Grassy Mountain Project

Access Road Design

Calico Resources

Vale OR and Vicinity

October 22, 2019

Contents

Appendices

1.1 Project Description

The Grassy Mountain Access Road Project consisted of reviewing and designing improvements to the existing access road for the Grassy Mountain Mine. The existing road begins at the intersection of Highway 20 and Russell Road and continues south along Cow Hollow Road and Twin Springs Road until reaching the mine. See Appendix A for Photomap sheets showing the proposed access road and improvements.

1.2 Roadway Design

HDR reviewed BLM and AASHTO design standards and developed a project specific design criteria matrix listing applicable standards (Appendix B). BLM *Gold Book* standards were used wherever available and supplemented with *AASHTO Guidelines for Geometric Design of Very Low Volume Local Roads (ADT<400).*

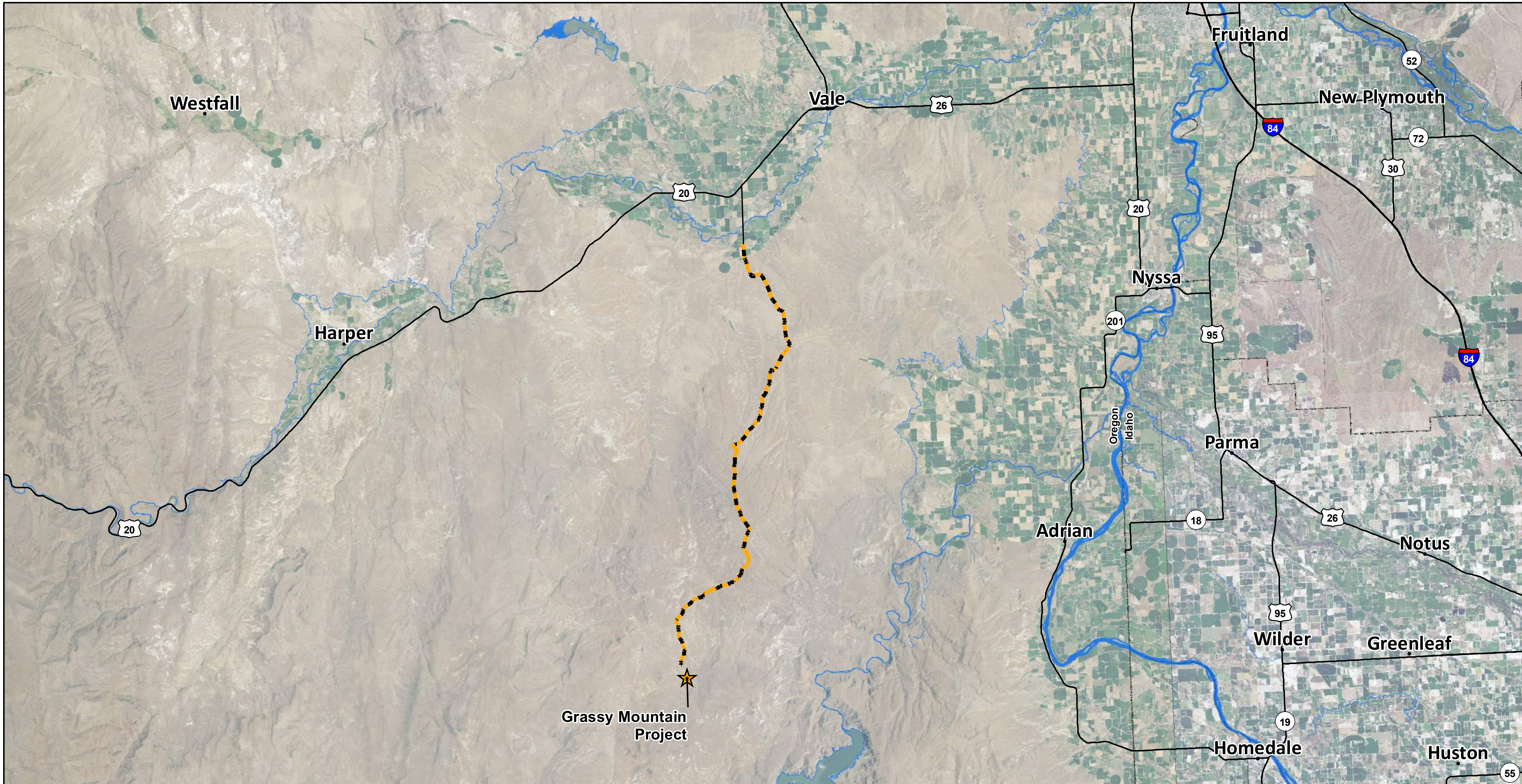
HDR reviewed the existing road to identify areas needing improvement to support equipment accessing the mine and to meet BLM standards. A field review was conducted to evaluate the existing road condition and document culvert sizes and locations. LIDAR survey data was provided by Calico and processed to create an existing ground model that could be reviewed to determine slopes and alignments. The existing road was then analyzed by laying out horizontal and vertical alignments to check that design standards were met. The cross section of the road was also checked during the field review and by cutting cross sections along the alignment to determine if the driving surface is wide enough and if ditches are adequate.

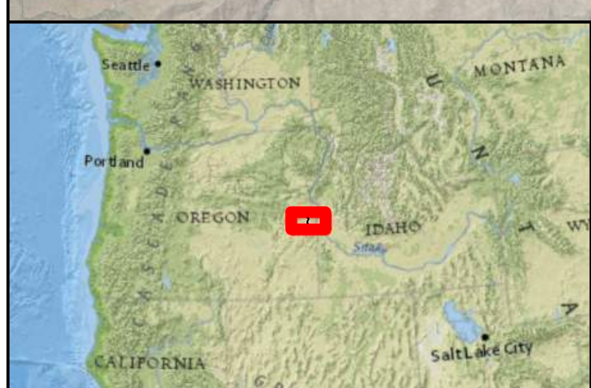
In locations where the existing road does not meet design standards, proposed alignments were developed and new road sections modeled to determine cut/fill limits. Improvements were focused on upgrading portions of the road that do not meet BLM design standards. The proposed design changes are shown in the Roadway and Drainage Plans (Appendix C).

1.3 Drainage Analysis

A drainage analysis was performed during the access road design to assess drainage patterns and identify locations requiring culverts. Existing culverts were examined for adequacy with new culverts and ditches specified where necessary. See Appendix D for Drainage Analysis Tech memo describing the methodology and recommendations. Proposed culverts are also identified on the roadway and drainage plans along with typical installation details and a culvert summary table.

Appendix A
Photomaps





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Miles

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Cattle Guard, Existing
- Cross Drain Culvert
- Project Location
- Permit Corridor Line
- Proposed Mine Features
- Parcel
- Perennial Stream/Canal
- Intermittent Stream/Ditch
- Wetland
- Adjacent Sheet

Photomaps
Vicinity Map
Sheet 1 of 19

Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

Date: 10/21/2019

Document: Q:\CalicoResources\Power_Access\Work_in_Progress\map_docs\AR_ledland.mxd

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Cattle Guard, Existing
- Permit Corridor Line
- Parcel
- Perennial Stream/Canal
- Intermittent Stream/Ditch
- Adjacent Sheet

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Feet

Photomaps
Plan View
Sheet 2 of 19

Calico - Grassy Mountain Project
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Access Road Improvements

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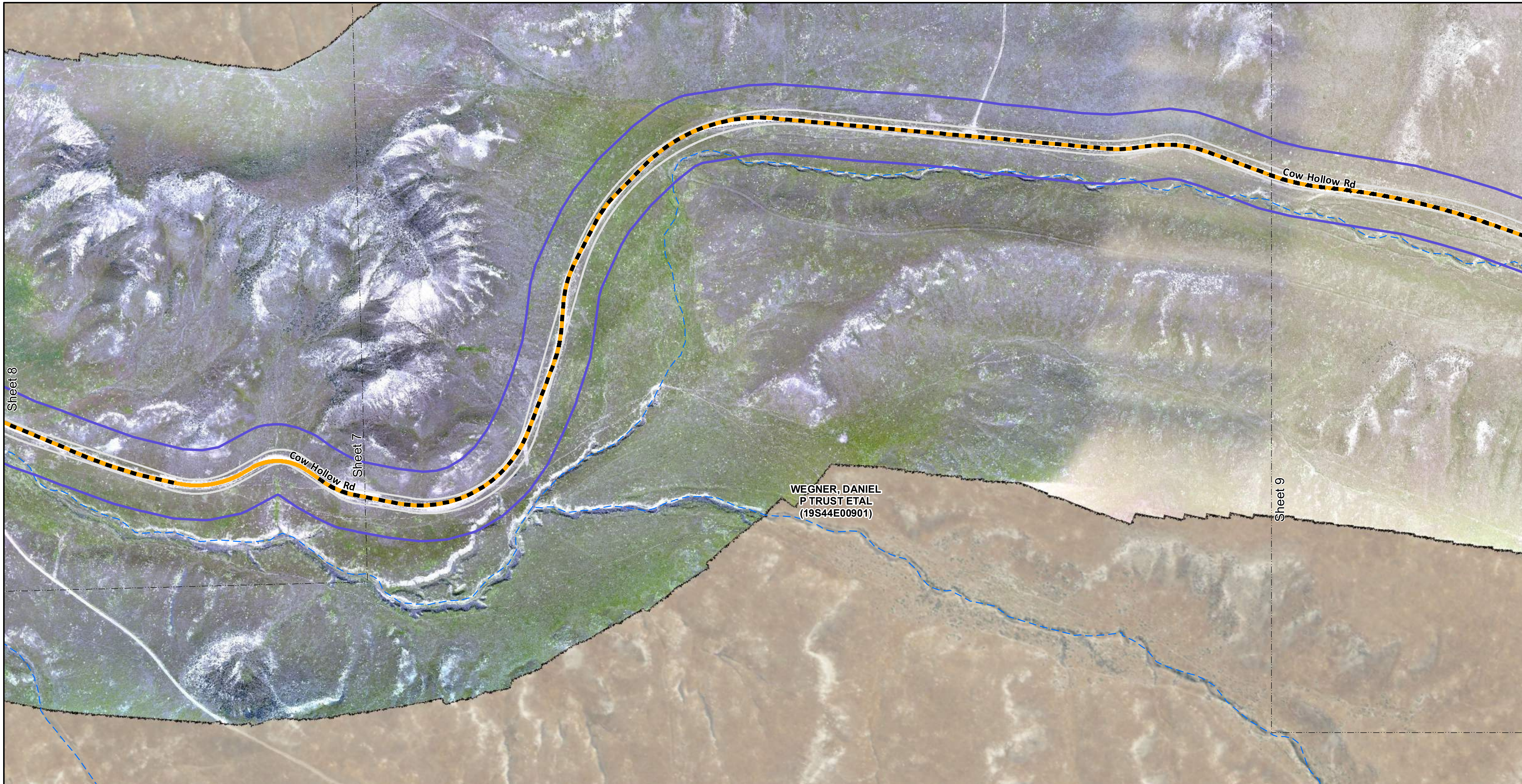

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

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Feet

Photomaps
Plan View
Sheet 3 of 19

Calico - Grassy Mountain Project
34.5 kV Distribution Line
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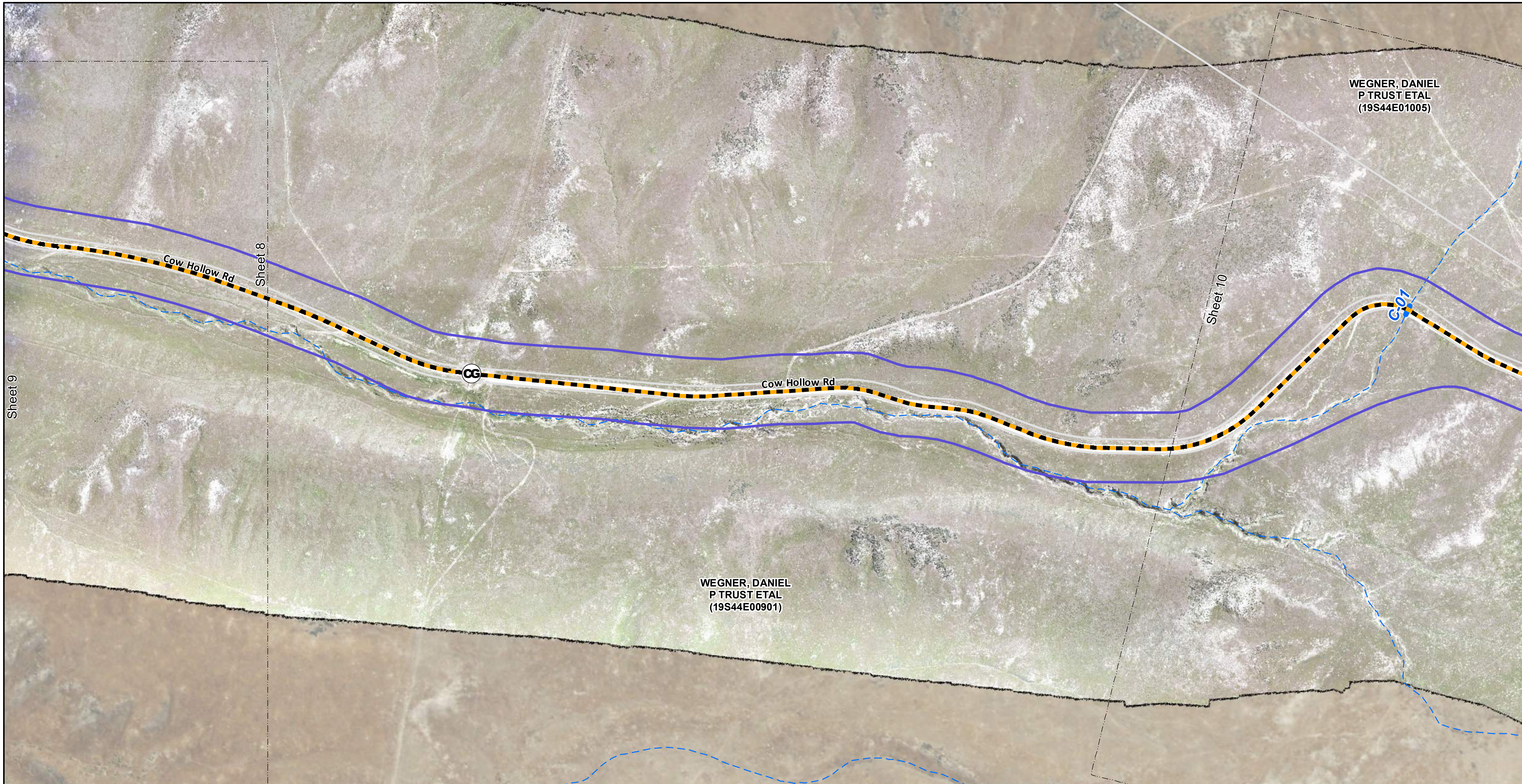

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Legend

- Existing Road (Widening)
- Cattle Guard, Existing
- Cross Drain Culvert
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Photomaps
Plan View
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Calico - Grassy Mountain Project
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Access Road Improvements

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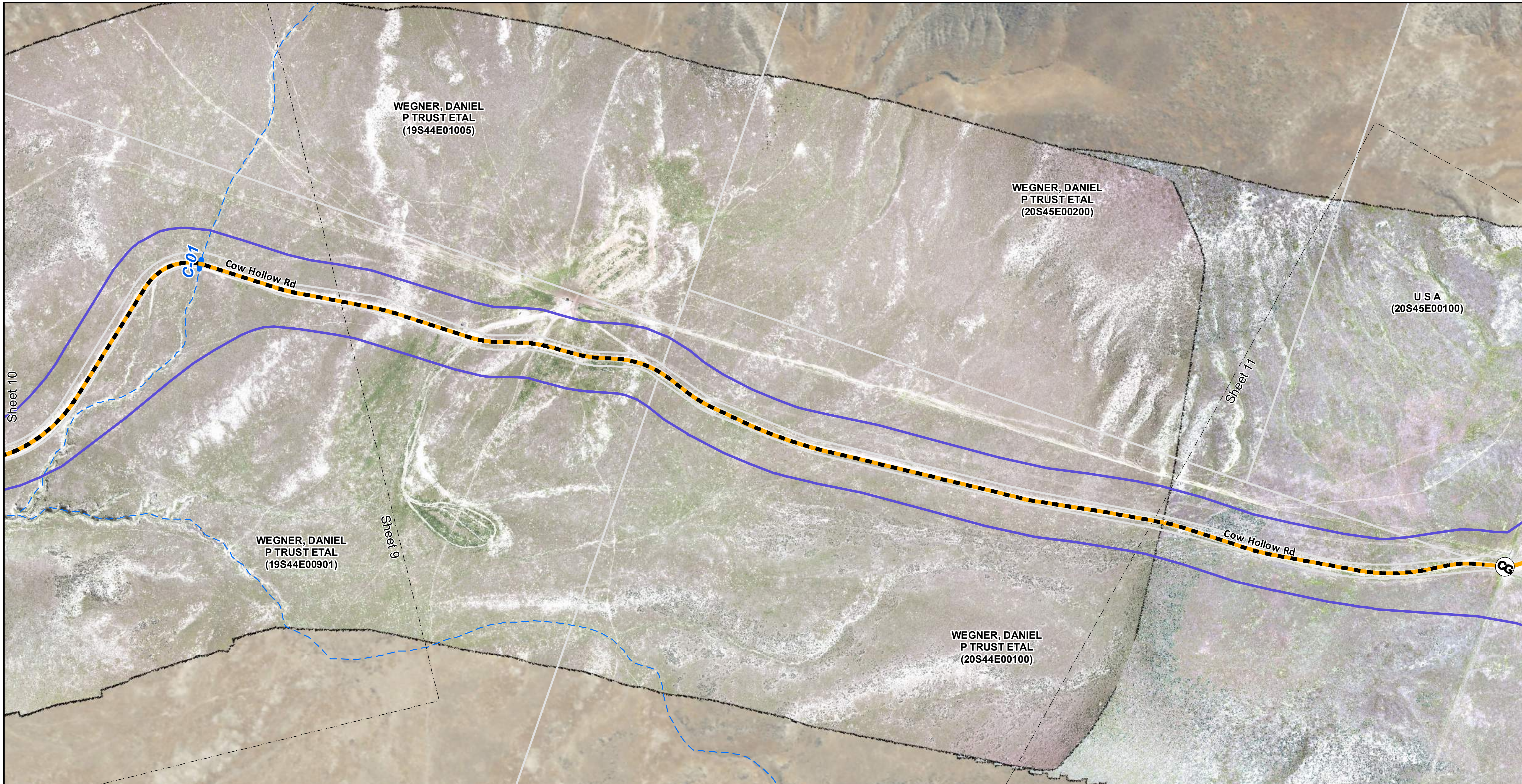

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Feet

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- CG Cattle Guard, Existing
- Cross Drain Culvert
- Permit Corridor Line
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Photomaps
Plan View
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Access Road Improvements

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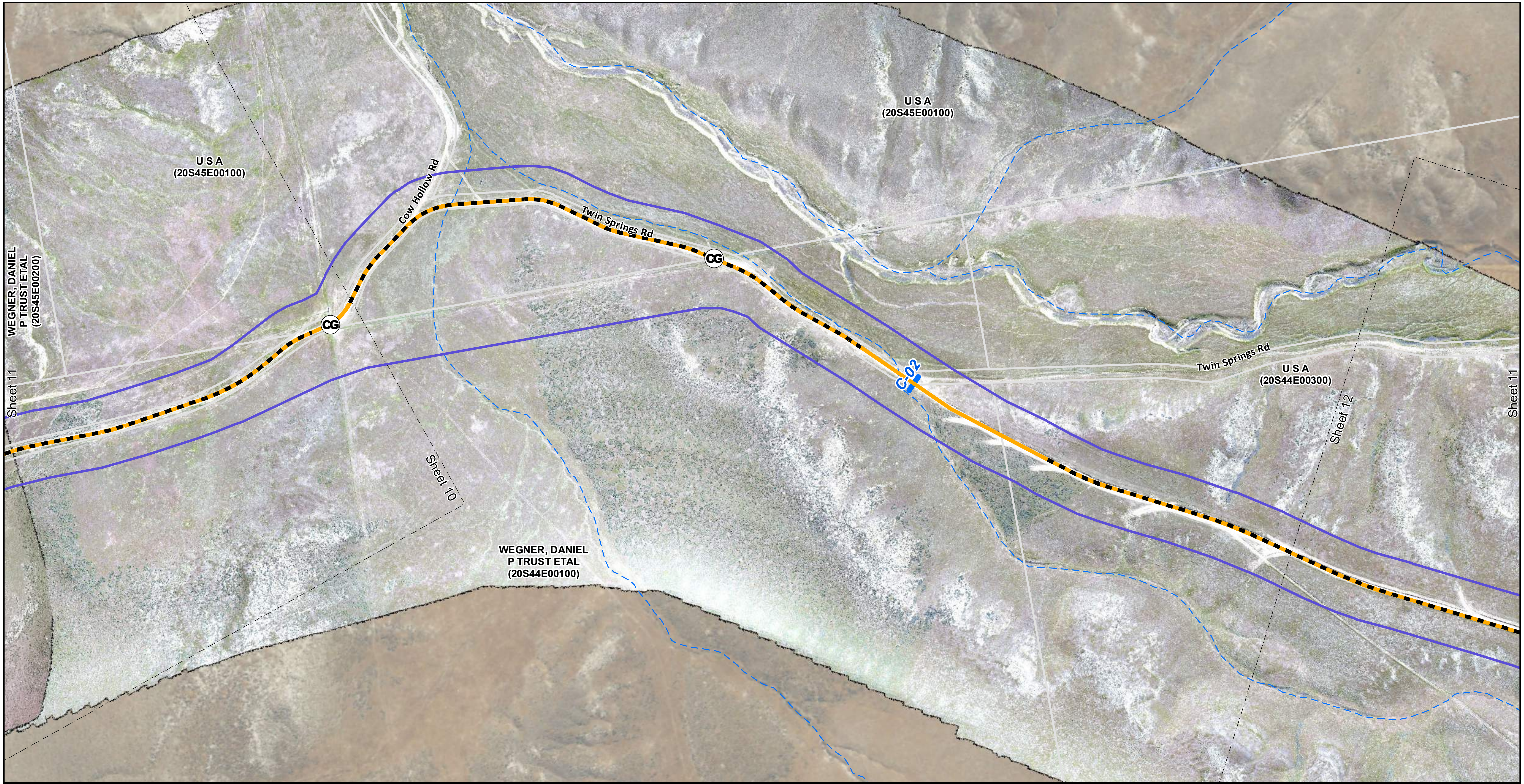

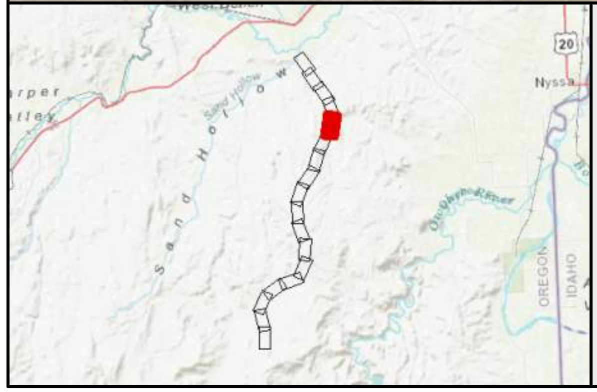

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- CG Cattle Guard, Existing
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
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0 400 800
Feet

Photomaps
Plan View
Sheet 6 of 19

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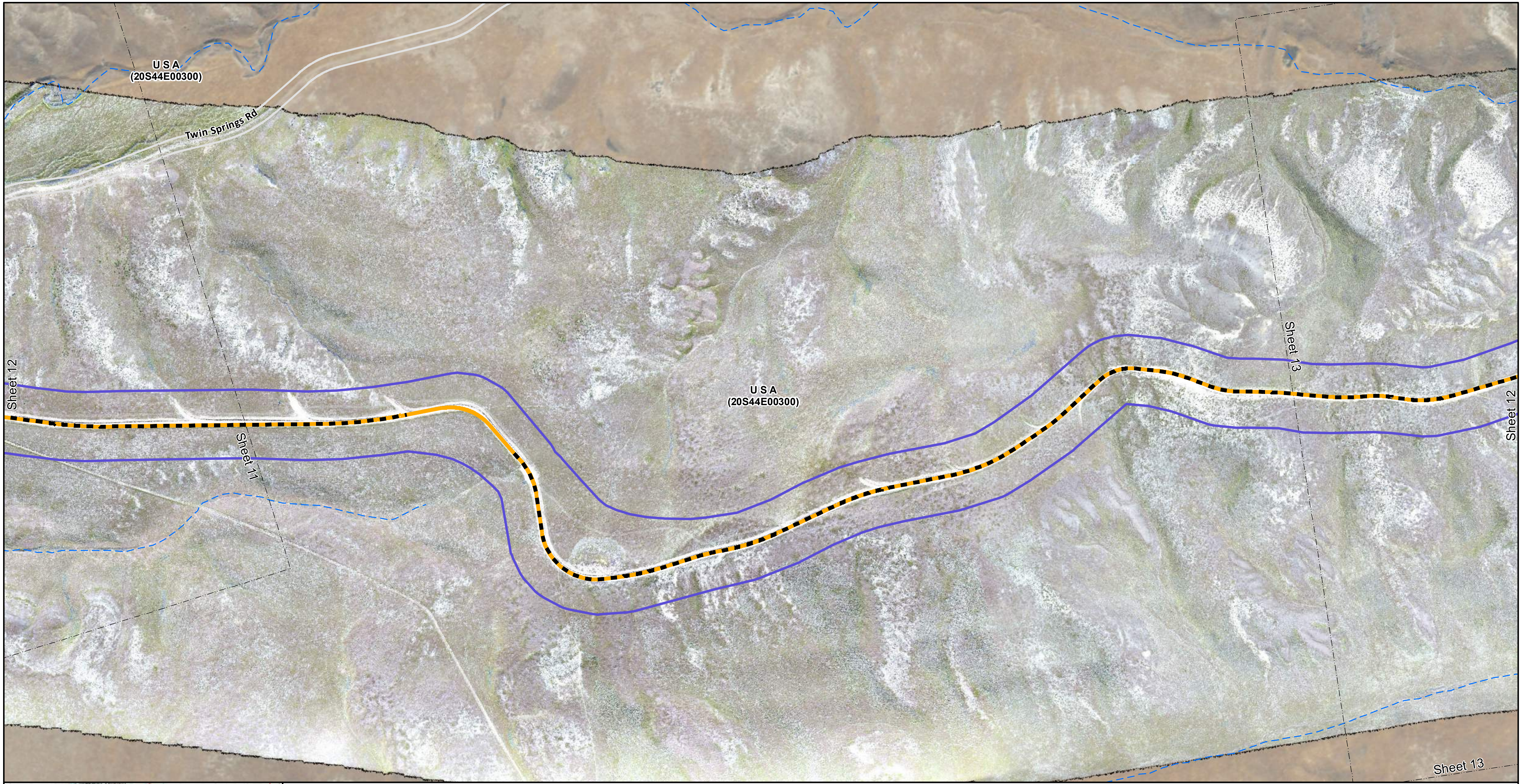

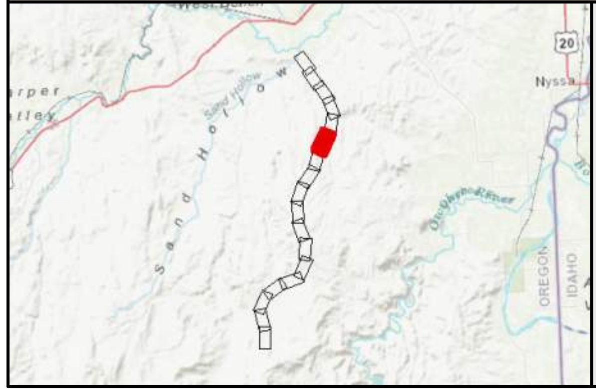

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Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
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Photomaps
Plan View
Sheet 7 of 19

Calico - Grassy Mountain Project
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Access Road Improvements

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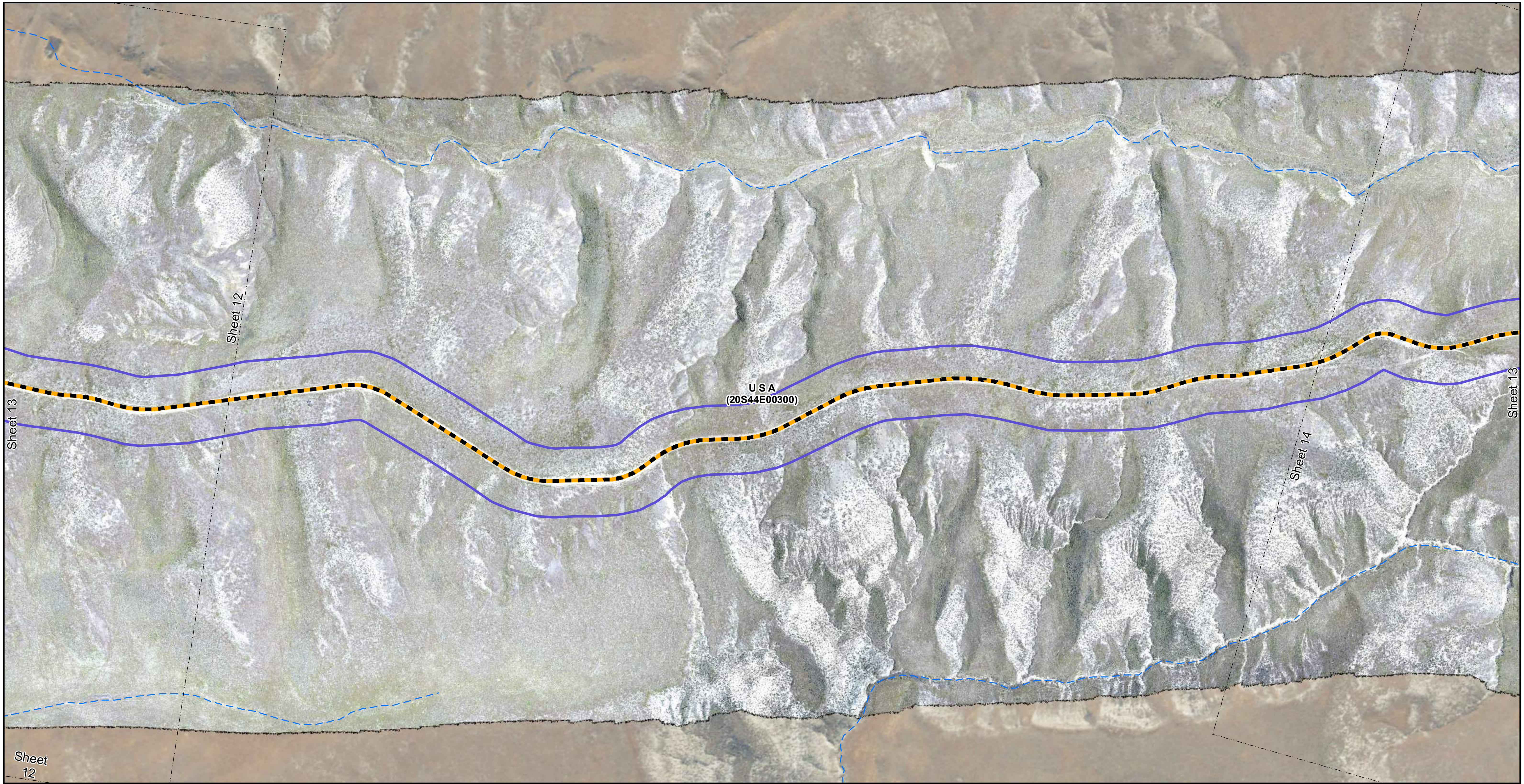

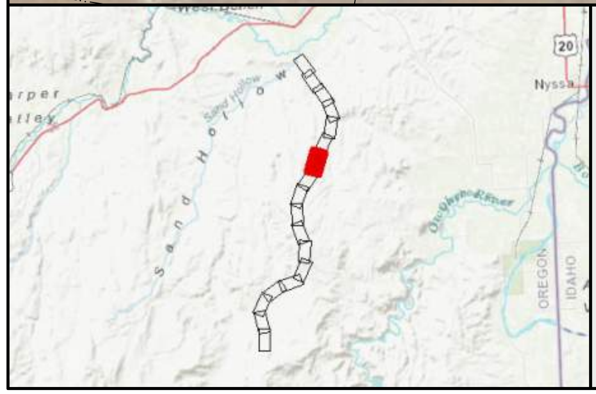

Legend

- Existing Road (Widening)
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

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Feet

Photomaps
Plan View
Sheet 8 of 19

Calico - Grassy Mountain Project
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Access Road Improvements

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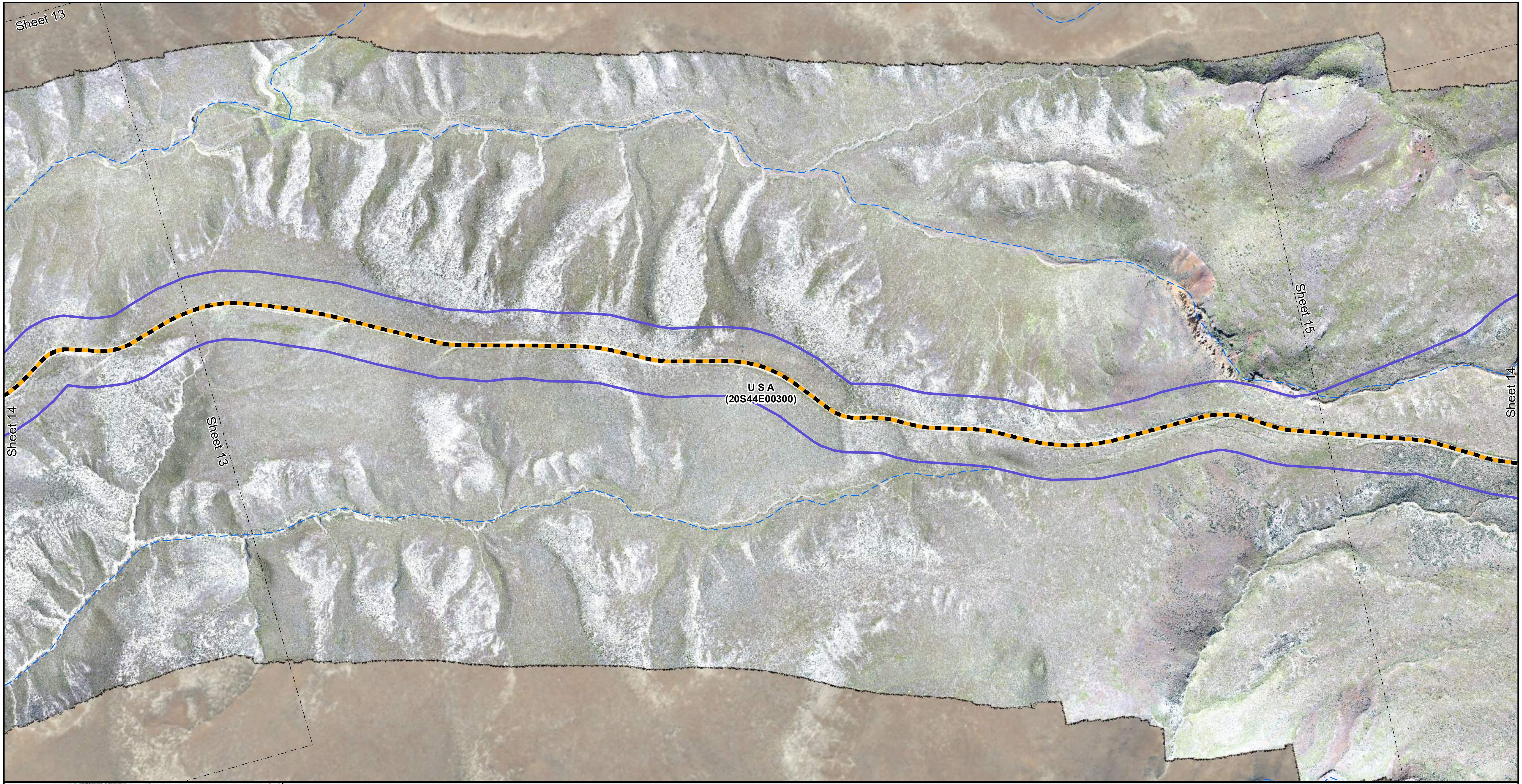

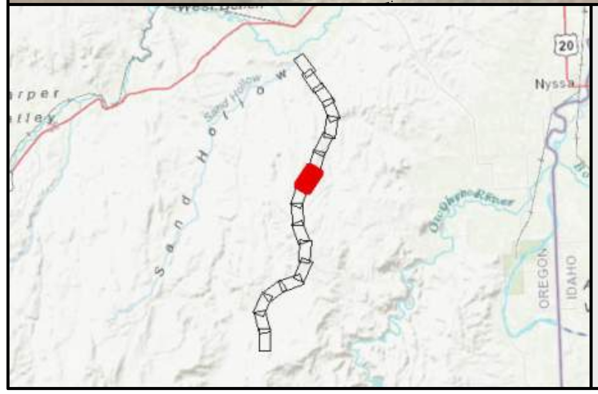

Legend

- Existing Road (Widening)
- Permit Corridor Line
- Parcel
- Perennial Stream/Canal
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
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Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

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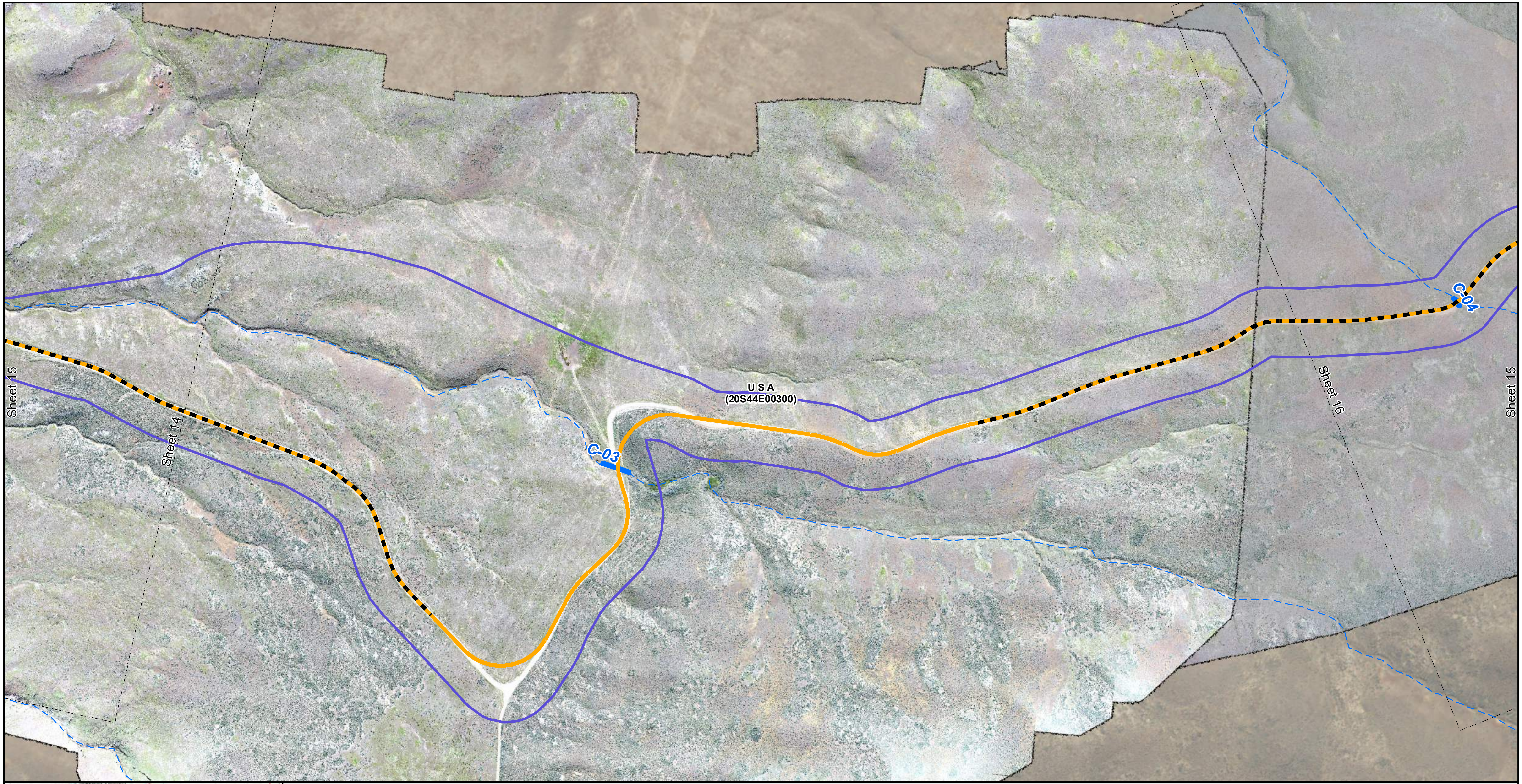

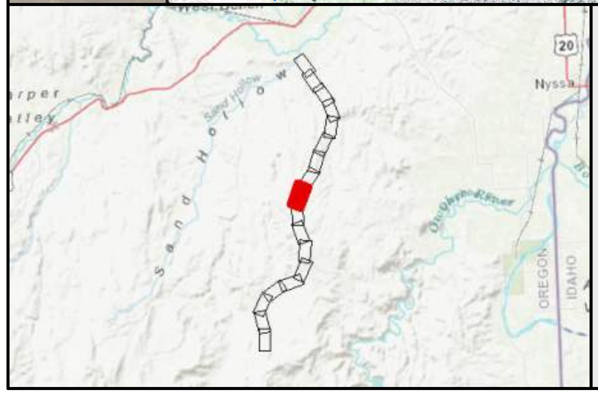

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
Sheet 10 of 19

Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

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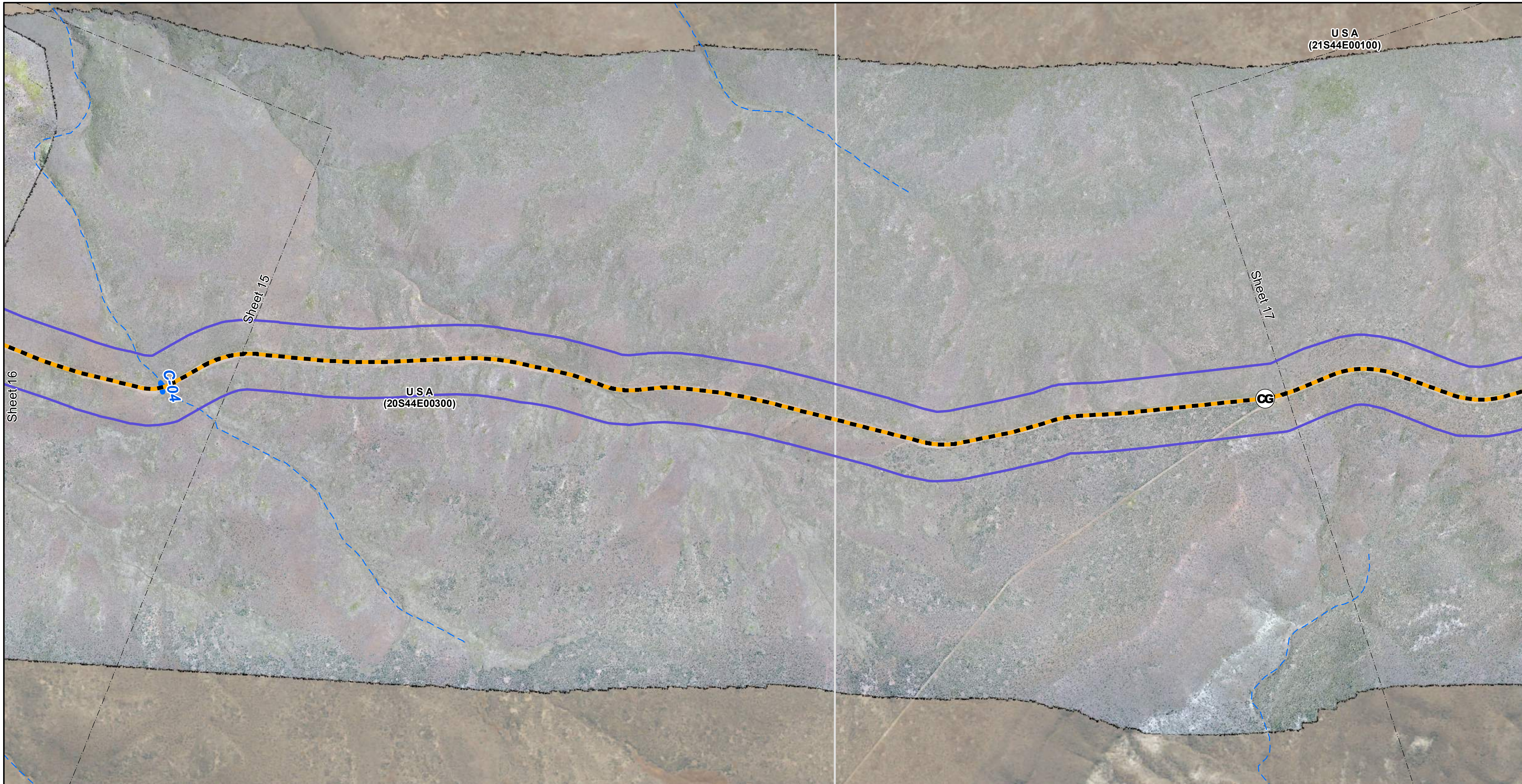

Legend

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- Cattle Guard, Existing
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

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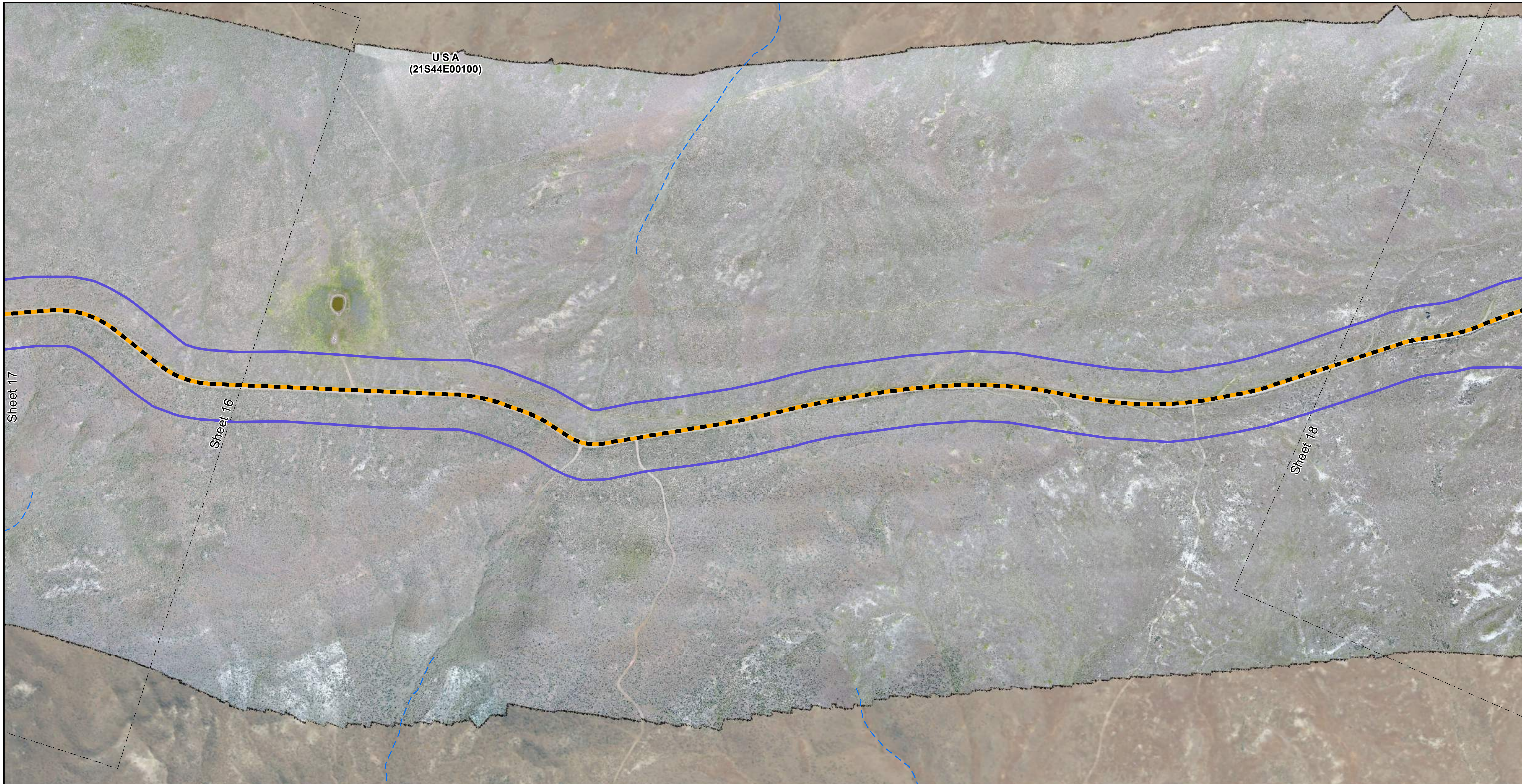

Legend

- Existing Road (Widening)
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
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Calico - Grassy Mountain Project
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Access Road Improvements

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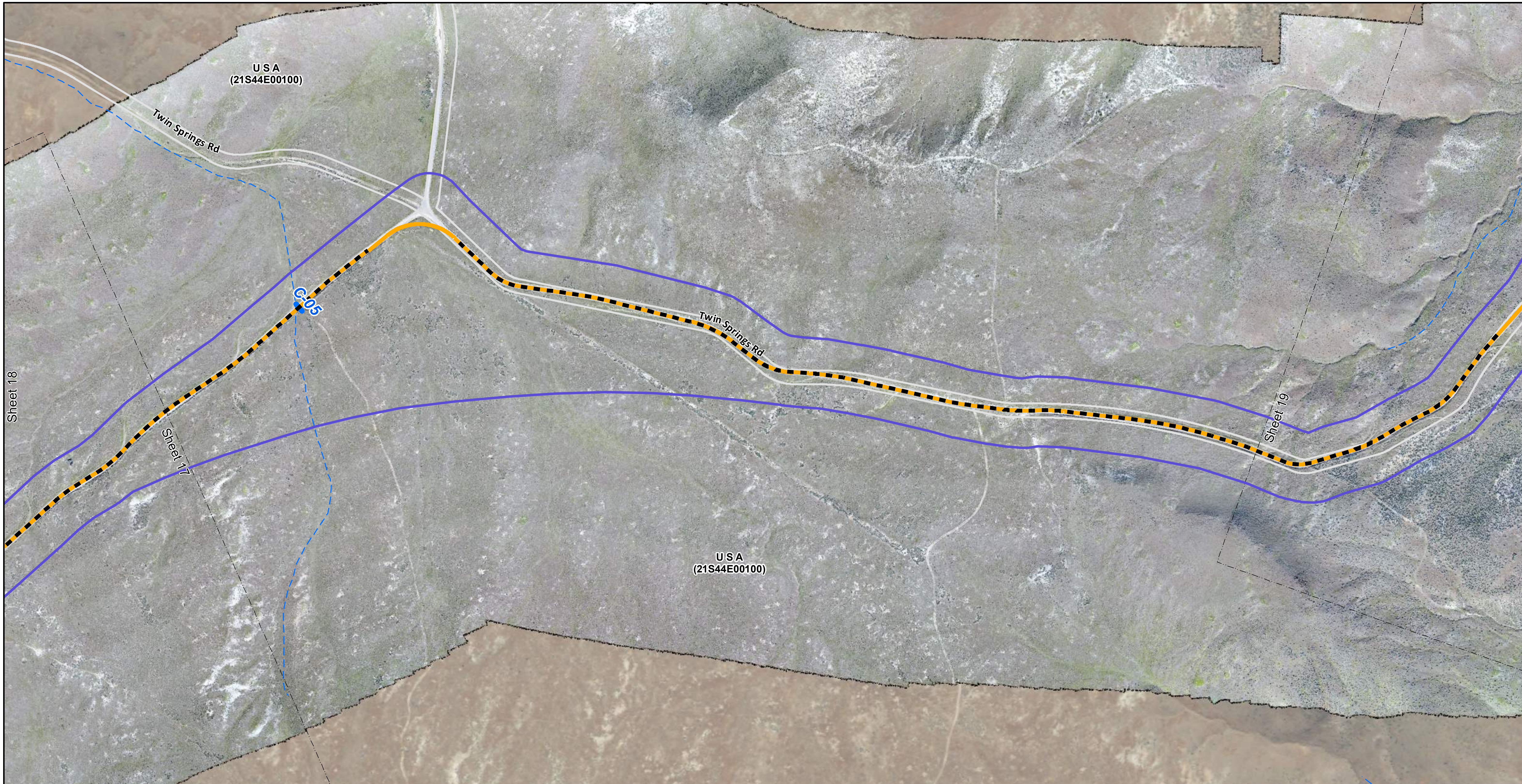

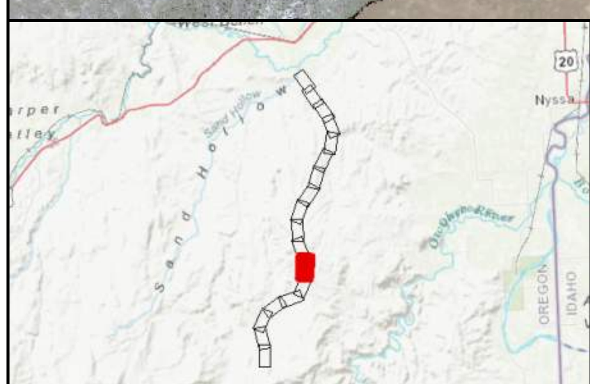

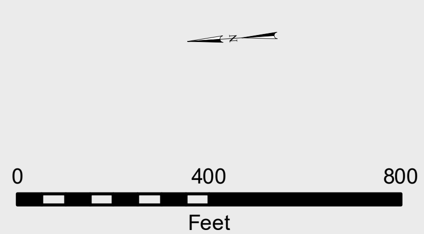

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

Photomaps
Plan View
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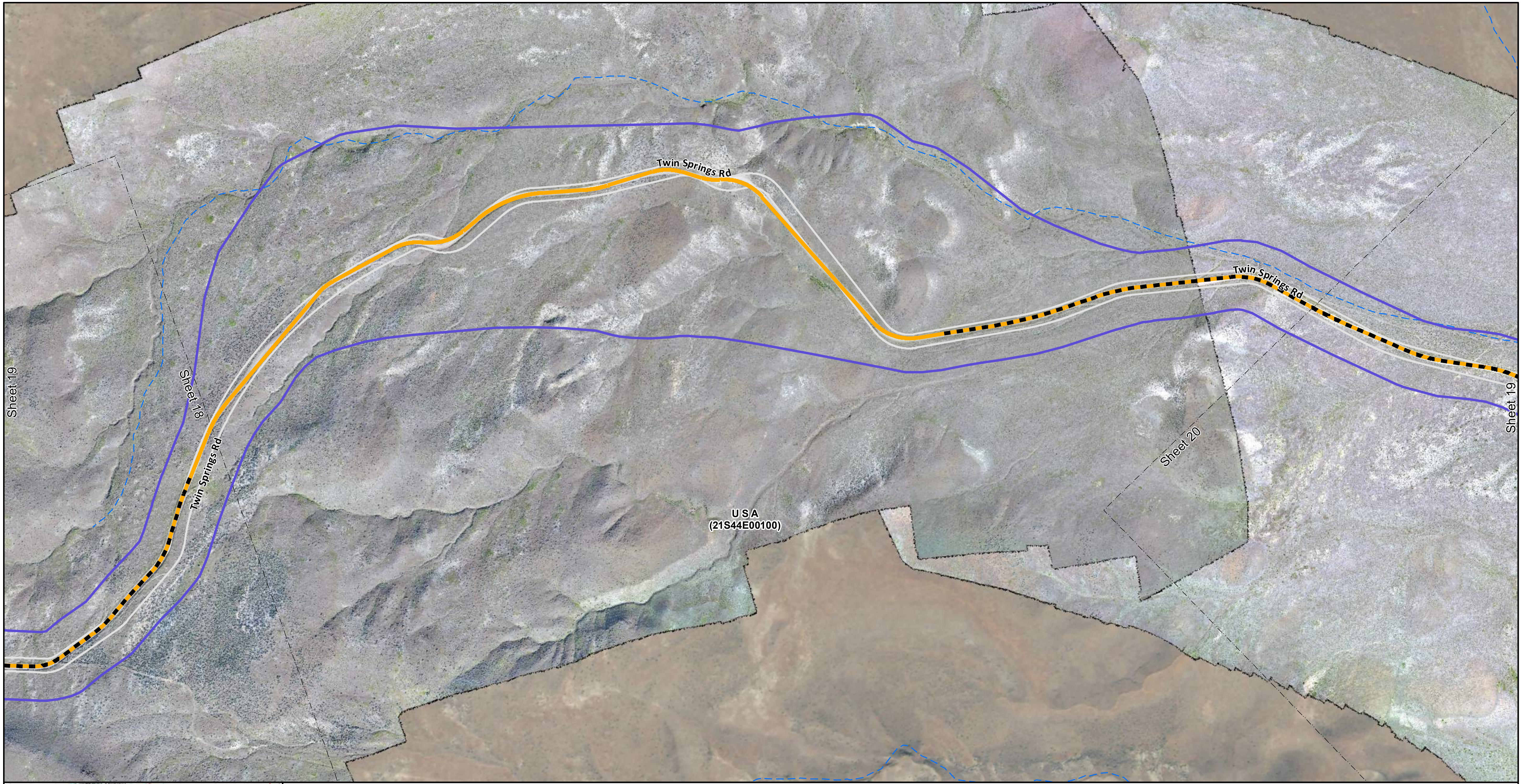

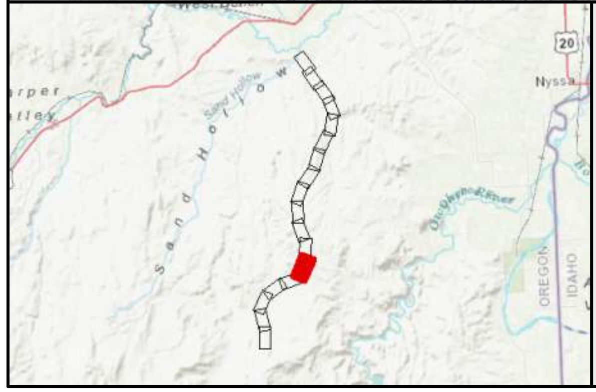

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
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Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

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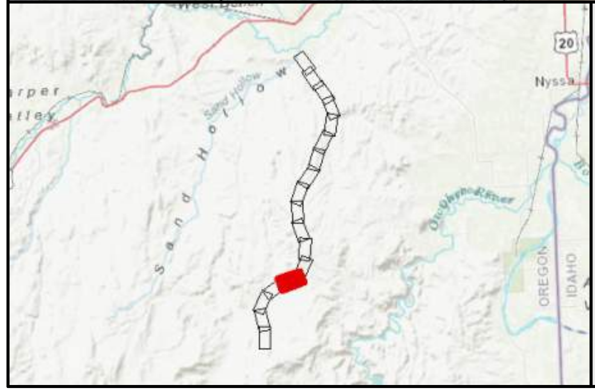

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
Sheet 15 of 19

Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

Date: 10/21/2019

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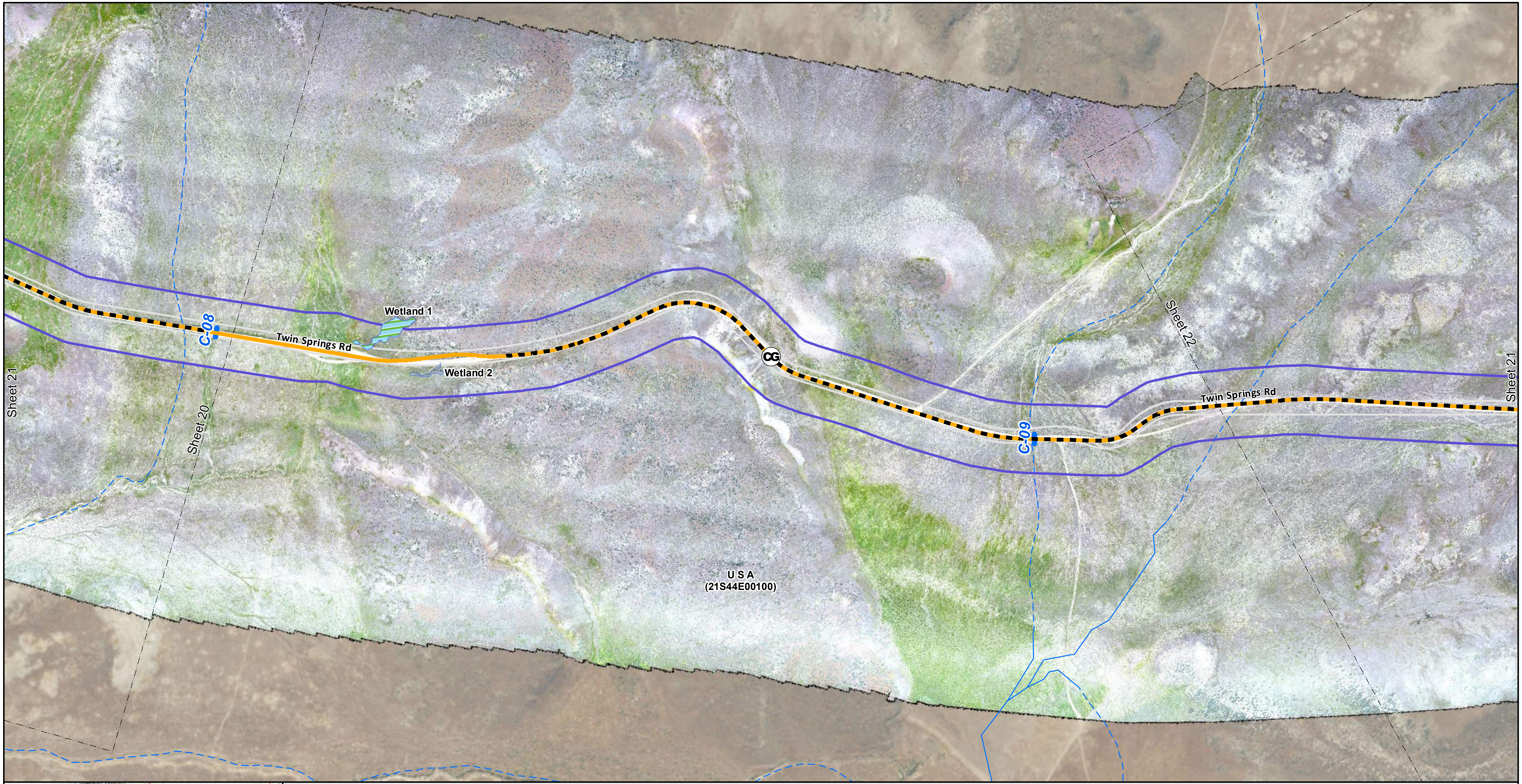

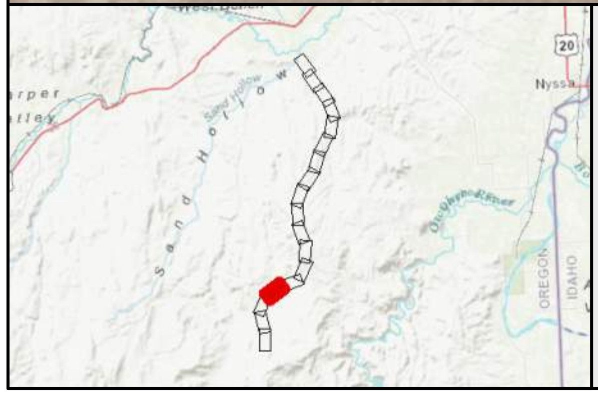

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- CG Cattle Guard, Existing
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Perennial Stream/Canal
- Intermittent Stream/Ditch
- Wetland
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
Sheet 16 of 19

Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

Date: 10/21/2019

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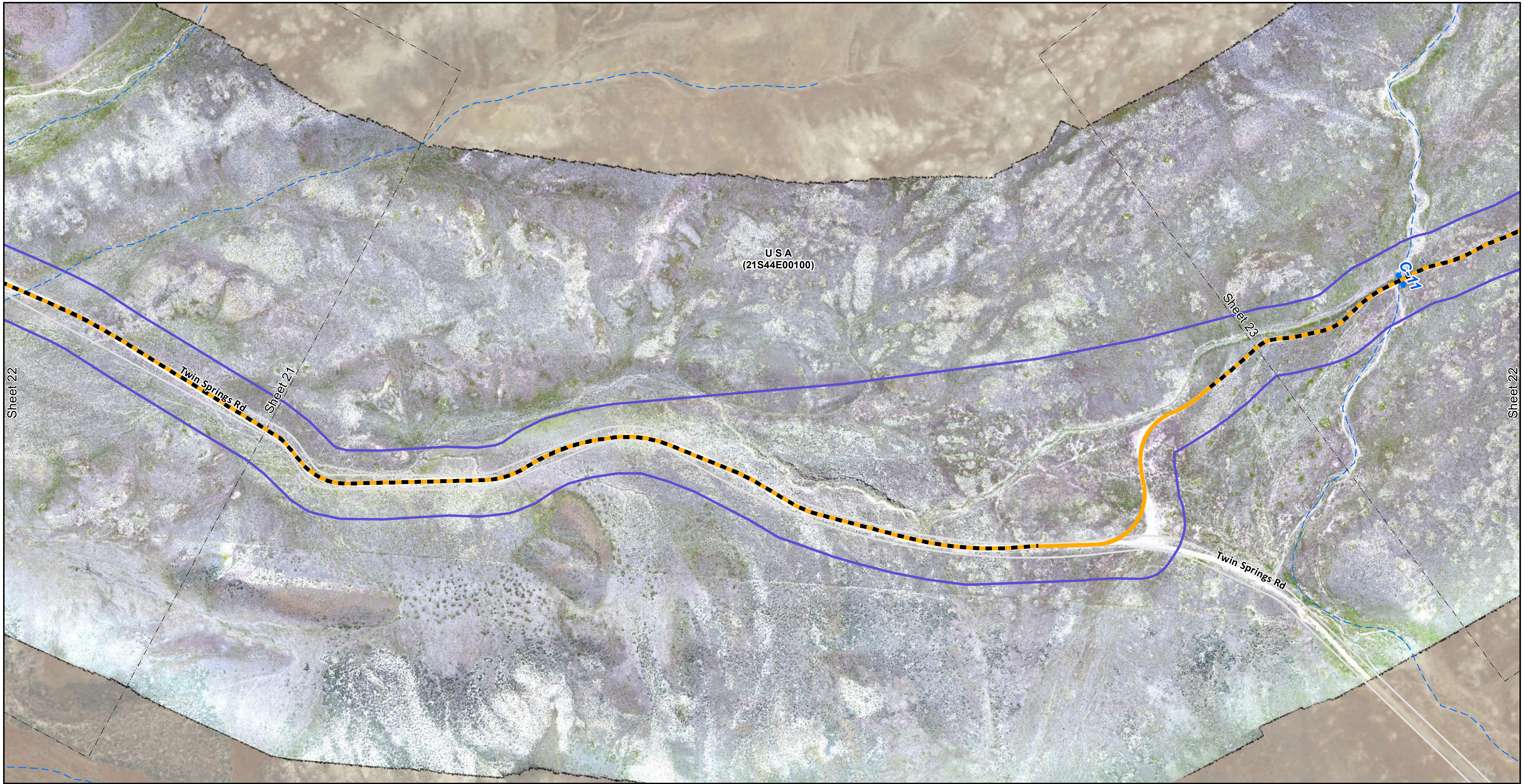

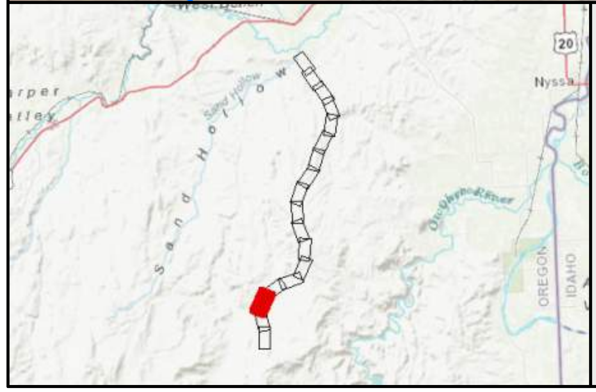

Legend

- Existing Road (Widening)
- Road Reconstruction Limits
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
Sheet 17 of 19

Calico - Grassy Mountain Project
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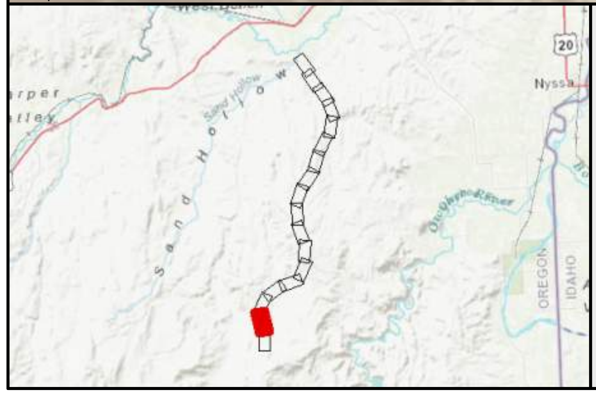

Legend

- Existing Road (Widening)
- Cross Drain Culvert
- Permit Corridor Line
- Parcel
- Perennial Stream/Canal
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
Sheet 18 of 19

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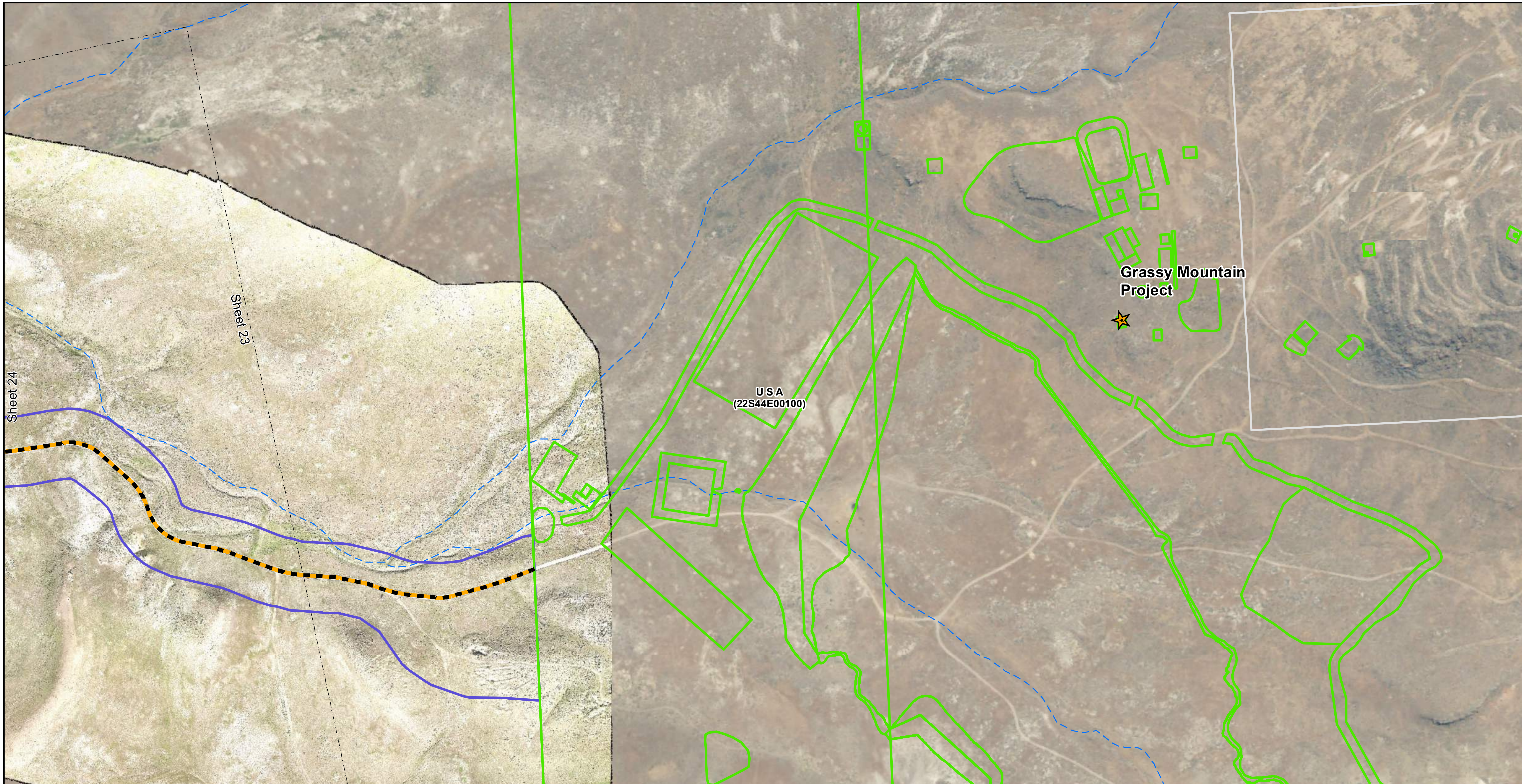

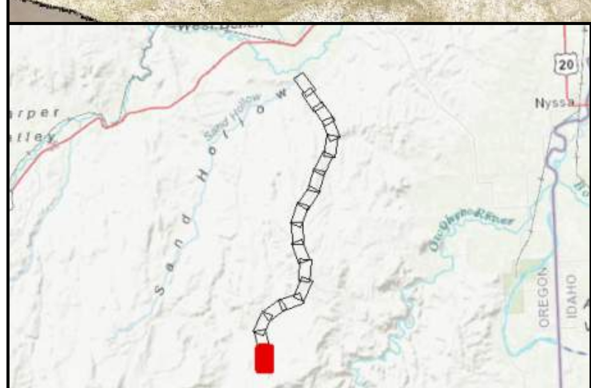

Legend

- Existing Road (Widening)
- Substation/Sub Tie-In
- Permit Corridor Line
- Proposed Mine Features
- Parcel
- Intermittent Stream/Ditch
- Adjacent Sheet

0 400 800
Feet

Photomaps
Plan View
Sheet 19 of 19

Calico - Grassy Mountain Project
34.5 kV Distribution Line
Access Road Improvements

Date: 10/21/2019

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Appendix B
Design Criteria Matrix

Design Criteria Matrix for Grassy Mountain Access Road Project

Project Number: 10162362	**Terrain Type:** Vaires	**Date:** 3/22/2019
GIS Number:	**Highway Number:**	**Project Standards:** BLM and Owner
Functional Classification: BLM Collector	**MP to MP:** Intersection of HWY-20 and Russel Rd to mine site.	**FHWA Project of Interest:** NO
Construction Year:	**Design Year:**	

Project Description:

The purpose of the project is to review the existing road from Highway 20 to the mine site to identify areas needing improvements to support equipment accessing the mine. Improvements will focus on upgrading portions of the road that do not meet BLM standards, existing sections of road that meet standard will not be improved. The design will include roadway design and culvert sizing and placement.

Proposed Work Includes: Excavation, Drainage, Base, Subbase

Design Item	Criteria	Ref. Material
Design Elements		
Design Speed (mph)	35	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27
Design Vehicle (max)	WB-67	Calico Requirement
Design Load	HS-20	Calico Requirement
Horizontal Alignment		
Minimum Curve Radius (ft.)	***460 feet unless shorter radii are approved*** Design without substantial truck recreational and vehicle volumes, acceptable operations can be obtained with smaller curve radii then shown in Exhibit 3 (p. 23). May reduce design speed 5 to 10 mph from tangents: 35 mph = 420’ radii @ 4% max e 30 mph = 300’ radii @ 4% max e 25 mph = 205’ radii @ 4% max e	***BLM Gold Book - BLM Collector and FS Arterial Road, Page 27*** AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400) (2001), page 24
Minimum Curve Length (ft.)	500 feet for a 5 degree central angle. Where sight distance is limited, choose curves that appear to flow rather than curves that appear abrupt	BLM Handbook 9113-1 pg 5
Curve Widening Radius, width	Designed to suit local road characteristics. Varies depending on degree of curve, WB-67 wheel path and topography $Z = V / \sqrt{R}$ where: Z = extra width allowance, ft V = design speed of the highway, mph R = radius of curve or turning roadway (two-lane), ft	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27 AASHTO - Green Book (2011) equation 3-33 page 3-90

Design Criteria Matrix for Grassy Mountain Access Road Project

Design Item	Criteria	Ref. Material
Vertical Alignment		
Maximum Grade (%)	Maximum grade is 8 percent (except pitch grades not exceeding 300 feet in length and 10 percent in grade).	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27
Minimum Grade (%)	Avoid grades less than 0.5 percent due to difficulty in providing drainage of side ditches	BLM Handbook 9113-1 pg 6
Curve Location	When possible, avoid locating a vertical curve within a horizontal curve.	BLM Handbook 9113-1 pg 6
Minimum Curve Length (ft.)	3 X Design Speed 105	AASHTO - Geometric Design of Highways and Streets, page 3-153
Minimum Crest (K)	Based on Design Speed 14	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27 AASHTO - Geometric Design of Very Low-Volume Local Roads Exhibit 12, page 39
Minimum Sag (K)	Based on Design Speed 14	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27 AASHTO - Geometric Design of Very Low-Volume Local Roads Exhibit 12, page 39
Stopping Sight Distance (ft.)	170	AASHTO - Geometric Design of Very Low-Volume Local Roads Exhibit 12, page 39
Cross Section Elements		
Travelway (ft.)	20	Calico Recommendation
Shoulder Width	2 (each side)	Calico Recommendation
Subgrade Width	Select to the nearest 2' (applies to curve widening too)	BLM Handbook 9113-1 pg 7
Friction Factor	0.14	Calico Recommendation
Road Crown	Place shoulderline crowns with the downstream shoulder highest in order to prevent erosion of fills. Recommended slopes are as follows: ***Earth Surface .03-.05 ft./ft.*** ***Aggregate Surface .02-.04 ft./ft.*** ***Paved Surface .02-.03 ft./ft.***	BLM Handbook 9113-1 pg 7
Ditches	2:1 Cut Slope	BLM Handbook 9113-1 pg 7
Fill Widening	Fill widening must be a minimum of 2 feet where the slope is 2:1 or steeper	BLM Handbook 9113-1 pg 7

Design Criteria Matrix for Grassy Mountain Access Road Project

Design Item	Criteria	Ref. Material
Traffic		
ADT (Present/Future)	< 100	Calico Recommendation
DHV (Present/Future)	< 100	Calico Recommendation
Drainage		
Design Storm (peak flow)	25 Year	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27
Minimum Culvert Diameter (in)	18	BLM Gold Book - BLM Collector and FS Arterial Road, Page 28
Minimum Culvert Cover (in)	12 inches or one-half the diameter, whichever is greater. Compliance with manufacturer's recommendations for cover over various culvert materials is necessary	BLM Handbook 9113-1 pg 11
Culvert Spacing	Culverts carrying runoff from one side of the road to the other between natural drainages are spaced as shown in Illustration 10 – Spacing for Drainage Laterals, unless local experience dictates otherwise.	BLM Handbook 9113-1 pg 23
Design Drawing and Templates		
Plan and Profile	To be plotted on standard plan and profle sheets to a scale of 1 inch = 100 feet horizontal and 1 inch = 20 feet vertical	BLM Gold Book - BLM Collector and FS Arterial Road, Page 27-29
Cross Sections	Standard templates of road cross-sections, drainage design, and culvert location and installation are required (Examples in Figures 3 through 6).	BLM Gold Book - BLM Collector and FS Arterial Road, Page 28
Materials	Mass diagrams and materials investigation and classifcation may be required.	BLM Gold Book - BLM Collector and FS Arterial Road, Page 28

Appendix C
Roadway and Drainage Plans

PARAMOUNT GOLD NEVADA CORPORATION

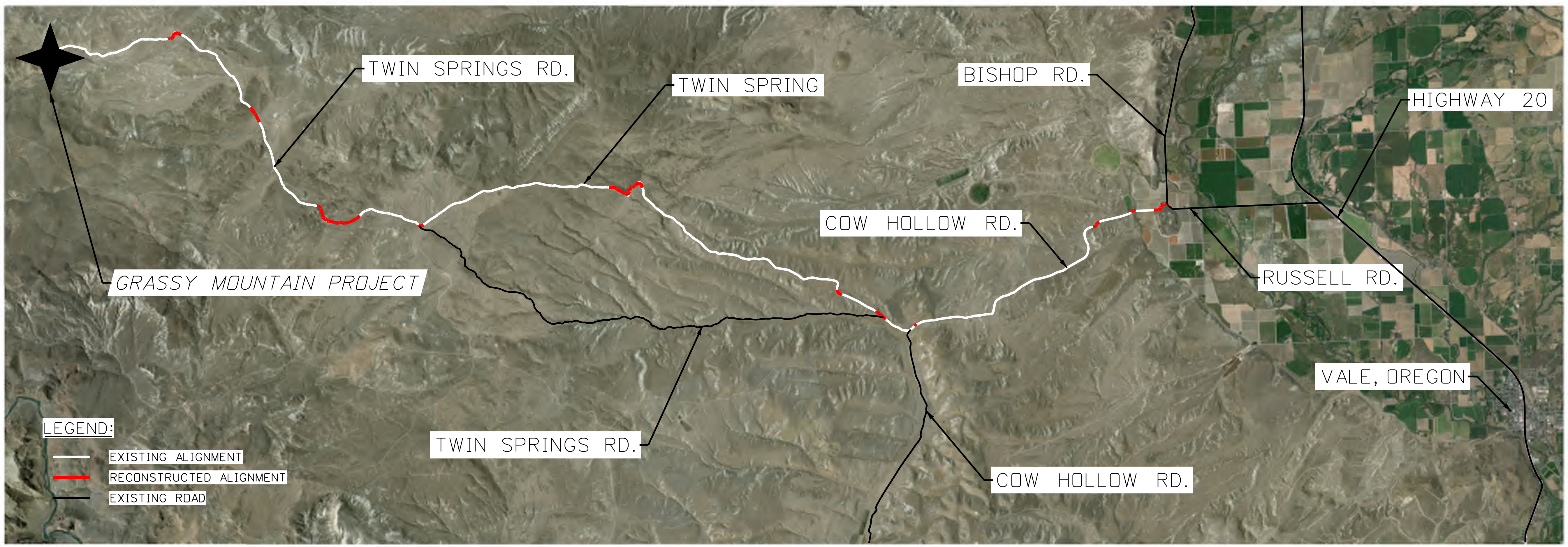
ROADWAY AND DRAINAGE PLANS

FOR

GRASSY MOUNTAIN PROJECT

MALHEUR COUNTY, OREGON

OCTOBER 2019



FEET
4250 0 8500

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR.

DESIGNED BY: S. WARMBRODT
DATE: OCTOBER 2019
DWN BY: SGW
CKD BY: L. GREBE
HDR PROJECT NUMBER: 10[illegible]
PLOT SCALE:
PLOT DATE: 10\2\2019
SIZE: 11X17
FILE NAME: TITL_001.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS

COVER AND VICINITY MAP

SHEET IDENTIFICATION
SHEET 1
OF 25

GENERAL NOTES:

1. TOPOGRAPHIC SURVEY WAS PERFORMED BY TCI CORP WITH A DRONE. THE COORDINATE SYSTEM USED FOR THIS PROJECT IS BASED ON THE OREGON STATE PLANE NAD 83 (2011) (EPOCH 2010), NAVD88 (GEOID12B) SOUTH ZONE (INTERNATIONAL FEET). THE CONTROL WAS DERIVED FROM THREE STATIONS USING STATIC DATA OBSERVATIONS PROCESSED THROUGH O.P.U.S. FROM THESE THREE STATIONS ADDITIONAL CONTROL FOR AERIAL TOPOGRAPHY WAS SET USING RTK METHODS FROM MAY 1 - MAY 5, 2017. AERIAL PHOTOGRAPHY WAS PERFORMED BY TCI CORP ON MAY 11, 2017.
2. ALL CONSTRUCTION MATERIAL AND WORKMANSHIP SHALL COMPLY WITH THE LATEST MALHEUR COUNTY, STATE OF OREGON, AND BUREAU OF LAND MANAGEMENT REQUIREMENTS. ALL CONSTRUCTION SHALL BE PERFORMED IN ACCORDANCE WITH THE MOST CURRENT STANDARDS FOR PUBLIC WORKS CONSTRUCTION AND THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY (D.E.Q) STANDARDS.
3. PRIOR TO ANY CONSTRUCTION OR EXCAVATION, CONTRACTOR IS REQUIRED TO SCHEDULE A PRE-CONSTRUCTION MEETING INVOLVING THE OWNER, ENGINEER, BUREAU OF LAND MANAGEMENT, COUNTY ROAD MASTER, AND THE UTILITY COMPANIES ASSOCIATED WITH THIS PROJECT.
4. THE CONTRACTOR IS RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE AGENCIES GOVERNING THE CONSTRUCTION FOR THIS PROJECT PRIOR TO THE START OF CONSTRUCTION.
5. THE CONTRACTOR SHALL VERIFY ALL EXISTING UTILITY LOCATIONS AND COORDINATE WITH UTILITY COMPANIES FOR ANY PROTECTIVE MEASURES OR RELOCATIONS REQUIRED.
6. THE CONTRACTOR SHALL COORDINATE INSTALLATION OF UTILITIES TO AVOID CONFLICTS AND ASSURE PROPER DEPTHS ARE ACHIEVED AS WELL AS COORDINATE WITH THE REGULATORY AGENCY AS TO THE LOCATIONS AND TIE-IN/CONNECTIONS TO THEIR FACILITIES.
7. THE CONTRACTOR IS RESPONSIBLE FOR THE INSTALLATION AND MAINTENANCE OF ALL SIGNS FOR SAFETY AND TRAFFIC.
8. CONTRACTOR IS RESPONSIBLE FOR VERIFYING ALL DESIGN GRADES AND LOCATIONS PRIOR TO CONSTRUCTION, ANY DISCREPANCY SHOULD BE REPORTED TO THE ENGINEER IMMEDIATELY. NO CHANGES OR DEVIATION FROM DESIGN WILL BE MADE WITHOUT APPROVAL FROM ENGINEER.
9. CONTRACTOR SHALL RETAIN AND PROTECT ALL EXISTING ROAD ACCESS AND DRIVEWAYS. IF THE ROAD ACCESS IS DISTURBED DURING CONSTRUCTION. THE CONTRACTOR IS RESPONSIBLE FOR THE REMOVAL AND REPLACEMENT OF ALL DAMAGED AREAS.

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10	STA. 1183+50 TO STA. 1190+00
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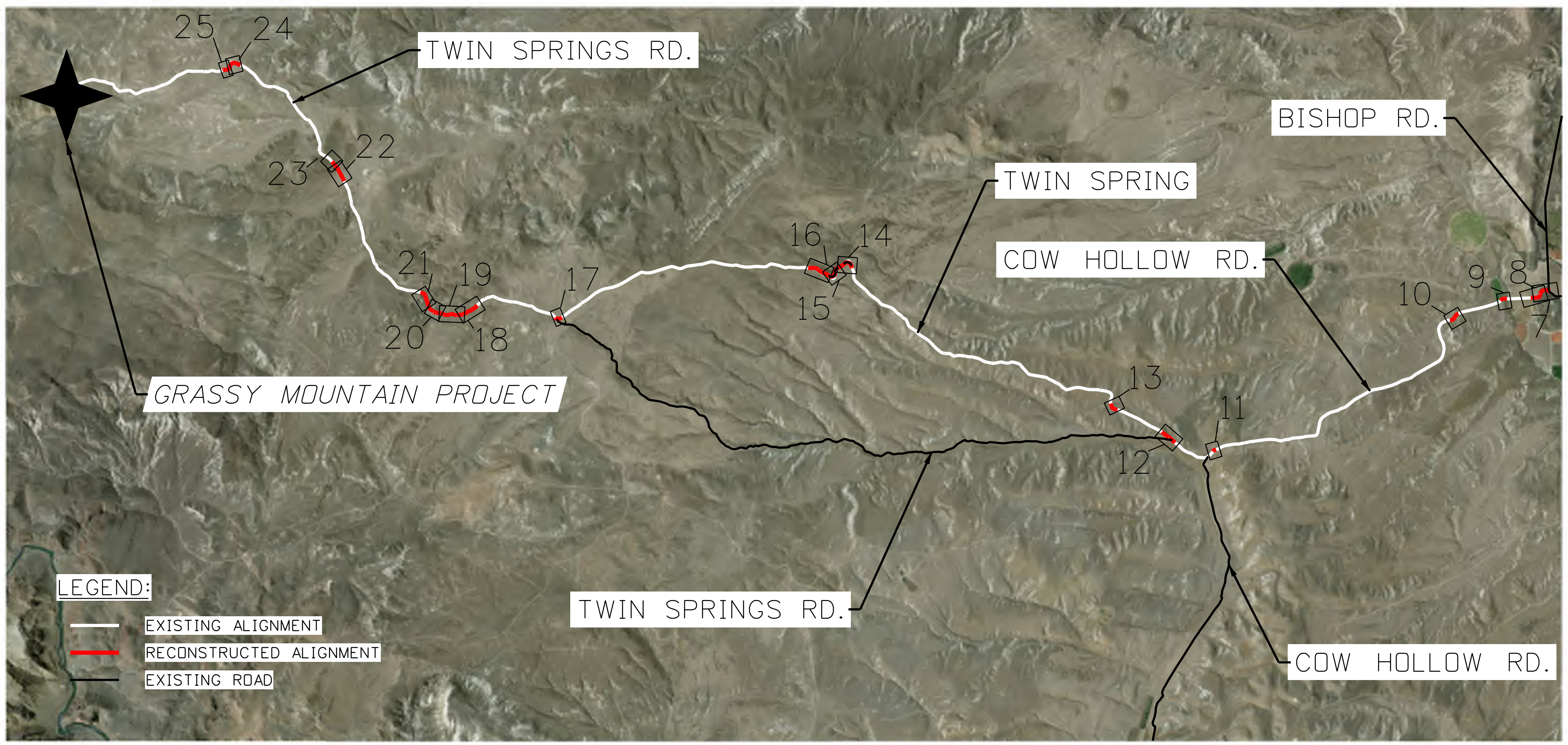
18	STA. 1857+70 TO STA. 1868+00
19	STA. 1868+00 TO STA. 1880+00
20	STA. 1880+00 TO STA. 1889+00
21	STA. 1889+00 TO STA. 1899+00
22	STA. 1983+00 TO STA. 1993+00
23	STA. 1993+00 TO STA. 1996+25
24	STA. 2078+50 TO STA. 2086+00
25	STA. 2086+00 TO STA. 2090+50



PLAN VIEW KEY MAP

FEET
4250 0 8500

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK | DESCRIPTION | DATE | APPR

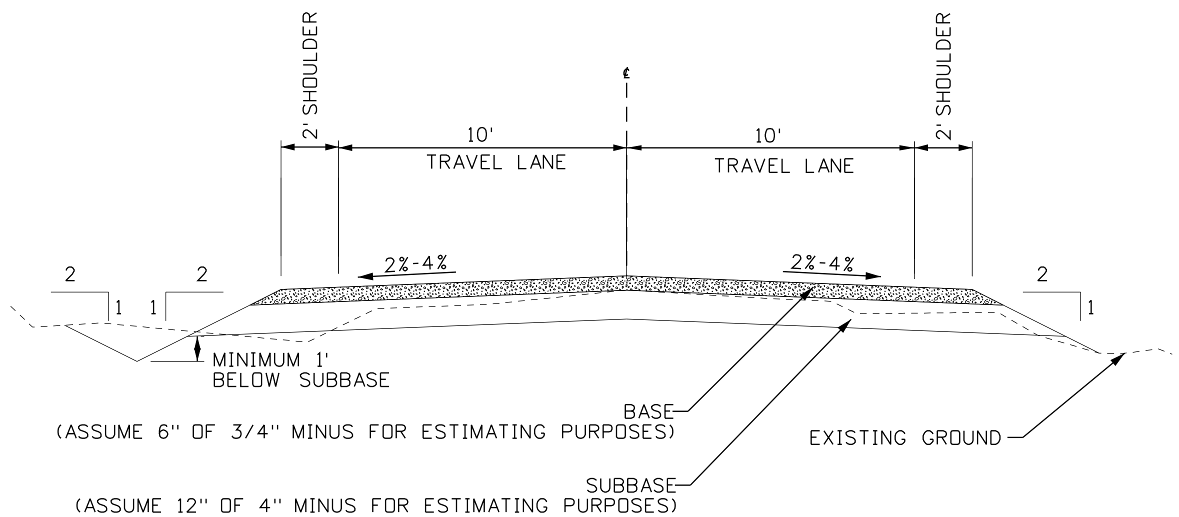
DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
SIZE: 11X17
FILE NAME: TITL_002.SHT

PRELIMINARY

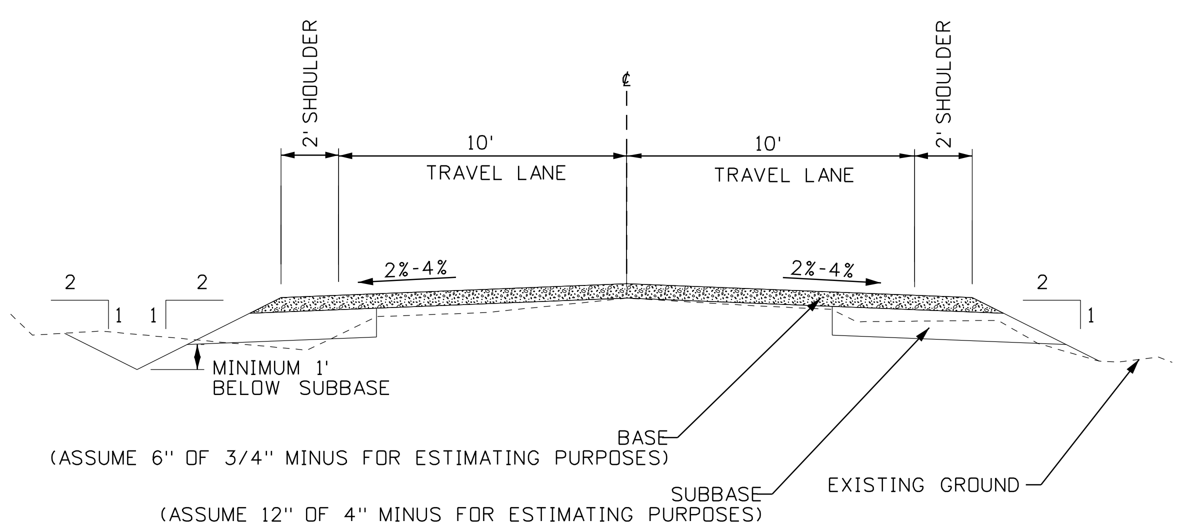
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
KEY MAP, NOTES AND DRAWING INDEX

SHEET IDENTIFICATION
SHEET 2
OF 25



TYPICAL SECTION
RECONSTRUCTION



TYPICAL SECTION
WIDENING

TYPICAL SECTION NOTES:

1. THE ROADWAY SOUTH OF BISHOP ROAD TO THE GRASSY MOUNTAIN MINE SITE SHALL BE GRADED AND WIDENED ACCORDINGLY. NEW SUBBASE MATERIAL SHALL BE ADDED BENEATH ROADWAY WIDENING.
2. ALL ROAD RECONSTRUCTION AND RE-ALIGNMENTS SHALL BE GRADED TO MATCH EXISTING AT THE STATIONS SHOWN ON THE PLANS.
3. ALL ORGANIC OR DISTURBED SOILS SHALL BE REMOVED TO A DEPTH OF 0.5 FOOT MINIMUM PRIOR TO ROAD CONSTRUCTION.
4. ALL ELEVATIONS ARE FINISH GRADE UNLESS OTHERWISE NOTED.

EARTHWORK QUANTITIES

STATIONING:	LENGTH (FEET)	EXCAVATION (CY)	BASE (CY)	SUBBASE (CY)
P: STA. 1127+00.00 TO STA. 1140+50.00	1,350	1,420	625	1,350
E: STA. 140+46.03 TO STA. 154+10.10	1,364	400	631	505
P: STA. 1154+10.00 TO STA. 1158+00.00	390	990	181	390
E: STA. 158+08.00 TO STA. 183+50.00	2,542	800	1,177	941
P: STA. 1183+50.00 TO STA. 1190+00.00	650	790	301	650
E: STA. 190+09.50 TO STA. 363+00.00	17,292	5,100	8,006	6,404
P: STA. 1363+00.00 TO STA. 1365+30.00	230	170	106	230
E: STA. 365+35.09 TO STA. 391+00.00	2,565	800	1,188	950
P: STA. 1391+00.00 TO STA. 1400+50.00	950	1,450	440	950
E: STA. 400+50.00 TO STA. 429+50.00	2,900	900	1,343	1,074
P: STA. 1429+50.00 TO STA. 1435+00.00	550	310	255	550
E: STA. 435+07.32 TO STA. 618+00.00	18,296	5,400	8,470	6,776
P: STA. 1618+00.00 TO STA. 1650+50.00	3,250	23,710	1,505	3,250
E: STA. 653+31.95 TO STA. 804+00.00	15,068	4,400	6,976	5,581
P: STA. 1804+00.00 TO STA. 1808+50.00	450	190	208	450
E: STA. 808+91.37 TO STA. 857+70.00	4,879	1,400	2,259	1,807
P: STA. 1857+70.00 TO STA. 1899+00.00	4,130	10,850	1,912	4,130
E: STA. 899+40.54 TO STA. 983+00.00	8,364	2,500	3,872	3,098
P: STA. 1983+00.00 TO STA. 1996+25.00	1,350	1,570	625	1,350
E: STA. 996+31.33 TO STA. 1078+50.00	8,218	2,400	3,805	3,044
P: STA. 2078+50.00 TO STA. 2090+50.00	1,200	290	556	1,200
E: STA. 1091+42.50 TO STA. 1176+57.88	8,515	2,500	3,942	3,154
TOTAL	104,500	68,340	48,380	47,830

* E: STATION ARE EXISTING NON-REALIGNMENT SECTIONS, AND P: STATION ARE PROPOSED REALIGNMENT SECTIONS.

** EMBANKMENT CONSTRUCTION IS INCIDENTAL TO EXCAVATION WORK AND QUANTITIES WILL BE BALANCED WITHIN EACH RECONSTRUCTION SEGMENT THROUGH SIDE-CASTING OF UNSUITABLE MATERIAL, OR ROADWAY WIDENING AND PROFILE ADJUSTMENTS WITH SUITABLE MATERIAL.

CURVE WIDENING TABLE

RADIUS	WIDEN INSIDE	LENGTH INSIDE
50	5	50
100	4	47
150	3	35
200	3	35
250	3	35
300	3	35
350	2	24
400	2	24
450	1	10
500	0	0

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK | DESCRIPTION | DATE | APPR

DESIGNED BY: S. WARMBROOT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
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PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
TYPICAL SECTIONS AND QUANTITIES

SHEET IDENTIFICATION
SHEET 3
OF 25

DITCH RELIEF CULVERT SUMMARY

BEGIN STA	END STA	REACH LENGTH (FT)	AVG. GRADE (%)	MIN CULVERT SPACING (FT)	NUMBER OF CULVERTS
119+25.65	129+64.34	1039	2	1225	1
129+64.34	132+58.74	294	9	270	2
132+58.74	136+15.09	356	-2	1225	1
136+15.09	137+95.69	181	-7	350	1
137+95.69	173+09.00	3513	-2	1225	3
173+09.00	177+00.00	391	2	1225	1
177+00.00	178+60.00	160	4	610	1
178+60.00	188+34.00	974	-3	815	2
188+34.00	190+55.00	221	4	610	1
190+55.00	191+96.00	141	-2	1225	1
191+96.00	210+48.00	1852	2	1225	2
210+48.00	283+77.00	7329	2	1225	6
283+77.00	304+73.00	2096	3	815	3
304+73.00	308+00.00	327	2	1225	1
308+00.00	311+00.00	300	7	350	1
311+00.00	315+84.00	484	2	1225	1
315+84.00	316+00.00	16	-8	305	1
316+00.00	324+32.00	832	5	490	2
324+32.00	331+00.00	668	-3	815	1
331+00.00	336+00.00	500	4	610	1
336+00.00	354+00.00	1800	8	305	6
354+00.00	371+00.00	1700	-2	1225	2
371+00.00	375+00.00	400	2	1225	1
375+00.00	394+00.00	1900	2	1225	2
394+00.00	402+00.00	800	8	305	3
402+00.00	468+00.00	6600	5	490	14
468+00.00	472+00.00	400	-4	610	1
472+00.00	506+00.00	3400	2	1225	3
506+00.00	535+00.00	2900	3	815	4
535+00.00	544+01.00	901	-7	350	3
544+01.00	563+00.00	1899	5	490	4
563+00.00	569+00.00	600	-2	1225	1
569+00.00	575+01.00	601	5	490	2
575+01.00	579+00.00	399	2	1225	1
579+00.00	624+00.00	4500	7	350	13
624+00.00	631+13.00	713	-2	1225	1
631+13.00	635+00.00	387	-11	220	2
635+00.00	650+00.00	1500	10	245	7
650+00.00	656+00.00	600	4	610	1
656+00.00	663+00.00	700	9	270	3
663+00.00	695+00.00	3200	2	1225	3
695+00.00	708+04.00	1304	6	410	4
708+04.00	737+00.00	2896	2	1225	3

DITCH RELIEF CULVERT SUMMARY CONT.

BEGIN STA	END STA	REACH LENGTH (FT)	AVG. GRADE (%)	MIN CULVERT SPACING (FT)	NUMBER OF CULVERTS
737+00.00	745+00.00	800	2	1225	1
745+00.00	751+00.00	600	-4	610	1
751+00.00	760+00.00	900	2	1225	1
760+00.00	801+00.00	4100	-4	610	7
801+00.00	807+00.00	600	2	1225	1
807+00.00	835+00.00	2800	3	815	4
835+00.00	848+16.00	1316	-3	815	2
848+16.00	861+00.00	1284	-6	410	4
861+00.00	880+00.00	1900	-8	305	7
880+00.00	908+00.00	2800	-6	410	7
908+00.00	956+00.00	4800	-4	610	8
956+00.00	992+77.00	3677	2	1225	4
992+77.00	1005+00.00	1223	4	610	3
1005+00.00	1033+00.00	2800	2	1225	3
1033+00.00	1074+00.00	4100	3	815	6
1074+00.00	1100+82.00	2682	2	1225	3
1100+82.00	1144+23.00	4341	3	815	6
1144+23.00	1146+39.00	216	-3	815	1
1146+39.00	1152+00.00	561	6	410	2
1152+00.00	1155+00.00	300	-7	350	1
1155+00.00	1176+84.00	2184	3	815	3
				TOTAL CULVERTS:	192

NOTES:
1. ALL DITCH RELIEF CULVERTS SHALL BE 18 INCHES IN DIAMETER

CROSS DRAIN CULVERT SUMMARY

CULVERT ID	EXISTING STATIONING	PEAK FLOWS (CFS)		PIPE MATERIAL	PIPE DIMENSIONS							NUMBER OF BARRELS	FILL HEIGHT (FEET)	RIPRAP D50 (FEET)
					SIZE (INCHES)									
		10-YR	5-YR		18	24	30	36	42	48	54			
					LENGTH (FEET)									
C-01	305+56.00	18	23	CMP		37.0						2	3.0	0.5
C-02	393+79.00	14	20	CMP		69.0						2	3.0	0.5
C-03	634+11.00	31	44	CMP			40.0					2	3.8	0.5
C-04	675+10.00	21	30	CMP		38.0						2	3.0	0.5
C-05	800+15.00	21	30	CMP		38.0						2	3.0	1.0
C-06	940+20.00	56	72	CMP				40.0				2	4.5	0.5
C-07	944+25.00	84	109	CMP					43.0			2	5.3	0.5
C-08	983+55.00	59	76	CMP						35.0		1	6.0	0.5
C-09	1021+30.00	75	97	CMP				35.0				3	4.5	0.5
C-10	1132+64.00	16	21	CMP		45.0						2	3.0	0.5
C-11	1101+19.00	130	169	CMP					48.0			3	5.3	0.5

PARAMOUNT GOLD Nevada

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK | DESCRIPTION | DATE | APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
PLOT SCALE:
PLOT DATE:
DATE: OCTOBER 2019
HDR PROJECT
SIZE 11X17
FILE NAME: DRAN_003.SHT

PRELIMINARY

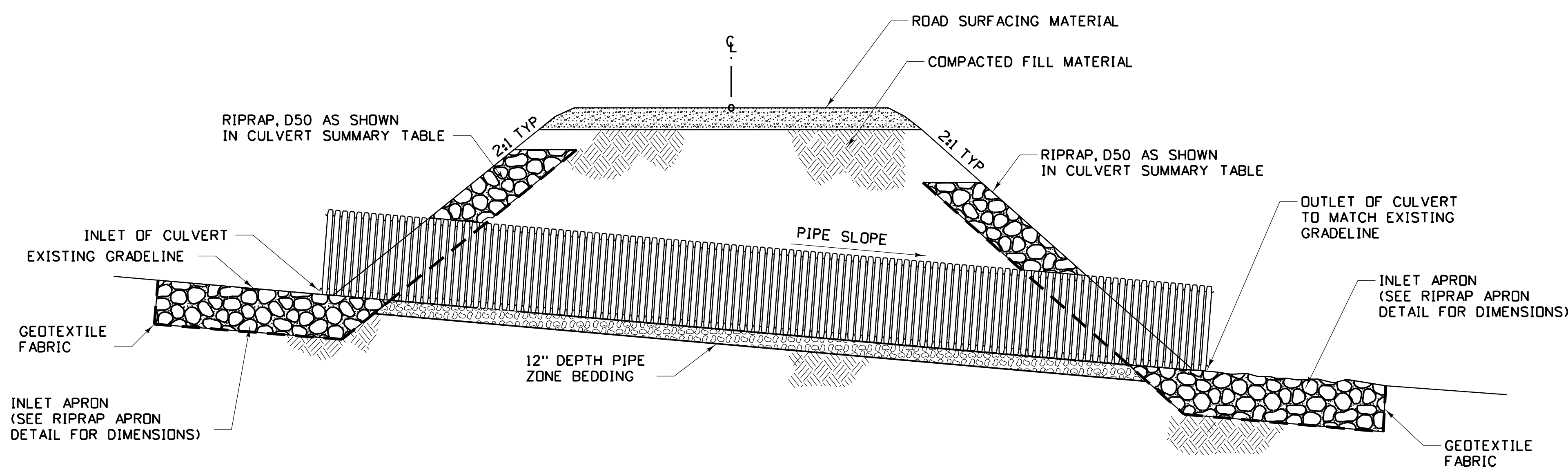
HDR

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS

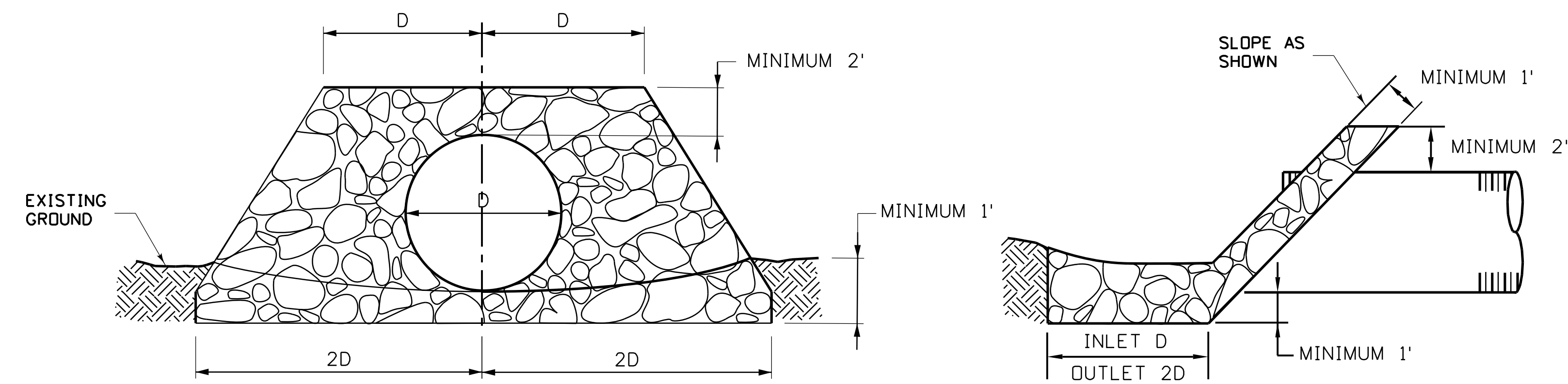
CULVERT SUMMARY

SHEET IDENTIFICATION
SHEET 4
OF 25



PROFILE VIEW - TYPICAL CULVERT INSTALLATION

NTS



FRONT VIEW

SIDE VIEW

RIPRAP APRON DETAIL

NTS

NOTES:

1. CULVERTS SHALL NOT BE INSTALLED AT SLOPES GREATER THAN 15%.
2. CONTRACTOR SHALL VERIFY ALL CULVERT LENGTHS BASED ON ACCESS ROAD DESIGN SIDE SLOPES AND EXISTING CONDITIONS FOUND IN THE FIELD.
3. CONTRACTOR TO VERIFY MINIMUM FILL HEIGHT BASED ON MANUFACTURERS SPECIFICATIONS.
4. SEE NOTES ON PLANS AND CULVERT SUMMARY TABLE FOR LOCATION AND SIZE OF CULVERT.
5. FOR CULVERT INSTALLATIONS AT ROADS WITH EXISTING ROADSIDE DITCHES, REGRADE THE DITCH TO PROVIDE THE MINIMUM REQUIRED CULVERT COVER AND POSITIVE DRAINAGE OF THE DITCH UPSTREAM AND DOWNSTREAM OF THE CULVERT. DITCH TRANSITION GRADING SHALL NOT EXCEED 15%.
6. ALL CULVERTS SHALL HAVE A MINIMUM SLOPE OF 0.50%.
7. APRON SURFACE MUST CONFORM TO SHAPE OF EXISTING GROUND AND BE LEFT ROUGH TO REDUCE WATER VELOCITY.

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

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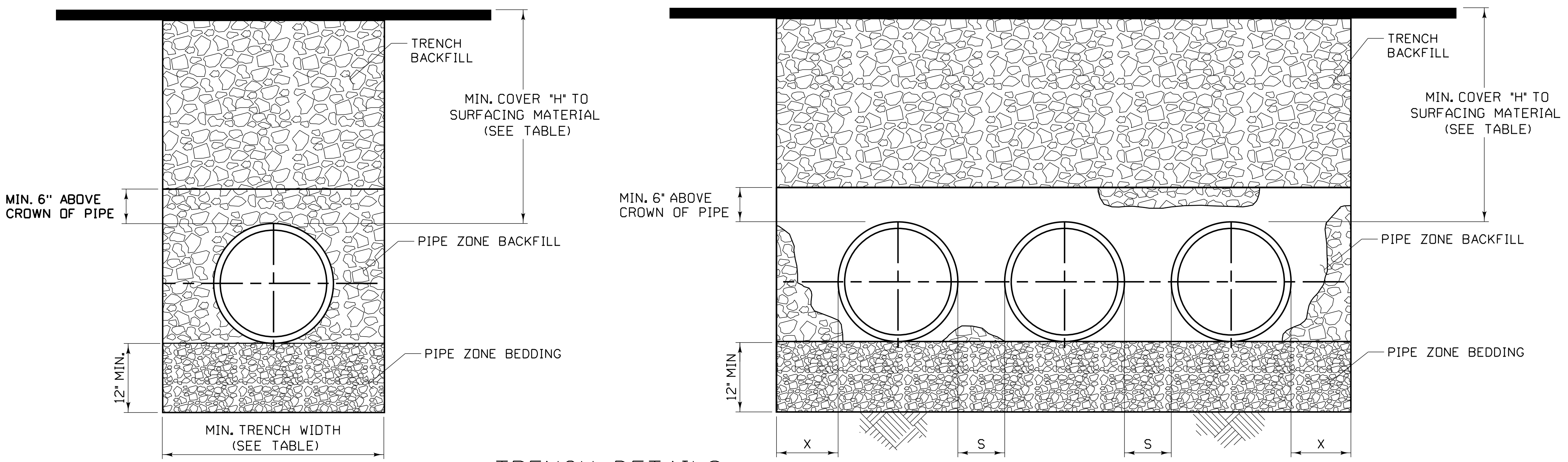
GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS

CULVERT DETAILS

SHEET IDENTIFICATION
SHEET 5
OF 25

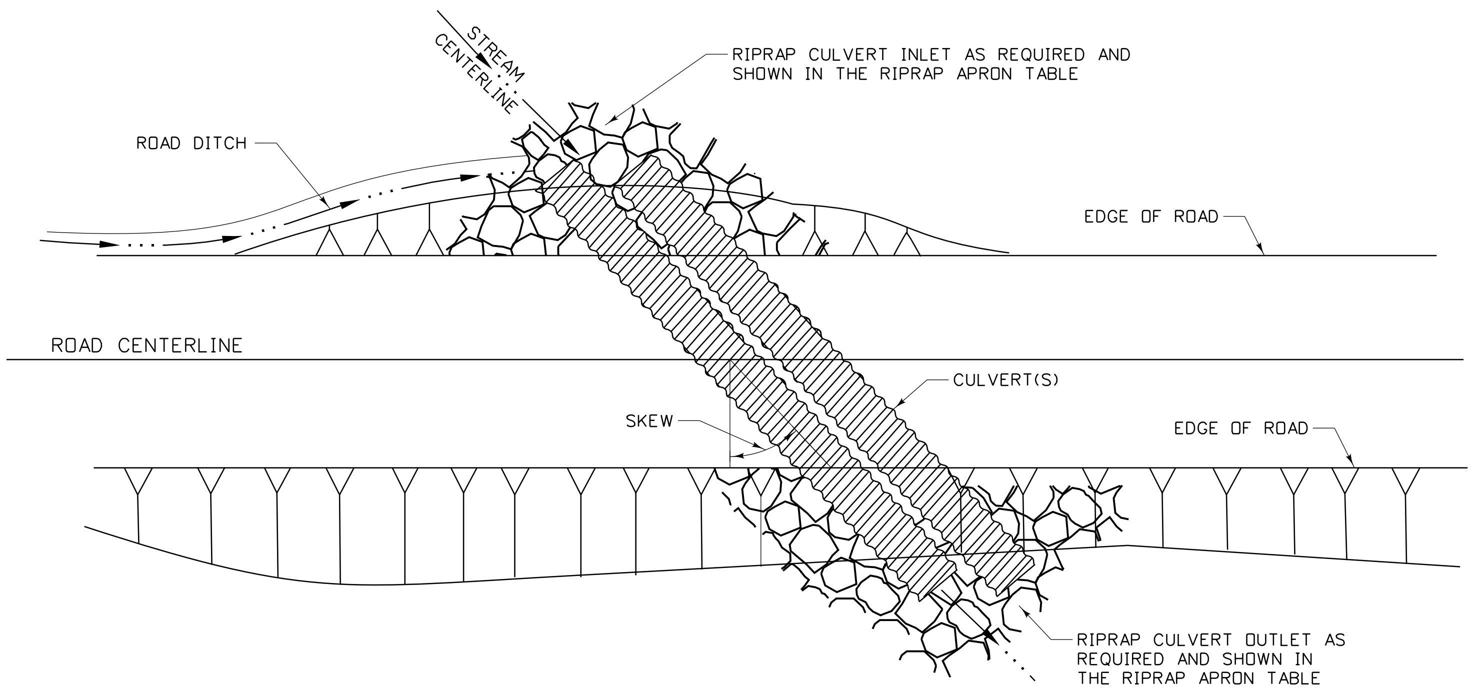


TRENCH DETAILS

NTS

NOTES:

1. MEASURES SHOULD BE TAKEN TO PREVENT MIGRATION OF NATIVE FINES INTO BACKFILL MATERIAL.
2. FOUNDATION: WHERE THE TRENCH BOTTOM IS UNSTABLE, THE CONTRACTOR SHALL EXCAVATE TO A DEPTH REQUIRED BY THE ENGINEER AND REPLACE WITH SUITABLE MATERIAL AS SPECIFIED BY THE ENGINEER. AS AN ALTERNATIVE, AND AT THE DISCRETION OF THE ENGINEER, THE TRENCH BOTTOM MAY BE STABILIZED USING A GEOTEXTILE MATERIAL.
3. COLLAR SHALL BE 2' THICK AS NOTED IN THE CULVERT INSTALLATION TYPICAL DETAIL.
4. COLLAR SHALL BE EMBEDDED INTO NATIVE MATERIAL A MINIMUM OF 6", COLLAR SHALL BE COMPOSED OF IMPERVIOUS MATERIAL TO PREVENT PIPING.
5. IMPERVIOUS MATERIAL COULD INCLUDE: COMPACTED CLAY, CONTROLLED DENSITY FILL, OR READY MIX ON-SITE CONCRETE.
6. SKEW CULVERT 30-45° FROM PERPENDICULAR TO ROAD CENTERLINE. NO SKEW NECESSARY ON ROADS WITH GRADE LESS THAN 3% OR AT A LOW POINT IN THE ROAD PROFILE.



SINGLE/DOUBLE CULVERT INSTALLATION
W/ SKEW & STAGGER GUIDANCE
PLAN VIEW

NTS

RECOMMENDED MINIMUM TRENCH WIDTHS AND COVER				
PIPE DIAM.	MIN. TRENCH WIDTH	MIN "X"	MIN "S" *	MIN. COVER "H"
18"	36"	9"	12"	12"
24"	48"	10"	12"	12"
30"	56"	18"	15"	12"
36"	64"	18"	18"	12"
42"	72"	18"	21"	12"
48"	80"	18"	24"	12"
54"	88"	18"	27"	24"
60"	96"	18"	30"	24"

* MINIMUM SPACING ("S") MEASUED FROM OUTSIDE DIAMETER TO OUTSIDE DIAMETER. ADDITTIONAL PARALLEL PIPES SHALL BE SPACED "S" DISTANCE APART WITH "X" DISTANCE FROM TRENCH SIDE WALL.

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665 ANDERSON ROAD
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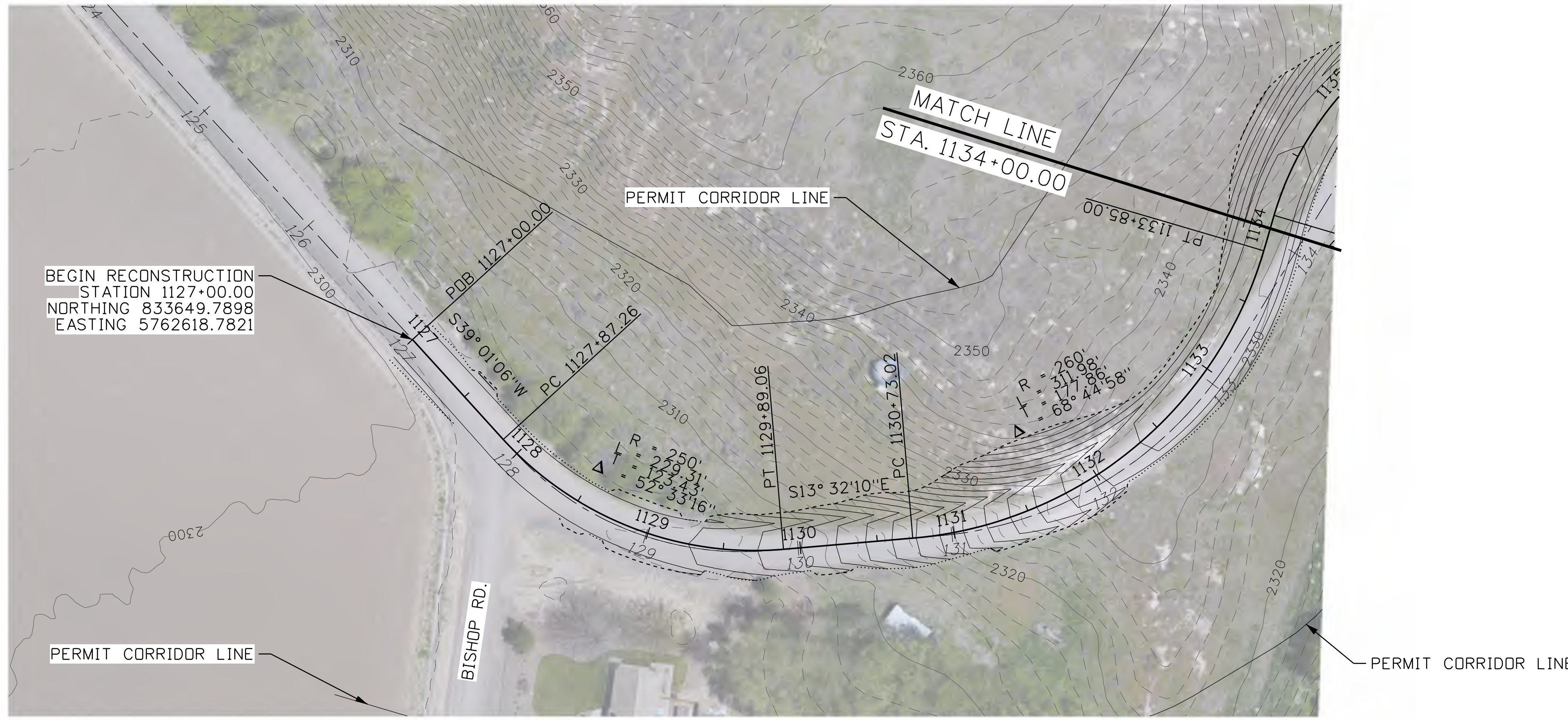
GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
TRENCH DETAIL FOR CULVERT INSTALLATION

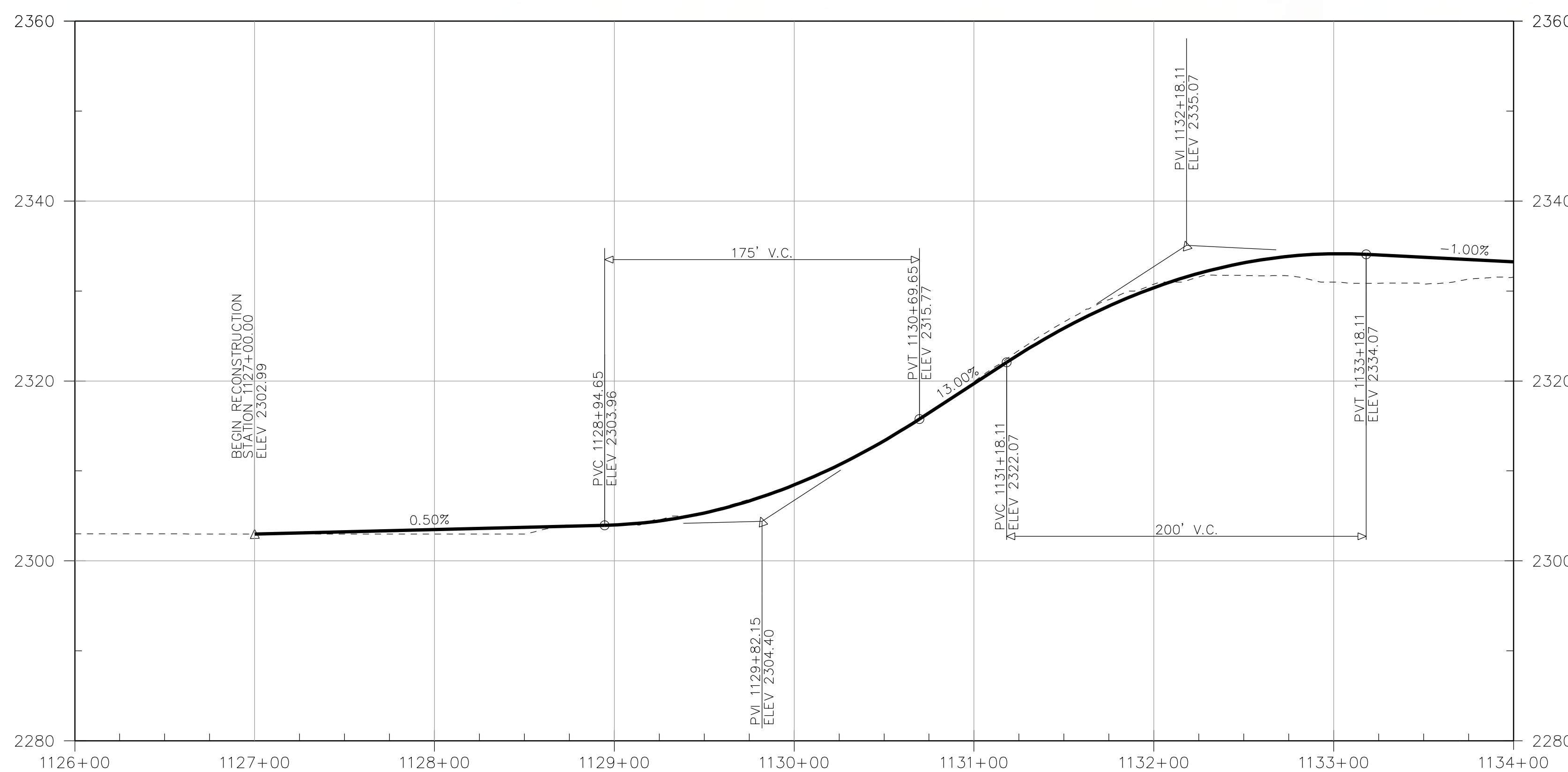
SHEET IDENTIFICATION
SHEET 6
OF 25

HORIZONTAL FEET

50 0 100



PLAN



PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_001.SHT

PRELIMINARY

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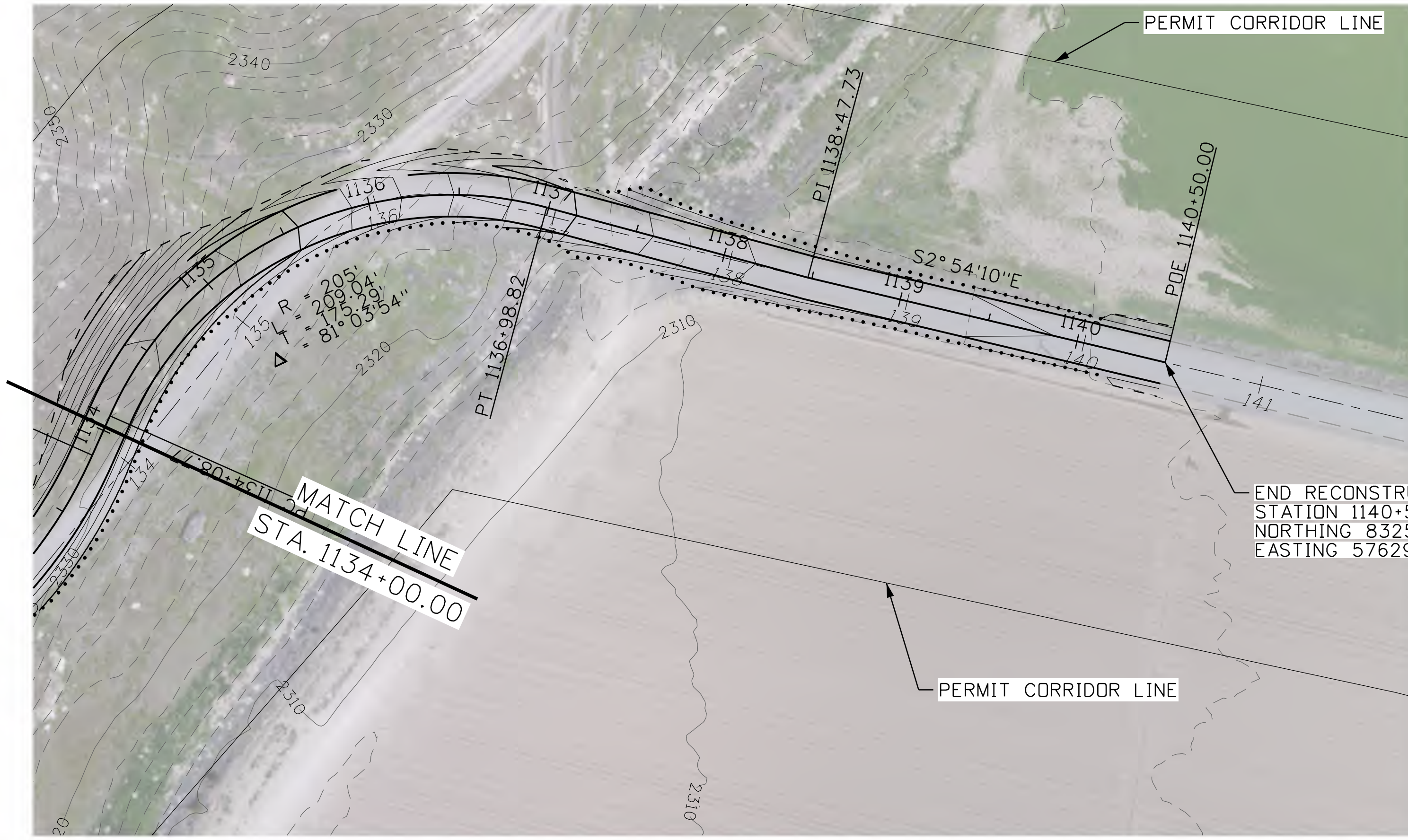
GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1127+00 TO STA. 1134+00

SHEET IDENTIFICATION

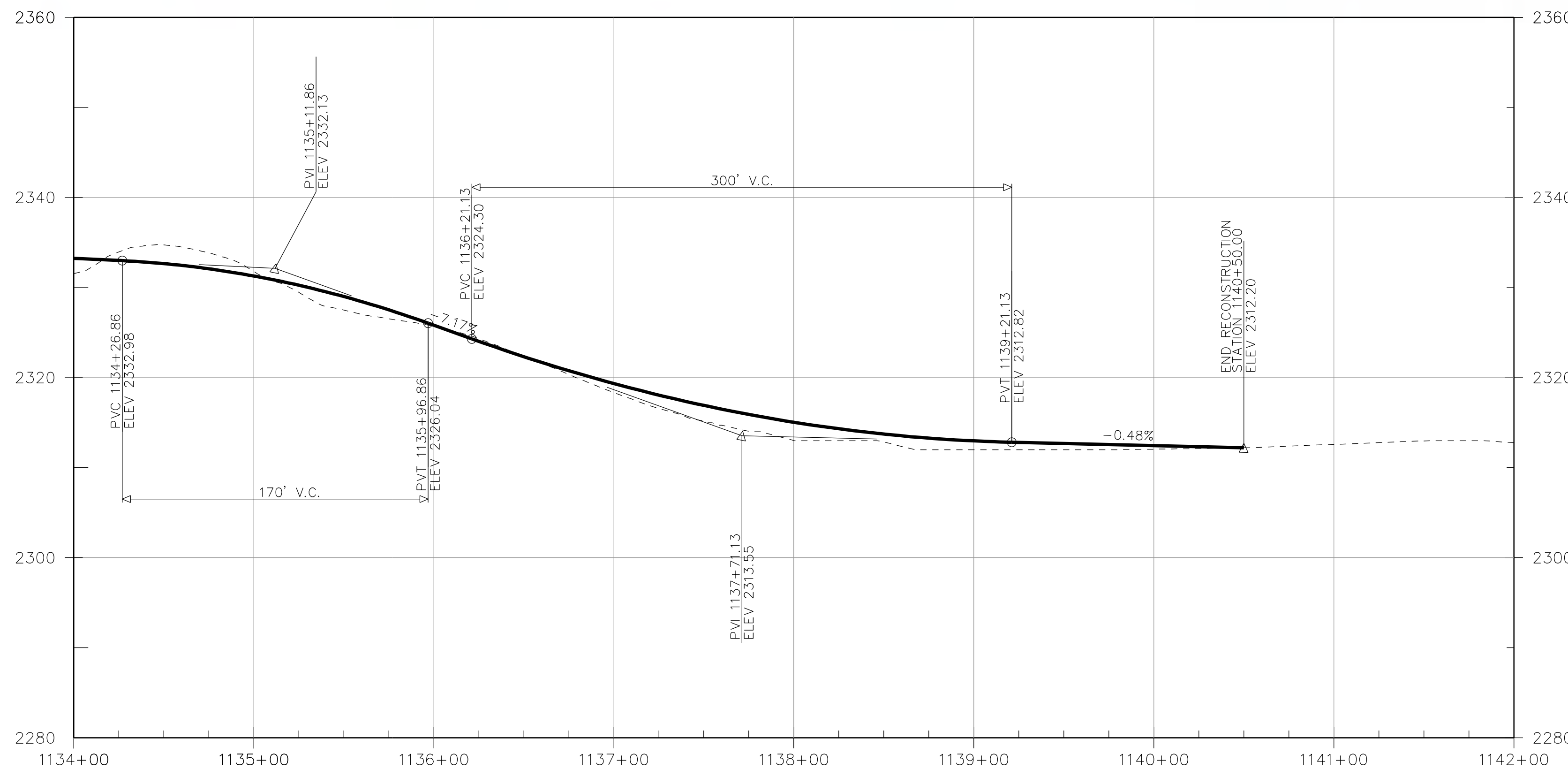
SHEET 7 OF 25

HORIZONTAL FEET

50 0 100



PLAN



PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBROOT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
HDR PROJECT NUMBER
PLOT SCALE: 1" = 100'
PLOT DATE
SIZE: 11X17
FILE NAME: PLAN_PROF_002.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

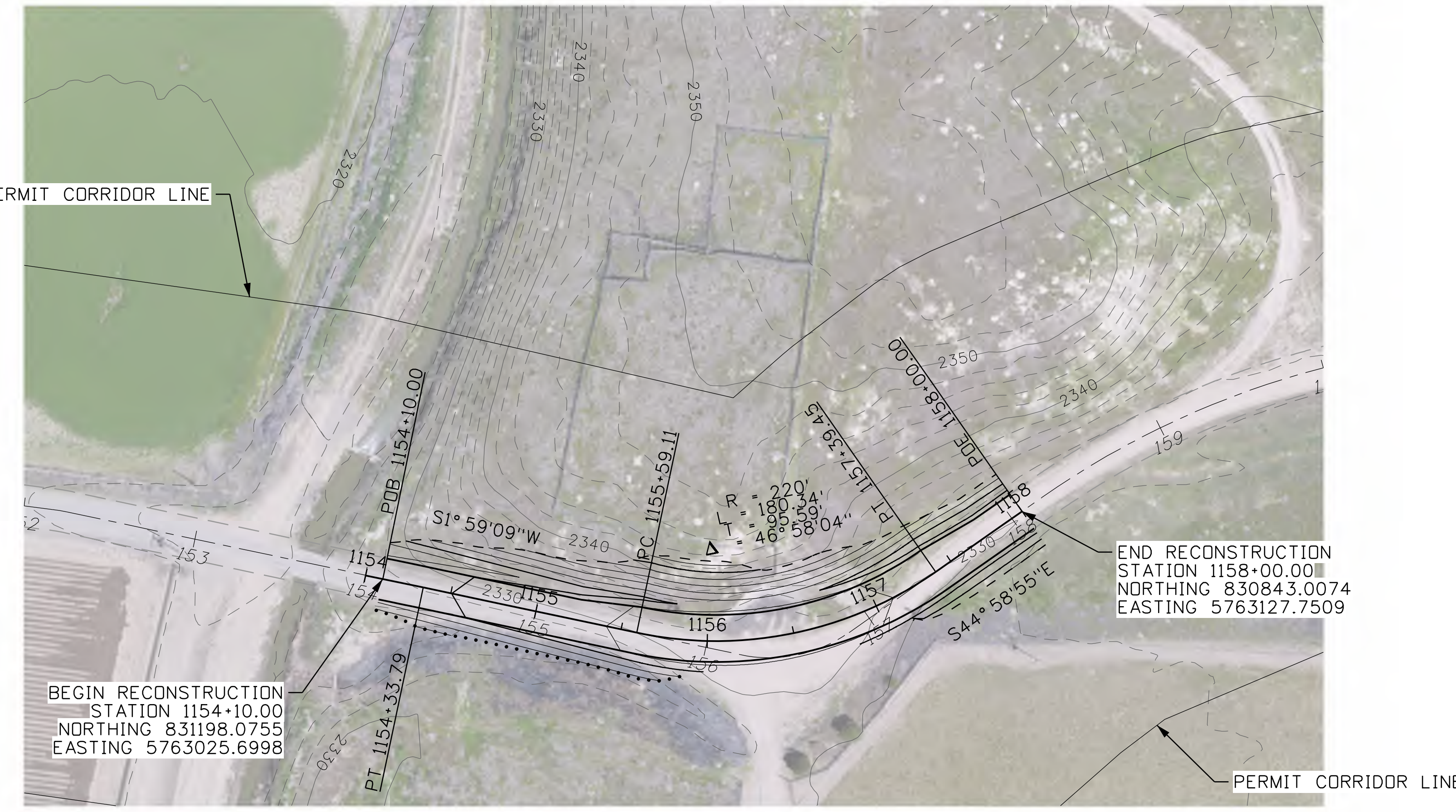
GRASSY MOUNTAIN PROJECT ROADWAY AND DRAINAGE PLANS RECONSTRUCTION STA. 1134+00 TO STA. 1140+50

SHEET IDENTIFICATION

SHEET 8 OF 25

HORIZONTAL FEET

50 0 100



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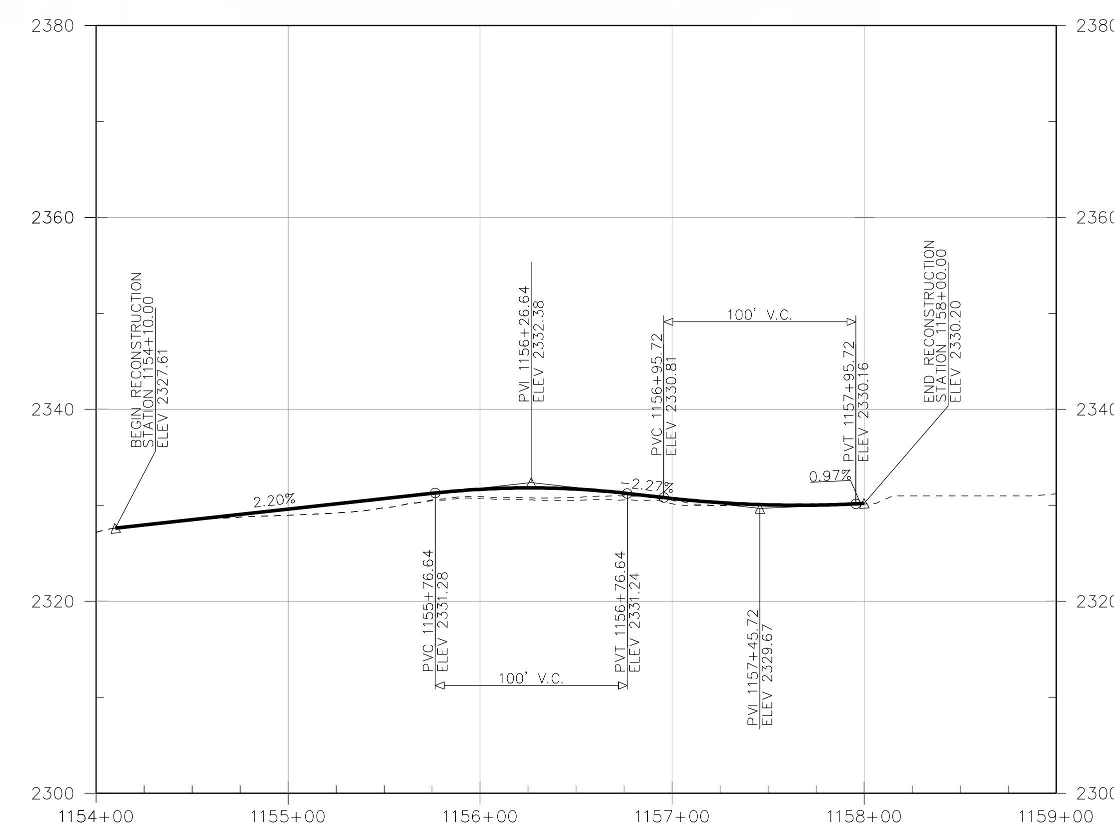


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_003.SHT

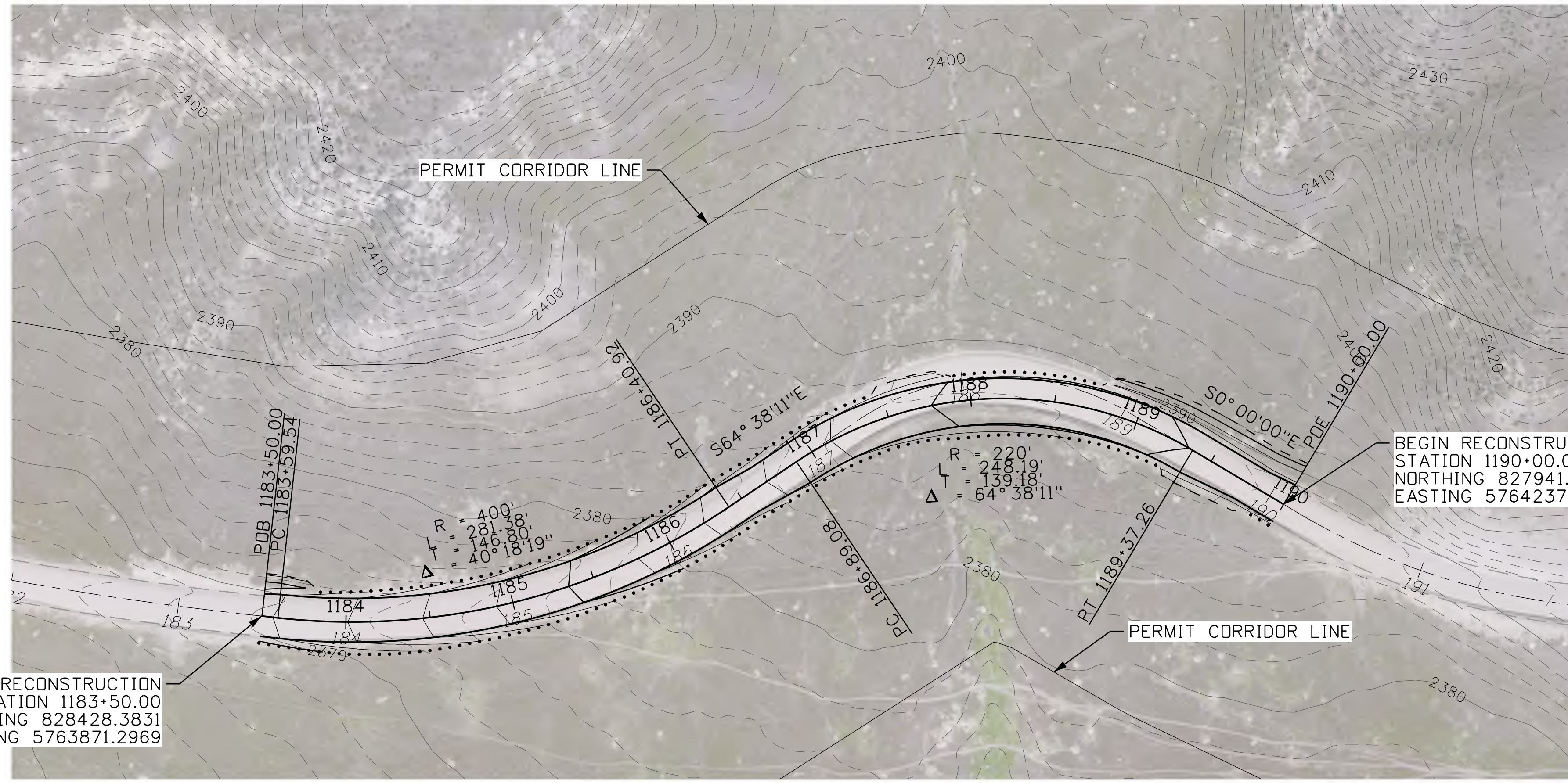
PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1154+10 TO STA. 1158+00

SHEET IDENTIFICATION
SHEET 9
OF 25

HORIZONTAL FEET
50 0 100



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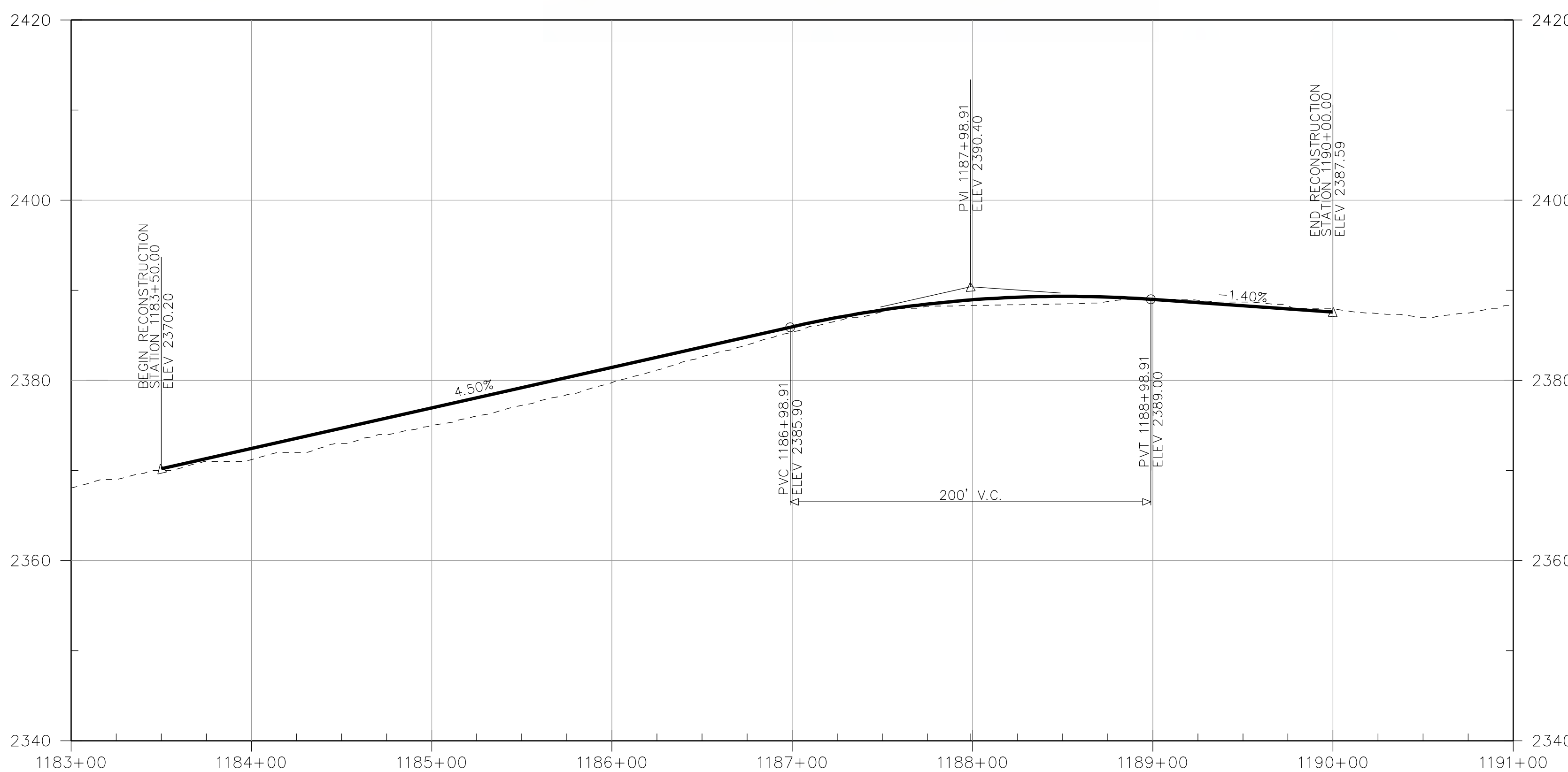


PROFILE

VERTICAL FEET
10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_004.SHT

PRELIMINARY

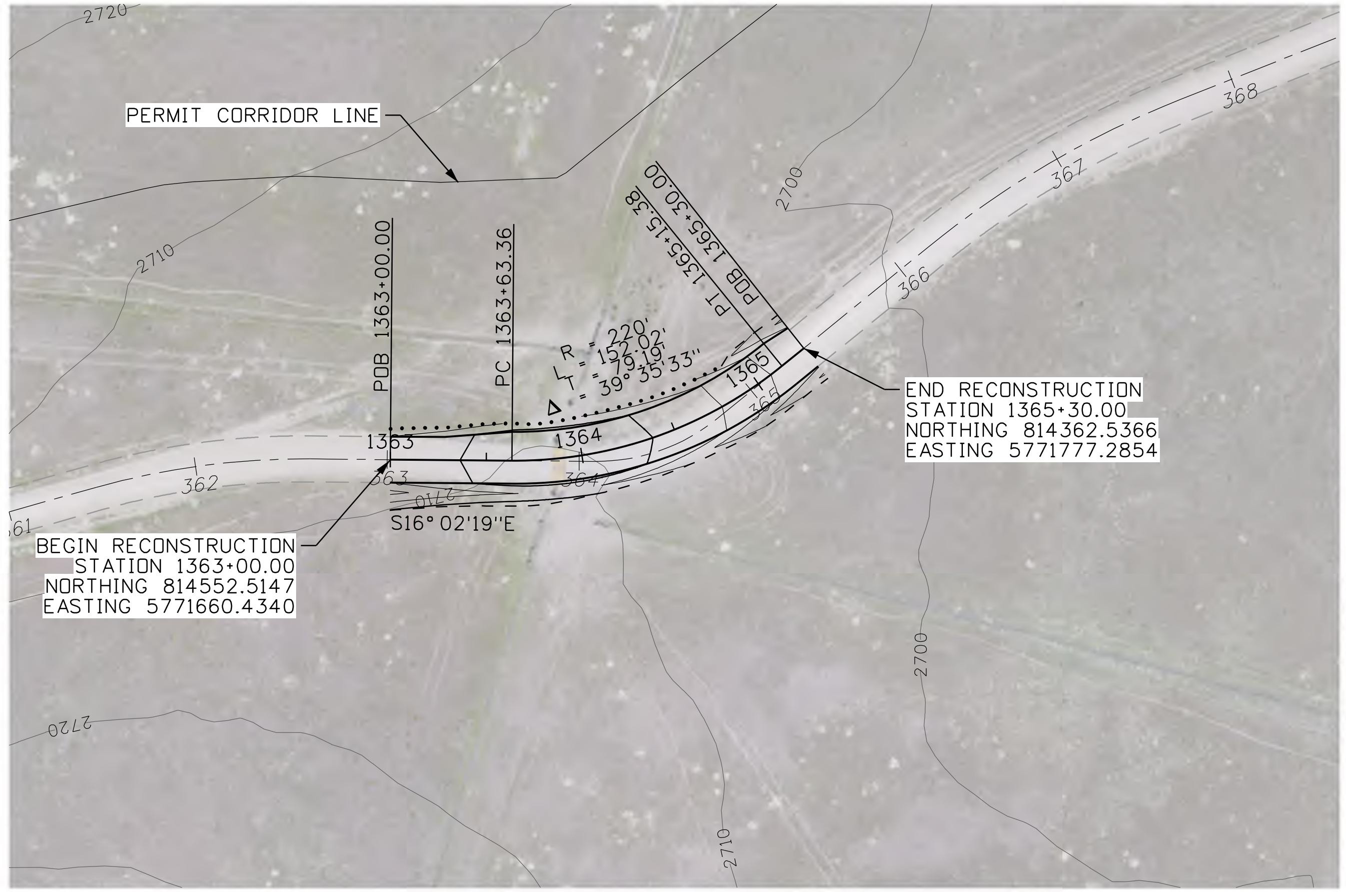
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1183+50 TO STA. 1190+00

SHEET IDENTIFICATION
SHEET 10
OF 25

HORIZONTAL FEET

50 0 100



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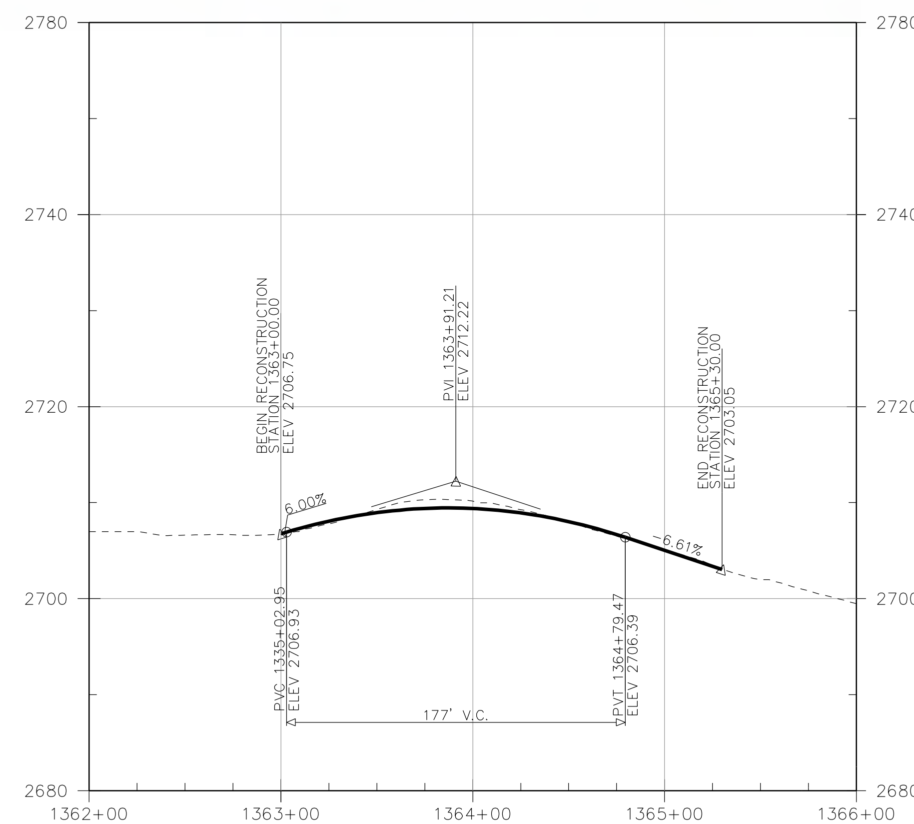


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

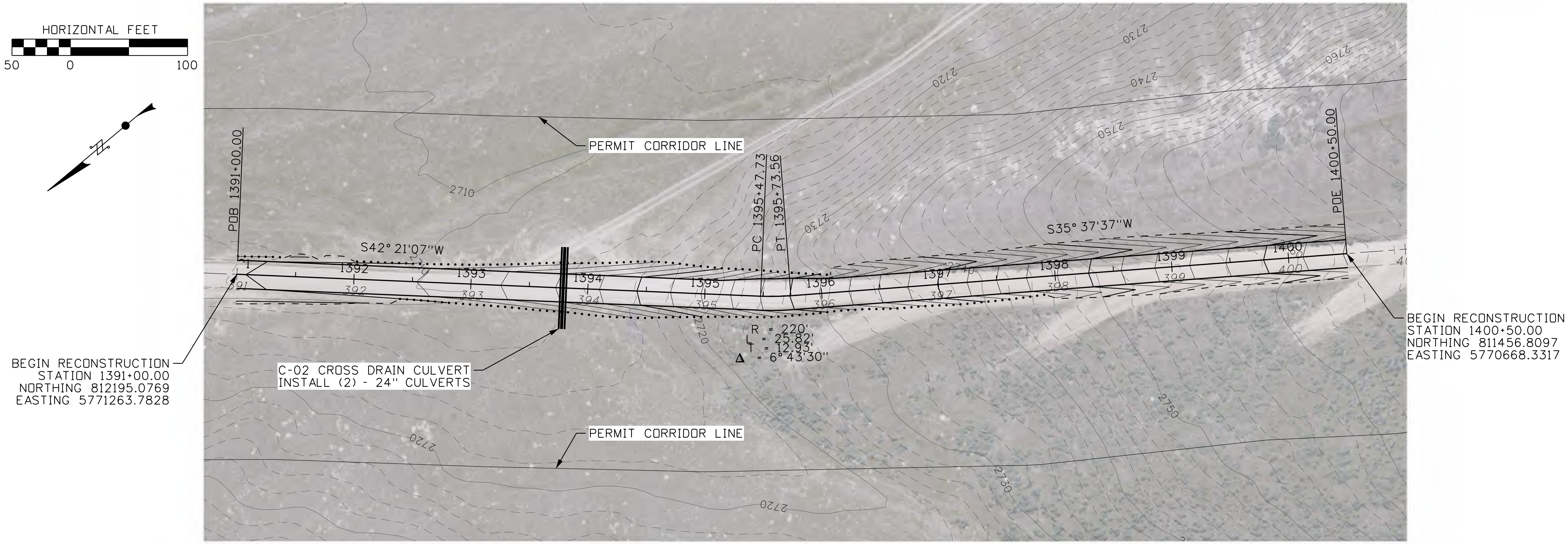
DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_005.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1363+00 TO STA. 1365+30

SHEET IDENTIFICATION
SHEET 11
OF 25



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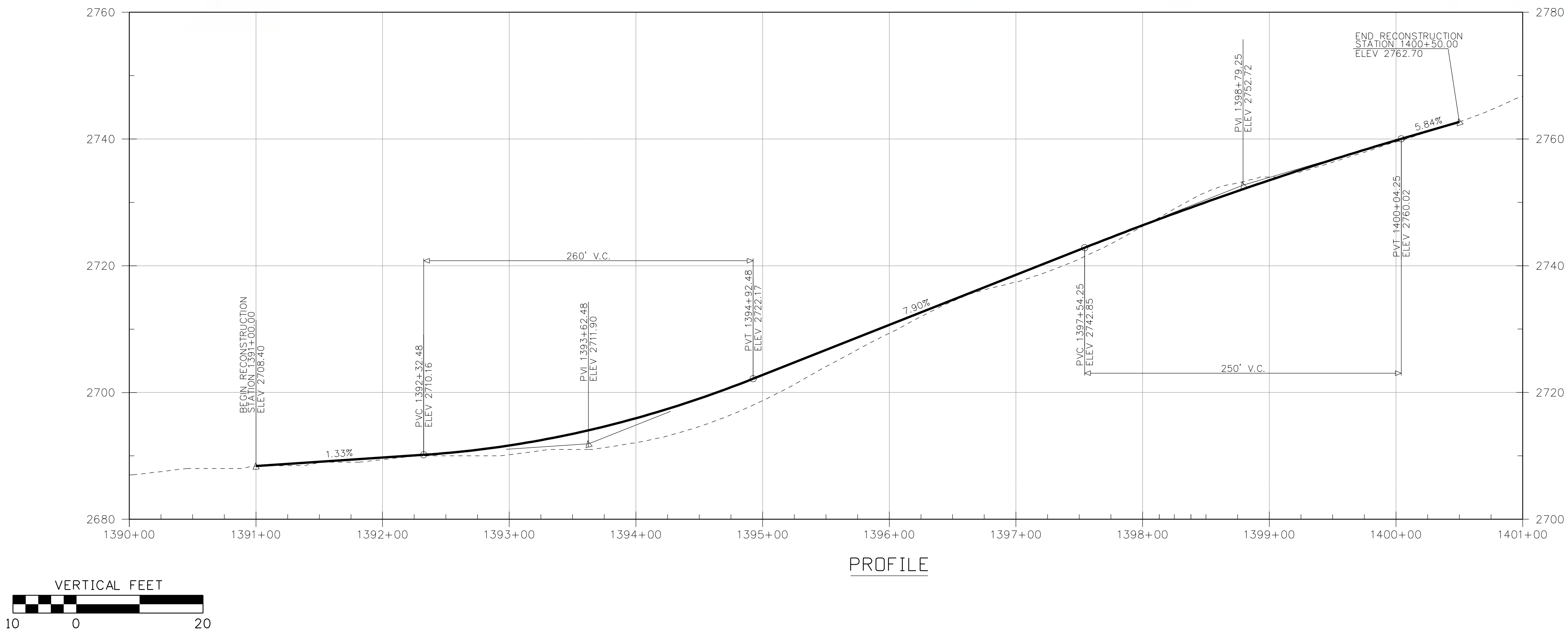


PROFILE

PARAMOUNT GOLD Nevada

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
PLOT SCALE: 1" = 100'
DATE: OCTOBER 2019
HDR PROJECT
SIZE: 11X17
FILE NAME: PLAN_PROF_006.SHT

PRELIMINARY

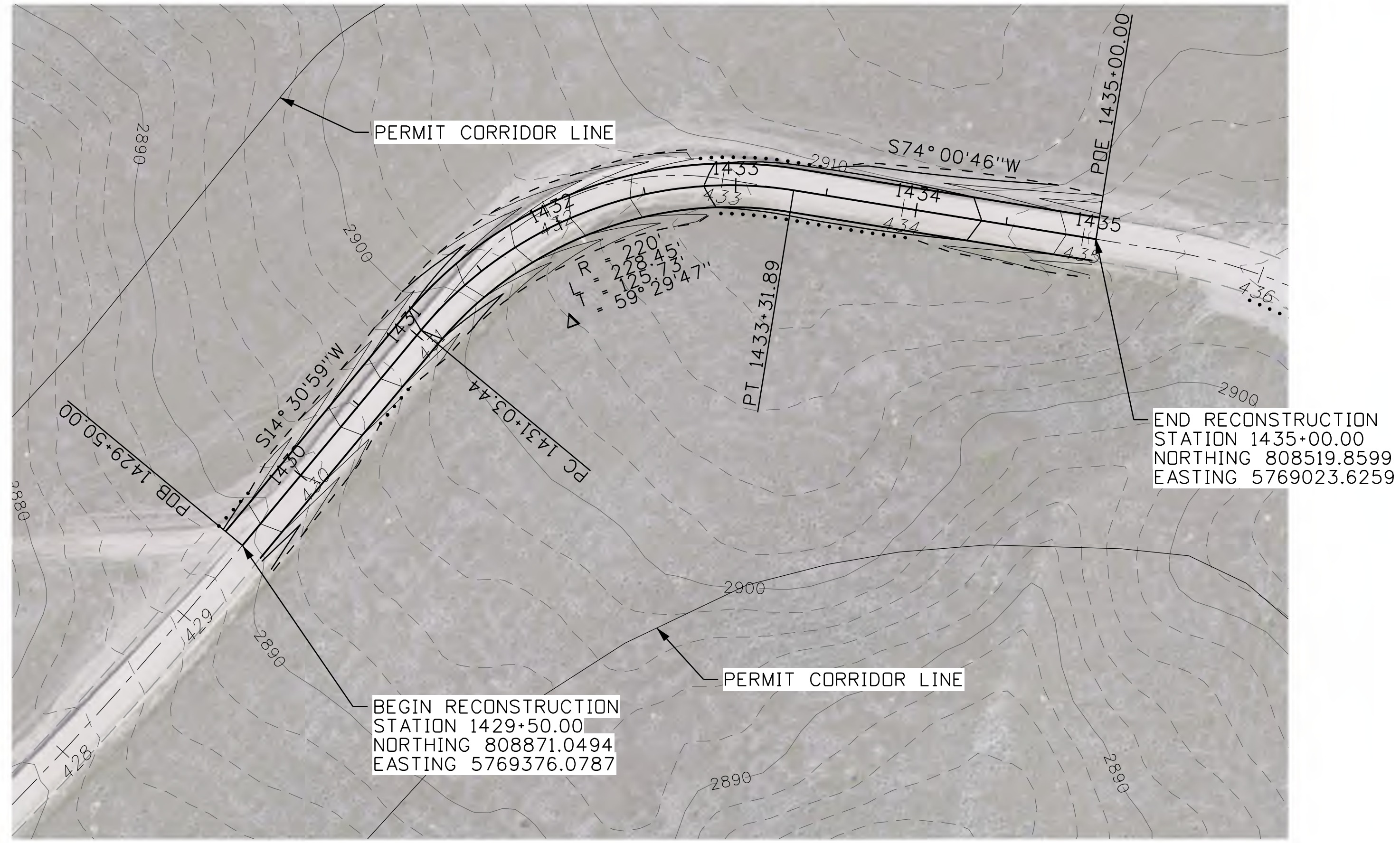
HDR
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1391+00 TO STA. 1400+50

SHEET IDENTIFICATION
SHEET 12 OF 25

HORIZONTAL FEET

50 0 100



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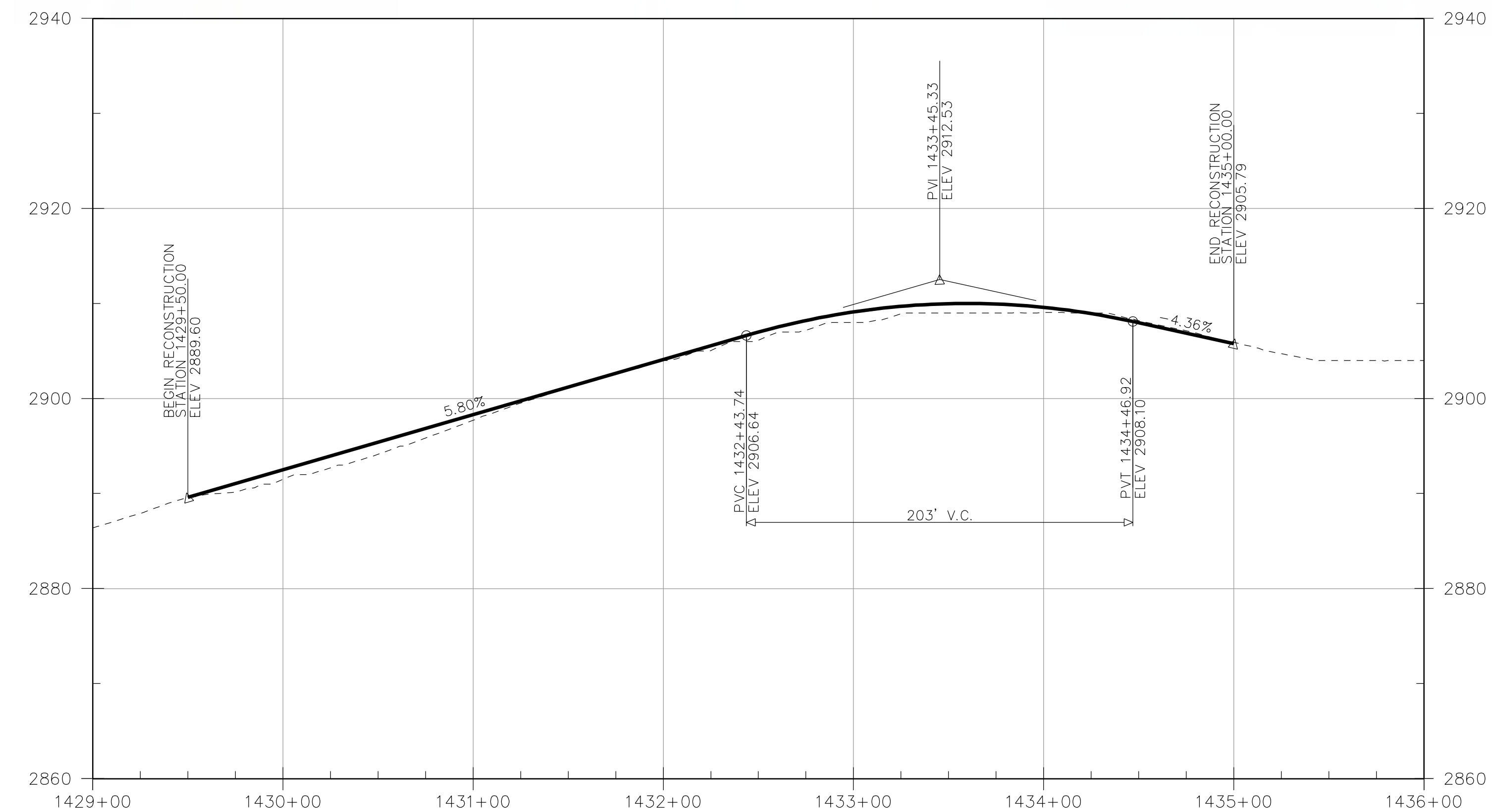


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
HDR PROJECT: 10...
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_007.SHT

PRELIMINARY

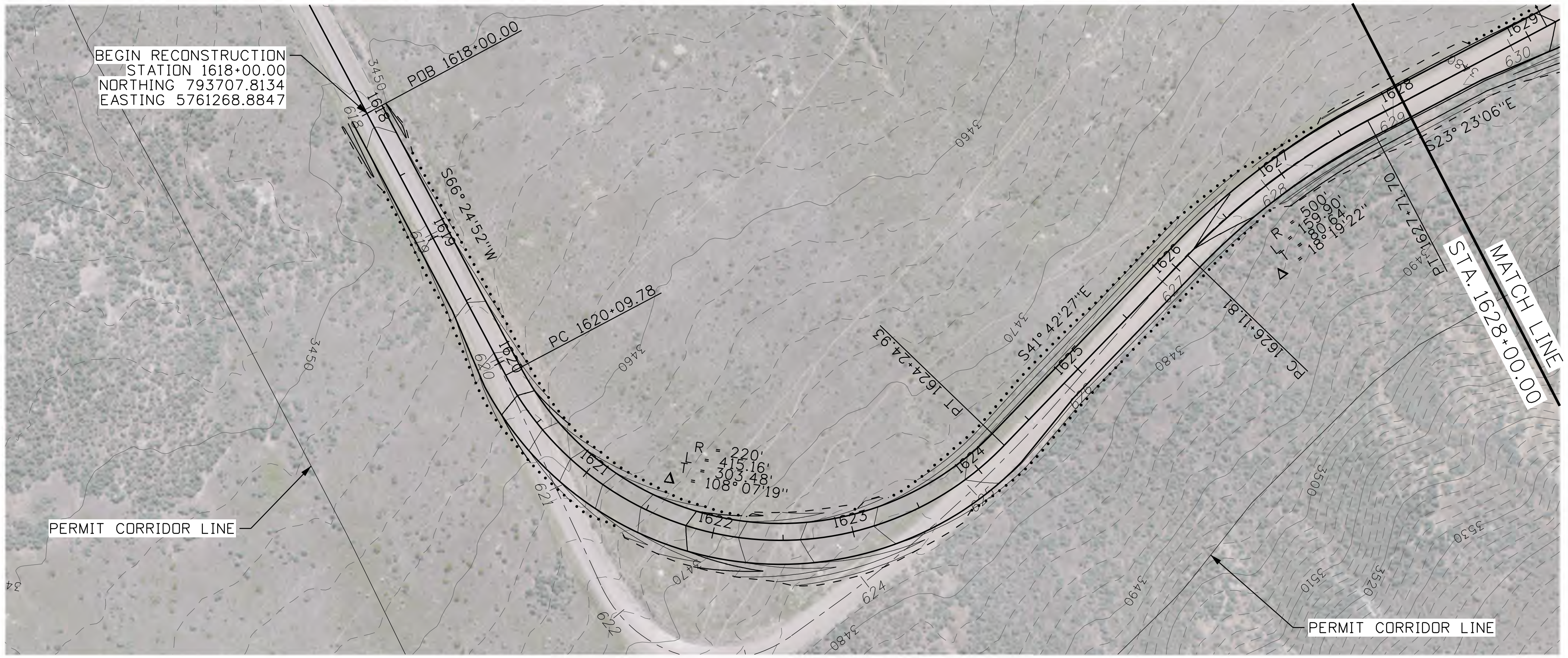
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1429+50 TO STA. 1435+00

SHEET IDENTIFICATION
SHEET 13
OF 25

HORIZONTAL FEET

50 0 100



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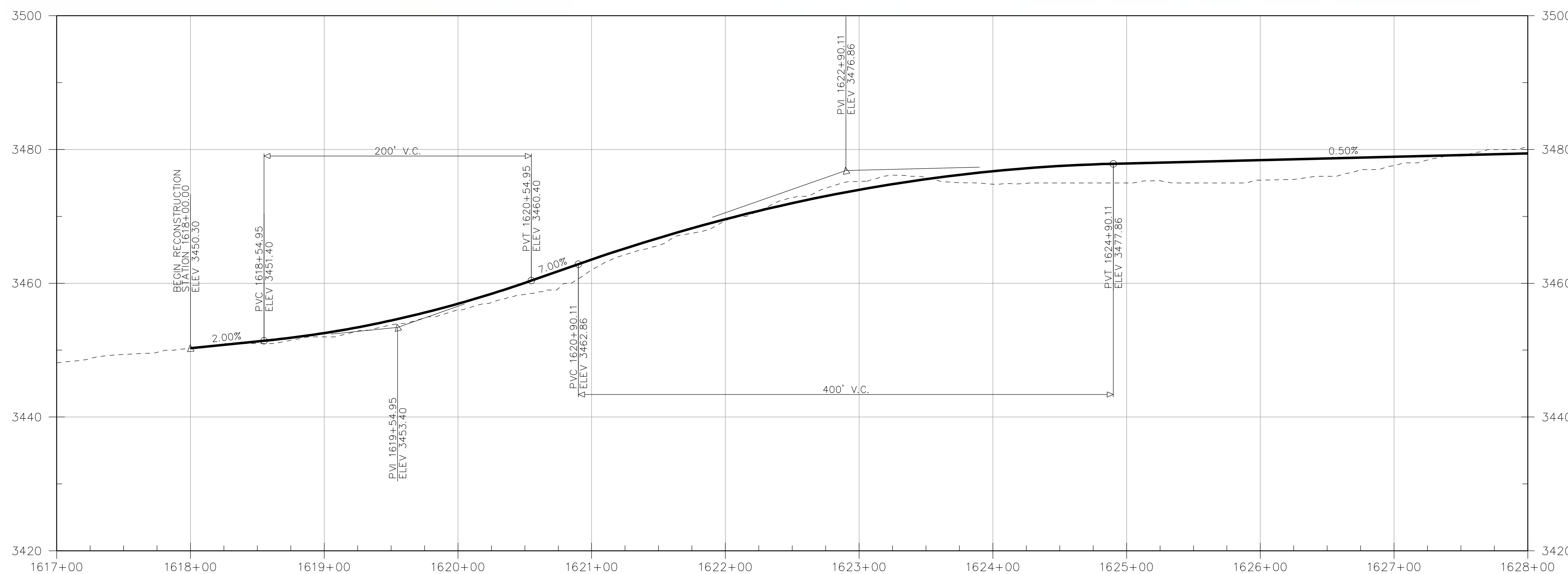


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
HDR PROJECT NUMBER:
PLOT SCALE: 1" = 100'
PLOT DATE:
SIZE: 11X17
FILE NAME: PLAN_PROF_006.SHT

PRELIMINARY

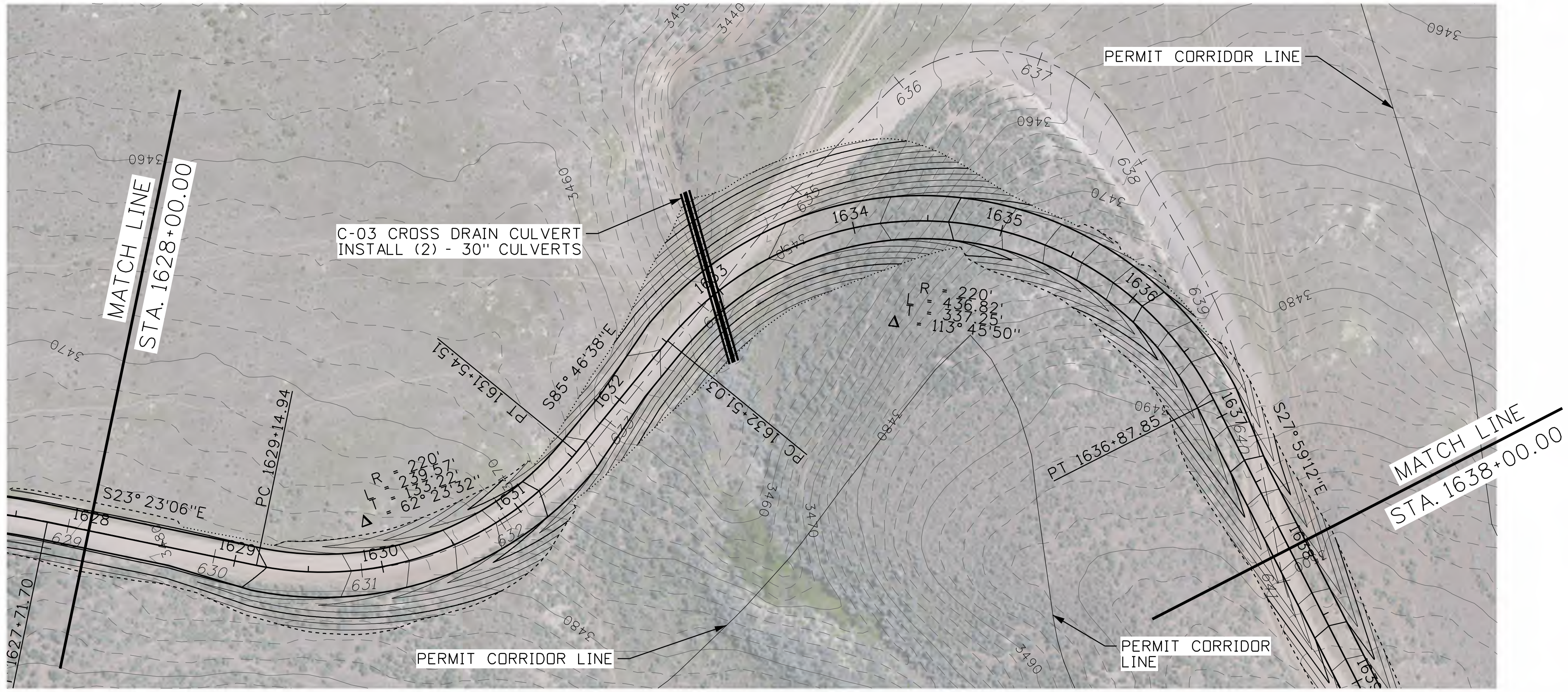
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1618+00 TO STA. 1628+00

SHEET IDENTIFICATION
SHEET 14
OF 25

HORIZONTAL FEET

50 0 100



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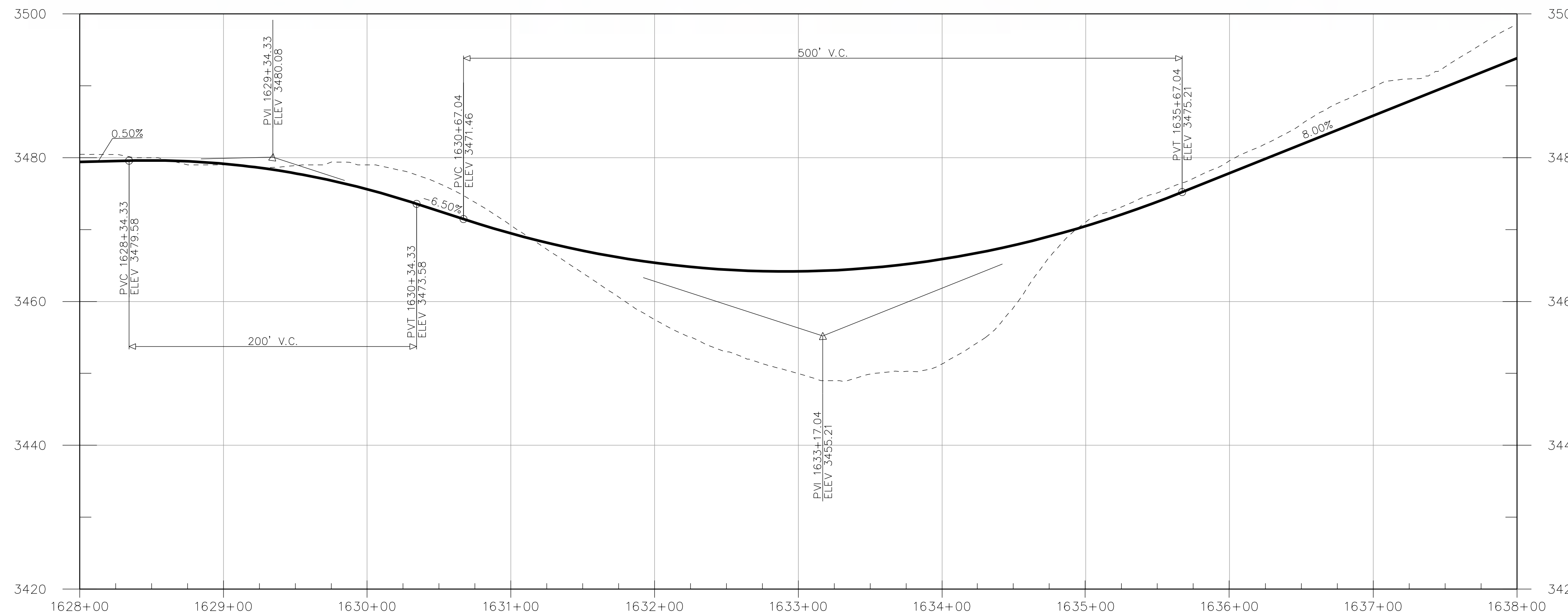


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD Nevada

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBROOT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
HDR PROJECT
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_009.SHT

PRELIMINARY

HDR

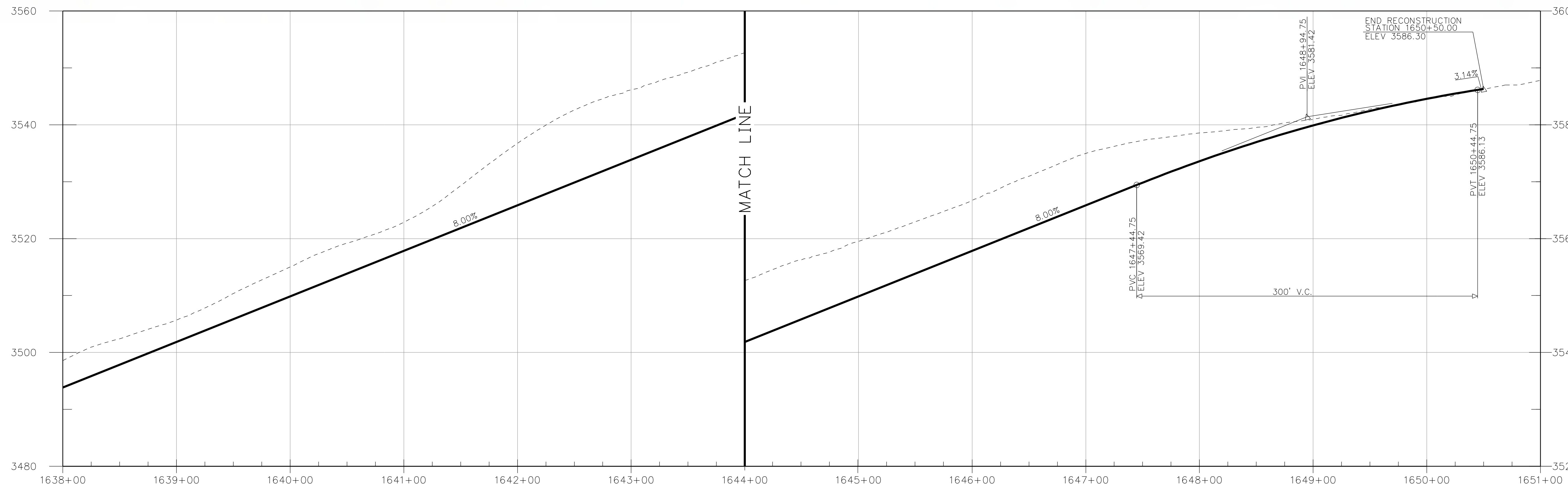
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1628+00 TO STA. 1638+00

SHEET IDENTIFICATION

SHEET 15
OF 25

PLAN



PROFILE

VERTICAL FEET
10 0 20

PARAMOUNT GOLD Nevada
PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_010.SHT

PRELIMINARY

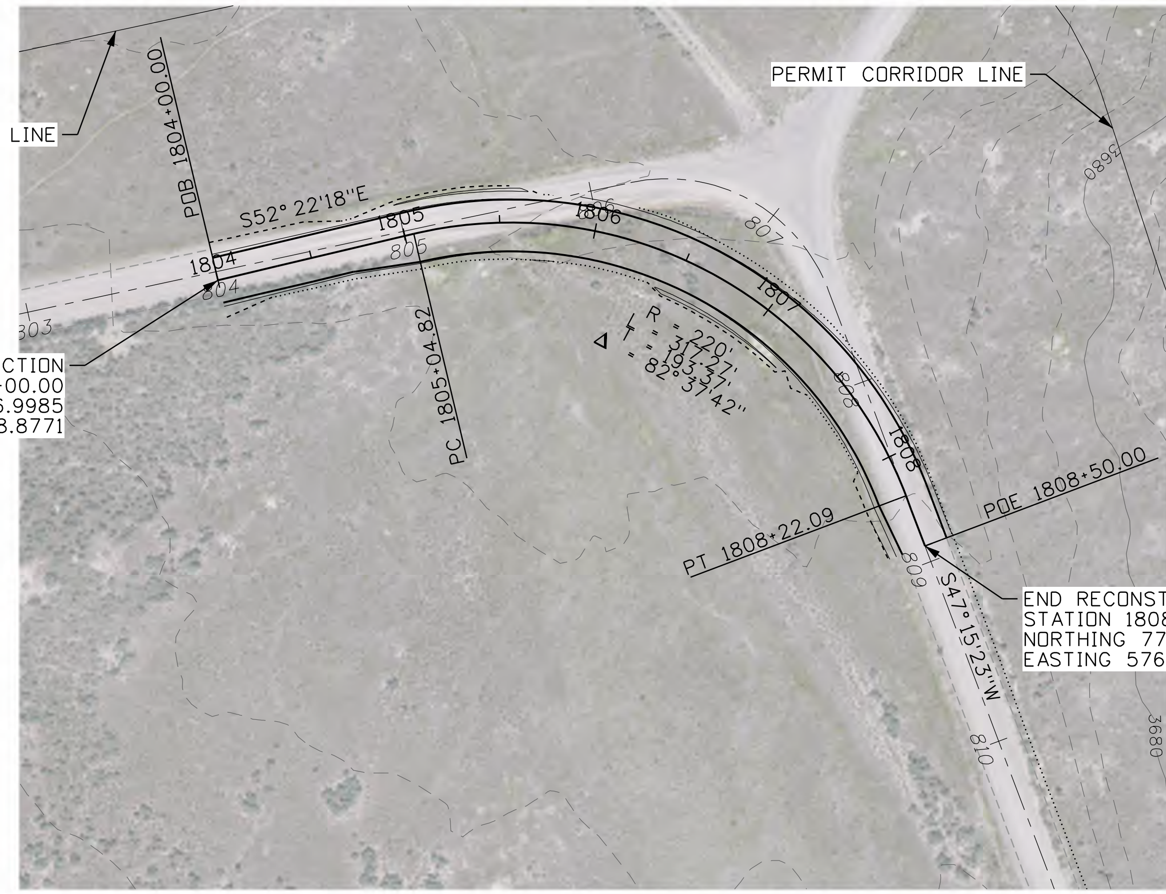
HDR
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1638+00 TO STA. 1650+50

SHEET IDENTIFICATION
SHEET 16
OF 25

HORIZONTAL FEET

50 0 100



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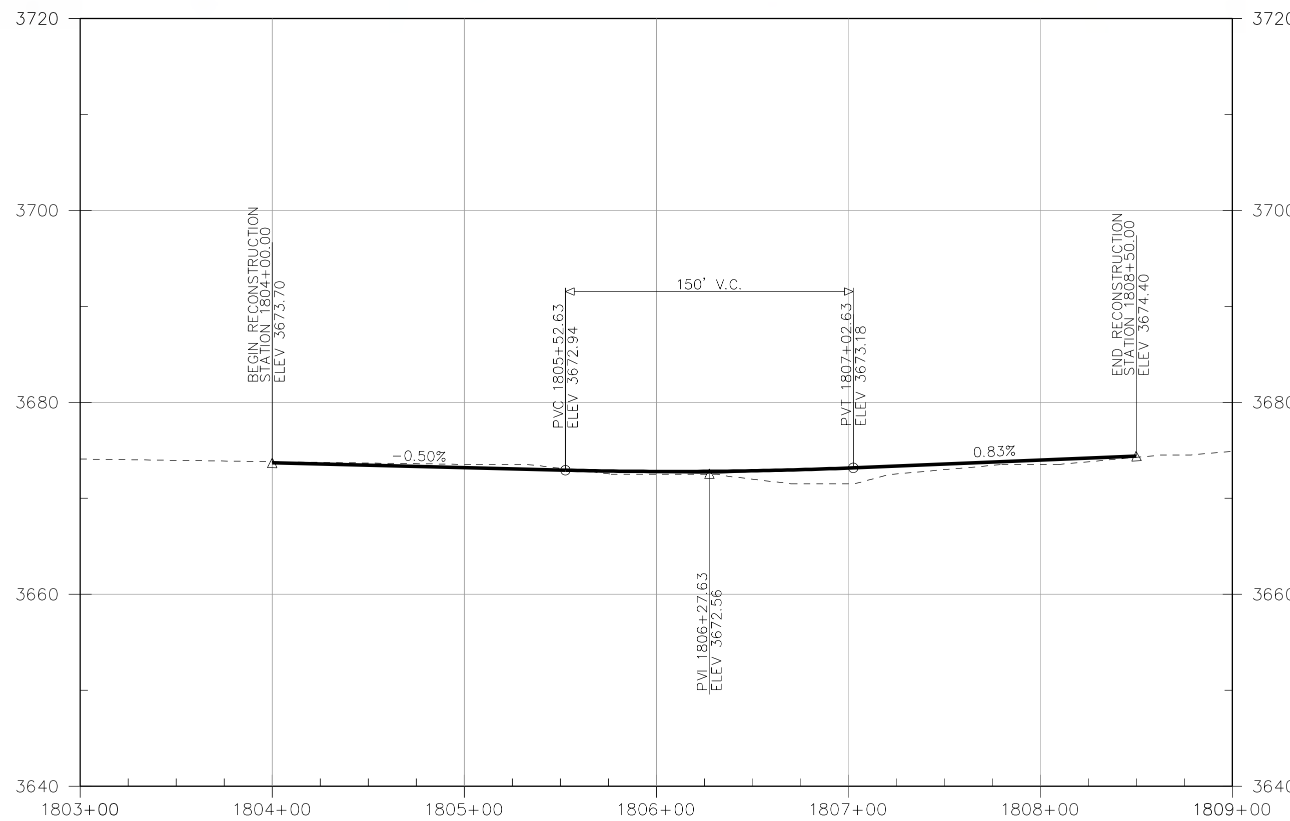


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

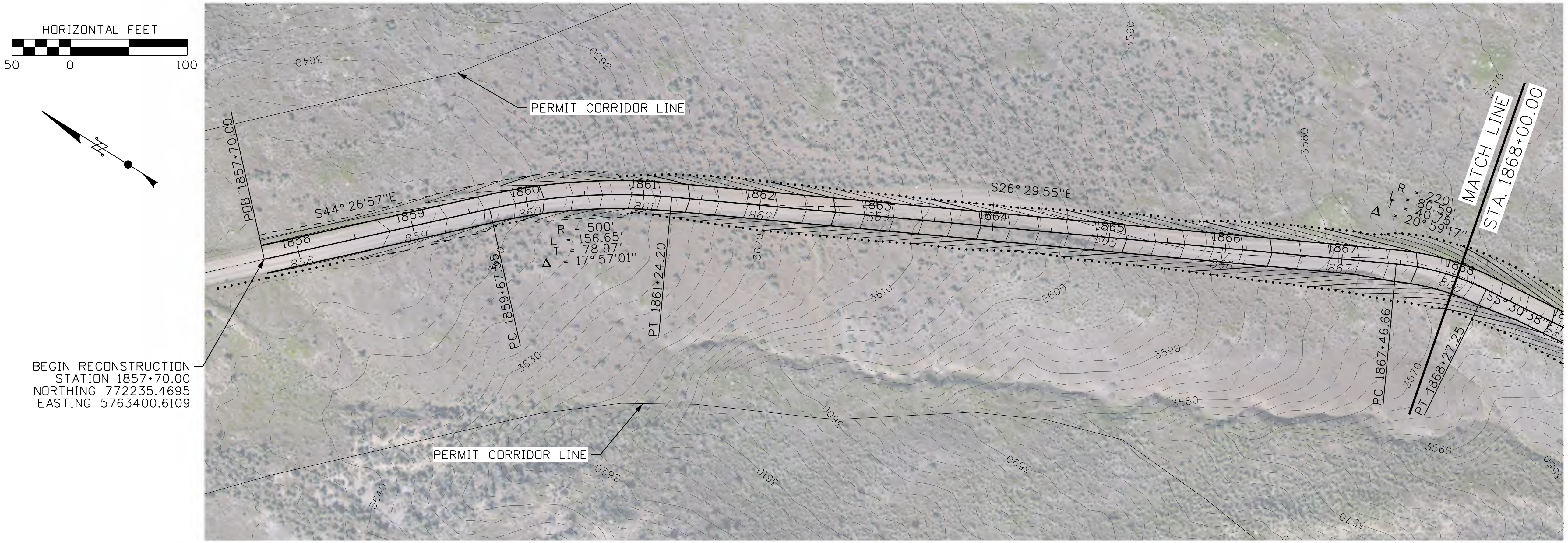
DESIGNED BY: S. WARMBRODT
DATE: OCTOBER 2019
DWN BY: SGW
CKD BY: L. GREBE
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_011.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1804+00 TO STA. 1808+50

SHEET IDENTIFICATION
SHEET 17
OF 25



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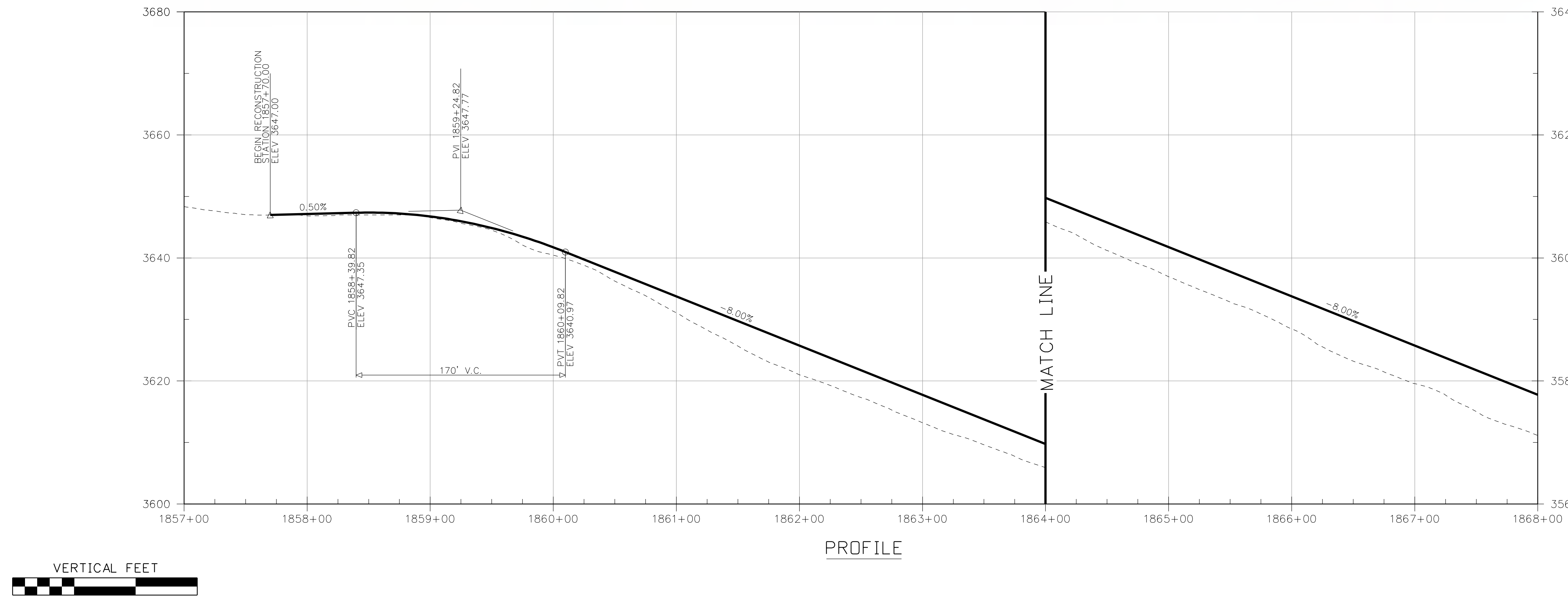


PROFILE

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_012.SHT

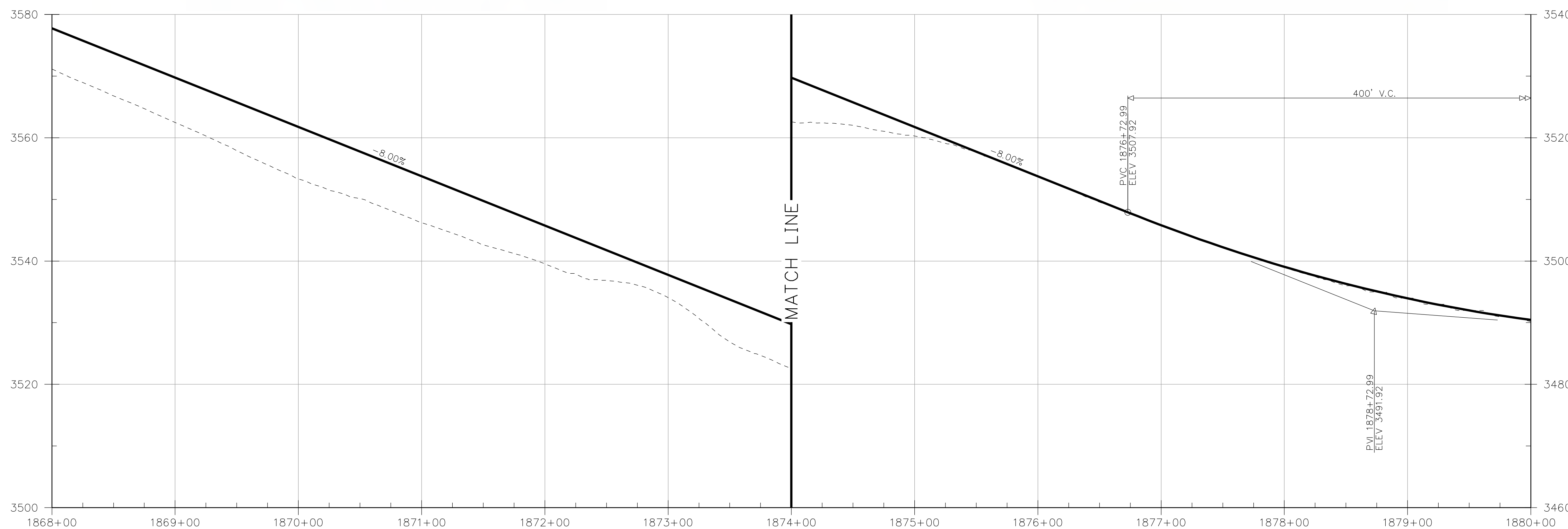
PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1857+70 TO STA. 1868+00

SHEET IDENTIFICATION
SHEET 18
OF 25

PLAN



PROFILE

VERTICAL FEET
10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_013.SHT

PRELIMINARY

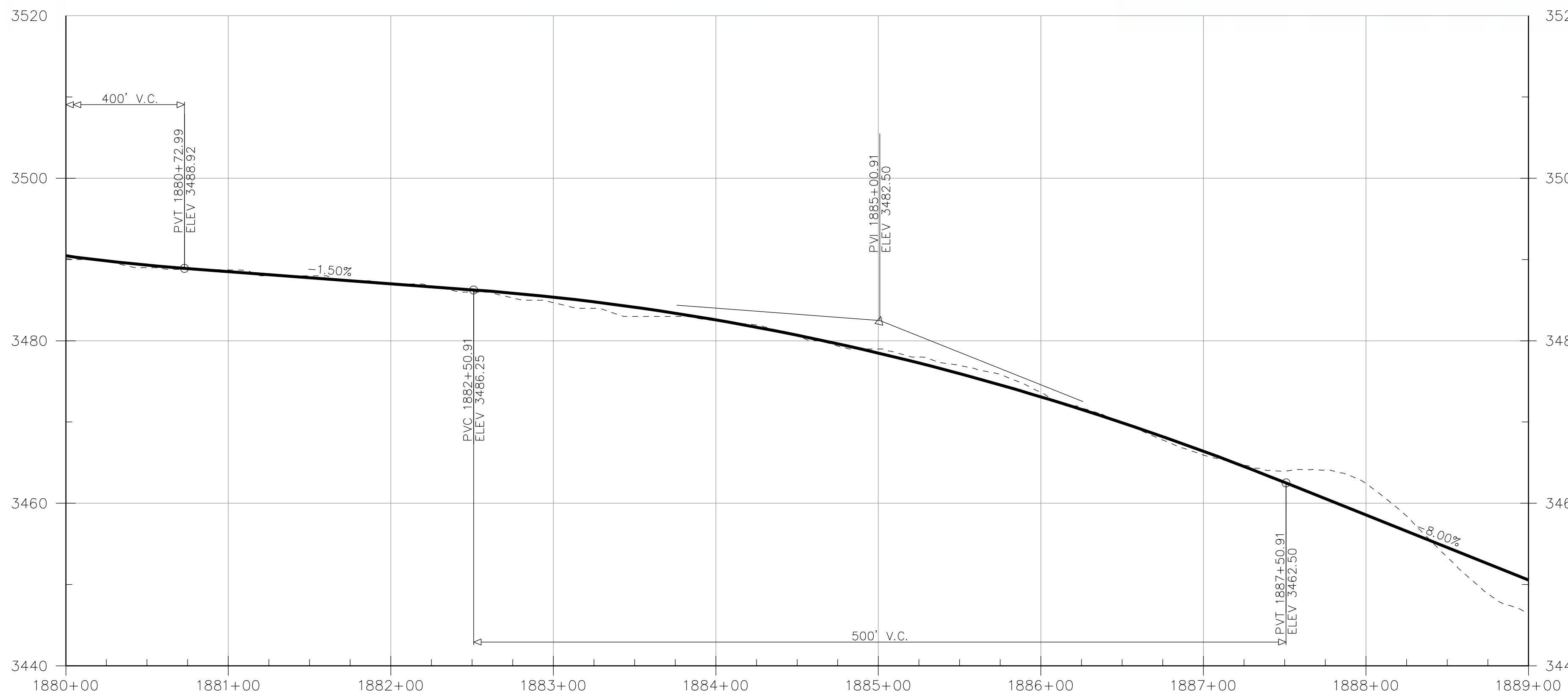
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1868+00 TO STA. 1880+00

SHEET IDENTIFICATION
SHEET 19
OF 25

HORIZONTAL FEET
50 0 100

PLAN



PROFILE

VERTICAL FEET
10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
HDR PROJECT NUMBER:
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_014.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

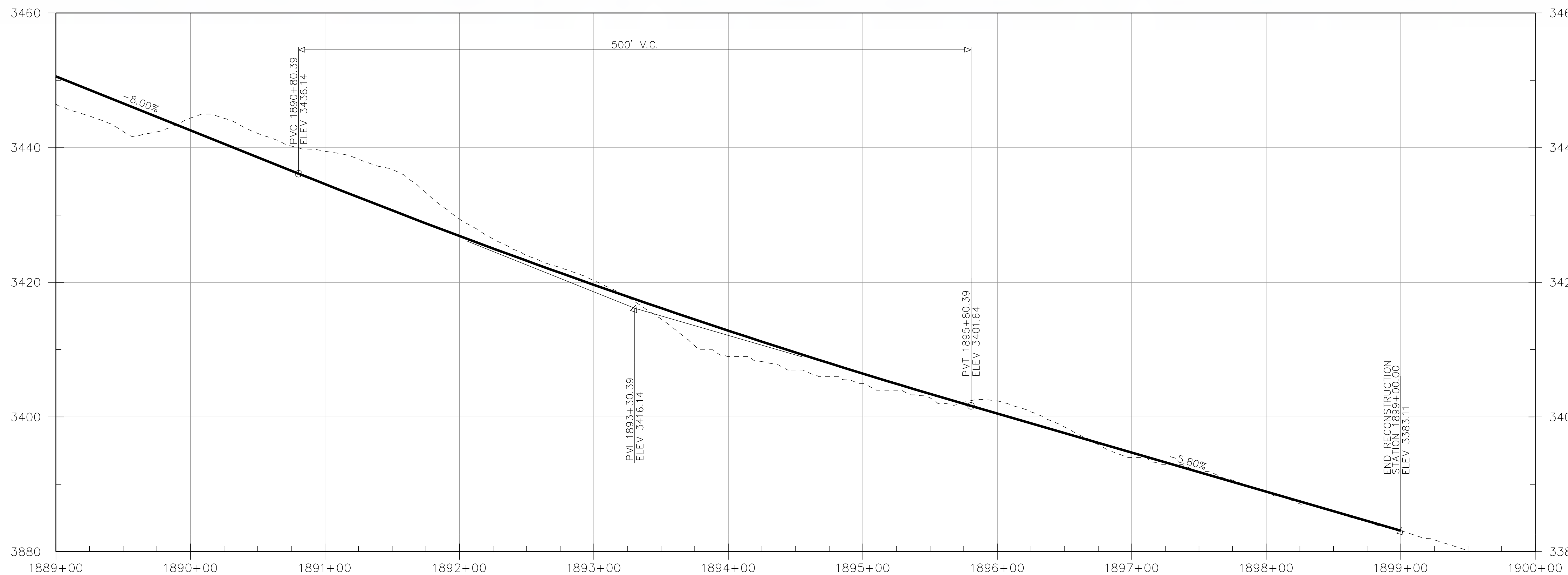
GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1880+00 TO STA. 1889+00

SHEET IDENTIFICATION
SHEET 20
OF 25

HORIZONTAL FEET

50 0 100

PLAN



PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD Nevada

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_015.SHT

PRELIMINARY

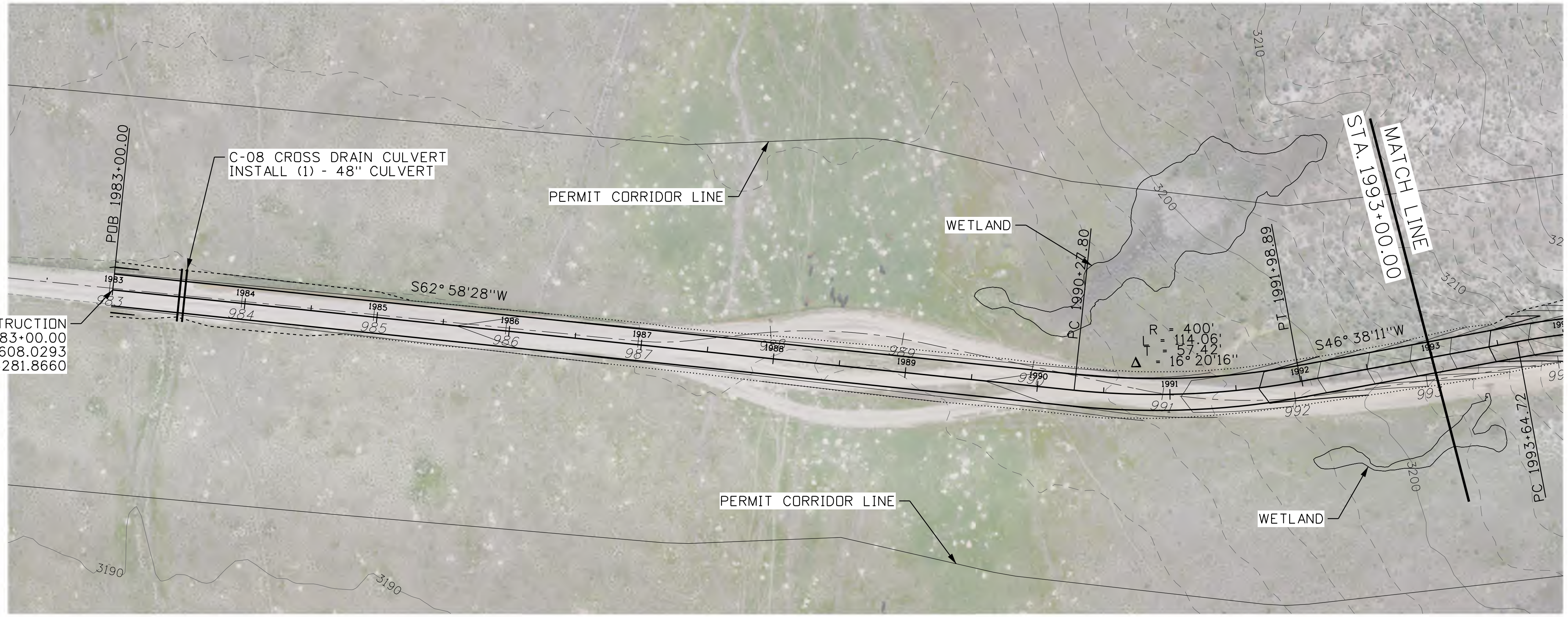
HDR

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1889+00 TO STA. 1899+00

SHEET IDENTIFICATION

SHEET 21
OF 25



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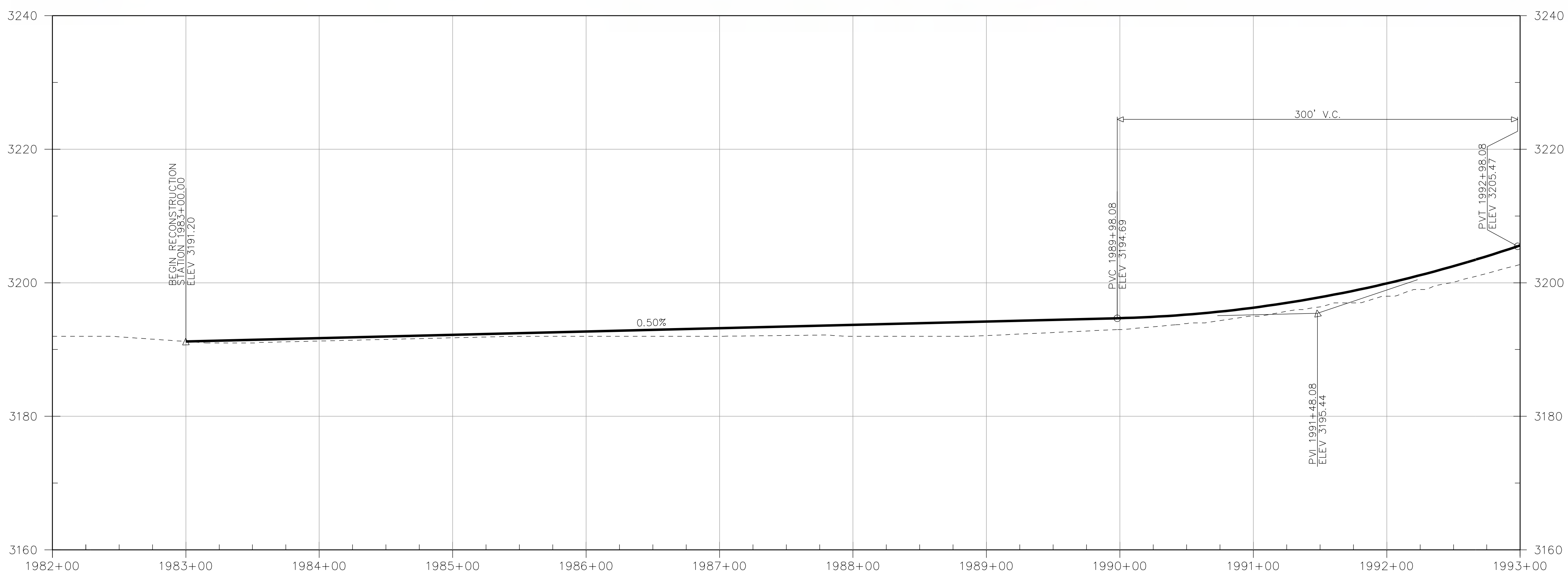


PROFILE

HORIZONTAL FEET
50 0 100

VERTICAL FEET
10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DATE: OCTOBER 2019
DWN BY: SGW
CKD BY: L. GREBE
HDR PROJECT NUMBER: 10162364
PLOT SCALE: 1" = 100'
PLOT DATE: 10\12\2019
SIZE: 11X17
FILE NAME: PLAN_PROF_016.SHT

PRELIMINARY

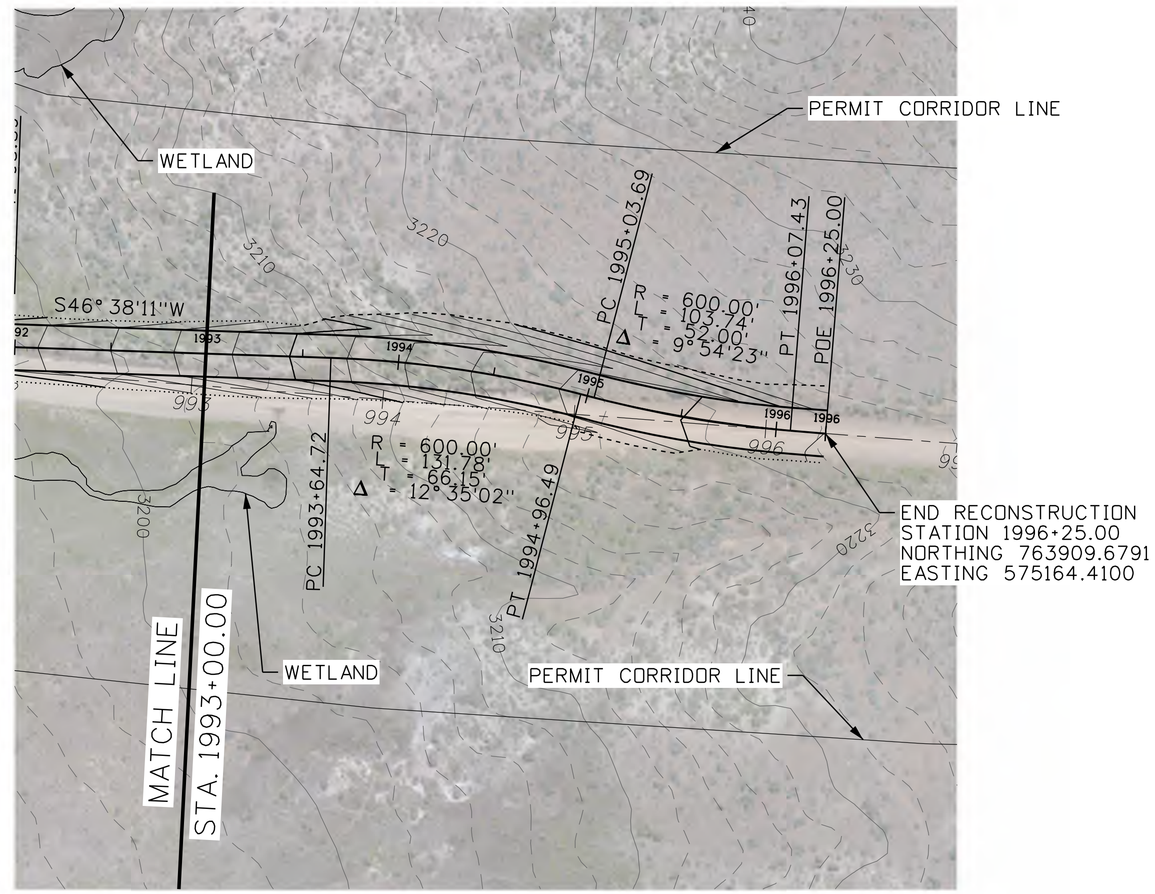
HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1983+00 TO STA. 1993+00

SHEET IDENTIFICATION
SHEET 22
OF 25

HORIZONTAL FEET

50 0 100



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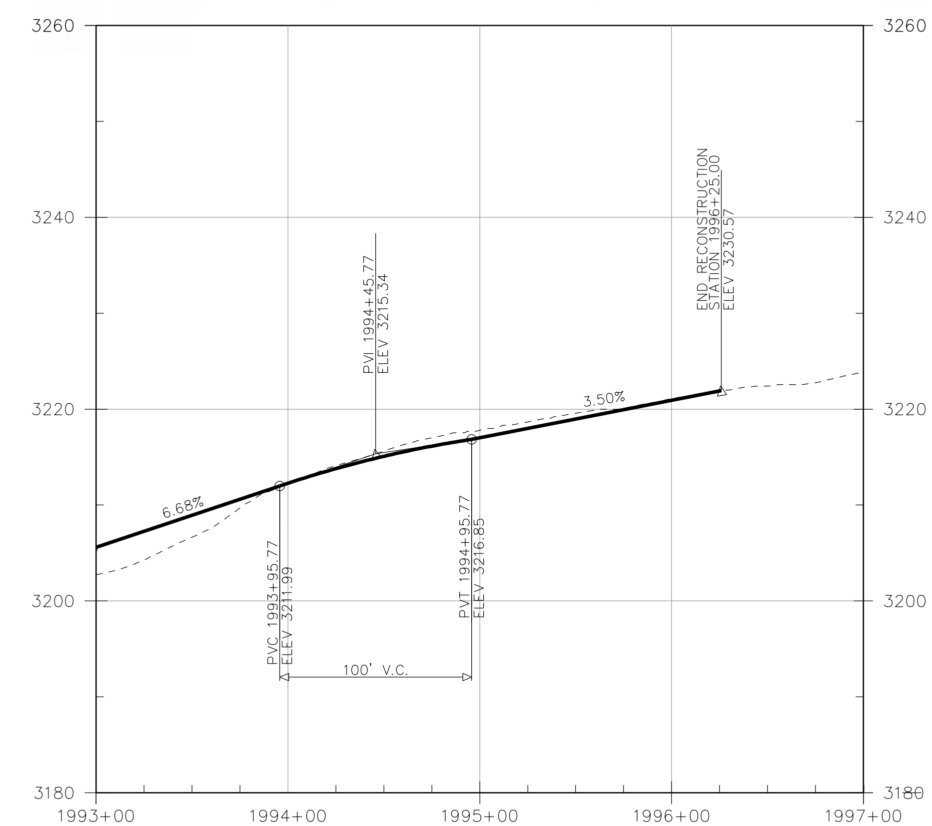


PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
PLOT SCALE: 1" = 100'
DATE: OCTOBER 2019
HDR PROJECT NUMBER:
SIZE: 11X17
FILE NAME: PLAN_PROF_017.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 1993+00 TO STA. 1996+25

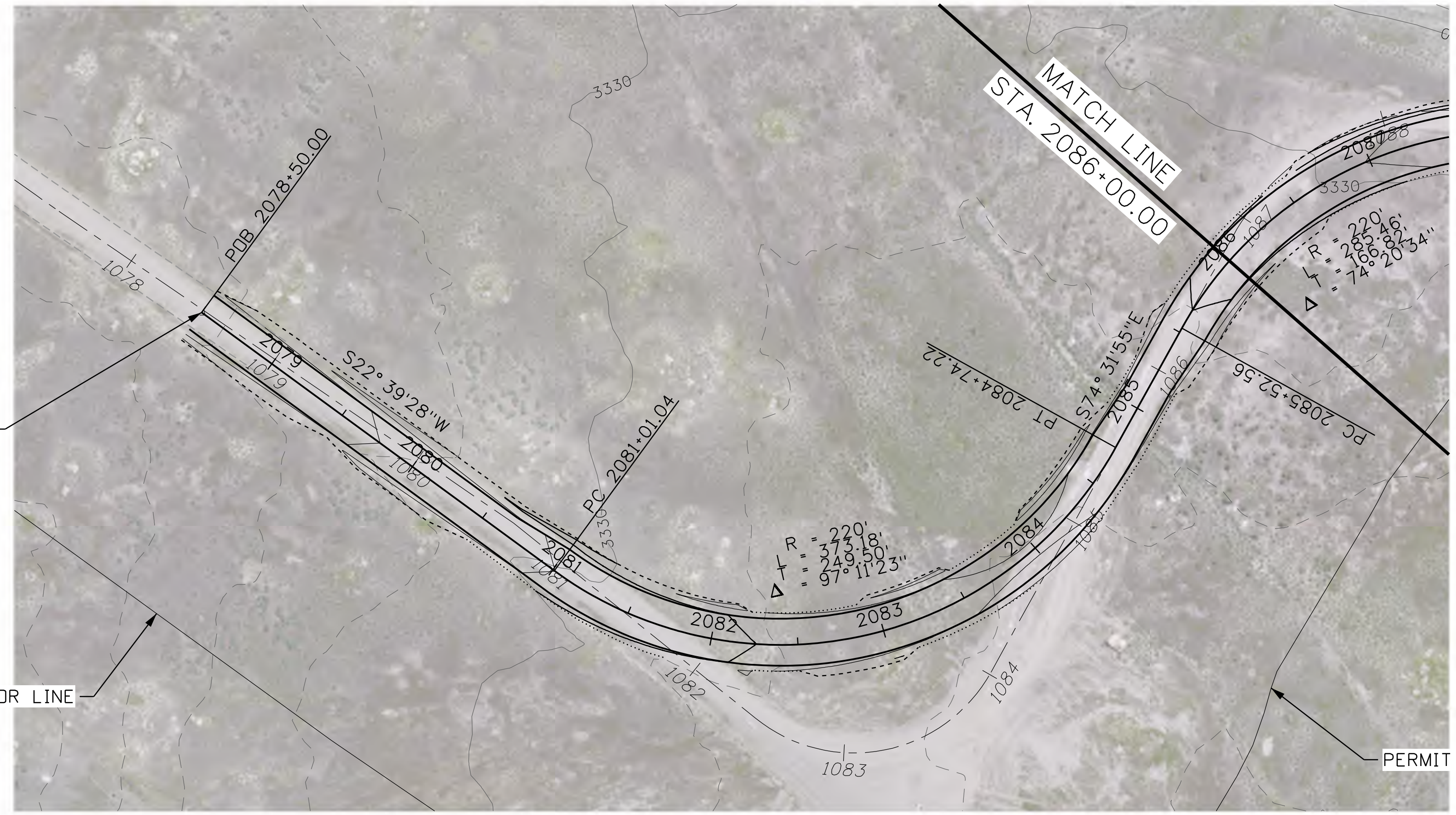
SHEET IDENTIFICATION
SHEET 23
OF 25

HORIZONTAL FEET

50 0 100

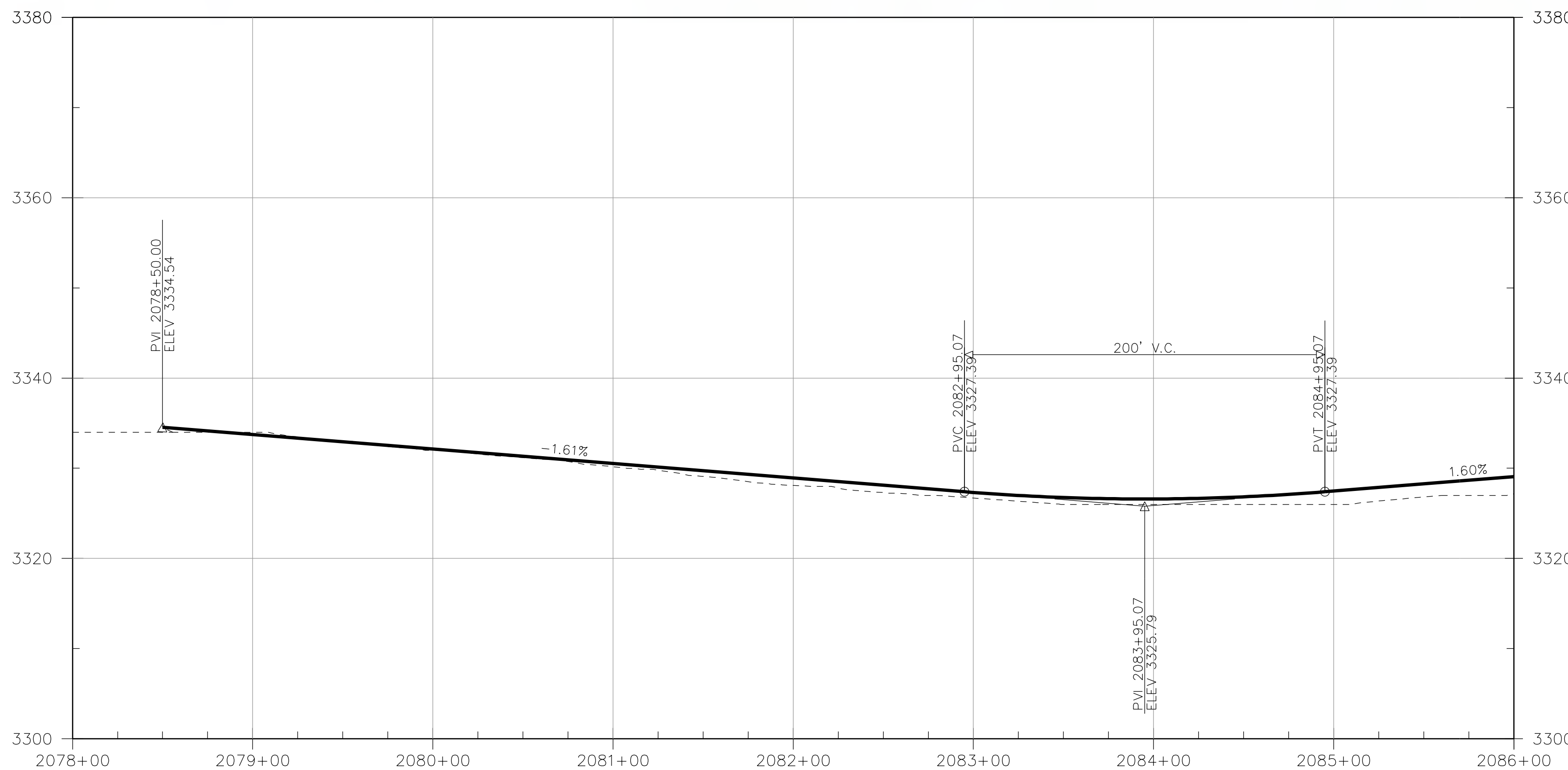
BEGIN RECONSTRUCTION
STATION 2078+50.00
NORTHING 758615.6407
EASTING 5749620.3244

PERMIT CORRIDOR LINE



PERMIT CORRIDOR LINE

PLAN



PROFILE

VERTICAL FEET

10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DATE: OCTOBER 2019
DWN BY: SGW
CKD BY: L. GREBE
HDR PROJECT
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_018.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 2078+50 TO STA. 2086+00

SHEET IDENTIFICATION
SHEET 24
OF 25

HORIZONTAL FEET
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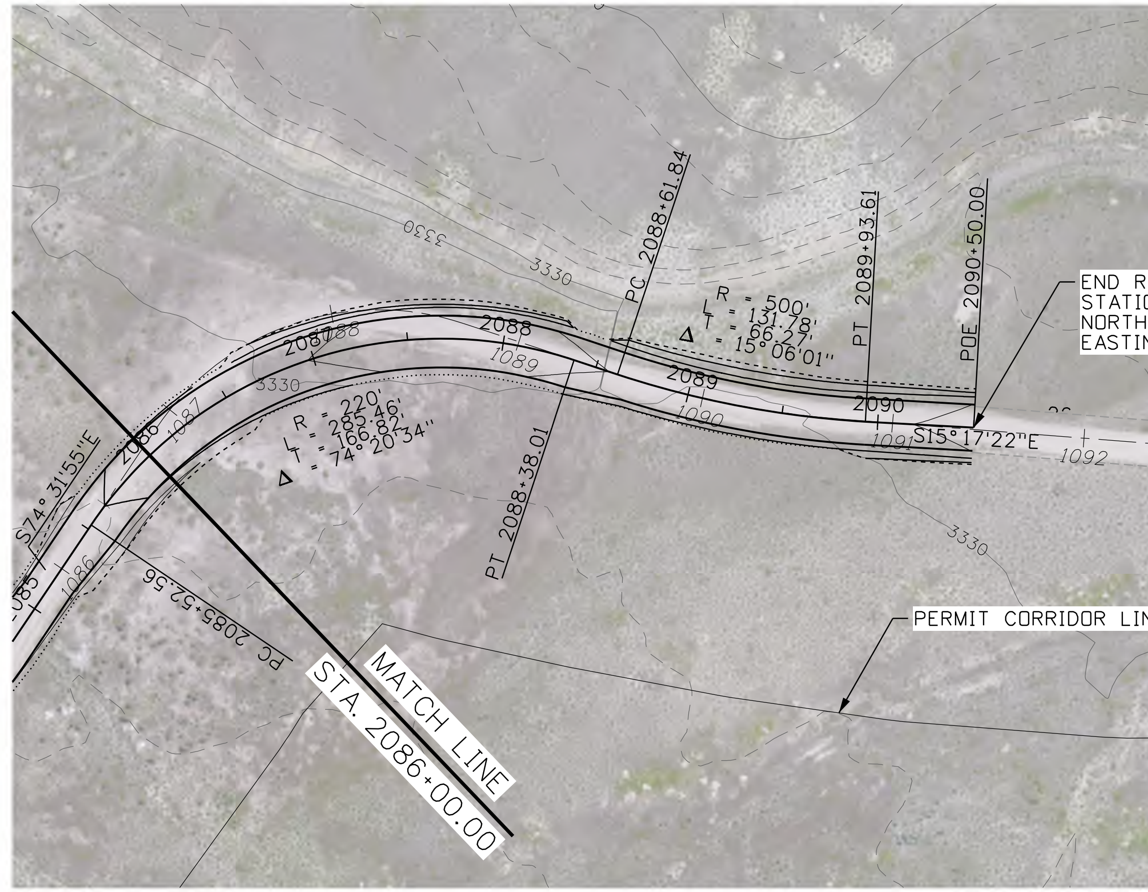

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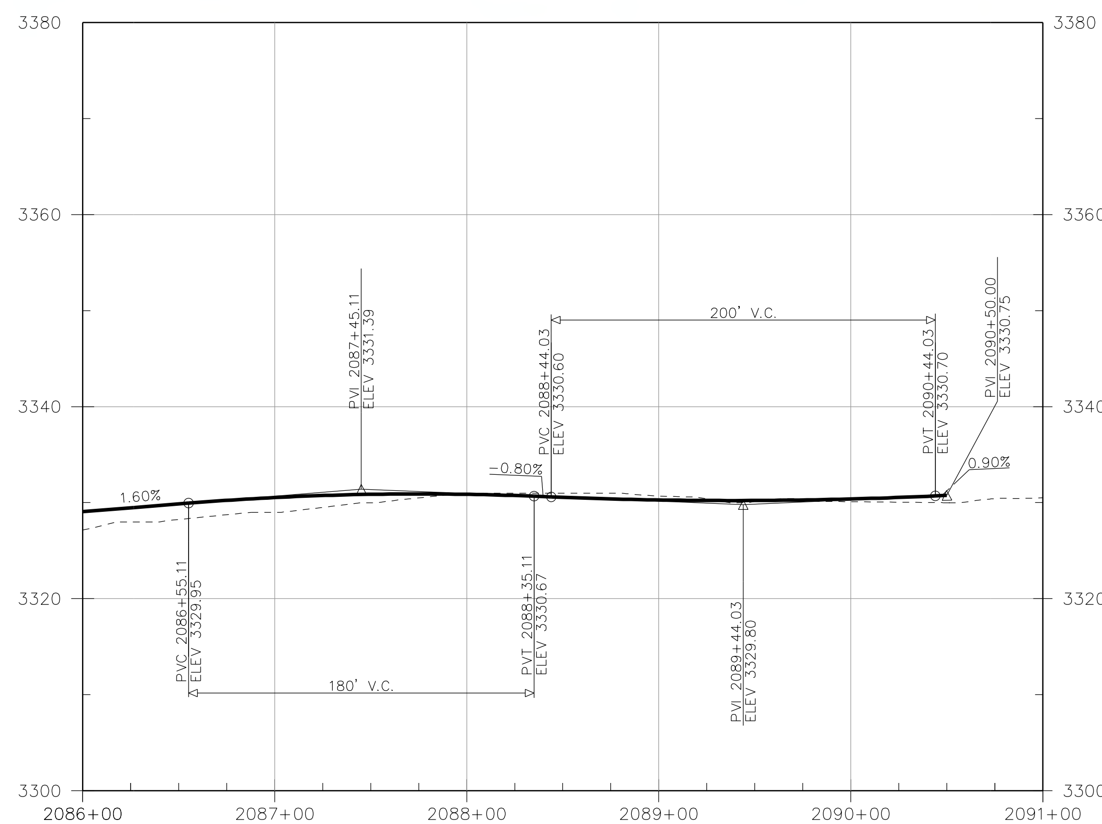


PROFILE

VERTICAL FEET
10 0 20

PARAMOUNT GOLD NEVADA CORP
665 ANDERSON ROAD
WINNEMUCCA, NEVADA

MARK	DESCRIPTION	DATE	APPR

DESIGNED BY: S. WARMBRODT
DWN BY: SGW
CKD BY: L. GREBE
DATE: OCTOBER 2019
HDR PROJECT
PLOT SCALE: 1" = 100'
SIZE: 11X17
FILE NAME: PLAN_PROF_019.SHT

PRELIMINARY

HDR ENGINEERING INC.
412 E. PARKCENTER BLVD.
BOISE, ID 83706

GRASSY MOUNTAIN PROJECT
ROADWAY AND DRAINAGE PLANS
RECONSTRUCTION
STA. 2086+00 TO STA. 2090+50

SHEET IDENTIFICATION
SHEET 25
OF 25

Appendix D
Drainage Analysis

Technical Memorandum

Client:	Calico Resources USA Corp.
Project:	**Grassy Mountain Access Road Design**
Computed By:	Spencer Savage, EIT Luke Grebe, PE
Date:	April 22, 2019
Purpose:	Access Road Drainage Design

Introduction & Background

The Grassy Mountain Access Road Project (Project) consists of designing improvements for the existing access road associated with the Grassy Mountain Mine. The existing road begins at the intersection of Highway 20 and Russell Road and continues south along Cow Hollow Road and Twin Springs Road until reaching the mine. For visual reference, Project Vicinity Maps are shown in Figure 1 and Figure 2. A drainage analysis was performed during the access road design in order to assess drainage patterns and identify locations requiring culverts. A total of 11 locations were identified as locations requiring culverts. The following sections describe the methodologies used during the drainage analysis and the proposed design recommendations.

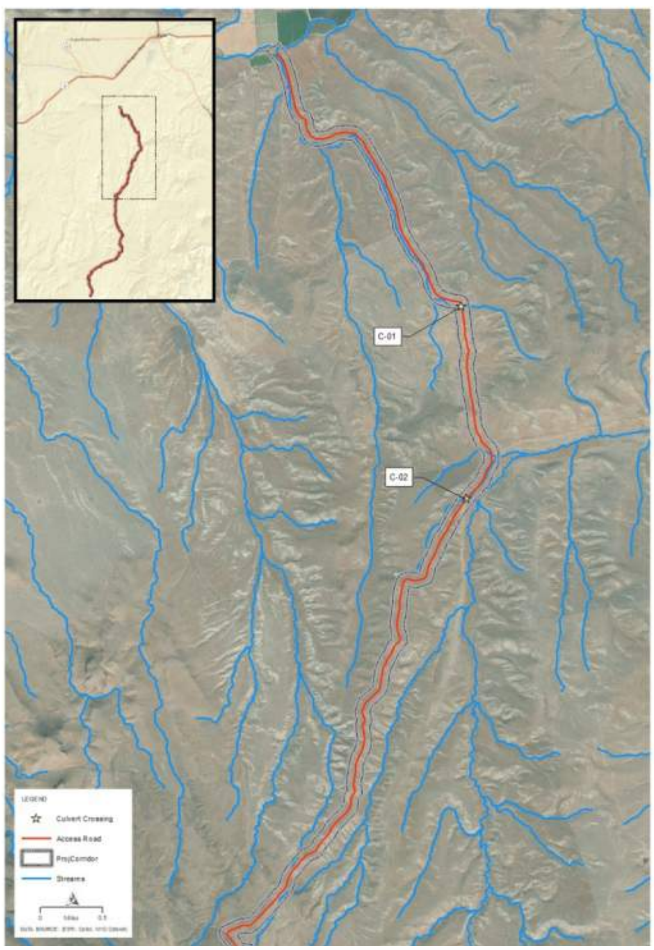


Figure 1. Project Vicinity Map

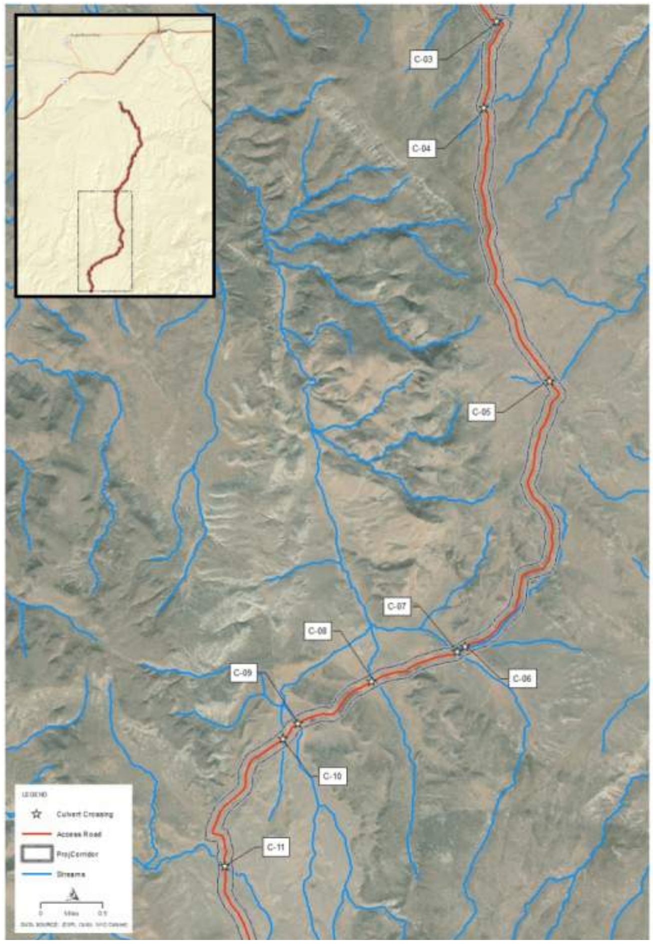


Figure 2. Project Vicinity Map

Assumptions & Design Criteria

Prior to the design of each culvert crossing, design guidance documents from the Bureau of Land Management (BLM) were reviewed in order to establish design assumptions and criteria. More specifically, the guidance documents that were reviewed consisted of the BLM Gold Book Standard (Reference 4) and the BLM Manual MS-9113 Roads (Reference 5). Based upon these two documents, the following assumptions and design criteria were established:

Assumptions

1. Culvert crossings were determined by cross referencing the access road alignment with publically available national hydrography datasets to identify locations where streams intersect the access road.
2. Publically available Digital Elevation Models (DEMs) are sufficient for delineating drainage basins.
3. The Oregon regression equations outlined in the Oregon Water Resources Department Open File Report SW 06-001, *Estimation of Peak Discharges for Rural, Unregulated Streams in Eastern Oregon* (Reference 3) were utilized to calculate peak-flow rates for each drainage basin.
4. For consistency and ease of construction, all culverts will be corrugated metal pipe (CMP).

5. Inlet and outlet protection will consist of hand-placed riprap headwalls. Riprap will be sized (D50) to verify that damage will not occur due to the velocity of the 25-year peak flow. Guidance provided in the *Hydraulic Engineering Circular No. 14 – Hydraulic Design of Energy Dissipators for Culverts & Channels* (HEC-14) (Reference 2) will be used for riprap sizing. To the extent practicable and for ease of construction, a standard D50 will be used for every culvert crossing.
6. All culverts will have end conditions that are projecting from fill.

Design Criteria

1. Culverts will be sized so that no static head is caused during the 10-year event per BLM Gold Book Standard. This requirement is interpreted to mean that the headwater elevation corresponding to the 10-year peak flow must be at or below the crown of the culvert.
2. Culverts will be sized so that no damaging velocities occur during the 25-year event per BLM Gold Book Standard. Where necessary, riprap will be sized to verify that damage will not occur due to the velocity of the 25-year peak flow.
3. The minimum fill height for culverts will be 1.5 times the culvert diameter measured from the culvert invert per BLM Manual 9113 – Roads.
4. Riprap aprons will be required at the culvert inlet and outlet to reduce the likelihood of erosion. The design of the aprons will be based upon the “Hand-Laid Rock Headwalls” diagram shown in Figure 7 of the BLM Gold Book Standard.
5. Ditch relief culverts will have a diameter of 18”. Relief culvert spacing will be based upon Illustration 10 located in the BLM Manual 9113 – Roads.

Hydrologic Analysis

A hydrologic analysis was performed for each culvert crossings in order to estimate peak-flow rates for the 10- and 25-year events. The hydrologic analysis was based upon the regression equations provided in the Oregon Water Resources Department Open File Report SW 06-001, *Estimation of Peak Discharges for Rural, Unregulated Streams in Eastern Oregon*. Eastern Oregon is separated into 6 hydrologic regions and the proposed culvert crossings are located within Region 3 and Region 6. Each hydrologic region has regression equations that incorporate various variables including drainage area and watershed aspect. The contributing drainage areas for each culvert were delineated using publically available Digital Elevation Models (DEM) developed by the U.S. Geological Survey. A summary of the hydrologic analysis and the calculated peak-flow rates are provided in Table 1.

Table 1. Summary of Hydrologic Analysis

Culvert Crossing ID	Station	Hydrologic Region	Drainage Area (mi^2)	Watershed Aspect (degrees)	10-year Peak Flow Rate (cfs)	25-year Peak Flow Rate (cfs)
C-01	305+56.00	3	0.27	-	18	23
C-02	393+79.00	6	0.19	134	14	20
C-03	634+11.00	6	0.34	118	31	44
C-04	675+10.00	6	0.16	109	21	30
C-05	800+15.00	6	0.37	139	21	30
C-06	940+20.00	3	1.23	-	56	72
C-07	944+25.00	3	2.14	-	84	109
C-08	983+55.00	3	1.32	-	59	76
C-09	1021+30.00	3	1.84	-	75	97
C-10	1132+64.00	3	0.23	-	16	21
C-11	1101+19.00	3	3.87	-	130	169

Hydraulic Analysis

A hydraulic analysis was performed for each stream crossing in order to size each culvert to meet the aforementioned design criteria. The culverts were sized using the software program HY8 (Reference 1). A copy of the HY8 analyses is provided in Appendix C. All culverts were designed to be CMP with varying diameters and lengths. In general, the proposed culvert diameters range from 24” to 48”. The culvert size and barrel configuration for each crossing were designed to satisfy the aforementioned design criteria. When possible, multiple barrel culvert configurations were used to optimize conveyance and minimize the reconstructed roadway profile. A summary of the proposed culvert design is provided in Table 2.

Table 2. Summary of Hydraulic Analysis

Stream Crossing ID	Material Type	Diameter	Number of Barrels	Pipe Length (ft)	10-year HW Depth(ft)	25-year Velocity (fps)
C-01	CMP	24”	2	37.0	1.6	9.8
C-02	CMP	24”	2	69.0	1.7	5.8
C-03	CMP	30”	2	40.0	2.0	9.0
C-04	CMP	24”	2	38.0	1.9	6.4
C-05	CMP	24”	2	38.0	1.9	6.4
C-06	CMP	36”	2	40.0	3.0	7.4
C-07	CMP	42”	2	43.0	3.3	8.9
C-08	CMP	48”	1	35.0	3.8	8.7
C-09	CMP	36”	3	35.0	2.5	7.1
C-10	CMP	24”	2	45.0	1.6	5.6
C-11	CMP	42”	3	48.0	3.1	8.0

Riprap Sizing

Each culvert crossing will have a riprap apron at the inlet and outlet to reduce the likelihood of erosion. The dimensions of the riprap apron will be based upon the hand-laid rock headwall drawing shown in Figure 7 within the BLM Gold Book Standard. For visual reference, a snapshot of the drawing is provided in Figure 3.

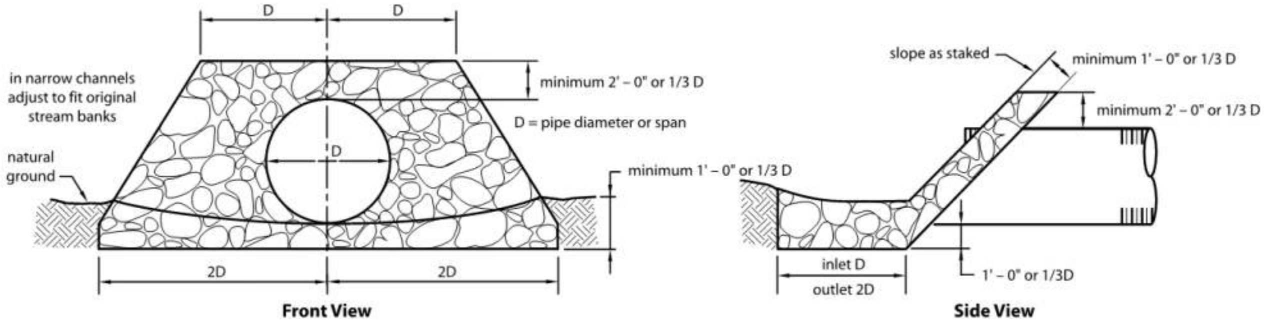


Figure 3. Schematic of Riprap Apron Detail

The riprap size (D50) for each culvert was calculated using equation D.1a located in Appendix D of *HEC-14 – Hydraulic Design of Energy Dissipators for Culverts and Channels*. The equation takes into account peak-flow, culvert diameter, tailwater depth, and flow intensity. The riprap calculations are provided in Appendix D and summarized in Table 3. To improve the efficiency of construction, the riprap sizes were separated into two categories by rounding up the calculated D50 values. Therefore, the two D50 sizes that will be required are 0.5' and 1.0'. It should be noted that these are the minimum D50 values recommended for this project.

Table 3. Summary of Hydraulic Analysis

Stream Crossing ID	Culvert Diameter (ft)	25-year Peak Flow Rate[1] (cfs)	Tailwater Depth (ft)	Calculated D50 (ft)	Assigned D50 (ft)
C-01	2.0	12	0.5	0.3	0.5
C-02	2.0	10	0.7	0.2	0.5
C-03	2.5	22	1.5	0.1	0.5
C-04	2.0	15	0.9	0.2	0.5
C-05	2.0	15	0.3	0.7	1.0
C-06	3.0	36	1.1	0.3	0.5
C-07	3.5	55	1.1	0.4	0.5
C-08	4.0	76	1.2	0.5	0.5
C-09	3.0	32	0.7	0.5	0.5
C-10	2.0	11	0.3	0.5	0.5
C-11	3.5	56	1.9	0.2	0.5

[1] Peak flows shown in this table reflect the flow passing through each culvert

Ditch Relief Culverts

Improvements to the access road will also include roadside ditches to accommodate roadway drainage. Multiple ditch relief culverts will be installed along the roadway alignment to maintain natural drainage patterns to the maximum extent practicable. Each ditch relief culvert will have a diameter of 18” per BLM Manual 9113 – Roads. The roadway profile was reviewed to determine the approximate spacing between ditch relief culverts. The spacing requirements were based on Illustration 10 within BLM Manual 9113 – Roads. It should be noted that geotechnical data was not available for the project corridor. Therefore, an erosion index of 20 was assumed for the project to be conservative. The ditch relief culverts are summarized in Table 4.

Table 4. Summary of Ditch Relief Culverts

Begin STA	End STA	Segment Length (ft)	Average Segment Slope (%)	Erosion index	Minimum Culvert spacing (ft)	Number of Culverts
119+25.65	129+64.34	1,039	2.0	20	1,225	1
129+64.34	132+58.74	294	9.0	20	270	2
132+58.74	136+15.09	356	-2.0	20	1,225	1
136+15.09	137+95.69	181	-7.0	20	350	1
137+95.69	173+09.00	3,513	-2.0	20	1,225	3
173+09.00	177+00.00	391	2.0	20	1,225	1
177+00.00	178+60.00	160	4.0	20	610	1
178+60.00	188+34.00	974	-3.0	20	815	2
188+34.00	190+55.00	221	4.0	20	610	1
190+55.00	191+96.00	141	-2.0	20	1,225	1
191+96.00	210+48.00	1,852	2.0	20	1,225	2
210+48.00	283+77.00	7329	2.0	20	1225	6
283+77.00	304+73.00	2,096	3.0	20	815	3
304+73.00	308+00.00	327	2.0	20	1,225	1
308+00.00	311+00.00	300	7.0	20	350	1
311+00.00	315+84.00	484	2.0	20	1,225	1
315+84.00	316+00.00	16	-8.0	20	305	1
316+00.00	324+32.00	832	5.0	20	490	2
324+32.00	331+00.00	668	-3.0	20	815	1
331+00.00	336+00.00	500	4.0	20	610	1
336+00.00	354+00.00	1,800	8.0	20	305	6
354+00.00	371+00.00	1,700	-2.0	20	1,225	2
371+00.00	375+00.00	400	2.0	20	1,225	1
375+00.00	394+00.00	1,900	2.0	20	1,225	2

394+00.00	402+00.00	800	8.0	20	305	3
402+00.00	468+00.00	6,600	5.0	20	490	14
468+00.00	472+00.00	400	-4.0	20	610	1
472+00.00	506+00.00	3,400	2.0	20	1,225	3
506+00.00	535+00.00	2,900	3.0	20	815	4
535+00.00	544+01.00	901	-7.0	20	350	3
544+01.00	563+00.00	1,899	5.0	20	490	4
563+00.00	569+00.00	600	-2.0	20	1,225	1
569+00.00	575+01.00	601	5.0	20	490	2
575+01.00	579+00.00	399	2.0	20	1,225	1
579+00.00	624+00.00	4,500	7.0	20	350	13
624+00.00	631+13.00	713	-2.0	20	1,225	1
631+13.00	635+00.00	387	-11.0	20	220	2
635+00.00	650+00.00	1,500	10.0	20	245	7
650+00.00	656+00.00	600	4.0	20	610	1
656+00.00	663+00.00	700	9.0	20	270	3
663+00.00	695+00.00	3,200	2.0	20	1,225	3
695+00.00	708+04.00	1,304	6.0	20	410	4
708+04.00	737+00.00	2,896	2.0	20	1,225	3
737+00.00	745+00.00	800	2.0	20	1,225	1
745+00.00	751+00.00	600	-4.0	20	610	1
751+00.00	760+00.00	900	2.0	20	1,225	1
760+00.00	801+00.00	4,100	-4.0	20	610	7
801+00.00	807+00.00	600	2.0	20	1,225	1
807+00.00	835+00.00	2,800	3.0	20	815	4
835+00.00	848+16.00	1,316	-3.0	20	815	2
848+16.00	861+00.00	1,284	-6.0	20	410	4
861+00.00	880+00.00	1,900	-8.0	20	305	7
880+00.00	908+00.00	2,800	-6.0	20	410	7
908+00.00	956+00.00	4,800	-4.0	20	610	8
956+00.00	992+77.00	3,677	2.0	20	1,225	4
992+77.00	1005+00.00	1,223	4.0	20	610	3
1005+00.00	1033+00.00	2,800	2.0	20	1,225	3
1033+00.00	1074+00.00	4,100	3.0	20	815	6

1074+00.00	1100+82.00	2,682	2.0	20	1,225	3
1100+82.00	1144+23.00	4,341	3.0	20	815	6
1144+23.00	1146+39.00	216	-3.0	20	815	1
1146+39.00	1152+00.00	561	6.0	20	410	2
1152+00.00	1155+00.00	300	-7.0	20	350	1
1155+00.00	1176+84.00	2,184	3.0	20	815	3

Conclusion

Upon review of the information presented in this report, it can be seen that the culvert diameters range from 24” to 48” and multiple crossings will require more than one barrel. The hydrologic analysis was performed using Oregon Department of Water Resources regression equations in order to estimate the 10- and 25-year peak flow rates. These peak flow rates were then used to hydraulically analyze each culvert in order to determine culvert diameters that would satisfy the aforementioned design assumptions and criteria. Furthermore, the results of the hydrologic and hydraulic analyses were then used to determine appropriate riprap sizes for the inlet and outlet apron protections.

The content included in this report is correct to the best of our knowledge and has been developed in accordance with the standard of care that is customarily followed by a practitioner in this industry. The standard of care was followed for collection and analysis of data, and for modeling efforts performed in support of this report.

The conclusions and recommendations in this report are based on the conditions of the project site and the associated watersheds at the time of this study. Any modifications to the site, man-made or natural, could alter and invalidate the analysis, findings, and recommendations contained herein. Site conditions, upstream or downstream land use changes, climate changes, vegetation changes, maintenance practice changes, or other factors may change over time. Additional analysis or revisions may be required in the future as a result of these changes.

References

1. Federal Highway Administration, HY-8 Version 7.5, July 2016.
2. Federal Highway Administration, Hydrologic Engineering Circular No. 14 (HEC-14), *Hydraulic Design of Energy Dissipators for Culverts & Channels*, July 2006.
3. State of Oregon – Department of Water Resources, Open File Report (OFR) SW 06-001, Estimation of Peak Discharges for Rural, Unregulated Streams in Eastern Oregon, March 2006.
4. U.S. Bureau of Land Management, *The Gold Book: Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development*, 2007.
5. U.S. Bureau of Land Management, Manual Transmittal Sheet MS-9113 – Roads, May 2015.

Appendix A – Design Standards

Drainage and Drainage Structures

The proper design and construction of structures for the drainage of water from or through the roadway often contributes the most to the long-term success of the road and structure and minimizes maintenance and adverse environmental effects, such as erosion and sediment production. It is vitally important to keep the water off the road.

Road Drainage Design

The most economical control measure should be designed to meet resource and road management objectives and constraints. The economic considerations should include both construction and maintenance costs. The need for drainage structures can be minimized by proper road location. However, adequate drainage is essential for a stable road. A proper drainage system should include the best combination of various design elements, such as ditches, culverts, drainage dips, crown, in-slope or out-slope, low-water crossings, subsurface drains, and bridges.

Surface Drainage

Surface drainage provides for the interception, collection, and removal of water from the surface of roads and slope areas. The design may need to allow for debris passage, mud flows, and water heavily laden with silt, sand, and gravel. Culverts should be designed in accordance with applicable practices adopted by State and Federal water quality regulators under authority of the Federal Clean Water Act (CWA). Culverts should accommodate a 10-year flood without development of a static head and avoid serious velocity damage from a 25-year flood.

Subsurface Road Drainage

Subsurface drainage is provided to intercept, collect, and remove groundwater that may flow into the base course and subgrade; to lower high water tables; or to drain locally saturated deposits or soils.

Drainage Structures

Proper location and design can provide economical and efficient drainage in many cases. However, structural measures are often required to ensure proper and adequate drainage. Some of the most common structures are drainage dips, ditches, road crowning, culverts, and bridges.

Drainage Dips

The primary purpose of a drainage dip is to intercept and remove surface water from the travelway and shoulders before the combination of water volume and velocity begins to erode the surface materials. Drainage dips should not be confused with water bars, which are normally used for drainage and erosion protection of closed or blocked roads. See Figure 5 for an illustration of a typical drainage dip and construction specifications. Spacing of drainage dips depends upon local conditions such as soil material, grade, and topography. The surface management agency should be consulted for spacing instructions.

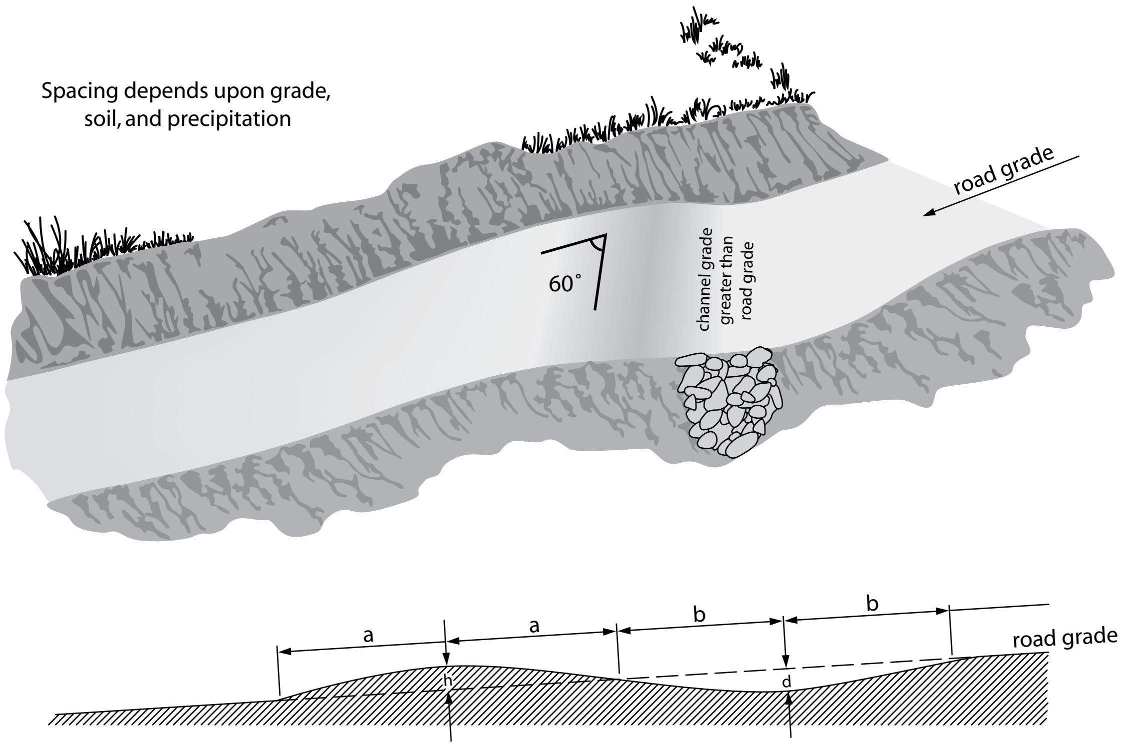
Ditches

The geometric design of ditches must consider the resource objectives for soil, water, and visual quality; maintenance capabilities and associated costs; and construction costs. Ditch grades should be no less than 0.5 percent to provide positive drainage and to avoid siltation. The types of ditches normally used are drainage, trap, interception, and outlet.

Road Crowning

Roads that use crowning and ditching are common and can be used with all road classes, except non-constructed roads. This design provides good drainage of water from the surface of the road.

Drainage of the inside ditch and sidehill runoff is essential if the travelway is to be kept dry and passable during wet weather.



Cross-Section of Waterdip on Center Line

Road Grade	d	h	a	b
2%	0.6'	0.4'	10'	10'
4%	1.0'	0.8'	14'	14'
6%	1.2'	1.4'	16'	18'
8%	2.0'	2.2'	22'	24'

Figure 5. Typical drainage dip and construction specifications.

Culverts

Culverts are used in two applications: in streams and gullies to allow normal drainage to flow under the travelway and to drain inside road ditches. The latter may not be required if drainage dips are used. The location of culverts should be shown on the plan and profile or similar drawings or maps submitted with the APD.

All culverts should be laid on natural ground or at the original elevation of any drainage crossed, except as noted for ditch relief culverts. See Figures 6 and 7 for installation details.

Culverts should have a minimum diameter of 18 inches. The diameter should be determined by the anticipated amount of water that would flow through the culvert. Factors to be considered include the geographic area being drained, soils and slopes in the drainage area, annual precipitation, and likely storm events.

The outlet of all culverts should extend at least 1 foot beyond the toe of any slope. It may be necessary to install rip-rap or other energy dissipation devices at the outlet end of the culvert to prevent soil erosion or trap sediment (see example in the photograph).

Properly sized rock rip-rap at culvert outlets helps reduce water velocity and resulting soil erosion.

Maximum Recommended Culvert Spacing (ft)

Soil Type	Road Grade 2–4%	Road Grade 5–8%	Road Grade 9–12%
Highly erosive granitic or sandy	240	180	140
Intermediate erosive clay or load	310	260	200
Low erosive shale or gravel	400	325	250

Figure 6. Culvert spacing.

All culverts used in the construction of access roads should be concrete, corrugated metal pipe made of steel, or properly bedded and backfilled corrugated plastic pipe. Only undamaged culverts are to be used, and any culvert should be inspected for damage prior to installation. All spots on the pipes where the zinc coating has been injured should be painted with two coats of zinc-rich paint or otherwise repaired as approved by the surface management agency.

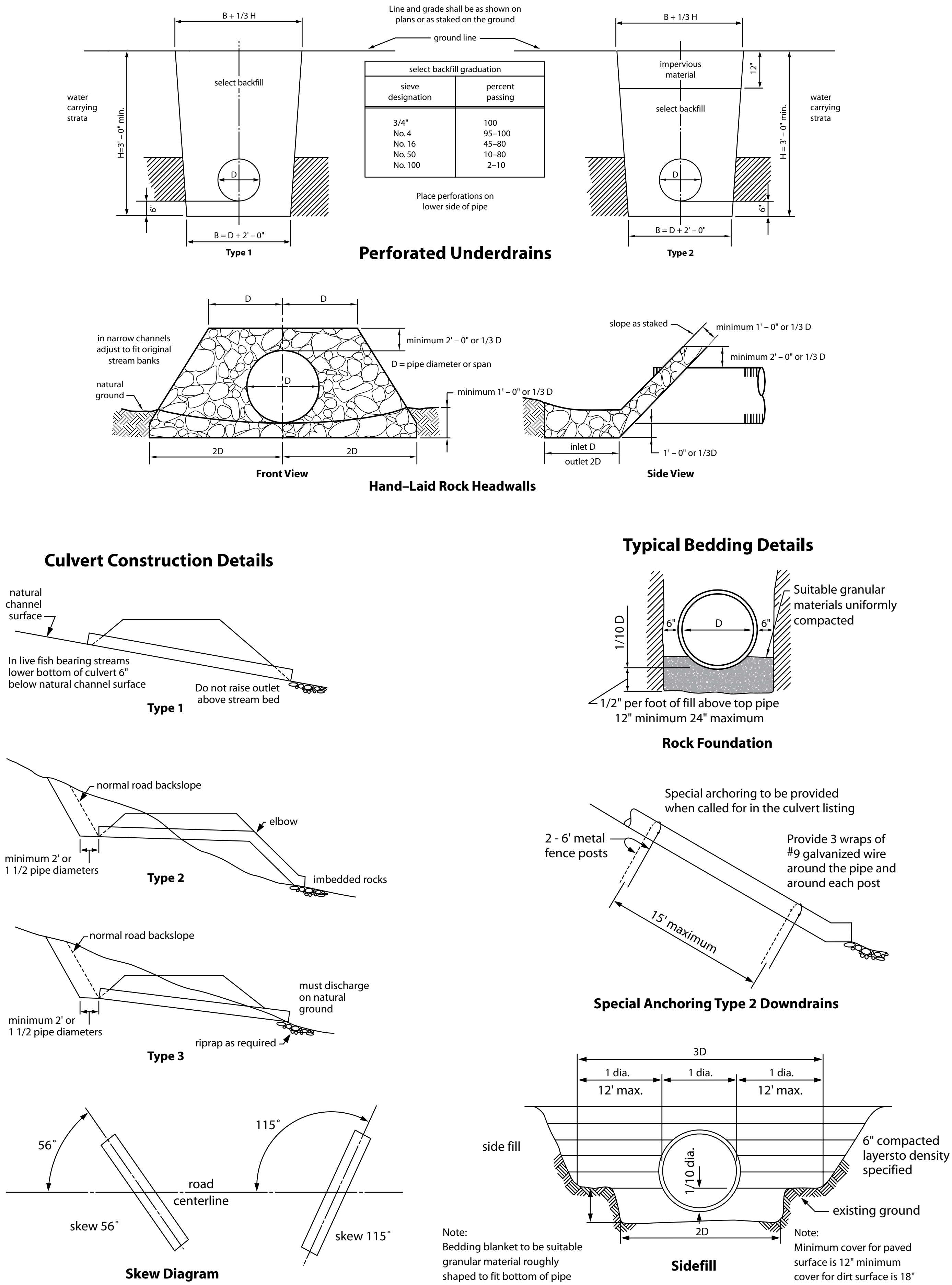
Excavation, bedding, and backfilling of culverts should be conducted according to requirements of the surface management agency and good engineering practices. Compliance with applicable Clean Water Act Best Management Practices and requirements for passage of aquatic species is required.

Ditch Relief Culverts

Ditch relief culverts are installed to periodically relieve the ditch line flow by piping water to the opposite side of the road where the flow can be dispersed away from the roadway. The spacing of ditch relief culverts (Figure 6) is dependent on the road gradient, soil types, and runoff characteristics.

A culvert with an 18-inch diameter is the minimum for ditch relief to prevent failure from debris blockage.

The depth of culvert burial must be sufficient to ensure protection of the culvert barrel for the design life of the culvert. This requires anticipating the amount of material that may be lost due to road use and erosion.



select backfill graduation	
sieve designation	percent passing
3/4"	100
No. 4	95–100
No. 16	45–80
No. 50	10–80
No. 100	2–10

Figure 7. Diagrams for proper culvert installation

Ditch relief culverts can provide better flow when skewed with an entrance angle of 45 to 60 degrees with the side of the ditch. The culvert gradient should be greater than the approach ditch gradient. This improves the flow hydraulics and reduces siltation and debris plugging the culvert inlet. Culverts placed in natural drainages can also be used for ditch relief.

Bridges and Major Culverts

Federal Highway Administration (FHA) regulations and BLM and FS road manuals require that on roads open to public travel, all bridges and culverts that in combination span at least 20 feet horizontal distance, must comply with the National Bridge Inspection and Reporting Standards. Thus, BLM and FS manuals require that all such facilities have engineering approval from Regional or State offices. Operators are encouraged to prepare applications requiring major culverts or bridges to allow sufficient time for agency engineering evaluations. Construction of some stream crossings may require a Section 404 Corps of Engineers permit in addition to the approval of the surface management agency.

Wetland Crossings

Wetlands are especially sensitive areas and should be avoided, if possible. Generally, these areas require crossings that prevent unnatural fluctuations in water level. Marshy and swampy terrain may contain bodies of water with no discernible current. The design of culverts for roads crossing these locations requires unique considerations. Construction of some wetland crossings may require a Section 404 Corps of Engineers permit in addition to the approval of the surface management agency.

The culvert should be designed with a flat grade so water can flow either way and maintain its natural water level on both sides. The culvert may become partially blocked by aquatic growth and should be installed with the flowline below the standing water level at its lowest elevation. Special attention must be given to the selection of culvert materials that will resist corrosion.

Low-Water Crossings

Roads may cross small drainages and intermittent streams where culverts and bridges are unnecessary. The crossing can be effectively accomplished by dipping the road down to the bed of the drainage. Site-specific designs and the construction of gravel, rip-rap, or concrete bottoms may be required in some situations. In no case should the drainage be filled so that water will be impounded. Low-water crossings that are not surfaced should not be used in wet conditions. Low-water crossings, in combination with culverts, may be utilized if the crossing is designed such that the structure is stable and self cleaning.

Subdrainage

If water is not removed from the subgrade or pavement structure, it may create instability, reduce load-bearing capacity, increase possible damage from frost action, and create a safety hazard by freezing on the road surface.

Perforated pipe drains and associated filter fabric or aggregate filters may be used when necessary to provide subdrainage. Other methods may be approved by the authorized officer.

Subdrainage systems may effectively reduce final road costs by decreasing the depth of base course needed, thereby reducing subgrade widths. This, in turn, results in less clearing and excavation. Maintenance savings may also be realized as the result of a more stable subgrade.

The solutions to subdrainage problems can be expensive. Road management techniques, such as reducing traffic loads or removing traffic until a subgrade dries out, may be considered as an alternative.

Form 1221-2
(June 1969)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

MANUAL TRANSMITTAL SHEET

Release	Date
9-405	May 4, 2015

Subject

MS 9113 – ROADS

1. Explanation of Material Transmitted: Added: 1.5 Policy, Paragraph B, concerning Federal Lands Transportation Designated Network roads, to be considered as fully "public roads" with added jurisdiction by the Secretary of Transportation.

2. Reports Required: N/A

3. Material Superseded: MS 9113, Release Number 9-390.

4. Filing Instructions: File as directed below.

REMOVE	INSERT
All of Release Number 9-390	9113 (19 pages)

Janine Velasco

Assistant Director,
Business, Fiscal and Information
Resources Management

Table of Contents

Chapter 1 - Overview

1.1 Purpose

This Manual Section provides for: inventory, functional classification, condition assessment, and establishment of maintenance intensities of the Bureau's roads for incorporation into the Bureau Planning System; Bureau road standards; and guidelines for road project planning, design, construction, and maintenance.

1.2 Objectives

The objectives are to:

A. Identify the role each organizational unit plays in providing engineering expertise for the management of BLM road programs. Provide direction for appropriate coordination with other organizations.

B. Provide direction for safe and adequate BLM roads for users.

C. Provide adequate information to ensure that planning, design, construction, maintenance and condition assessment activities for road projects meet BLM needs and are performed in an acceptable manner.

1.3 Authority

The authority for providing road facilities is contained in the Federal Land Policy and Management Act of 1976 (FLPMA), as amended. Also see Manual Sections 9100.03, 9103.03, and 9104.3. Authorities affecting planning, design, construction, maintenance, and condition assessment of roads include:

A. Federal Highway Act of 1962, as amended.

B. Highway Beautification Act of 1965, as amended.

C. Highway Safety Act of 1966, as revised.

D. Surface Transportation Act of 1978, as amended.

E. Surface Transportation Assistance Act of 1982.

F. Government Performance and Results Act of 1993 (GPRA).

1.4 Responsibility

The responsibilities described below are commensurate with those approved functional statements and Manual Sections 9100.04, 9103.04, 9104.04 and 9110.04.

A. The Chief, Division of Business Services, as exercised through the Chief, Engineering and Asset Management Policy Branch, is responsible for:

   1. Providing Bureau-wide leadership and guidance for planning, design, construction, maintenance, and condition assessment of roads associated with managing public lands.

   2. Establishing Bureau-wide road standards.

   3. Developing Bureau-wide systems and standards for road inventory, road classification, and maintenance intensities.

   4. Providing overall direction and quality of the Bureau Facilities Asset Management System (FAMS) database for the BLM roads inventory.

   5. Coordinating with other Federal agencies, national interest groups, and road associations to ensure that Bureau interests are represented and that the Bureau is kept abreast of the newest developments regarding road-related activities.

B. The Chief, Branch of Engineering and Asset Management, National Operations Center (NOC), is responsible for:

   1. Providing stewardship of the Bureau FAMS database for the BLM roads inventory.

   2. Providing technical manual and handbook updates and revisions for approval and issuance by WO.

   3. Providing technical engineering support to the WO/State/Field Offices, when requested.

   4. Providing Contracting Officer’s Representative services, on Indefinite Delivery/Indefinite Quantity Architectural and Engineering contracts, when requested on State planning, design, construction, maintenance, and condition assessment projects.

C. The State Engineer in each State is responsible for:

1. Providing State-wide leadership and guidance for planning, design, construction, maintenance, and condition assessment of roads associated with managing public lands within their geographic area of responsibility.

2. Providing overall direction and quality of the State FAMS database for the BLM roads inventory.

3. Ensuring that personnel assigned to road design, construction inspection, and condition assessment duties receive training and are otherwise qualified.

4. Ensuring all road designs are reviewed and approved by qualified individuals before construction work begins.

5. Coordinating with State Department of Transportation, FHWA Regional and Division officials, and various other organizations as necessary to ensure that the statewide road program interests are represented.

D. The District Manager or Field Manager, as appropriate, is responsible for:

1. Coordinating an interdisciplinary review and approval of all route selections for new or relocated routes.

2. Making determinations on the location of new or relocated roads based on environmental and route analysis reports generated by the interdisciplinary review team.

3. Ensuring the overall quality of the District/Field Office FAMS database for the BLM roads inventory.

4. Ensuring that proposed roads are designed and constructed to BLM road standards or approved plan/permit.

E. The District Engineer, Field Engineer, Zone Engineer, or other engineer as designated by the responsible line manager, is responsible for:

1. Accomplishing assigned road project tasks, such as inventory work, condition assessments, designs, design reviews, in a timely manner, within budget, and in conformity with this Manual Section.

2. Assigning construction inspection tasks only to those personnel who have completed the required training or and are otherwise qualified.

3. Recommending training for local personnel to ensure that road design and construction inspection capabilities meet the District or Field Office needs.

4. Coordinating with County road officials, State Department of Transportation (DOT) officials and other appropriate officials to ensure the District or Field Office road program interests are represented.

5. Coordinating with resource specialists to ensure road inventories and condition assessments are accomplished in a timely manner and that the data is properly input into the FAMS database.

1.5 Policy

It is Bureau policy that:

A. Bureau roads must be designed and maintained to an appropriate standard no higher than necessary to accommodate their intended functions; and planning, design, construction, maintenance, and condition assessment activities must be consistent with national policies for safety, esthetics, protection, and preservation of cultural, historic, wildlife, and scenic values, and accessibility for the physically challenged.

B. Bureau roads are for use, development, protection, and administration of public lands and resources. Though administered by a public agency, bureau roads are not currently designated as public roads. Bureau roads are subject to rules and regulations of the Secretary of the Interior, thus, roads may be closed or use restricted to fulfill management objectives such as protecting public health and safety, preserving resources, or in support of security issues. Bureau roads may also be subject to State and other Federal regulations as necessary to protect public health and safety.

   Bureau roads selected for inclusion into the Federal Lands Transportation (FLT) designated network are considered to be fully "Public Roads". While these roads remain under the Secretary of Interior's jurisdiction, FLT roads are also subject to the authorities of the Secretary of Transportation.

   Reclamation/decommissions, closures, and use restrictions, except for emergency reasons, are identified prior to construction or through the Land Use Planning Process. Bureau roads which no longer support management objectives are to be reclaimed/decommissioned.

C. Continuous coordination with other agencies and public road authorities is undertaken to assure that land use, resources, and public interests are represented and that Bureau road management actions and activities are appropriate.

D. The location, design, construction, and maintenance of roads crossing public lands must comply with all applicable Federal laws.

E. All roads controlled by the Bureau must meet appropriate Bureau road standards, whether or not they are constructed by Bureau initiative.

F. All Bureau road designers must be qualified. Roads constructed by non-governmental entities across public lands must be designed by or under the direction of a licensed professional engineer when the Field Manager identifies road safety and resource protection issues warranting an engineering design. Issues the Field Manager should take into consideration include average daily traffic, design speed, topography, soil types, and anticipated amount of use by the public.

G. The acquisition of easements may not be initiated until a route analysis has been completed and approved by the appropriate District or Field Office Manager. Technical approval of easement surveys, easement plats, and legal descriptions for acquisitions is delegated through the State Director and the appropriate line manager to the District or Field Office Engineer or the Chief Cadastral Surveyor. If there are no qualified Field Office Engineers, then delegation of authority goes to the next highest organizational level in engineering.

H. Comprehensive Condition Assessments of Bureau surfaced roads (aggregate, paved, etc.) are performed on a ten-year cycle and inspected after events such as severe storms to determine emergency actions or priority maintenance needs. Non-surfaced roads are inspected as needed on a local basis, or after events such as severe storms, or on a discovery basis. These roads do not include roads which fall within the boundaries of administrative and recreation sites. Roads within these boundaries are assessed during the recreation/administrative site assessments.

   All Bureau roads that have been included in the FLT Designated Network are inspected on a five year cycle.

1.6 Scope of Road Program

The management of public lands and resources is affected by continually changing social, economic, and political needs. As management objectives change, road needs could also change. An effective program to provide a road system needed to support these changing management objectives must be predicated on current and future needs and must allocate limited resources by the most effective method. A current inventory of facilities and a method of measuring their adequacy are basic to managing a road system. The FAMS has been designated as the central repository of all BLM required road condition and inventory data

Chapter 2 - Road Program Management

The management of the road program requires data collection, information dissemination, and inter- and intra- Bureau coordination to determine the need to construct, improve, maintain, acquire, transfer jurisdiction, restrict use, or close and reclaim/decommission certain roads. Coordination is particularly important, since most Bureau roads affect or are affected by resource management decisions or by road management decisions made by other organizations.

2.1 Road Inventory and Condition

The Bureau's official inventory of roads is contained within the FAMS. Guidance on conducting Bureau road condition assessments is contained within H-9113-2.

A. Route Numbers

Use the same route number throughout the length of the route. Do not duplicate route numbers within the State. The State Office may assign blocks of numbers to each District or Field Office to assure that no duplication occurs. Numbers are assigned by the District or Field Office in which the route originates and continues into the other resource area or District or Field Office jurisdiction if the route crosses a boundary.

B. BLM's Transportation System

Changes to the BLM's transportation system, as recorded in FAMS, may occur as part of the formal evaluation and designation process through one of four events:

1. Record of Decision (ROD) – for a Resource Management/Environmental Impact Statement (RMP/EIS) or an amendment of an RMP/EIS.
2. Decision of Record for an Activity Plan, Plan Amendment/Environmental Assessment (EA).
3. Federal Register Notice Action (under authority of 43 CFR 8341.2, 8364.1, 8365.1-6, or 9268.3) that has a follow-up land-use planning action and associated NEPA action.
4. Management decision of appropriate routes in an area that has been designated open to off-highway vehicle use.

2.2 Functional Classification

The Bureau categorizes its roads as Collector Roads, Local Roads, and Resource Roads.

A. Collector Roads

These Bureau roads normally provide primary access to large blocks of land, and connect with or are extensions of a public road system. Collector roads accommodate mixed traffic and serve many uses. They generally receive the highest volume of traffic of all the roads in the Bureau system. User cost, safety, comfort, and travel time are primary road management considerations. Collector roads usually require application of the highest standards used by the Bureau. As a result, they have the potential for creating substantial environmental impacts and often require complex mitigation procedures.

B. Local Roads

These Bureau roads normally serve a smaller area than collectors, and connect to collectors or public road systems. Local roads receive lower volumes, carry fewer traffic types, and generally serve fewer uses. User cost, comfort, and travel time are secondary to construction and maintenance cost considerations. Low volume local roads in mountainous terrain, where operating speed is reduced by effect of terrain, may be single lane roads with turnouts. Environmental impacts are reduced as steeper grades, sharper curves, and lower design speeds than would be permissible on collector roads are allowable.

C. Resource Roads

These Bureau roads normally are spur roads that provide point access and connect to local or collector roads. They carry very low volume and accommodate only one or two types of use. Use restrictions are applied to prevent conflicts between users needing the road and users attracted to the road. The location and design of these roads are governed by environmental compatibility and minimizing Bureau costs, with minimal consideration for user cost, comfort, or travel time.

2.3 Average Daily Traffic (ADT)

For Bureau purpose, the average daily traffic (ADT) is defined as the annual traffic divided by 365 or by the actual number of days the road is open to traffic. The amount of traffic is determined by the number of vehicles passing a point, regardless of the direction of travel. ADT provides some criteria for geometric standards and is used for justifications and in the design of structural elements. ADT is used as one of the factors in determining the functional classification. In determining ADT, consider Seasonal Average Daily Traffic (SADT), such as during hunting season, may necessitate a higher geometric design standard for the road and a seasonally adjusted higher level of maintenance. Functional classification then determines the appropriate geometric standards.

2.4 Emergency Relief for Federally Owned Roads (ERFO)

The Federal Highway Administration (FHWA) has responsibility to administer the Emergency Relief for Federally Owned Toads (ERFO) program. Refer to the FHWA "Emergency Relief for Federally Owned Roads, Disaster Assistance Manual" for guidance on timelines, coordination, and funding. The ERFO Program is intended to help pay the unusually heavy expenses associated with the repair and reconstruction of Federal roads and bridges seriously damaged by a natural disaster over a wide area of catastrophic failure. Restoration in-kind to pre-disaster conditions is expected to be the predominant type of repair.

2.5 Use of Bureau Funds on Non-Bureau Controlled Roads

Appropriated Bureau funds may not be used to construct, improve, or maintain roads not owned or controlled by the Bureau, or otherwise authorized.

Chapter 3 - Road Standards

Standards are values established to ensure adequate uniformity and quality of all roads constructed on lands administered by the Bureau. These standards are applied to all Bureau or non-Bureau initiated road construction, and are used to determine the sufficiency of existing roads.

3.1 Development of Geometric Standards

To determine the appropriate design application, road functional classification should be used. The American Society of Civil Engineers "Local Low Volume Roads and Streets" manual contains information that relates to the Bureau's low-volume roads. The American Association of State Highway and Transportation Officials (AASHTO) "A Policy on Geometric Design of Highways and Streets" is applicable for some of the Bureau roads. In addition, it contains a section addressing 'Special Purpose Roads,' including recreation and resource development roads that may also be applicable to some of the Bureau roads. AASHTO "Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT<400)" is also applicable for some of the Bureau's roads. Since AASHTO geometric standards for low-volume, low-speed, single-lane roads, and unpaved roads are not always applicable to Bureau roads, coordination with other agencies in addition to those listed above, continues to be the best source of information for the development of realistic standards.

3.2 Relationship Between Standards and Design Element Values

The values for curve radii, vertical curve lengths, sight distance, superelevation rates, and runoff lengths are closely related to design speed. The designer must utilize design element values appropriate to the standard. See H-9113-1 - Road Design Handbook."

3.3 Geometric Standards

Design speed, travelway widths, and maximum grades for various combinations of estimated average daily traffic (ADT), functional classification, and terrain types are shown below.

GEOMETRIC STANDARDS FOR BUREAU ROADS

Functional Classification	Est. 20 Yr. ADT	Terrain	Design Speed		Travelway Width		Maximum Grade	
			Pref.	Min.	Pref.	Min.	Pref.	Max.
Resource	Less Than 20	Level & Rolling	30	*	14	*	8	10*
		Mountainous	15	*	14	*	8	16*
Local	Less Than 100	Level & Rolling	40	30	20	20	6	10
		Mountainous	20	15	14	12	8	15
	More Than 75	Level & Rolling	50	40	24	20	6	10
		Mountainous	30	15	24	20	8	14
Collector	50 - 100	Level & Rolling	50	30	24	20	6	8
		Mountainous	30	20	20	20	8	12
	More Than 100	Level & Rolling	50	40	24	20	6	8
		Mountainous	30	20	24	20	8	12

Note: Design speeds and surface widths chosen are limited to values shown, except that greater widths are allowed when oversized traffic justifies wider widths.
* If preferred design, speed, travelway width, and maximum grade are not feasible for specific resource roads, alternative values are determined by the State Engineer.

3.4 Loadings

Design roads and structures for H-20 or HS-20 loadings, as appropriate, and as specified by the AASHTO. Designs with heavier loadings will be used if the road is used by overweight traffic from adjacent roads.

3.5 Structure Widths

Bridges, culverts, tunnels, cattleguards, and other structures must have a minimum curb-to-curb or rail-to-rail width (whichever is less) of 14 feet for single lane roads and 24 feet for double lane roads, but in all cases not less than the nominal width of the adjacent travelway as measured at right angles to the road centerline.

3.6 Vertical Clearance

Overhead vertical clearance must be a minimum of 16-feet from the traveled way elevation. (See H-9113-1 - Road Design Handbook.)

3.7 Horizontal Clearance

A horizontal clearance of 4-feet from edge of roadway is recommended. (See H-9113-1 - Road Design Handbook.)

3.8 Traffic Control Signs and Markers

Signs and markers placed on or adjacent to the roadway to regulate, inform, or guide vehicle occupants must conform to the requirements of Manual Section 9130 – Sign Manual and the FHWA "Manual on Uniform Traffic Control Devices."

3.9 Easement Widths

The width of easements for Bureau roads is limited to the minimum width necessary for construction and maintenance operations, and for user safety. A minimum width of 50-feet or the width of construction plus 10-feet on each side (whichever is greater) is generally required. Maintain uniform widths through varying ownerships or legal subdivisions whenever possible, rather than allowing frequent width changes.

Chapter 4 - Road Project Planning

Road project planning ensures that the project provides safe and adequate service to the user and is compatible with environmental values. Prior to final selection of a route, alternative locations and environmental factors must be analyzed.

4.1 Route Analysis

Perform a route analysis to identify feasible routes that satisfy the required road function. In cases where an existing road could be acquired, the existing road is an alternative and is assessed with other feasible routes. This ensures that the selected route best meets management needs and is not a short-term solution.

A. Management Requirements

Identify the anticipated vehicle type and traffic volume to include additional traffic that may be attracted to the new route. Identify the functional classification of the road and specific locations that the road must serve. Map any areas that the road must not penetrate because of withdrawals, easements, private lands, or reservations, and identify any other special considerations or constraints on selection of feasible routes.

B. Feasible Route Locations

Plot feasible route locations (those that meet management requirements and the appropriate road standards) on a topographic map. Make route locations as wide as possible, as this gives the greatest freedom in selecting the alignment to ensure free traffic flow, minimal impact on the environment, and relative economy of construction and maintenance.

C. Route Selection Review

Determine the most desirable route locations and analyze these locations for the Field review. Document the reasons for eliminating the less desirable feasible route locations (or portions thereof) from further consideration in the analysis report.

D. Field Review

Perform an in-depth field review for each feasible location. Prior to field review, affected private land must be identified and appropriate documented permission secured to perform any needed survey work, soil borings, etc. For each feasible location, consider environmental impacts, resource value impacts, user cost, safety, construction and maintenance costs, acquisition costs (if applicable), suitability of soil and geology for construction, and any other factors relevant to choosing the best locations. If an existing road is to be acquired, consider construction costs necessary to meet appropriate road standards.

E. Report

Upon completing the field review listed above, the team prepares a report for management review and approval.

4.2 Route Selection

Using the route analysis report and any required environmental analysis, the District/Field Office Manager selects the location. If the route analysis report or the environmental analysis addresses special problems, the selection decision may include specific mitigation requirements or limitations that must be addressed in the design.

4.3 Design

Final design work, whether "in-house," by another agency or by an architectural and engineering firm commences when project planning is complete and the project has been programmed and funded in an approved Annual Work Plan. Work on non-Bureau road designs should normally not begin until the preliminary location has been approved and the road stipulations have been provided to the applicant. Bureau road standards are provided in .2 of this Manual Section and the design guides found in H-9113-1 – Road Design Handbook.

A. Designer Qualifications

Any road designer and reviewer assigned responsibility for the design and/or review of any road must have a working knowledge of highway engineering principles and procedures, and have satisfactorily completed a college or other approved road design course.

All "in-house" designs must receive an independent technical review by a qualified road designer. The State Engineer reviews and determines the procedures and organizational level for such reviews. Roads designed by non-Bureau personnel are approved for technical correctness by a qualified registered engineer or another agency's design chief, and are reviewed by the State Engineer, qualified District engineering personnel, or a qualified reviewer appointed by the District Engineer, to assure that the design meets the appropriate Bureau road standards.

B. Approved Road Design Courses

Satisfactory completion of the following are acceptable for qualifying BLM road design personnel:

1. U.S. Forest Service Basic and Advanced Road Design Courses

2. University Level Engineering Curriculum Road Design Courses

3. Other qualifications approved by the State Engineer

Chapter 5 - Construction

See Manual 9103 - Facility Construction.

5.1 Signing

Roads under construction are required to be signed according to the current edition of the FHWA “Manual of Uniform Traffic Control Devices.”

5.2 Inspections

Construction inspection must be done by qualified inspectors regardless of the method of construction, such as force account, contract, timber sale, etc. (See Manual 9103 – Facility Construction)

Chapter 6 - Maintenance

See Manual 9104 - Facility Maintenance.

6.1 Maintenance Management

Follow guidance in Manual 9104 - Facility Maintenance for the establishment of a maintenance management program.

6.2 Maintenance Intensities

Transportation System Assets BLM route Maintenance Intensities provide guidance for appropriate "standards of care" to recognized routes within the BLM. Recognized routes by definition include Roads, Primitive Roads, and Trails carried as assets within the BLM FAMS.

Maintenance Intensities provide consistent objectives and standards for the care and maintenance of BLM routes based on identified management objectives. Maintenance Intensities are consistent with land-use planning management objectives (for example, natural, cultural, recreation setting, and visual). Maintenance Intensities provide operational guidance to field personnel on the appropriate intensity, frequency, and type of maintenance activities that should be undertaken to keep the route in acceptable condition and provide guidance for the minimum standards of care for the annual maintenance of a route.

Maintenance Intensities do not describe route geometry, route types, types of use or other physical or managerial characteristics of the route. Those terms are addressed as other descriptive attributes to a route.

Maintenance Intensities provide a range of management objectives and standards. (See Appendix A – Maintenance Intensities)

Appendix A - Maintenance Intensities

Level 0

Maintenance Description: Existing routes that will no longer be maintained and no longer be declared a route. Routes identified as Level 0 are identified for removal from the Transportation System entirely.

Maintenance Objectives:

- No planned annual maintenance,
- meet identified environmental needs,
- no preventative maintenance or planned annual maintenance activities

Maintenance Funds: No annual maintenance funds

Level 1

Maintenance Description: Routes where minimum (low intensity) maintenance is required to protect adjacent lands and resource values. These roads may be impassable for extended periods of time.

Maintenance Objectives:

- Low (Minimal) maintenance intensity,
- Emphasis is given to maintaining drainage and runoff patterns as needed to protect adjacent lands. Grading, brushing, or slide removal is not performed unless route bed drainage is being adversely affected, causing erosion.
- Meet identified resource management objectives
- Perform maintenance as necessary to protect adjacent lands and resource values
- No preventative maintenance
- Planned maintenance activities limited to environmental and resource protection
- Route surface and other physical features are not maintained for regular traffic. Maintenance Funds: Maintenance funds provided to address environmental and resource protection requirements. No maintenance funds provided to perform preventative maintenance.

Level 2 *Reserved for Possible Future Use*

Level 3

Maintenance Description: Routes requiring moderate maintenance due to low volume use (for example, seasonally or year-round for commercial, recreational, or administrative access). Maintenance Intensities may not provide year-round access but are intended to generally provide resources appropriate to keep the route in use for the majority of the year.

Maintenance Objectives:

- Medium (Moderate) maintenance intensity,
- Drainage structures will be maintained as needed. Surface maintenance will be

conducted to provide a reasonable level of riding comfort at prudent speeds for the route conditions and intended use. Brushing is conducted as needed to improve sight distance when appropriate for management uses. Landslides adversely affecting drainage receive high priority for removal; otherwise, they will be removed on a scheduled basis.

- Meet identified environmental needs
- Generally maintained for year-round traffic
- Perform annual maintenance necessary to protect adjacent lands and resource values
- Perform preventative maintenance as required to generally keep the route in acceptable condition
- Planned maintenance activities should include environmental and resource protection efforts, annual route surface
- Route surface and other physical features are maintained for regular traffic Maintenance Funds: Maintenance funds provided to preserve the route in the current condition, perform planned preventive maintenance activities on a scheduled basis, and address environmental and resource protection requirements.

Level 4 *Reserved for Possible Future Use*

Level 5

Maintenance Description: Route for high (maximum) maintenance due to year-round needs, high volume of traffic, or significant use. Also may include route identified through management objectives as requiring high intensities of maintenance or to be maintained open on a year-round basis.

Maintenance Objectives:

- High (Maximum) maintenance intensity
- The entire route will be maintained at least annually. Problems will be repaired as discovered. These routes may be closed or have limited access due to weather conditions but are generally intended for year-round use.
- Meet identified environmental needs
- Generally maintained for year-round traffic
- Perform annual maintenance necessary to protect adjacent lands and resource values
- Perform preventative maintenance as required to generally keep the route in acceptable condition
- Planned maintenance activities should include environmental and resource protection efforts, annual route surface
- Route surface and other physical features are maintained for regular traffic Maintenance Funds: Maintenance funds provided to preserve the route in the current condition, perform planned preventative maintenance activities on a scheduled basis, and address environmental and resource protection requirements.

Appendix B – Hydrolgoic Calculations

Project:	Calico - Grassy Mountain Access Road Design
Task:	Hydrologic Analysis - Culverts
Date:	4/22/2019
Calculated By:	S. Savage, EIT
Checked By:	D. March, PE, CFM

	User input
	Resulting calculation

Drainage Basin Parameters					Peak Flow for Return Intervals, Q (cfs)	
Crossing ID	Station (Existing)	Flood Region[1]	Drainage Area, DA (mi^2)	Watershed Aspect (degrees)	*10-year*	*25-year*
C-01	305+56.00	3 - Northeast Eastern Oregon	0.27	-	18	23
C-02	393+79.00	6 - Southeast Eastern Oregon	0.19	134	14	20
C-03	634+11.00	6 - Southeast Eastern Oregon	0.34	118	31	44
C-04	675+10.00	6 - Southeast Eastern Oregon	0.16	109	21	30
C-05	800+15.00	6 - Southeast Eastern Oregon	0.37	139	21	30
C-06	940+20.00	3 - Northeast Eastern Oregon	1.23	-	56	72
C-07	944+25.00	3 - Northeast Eastern Oregon	2.14	-	84	109
C-08	983+55.00	3 - Northeast Eastern Oregon	1.32	-	59	76
C-09	1021+30.00	3 - Northeast Eastern Oregon	1.84	-	75	97
C-10	1132+64.00	3 - Northeast Eastern Oregon	0.23	-	16	21
C-11	1101+19.00	3 - Northeast Eastern Oregon	3.87	-	130	169

[1] Flood region determined from Figure 14 in OFR SW 06-001, *Estimation of Peak Discharges for Rural, Ungregulated Streams in Eastern Oregon* , State of Oregon Water Resoureces)

[2] Peak flow rates were calculated using the regression equations described in OFR SW 06-001

Table 23. Prediction equations for estimating peak discharges for ungaged watersheds in flood region 3, northeast eastern Oregon.

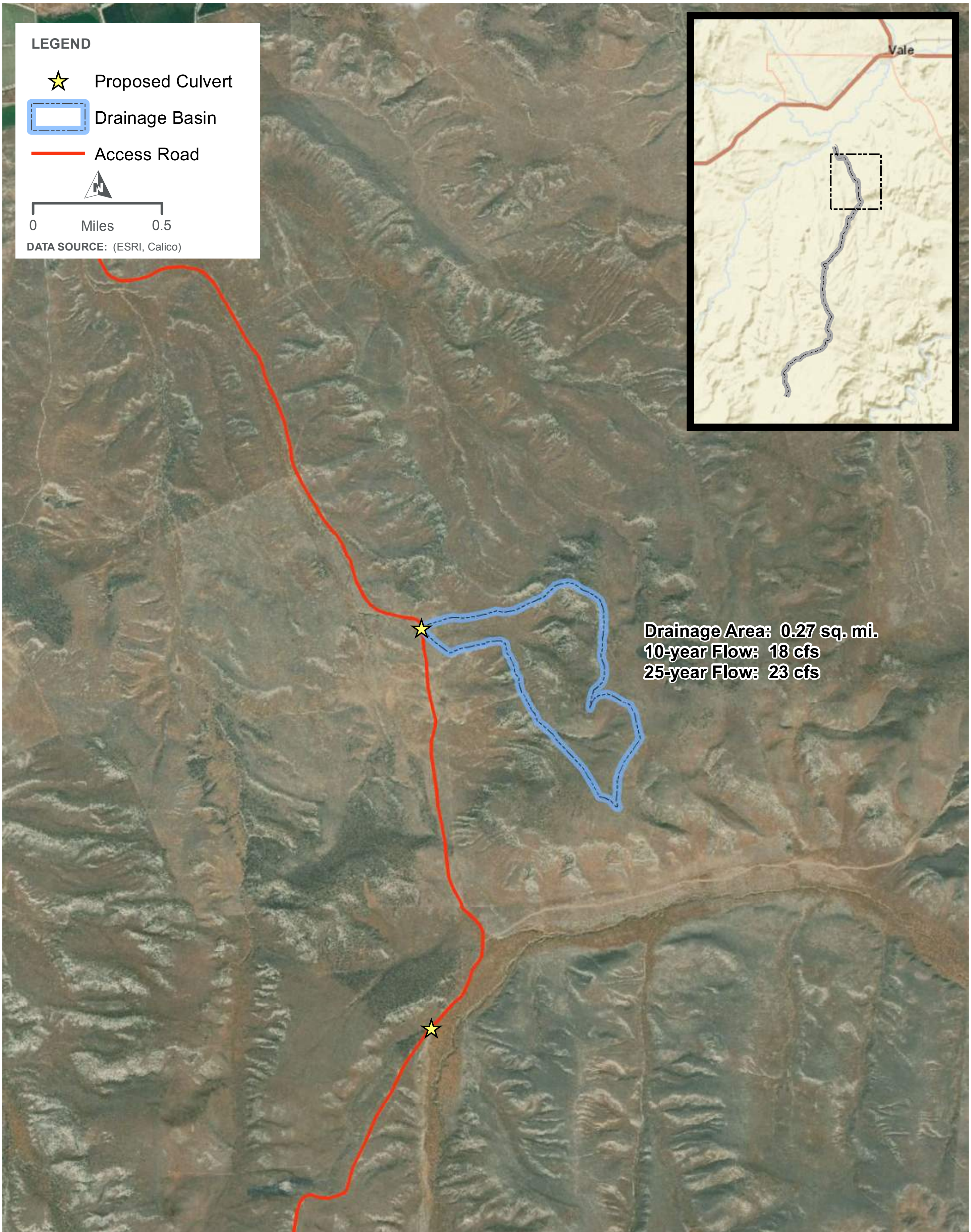
[**Q(n)**, discharge in cubic feet per second for the n-year recurrence interval; **Area**, drainage area, in square miles.]

Prediction equation	Percent standard error of the model, in percent	Average standard error of sampling, in percent	Average prediction error, in percent	Average equivalent years of record
$Q(2) = 21.83\ Area^{0.7546}$	56.8	10.9	58.2	1.3
$Q(5) = 36.80\ Area^{0.7459}$	47.3	10.1	48.6	2.5
$Q(10) = 47.68\ Area^{0.7431}$	44.8	10.2	46.1	3.6
$Q(25) = 61.90\ Area^{0.7415}$	44.3	10.7	45.8	5.2
$Q(50) = 72.81\ Area^{0.7408}$	45.1	11.2	46.8	6.1
$Q(100) = 84.03\ Area^{0.7402}$	46.7	11.8	48.5	6.8
$Q(500) = 111.9\ Area^{0.7388}$	52.2	13.3	54.3	7.7

Table 26. Prediction equations for estimating peak discharges for ungaged watersheds in flood region 6, southeast eastern Oregon.

[**Q(n)**, discharge in cubic feet per second for the n-year recurrence interval; **Area**, drainage area, in square miles; **Aspect**, mean watershed aspect, in degrees.]

Prediction equation	Percent standard error of the model, in percent	Average standard error of sampling, in percent	Average prediction error, in percent	Average equivalent years of record
$Q(2) = 29.38\ Area^{0.7718}\ (Aspect/100)^{-2.200}$	94.6	32.1	104	1.2
$Q(5) = 75.05\ Area^{0.7796}\ (Aspect/100)^{-2.556}$	76.0	27.6	83.6	1.9
$Q(10) = 112.5\ Area^{0.7873}\ (Aspect/100)^{-2.664}$	69.7	26.4	76.2	2.8
$Q(25) = 164.7\ Area^{0.7977}\ (Aspect/100)^{-2.749}$	66.2	26.1	73.2	4.1
$Q(50) = 207.8\ Area^{0.8051}\ (Aspect/100)^{-2.808}$	66.0	26.6	73.3	4.9
$Q(100) = 255.6\ Area^{0.8120}\ (Aspect/100)^{-2.872}$	67.2	27.4	74.9	5.5
$Q(500) = 389.6\ Area^{0.8267}\ (Aspect/100)^{-3.039}$	73.5	30.1	82.5	6.3



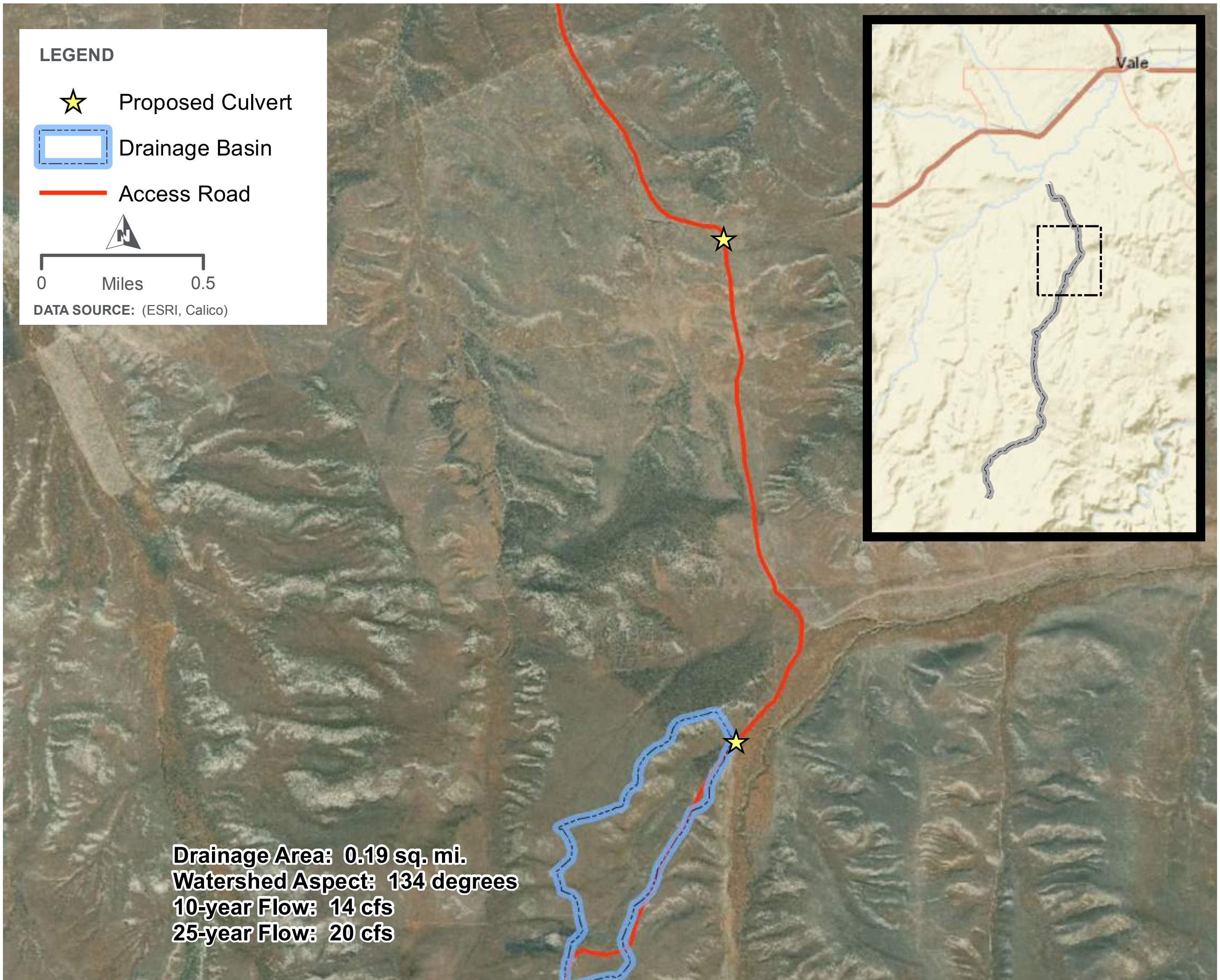
DRAINAGE BASIN MAP

PROPOSED CULVERT C-01

FIGURE B.1

PATH: C:\USERS\SSAVAGE\DESKTOP\CALICO\CALICO.MXD - USER: SSAVAGE - DATE: 4/22/2019

GRASSY MOUNTAIN ACCESS ROAD DESIGN



HDR

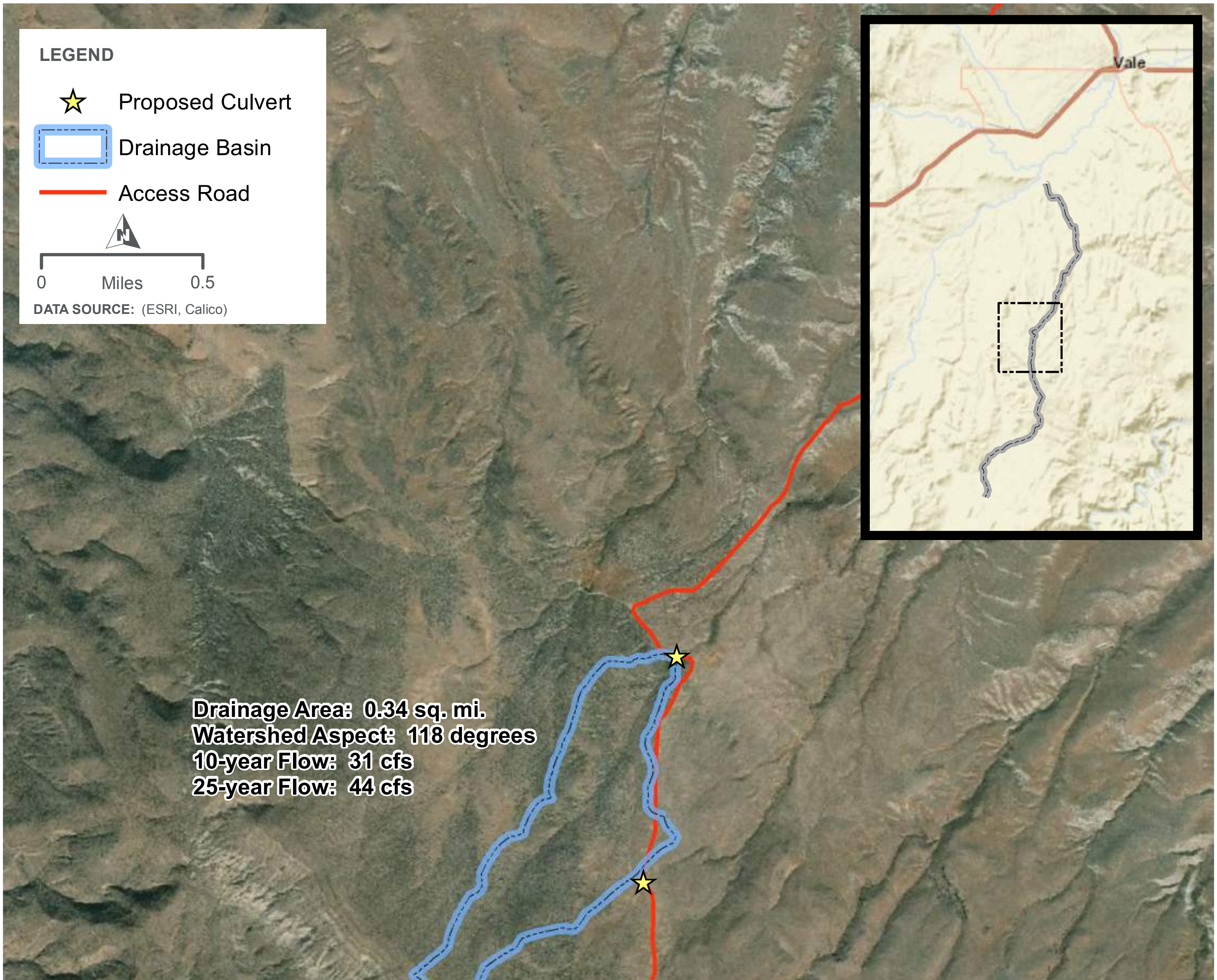
DRAINAGE BASIN MAP

PROPOSED CULVERT C-02

FIGURE B.2

PATH: C:\USERS\SSAVAGE\DESKTOP\CALICO\CALICO_DAMAPC02.MXD - USER: SSAVAGE - DATE: 4/22/2019

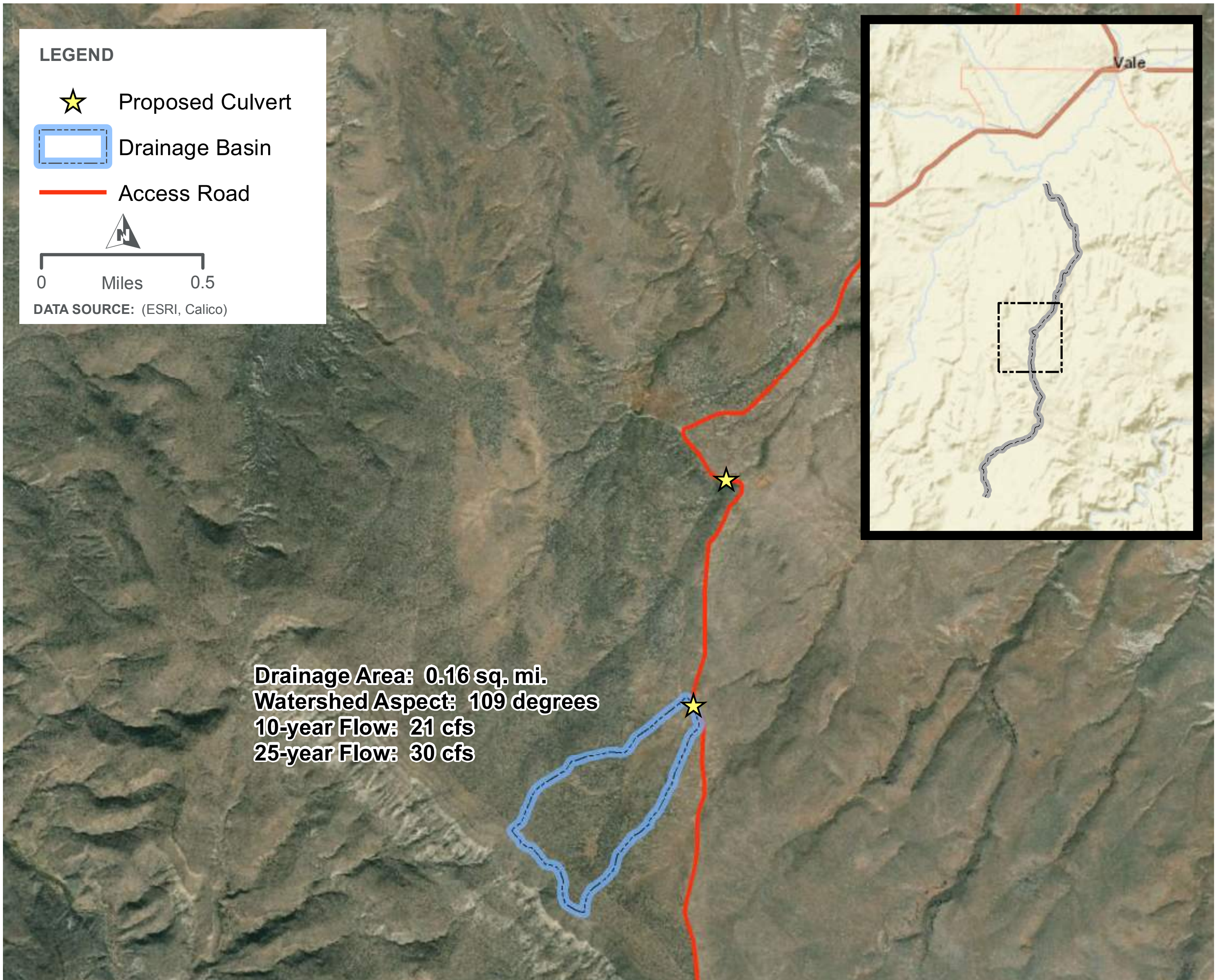
GRASSY MOUNTAIN ACCESS ROAD DESIGN



DRAINAGE BASIN MAP

PROPOSED CULVERT C-03

FIGURE B.3



DRAINAGE BASIN MAP

PROPOSED CULVERT C-04

FIGURE B.4

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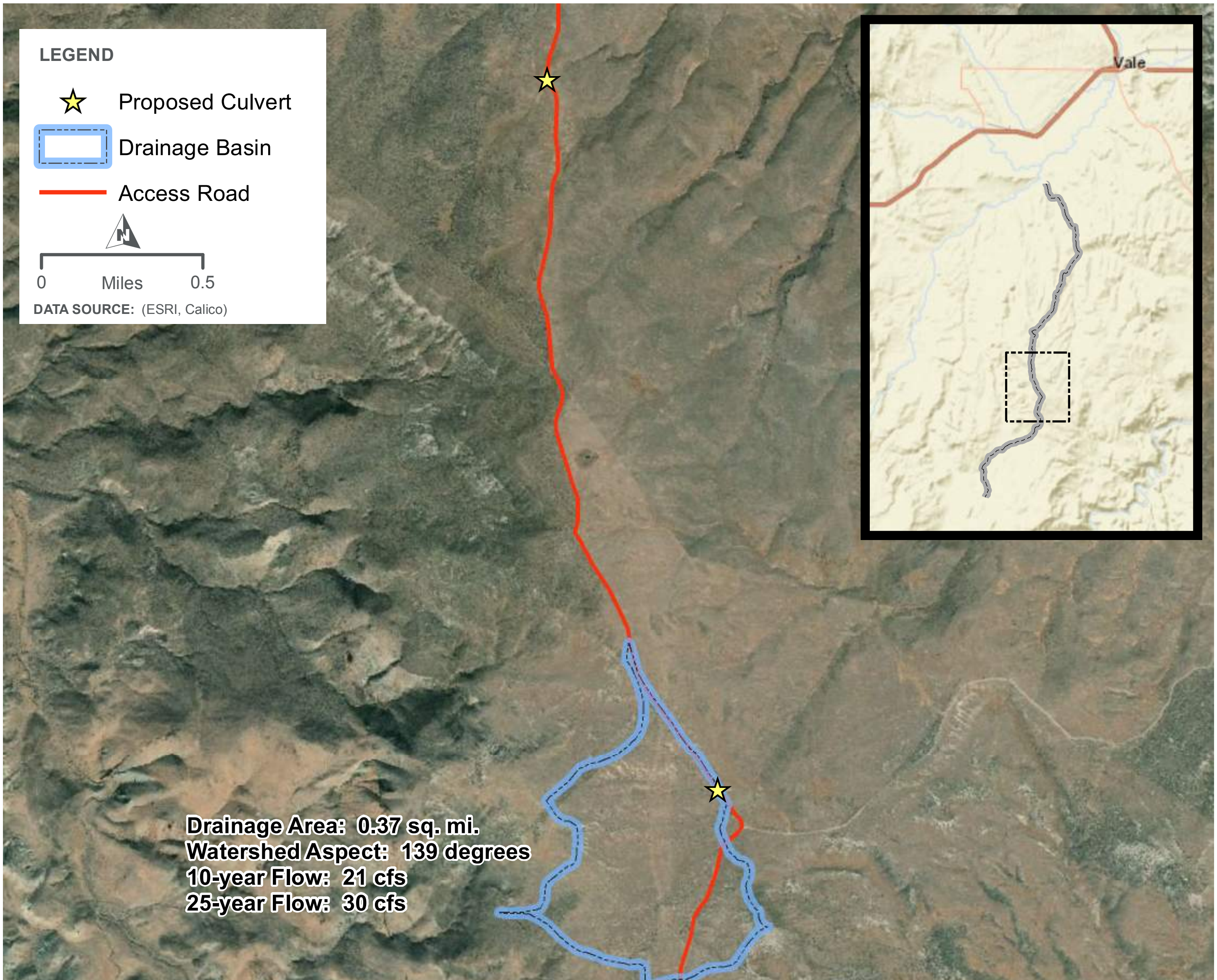
GRASSY MOUNTAIN ACCESS ROAD DESIGN



HDR

DRAINAGE BASIN MAP

PROPOSED CULVERT C-05

FIGURE B.5

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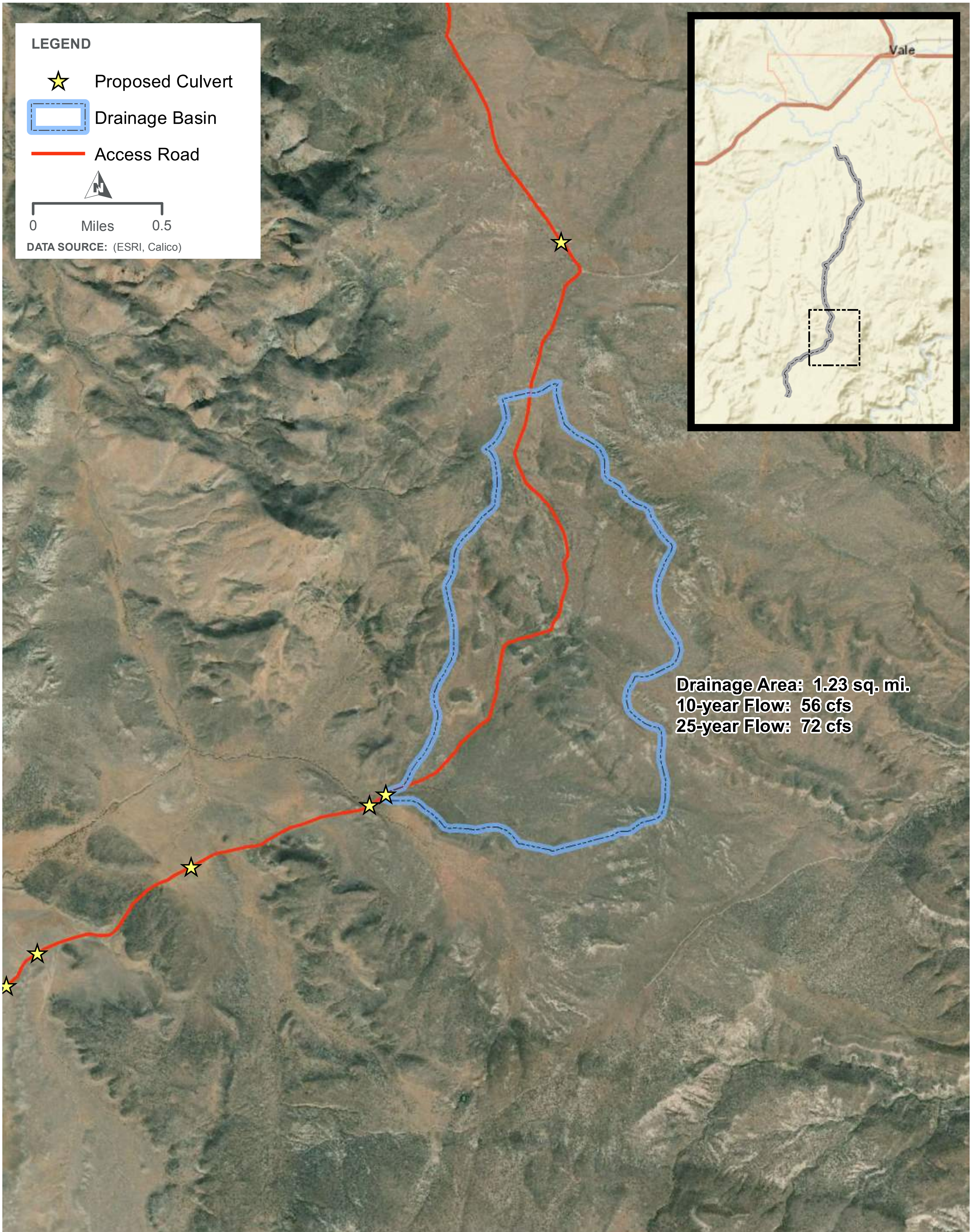
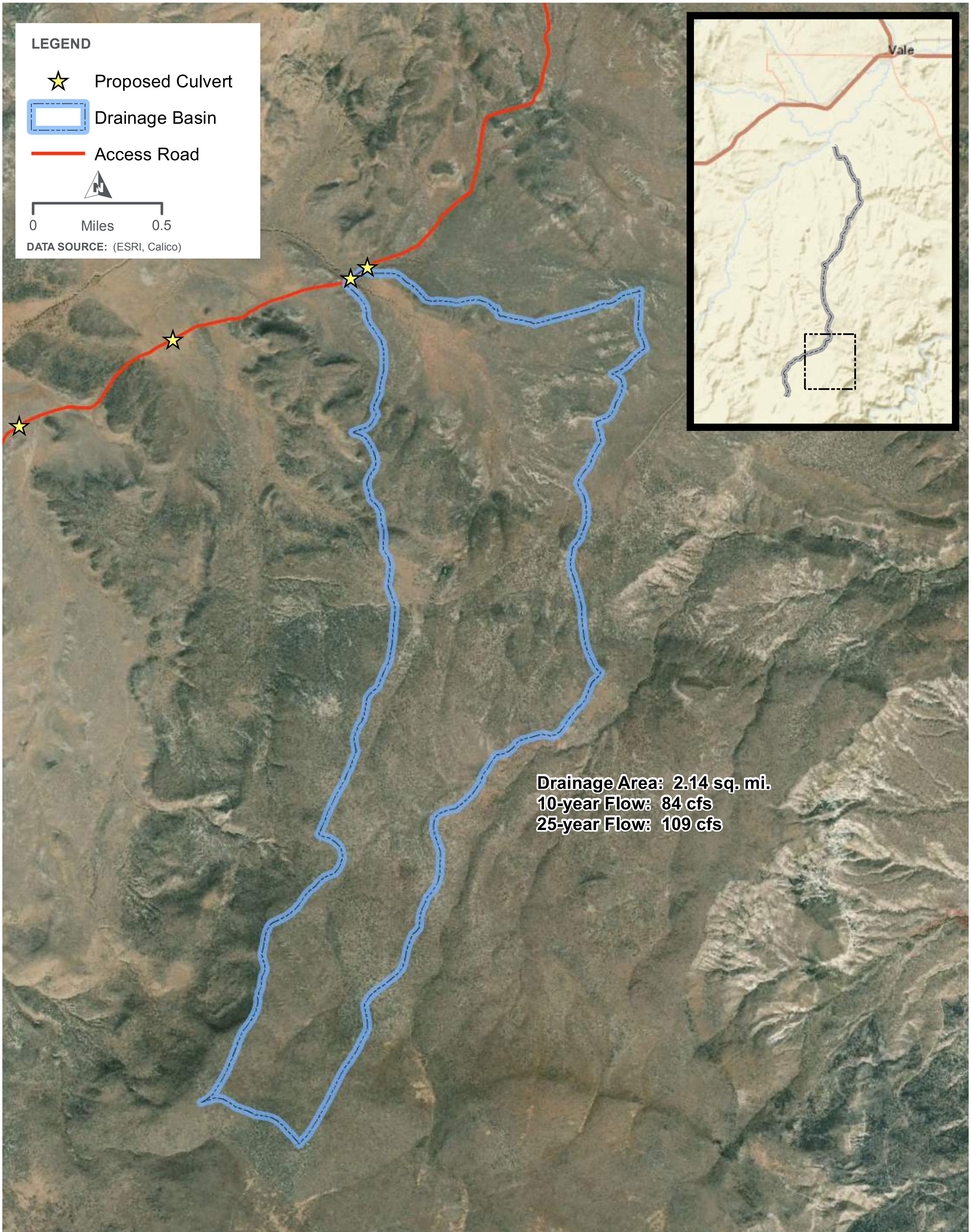
GRASSY MOUNTAIN ACCESS ROAD DESIGN



DRAINAGE BASIN MAP

PROPOSED CULVERT C-06

FIGURE B.6

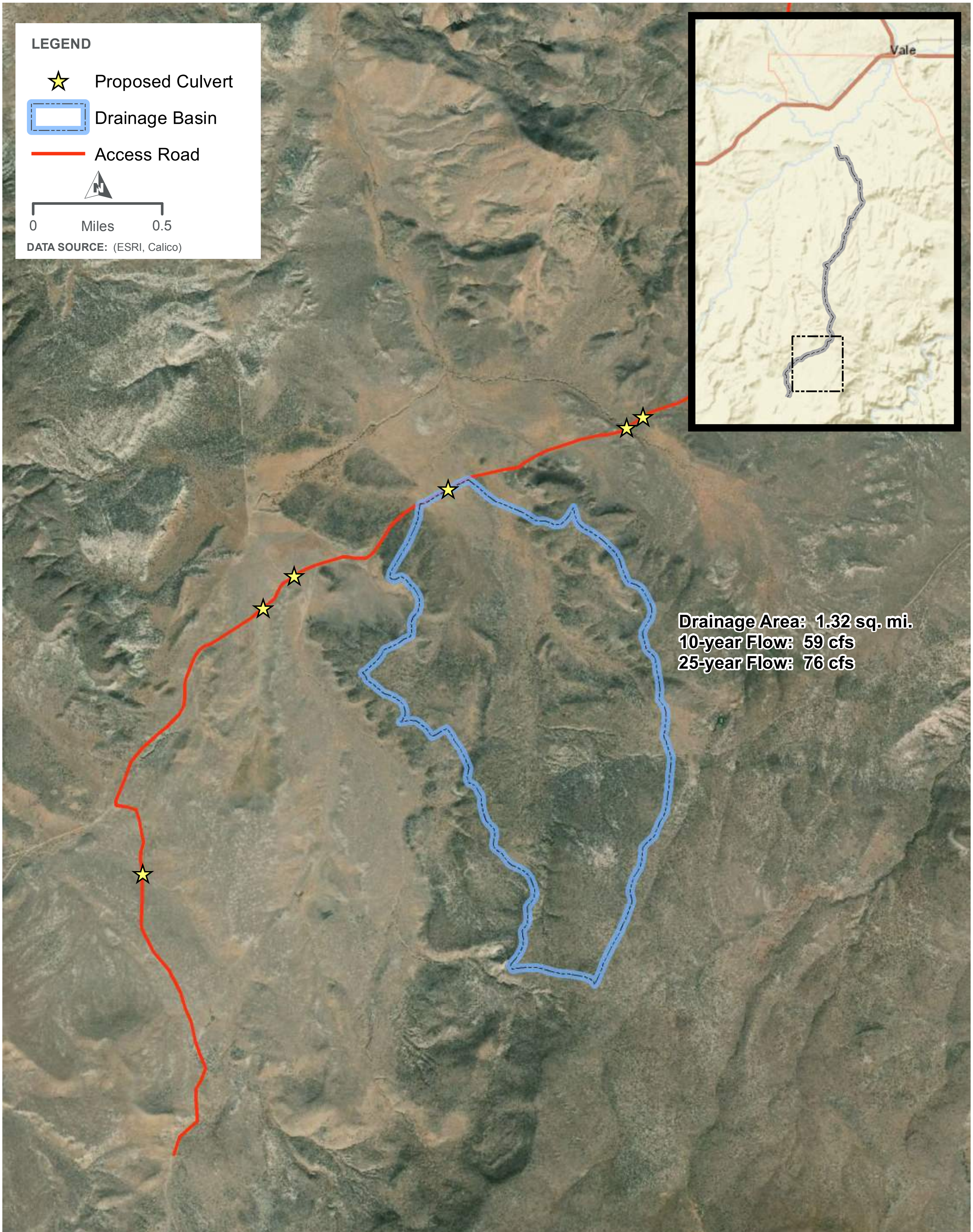


HDR

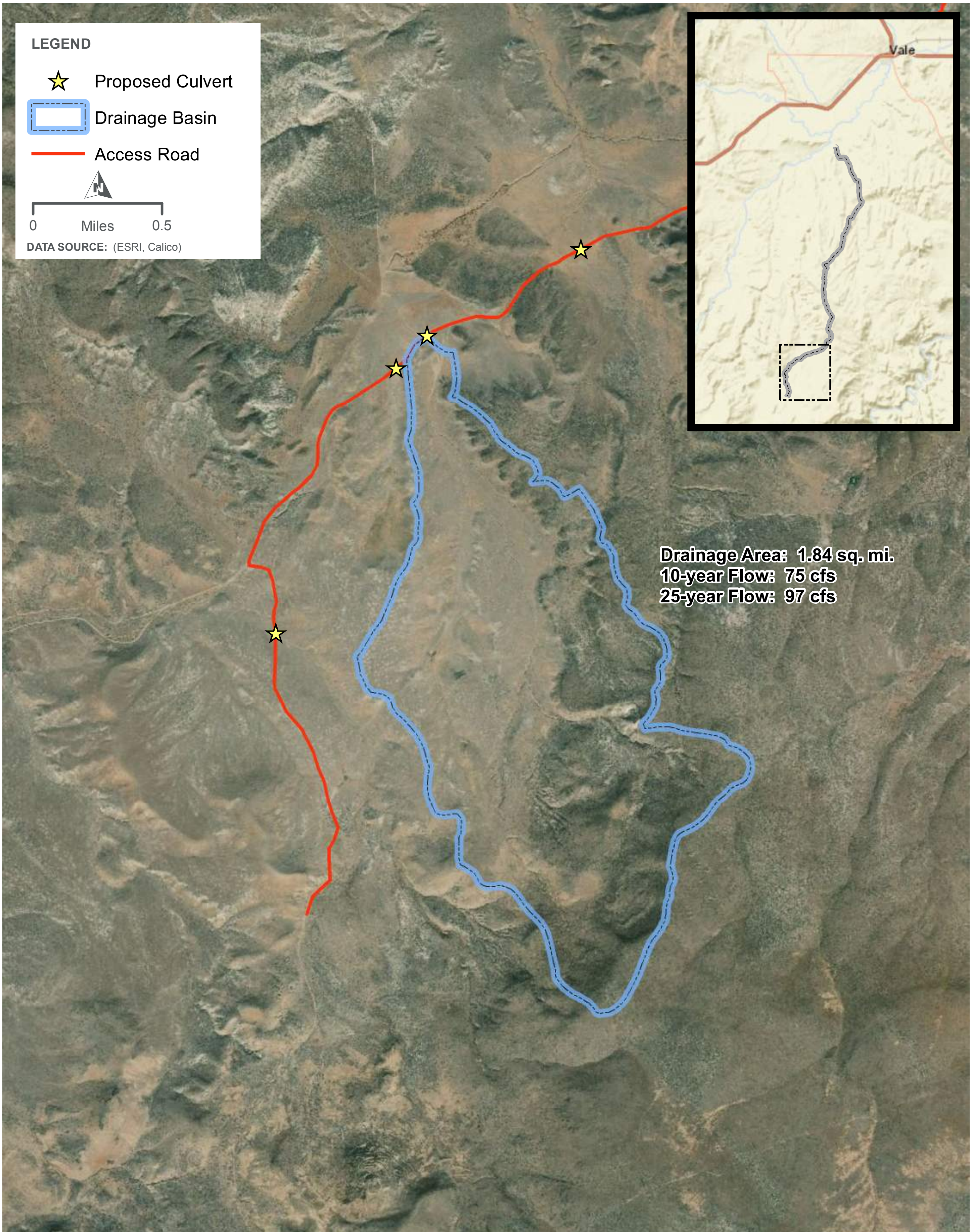
DRAINAGE BASIN MAP

PROPOSED CULVERT C-07

FIGURE B.7



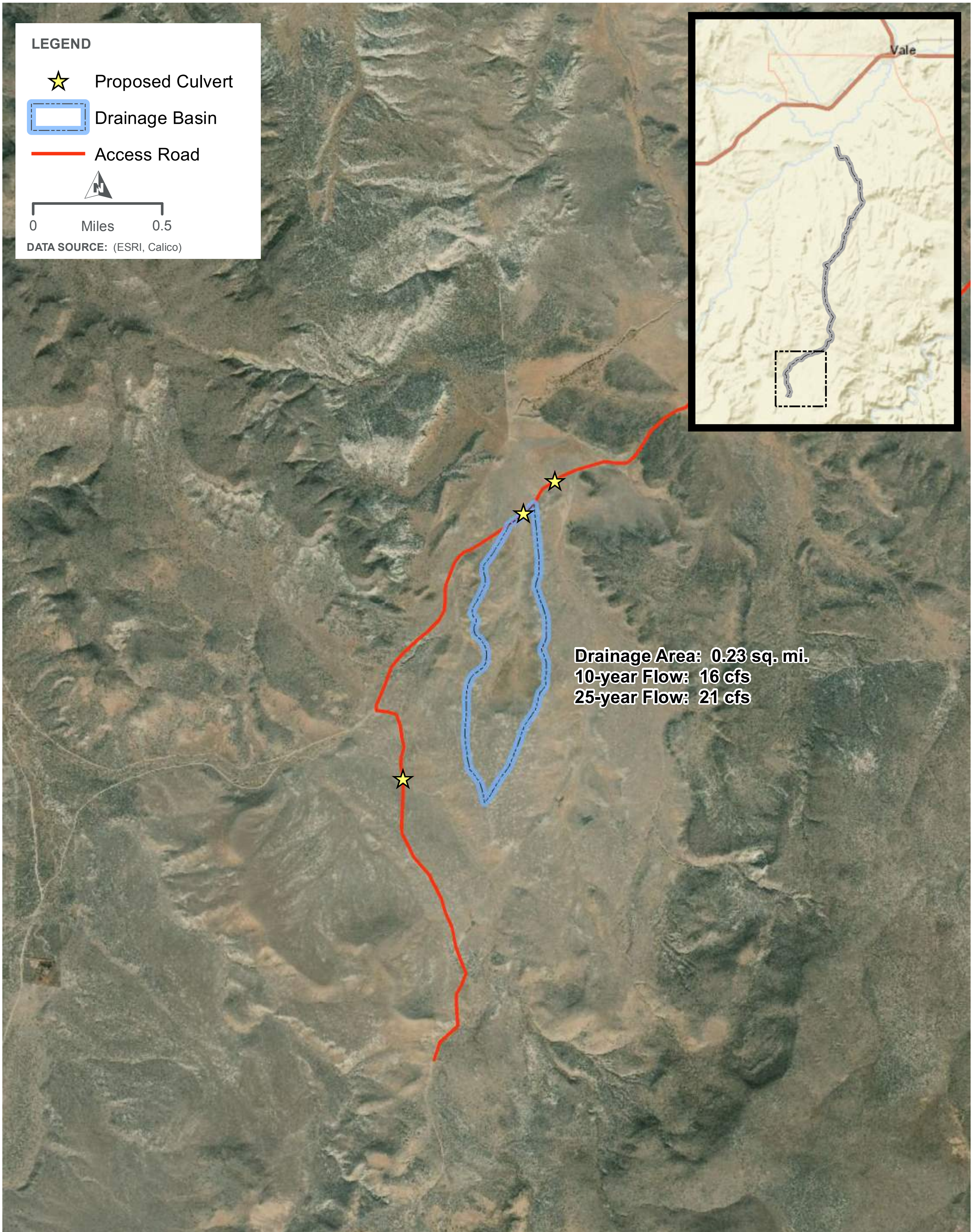
DRAINAGE BASIN MAP
PROPOSED CULVERT C-08
FIGURE B.8



DRAINAGE BASIN MAP

PROPOSED CULVERT C-09

FIGURE B.9



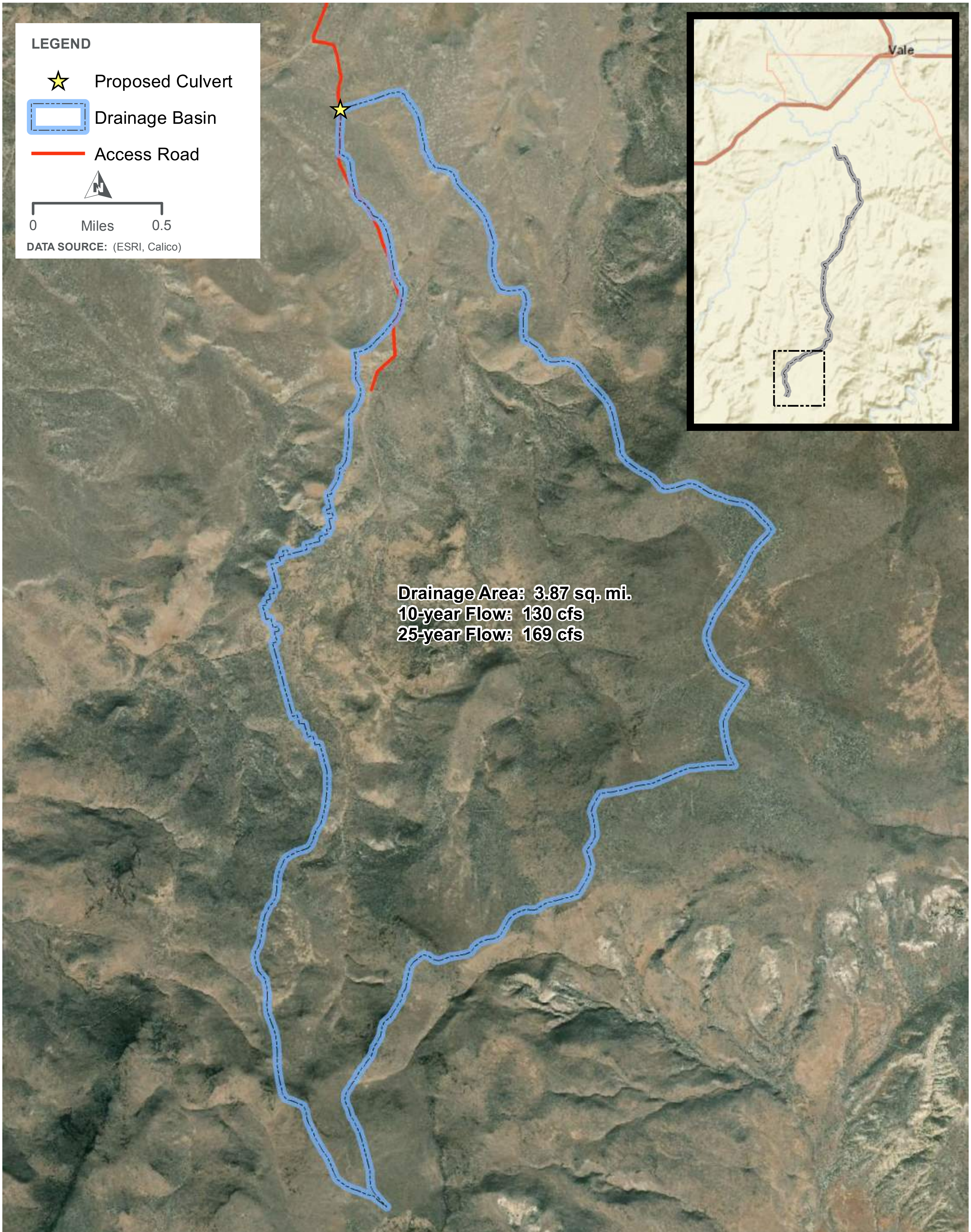
DRAINAGE BASIN MAP

PROPOSED CULVERT C-10

FIGURE B.10

PATH: C:\USERS\SSAVAGE\DESKTOP\CALICO\CALICO_DAMAPC10.MXD - USER: SSAVAGE - DATE: 4/22/2019

GRASSY MOUNTAIN ACCESS ROAD DESIGN



DRAINAGE BASIN MAP

PROPOSED CULVERT C-11

FIGURE B.11

Appendix C – Hydraulic Calculations

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: C-01

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-01 Discharg (cfs)	Roadway Discharge (cfs	Iterations
2554.03	10-yr	18.00	18.00	0.00	1
2554.29	25-yr	23.00	23.00	0.00	1
2555.25	Overtopping	38.43	38.43	0.00	Overtopping

Table 2 - Culvert Summary Table: C-01

Dischar e Name	Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	18.00	18.00	2554.0	1.565	0.079	1-S2	0.592	1.069	0.672	0.429	9.377	7.518
25-yr	23.00	23.00	2554.2	1.833	0.376	1-S2	0.673	1.213	0.779	0.470	9.815	7.993

****
Straight Culvert
Inlet Elevation (invert): 2552.46 ft,   Outlet Elevation (invert): 2551.23 ft
Culvert Length: 37.02 ft,   Culvert Slope: 0.0332
****

Site Data - C-01

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 2552.46 ft
Outlet Station: 37.00 ft
Outlet Elevation: 2551.23 ft
Number of Barrels: 2

Culvert Data Summary - C-01

Barrel Shape: Circular
Barrel Diameter: 2.00 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0120
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: C-01)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
18.00	2551.66	0.43	7.52	8.57	2.86
23.00	2551.70	0.47	7.99	9.39	2.90

Tailwater Channel Data - C-01

Tailwater Channel Option: Triangular Channel
Side Slope (H:V): 13.00 (_:1)
Channel Slope: 0.3200
Channel Manning's n: 0.0400
Channel Invert Elevation: 2551.23 ft

Roadway Data for Crossing: C-01

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 2555.25 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 4 - Summary of Culvert Flows at Crossing: C-02

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-02 Discharg (cfs)	Roadway Discharge (cfs	Iterations
2710.80	10-yr	18.00	18.00	0.00	1
2711.12	25-yr	23.00	23.00	0.00	1
2712.40	Overtopping	38.62	38.62	0.00	Overtopping

Table 5 - Culvert Summary Table: C-02

Discharge Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	18.00	18.00	2710.8(	1.687	0.0*	1-S2	1.011	1.069	1.011	0.589	5.469	2.982
25-yr	23.00	23.00	2711.1	2.010	0.903	5-S2	1.178	1.213	1.178	0.671	5.790	3.204

* Full Flow Headwater elevation is below inlet invert.

****

Straight Culvert

Inlet Elevation (invert): 2709.11 ft,   Outlet Elevation (invert): 2707.80 ft

Culvert Length: 69.01 ft,   Culvert Slope: 0.0190

****

Site Data - C-02

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 2709.11 ft
Outlet Station: 69.00 ft
Outlet Elevation: 2707.80 ft
Number of Barrels: 2

Culvert Data Summary - C-02

Barrel Shape: Circular
Barrel Diameter: 2.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: C-02)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
18.00	2708.39	0.59	2.98	0.70	0.79
23.00	2708.47	0.67	3.20	0.80	0.80

Tailwater Channel Data - C-02

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 7.00 ft
Side Slope (H:V): 5.50 (_:1)
Channel Slope: 0.0190
Channel Manning's n: 0.0400
Channel Invert Elevation: 2707.80 ft

Roadway Data for Crossing: C-02

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 2712.40 ft
Roadway Surface: Gravel
Roadway Top Width: 48.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 7 - Summary of Culvert Flows at Crossing: C-03

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-03 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3450.57	10-yr	31.00	31.00	0.00	1
3451.07	25-yr	44.00	44.00	0.00	1
3452.00	Overtopping	64.84	64.84	0.00	Overtopping

Table 8 - Culvert Summary Table: C-03

Discharge Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	31.00	31.00	3450.51	1.962	0.997	1-S2n	0.885	1.326	0.993	1.308	8.250	6.042
25-yr	44.00	44.00	3451.01	2.462	1.547	1-S2n	1.071	1.592	1.219	1.491	8.955	6.595

****
Straight Culvert
Inlet Elevation (invert): 3448.61 ft,   Outlet Elevation (invert): 3448.00 ft
Culvert Length: 40.00 ft,   Culvert Slope: 0.0153
****

Site Data - C-03

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3448.61 ft
Outlet Station: 40.00 ft
Outlet Elevation: 3448.00 ft
Number of Barrels: 2

Culvert Data Summary - C-03

Barrel Shape: Circular
Barrel Diameter: 2.50 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0120
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: C-03)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
31.00	3449.31	1.31	6.04	4.08	1.32
44.00	3449.49	1.49	6.59	4.65	1.35

Tailwater Channel Data - C-03

Tailwater Channel Option: Triangular Channel
Side Slope (H:V): 3.00 (_:1)
Channel Slope: 0.0500
Channel Manning's n: 0.0400
Channel Invert Elevation: 3448.00 ft

Roadway Data for Crossing: C-03

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3452.00 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 10 - Summary of Culvert Flows at Crossing: C-04

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-04 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3668.72	10-yr	21.00	21.00	0.00	1
3669.35	25-yr	30.00	30.00	0.00	1
3670.64	Overtopping	43.31	43.31	0.00	Overtopping

Table 11 - Culvert Summary Table: C-04

Discharge Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	21.00	21.00	3668.72	1.877	0.0*	1-S2n	1.075	1.158	1.075	0.723	5.905	3.128
25-yr	30.00	30.00	3669.35	2.514	1.836	5-S2n	1.370	1.392	1.370	0.849	6.355	3.430

* Full Flow Headwater elevation is below inlet invert.

****
Straight Culvert
Inlet Elevation (invert): 3666.84 ft,   Outlet Elevation (invert): 3666.06 ft
Culvert Length: 37.01 ft,   Culvert Slope: 0.0211
****

Site Data - C-04

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3666.84 ft
Outlet Station: 37.00 ft
Outlet Elevation: 3666.06 ft
Number of Barrels: 2

Culvert Data Summary - C-04

Barrel Shape: Circular
Barrel Diameter: 2.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: C-04)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
21.00	3666.78	0.72	3.13	0.95	0.83
30.00	3666.91	0.85	3.43	1.11	0.85

Tailwater Channel Data - C-04

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 3.50 ft
Side Slope (H:V): 8.00 (_:1)
Channel Slope: 0.0210
Channel Manning's n: 0.0400
Channel Invert Elevation: 3666.06 ft

Roadway Data for Crossing: C-04

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3670.64 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 13 - Summary of Culvert Flows at Crossing: C-05

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-05 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3673.73	10-yr	21.00	21.00	0.00	1
3674.46	25-yr	30.00	30.00	0.00	1
3675.65	Overtopping	43.30	43.30	0.00	Overtopping

Table 14 - Culvert Summary Table: C-05

Discharge Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	21.00	21.00	3673.7	1.878	0.0*	1-S2	1.093	1.158	1.093	0.218	5.787	1.861
25-yr	30.00	30.00	3674.4	2.515	2.606	7-M2	1.398	1.392	1.392	0.270	6.428	2.133

* Full Flow Headwater elevation is below inlet invert.

****
Straight Culvert
Inlet Elevation (invert): 3671.85 ft,   Outlet Elevation (invert): 3671.09 ft
Culvert Length: 38.01 ft,   Culvert Slope: 0.0200
****

Site Data - C-05

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3671.85 ft
Outlet Station: 38.00 ft
Outlet Elevation: 3671.09 ft
Number of Barrels: 2

Culvert Data Summary - C-05

Barrel Shape: Circular
Barrel Diameter: 2.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: C-05)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
21.00	3671.31	0.22	1.86	0.27	0.71
30.00	3671.36	0.27	2.13	0.34	0.74

Tailwater Channel Data - C-05

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 50.00 ft
Side Slope (H:V): 8.00 (_:1)
Channel Slope: 0.0200
Channel Manning's n: 0.0400
Channel Invert Elevation: 3671.09 ft

Roadway Data for Crossing: C-05

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3675.65 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 16 - Summary of Culvert Flows at Crossing: C-06

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-06 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3236.78	10-yr	56.00	56.00	0.00	1
3237.24	25-yr	72.00	72.00	0.00	1
3238.29	Overtopping	98.86	98.86	0.00	Overtopping

Table 17 - Culvert Summary Table: C-06

Dischar e Name	Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	56.00	56.00	3236.7	2.760	3.035	7-M2	1.723	1.708	1.708	0.988	6.736	3.170
25-yr	72.00	72.00	3237.2	3.346	3.493	7-M2	2.053	1.947	1.947	1.108	7.417	3.385

****
Straight Culvert
Inlet Elevation (invert): 3233.75 ft,   Outlet Elevation (invert): 3233.19 ft
Culvert Length: 40.00 ft,   Culvert Slope: 0.0140
****

Site Data - C-06

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3233.75 ft
Outlet Station: 40.00 ft
Outlet Elevation: 3233.19 ft
Number of Barrels: 2

Culvert Data Summary - C-06

Barrel Shape: Circular
Barrel Diameter: 3.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: C-06)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
56.00	3234.18	0.99	3.17	0.86	0.71
72.00	3234.30	1.11	3.38	0.97	0.72

Tailwater Channel Data - C-06

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 7.00 ft
Side Slope (H:V): 11.00 (_:1)
Channel Slope: 0.0140
Channel Manning's n: 0.0400
Channel Invert Elevation: 3233.19 ft

Roadway Data for Crossing: C-06

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3238.29 ft
Roadway Surface: Gravel
Roadway Top Width: 28.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 19 - Summary of Culvert Flows at Crossing: C-07

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-07 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3227.15	10-yr	84.00	84.00	0.00	1
3227.89	25-yr	109.00	109.00	0.00	1
3228.63	Overtopping	130.92	130.92	0.00	Overtopping

Table 20 - Culvert Summary Table: C-07

Discharge Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	84.00	84.00	3227.1	3.254	1.930	1-S2	1.768	2.013	1.768	0.990	8.338	4.600
25-yr	109.00	109.00	3227.8	3.989	2.780	5-S2	2.082	2.305	2.082	1.142	8.856	4.986

****
Straight Culvert
Inlet Elevation (invert): 3223.90 ft,   Outlet Elevation (invert): 3223.00 ft
Culvert Length: 43.01 ft,   Culvert Slope: 0.0209
****

Site Data - C-07

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3223.90 ft
Outlet Station: 43.00 ft
Outlet Elevation: 3223.00 ft
Number of Barrels: 2

Culvert Data Summary - C-07

Barrel Shape: Circular
Barrel Diameter: 3.50 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: C-07)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
84.00	3223.99	0.99	4.60	1.30	0.91
109.00	3224.14	1.14	4.99	1.50	0.93

Tailwater Channel Data - C-07

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 14.00 ft
Side Slope (H:V): 4.50 (_:1)
Channel Slope: 0.0210
Channel Manning's n: 0.0400
Channel Invert Elevation: 3223.00 ft

Roadway Data for Crossing: C-07

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3228.63 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 22 - Summary of Culvert Flows at Crossing: C-08

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-08 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3193.91	10-yr	59.00	59.00	0.00	1
3194.54	25-yr	76.00	76.00	0.00	1
3195.50	Overtopping	95.96	95.96	0.00	Overtopping

Table 23 - Culvert Summary Table: C-08

Dischar e Name	Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	59.00	59.00	3193.9	3.751	4.112	7-M2	2.328	2.308	2.308	1.093	7.855	2.797
25-yr	76.00	76.00	3194.5	4.570	4.740	7-M2	2.785	2.637	2.637	1.214	8.651	2.982

****

Straight Culvert

Inlet Elevation (invert): 3189.80 ft, Outlet Elevation (invert): 3189.35 ft

Culvert Length: 35.00 ft, Culvert Slope: 0.0129

****

Site Data - C-08

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3189.80 ft
Outlet Station: 35.00 ft
Outlet Elevation: 3189.35 ft
Number of Barrels: 1

Culvert Data Summary - C-08

Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: C-08)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
59.00	3190.44	1.09	2.80	0.75	0.63
76.00	3190.56	1.21	2.98	0.83	0.64

Tailwater Channel Data - C-08

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 4.00 ft
Side Slope (H:V): 14.00 (_:1)
Channel Slope: 0.0110
Channel Manning's n: 0.0400
Channel Invert Elevation: 3189.35 ft

Roadway Data for Crossing: C-08

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3195.50 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 25 - Summary of Culvert Flows at Crossing: C-09

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-09 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3238.49	10-yr	75.00	75.00	0.00	1
3238.95	25-yr	97.00	97.00	0.00	1
3239.75	Overtopping	125.53	125.53	0.00	Overtopping

Table 26 - Culvert Summary Table: C-09

Dischar e Name	Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	75.00	75.00	3238.4	2.558	2.745	2-M2	1.786	1.609	1.609	0.569	6.473	2.416
25-yr	97.00	97.00	3238.9	3.075	3.200	7-M2	2.154	1.842	1.842	0.662	7.103	2.652

****

Straight Culvert

Inlet Elevation (invert): 3235.75 ft,   Outlet Elevation (invert): 3235.40 ft

Culvert Length: 35.00 ft,   Culvert Slope: 0.0100

****

Site Data - C-09

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3235.75 ft
Outlet Station: 35.00 ft
Outlet Elevation: 3235.40 ft
Number of Barrels: 3

Culvert Data Summary - C-09

Barrel Shape: Circular
Barrel Diameter: 3.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: C-09)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
75.00	3235.97	0.57	2.42	0.36	0.59
97.00	3236.06	0.66	2.65	0.41	0.60

Tailwater Channel Data - C-09

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 50.00 ft
Side Slope (H:V): 8.00 (_:1)
Channel Slope: 0.0100
Channel Manning's n: 0.0400
Channel Invert Elevation: 3235.40 ft

Roadway Data for Crossing: C-09

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3239.75 ft
Roadway Surface: Gravel
Roadway Top Width: 24.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 28 - Summary of Culvert Flows at Crossing: C-10

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-10 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3237.40	10-yr	16.00	16.00	0.00	1
3237.70	25-yr	21.00	21.00	0.00	1
3239.00	Overtopping	36.58	36.58	0.00	Overtopping

Table 29 - Culvert Summary Table: C-10

Dischar e Name	Total Dischar e (cfs)	Culvert Dischar e (cfs)	Headwa r Elevatio (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwate Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	16.00	16.00	3237.4(	1.570	1.693	2-M2(	1.138	1.006	1.006	0.228	5.052	1.354
25-yr	21.00	21.00	3237.7(	1.887	1.989	2-M2(	1.375	1.158	1.158	0.268	5.569	1.503

****
Straight Culvert
Inlet Elevation (invert): 3235.71 ft,   Outlet Elevation (invert): 3235.25 ft
Culvert Length: 45.00 ft,   Culvert Slope: 0.0102
****

Site Data - C-10

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3235.71 ft
Outlet Station: 45.00 ft
Outlet Elevation: 3235.25 ft
Number of Barrels: 2

Culvert Data Summary - C-10

Barrel Shape: Circular
Barrel Diameter: 2.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Thin Edge Projecting
Inlet Depression: None

Table 30 - Downstream Channel Rating Curve (Crossing: C-10)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
16.00	3235.48	0.23	1.35	0.14	0.51
21.00	3235.52	0.27	1.50	0.17	0.52

Tailwater Channel Data - C-10

Tailwater Channel Option: Trapezoidal Channel
Bottom Width: 50.00 ft
Side Slope (H:V): 8.00 (_:1)
Channel Slope: 0.0100
Channel Manning's n: 0.0400
Channel Invert Elevation: 3235.25 ft

Roadway Data for Crossing: C-10

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3239.00 ft
Roadway Surface: Gravel
Roadway Top Width: 31.00 ft

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 31 - Summary of Culvert Flows at Crossing: C-11

Headwater Elevation (ft)	Discharge Nam	Total Discharg (cfs)	C-11 Discharg (cfs)	Roadway Discharge (cfs	Iterations
3340.83	10-yr	130.00	130.00	0.00	1
3341.44	25-yr	169.00	169.00	0.00	1
3342.00	Overtopping	200.90	200.90	0.00	Overtopping

Table 32 - Culvert Summary Table: C-11

Discharge Name	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (f	Outlet Control Depth (f	Flow Type	Normal Depth (f	Critical Depth (f	Outlet Depth (f	Tailwater Depth (f	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
10-yr	130.00	130.00	3340.8	3.089	1.899	1-S2	1.327	2.046	2.046	1.703	7.192	4.076
25-yr	169.00	169.00	3341.4	3.702	2.576	5-S2	1.535	2.348	2.348	1.879	7.975	4.352

****

Straight Culvert

Inlet Elevation (invert): 3337.74 ft,   Outlet Elevation (invert): 3337.05 ft

Culvert Length: 45.01 ft,   Culvert Slope: 0.0153

****

Site Data - C-11

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 3337.74 ft
Outlet Station: 45.00 ft
Outlet Elevation: 3337.05 ft
Number of Barrels: 3

Culvert Data Summary - C-11

Barrel Shape: Circular
Barrel Diameter: 3.50 ft
Barrel Material: Concrete
Embedment: 0.00 in
Barrel Manning's n: 0.0120
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: None

Table 33 - Downstream Channel Rating Curve (Crossing: C-11)

Flow (cfs)	Water Surfac Elev (ft)	Depth (ft)	Velocity (ft/s	Shear (psf)	Froude Number
130.00	3338.75	1.70	4.08	1.59	0.78
169.00	3338.93	1.88	4.35	1.76	0.79

Tailwater Channel Data - C-11

Tailwater Channel Option: Triangular Channel
Side Slope (H:V): 11.00 (_:1)
Channel Slope: 0.0150
Channel Manning's n: 0.0400
Channel Invert Elevation: 3337.05 ft

Roadway Data for Crossing: C-11

Roadway Profile Shape: Constant Roadway Elevation
Crest Length: 100.00 ft
Crest Elevation: 3342.00 ft
Roadway Surface: Gravel
Roadway Top Width: 31.00 ft

Appendix D – Riprap Sizing Calculations

Project:	Calico - Grassy Mountain Access Road Design
Project Number:	10162362
Task:	Culvert Protection - Riprap Sizing
Date:	4/22/2019
Calculated By:	S. Savage, EIT
Checked By:	D. March, PE, CFM

RIPRAP SIZING CALCULATION

Stream Crossing ID	Culvert Diameter (ft)	25-yr Design Flow (cfs)	Tailwater Depth (ft)	Calculated D50 (ft)	Assigned D50 (ft)
C-01	2.0	12	0.5	0.3	0.5
C-02	2.0	10	0.7	0.2	0.5
C-03	2.5	22	1.5	0.1	0.5
C-04	2.0	15	0.9	0.2	0.5
C-05	2.0	15	0.3	0.7	1.0
C-06	3.0	36	1.1	0.3	0.5
C-07	3.5	55	1.1	0.4	0.5
C-08	4.0	76	1.2	0.5	0.5
C-09	3.0	32	0.7	0.5	0.5
C-10	2.0	11	0.3	0.5	0.5
C-11	3.5	56	1.9	0.2	0.5

Governing Equation:

$$D_{50} = 0.023 * D * \left(\frac{Q}{a * D^{2.5}}\right) * \left(\frac{D}{TW}\right)^{1.2}$$

Where:

D50 = riprap size (ft)
Q = design discharge (cfs)
D = culvert diameter (ft)
TW = tailwater depth (ft)
a = unit conversion (1.811)

Source: *Appendix D - Riprap Apron Sizing Equations, HEC-14 - Hydraulic Design of Energy Dissipators for Culverts & Channels*