I-40/Country Club Drive Traffic Interchange Design: Final Design Submittal

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1.0 Introduction

This is a final report update on the proposed right-turn lane and on-ramp widening of the Westbound Interstate 40 on-ramp at Country Club Drive in Flagstaff, AZ. Due to increasing volumes of vehicles on this arterial, the Arizona Department of Transportation has requested a Design Concept Report for a proposed additional right-turn lane and an additional on-ramp lane to alleviate congestion from Country Club Drive onto Interstate 40 Westbound. Figure 1-1 displays the Project Site with respect to its proximity within the City of Flagstaff.

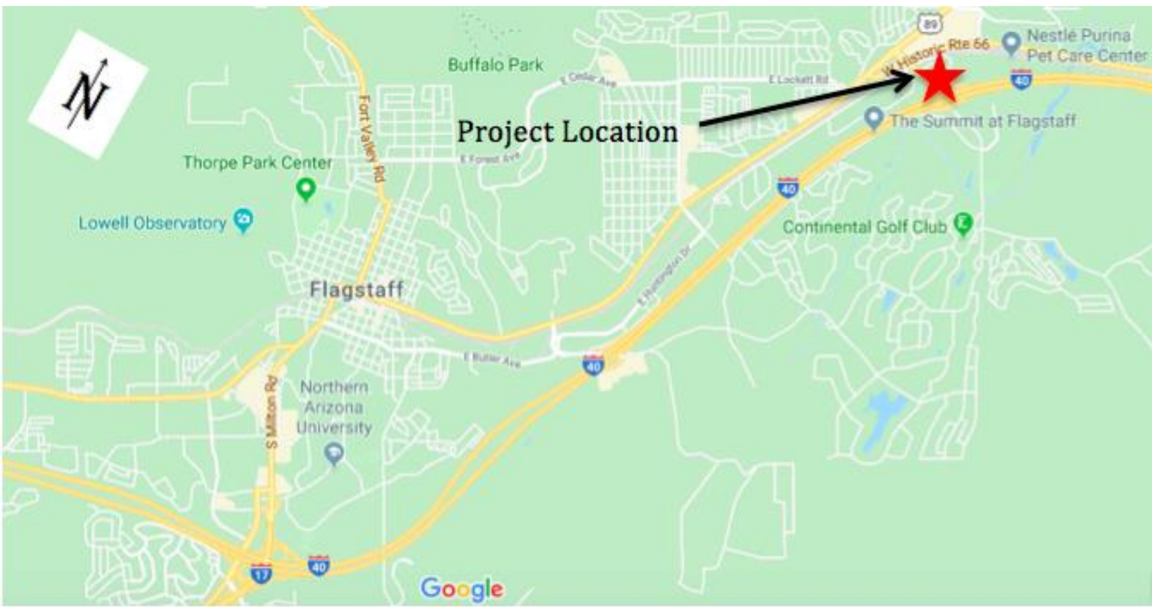

Figure 1-1: Project Location Map (NTS)

Currently at the project site, a dedicated right turn lane from the southbound Country Club Drive approach feeds the existing single lane on-ramp onto Westbound I-40. During peak hour operation at this intersection, the previously mentioned dedicated right turn lane experiences congestion. This congestion results in a long queue of vehicles waiting to enter the highway and will often back up onto the adjacent intersection of Country Club Drive and Nestle Purina Ave. Figure 1-2 contains a satellite aerial map of the on-ramp with sections of Interstate 40 and Country Club Drive included for proximity.

Figure 1-2: Existing Aerial View of Project Location (NTS)

The other legs of this intersection contain typical traffic interchange roadway geometry with respect to entering and leaving a highway from a collector or arterial facility. The northbound approach contains two through lanes and a dedicated left turn lane. The westbound approach is simply an off-ramp lane from Westbound I-40 and users must turn right or left and continue on Country Club Drive to their destination. Figures 1-3 to 1-5 provide street view images of the North/Southbound approaches as well as the entrance of the on-ramp.

Figure 1-3: Country Club Drive Northbound

Figure 1-4: Country Club Drive Southbound

Figure 1-5: I-40 Westbound On-Ramp

The constraints for this project are mainly limited in the proposed design, with scheduling having the most significant impact. This project will require tasks to be completed on schedule if not before in order to ensure quality assurance. Hydrologic impacts as a result of this project will contribute to an increase in surface runoff of impervious surfaces and will therefore increase the volumetric flow rate of runoff for all adjacent and nearby hydraulic infrastructure such as culverts and open channels. The existing hydraulic infrastructure will also need to be remediated due to the increase in discharge.

2.0 Acknowledgements

The completion of this project could not have been accomplished without the support of our grading instructor, Gary Miller, a Development Engineer at the City of Flagstaff, our technical advisor Caleb Lanting, a Project Engineer at Peak Engineering, Inc. and finally to our client, Nate Reisner, a District Development Engineer at the Arizona Department of Transportation. Secondly, thanks to all the professors who offered their guidance and support during the length of this project.

3.0 Technical Sections

3.1 Site Visit

The site visit for this project was limited to driving. Meaning that all site visit participants never left their vehicle when present at the project site. The reasoning for this was the concern of safety to all team members. However, this limitation did not affect the quality of the site visit. This project task was conducted on January 13th, 2020. Essentially, team members drove around the site, with multiple members taking notes regarding the geometry of the site. These notes included the lane striping/usage, roadway and embankment grading, drainage infrastructure quality, etc. Once, this site visit was concluded, a team meeting was conducted to discuss possible design challenges not previously seen by team members.

3.2 Survey Data

All contour data used was imported into AutoCAD Civil 3D, from ArcGIS. Essentially, a large amount of contour data was created within GIS, based on the existing topography, and this information was then exported as polylines into Civil 3D. However, due to the contour data being in the form of polylines, a surface had to be created within Civil 3D, and the contour lines were added to said surface. Once this process was complete, the topographic surface was externally referenced into other drawings in Civil 3D, in order to decrease the likelihood of other drawings freezing, due to an overabundance of information.

This same process was used to collect parcel information, as well. All parcel information was exported to Civil 3D using ArcGIS. The parcel information was obtained using the public GIS system from Coconino County.

3.3 Existing Drainage Conditions/As-Built Information

3.3.1: Existing Drainage Studies

An existing drainage study conducted in the year of 2001 at the north end of this project, was provided for design purposes by ADOT [1]. The specific location of this study includes a portion of US89 from Fanning Dr. to Cummings St. This drainage study uses multiple methods of analysis, including HEC-1 Flood Hydrograph Package, the Rational Method, Culvert Master, and Hec-5. The 2001 drainage study analyzed the existing topography, as well as relevant drainage infrastructure within the delineated watershed. The information of interest within this study is the culvert analysis done for the box culvert passing under the existing I-40 westbound on-ramp at Country Club Drive. This culvert is the control point for the existing runoff calculations within this project area. The findings of this study show that the dimensions of this culvert are 10 ft x 6 ft. This study also shows that the peak flows for the 50 year and 100 year storms are 1159 cfs and 1400 cfs [1].

3.3.2: As-Built Information

As-Built information was provided by ADOT, for a reference of existing conditions. The as-built information used for design, results from a design created by DMJM Harris, and constructed by Vastco Construction Company. The information within these as-builts, as well as aerial views, were used to create existing information within AutoCAD Civil 3D. This information includes construction details, various offsets, material types and quantities, etc.

3.4 Existing and Proposed Runoff Calculations

Existing drainage runoff conditions, for the entire project area, were calculated using USGS quad maps and National Stream Statistics (NSS), with the concentration point being the 10 ft x 6 ft box culvert crossing I-40 westbound. The process of these calculations began with inserting quad maps into Civil 3D and delineating a watershed with the provided contours. Once a watershed was delineated, the area of the watershed was inputted into the NSS program,, which uses a mean watershed elevation and average annual precipitation to calculate the peak flows for various storms for the delineated watershed. The existing peak flows for various storm events are shown below. Due to the fact that these flows are smaller when compared to the flows calculated in the 2001 drainage study, the capacity analysis regarding the 10 ft x 6 ft box culvert will use the flows calculated by the 2001 drainage study. The reason for this is because the higher flow will lead to a more conservative analysis.

Table 3-1: Various Storm Event Peak Flows for Project Site

Statistic	Value, ft3/s	Pred. Intervals Low	High	Prediction Error, %
PK2	27.6	7.48	102	86
PK5	65.3	23.2	184	64
PK10	101	38.9	261	58
PK25	157	63.3	392	55
PK50	208	83.1	518	55
PK100	264	104	671	56
PK200	328	125	862	59
PK500	425	152	1190	63

The runoff calculations for the existing catch basin and storm pipe were completed using Bentley FlowMaster. This process began with creating a watershed, with the existing catch basin acting as the concentration point for the watershed. Next, the time of concentration for this watershed was calculated, as well as the area of the watershed. These values were used, along with coefficients of roughness, to calculate the peak flows within this watershed. Specifically, the rational method was used to calculate the peak flows for the catch basin of interest. The peak flows for a 50-year storm event were used for analysis, based on the requirements listed in the ADOT Roadway Design Guidelines, specifically Table 603.2A and Appendix C. The figure shown in Appendix C of this manual list classifies this roadway as Class 1, which uses a 50-year design storm [3]. The pipe capacity of the 18” CMP of interest and the total existing flow are shown in the table below.

Table 3-2: Runoff Calculation for Existing Storm Pipe [2] [3]

Pipe	18" CMP
Max Flow Capacity (cfs)	31.12
Total Proposed Flow (cfs)	29.20

3.5 Geotechnical Information

A minimum compaction of 95% maximum soil density is recommended for fill areas within this design. This is assuming the soil type is a poor soil for construction, such as clayey type soil per the American Association of State Highway and Transportation Officials (AASHTO) soil classification system [4]. An assumption for soil type is required, due to the design team not yet acquiring a geotechnical report for the project area.

Earthwork quantities have been calculated for the project area and are estimated to be a net fill of 147,530 cubic yards, for the entire project. The earthwork report, created using Civil 3D, can be seen in Appendix B: Final Earthwork Report. It should be noted that this earthwork estimate is calculated to finished grade.

3.6 Existing Geometry

The existing geometry for the project area was drawn in Civil 3D, using various line types and layers, to show various information. This information includes curb and gutter, centerline offsets, striping, pavement structure, and much more. The reason for this information being drawn in, is due to the project design team not completing a full survey of the project area. Without completing a survey, the team was required to draw in a best fit, for all existing geometry.

3.7 Existing Cross-Sectional Information

Cross-sectional information for the existing roadway was obtained from the previously mentioned as-built information, in section 3.3.2. Once this information was collected, existing typical cross-sections were created using Civil 3D. The information within these cross-sections includes structural pavement section information, lane widths/usages, right-of-way offsets, cross-slopes, etc. There were a total of 4 cross-sections created, showing the existing geometry.

3.8 Roadway Alignments/Base Files

3.8.1 Roadway Alignments

A centerline alignment was created on North Country Club Drive, as a reference for all construction along this roadway. Additionally, an edge line alignment was created for all construction on the westbound on-ramp. Due to a time constraint and no survey data being collected, the center line alignment was created by copying the edge of pavement for Country Club Drive and offsetting this line half the width of the roadway.

The edge line alignment for the westbound on-ramp was created by copying the existing edge of pavement and offsetting it two feet into the roadway.

3.8.2 Base Files

Various base files were created within Civil 3D. These base files include an existing contour file, a title block file, an existing geometry file, and many others. All base files created, will be referenced into design drawings using Civil 3D. The reason for this is to decrease buffer time within design drawings, and to retain the ability to edit base files if needed. The geometry for all files is based on stationing and offsets from the construction centerline and edge line created for design.

3.9 Proposed Cross-Sectional Information

The cross-sectional design for this proposed roadway improvement began with analyzing the existing pavement structure. This information was obtained through both the as-built and geotechnical report created for this project area, as provided by ADOT. Essentially, the existing pavement will be saw cut, 24" offset from the existing edge of pavement, and the existing pavement structure will be extended into the proposed roadway. A typical 12' lane width was chosen for the proposed right-turn lane, per ADOT standard details and specifications.

After typical cross-sections were created, additional cross-sections showing lane widths for the on-ramp lane taper were also created. These cross-section were created every 50' along the I-40 on-ramp edge line alignment, in order to show how the geometry should be constructed at these locations. Cross-sections were also created along the runoff at the end of the superelevation for the horizontal curve. However, the runoff is relatively short for this project, because the roadway only has to match a 2% slope, in order to match the cross-slope of westbound I-40. This length of runoff to match the 2% cross-slope of I-40 westbound, is ⅓ the length of what the total runoff length would be if the design did not only have to match this cross-slope [5]. The runoff length would be much longer if any of the lanes were required to rotate over the crown of the roadway. The calculations for this runoff length are shown in Appendix A: Runoff and Runout Calculations.

3.10 Proposed Intersection Design

Typical lane taper standard details were obtained from the Federal Highway Administration (FHWA), for the design of the proposed right-turn lane. As stated previously, a typical lane width of 12' was used for this design, with a lane taper of 8:1 per FHWA lane taper recommendations [6]. This lane taper, along with a 12' width, results in a total length of 96' for the proposed right-turn lane for the lane taper, and a total lane length of 457'. A typical cross-slope of 2% will be used for drainage design purposes, as well as to match the existing conditions. The existing shoulder width dimension of 4' was retained when designing this right turn lane.

Other design elements for this area of the project include a concrete half barrier per ADOT standard detail C-10.52, Type F, Gutter = 2.5'. This detail will match the existing concrete barrier design along Country club Drive.

A retaining wall will be required for this design at the north end of the project. This design will be completed by a sub-consultant and provided to the design team and contractor prior to construction.

The profile for the Country Club Drive, is displayed on each of the plan and profile sheets corresponding to this area of the project. The information shown on the profile for Country Club Drive includes the existing ground at the centerline alignment, as well as the proposed edge of pavement, the proposed back of curb, and the saw cut location.

3.11 Proposed On-Ramp Design

Similar to the proposed right-turn lane, the initial design of the additional on-ramp merge lane began with analyzing FHWA typical design details. These details stated that a typical taper length for merge lanes is 300', per FHWA lane taper recommendations [7]. This taper lane length was used for design, with a total lane length of 800'. As a result of the taper length and lane width, the taper slope for this merge lane is 25:1. Similar to the right-turn lane, the existing superelevation of the existing on-ramp was used for design. This superelevation being 4% typical.

The runoff calculated for this on-ramp will be ⅓ of the calculated length, if the roadway was required to rotate lanes over the crown of the roadway. This calculated length resulted in 43.5'.

The profile for the on-ramp, is displayed on each of the plan and profile sheets corresponding to this area of the project. The information shown on the profile for the on-ramp includes the existing ground at the edge line alignment, as well as the proposed edge of pavement for the on-ramp. The saw cut line for the on-ramp is along the edge line alignment.

3.12 Final Drainage Analysis and Design

The drainage design for this project includes one major improvement, as a result of the increase in flow. This improvement will be to reconstruct a catch basin at the intersection of the I-40 westbound on-ramp and Country Club Drive, per ADOT standard detail C-15.20. The inlet length for this catch basin will be a minimum of 38.4 ft. This value was determined using Bentley FlowMaster, and the report generated for this analysis can be seen in Appendix C: Catch Basin Inlet FlowMaster Report. The previously determined flow of 35.35 cfs for the 50-year storm event in this area was used for analysis and all slope information was determined using the proposed cross-sections for this area, as well as the as built information acquired from ADOT.

The existing 18" storm pipe attached to this catch basin is able to sufficiently distribute the calculated flow from the 50-year storm event in this area. However, this storm pipe will be upsized to 24". The reason for this is because the maximum flow capacity for an 18" storm pipe, at the proposed slope, is within 2 cfs of the 50-year storm event for this area. The flow capacity reports created within FlowMaster can be seen in Appendix D: Catch Basin Pipe Capacity FlowMaster Report.

Regarding the flow associated with the reinforced concrete box culvert crossing I-40 westbound, the design team did calculate a flow. However, this flow is less than the flow calculated by the 2001 drainage study, so the more conservative value was used for box culvert analysis. The flow used for this analysis was 1159 cfs, as stated in section 3.4 [1]. Using CulvertMaster, and the provided 50 year flow, it was determined that the existing concrete box culvert cannot sufficiently convey this flow [3]. The report generated using CulvertMaster can be seen in Appendix E: I-40 RCBC CulvertMaster Report. It is the design team's recommendation to upgrade this drainage infrastructure to 4 8'x6' RCBC. This drainage improvement would be able to handle the designated flow for this area per ADOT drainage standards [8].

3.13 Proposed Erosion Control Plan

A preliminary erosion control plan was created by first designating locations for wattles within the project area. This was done based on various locations of drainage infrastructure, and areas with large grades in the project area. Additionally, wattles were placed at the existing concrete box culvert near the end of the existing westbound on-ramp. A standard detail for wattle placement was obtained from ADOT, which is shown on sheet 27 of 27, within the provided construction plan set.

3.14 Final Construction Plan Set

A construction plan set was created for the preliminary design of this project. Included in this plan set are removal and construction quantities, as well as typical construction details used, which can be seen in Appendix H: Construction Plan Set. The plan set was created using the CADD standards provided by ADOT. These standards include sheets dedicated to general notes, a cover sheet, an index sheet, plan and profile sheets, typical proposed cross-sections, typical detail sheets, drainage sheets, project overview sheets, and an erosion control plan [9].

3.15 Capacity Analysis

The capacity of a lane is defined as the maximum number of vehicles expected to pass through an intersection. Since traffic count data wasn't provided by ADOT, it is assumed that the adjusted saturation flow rate will not change. The saturation flow rate was found from Equation 3 [Appendix F], this equation was found in the Highway Capacity Manual [10]. Other variables in the capacity equation that will not change are Equation 2 effective green time and cycle length due to the timing signal operations being outside of the project scope. The only variable changing in Equation 4 [Appendix F] is the number of lanes. Since the number of lanes on Country Club Dr. and on the I-40 on ramp westbound is moving from one lane to two lanes, the capacity of both Country Club Dr. and the I-40 on ramp will be doubled.

3.16 Environmental Impacts Assessment

The environmental impacts associated with this project are similar to those of most roadway design projects. Some of these impacts include an increase in stormwater pollution due to an increase in impervious surface area, and an increase in emissions as a result of increased roadway use. These impacts are present within this proposed construction project. Some possible treatments for these impacts include Low Impact Development (LID) design for the increase in runoff, to hinder the effects of stormwater pollution. While these impacts are inevitable for this type of project, it is important to identify them, in order to find a solution, or a treatment.

3.17 Social Impacts Assessment

Typical social impacts for roadway construction projects may include an increase in level of service, or an increase in roadway capacity. These impacts can lead to users spending less time on the roadway, and getting to their destinations quicker. Results of this decrease in roadway time can lead to more time spent on things that said user wants, or needs, to spend time doing. A domino effect of this can lead to more time spent working, or more time spent with family, or friends. Which, will possibly lead to said roadway user living a happier lifestyle.

3.18 Economic Impacts Assessment

The economic impacts associated with this project are similar to those of most roadway design and expansion projects. The economic impacts associated with this project are, since an additional lane is being added on to the onramp and on Country Club Dr. The amount of time waiting at the intersection will be less so people can get to their jobs and services quicker, making the travel time less will increase the ability for people and stores to make more money. Since the I-40 is a major trucking route, the amount of time waiting at the intersection is reduced allowing delivery’s to make it to the final destination shorter, saving companies money.

4.0 Summary of Engineering Work

The work for this submittal included a proposed final design of both the proposed right-turn lane onto I-40 westbound, and the additional I-40 westbound on-ramp merge lane. As stated in previous sections, this included developing proposed final cross-sections, an erosion control plan, intersection design, on-ramp design, and drainage design per ADOT standard details and specifications. All work completed for this submittal was completed as shown in the updated project schedule in Appendix G: Updated Project Schedule. The construction plan set has been finalized, and has addressed all final comments. This final plan set is a 30% Design Concept Report, as outlined by the scope of this project.

5.0 Summary of Engineering Costs

The total hours of design and drafting throughout this project were originally projected at 227 hours. At the conclusion of this project, the design team has allocated 365 hours to design and drafting. While this is a much higher total of hours than originally predicted, there were unforeseen conflicts, which arose throughout the duration of this project. One example of these unforeseen circumstances was the additional time needed to obtain existing contour information for design. The project management included in this submittal is a reflection of time dedicated to this task over the entire course of the project.

Table 5-1: Hourly Breakdown of 100% Deliverables

Tasks	PM	PE	EIT	TECH	Total
2.2.6: Task 2.6 Construction Plan Set	1	1	4	0	6
2.3.4: Task 3.4 Final Design Report	1	1	6	0	8
2.3.5: Website	1	2	4	8	15
2.5 Project Management	42	42	38	38	160
Total	45	46	52	46	189

Table 5-2: Total Hours and Rates for 100% Deliverables

Team Member	PM	PE	EIT	TECH	Total
Rate	$195	$155	$110	$75	N/A
Total Billed	$8,775	$7,130	$5,720	$3,450	$25,075
Total Cost	-	-	-	-	$25,075

\

Table 5-3: Total Hours and Rates for All Completed Work

Submittal	PM	PE	EIT	TECH	Total
Total Cost of 30% Design Report	$2,535	$3,410	$5,830	$4,500	$16,275
Total Cost of 60% Design Report	$3,900	$4,650	$8,360	$4,725	$21,635
Total Cost of 90% Design Report	$5,460	$4,805	$10,120	$6,000	$26,385
Total Cost of Final Design Report	$8,775	$7,130	$5,720	$3,450	$25,075
Total Summary Cost of Project	$6,435	$8,060	$14,190	$9,225	$89,370.00

6.0 Conclusion

This project was completed on schedule, despite conflicts and unforeseen circumstances throughout the design process. These conflicts did result in an increase in cost, due to additional hours spent gathering existing information, or completing the design process. All working hours, as well as a design concept, have been completed for this project and are shown within the report.

7.0 References

[1] 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].

[2] City of Flagstaff Engineering Division (2009). CITY OF FLAGSTAFF STORMWATER MANAGEMENT DESIGN MANUAL. Flagstaff: City of Flagstaff, pp.3-1, 3-3, 3-4, 6-2, 6-22, 6-29.

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

[4] Jamal, H., 2019. *AASHTO Soil Classification System - AASHTO Chart*. [online] Aboutcivil.org. Available at: <https://www.aboutcivil.org/aashto-soil-classification-system> [Accessed 13 April 2020].

[5] Deutsch, P., 2020. *Design Of Horizontal Curves*.

[6] Federal Highway Administration (2016). *Signalized Intersections: Information Guide*. Washington D.C.: Federal Highway Administration.

[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). Roadway Design Guidelines. Arizona Department of Transportation, pp.8-6, Appendix B.

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

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

8.0 Appendices

Appendix A: Runoff and Runout Calculations

Equation A-1: Relative Gradient Calculation

The relative gradient for the runoff length is found using the equation below:

$$G = \frac{we}{L}$$

Where:

$G = Relative\ Gradient$ (%).
$w = Lane\ Width\ (ft)$.
$e = design\ superelevation\ rate$ (%) .

Equation A-2: Runoff Length Gradient Calculation

The duration of an actuated phase is found by the equation below:

$$RL = \frac{weN\ b_w}{G}$$

Where:

$RL = Runoff\ Length\ (ft)$.
$w = Lane\ Width\ (ft)$.
$N = Number\ of\ Lanes\ (Unitless)$.
$G = Relative\ Gradient$ (%).
$w = Adjustment\ Factor\ for\ Number\ of\ Lanes\ (Unitless)$.
$e = design\ superelevation\ rate$ (%) .

Appendix B: Final Earthwork Report

Cut/Fill Report

Generated:	2020-05-01 12:45:20
By user:	mlt289
Drawing:	S:\Capstone\CENE\CENE-Cap-24\I-40 On-Ramp Team Folder\Earth Work\S:\Capstone\CENE\CENE-Cap-24\I-40 On-Ramp Team Folder\Earth Work\Final Earth Work.dwg

Volume Summary

Name	**Type**	**Cut Factor**	**Fill Factor**	**2d Area** (Sq. Ft.)	**Cut** (Cu. Yd.)	**Fill** (Cu. Yd.)	**Net** (Cu. Yd.)
Proposed Earthwork	full	1.000	1.000	126534.03	6671.03	154200.34	147529.32<Fill>

Totals

	2d Area (Sq. Ft.)	**Cut** (Cu. Yd.)	**Fill** (Cu. Yd.)	**Net** (Cu. Yd.)
Total	126534.03	6671.03	154200.34	147529.32<Fill>

* Value adjusted by cut or fill factor other than 1.0

Figure B-1: Final Cut/Fill Report

Appendix C: Catch Basin Inlet FlowMaster Report

Worksheet for Curb Inlet On Grade - 1

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Project Description	
Solve For	Curb Opening Length

Input Data	
Discharge	35.35
Slope	0.011
Gutter Width	2.50
Gutter Cross Slope	0.032
Road Cross Slope	0.020
Roughness Coefficient	0.013
Efficiency	80.00
Local Depression	2.0
Local Depression Width	6.0

Results	
Curb Opening Length	38.4
Intercepted Flow	28.28
Bypass Flow	7.07
Spread	24.7
Depth	6.3
Flow Area	6.1
Gutter Depression	0.4
Total Depression	2.4
Velocity	5.75
Equivalent Cross Slope	0.040
Length Factor	0.591
Total Interception Length	65.0

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Figure C-1: Catch Basin Inlet Length FlowMaster Report

Appendix D: Catch Basin Pipe Capacity FlowMaster Report

18" Pipe

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Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data	
Roughness Coefficient	0.022
Channel Slope	0.251
Normal Depth	18.0
Diameter	18.0
Discharge	31.12

Results	
Discharge	31.12
Normal Depth	18.0
Flow Area	1.8
Wetted Perimeter	4.7
Hydraulic Radius	4.5
Top Width	0.00
Critical Depth	17.9
Percent Full	100.0
Critical Slope	0.239
Velocity	17.61
Velocity Head	4.82
Specific Energy	6.32
Froude Number	(N/A)
Maximum Discharge	33.48
Discharge Full	31.12
Slope Full	0.251
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	18.0
Critical Depth	17.9
Channel Slope	0.251
Critical Slope	0.239

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FlowMaster
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Figure D-1: Existing 18" CMP Capacity FlowMaster Report

24" Pipe
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Project Description	
Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data	
Roughness Coefficient	0.022
Channel Slope	0.251
Normal Depth	24.0
Diameter	24.0
Discharge	66.97

Results	
Discharge	66.97
Normal Depth	24.0
Flow Area	3.1
Wetted Perimeter	6.3
Hydraulic Radius	6.0
Top Width	0.00
Critical Depth	23.9
Percent Full	100.0
Critical Slope	0.239
Velocity	21.32
Velocity Head	7.06
Specific Energy	9.06
Froude Number	(N/A)
Maximum Discharge	72.04
Discharge Full	66.97
Slope Full	0.251
Flow Type	Undefined

GVF Input Data	
Downstream Depth	0.0
Length	0.0
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0
Profile Description	N/A
Profile Headloss	0.00
Average End Depth Over Rise	0.0
Normal Depth Over Rise	100.0
Downstream Velocity	Infinity
Upstream Velocity	Infinity
Normal Depth	24.0
Critical Depth	23.9
Channel Slope	0.251
Critical Slope	0.239

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FlowMaster
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Figure D-2: Proposed 24" CMP Capacity FlowMaster Report

Appendix E: I-40 RCBC CulvertMaster Report

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary						
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	6,794.70	ft	Discharge	1,159.00	cfs
Headwater Depth/Height	2.45		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	6,794.59	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,794.70	ft			

Grades					
Upstream Invert	6,780.00	ft	Downstream Invert	6,776.04	ft
Length	123.89	ft	Constructed Slope	0.031964	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	4.66	ft
Slope Type	Steep		Normal Depth	3.50	ft
Flow Regime	Supercritical		Critical Depth	6.00	ft
Velocity Downstream	24.90	ft/s	Critical Slope	0.012353	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	10.00	ft
Section Size	10 x 6 ft		Rise	6.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6,794.70	ft	Upstream Velocity Head	5.80	ft
Ke	0.50		Entrance Loss	2.90	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,794.59	ft	Flow Control	Submerged	
Inlet Type	33.7° wingwall flares - offset		Area Full	60.0	ft²
K	0.49500		HDS 5 Chart	13	
M	0.66700		HDS 5 Scale	2	
C	0.02520		Equation Form	2	
Y	0.88100				

Title: I-40/CC
Project Engineer: mlt289
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Page 1 of 1

Figure E-1: Existing Box Culvert Design Storm CulvertMaster Report

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	N/A ft	Storm Event	Check
Computed Headwater Eleva	6,798.91 ft	Discharge	1,400.00 cfs
Headwater Depth/Height	3.15	Tailwater Elevation	0.00 ft
Inlet Control HW Elev.	6,798.91 ft	Control Type	Inlet Control
Outlet Control HW Elev.	6,798.69 ft		

Grades			
Upstream Invert	6,780.00 ft	Downstream Invert	6,776.04 ft
Length	123.89 ft	Constructed Slope	0.031964 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	5.17 ft
Slope Type	Steep	Normal Depth	4.02 ft
Flow Regime	Supercritical	Critical Depth	6.00 ft
Velocity Downstream	27.07 ft/s	Critical Slope	0.018024 ft/ft

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	10.00 ft
Section Size	10 x 6 ft	Rise	6.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	6,798.69 ft	Upstream Velocity Head	8.46 ft
Ke	0.50	Entrance Loss	4.23 ft

Inlet Control Properties			
Inlet Control HW Elev.	6,798.91 ft	Flow Control	Submerged
Inlet Type 33.7° wingwall flares - offset		Area Full	60.0 ft²
K	0.49500	HDS 5 Chart	13
M	0.66700	HDS 5 Scale	2
C	0.02520	Equation Form	2
Y	0.88100		

Title: I-40/CC Project Engineer: mlt289
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Figure E-2: Existing Box Culvert Check Storm CulvertMaster Report

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	N/A	ft	Storm Event	Design	
Computed Headwater Eleva	6,786.02	ft	Discharge	1,159.00	cfs
Headwater Depth/Height	1.00		Tailwater Elevation	0.00	ft
Inlet Control HW Elev.	6,785.42	ft	Control Type	Entrance Control	
Outlet Control HW Elev.	6,786.02	ft			

Grades					
Upstream Invert	6,780.00	ft	Downstream Invert	6,776.04	ft
Length	123.89	ft	Constructed Slope	0.031964	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.91	ft
Slope Type	Steep		Normal Depth	1.61	ft
Flow Regime	Supercritical		Critical Depth	3.44	ft
Velocity Downstream	18.95	ft/s	Critical Slope	0.003732	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	8.00	ft
Section Size	8 x 6 ft		Rise	6.00	ft
Number Sections	4				

Outlet Control Properties					
Outlet Control HW Elev.	6,786.02	ft	Upstream Velocity Head	1.72	ft
Ke	0.50		Entrance Loss	0.86	ft

Inlet Control Properties					
Inlet Control HW Elev.	6,785.42	ft	Flow Control	Unsubmerged	
Inlet Type	33.7° wingwall flares - offset		Area Full	192.0	ft²
K	0.49500		HDS 5 Chart	13	
M	0.66700		HDS 5 Scale	2	
C	0.02520		Equation Form	2	
Y	0.88100				

Title: I-40/CC
Project Engineer: mlt289
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Page 1 of 1

Figure E-3: Proposed Box Culvert Design Storm CulvertMaster Report

Culvert Design Report
N/A

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	N/A ft	Storm Event	Check
Computed Headwater Eleva	6,786.83 ft	Discharge	1,400.00 cfs
Headwater Depth/Height	1.14	Tailwater Elevation	0.00 ft
Inlet Control HW Elev.	6,786.15 ft	Control Type	Entrance Control
Outlet Control HW Elev.	6,786.83 ft		

Grades			
Upstream Invert	6,780.00 ft	Downstream Invert	6,776.04 ft
Length	123.89 ft	Constructed Slope	0.031964 ft/ft

Hydraulic Profile			
Profile	S2	Depth, Downstream	2.22 ft
Slope Type	Steep	Normal Depth	1.84 ft
Flow Regime	Supercritical	Critical Depth	3.90 ft
Velocity Downstream	19.71 ft/s	Critical Slope	0.003878 ft/ft

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	8.00 ft
Section Size	8 x 6 ft	Rise	6.00 ft
Number Sections	4		

Outlet Control Properties			
Outlet Control HW Elev.	6,786.83 ft	Upstream Velocity Head	1.95 ft
Ke	0.50	Entrance Loss	0.98 ft

Inlet Control Properties			
Inlet Control HW Elev.	6,786.15 ft	Flow Control	Unsubmerged
Inlet Type 33.7° wingwall flares - offset		Area Full	192.0 ft²
K	0.49500	HDS 5 Chart	13
M	0.66700	HDS 5 Scale	2
C	0.02520	Equation Form	2
Y	0.88100		

Title: I-40/CC Project Engineer: mlt289
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Figure E-4: Proposed Box Culvert Check Storm CulvertMaster Report

Appendix F: Capacity Analysis

Capacity Equations:

Equation F-1: Phase Duration

The duration of an actuated phase is found by the equation below:

$$D_P = l_1 + g_s + g_e + Y + R_c$$

Where:

$D_P = Phase\ Duration\ (s).$
$l_1 = Start - Up\ Lost\ Time = 2.0\ (s).$
$g_s = Queue\ Service\ Time\ (s).$
$g_e = Green\ Extension\ Time\ (s).$
$Y = Yellow\ Change\ Interval\ (s).$
$R_c = Red\ Clearance\ Interval\ (s).$

Equation F-2: Effective Green Time

The effective green time for the phase is found by the equation below:

$$g = D_P - l_1 - l_2$$

Where:

$g = Effective\ Green\ Time.$
$l_2 = Clearance\ Lost\ Time = Y + R_c - e\ (s).$
$e = Extension\ of\ Effective\ Green = 2.0\ (s).$

Equation F-3: Adjusted Saturation Flow Rate

The capacity of the additional right turn lane was "analyzed" using methods presented within the Highway Capacity Manual. The adjusted saturation flow rate for a lane is found using the following equation:

$$s = s_0 f_w f_{HV_g} f_P f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{L_Pb} f_{R_Pb} f_{wz} f_{ms} f_{sp}$$

Where:

s = adjusted saturation flow rate (veh/h/ln),

s_0 = base saturation flow rate (pc/h/ln),

f_w = adjustment factor for lane width,

f_{HVg} = adjustment factor for heavy vehicles and grade,

f_p = adjustment factor for existence of a parking lane and parking activity adjacent to lane group,

f_{bb} = adjustment factor for blocking effect of local buses that stop within intersection area,

f_a = adjustment factor for area type,

f_{LU} = adjustment factor for lane utilization,

f_{LT} = adjustment factor for left-turn vehicle presence in a lane group,

f_{RT} = adjustment factor for right-turn vehicle presence in a lane group,

f_{Lpb} = pedestrian adjustment factor for left-turn groups,

f_{Rpb} = pedestrian–bicycle adjustment factor for right-turn groups,

f_{wz} = adjustment factor for work zone presence at the intersection,

f_{ms} = adjustment factor for downstream lane blockage, and

f_{sp} = adjustment factor for sustained spillback.

Adjustment for Lane Width

The lane width adjustment factor f_w accounts for the negative impact of narrow lanes on saturation flow rate and allows for an increased flow rate on wide lanes. Values of this factor are listed in Exhibit 19-20.

Average Lane Width (ft)	Adjustment Factor f_w
<10.0[a]	0.96
≥10.0–12.9	1.00
>12.9	1.04

Note: [a] Factors apply to average lane widths of 8.0 ft or more.

Exhibit 19-20
Lane Width Adjustment Factor

Figure F-1: Lane Width Adjustment

Equation F-4: Capacity

The capacity of a lane or lane group is found by the capacity equation below:

$$c = N\, s\, \frac{g}{C}$$

Where:

$c = Capacity.$

$s = Adjusted\ Saturated\ Flow\ Rate\ (veh/hr/ln).$

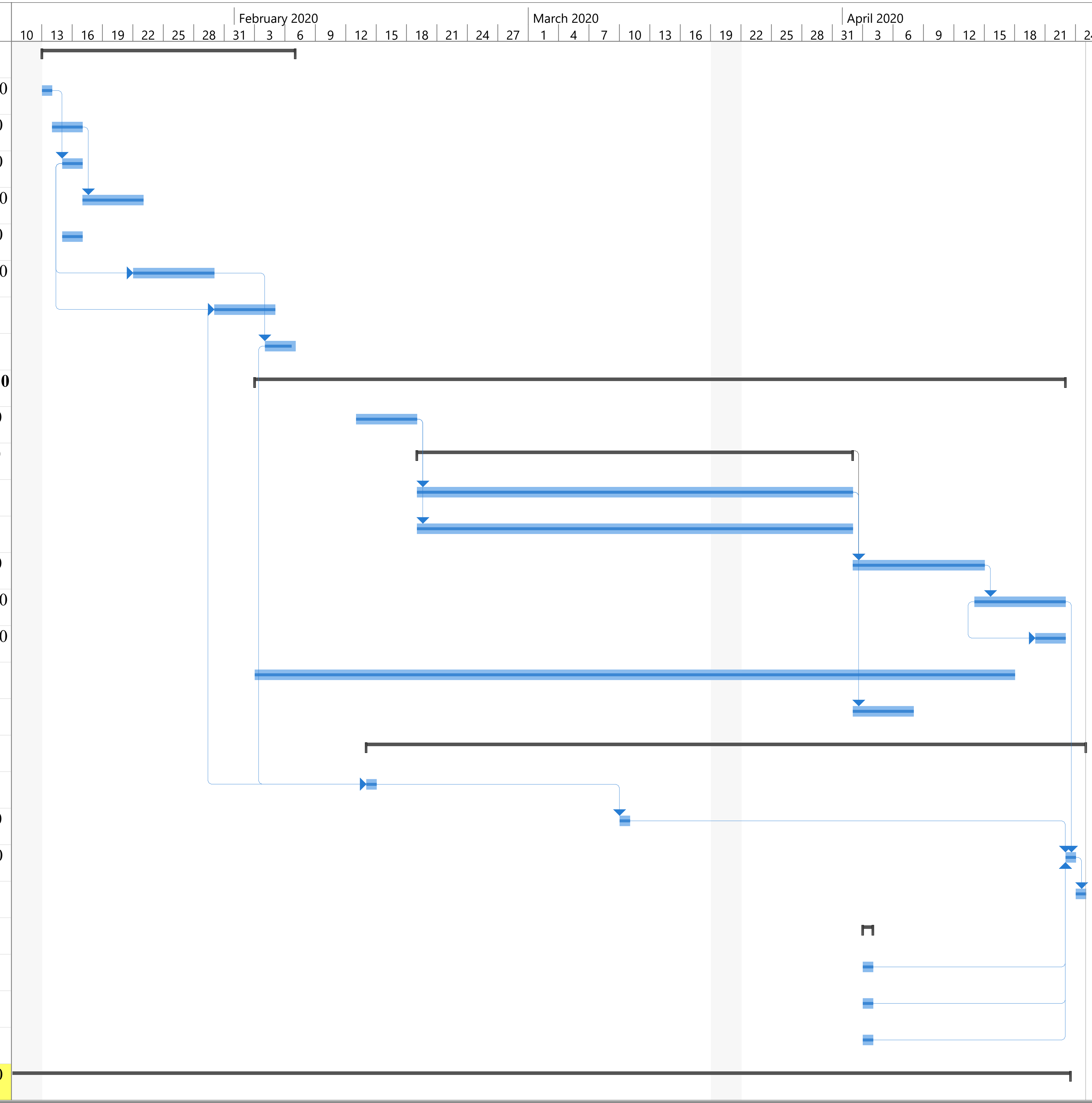
$N = Number\ of\ Lanes.$

$g = Effective\ Green\ Time.$

$C = Cycle\ Time.$

Appendix G: Updated Project Schedule

ID	Task Name	Start	Finish
1	**Task 1: Existing Studies**	**Mon 1/13/20**	**Thu 2/6/20**
2	1.1: Site Visit	Mon 1/13/20	Mon 1/13/20
3	1.2: Process Survey Data from GIS	Tue 1/14/20	Thu 1/16/20
4	1.3: Studying/Analyzing Existing Drainage Studies/As-Built Infc	Wed 1/15/20	Thu 1/16/20
5	1.4: Runoff Calculations	Fri 1/17/20	Wed 1/22/20
6	1.5: Analyze Existing Geotechnical Information	Wed 1/15/20	Thu 1/16/20
7	1.6: Enter Existing Geometry into Civil3D	Wed 1/22/20	Wed 1/29/20
8	1.7: Create Existing Cross-Sections	Thu 1/30/20	Tue 2/4/20
9	1.8: Create Roadway Alignments/Base Files	Tue 2/4/20	Thu 2/6/20
10	**Task 2: Design**	**Mon 2/3/20**	**Wed 4/22/20**
11	2.1: Create Proposed Cross-Sections	Thu 2/13/20	Tue 2/18/20
12	**2.2: Initial Design**	**Wed 2/19/20**	**Wed 4/1/20**
13	2.2.1: Intersection Design	Wed 2/19/20	Wed 4/1/20
14	2.2.1: On-Ramp Design	Wed 2/19/20	Wed 4/1/20
15	2.4: Final Design Geometry/Cross-Sections	Thu 4/2/20	Tue 4/14/20
16	2.5: Final Drainage Design	Tue 4/14/20	Wed 4/22/20
17	2.6: Stormwater Pollution Prevention Control Plan	Mon 4/20/20	Wed 4/22/20
18	2.7: Construction Plan Set	Mon 2/3/20	Fri 4/17/20
19	2.8 Synchro Analysis and Traffic Analysis Recommendation	Thu 4/2/20	Tue 4/7/20
20	**Task 3: Deliverables**	**Fri 2/14/20**	**Fri 4/24/20**
21	3.1: 30% Submittal	Fri 2/14/20	Fri 2/14/20
22	3.2: 60% Submittal	Tue 3/10/20	Tue 3/10/20
23	3.3: 90% Submittal	Thu 4/23/20	Thu 4/23/20
24	3.4: Final Design Report	Fri 4/24/20	Fri 4/24/20
25	**Task 4: Impacts**	**Fri 4/3/20**	**Fri 4/3/20**
26	4.1: Social Impacts Assessment	Fri 4/3/20	Fri 4/3/20
27	4.2: Economic Impacts Assessment	Fri 4/3/20	Fri 4/3/20
28	4.3: Environmental Impacts Assessment	Fri 4/3/20	Fri 4/3/20
29	Task 5 Project Management	Mon 12/16/1	Thu 4/23/20



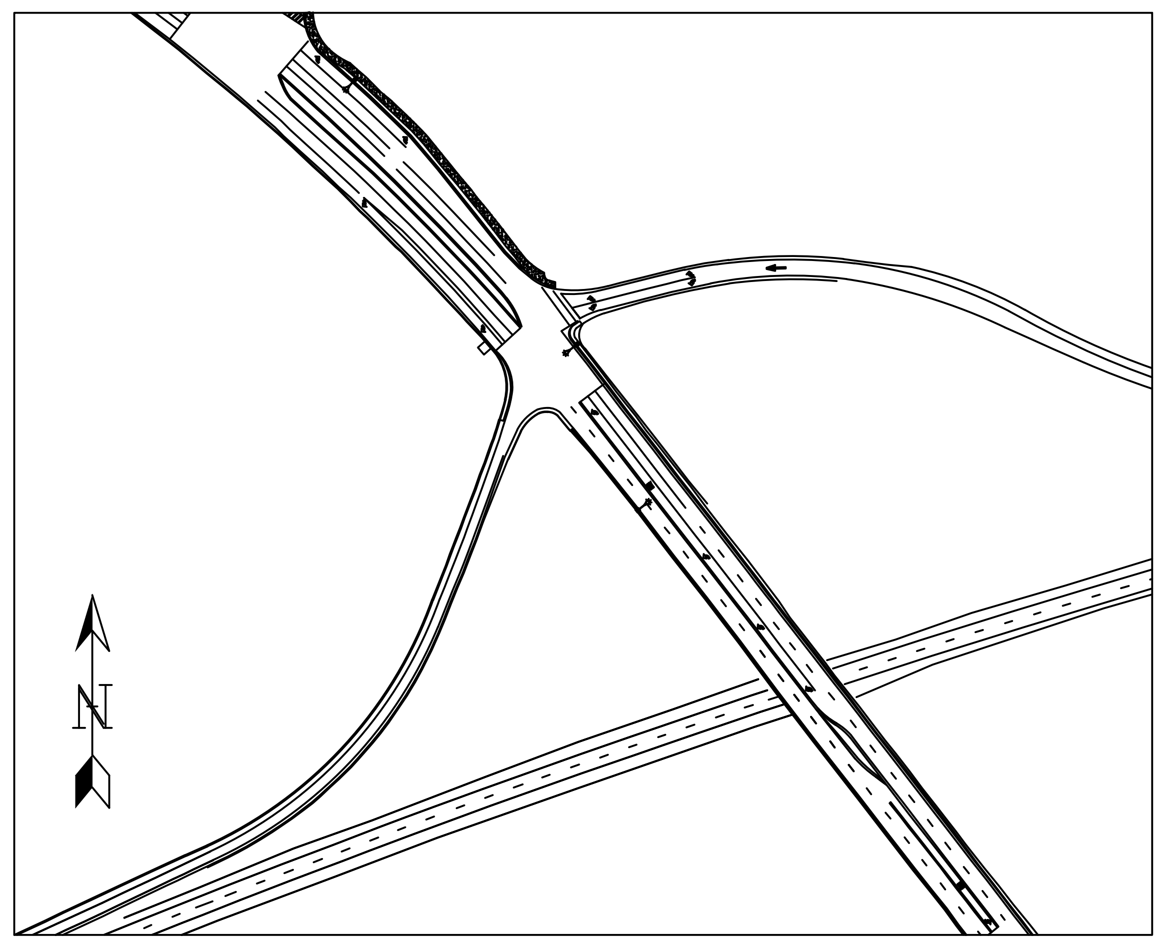
Appendix H: Construction Plan Set

ON-RAMP WIDENING PROJECT

SR 89 - INTERSTATE 40 HIGHWAY
COUNTRY CLUB DRIVE NESTLE PURINA - HIGHWAY ENTRANCE

ARIZONA DEPARTMENT OF TRANSPORTATION
INTERMODAL TRANSPORTATION DIVISION

★ PROJECT LOCATION
COUNTY NAME: COCONINO
LENGTH OF PROJECT: 0.27 MILES
ADOT DISTRICT: NORTHEAST
DRAWING NUMBER: 6842976



PROJECT SITE MAP

SHEET LIST

General Notes

1. Roadway plans have been designed utilizing the Construction Standard Drawing (C-Series). Refer to the 1A sheet of a listing of current revision dates.

2. Right-of-Way markers shall be furnished and placed by ADOT Right of Way Plans Section forces.

3. The project roadway shall be striped by the contractor in accordance with the current edition of the Signing and Marking Standard Drawings (M and S-Series) and the pavement marking plans.

4. The project roadway shall be striped by the contractor in accordance with the current edition of the Signing and Marking Standard Drawings (M and S-Series).

5. For Right-of-Way information not shown, see Right of Way Project No 6842976.

6. Bench markers will be furnished by the state and shall be placed by the contractor: Std C-21.20.

7. Pavement lift thickness is nominal

8. WHERE ONLY THE HORIZONTAL LOCATION OF AN EXISTING UTILITY IS SHOWN, THE LOCATION IS APPROXIMATE. WHERE BOTH THE HORIZONTAL AND VERTICAL LOCATION OF AN EXISTING UTILITY IS SHOWN, THE LOCATION HAS BEEN VERIFIED BY FIELD SURVEY METHODS. THE CONTRACTOR SHALL COMPLY WITH ALL CURRENT BLUE STAKE LAWS AND SECTION 107.15 OF THE SPECIFICATIONS.

9. DELINEATORS, OBJECT MARKERS AND MILE POST MARKERS SHALL BE REMOVED AND RESET AS REQUIRED.

10. THE AVERAGE PROJECT ELEVATION IS 6812.5 ft.

11. NEW RIGHT OF WAY AND EASEMENTS ARE NOT REQUIRED.

12. CHANGES IN LOCATION OR LENGTH OF SPILLWAY OR DOWNDRAIN INSTALLATION MAY BE MADE BY THE ENGINEER TO IMPROVE DRAINAGE CONDITIONS.

13. SURVEY MONUMENTS IN THE MEDIAN MUST NOT BE DISTURBED.

14. SLOPE ROUNDING SHALL BE APPLIED PER STANDARD C-02 SERIES UNLESS OTHERWISE NOTED.

15. RIGHT OF WAY IS NOT REQUIRED. SPECIFIC USE EASEMENTS ARE REQUIRED: SEE PLANS.

16. THE PAVEMENT SHOULDERS SHALL BE TREATED WITH A RUMBLE STRIP: SEE TRAFFIC SHEETS.

DATE	05/05/20
REV 1:	
REV 2:	
	I-40/CC IMPROVEMENT PROJECT
LOCATION	FLAGSTAFF, AZ
DESIGN	N/A
DRAWN	ZJ
CHECK	MT
SHEET TITLE	GN01
NO.	02 OF 27

LINE TYPES

= CENTER LINE
= EDGE LINE
= EX BOC
= EX CONTOUR
= EX EOP
= EX GUARD RAIL
= EX GUTTER
= EX RETAINING WALL
= EX STORM PIPE
= PROP BOC
= PROP CONTOUR
= PROP EOP
= PROP GUARD RAIL
= PROP GUTTER
= PROP RETAINING WALL
= PROP STORM PIPE
= SAW CUT
= WATTLE

HATCHING TYPES

= PCCP
= PROPOSED PVMT
= AB
= AC
= TACK COAT
= AR-ACFC
= EARTH

SYMBOLS

= CATCH BASIN

= LIGHT POLE

ABBREVIATIONS

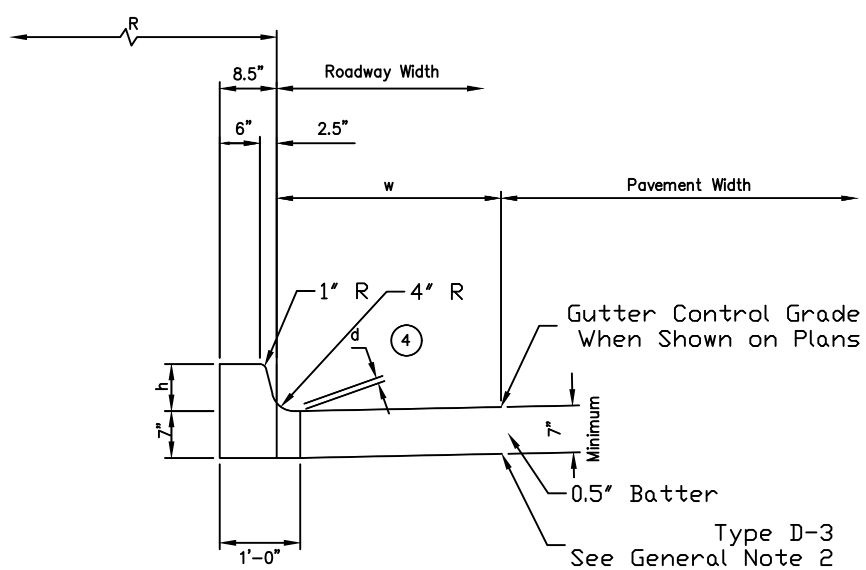
AB = AGGREGATE BASE
ABC = AGGREGATE BASE COARSE
AC = ASPHALTIC CONCRETE
ADOT = ARIZONA DEPARTMENT OF TRANSPORTATION
AR-ARCF = ASPHALT RUBBER-ASPHALT CONCRETE FRICTION COARSE
BOC = BACK OF CURB
CC = COUNTRY CLUB
℄ = CENTERLINE
CL = CENTERLINE
CMP = CORRUGATED METAL PIPE
CONC. = CONCRETE
D = DIAMETER
DTL = DETAIL
DWG = DRAWING
EA = EACH
EL = EDGE LINE
EL = EDGE LINE
ELEV = ELEVATION
EOP = EDGE OF PAVEMENT
EX = EXISTING
GRD = GRADE
INV = INVERT
LF = LINEAR FEET
MIN = MINIMUM
MAX = MAXIMUM
NO. = NUMBER
PCCP = PORTLAND CEMENT CONCRETE PAVEMENT
PROP = PROPOSED
PVMT = PAVEMENT
R = RADIUS
RCBC = REINFORCED CONCRETE BOX CULVERT
SR = STATE ROUTE
STA = STATION
STD =STANDARD
SY = SQUARE YARD
THRU = THRU
TYP. = TYPICAL
W = WIDTH

DATE 05/05/20
REV 1:
REV 2:

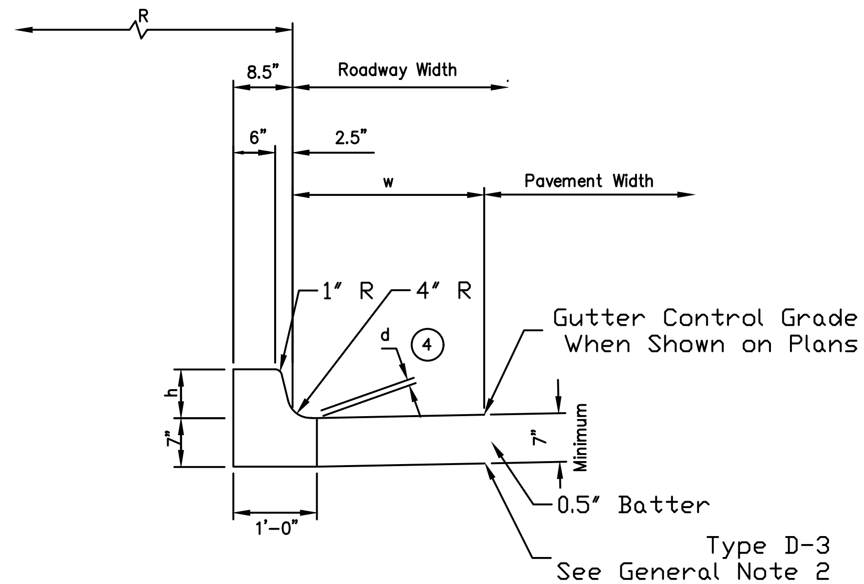
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	
DRAWN	MT	IX01	
CHECK	ZJ	NO. 03	OF 27



ADOT STD DTL C-5.10
TYPE D-1, H=7″



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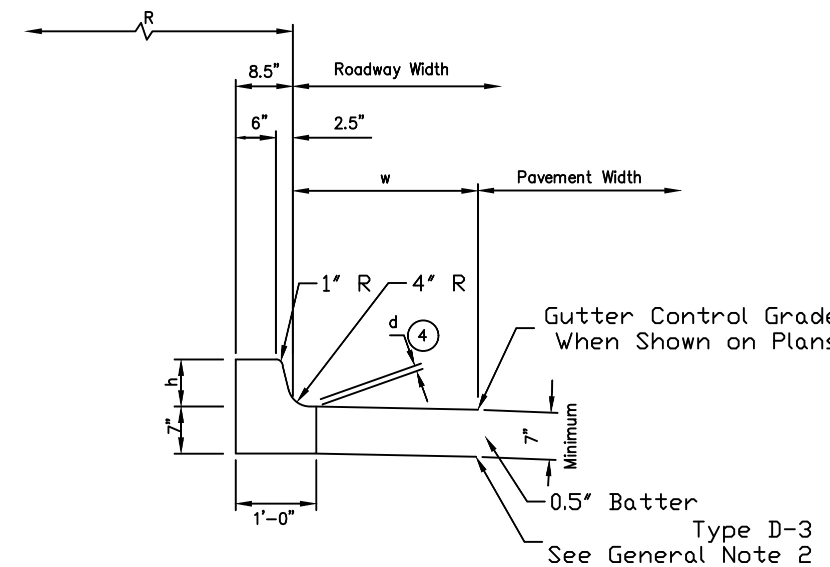
TYPE D, H=7″



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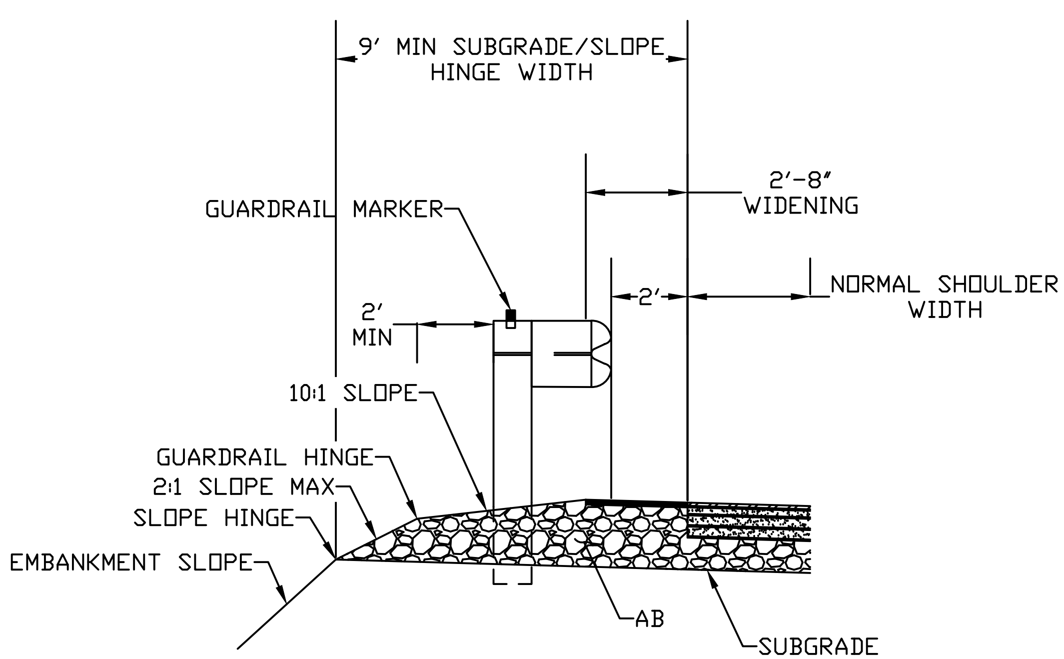
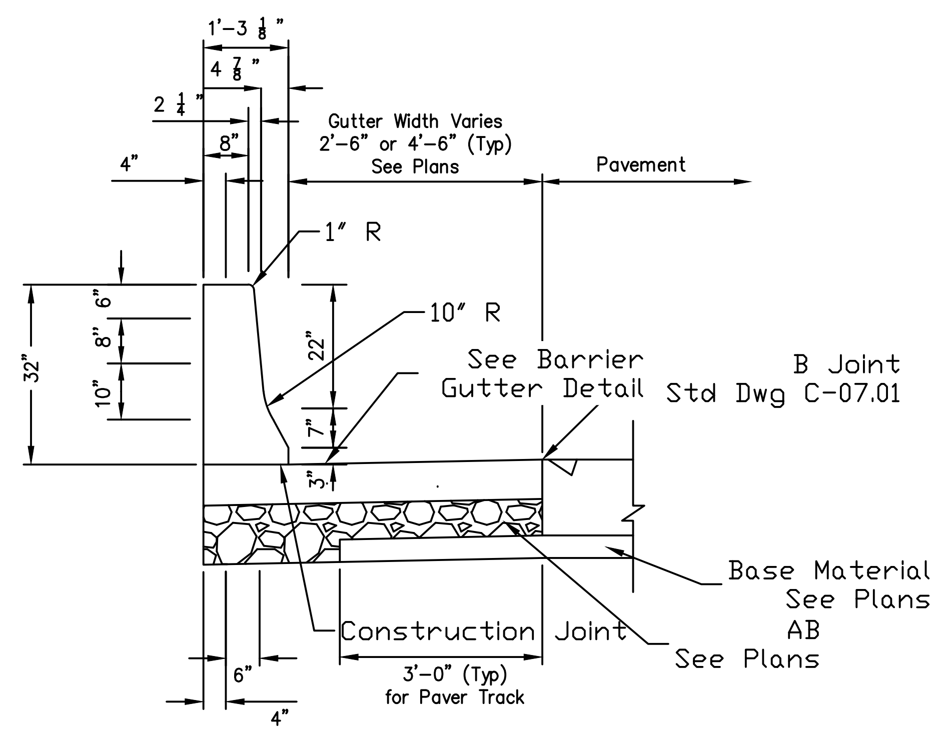


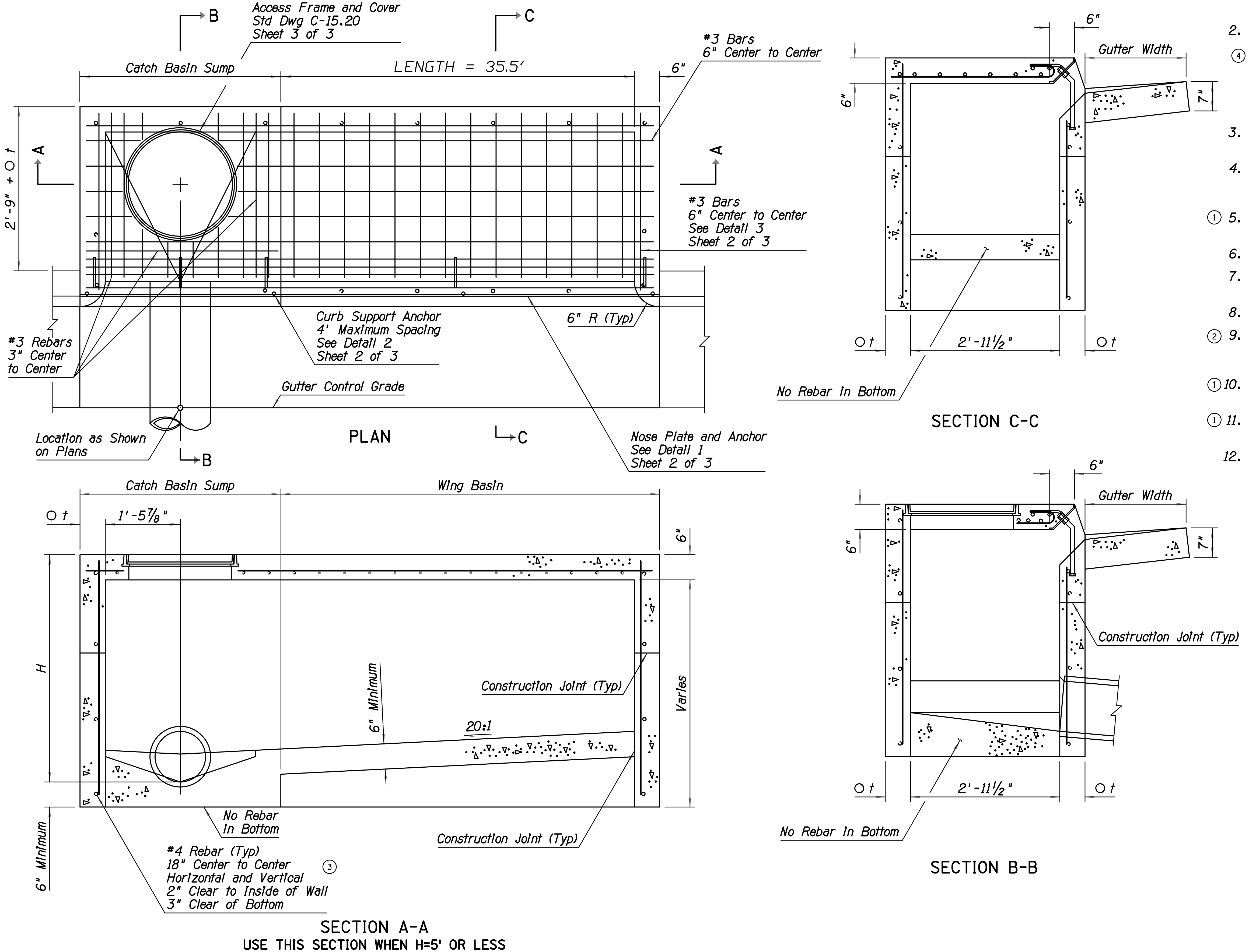
ADOT STD DTL
C-10.01
NO EMBANKMENT CURB
GUARDRAIL



ADOT STD DTL C-10.52
TYPE F, GUTTER = 2.5′

CONCRETE HALF BARRIER

DATE	05/05/20
REV 1:	
REV 2:	
	I-40/CC IMPROVEMENT PROJECT
LOCATION	FLAGSTAFF, AZ
DESIGN	ADOT
DRAWN	MT
CHECK	ZJ
SHEET TITLE	DT01
NO.	04 OF 27



GENERAL NOTES

1. Catch basin can be used on grade or at roadway sag.
2. Catch basin has three configurations:
   - (4) Sump Only-Sump portion of catch basin (See Detail 4, Sheet 2 of 3).
   - Single Wing (Illustrated)-Sump with wing basin upstream.
   - Double Wing-Sump with symetrical wing basins each side.
3. Pipes can be placed in any wall except wall adjacent to wing basin.
4. Floor shall be a wood troweled finish. Slope of the sump portion of the catch basin along the axis of the pipe shall be 4:1.
5. (1) Any specified inlet depression shall be warped to opening according to Std Dwg C-15.70.
6. All rebar shall be ASTM A36.
7. Nose plate, access frame and cover shall be given one shop coat of Number 1 paint.
8. All concrete shall be Class B.
9. (2) Curb opening area (sq ft) per inch of curb "h" + gutter depression = curb opening length (ft) x 0.0833.
10. (1) All welding shall be in accordance with Std Spec 604-3.06.
11. (1) Construction joints and drains shall be placed to meet field conditions. See Std Dwg C-15.70.
12. O t = 6" when H is 8' or less. 8" when H is greater than 8'.

DATE	05/05/20
REV 1:	
REV 2:	
	I-40/CC IMPROVEMENT PROJECT
LOCATION	FLAGSTAFF, AZ
DESIGN	ADOT
DRAWN	RL
CHECK	MT
SCALE	NTS
SHEET TITLE	DT02
NO.	05 OF 27

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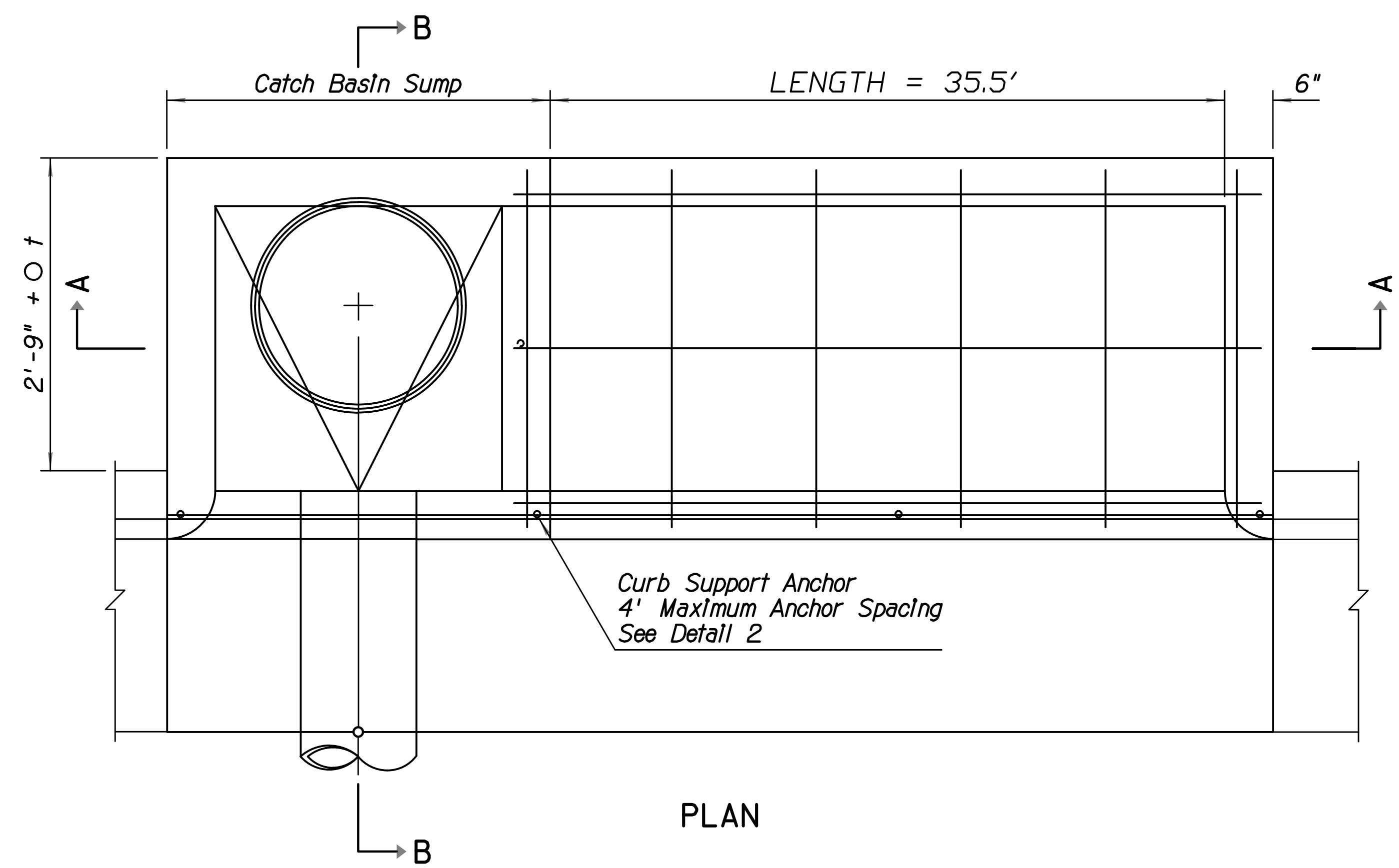
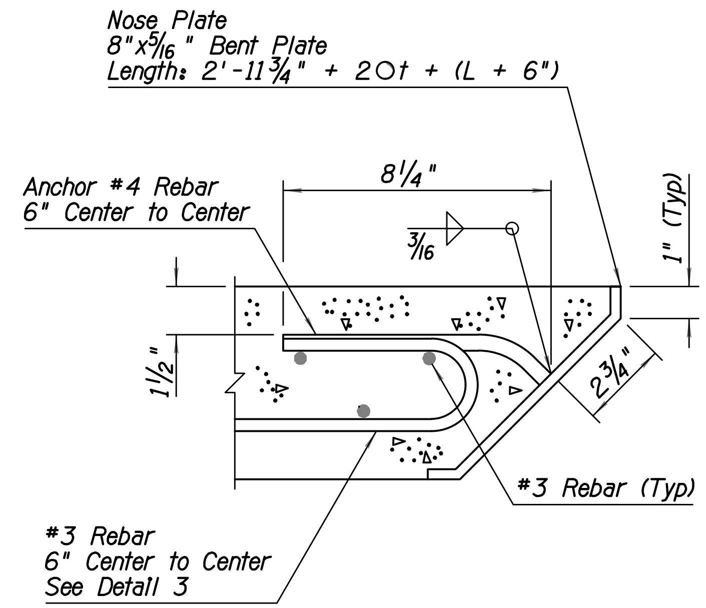
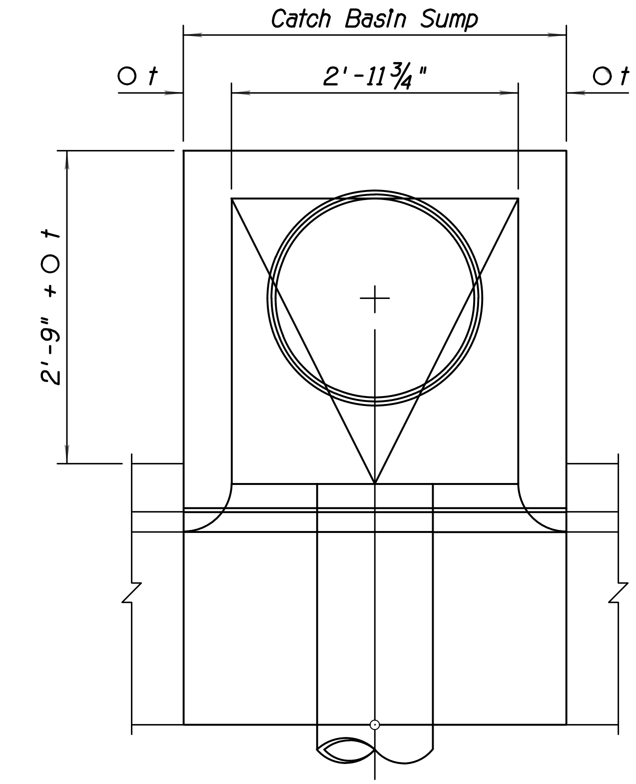


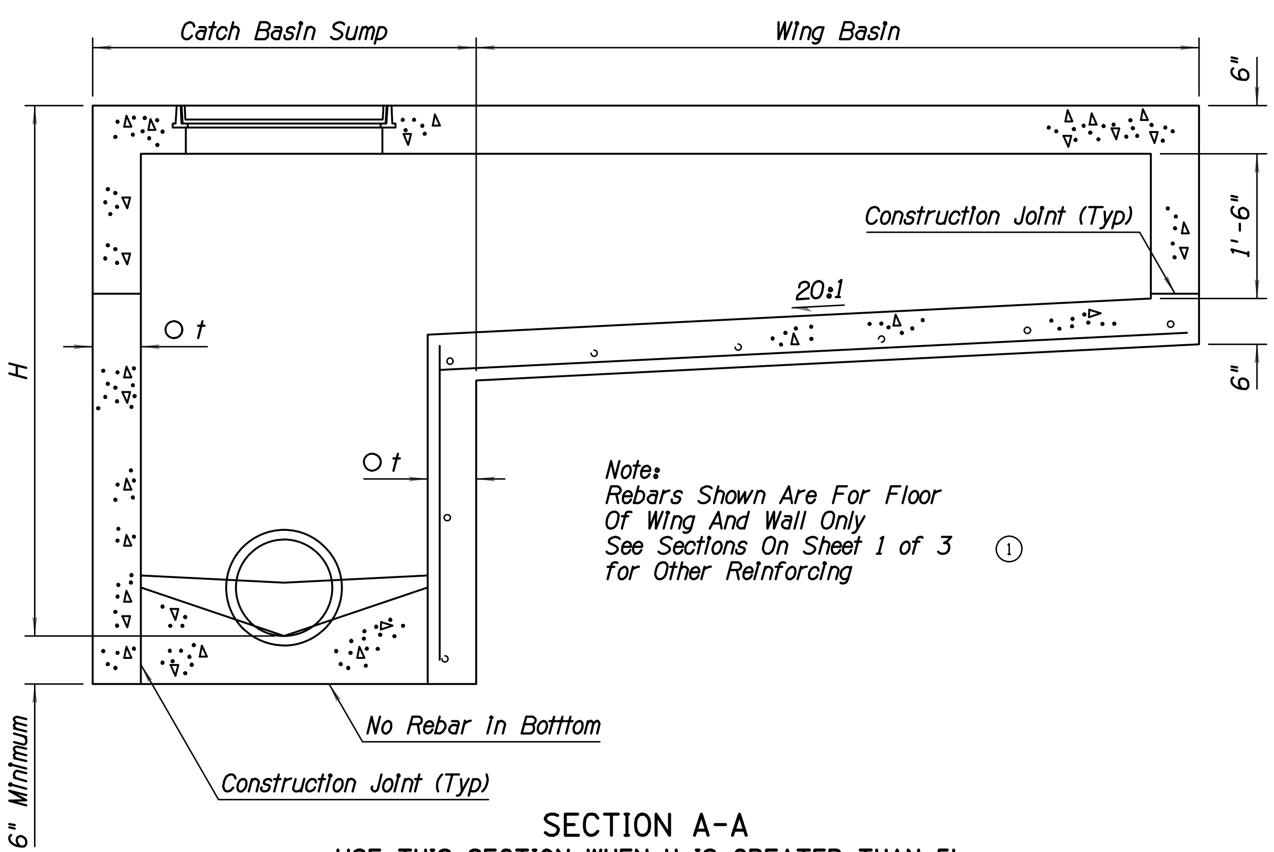
PLAN



DETAIL 1

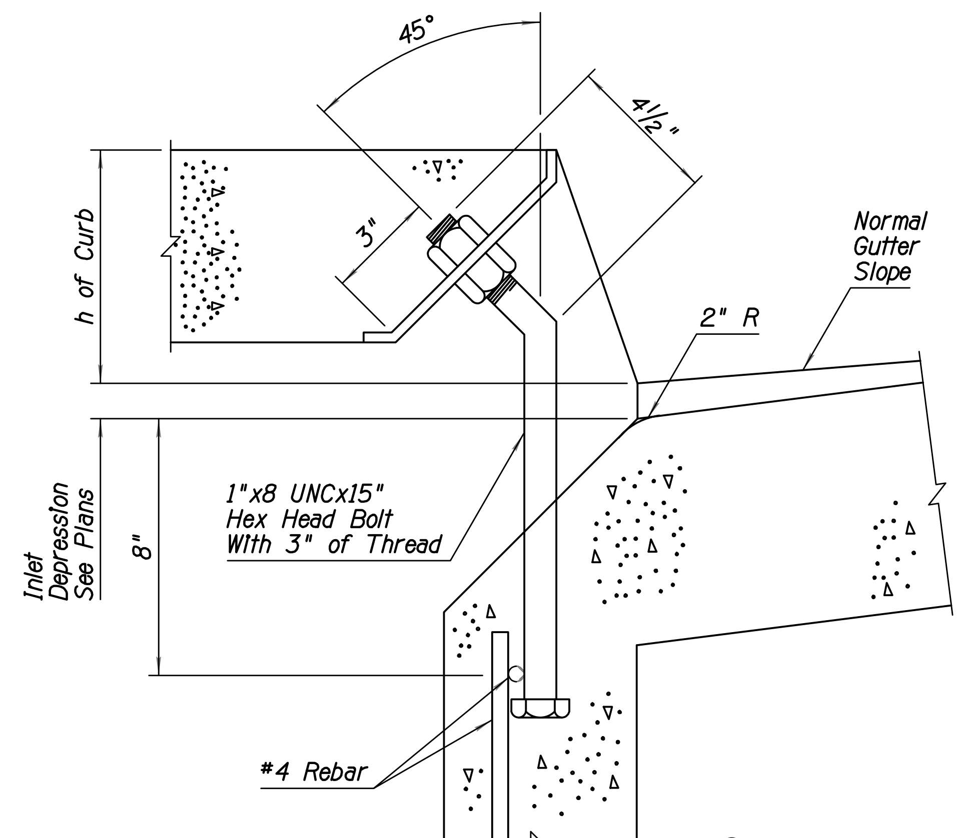


DETAIL 4



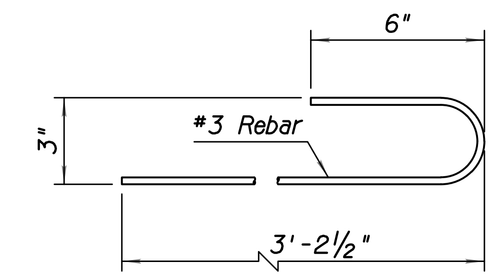
SECTION A-A

USE THIS SECTION WHEN H IS GREATER THAN 5'



DETAIL 2

CURB SUPPORT ANCHOR



DETAIL 3

GENERAL NOTES

① 1. See Sheet 1 of 3 for other dimensions, notes and rebar.

2. ⌀t = 6" when H is 8' or less
8" when H is greater than 8'

DATE	05/05/20
REV 1:	
REV 2:	

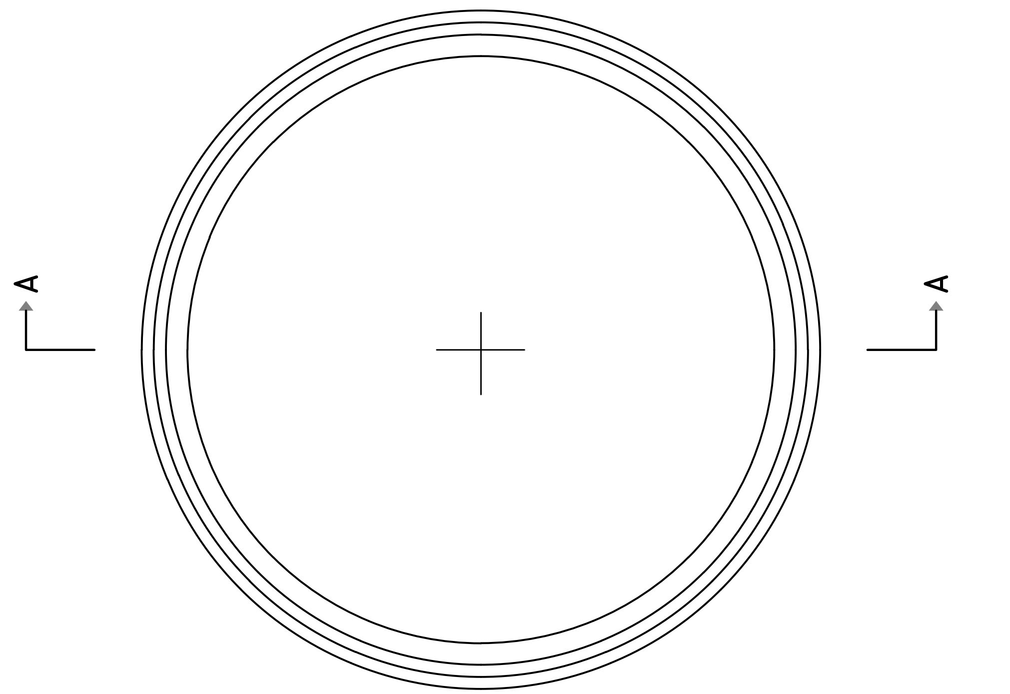
I-40/CC IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

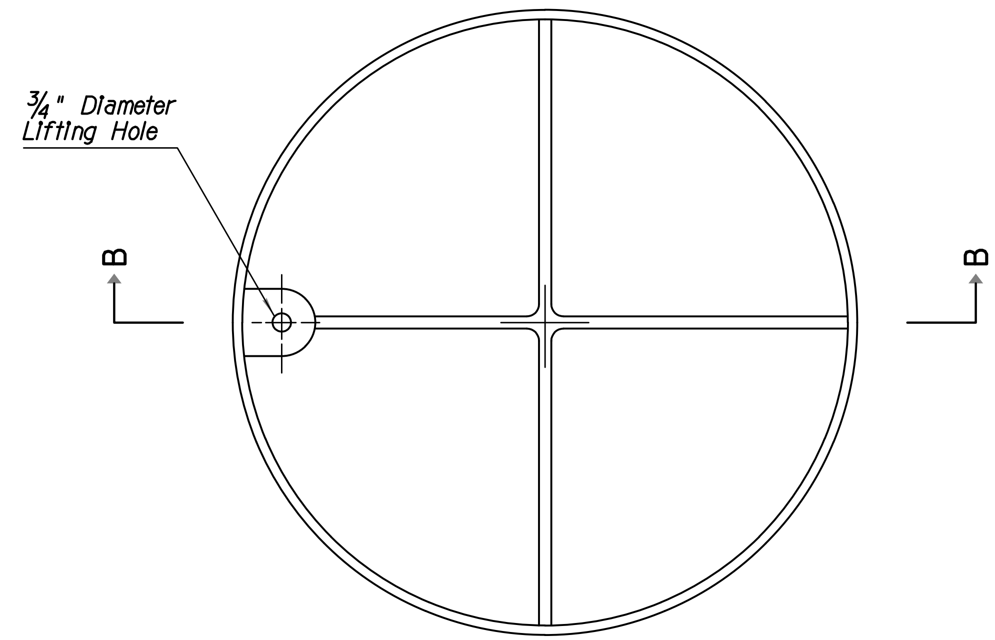
SCALE	NTS		
DESIGN	ADOT	SHEET TITLE	
DRAWN	RL		DT03
CHECK	MT	NO. 06	OF 27

GENERAL NOTES

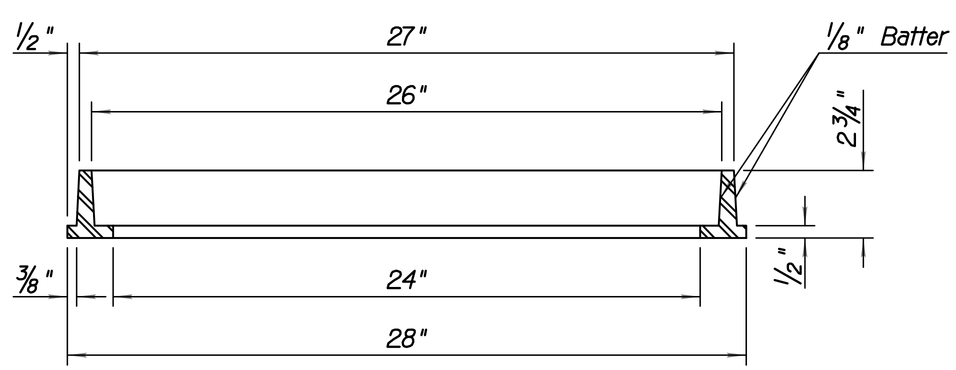
1. *Cover shall be non-locking.*
2. *Frame and cover shall be cast iron or structural steel.*
3. *Catch basin access frame and cover is for use in sidewalk area only.*
4. *Cover shall be filled with concrete and broom finished.*



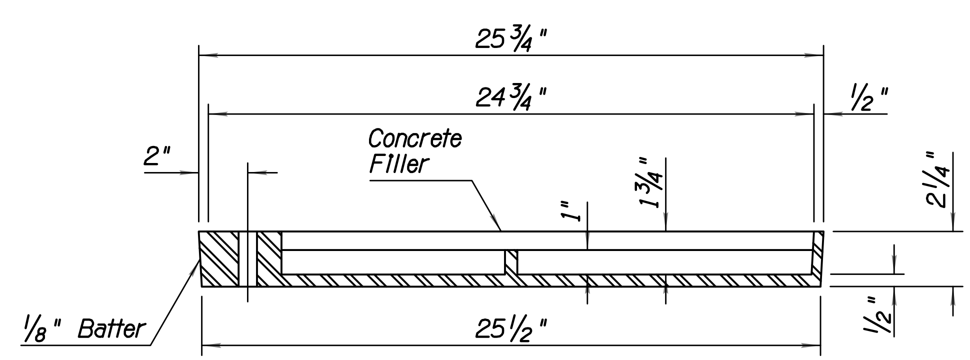
PLAN



PLAN

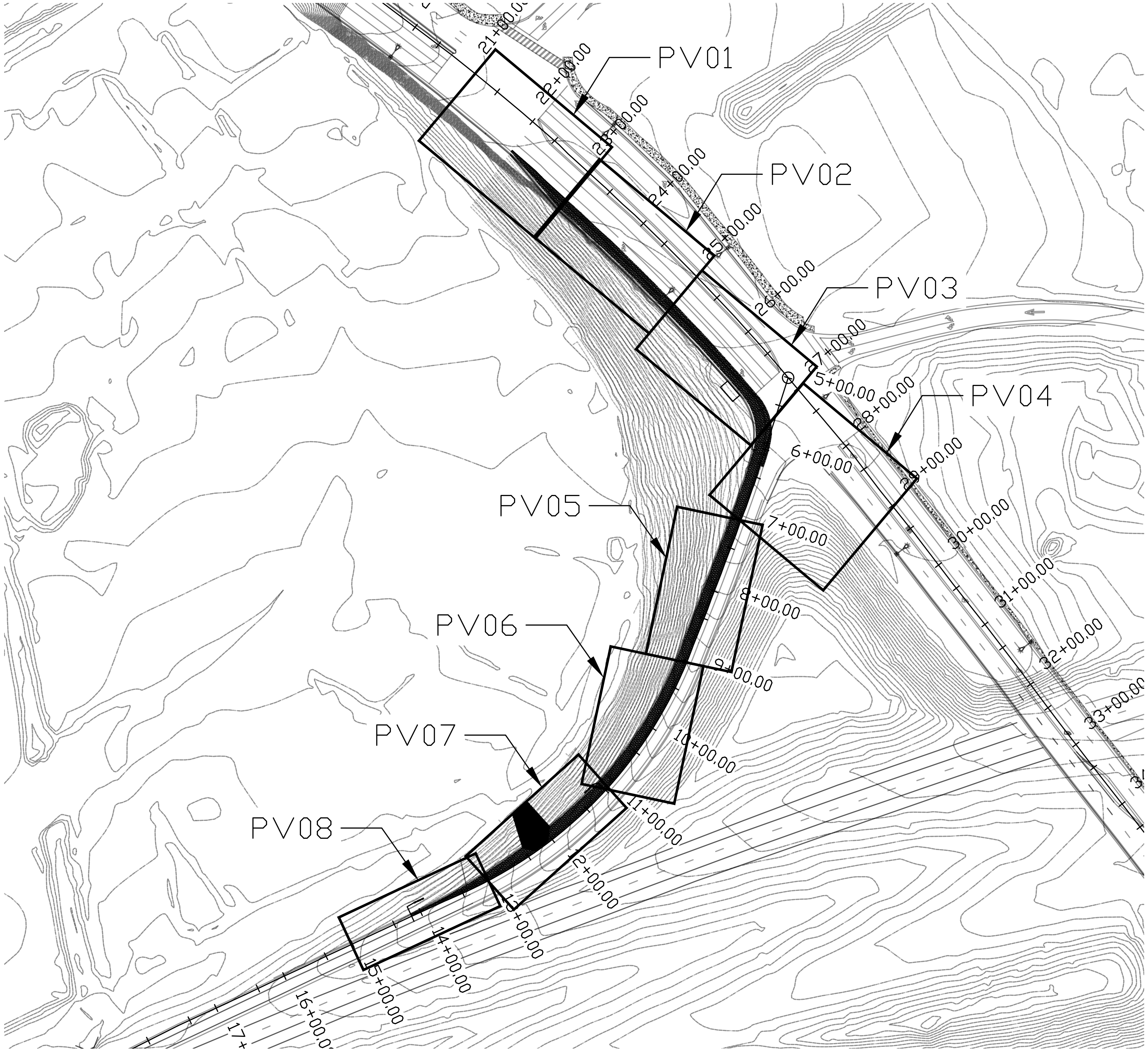


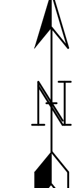
SECTION A-A
FRAME

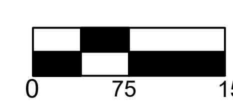


SECTION B-B
COVER

DATE	05/05/20
REV 1:	
REV 2:	
	I-40/CC IMPROVEMENT PROJECT
LOCATION	FLAGSTAFF, AZ
DESIGN	ADOT
DRAWN	RL
CHECK	MT
SCALE	NTS
SHEET TITLE	DT04
NO.	07 OF 27







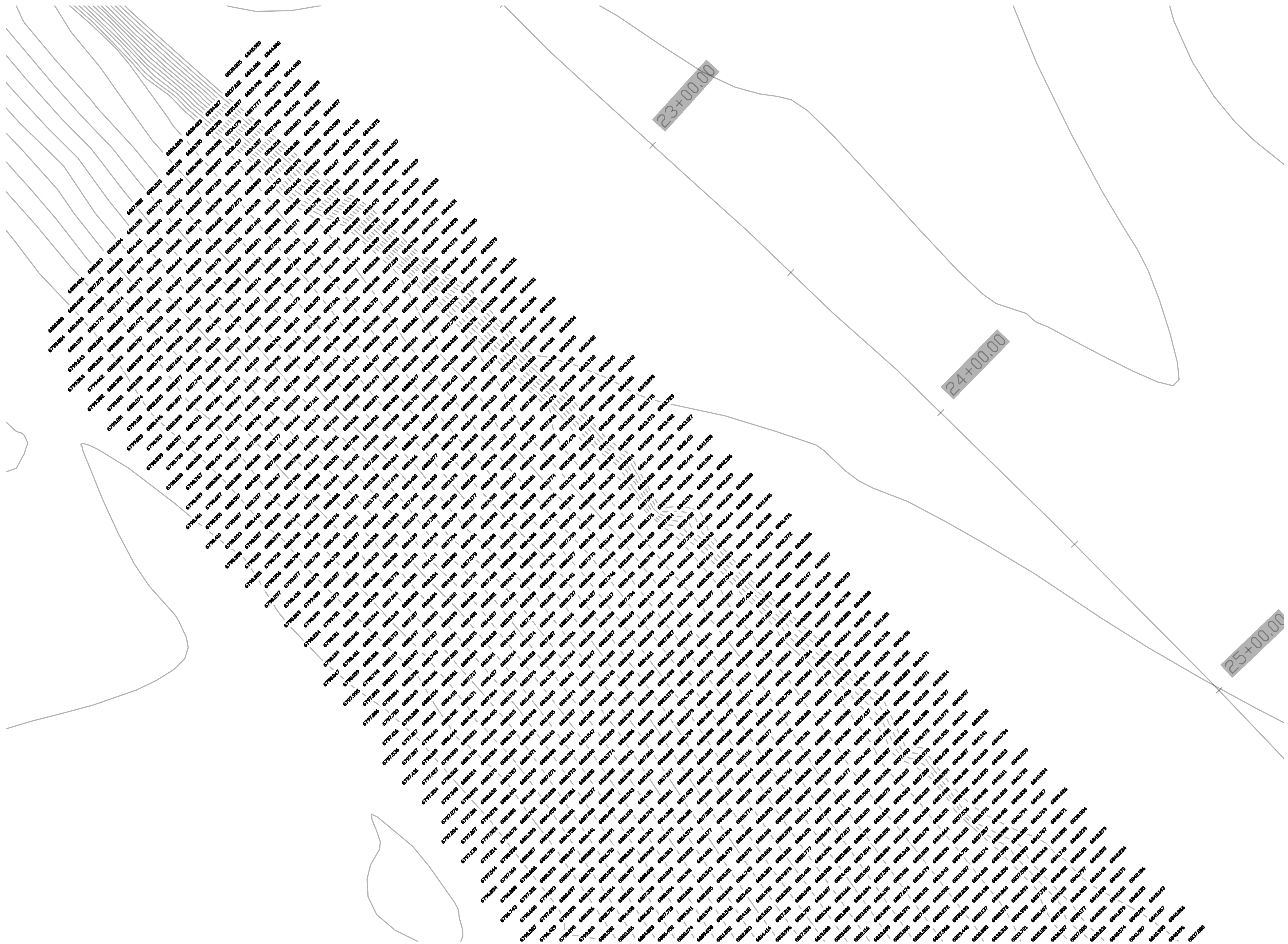
DATE	05/05/20
REV 1:	
REV 2:	

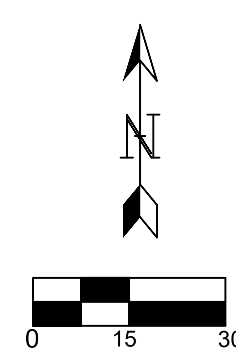
I-40/CC
IMPROVEMENT PROJECT

LOCATION
FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	
DRAWN	MT		OV01
CHECK	ZJ	NO. 08	OF 27

SCALE 1" = 150'





DATE 05/05/20

REV 1:

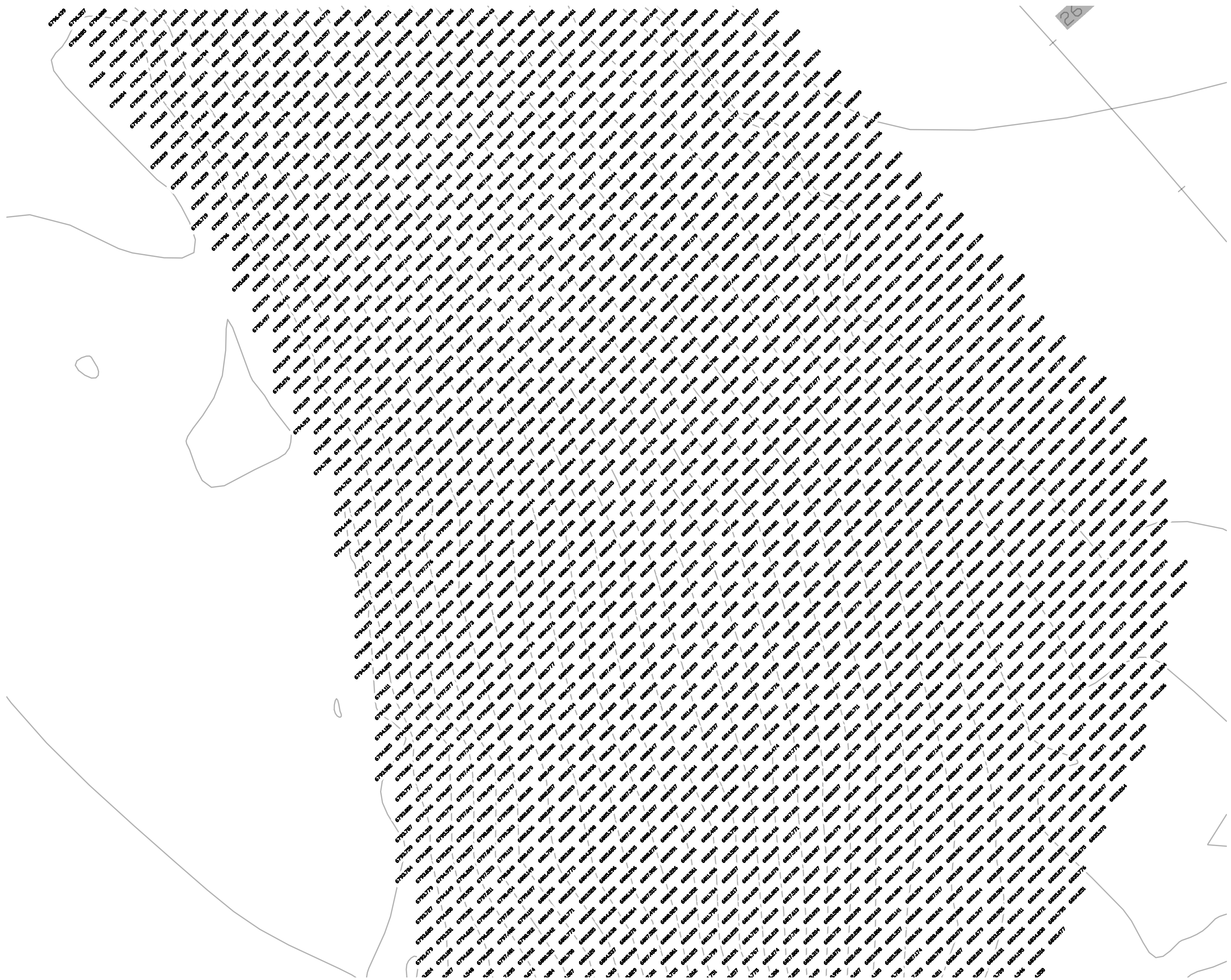
REV 2:

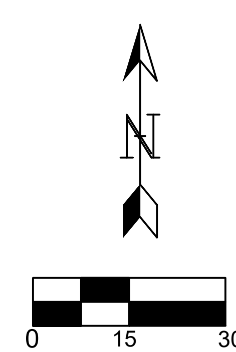
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	
DRAWN	MT	GR01	
CHECK	ZJ	NO. 09	OF 27

SCALE 1" = 30'





SCALE 1" = 30'

DATE 05/05/20

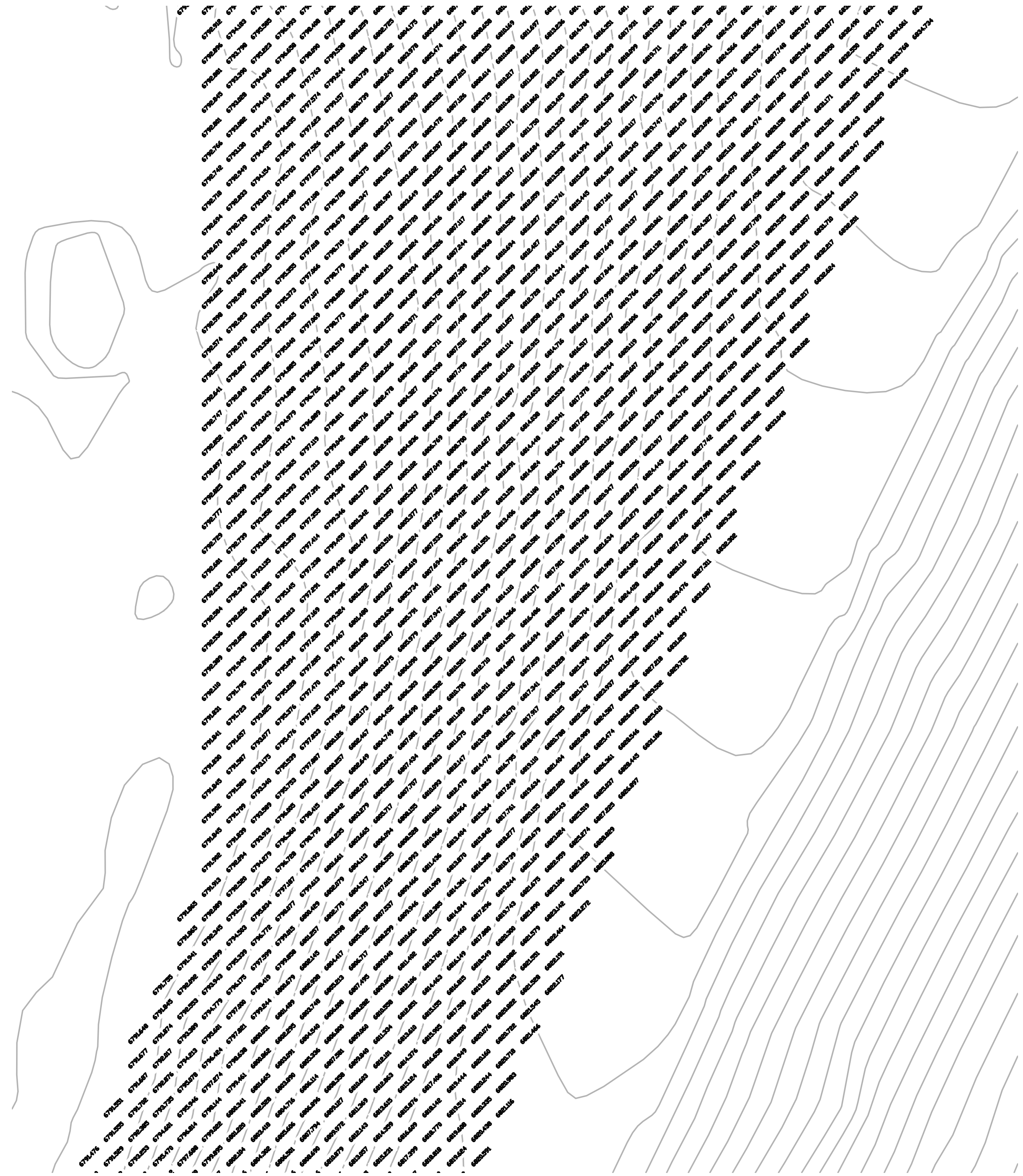
REV 1:

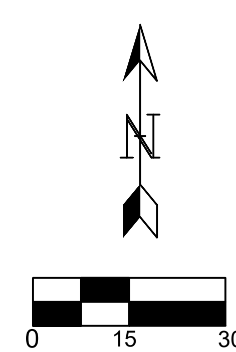
REV 2:

I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	GR02
DRAWN	MT		
CHECK	ZJ	NO. 10	OF 27





DATE	05/05/20
REV 1:	
REV 2:	

I-40/CC
IMPROVEMENT PROJECT

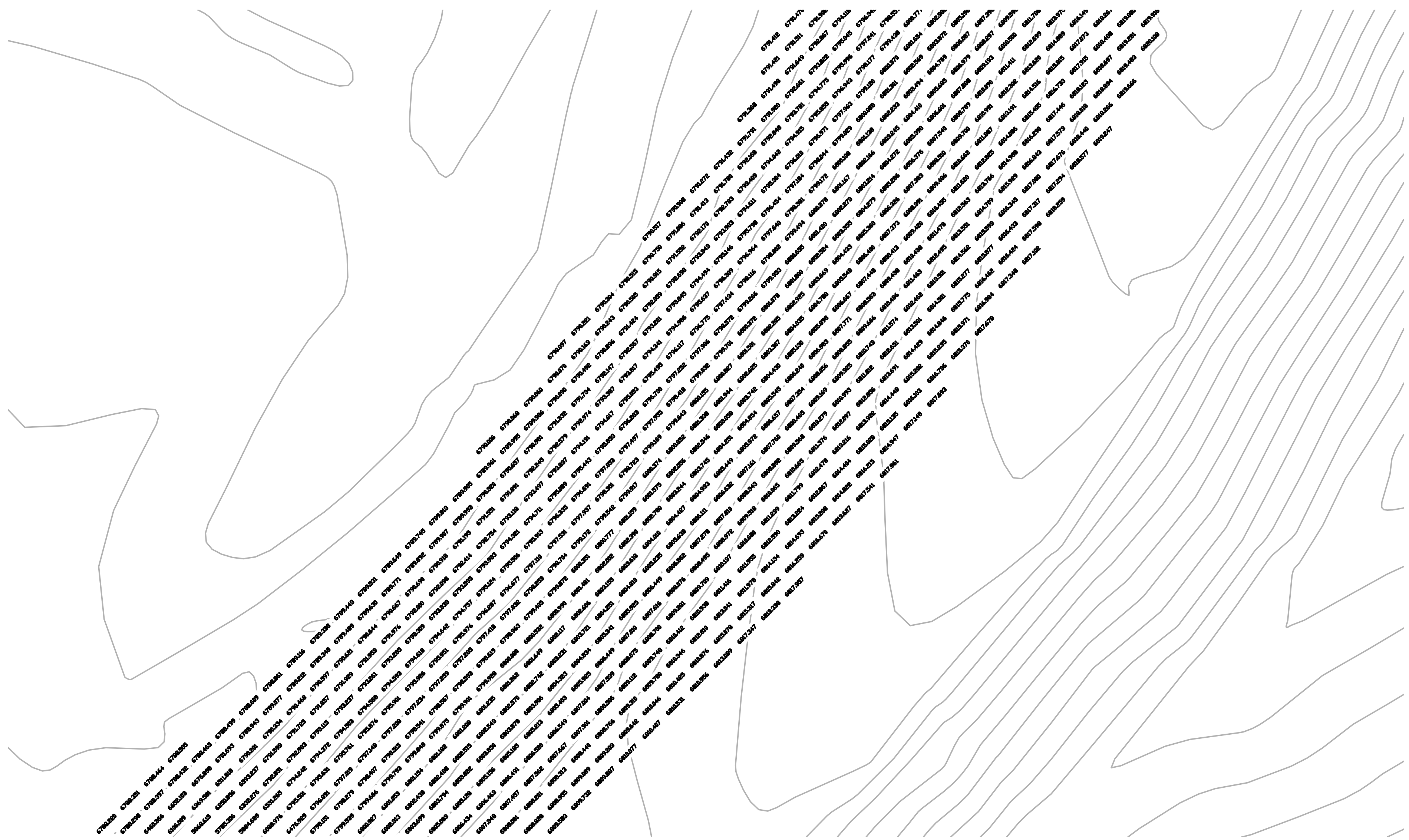
LOCATION
FLAGSTAFF, AZ

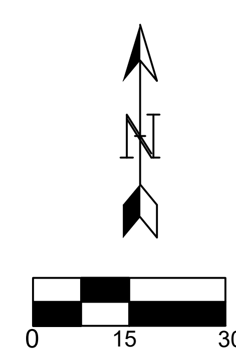
DESIGN	MT
DRAWN	MT
CHECK	ZJ

SHEET TITLE
GR03

NO. 11 OF 27

SCALE 1" = 30'





SCALE 1" = 30'

DATE 05/05/20

REV 1:

REV 2:

I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

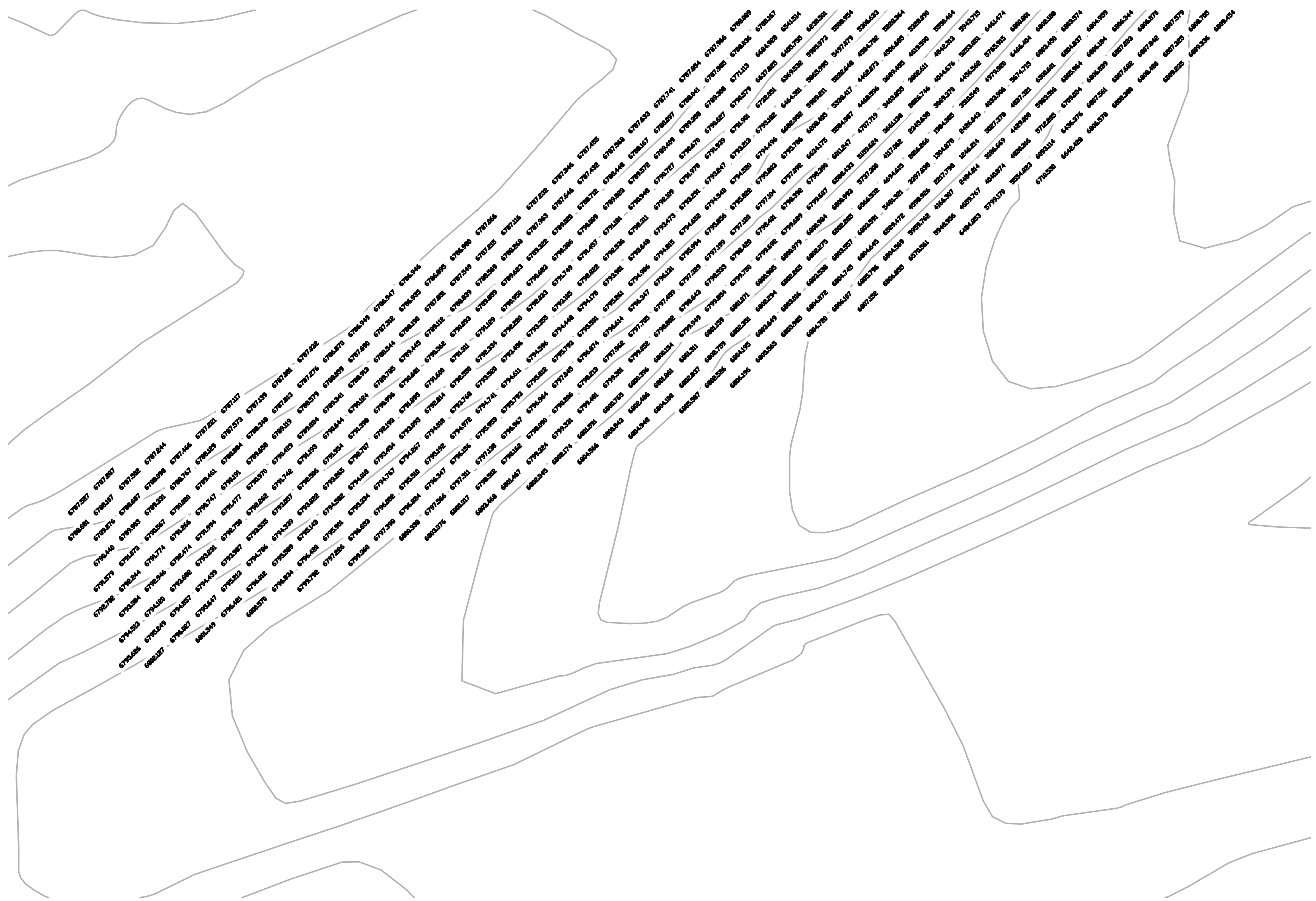
DESIGN MT

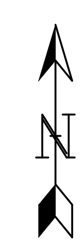
DRAWN MT

CHECK ZJ

SHEET TITLE GR04

NO. 12 OF 27





SCALE 1" = 30'

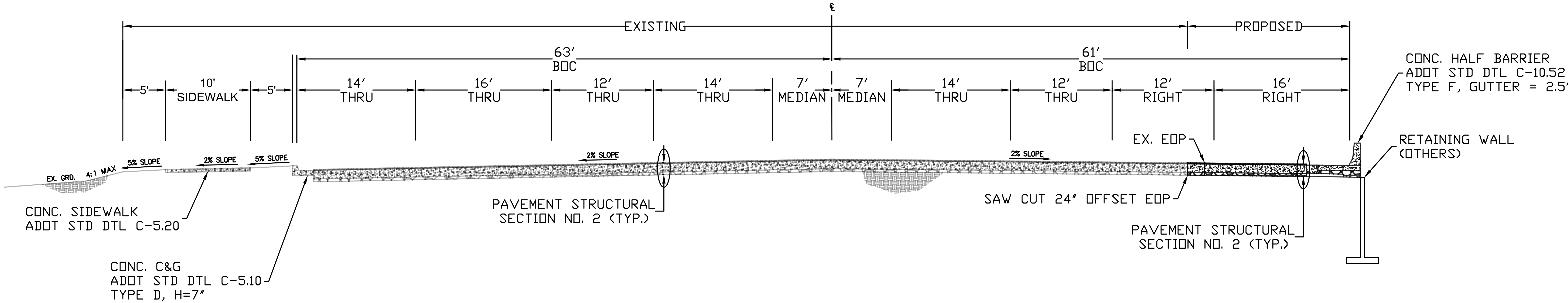
DATE	05/05/20
REV 1:	
REV 2:	

I-40/CC
IMPROVEMENT PROJECT

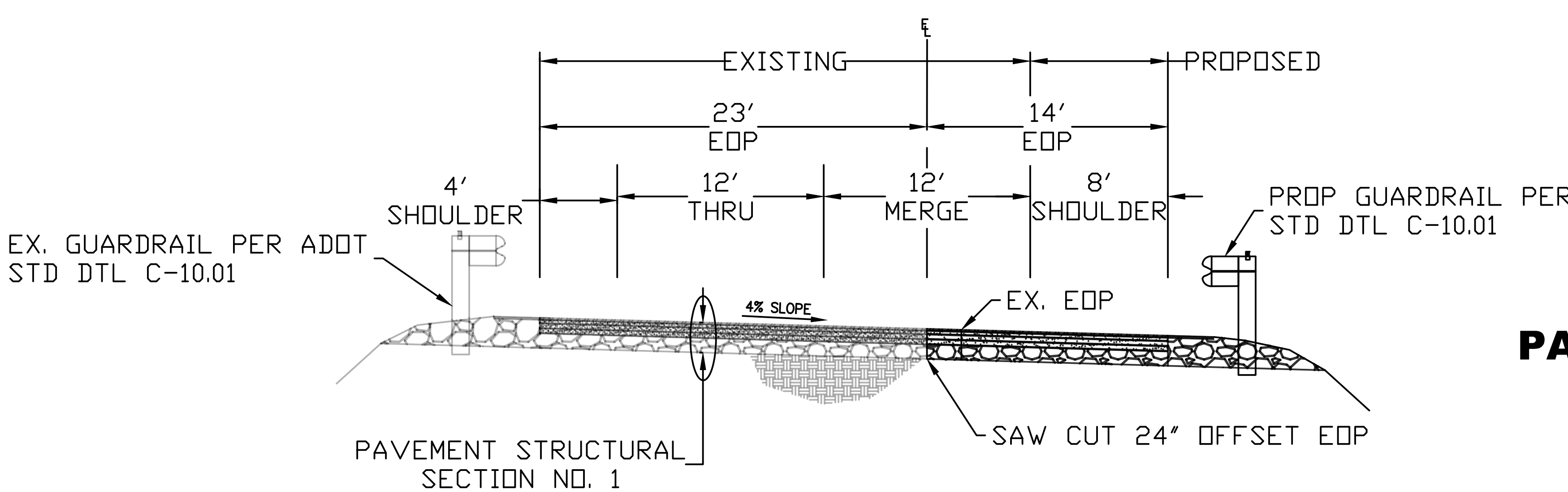
LOCATION
FLAGSTAFF, AZ

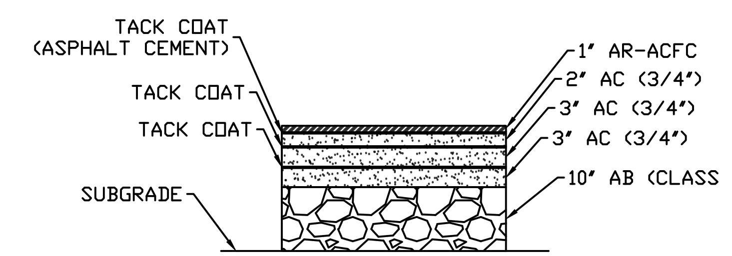
DESIGN	MT	SHEET TITLE	GR05
DRAWN	MT		
CHECK	ZJ	NO. 13	OF 27

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

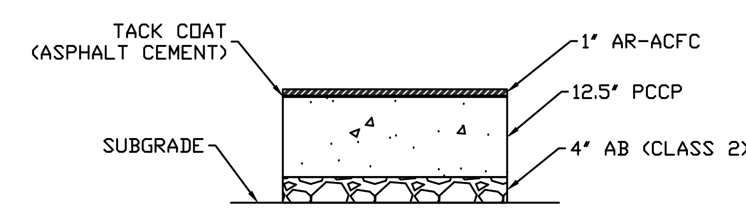


PROPOSED ROADWAY
STA 06+03.75 TO STA 11+03.44
I-40 WESTBOUND ON-RAMP





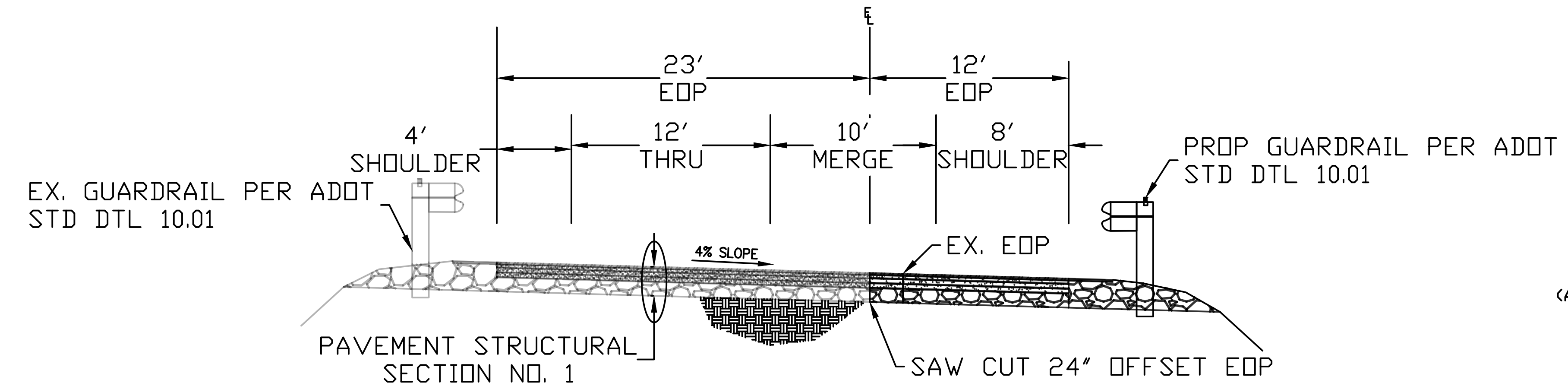
PAVEMENT STRUCTURAL SECTION NO. 1



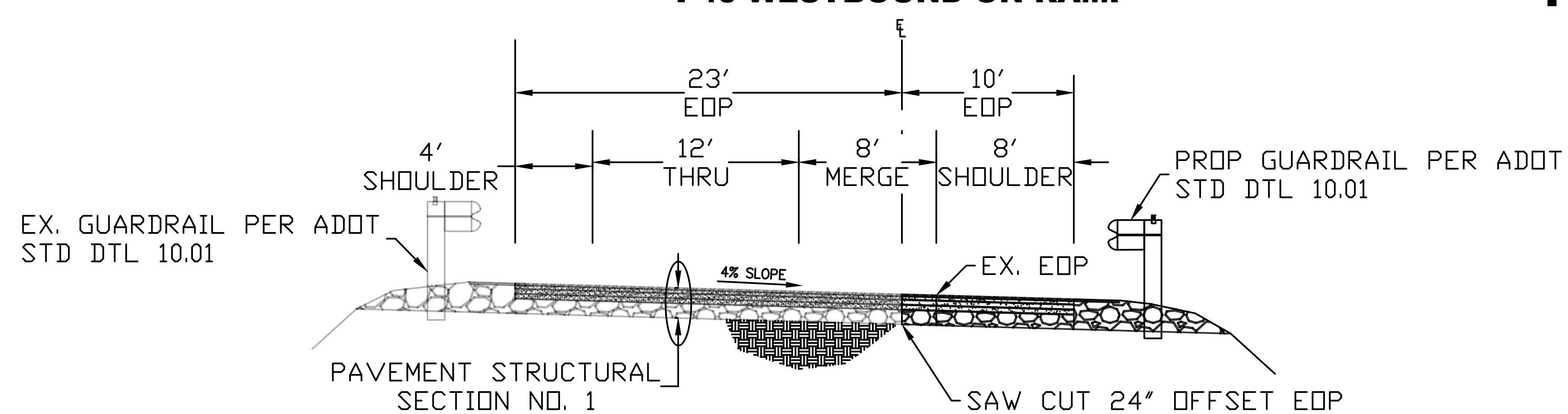
PAVEMENT STRUCTURAL SECTION NO. 2

DATE	05/05/20
REV 1:	
REV 2:	
PROJECT	I-40/CC IMPROVEMENT PROJECT
LOCATION	FLAGSTAFF, AZ
DESIGN	MT
DRAWN	MT
CHECK	ZJ
SHEET TITLE	TX01
NO.	14 OF 27

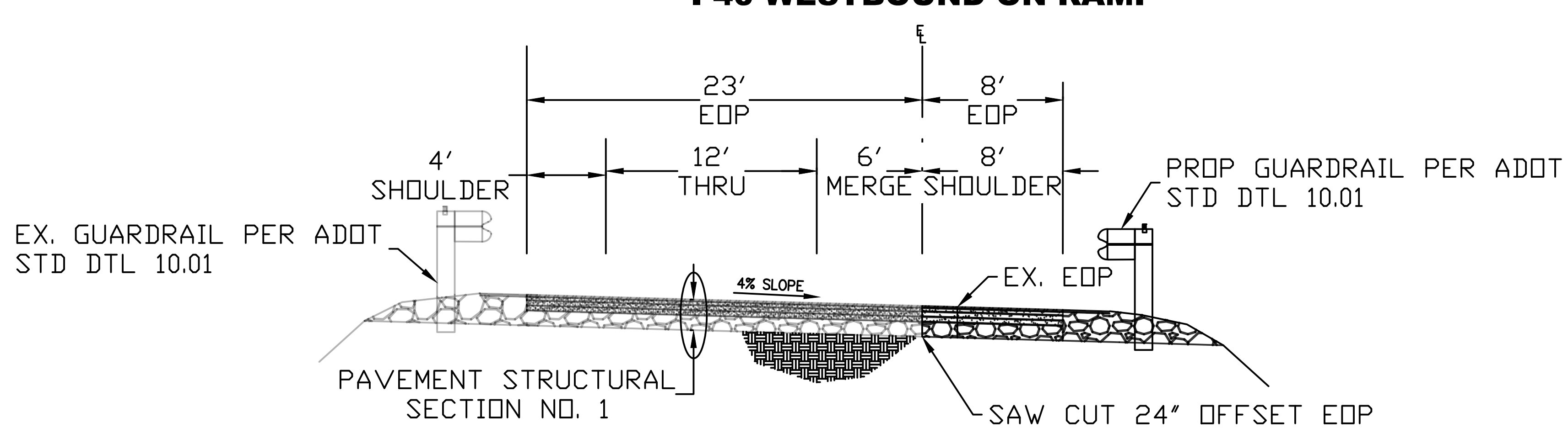
PROPOSED ROADWAY
STA 11+53.44
I-40 WESTBOUND ON-RAMP

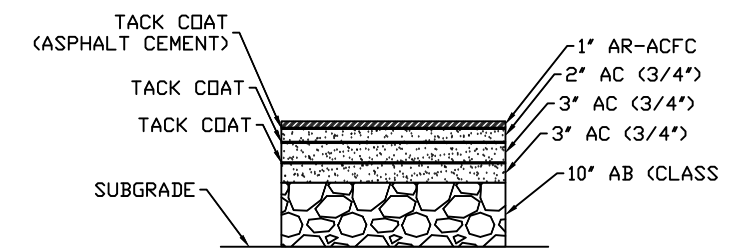


PROPOSED ROADWAY
STA 12+03.44
I-40 WESTBOUND ON-RAMP



PROPOSED ROADWAY
STA 12+53.44
I-40 WESTBOUND ON-RAMP





PAVEMENT STRUCTURAL SECTION NO. 1

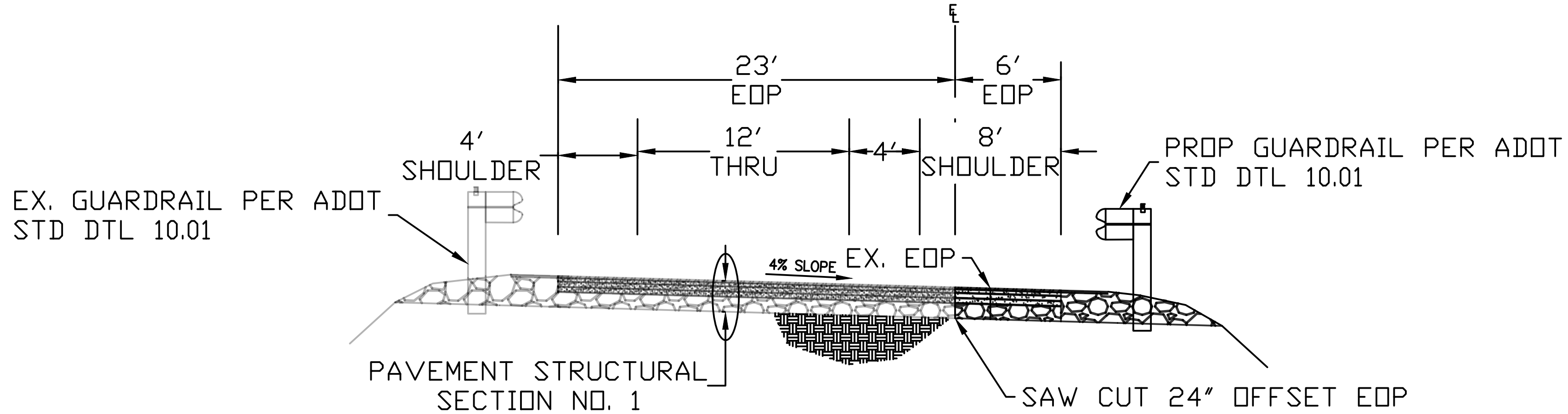
DATE 05/05/20
REV 1:
REV 2:

I-40/CC
IMPROVEMENT PROJECT

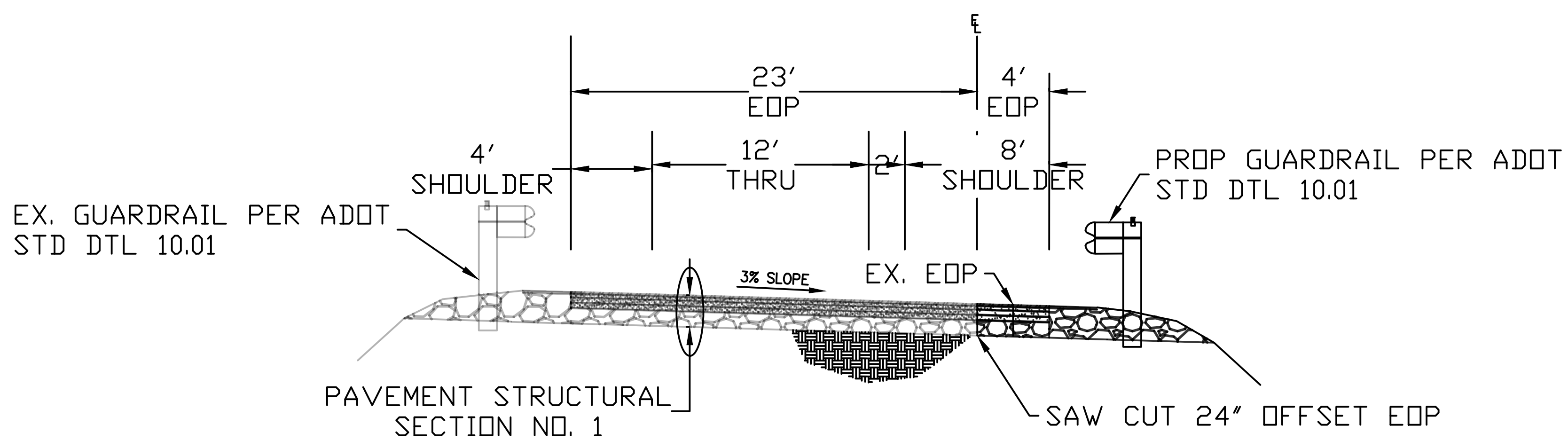
LOCATION FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	
DRAWN	MT	TX02	
CHECK	ZJ	NO. 15	OF 27

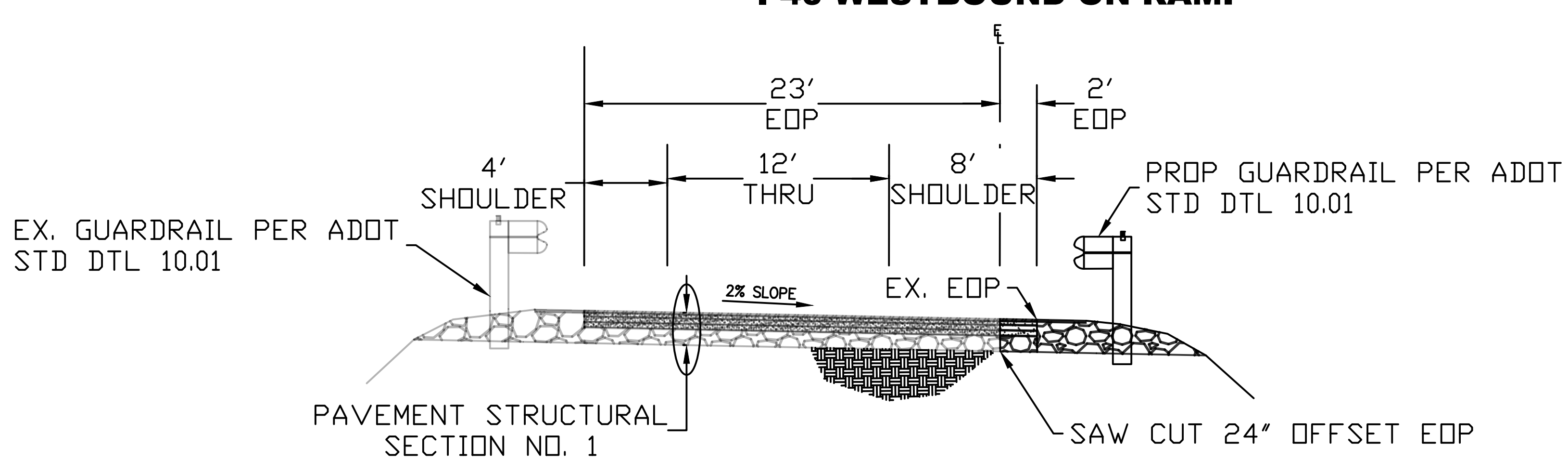
PROPOSED ROADWAY
STA 13+03.44
I-40 WESTBOUND ON-RAMP

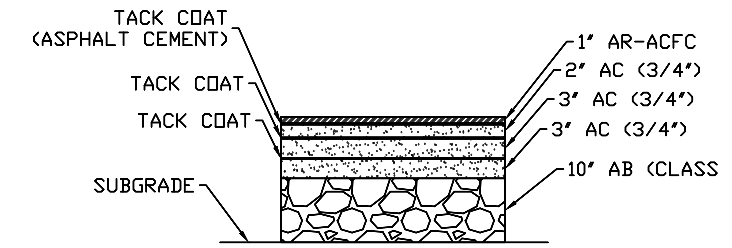


PROPOSED ROADWAY
STA 13+53.44
I-40 WESTBOUND ON-RAMP



PROPOSED ROADWAY
STA 14+13.29
I-40 WESTBOUND ON-RAMP





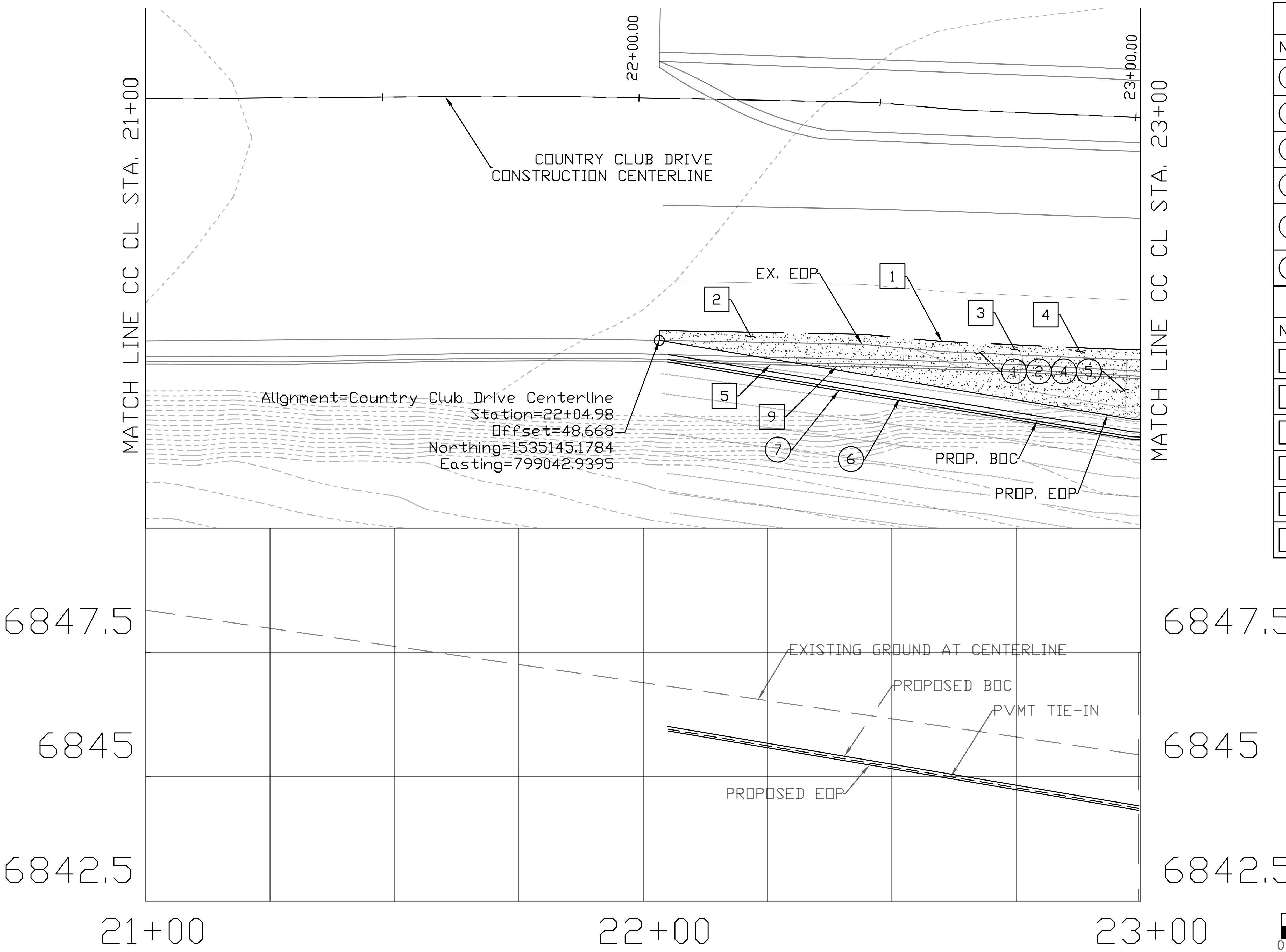
PAVEMENT STRUCTURAL SECTION NO. 1

DATE	05/05/20
REV 1:	
REV 2:	

I-40/CC
IMPROVEMENT PROJECT

LOCATION: FLAGSTAFF, AZ

DESIGN	MT
DRAWN	MT
CHECK	ZJ
SHEET TITLE	TX03
NO.	16 OF 27



CONSTRUCTION

NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	15	TON
2	PORTLAND CEMENT CONCRETE PAVEMENT (12.5")	90	SY
3	BITUMINOUS TACK COAT (0.5")	2	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	4	TON
6	CONCRETE HALF BARRIER PER ADOT STD DTL C-10.52, TYPE F, GUTTER = 2.5'	98	LF
7	RETAINING WALL (OTHERS)	98	LF

REMOVAL

NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	59	LF
2	PCCP	13	SY
3	AGGREGATE BASE	13	SY
4	ASPHALTIC PAVEMENT	13	SY
5	CONC HALF BARRIER	57	LF
9	RETAINING WALL	57	LF

0 5 10 20

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

DATE 05/05/20
REV 1:
REV 2:

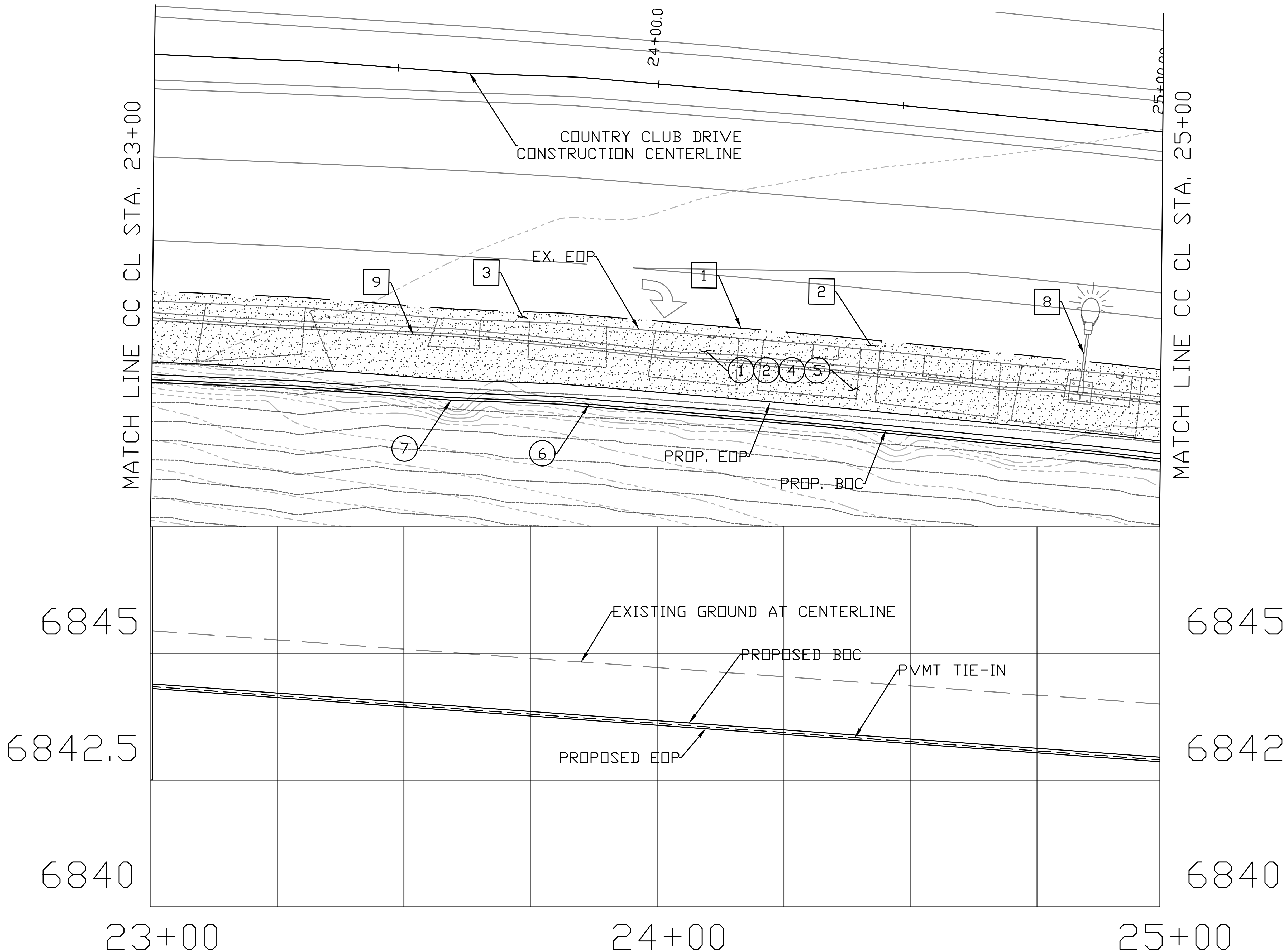
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

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

SHEET TITLE PV01

NO. 17 OF 27

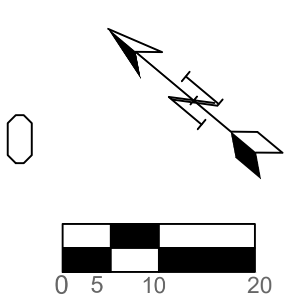


CONSTRUCTION

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



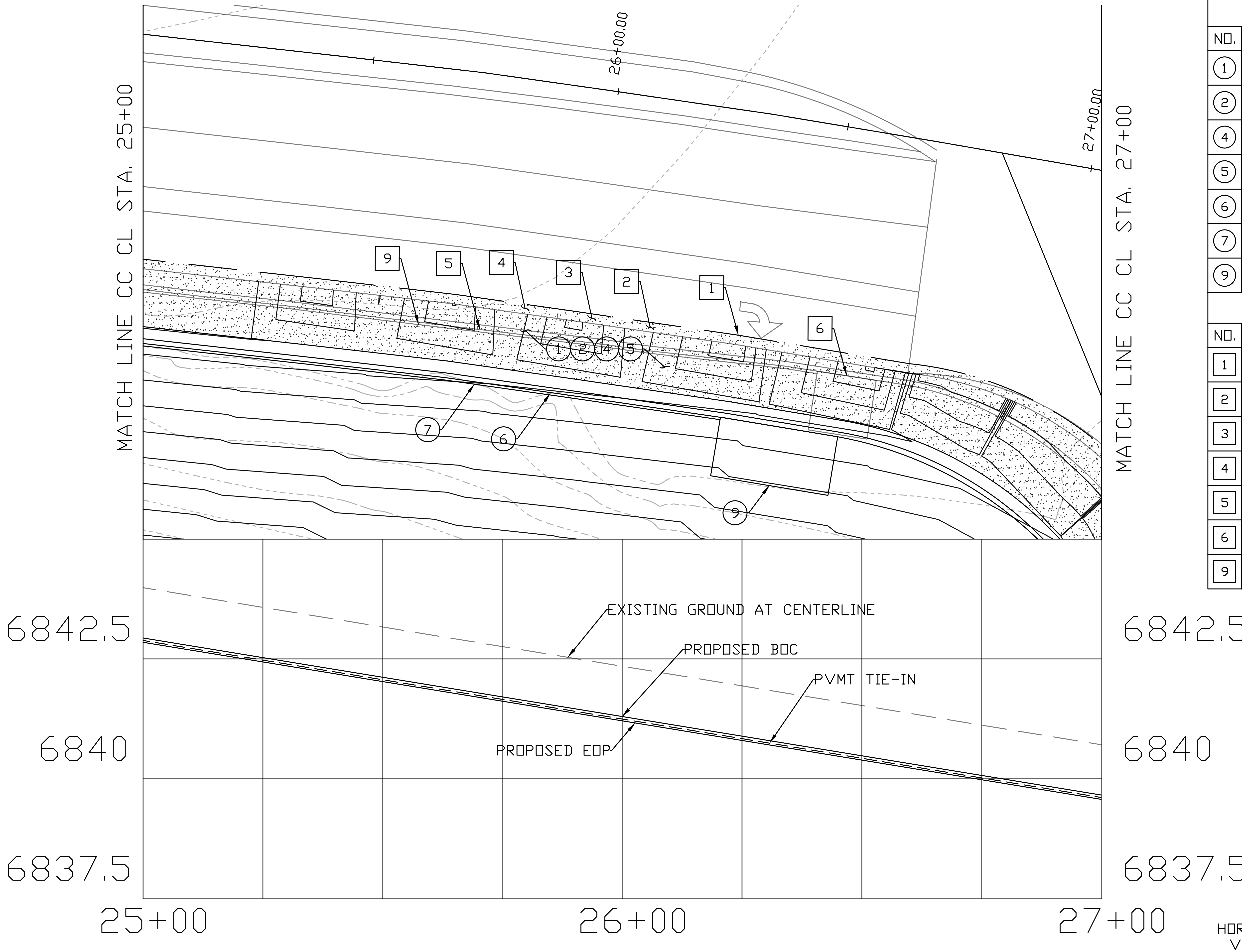
HORIZONTAL: 1" = 20'
VERTICAL: 1" = 2'

DATE 05/05/20
REV 1:
REV 2:

I-40/CC IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	PV02
DRAWN	MT		
SCALE 1" = 20'	CHECK ZJ	NO. 18	OF 27



CONSTRUCTION

NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	58	TON
2	PORTLAND CEMENT CONCRETE PAVEMENT (12.5")	346	SY
4	BITUMINOUS TACK COAT (0.5")	8	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	15	TON
6	CONCRETE HALF BARRIER PER ADOT STD DTL C-10.52, TYPE F, GUTTER = 2.5'	122	LF
7	RETAINING WALL (OTHERS)	122	LF
9	CATCH BASIN PER MODIFIED ADOT STD DTL C-15.2, INLET LENGTH = 38.5'	1	EA

REMOVAL

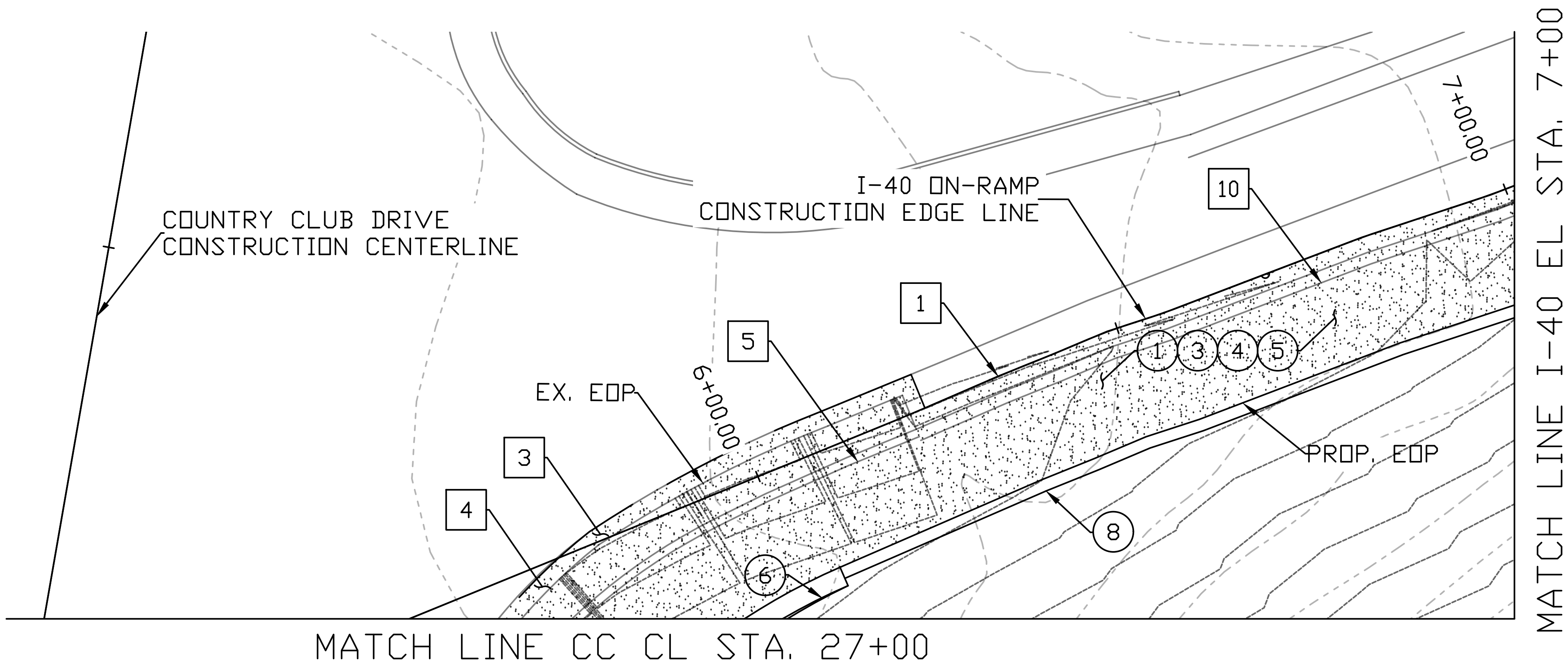
NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	206	LF
2	PCCP	34	SY
3	AGGREGATE BASE	46	SY
4	ASPHALTIC PAVEMENT	46	SY
5	CONC HALF BARRIER	204	LF
6	CATCH BASIN	1	EA
9	RETAINING WALL	122	LF

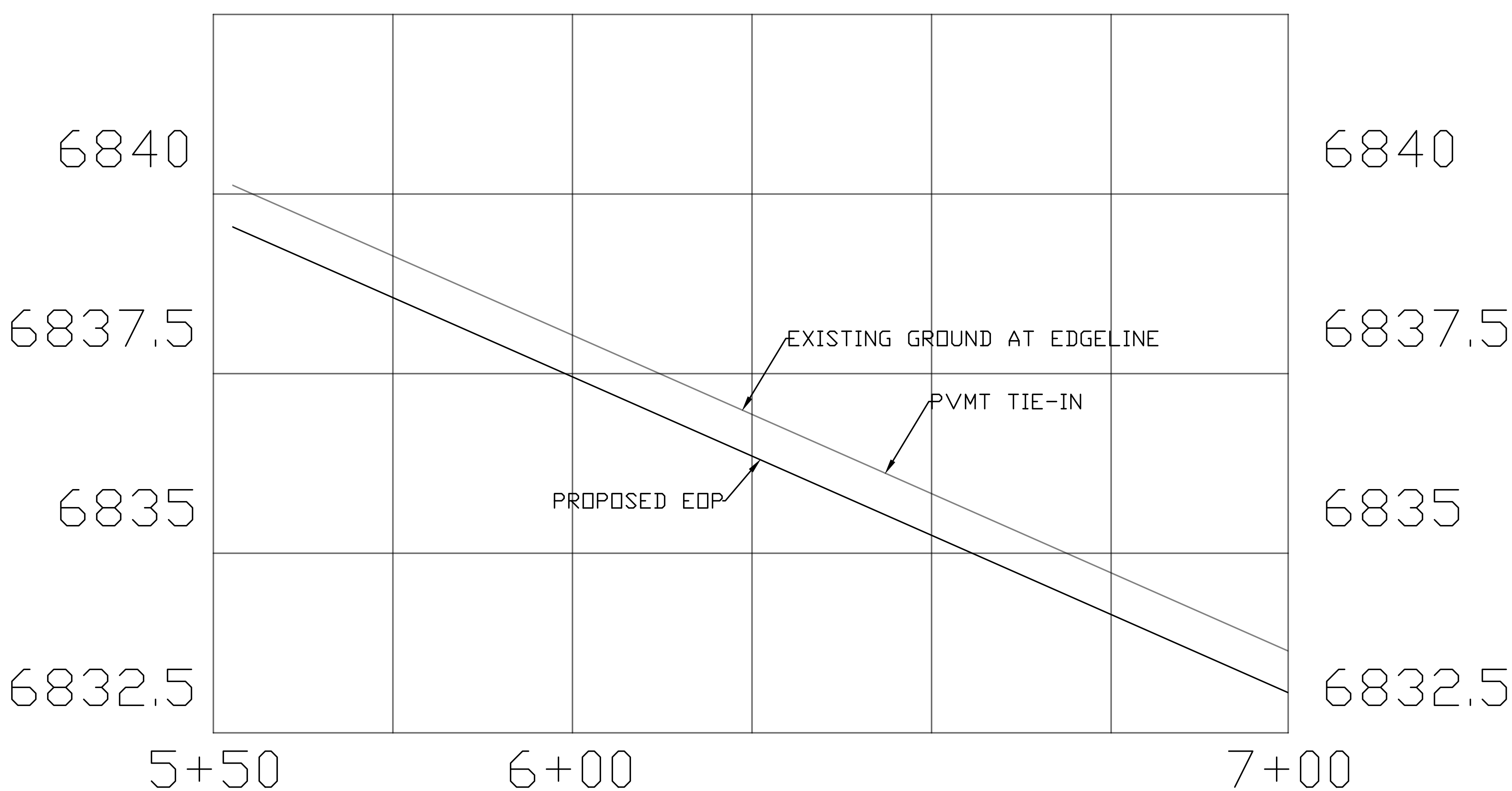
DATE 05/05/20
REV 1:
REV 2:

I-40/CC IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

DESIGN	MT	SHEET TITLE	PV03
DRAWN	MT		
SCALE 1" = 20'	CHECK ZJ	NO. 19	OF 27





CONSTRUCTION			
NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	91	TON
3	ASPHALTIC CONCRETE PAVEMENT (3/4")	55	TON
4	BITUMINOUS TACK COAT (0.5")	14	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	9	TON
6	CONCRETE HALF BARRIER PER ADOT STD DTL C-10.52, TYPE F, GUTTER = 2.5'	9	LF
8	GUARD RAIL PER ADOT STD DTL C-10.01	90	LF

REMOVAL			
NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	144	LF
3	AGGREGATE BASE	32	SY
4	ASPHALTIC PAVEMENT	32	SY
5	CONC HALF BARRIER	29	LF
10	GUARD RAIL	79	LF

0 5 10 20

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

DATE 05/05/20
REV 1:
REV 2:

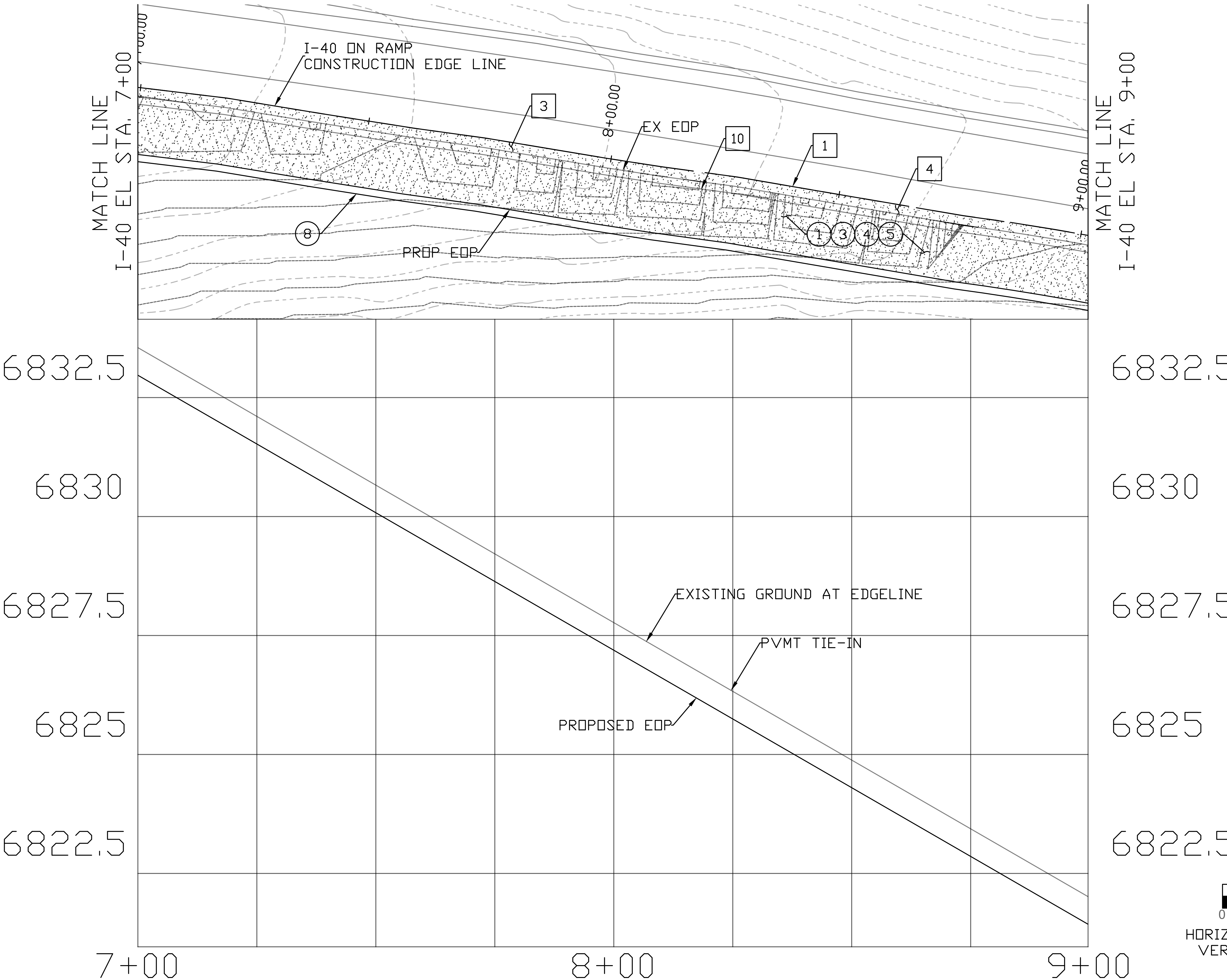
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

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

SHEET TITLE PV04

NO. 20 OF 27



CONSTRUCTION

NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	131	TON
3	ASPHALTIC CONCRETE PAVEMENT (3/4")	79	TON
4	BITUMINOUS TACK COAT (0.5")	20	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	14	TON
8	GUARD RAIL PER ADOT STD DTL C-10.01	202	LF

REMOVAL

NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	202	LF
3	AGGREGATE BASE	45	SY
4	ASPHALTIC PAVEMENT	45	SY
10	GUARD RAIL	202	LF

N

0 5 10 20

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

DATE 05/05/20
REV 1:
REV 2:

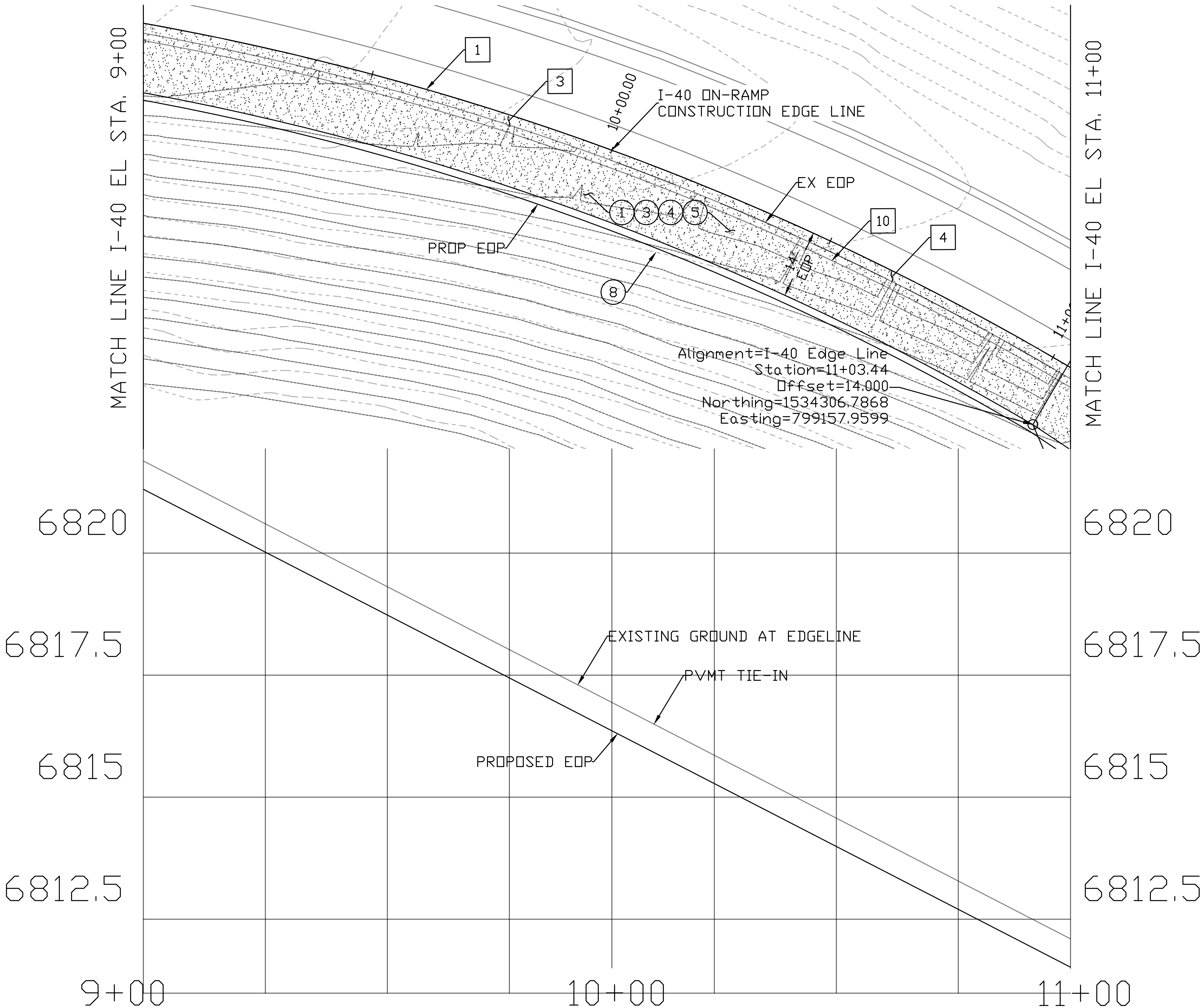
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

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

SHEET TITLE PV05

NO. 21 OF 27

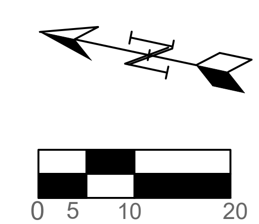


CONSTRUCTION

NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	132	TON
3	ASPHALTIC CONCRETE PAVEMENT (3/4")	79	TON
4	BITUMINOUS TACK COAT (0.5")	20	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	14	TON
8	GUARD RAIL PER ADOT STD DTL C-10.01	195	LF

REMOVAL

NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	205	LF
3	AGGREGATE BASE	46	SY
4	ASPHALTIC PAVEMENT	46	SY
10	GUARD RAIL	205	LF



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

DATE 05/05/20
REV 1:
REV 2:

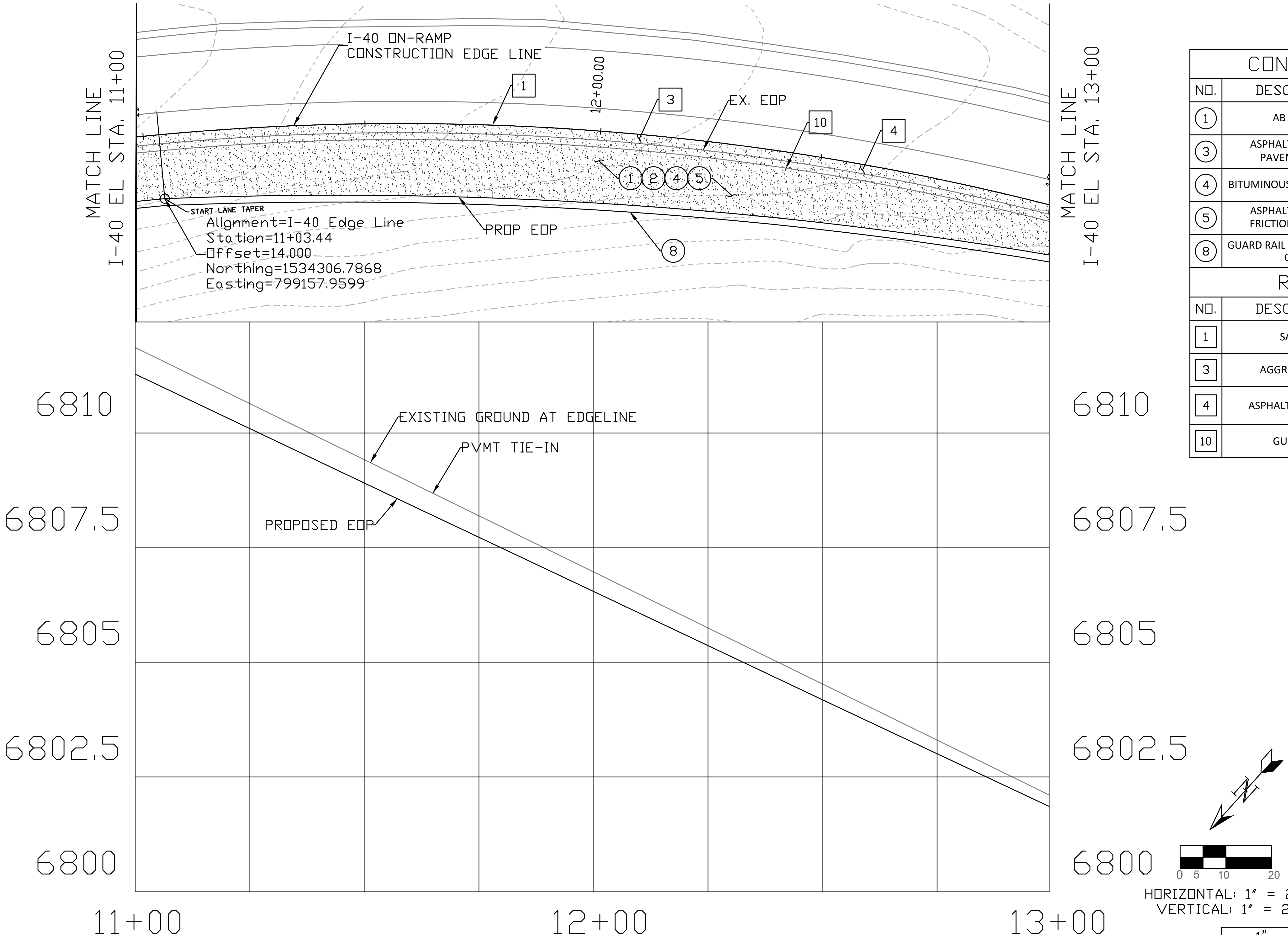
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

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

SHEET TITLE PV06

NO. 22 OF 27



CONSTRUCTION			
NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	135	TON
3	ASPHALTIC CONCRETE PAVEMENT (3/4")	81	TON
4	BITUMINOUS TACK COAT (0.5")	21	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	14	TON
8	GUARD RAIL PER ADOT STD DTL C-10.01	196	LF

REMOVAL			
NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	202	LF
3	AGGREGATE BASE	45	SY
4	ASPHALTIC PAVEMENT	45	SY
10	GUARD RAIL	202	LF

DATE 05/05/20
REV 1:
REV 2:

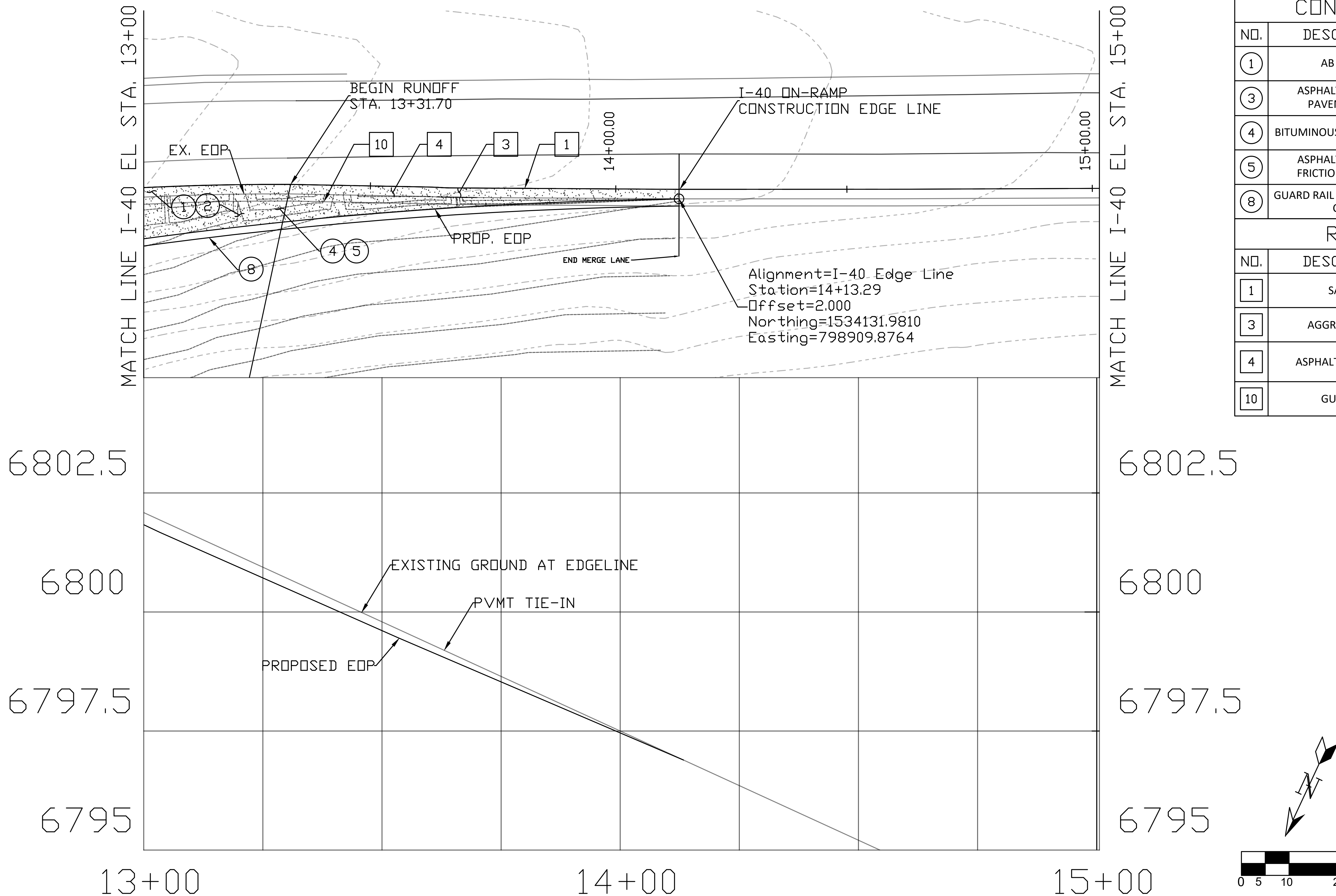
I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

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

SHEET TITLE PV07

NO. 23 OF 27



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

CONSTRUCTION

NO.	DESCRIPTION	QTY.	UN.
1	AB (CLASS 2)	29	TON
3	ASPHALTIC CONCRETE PAVEMENT (3/4")	17	TON
4	BITUMINOUS TACK COAT (0.5")	5	TON
5	ASPHALTIC CONCRETE FRICTION COARSE (1")	3	TON
8	GUARD RAIL PER ADOT STD DTL C-10.01	113	LF

REMOVAL

NO.	DESCRIPTION	QTY.	UN.
1	SAW CUT	115	LF
3	AGGREGATE BASE	26	SY
4	ASPHALTIC PAVEMENT	26	SY
10	GUARD RAIL	113	LF

DATE 05/05/20
REV 1:
REV 2:

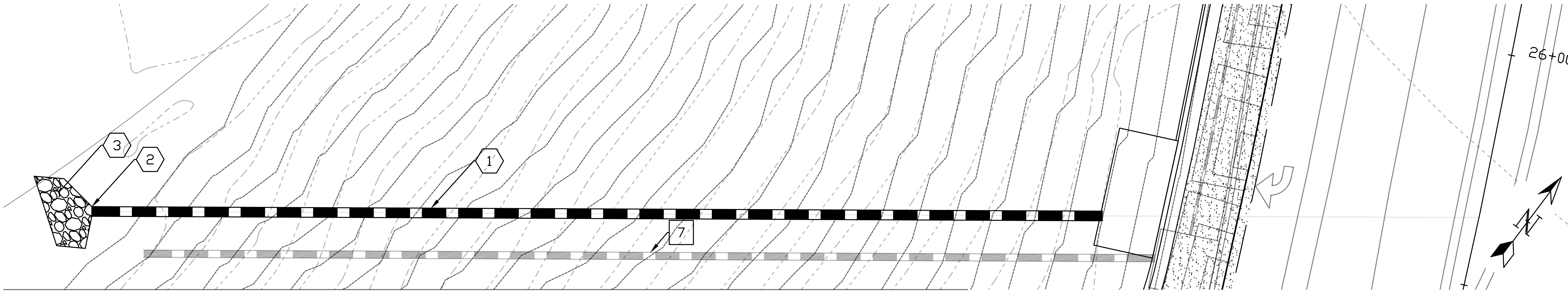
I-40/CC IMPROVEMENT PROJECT

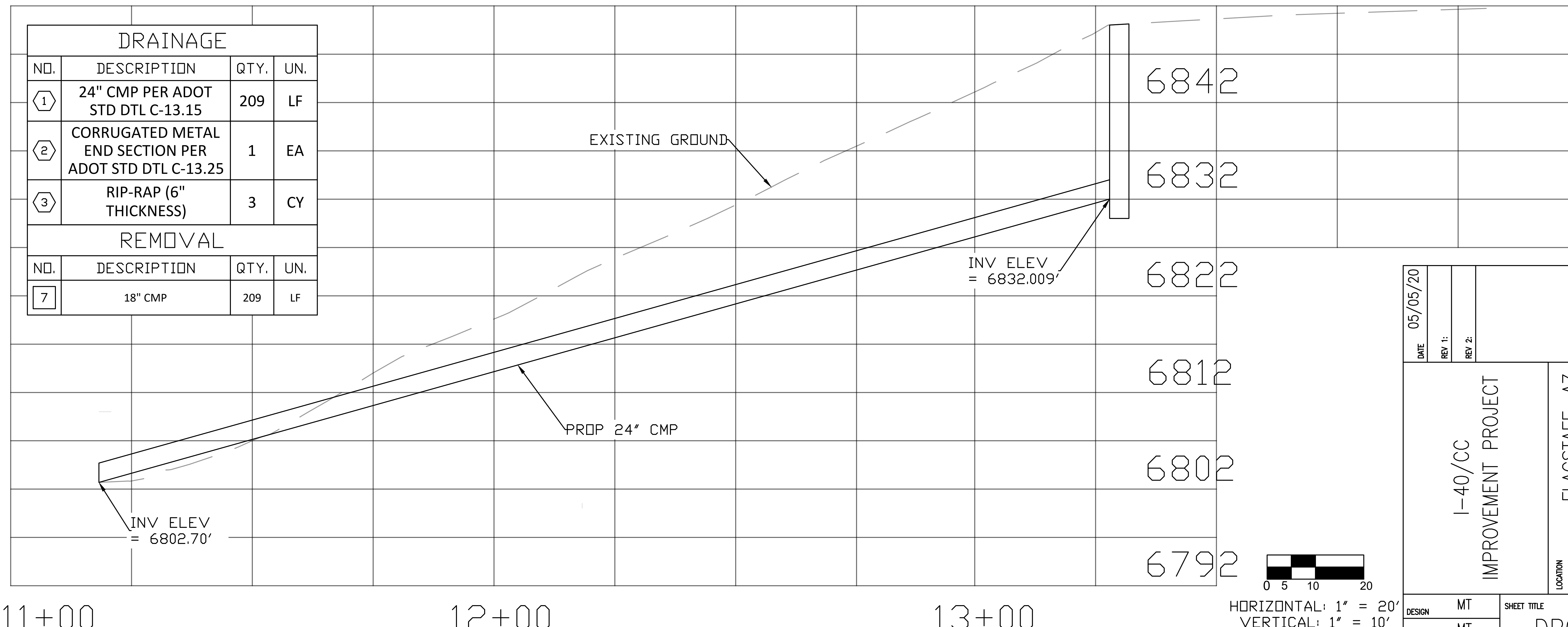
LOCATION FLAGSTAFF, AZ

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

SHEET TITLE PV08

NO. 24 OF 27





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

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

DATE 05/05/20
REV 1:
REV 2:

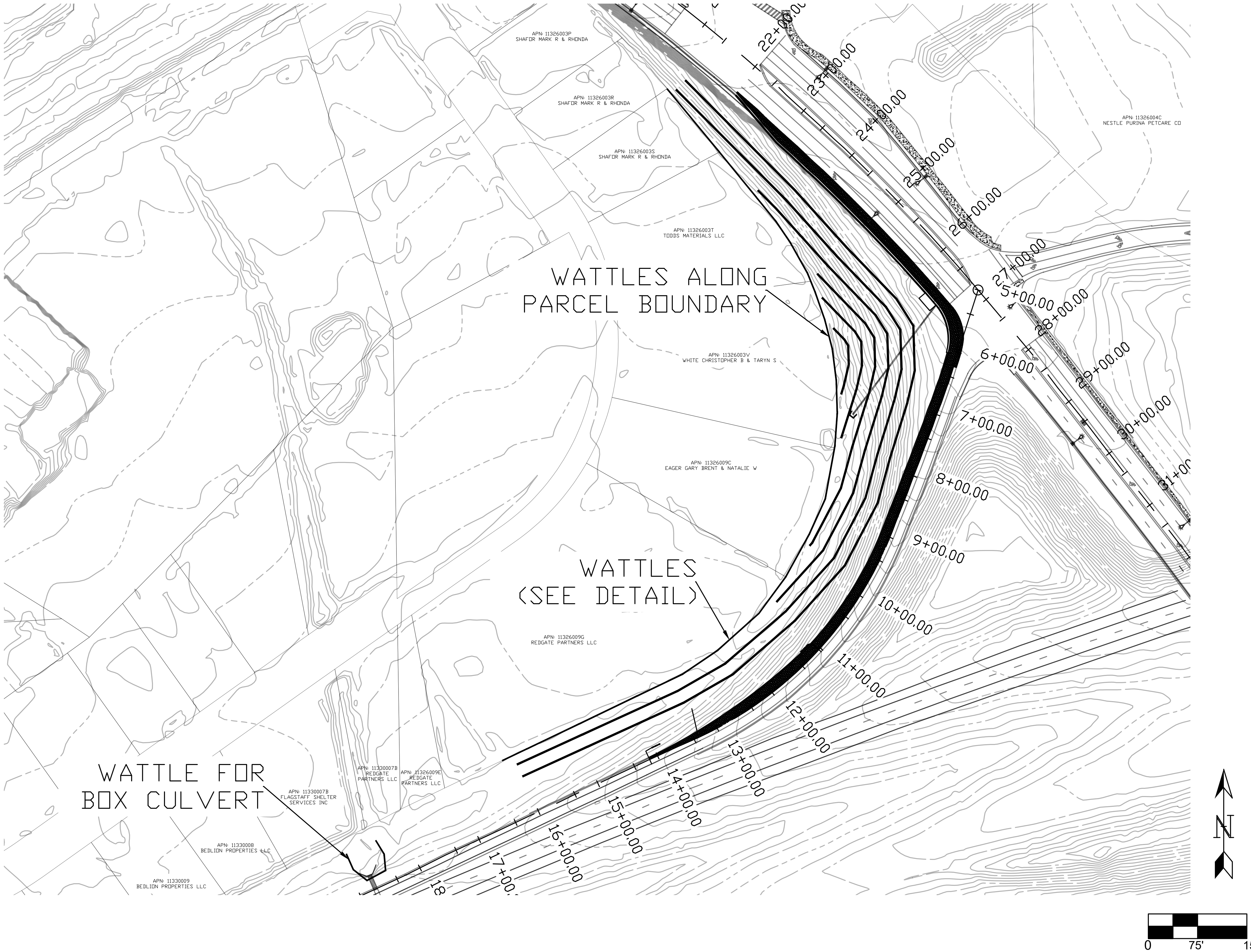
I-40/CC IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

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

SHEET TITLE DR01

NO. 25 OF 27

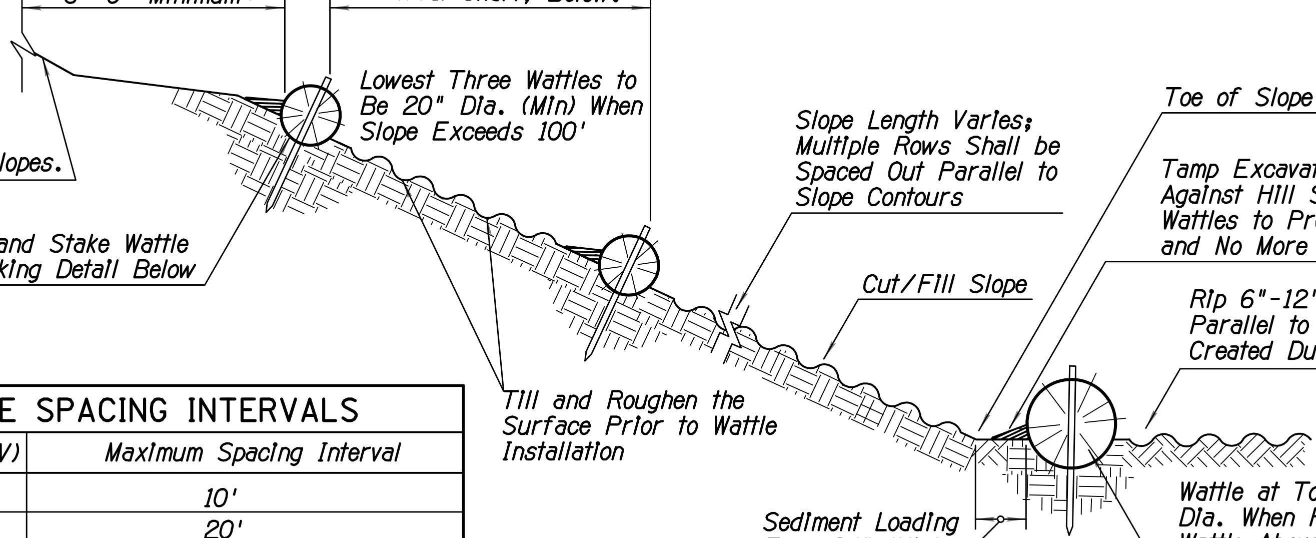


DATE	05/05/20
REV 1:	
REV 2:	

I-40/CC
IMPROVEMENT PROJECT

LOCATION FLAGSTAFF, AZ

SCALE 1" = 150'	DESIGN RL	SHEET TITLE	
	DRAWN RL	EC01	
	CHECK MT	NO. 26	OF 27

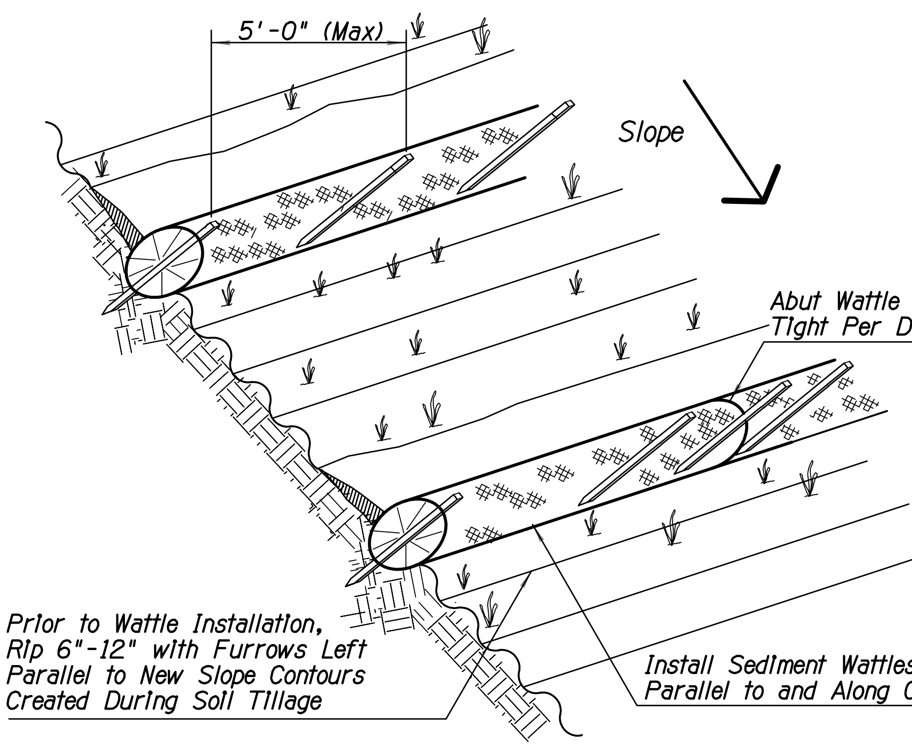


NOTE:
Construct bottom wattle above estimated bankfull level of roadside ditch, when the ditch is installed at toe of new slope.

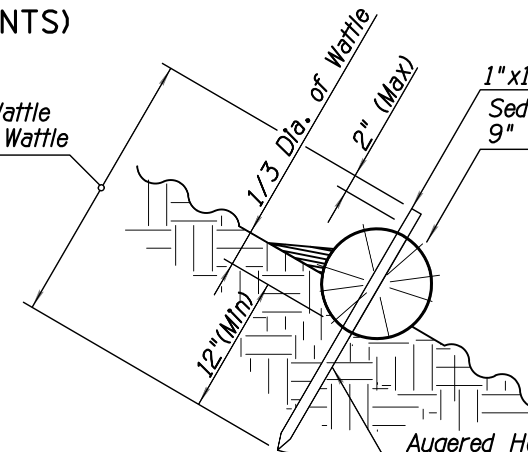
SECTION (NTS)

WATTLE SPACING INTERVALS	
Slope Ratio (H:V)	Maximum Spacing Interval
2:1	10'
3:1	20'
4:1	30'
5:1	40'
6:1	40'

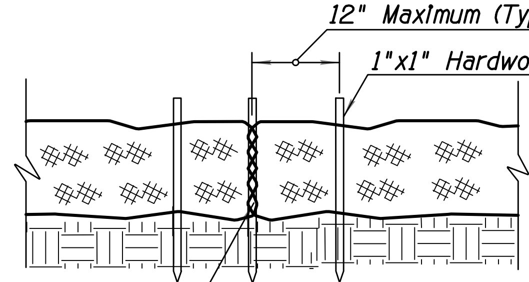
* Notes:
1) Top Row Shall Not be Placed within 6'-0" of Edge of Pavement and 9'-0" from Outside Surface of Barrier.
2) For erosive soils, place rows of wattles closer together.
3) For soils with low erosive potential, place rows of wattles further apart.



SEDIMENT WATTLE LAYOUT (NTS)



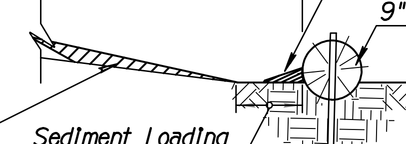
SEDIMENT WATTLE STAKING DETAIL (NTS)



SEDIMENT WATTLE OVERLAP (NTS)

NOTES:

1. Install Sediment Wattles as slopes are constructed to grade or as directed by the Engineer. Select, install and maintain in conformance with manufacturers' specifications to meet site conditions for slope protection and in accordance with good engineering practices. No Sediment Wattles shall be installed in urban freeway medians, nor where cable barrier systems are employed.
2. Sediment Wattles shall be in continuous contact with trench bottom and sides. Do not overlap wattle ends on top of each other. A 20" Dia. wattle may be made from 2-3 rolled excelsior or straw blankets.
3. Butt adjoining wattles tightly against each other. Drive the first end stake of the second wattle at an angle toward the first wattle to help abut them tightly.
4. Repair any rills or gullies promptly. Make field adjustments and corrections of Wattle BMP immediately if it is causing flooding, erosion, and/or affecting roadway safety.
5. Construction of cut slopes 2:1 and steeper in soil and rock materials that can be ripped shall be constructed, whenever possible, by Minibenching. Refer to Slope Minibenching BMP Detail.
6. Loosening surface soil is not required where Minibenches are used. For seeded areas, tillage shall be performed to form minor ridges and furrows parallel to new slope contours and as specified in Section 805 of the Standard Specifications and these special provisions.
7. Divert and direct run-on water from outside of the slopes to the spillways and/or rock riprap/rock mulch. Diversion dikes and/or ditches are necessary on natural undisturbed slopes beyond the top limits of new slopes to divert run-on water.
8. Installation and maintenance of Sediment Wattle BMPs shall not negatively impact traffic safety, nor the designed function of roadway or bridge drainage facilities.
9. Install and maintain Sediment Wattle BMPs to carry the stormwater of at least 2-year, 24-hour events.
10. The Sediment Wattle BMP's pay/bid item shall include all materials used for this BMP: all ground preparation, furnishing, installing, maintenance, final removal, and disposal of this temporary BMP, as well as returning the area to an acceptable condition as approved by the Engineer.
11. Refer to Standard Specification Section 810-2.06(C) for Sediment Wattle material specifications.
12. Make field adjustments and corrections to ensure NO sensitive biological resources (native species / habitats) will be adversely impacted.



** Note:
Applicable only in the areas of concentrated flow - to include but not be limited to roadway sag spots and drop-off repair locations as per the direction of the Engineer.

NEW SHOULDER BUILDUP **
PROTECTION SECTION (NTS)

DATE	05/05/20
REV 1:	
REV 2:	
	I-40/CC IMPROVEMENT PROJECT
LOCATION	FLAGSTAFF, AZ
DESIGN	ADOT
DRAWN	RL
CHECK	MT
SCALE	NTS
SHEET TITLE	EC02
NO.	27 OF 27

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