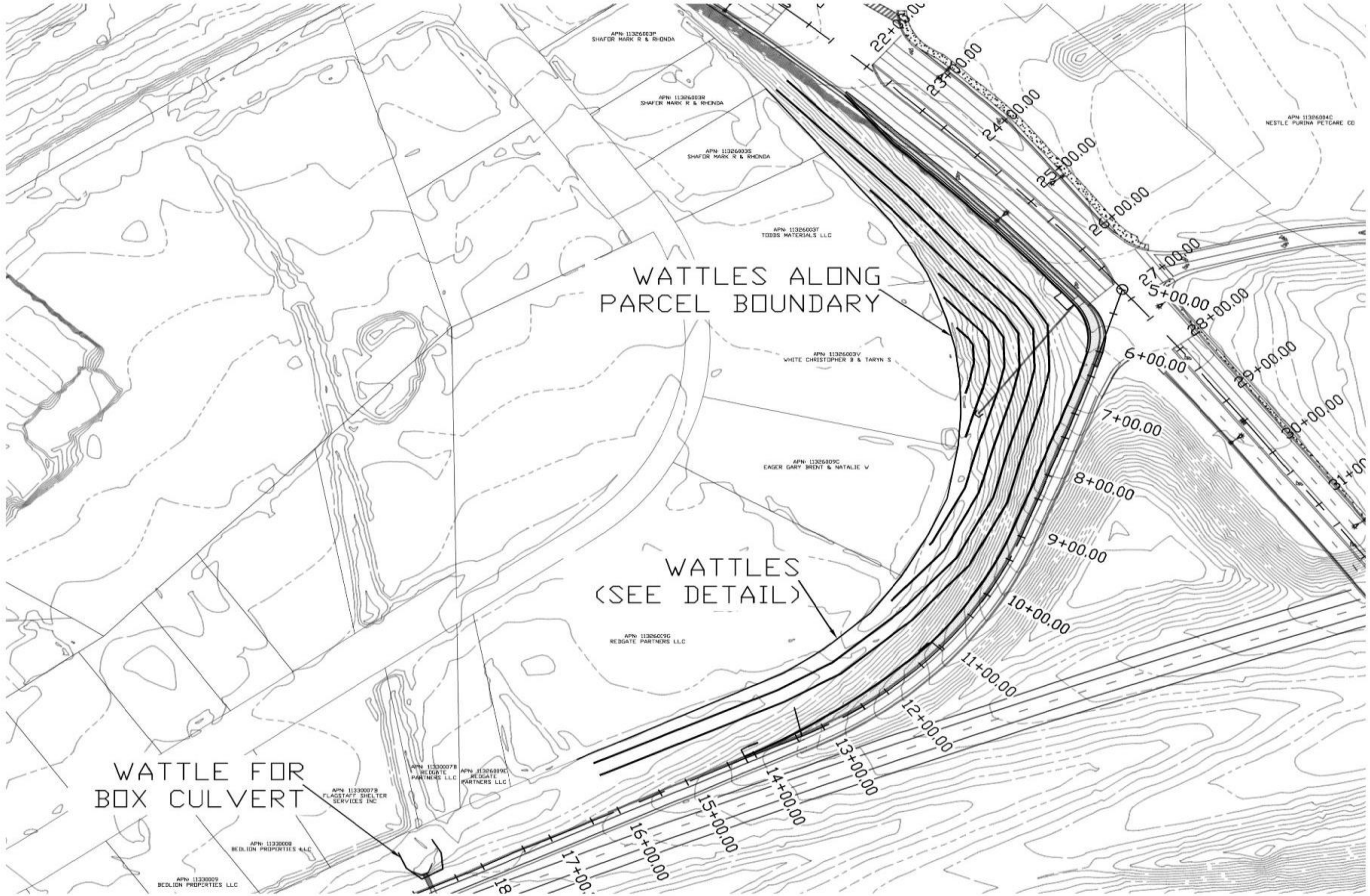
DESIGN	MT
DRAWN	MT
CHECK	ZJ
SCALE	1" = 20'

SHEET TITLE DR01

NO. 21 OF 22

Erosion Control Plan

- Basic Erosion Control Plan Created Using ADOT Standard Details and Specifications
- Wattles Placed along Project for Erosion Control
- Horizontal Spacing = 20 ft maximum
- Detail Sheet Created for Wattle Placement Along Project
- Wattle Placement Designated at Storm Infrastructure Locations
  - Existing 10 ft x 6 ft Box Culvert Crossing I-40 Westbound at Southwestern End of Project
  - Outlet of Existing 18” Corrugated Metal Pipe
- Wattle Placement Designated at Parcel Boundary of Adjacent Properties



DATE	04/13/20
REV 1:	
REV 2:	

I-40/CC
IMPROVEMENT PROJECT

LOCATION: FLAGSTAFF, AZ

DESIGN	RL	SHEET TITLE
DRAWN	RL	EC01
CHECK	MT	NO. 22 OF 22

SCALE 1" = 150'

Capacity Analysis of Right-Turn Lane Group

Equation 1: Capacity

The Capacity of a Lane Group was Found using the Capacity Equation Below [9]:

$$c = Ns \cdot \frac{g}{C}$$

Where:

- c = Capacity of Lane Group
- N = Number of Lanes
- s = Adjusted Saturation Flow Rate
- g = Effective Green Time
- C = Cycle Length

- **Capacity** is the Amount of Vehicles that can pass a Point within a Lane per Hour.
- Capacity is Important due to its Direct Correlation to a Facility's Ability to Account for Various Traffic Conditions and Demands
- Only the Capacities of the Exclusive Right-Turn Lanes were Analyzed

Capacity Analysis of Right-Turn Lane Group Cont.

Equation 2: Adjusted Saturation Flow Rate:

$$s = s_0 f_w f_{HV_g} f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb} f_{wz} f_{ms} f_{sp}$$

- **Adjusted Saturation Flow Rate** is Amount of Vehicles that can Travel in an Individual Lane under Prevailing Conditions.
- Accounts for Factors such as Heavy Vehicles, Parking use, Work Zones, Lane Utilizations, and Public Transit Among Others
- Most Variables will have a Value of 1.0, having no Effect on the Adjusted Saturation Flow Rate

Capacity Analysis Calculation

- **Existing Conditions (1 RT Lane)**
  - Base Saturation Flow Rate
    - s = 1514 pc/hr/ln
  - Effective Green = 30 sec (Assumed)
  - Cycle Length = 45 sec (Assumed)

$$c = (1\,lane)(1514\,pc/hr/ln) \cdot \frac{30sec}{45sec}$$

$$c = 1009\,veh/hr$$

- **Proposed Design (2 RT Lanes)**
  - Base Saturation Flow Rate
    - s = 1514 pc/hr/ln
  - Effective Green = 30 sec (Assumed)
  - Cycle Length = 45 sec (Assumed)

$$c = (2\,lane)(1514\,pc/hr/ln) \cdot \frac{30sec}{45sec}$$

$$c = 2018\,veh/hr$$

Conclusion

- Final Earthwork = 151,467.8 Net Cubic Yards of Fill
- Capacity of Intersection Doubled from Addition of New Lane
- Storm Water Pipe Attached to Catch Basin Up-Sized from 18” to 24”
- Recommendation to Increase Culvert Capacity Crossing I-40 Westbound to Three 8’ x 6’ RCBC
- Final On Ramp Design:
  - 4% Superelevation (Typical)
  - Taper Slope 25:1
  - Total Length 800’
  - Merge Lane Taper Length 300’
- Final Intersection Design:
  - 2% Cross-Slope (Typical)
  - Lane Taper 8:1
  - Total Length 96’
  - Additional Lane Width 12’

Impacts Assessment

Environmental Impacts

- Increase in Stormwater Pollution
- Increase in Impervious Surface Area
- Increase in Emissions

Social Impacts

- Increased Roadway Capacity
- Less Time on Roadway, more Time Getting to their Destination
- More Time with Family or Friends

Economic Impacts

- Less Time Waiting at Intersection, Quicker to get to Jobs or Businesses
- Less Waiting for Trucks to Deliver Goods

References

- **[1]** "Arizona Department of Transportation Logo", *En.wikipedia.org*, 2020. [Online]. Available: *https://en.wikipedia.org/wiki/Arizona_Department_of_Transportation.* [Accessed: 12- Mar- 2020].

- **[2]** "County Map of Arizona", *Mapsales.com*, 2020. [Online]. Available: *https://www.mapsales.com/county-wall-maps/arizona.aspx.* [Accessed: 12- Mar- 2020].

- **[3]** "Map of Project Site", *Google Maps*, 2020. [Online]. Available: https://www.google.com/maps/@35.2173383,-111.5841945,457m/data=!3m1!1e3. [Accessed: 12- Mar- 2020].

- **[4]** Primatech (2020). *Interstate 40 East Flagstaff Traffic Interchange at SR 89 and US 66*. [online] Arizona Department of Transportation, pp.7, 8, 16, 18. Available at: http://file:///C:/Users/mlt289/AppData/Local/Downloads/SR89%20and%20US66%20TI.pdf [Accessed 9 Feb. 2020].

References Cont.

- **[5]** City of Flagstaff Engineering Division (2009). *CITY OF FLAGSTAFF STORMWATER MANAGEMENT DESIGN MANUAL*. Flagstaff: City of Flagstaff, pp.3-1, 3-3, 3-4.

- **[6]** Arizona Department of Transportation (2020). *Roadway Design Guidelines*. Arizona Department of Transportation, pp.600-6, Appendix C.

- **[7]** Federal Highway Administration, 2013. *Guide For Highway Capacity And Operations Analysis Of Active Transportation And Demand Management Strategies*. United States Department of Transportation, p.55.

- **[8]** Arizona Department of Transportation, 2020. *Construction Standard Drawings*. Arizona Department of Transportation.

- **[9]** Highway Capacity Manual 2020. *Capacity Analysis Formula,* Appendix F.

Questions?