DESCHUTES COUNTY

ROAD DEPARTMENT

ADDENDUM NO. 1

TUMALO RESERVOIR RD IMPROVEMENT

The Bidding Documents for the TUMALO RESERVOIR RD IMPROVEMENT project are amended as follows:

SUPPLEMENTAL INFORMATION

- ***The following documents are included as Supplemental Information for bidders and are attached hereto.***
    - ***Cross-Section Exhibits***
    - ***Pavement Improvement Report***

The Bidding Documents for the TUMALO RESERVOIR RD IMPROVEMENT project are amended as described above.

Cody Smith, PE
County Engineer/Assistant Director

Date

THE BIDDER SHALL ACKNOWLEDGE THIS ADDENDUM USING THE ADDENDA CERTIFICATION FORM PROVIDED IN THE BIDDING DOCUMENTS.

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD
DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 1+00 TO STA 21+50

DRAWING NO.
1 OF 14

SHEET NO.
X-01

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
FOR REFERENCE ONLY
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 22+00 TO STA 42+50

DRAWING NO.
2 OF 14
SHEET NO.
X-02

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 43+00 TO STA 63+50

DRAWING NO.
3 OF 14

SHEET NO.
X-03

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
FOR REFERENCE ONLY
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 64+00 TO STA 84+50

DRAWING NO.
4 OF 14

SHEET NO.
X-04

10
2
0

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'
0 5 30 60

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

ROAD
DEPARTMENT

87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 85+00 TO STA 102+00

DRAWING NO.
5 OF 14

SHEET NO.
X-05

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 102+50 TO STA 119+50

DRAWING NO.
6 OF 14

SHEET NO.
X-06

ROAD DEPARTMENT

87553PE
NOV. 13, 2018
ALEC VEIKKO FRANSEN
FOR REFERENCE ONLY
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 120+00 TO STA 137+00

DRAWING NO.
7 OF 14

SHEET NO.
X-07

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 137+50 TO STA 154+50

DRAWING NO.
8 OF 14

SHEET NO.
X-08

10
2
0

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'
0 5 30 60

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD
DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 155+00 TO STA 172+00

DRAWING NO.
9 OF 14

SHEET NO.
X-09

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'
10 2 0
0 5 30 60

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD
DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
FOR REFERENCE ONLY
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 172+50 TO STA 189+50

DRAWING NO.
10 OF 14

SHEET NO.
X-10

10
2
0

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'

0 5 30 60

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD
DEPARTMENT

87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON
ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON
THIS SHEET, ADJUST
SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 190+00 TO STA 216+50

DRAWING NO.
11 OF 14

SHEET NO.
X-11

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

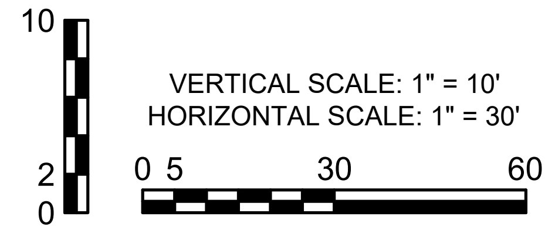
DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
217+OO TO STA 228+50

DRAWING NO.
12 OF 14

SHEET NO.
X-12



VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

87553PE
FOR REFERENCE ONLY
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV
DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 229+00 TO STA 239+00

DRAWING NO.
13 OF 14

SHEET NO.
X-13

10
2
0
0 5 30 60

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 30'

X:\Projects\Deschutes County\Tumalo Reservoir Road\CAD_WORKING\XREF\TITLE\TITLE_BLK.dwg

DESCHUTES COUNTY
ROAD DEPARTMENT

87553PE
FOR REFERENCE ONLY
OREGON
NOV. 13, 2018
ALEC VEIKKO FRANSEN
RENEWS: DEC 31, 2025

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING.
0" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

NO.	DATE	BY	APPR	REVISIONS

CENTURY WEST
ENGINEERING

BEND OFFICE
1020 SW EMKAY DRIVE, #100
BEND, OR 97702
541.322.8962
541.382.2423 FAX

DESIGNED BY: AVF
DRAWN BY: SCL
CHECKED BY: RDV

DATE: DECEMBER 2025
PROJECT NO: 12602.002.01
SCALE: AS NOTED

DESCHUTES COUNTY
TUMALO RESERVOIR ROAD IMPROVEMENT

CROSS SECTIONS
STA 239+50 TO STA 250+00

DRAWING NO.
2 OF 14

SHEET NO.
X-02

Pavement Improvement Report
Tumalo Reservoir Road

Deschutes County, Oregon

December 18, 2024

Prepared for

Century West Engineering
1020 SW Emkay Drive, Suite 100
Bend, OR 97702

Prepared by

GRI

16250 SW Upper Boones Ferry Road, Suite 100
Tigard, OR 97224
(503) 641-3478 | www.gri.com

EXECUTIVE SUMMARY

I PROJECT DESCRIPTION

GRI completed a pavement evaluation for the proposed rehabilitation, reconstruction, and/or widening of Tumalo Reservoir Road from O.B. Riley Road to Sisemore Road in Deschutes County, Oregon. The approximate location of the street segments is shown on the Vicinity Map, Figure 1.

Our recommendations for the rehabilitation and/or reconstruction of the project street segments are based on the results of our field investigation, subsurface explorations, Dynamic Cone Penetration testing, ground-penetrating radar testing, laboratory testing, engineering analyses, and engineering judgment. This report summarizes our pavement design recommendations and presents the data collected during our field and laboratory investigations. The approximate exploration locations along project segments are provided on the Site Plan, Figure 2.

II PAVEMENT DESIGN RECOMMENDATIONS

GRI provided rehabilitation, partial-depth reconstruction, full-depth reconstruction, and/or widening recommendations for the project segment. Details of our treatment options for rehabilitation, partial-depth reconstruction, full-depth reconstruction, and/or widening recommendations are presented in Table II-I. Our recommendations, materials, and construction considerations are further discussed in Section 5 of this report.

Table II-I: REHABILITATION, PARTIAL-DEPTH, AND FULL-DEPTH RECONSTRUCTION RECOMMENDATIONS

	Rehabilitation(a)	Partial-Depth Reconstruction(b),(c),(d)	Full-Depth Reconstruction and/or Widening		
Design Segment	**Overlay AC Thickness, inches**	**Required AC Thickness Above Exposed Subgrade, inches**	**AC Thickness, inches**	**AB Thickness, inches(e)**	**In-Place Pulverization of Existing AC and SG, inches(f)**
Segment-1	3	6	4.5	4	8
Segment-2	3.5(g)	6	5	4	8
Segment-3	3.5(g)	6	4.5	4	8

Abbreviations: AC = asphalt concrete; AB = aggregate base; SG = subgrade; FDR = full-depth reclamation

Notes:

(a) It should be expected that the existing cracking will eventually reflect through the new AC overlay.

(b) Partial-depth reconstruction analysis involves removal of the existing AC.

(c) The partial-depth reconstruction analysis indicates that the exposed subgrade after removal of the existing pavement is not adequate to support construction traffic due to the subgrade strength properties.

(d) The partial-depth reconstruction analysis indicates that a grade increase ranging from 2½ inches to 2¾ inches is required to support approximated 20-year design traffic.

[e]The AB layer shall be underlain by a nonwoven subgrade geotextile.

[f]Minimum recommended depth. During construction, contract provisions should be made for the contractor to determine the moisture-density relationship of the actual AC and SG blend used in the FDR in order to verify they achieve the specified level of compaction. We recommend an FDR depth such that the blended material has 50% or less of AC material.

[g]If a 3.5-inch-thick overlay is not practical from a constructability standpoint, we suggest increasing the ACP thickness by 0.5 inches for a total AC thickness of 4.0 inches, even though 4.0-inch-thick AC is not warranted structurally.

III DURATION OF PAVEMENT DESIGN RECOMMENDATIONS

The findings and recommendations for pavement rehabilitation and reconstruction are based on the condition of the pavement and subgrade encountered at the time of our investigation and our traffic-loading approximations, which assume construction will occur in 2025. If the recommended pavement rehabilitation and reconstruction work are not accomplished prior to 2028, our recommendations should be reevaluated to determine if modifications are necessary to account for additional deterioration of the pavement condition and the increase in traffic loading or environmental impacts over the design period.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

GRI completed a pavement evaluation for Century West Engineering (design team) for the proposed rehabilitation, reconstruction, and/or widening of Tumalo Reservoir Road between O.B. Riley Road and Sisemore Road in Deschutes County, Oregon. The approximate location of the project street is shown on the Vicinity Map, Figure 1.

2 PROJECT DESCRIPTION

Deschutes County (County) has identified the Tumalo Reservoir Road as being in need of rehabilitation or reconstruction and widening to accommodate paved bikeways. Our recommendations for the rehabilitation and/or reconstruction of the project street segments are based on the results of our field investigation, subsurface explorations, Dynamic Cone Penetration (DCP) testing, ground-penetrating radar (GPR) testing, laboratory testing, engineering analyses, and engineering judgment. This report summarizes our pavement design recommendations and presents the data collected from our field investigations and laboratory testing. The project limits, approximate length, basis of stationing, and functional classification are summarized below, in Table 2-1.

Table 2-1: GENERAL PROJECT INFORMATION

Project Feature	Project Attribute
Project Street	Tumalo Reservoir Road
Project Limits	Sisemore Road to O.B. Riley Road
Approximate Project Length, feet	24,342
Stationing Reference	1+00 = Approximately 230 feet west of Sisemore Road Centerline
Functional Classification	Rural Minor Collector

3 PAVEMENT DESIGN APPROACH AND METHODOLOGY

GRI accomplished the pavement design analysis in general accordance with the guidelines given in the 1993 American Association of State Highway and Transportation Officials *AASHTO Guide for Design of Pavement Structures* and the 2019 Oregon Department of Transportation (ODOT) Pavement Design Guide. Our pavement design analysis is based on our field explorations and DCP testing results provided in Appendix A, our GPR survey presented in Appendix B, our traffic-loading approximations presented in Appendix C, and our pavement design analysis presented in Appendix D. The approximate exploration locations along the various streets are provided on the Site Plan, Figure 2.

4 PAVEMENT AND SUBSURFACE CONDITIONS

4.1 General

GRI investigated subsurface conditions along the project street segment on January 30 and 31, 2024, by completing 12 pavement cores and shallow boring explorations. We conducted DCP testing at every core location at the bottom of the asphalt concrete (AC). Additional details of our field investigations are provided below.

4.2 Pavement Surface Condition

In general, the pavement surface condition for the project street segment is in fair condition. We observed intermittent longitudinal and transverse cracking.

4.3 Pavement Cores

In our pavement core and shallow boring explorations, we encountered AC at each location. A summary of the pavement layer thicknesses encountered at the core exploration locations is provided in Table 4-1, below. A plot summarizing the thickness and relative condition of the pavement cores is provided on Figure 1A in Appendix A. In addition, shallow boring logs are presented on Figures 2A to 13A, and photographs of the pavement cores and locations are provided on Figures 14A to 25A in Appendix A.

Table 4-1: SUMMARY OF PAVEMENT LAYER THICKNESS

Pavement Boring ID	Lane	AC Thickness, inches
PB-1	WB	3¾
PB-2	EB	3½
PB-3	SB	4
PB-4	SB	3½
PB-5	WB	3
PB-6	WB	3½
PB-7	EB	5
PB-8	WB	3½
PB-9	EB	3
PB-10	WB	3½
PB-11	EB	3¼
PB-12	SB	3½

Abbreviations: ID = identification; AC = asphalt concrete; SB = southbound; EB = eastbound; WB = westbound

Note: We encountered 9 inches of aggregate base below the AC layer in boring PB-9.

4.4 Subgrade Soils

The subgrade soils beneath the AC layer at most of the core locations generally consist of sand with varying amounts of gravel and silt. Additional details are provided on the boring logs shown on Figures 2A through 13A in Appendix A.

4.5 Groundwater

We did not encounter groundwater in any of our explorations. Based on review of nearby well logs, groundwater is typically encountered at depths ranging from approximately 350 feet to 789 feet below ground surface. However, we anticipate that localized perched groundwater conditions may occur shallower and could approach the ground surface during the wet winter and spring months or following periods of heavy or prolonged rainfall.

4.6 Dynamic Cone Penetration Testing

We performed DCP testing to approximate the subgrade resilient modulus at all our shallow boring explorations. Additional details of our DCP testing are presented in Appendix A. Logs of the test data and the test results are provided on Figures 26A through 37A in Appendix A. A summary of the subgrade resilient moduli at each test location and design subgrade resilient modulus value for the project street segment is provided in Table 2A in Appendix A.

4.7 Laboratory Testing

GRI performed visual classifications, determined moisture contents, and conducted grain-size analyses on select samples obtained from the shallow boring explorations. Details of our laboratory testing program are provided in Appendix A. Results of the tests are shown on the boring logs in Figures 2A through 13A and tabulated in Table 3A in Appendix A. The results of laboratory testing to determine the feasibility and develop a mix design for the full-depth reclamation (FDR) with bituminous stabilization are provided in Appendix A.

4.8 Ground-Penetrating Radar Data Collection

GRI conducted a longitudinal GPR survey along the project roadway segments (i.e., parallel to the roadway centerline) for the purpose of estimating the continuous AC thickness. We used our 2-gigahertz, truck-mounted antenna in each lane of travel. Further details of our GPR equipment and survey process are provided in Appendix B. A plot showing the continuous AC thickness along the GPR test lines for the project street segments is shown on Figures 1B through 3B in Appendix B. We also completed a 350-megahertz survey along the project limits to potentially identify the presence and depth of bedrock. Based on the GPR data, we generally did not encounter bedrock except near O.B. Riley Road, as shown on Figure 4B in Appendix B. Based on the area geology where we observed potential bedrock, the material may be basaltic bedrock or hard decomposed rock, which may present difficulties during drilling and/or removal during construction. Without further subsurface exploration, we cannot confirm the subsurface material and hardness value.

5 PAVEMENT DESIGN

5.1 Overview

We conducted pavement design analysis for Tumalo Reservoir Road within project limits to approximate the structural requirements necessary to meet the 20-year design period based on the existing roadway structural capacity, subgrade support conditions, and approximated traffic loading. For the purpose of design, we have divided the project into three segments as follows:

1. Design Segment 1: Tumalo Reservoir Road – Sisemore Road to West of Mock Road (approximate station 3+00 to 149+00)

2. Design Segment 2: Tumalo Reservoir Road – West of Mock Road to Bailey Road (approximate station 149+00 to 189+00)

3. Design Segment 3: Tumalo Reservoir Road – Bailey Road to O.B. Riley Road (approximate station 189+00 to 244+50)

Further details are provided below.

5.2 Traffic-Loading Analysis

For the project segment, the County provided 48-hour traffic classification count data. A description of our traffic loading analysis for the project is provided in Appendix C. The results of our analysis are presented in Tables 1C through 6C. For Segments 1, 2, and 3, we used 20-year design traffic loading of 316,000, 373,000, and 192,000 Equivalent Single Axle Loads, respectively.

5.3 Subgrade Resilient Modulus

We used the DCP test data summarized in Appendix A to estimate the design subgrade resilient modulus value as the average of calculated subgrade modulus for the project street segment, which is correlated to the subgrade resilient modulus based on the relationship developed by Chen et al. (1999). The recommended design subgrade moduli are 9,600 pounds per square inch (psi) for Segments 1 and 2 and 7,400 psi for Segment 3. Additional details are presented in Table 2A in Appendix A.

5.4 Pavement Design Recommendations

We conducted rehabilitation, partial-depth reconstruction, and full-depth reconstruction analyses for each project street segment. For the rehabilitation analysis, we calculated the AC overlay thickness required above the existing pavement to support the approximated traffic for a 20-year design life. For the partial-depth reconstruction, we calculated the AC thickness required to support the approximated traffic for a 20-year design life after removing the existing AC. For the full-depth reconstruction analysis, we calculated the pavement structure required for a 20-year design life using approximated traffic loading.

The proposed rehabilitation and partial-depth reconstruction options are cost-conscious alternatives, and such treatment options carry additional risk, as discussed below:

- Based on the observed existing cracks, reflective cracking is expected to appear at the end of design life for the rehabilitation with overlay alternative.
- Construction traffic traveling on exposed subgrade may result in subgrade disturbance due to the absence of AB. Construction traffic and truck weight should be minimized on the exposed subgrade to limit the potential need for full-depth base repairs and/or subgrade stabilization.
- Some thicker areas of AC may remain after milling and may need to be removed before the new AC is placed. A contract provision should be included for repairs in these areas.
- Consider performing construction during the later parts of the summer, when subsurface conditions will be drier, to reduce (but not eliminate) the risk of subgrade damage.
- Contract provisions should be included for subgrade stabilization if construction results in disturbed subgrade material.
- Consistent communication with the contractor, considerate construction sequencing, and careful construction monitoring will be required to limit subgrade disturbance. This should include completing construction on half the roadway width at a time. The contractor should not be allowed to remove the entire roadway width of AC at any point during construction.

The County was interested in evaluating the feasibility of implementing FDR with bituminous stabilization for the project segments. American Engineering Testing, Inc. completed the laboratory testing to develop the mix design using foamed asphalt. Based on the laboratory results, it is our opinion that the FDR with bituminous stabilization is not feasible for the project segments because it will not reach the necessary design strengths. The letter summarizing the results of laboratory testing is presented in Appendix A.

Sections 5.4.1 through 5.4.3 provide a brief summary of the proposed treatment options for each design segment. Table 5-1 outlines the results of our partial-depth reconstruction analysis and full-depth reconstruction and/or widening analysis for each segment. Additional details of our rehabilitation analysis can be found in Tables 1D through 3D in Appendix D. Additional details of our partial-depth reconstruction analysis can be found in Tables 4D through 6D in Appendix D. Additional details of our full-depth reconstruction and/or widening analysis can be found in Tables 7D through 9D in Appendix D.

5.4.1 Design Segment 1: Tumalo Reservoir Road – Sisemore Road to West of Mock Road (Approximate Station 3+00 to 149+00)

The pavement surface condition is generally fair and exhibits intermittent longitudinal/transverse cracking throughout. Six pavement borings completed on Segment 1 show an average AC thickness of approximately 3½ inches with no AB. The AC thicknesses observed in the pavement borings correlate well with the GPR data, which show an AC thickness predominantly ranging on average from approximately 2½ inches to 6 inches. Based on our field observations and analysis, the existing pavement is structurally deficient by about 3 inches to adequately support the 20-year design traffic loading.

5.4.2 Design Segment 2: Tumalo Reservoir Road – West of Mock Road to Bailey Road (Approximate Station 149+00 to 189+00)

The pavement surface condition is generally fair and exhibits intermittent longitudinal/transverse cracking throughout. Two pavement borings completed on Segment 2 show an average AC thickness of approximately 4¼ inches with no AB. The AC thicknesses observed in the pavement borings correlate well with the GPR data, which show an AC thickness predominantly ranging on average from approximately 2½ inches to 6 inches. Based on our field observations and analysis, the existing pavement is structurally deficient by about 3½ inches to adequately support the 20-year design traffic loading.

5.4.3 Design Segment 3: Tumalo Reservoir Road – Bailey Road to O.B. Riley Road (Approximate Station 189+00 to 244+50)

The pavement surface condition is generally fair and exhibits intermittent longitudinal/transverse cracking throughout. Four pavement borings completed on Segment 3 show an average AC thickness of approximately 3¼ inches with no AB. The AC thicknesses observed in the pavement borings correlate well with the GPR data, which show an AC thickness predominantly ranging on average from approximately 2½ inches to 5 inches. Based on our field observations and analysis, the existing pavement is structurally deficient by about 3½ inches to adequately support the 20-year design traffic loading.

5.4.4 Summary of Pavement Design Recommendations

Table 5-1: REHABILITATION, PARTIAL-DEPTH, AND FULL-DEPTH RECONSTRUCTION RECOMMENDATIONS

	Rehabilitation(a)	Partial-Depth Reconstruction(b),(c),(d)	Full-Depth Reconstruction and/or Widening		
Design Segment	**Overlay AC Thickness, inches**	**Required AC Thickness Above Exposed Subgrade, inches**	**AC Thickness, inches**	**AB Thickness, inches(e)**	**In-Place Pulverization of Existing AC and SG, inches(f)**
Segment-1	3	6	4.5	4	8
Segment-2	3.5(g)	6	5	4	8
Segment-3	3.5(g)	6	4.5	4	8

Abbreviations: AC = asphalt concrete; AB = aggregate base; SG = subgrade; FDR = full-depth reclamation

Notes:

(a)It should be expected that the existing cracking will eventually reflect through the new AC overlay.

(b)Partial-depth reconstruction analysis involves removal of the existing AC.

(c)The partial-depth reconstruction analysis indicates that the exposed subgrade after removal of the existing pavement is not adequate to support construction traffic due to the subgrade strength properties.

(d)The partial-depth reconstruction analysis indicates that a grade increase ranging from 2½ inches to 2¾ inches is required to support approximated 20-year design traffic.

(e)The AB layer shall be underlain by a nonwoven subgrade geotextile.

(f)Minimum recommended depth. During construction, contract provisions should be made for the contractor to determine the moisture-density relationship of the actual AC and SG blend used in the FDR in order to verify they achieve the specified level of compaction. We recommend an FDR depth such that the blended material has 50% or less of AC material.

(g)If a 3.5-inch-thick overlay is not practical from a constructability standpoint, we suggest increasing the ACP thickness by 0.5 inches for a total AC thickness of 4.0 inches, even though 4.0-inch-thick AC is not warranted structurally.

5.5 Duration of Pavement Design Recommendations

The findings and recommendations for pavement rehabilitation and reconstruction are based on the condition of the pavement and subgrade encountered at the time of our investigation and our traffic-loading approximations, which assume construction will occur in 2025. If the recommended pavement rehabilitation and reconstruction work are not accomplished prior to 2028, our recommendations should be reevaluated to determine if modifications are necessary to account for additional deterioration of the pavement condition and the increase in traffic loading or environmental impacts over the design period.

5.6 Pavement Construction Considerations

Construction materials and procedures should comply with the applicable sections of the 2024 ODOT *Oregon Standard Specifications for Construction* (OSSC) and the modifications given in Table 5-2, below.

Table 5-2: OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION

Materials/Activity	Specification
Subgrade Compaction	Special Provision 00331
Subgrade Geosynthetics	Special Provision 00350
Reconditioning Existing Roadway	Special Provision 00610 (for partial-depth reconstruction)
Cold Plane Pavement Removal	Special Provision 00620
AB	Special Provision 00641 (¾-inch-0).
AC	Special Provision 00744. The minimum lift thickness is 2 inches, and the maximum lift thickness is 3 inches for dense HMA. Use Level 2, ½-inch dense ACP.
Asphalt Binder	Use PG 58-22 Asphalt Cement.

Abbreviations: AB = aggregate base; AC = asphalt concrete; HMA = Hot Mix Asphalt; ACP = asphalt concrete pavement; PG = Performance Grade

The pavement sections provided above are based on the assumptions that pavement construction will be accomplished during warm, dry conditions and that all workmanship and materials will conform to the applicable specifications. An experienced geotechnical engineer should evaluate the exposed subgrade conditions during construction. During periods of wet weather or when wet ground conditions exist, it may be necessary to increase the thickness of the AB to support construction equipment.

5.7 Subgrade Stabilization/Wet Weather Construction

Subgrade stabilization should be completed where the subgrade soils exhibit unsuitable conditions based on proof rolling or foundation probing and/or where the finished AB exhibits deflections or pumping based on proof rolling. Our recommendations for subgrade stabilization are presented below:

- 12-inch-thick Subgrade Stabilization
- Nonwoven Subgrade Geotextile
- On Undisturbed Subgrade

For extremely soft conditions or in periods of wet weather, an additional thickness of subgrade stabilization may be required.

5.8 Opening to Traffic

Traffic should not be allowed on the milled pavement surface or exposed subgrade.

6 DESIGN REVIEW AND CONSTRUCTION SERVICES

We welcome the opportunity to review and discuss construction plans and specifications for this project as they are being developed. In addition, GRI should be retained to review all geotechnical- and pavement-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in our report and to observe compliance with the intent of our recommendations, the design concepts, and the plans and specifications. Our construction-phase services will allow for timely design changes if site conditions are encountered that are different from those described in our report. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions different from those described in this report.

7 LIMITATIONS

This report has been prepared to aid the project team in the design of this project. The scope is limited to the specific project and location described in this report, and our description of the project represents our understanding of the significant aspects of the project relevant to the design and construction of the street segments evaluated as part of project scope. In the event that any changes in the design and location of the project elements as outlined in this report are planned, we should be given the opportunity to review the changes and modify or reaffirm the conclusions and recommendations of this report in writing.

The conclusions and recommendations in this report are based on the data obtained from the subsurface explorations at the locations shown on Figure 2 and other sources of information discussed in this report. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in subsurface conditions may exist between exploration locations. This report does not reflect variations that may occur between these explorations. The nature and extent of variation may not become evident until construction. If subsurface conditions during construction differ from those encountered in the explorations, we should be advised at once so we can observe and review these conditions and reconsider our recommendations where necessary.

Submitted for GRI,

88693PE

Lindsi Hammond

MAY 21, 2014

LINDSI ALEYCE HAMMOND

RENEWS: 06/2025

Shashwath

Lindsi A. Hammond, PE	Shashwath Sreedhar, PhD, PE	Matthew A. Haynes, PE
Principal	Project Engineer	Project Engineer

This document has been submitted electronically.

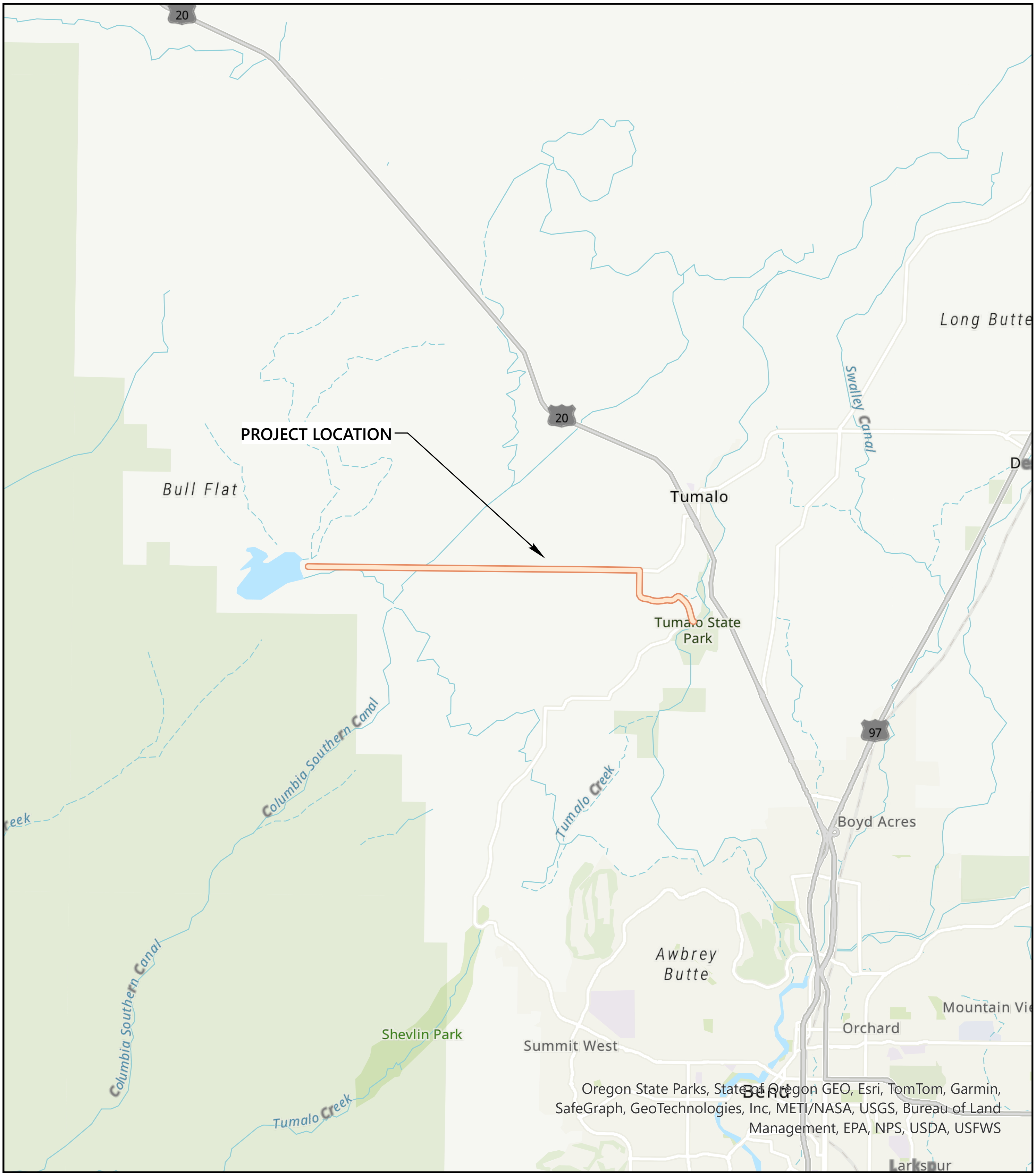
8 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 1993, AASHTO guide for design of pavement structures: Washington, D.C.

Chen, J., Hossain, M., and LaTorella, T. M., 1999, Use of Falling Weight Deflectometer and Dynamic Cone Penetrometer in pavement evaluation: Transportation Research Record 1655, pp. 145–151, Transportation Research Board, Washington, D.C.

Oregon Department of Transportation (ODOT), 2019, ODOT pavement design guide: Pavement Services Unit, Salem, Oregon.

ODOT, 2024, Oregon standard specifications for construction: Salem, Oregon.



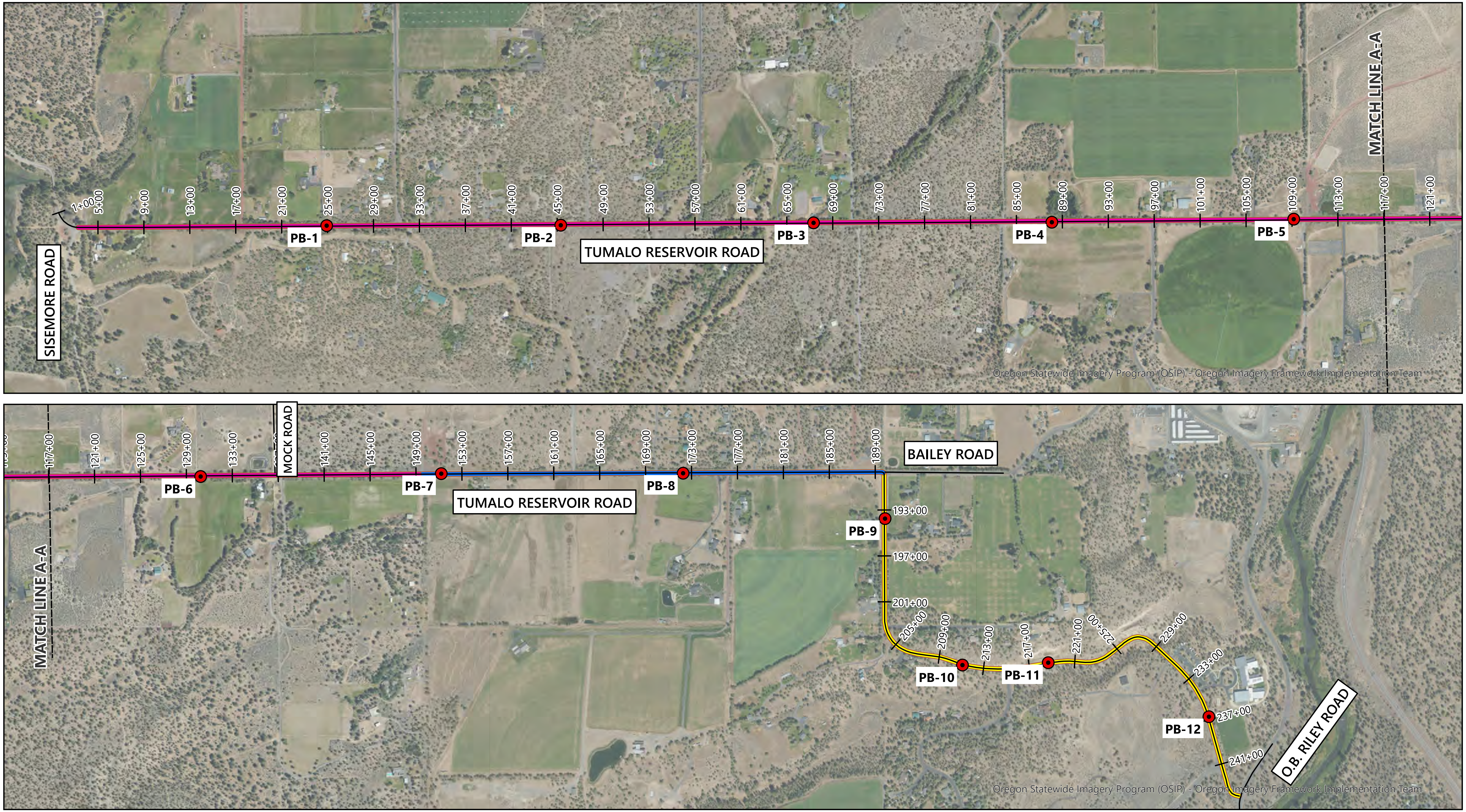
BASEMAP PROVIDED BY ESRI, 2023

GRI

CENTURY WEST ENGINEERING
TUMALO RESERVOR ROAD
PAVEMENT EVALUATION
DESCHUTES COUNTY, OREGON

VICINITY MAP

DEC. 2024 JOB NO. 6894-A FIG. 1



Aerial Imagery Source: Oregon Statewide Imagery Program, OSIP 2022 (Accessed December 2023)

LEGEND

● APPROXIMATE BORING LOCATIONS
▬ DESIGN PROJECT SEGMENT 1
▬ DESIGN PROJECT SEGMENT 2
▬ DESIGN PROJECT SEGMENT 3

N

0 800 1,600 Feet

GRI

CENTURY WEST ENGINEERING
TUMALO RESERVOIR ROAD
PAVEMENT EVALUATION
DESCHUTES COUNTY, OREGON

SITE PLAN

DEC. 2024 JOB NO. 6894-A FIG. 2

APPENDIX A

Field Explorations and Laboratory Testing

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

A.1 FIELD EXPLORATIONS

A.1.1 General

GRI completed 12 pavement cores / shallow borings within the project limits on January 30 and 31, 2024. The approximate locations of the subsurface explorations are shown on the Site Plan, Figure 2. We advanced the shallow boring explorations through the asphalt concrete (AC) and subgrade layers to depths between approximately 1 foot and 5 feet below ground surface. The field-exploration and laboratory-testing programs completed for this project are described below.

A.1.2 Pavement Core Explorations and Shallow Borings

GRI retained Dan J. Fischer Excavating, Inc. (Fischer) of Forest Grove, Oregon, to complete the pavement borings for the purposes of evaluating the type, thickness, and condition of subsurface materials present at the site. Fischer completed the pavement core explorations using a 6-inch inside-diameter diamond-tipped core barrel and advanced the borings into the subgrade using a solid-stem auger with a Big Beaver Portable Drill rig. We retained the core samples obtained from borings PB-1 through PB-12. A plot summarizing the thickness and relative condition of the pavement cores is provided on Figure 1A in this appendix. Core samples are shown on the boring logs (Figures 2A through 13A), and boring location and pavement core photographs are provided on Figures 14A through 25A. Additional details are presented on the boring logs (Figures 2A through 13A), and the terms and symbols used to describe the subsurface materials encountered in the explorations are defined in Table 1A and the attached legend in this appendix.

We collected disturbed samples from the borings at approximately 1- to 3½-foot intervals as identified on the boring logs using a standard split-spoon sampler.

An experienced member of the GRI engineering team directed the explorations and maintained logs of the materials and conditions encountered during the boring operations. Our staff examined the soil samples in the field and retained portions of the materials encountered in zip-top bags for further examination. The boring logs are presented on Figures 2A through 13A in this appendix.

A.1.3 Dynamic Cone Penetrometer

A.1.3.1Overview

During the shallow boring explorations conducted on January 30 and 31, 2024, GRI completed Dynamic Cone Penetration (DCP) testing in all exploration locations. We advanced the DCP test probes below the AC layer and into the subgrade soil.

We used our Kessler Dynamic Cone Penetrometer manufactured by KSE Testing Equipment to complete the tests in general accordance with ASTM International (ASTM) D6951 by driving a ⅝-inch-diameter steel rod with a cone tip into the soil using a 17.6-pound sliding hammer dropped to a fixed height of 22.6 inches. We recorded the number of hammer drops (blows) required to drive the probe in increments of approximately 2 inches, or the penetration depth for each blow, and terminated testing at refusal of penetration or end of rod length.

A.1.3.2 Subgrade Resilient Modulus Approximation

Using the recorded test data, we plotted cumulative blows against cumulative penetration depths and visually assessed the resulting curve to delineate regions with approximately linear slopes. We then used least square regression to calculate the slope of the approximately linear regions along the curve and used the procedures described by Chen et al. (1999) to approximate the resilient modulus for each region. Where a curve exhibited more than one slope, we used Odemark's Method of Equivalent Thickness described by Ullidtz (1998) to calculate an equivalent modulus value for the entire data set of similar soil types.

A.1.3.3 Dynamic Cone Penetrometer Test Results

Cumulative blows versus cumulative penetration depths are listed and presented graphically on Figures 26A through 37A in this appendix. Also shown on the figures are the approximated resilient modulus values and the equivalent modulus value if the data exhibit more than one approximately linear region for a given soil type. A summary of the approximated resilient modulus values at each test location, as well as the average value for each project street segment, is provided in Table 2A, below.

Table 1A: APPROXIMATED SUBGRADE RESILIENT MODULI BASED ON DCP TESTING

Core ID	Approximate Subgrade Modulus, psi	Segment Number	Average Subgrade Modulus Used for Design, psi
PB-1	9,690	3	9,600
PB-2	10,120		
PB-3	7,960		
PB-4	12,420		
PB-5	8,890		
PB-6	9,210		
PB-7	6,880	2	9,600
PB-8	12,310		
PB-9	6,580	1	7,400
PB-10	7,510		
PB-11	6,850		
PB-12	8,810		

Abbreviations: ID = identification; psi = pounds per square inch

A.2 LABORATORY TESTING

A.2.1 General

We obtained samples from the pavement-core explorations and geotechnical borings for further examination in our laboratory, where we noted the physical characteristics of the samples and modified the field classifications where necessary. We determined the natural moisture content of each sample and performed Atterberg limits tests and No. 200 grain-size analyses on select samples. A summary of the laboratory test results is provided in Table 3A. The following sections describe the testing program in more detail.

A.2.2 Natural Moisture Content

We determined natural moisture contents in conformance with ASTM D2216. The results are summarized on Figures 2A through 13A and in Table 3A.

A.2.3 Grain-Size Analysis

GRI performed a grain-size analysis to evaluate the percent passing the No. 200 sieve on selected samples collected from borings PB-12, PB-21, and PB-24. The results are shown on Figures 13A, 22A, and 25A and tabulated in Table 3A.

A.3 REFERENCES

Chen, J., Hossain, M., and LaTorella, T. M., 1999, Use of Falling Weight Deflectometer and Dynamic Cone Penetrometer in pavement evaluation: Transportation Research Record 1655, pp. 145–151, Transportation Research Board, Washington, D.C.

Ullidtz, P., 1998, Modelling flexible pavement response and performance: Tech Univ. of Denmark Polytekn.

Table 2A

SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
PB-1	S-1	0.3	--	11	--	--	--	--	Gravelly SAND
PB-3	S-1	0.3	--	9	--	--	--	--	SAND
PB-5	S-1	0.3	--	26	--	--	--	--	SAND
PB-7	S-2	3.5	--	15	--	--	--	--	Gravelly SAND
PB-9	S-3	2.5	--	9	--	--	--	--	Sandy GRAVEL
PB-10	S-1	0.3	--	16	--	--	--	--	Gravelly SAND
PB-12	S-1	0.3	--	11	--	--	--	--	Gravelly SAND

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
⁙	LANDSCAPE MATERIALS
▩	FILL
○	GRAVEL; clean to some silt, clay, and sand
○	Sandy GRAVEL; clean to some silt and clay
○	Silty GRAVEL; up to some clay and sand
○	Clayey GRAVEL; up to some silt and sand
⁘	SAND; clean to some silt, clay, and gravel
⁘	Gravelly SAND; clean to some silt and clay
⁘	Silty SAND; up to some clay and gravel
⁘	Clayey SAND; up to some silt and gravel
▥	SILT; up to some clay, sand, and gravel
▥	Gravelly SILT; up to some clay and sand
▥	Sandy SILT; up to some clay and gravel
▥	Clayey SILT; up to some sand and gravel
▨	CLAY; up to some silt, sand, and gravel
▨	Gravelly CLAY; up to some silt and sand
▨	Sandy CLAY; up to some silt and gravel
▨	Silty CLAY; up to some sand and gravel
≋	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
✚	BASALT
▤	MUDSTONE
▤	SILTSTONE
▤	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
■	Asphalt concrete PAVEMENT
▒	Portland cement concrete PAVEMENT
○	Crushed rock BASE COURSE

SAMPLER SYMBOLS

Symbol	Sampler Description
I	2.0 in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
▮	Shelby tube sampler with recovery (ASTM D1587)
▮	3.0 in. O.D. split-spoon sampler with recovery (ASTM D3550)
⊠	Grab Sample
▯	Rock core sample interval
▒	Sonic core sample interval
░	Push probe sample interval

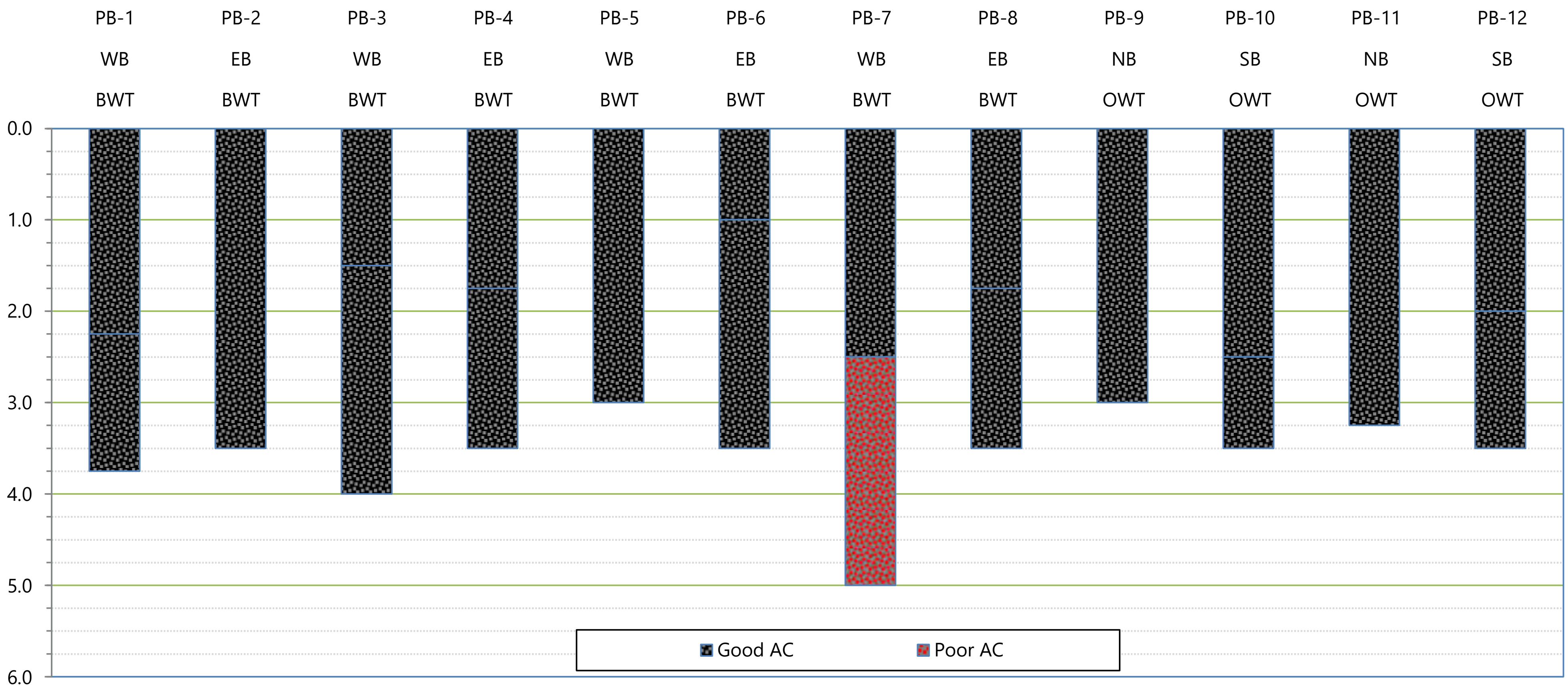
INSTALLATION SYMBOLS

Symbol	Symbol Description
▥	Flush-mount monument set in concrete
▥	Concrete, well casing shown where applicable
▨	Bentonite seal, well casing shown if applicable
⁘	Filter pack, machine-slotted well casing shown where applicable
▥	Grout, vibrating-wire transducer cable shown where applicable
P	Vibrating-wire pressure transducer
▯	1-in.-diameter solid PVC
▯	1-in.-diameter hand-slotted PVC
▥	Grout, inclinometer casing shown where applicable

FIELD MEASUREMENTS

Symbol	Typical Description
▽	Groundwater level during drilling and date measured
▼	Groundwater level after drilling and date measured
▨	Rock/sonic core or push probe recovery (%)
▨	Rock quality designation (RQD, %)

Y Axis = Depth, inches | X Axis = Boring Number / Direction / Location

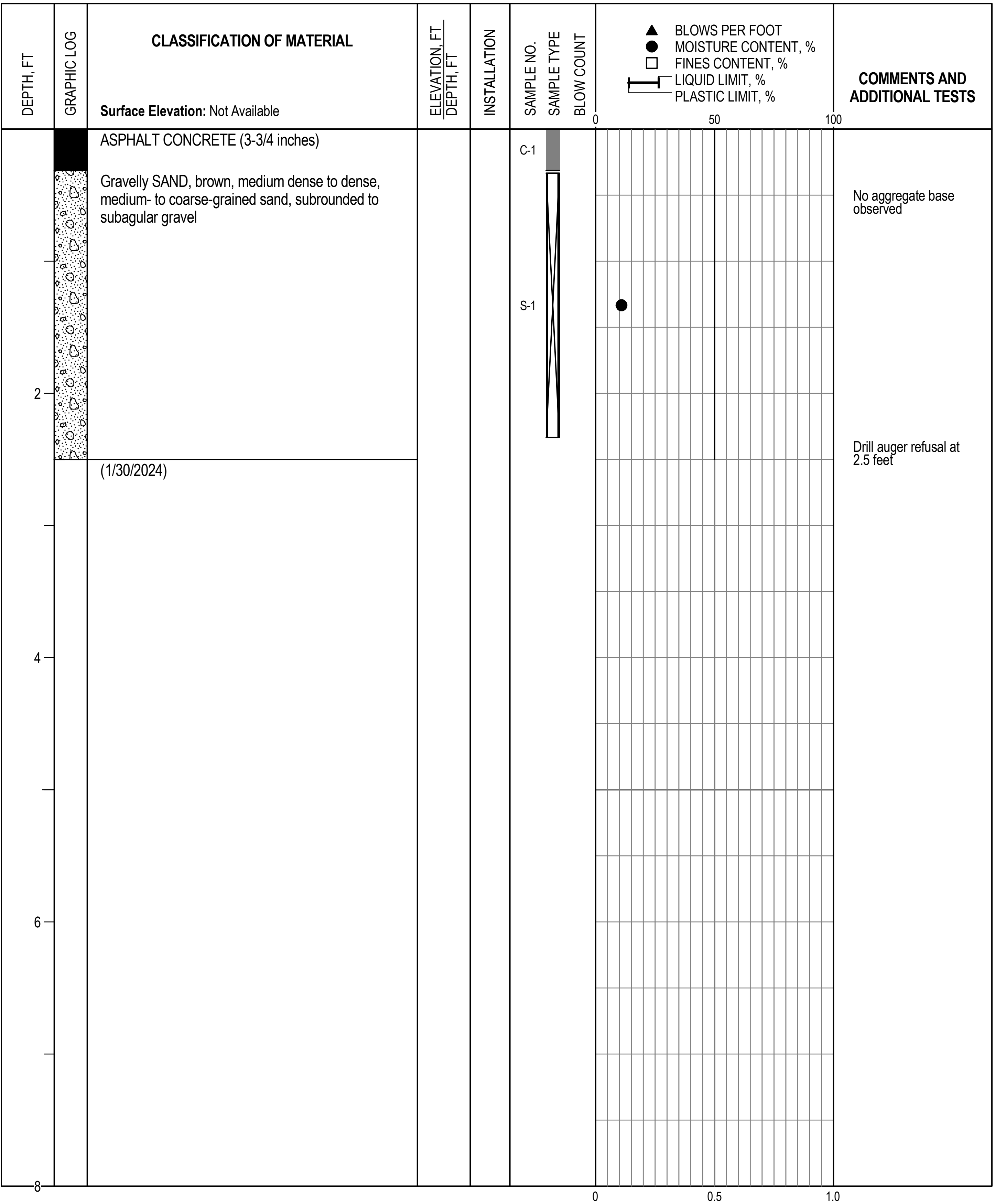


Abbreviations: WB = Westbound; EB = Eastbound; NB = Northbound; SB = Southbound; BWT = Between Wheel Tracks; OWT = Outside Wheel Tracks; AC = Asphalt Concrete

GRI

CORE SUMMARY CHART

DEC. 2024 JOB NO. 6894-A FIG. 1A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3-3/4 inches)

Gravelly SAND, brown, medium dense to dense, medium- to coarse-grained sand, subrounded to subagular gravel

(1/30/2024)

COMMENTS AND ADDITIONAL TESTS

No aggregate base observed

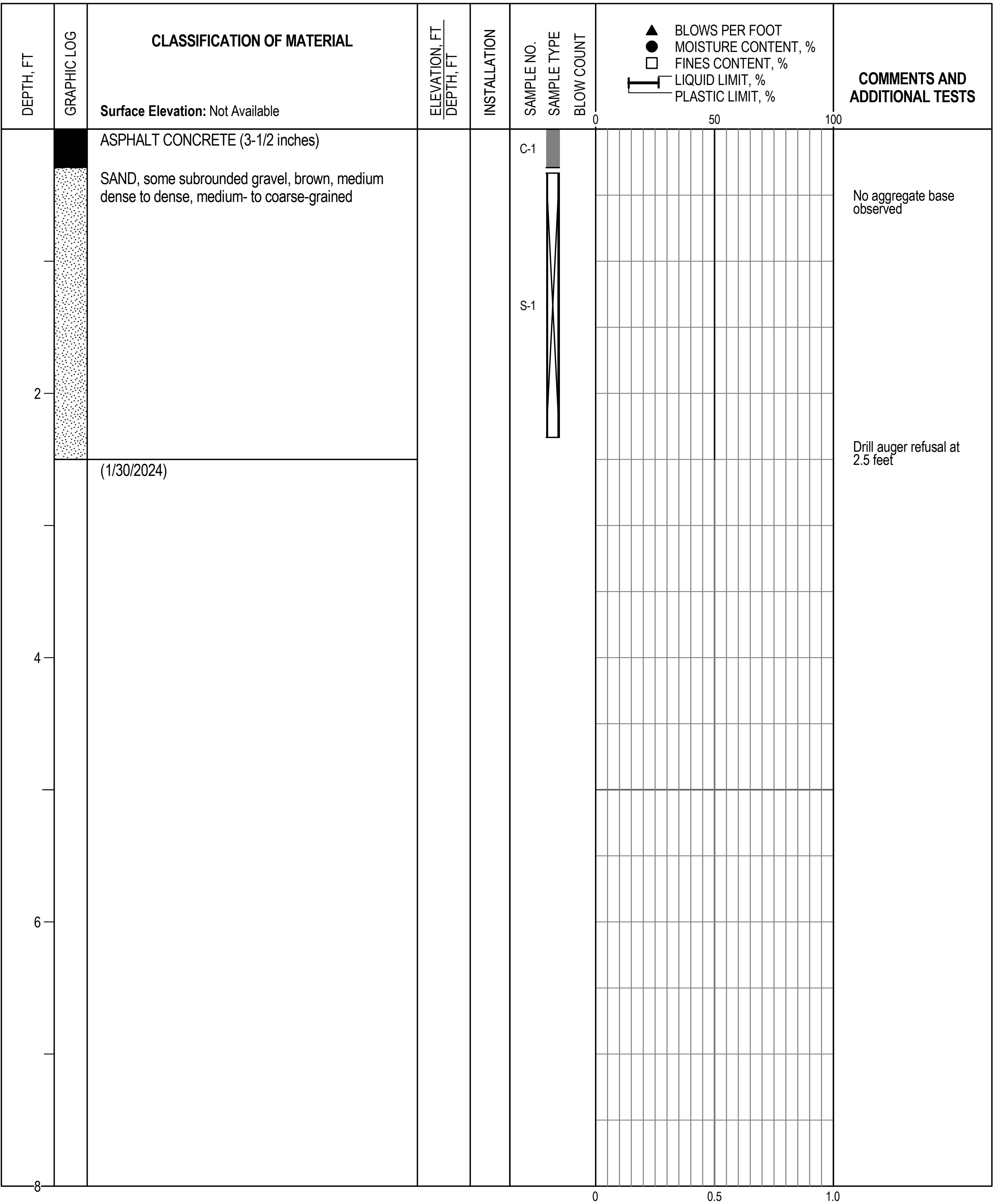
Drill auger refusal at 2.5 feet

Logged By: S. Sreedhar	**Drilled by:** Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24	**Coordinates:** 44.138252° N 121.406227° W (WGS 84)
Drilling Method: Solid-Stem Auger **Equipment:** Buck Rogers 160 Trailer-Mounted Rig **Hole Diameter:** 5 in.	**Hammer Type:** Cat Head **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** Not Available
Note: See Legend for Explanation of Symbols	

GRI

BORING PB-1

DEC. 2024 JOB NO. 6894-A FIG. 2A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3-1/2 inches)

SAND, some subrounded gravel, brown, medium dense to dense, medium- to coarse-grained

(1/30/2024)

COMMENTS AND ADDITIONAL TESTS

No aggregate base observed

Drill auger refusal at 2.5 feet

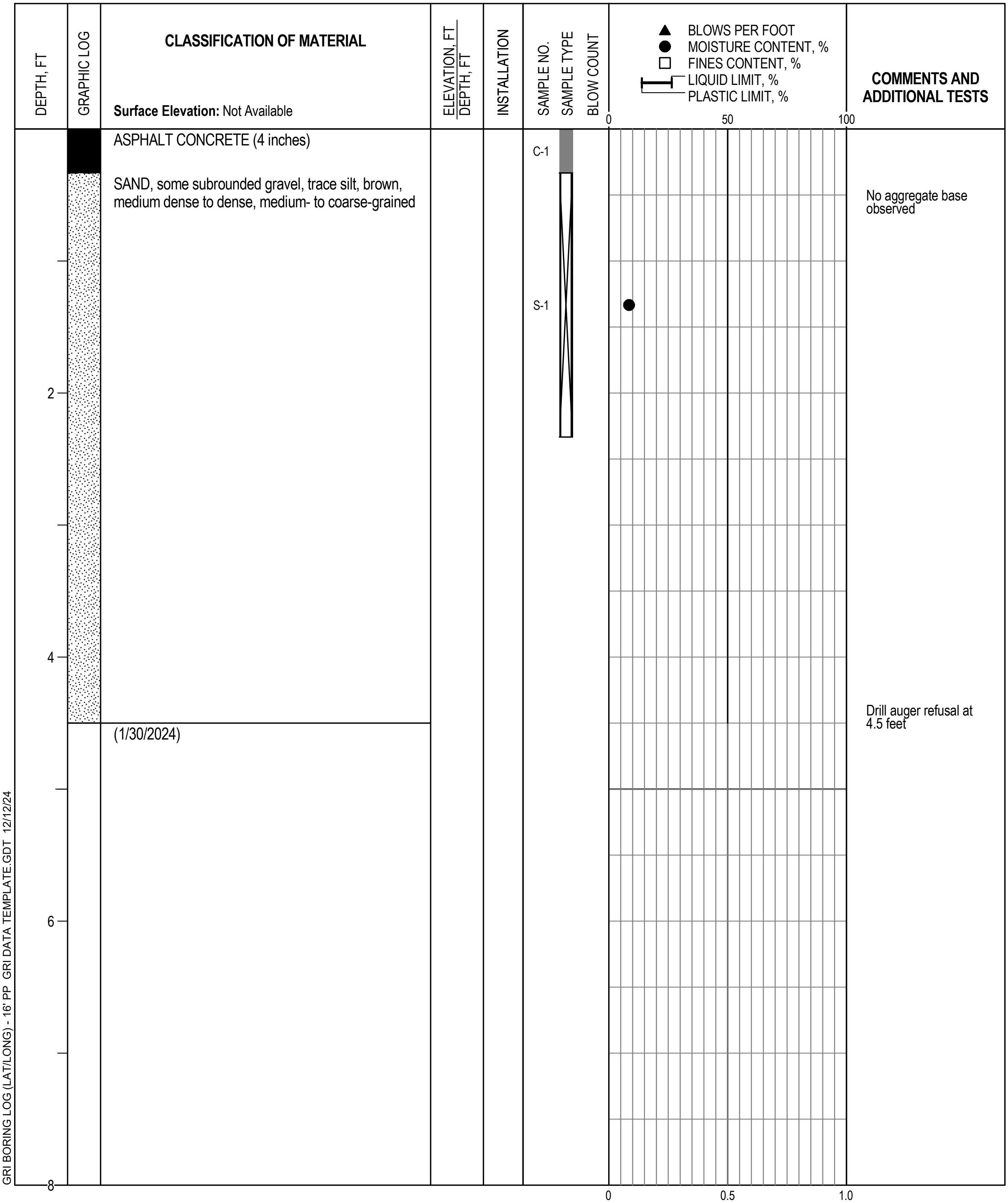
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24
Coordinates: 44.138226° N 121.398221° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

GRI

BORING PB-2

DEC. 2024 JOB NO. 6894-A FIG. 3A



Surface Elevation: Not Available

ASPHALT CONCRETE (4 inches)

SAND, some subrounded gravel, trace silt, brown, medium dense to dense, medium- to coarse-grained

(1/30/2024)

No aggregate base observed

Drill auger refusal at 4.5 feet

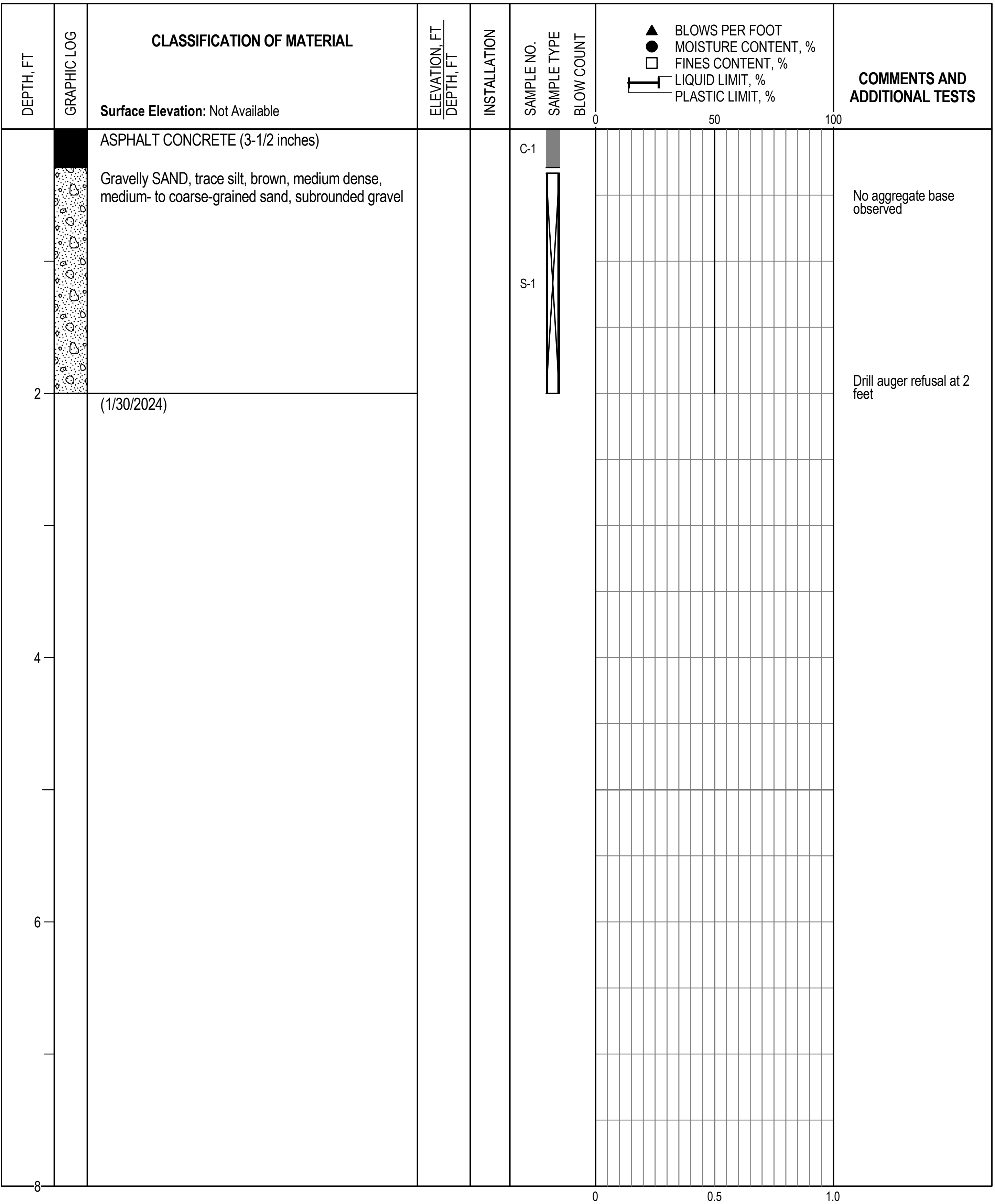
GRI BORING LOG (LAT/LONG) - 16' PP GRI DATA TEMPLATE.GDT 12/12/24

Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24
Coordinates: 44.138234° N 121.39012° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

GRI

BORING PB-3

DEC. 2024 JOB NO. 6894-A FIG. 4A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3-1/2 inches)

Gravelly SAND, trace silt, brown, medium dense, medium- to coarse-grained sand, subrounded gravel

(1/30/2024)

COMMENTS AND ADDITIONAL TESTS

No aggregate base observed

Drill auger refusal at 2 feet

◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

GRI BORING LOG (LAT/LONG) - 16' PP GRI DATA TEMPLATE.GDT 12/12/24

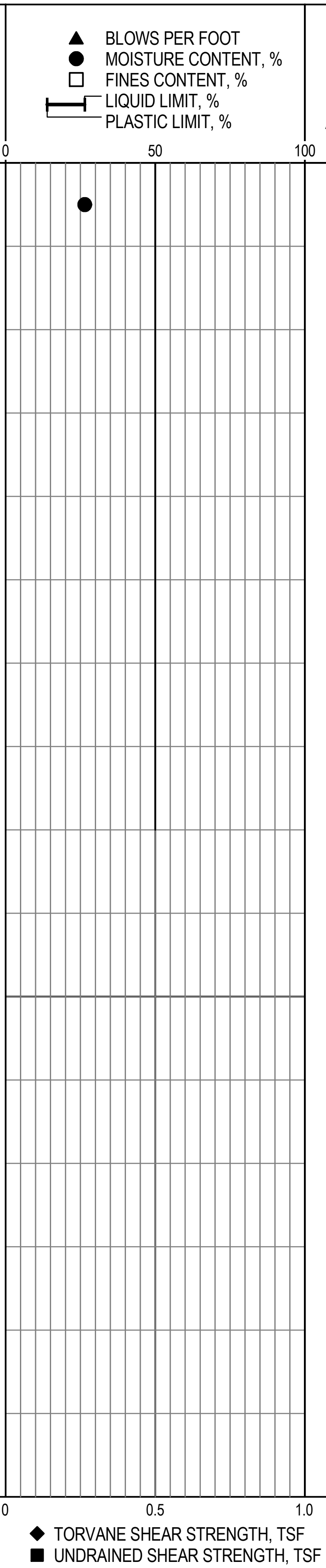
Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24
Coordinates: 44.138217° N 121.382048° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

GRI

BORING PB-4

DEC. 2024 JOB NO. 6894-A FIG. 5A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
0	■	ASPHALT CONCRETE (3 inches)			C-1	▨		
	▨	SAND, some subrounded gravel and silt, brown, medium dense to dense, medium- to coarse-grained			S-1	☒		No aggregate base observed Drill auger refusal at 4 feet
2								
4		(1/30/2024)						
6								
8								

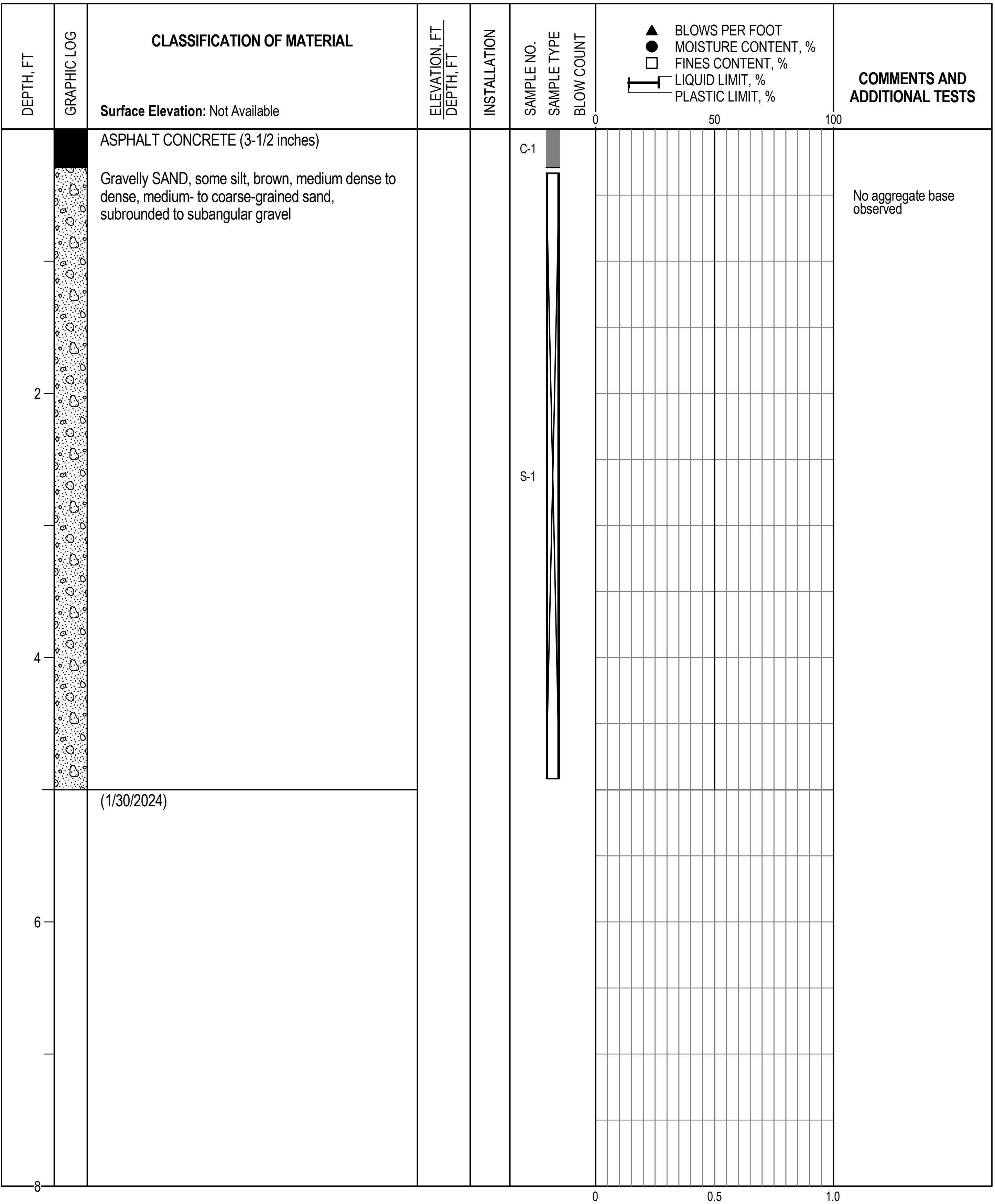


Logged By: S. Sreedhar	**Drilled by:** Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24	**Coordinates:** 44.138254° N 121.37406° W (WGS 84)
Drilling Method: Solid-Stem Auger **Equipment:** Buck Rogers 160 Trailer-Mounted Rig **Hole Diameter:** 5 in.	**Hammer Type:** Cat Head **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** Not Available
Note: See Legend for Explanation of Symbols	

GRI

BORING PB-5

DEC. 2024 JOB NO. 6894-A FIG. 6A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3-1/2 inches)

Gravelly SAND, some silt, brown, medium dense to dense, medium- to coarse-grained sand, subrounded to subangular gravel

(1/30/2024)

COMMENTS AND ADDITIONAL TESTS

No aggregate base observed

◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: S. Sreedhar | **Drilled by:** Dan J. Fischer Excavating, Inc.

Date Started: 1/30/24 | **Coordinates:** 44.138215° N 121.366077° W (WGS 84)

Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.

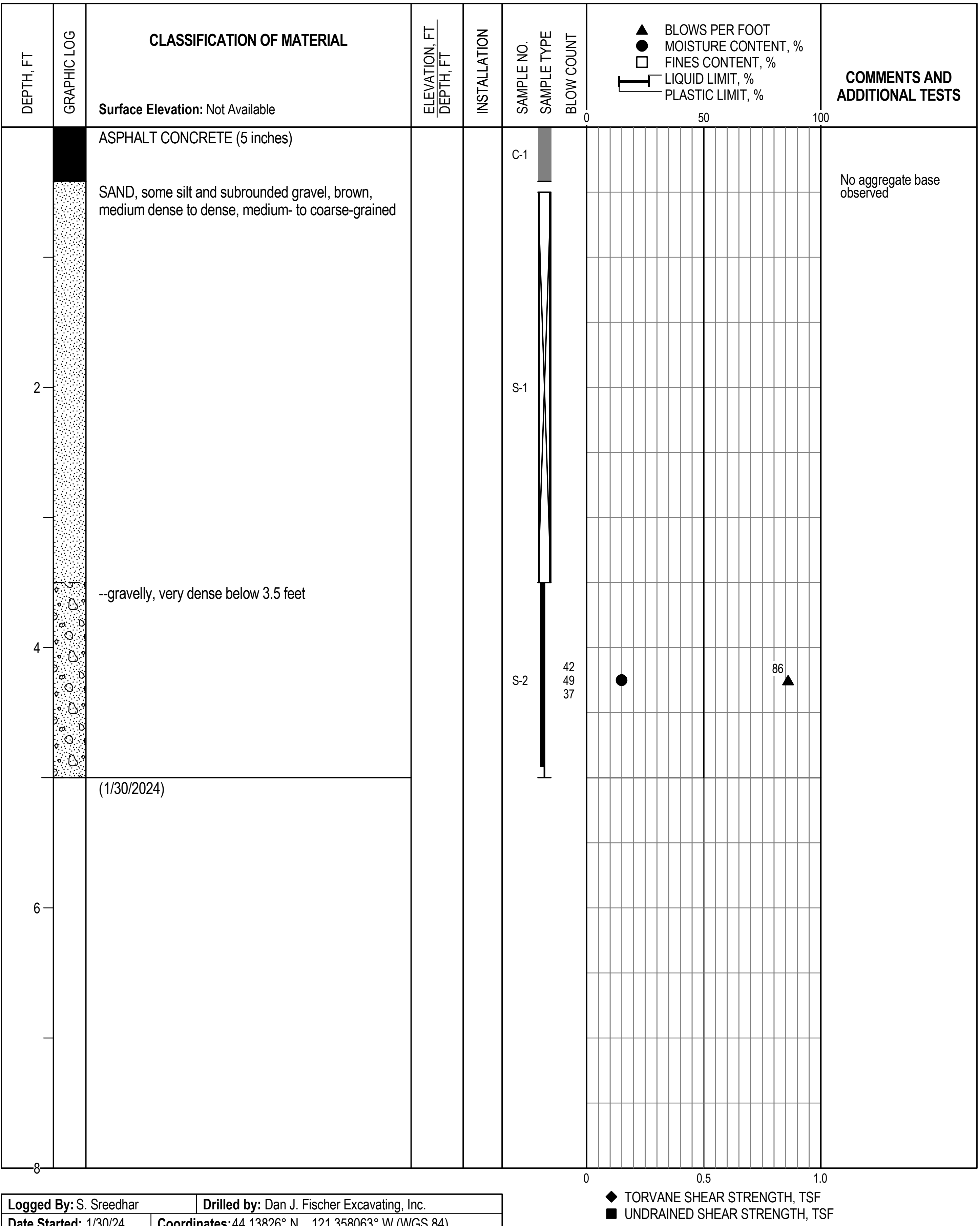
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

Note: See Legend for Explanation of Symbols

GRI

BORING PB-6

DEC. 2024 JOB NO. 6894-A FIG. 7A



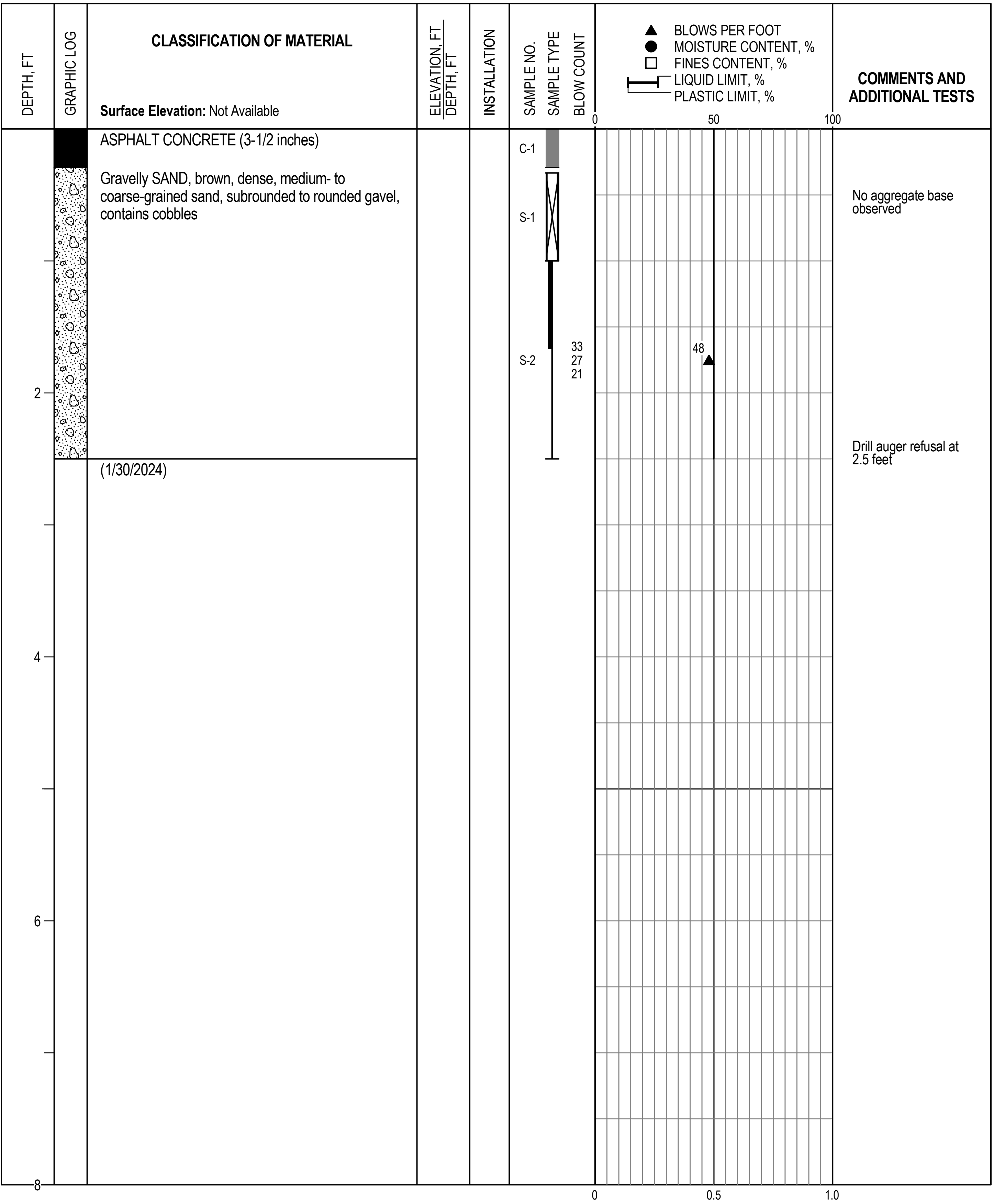
GRI BORING LOG (LAT/LONG) - 16' PP GRI DATA TEMPLATE.GDT 12/12/24

Logged By: S. Sreedhar	**Drilled by:** Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24	**Coordinates:** 44.13826° N 121.358063° W (WGS 84)
Drilling Method: Solid-Stem Auger **Equipment:** Buck Rogers 160 Trailer-Mounted Rig **Hole Diameter:** 5 in.	**Hammer Type:** Cat Head **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** Not Available
Note: See Legend for Explanation of Symbols	

GRI

BORING PB-7

DEC. 2024 JOB NO. 6894-A FIG. 8A



Surface Elevation: Not Available

ASPHALT CONCRETE (3-1/2 inches)

Gravelly SAND, brown, dense, medium- to coarse-grained sand, subrounded to rounded gavel, contains cobbles

(1/30/2024)

No aggregate base observed

Drill auger refusal at 2.5 feet

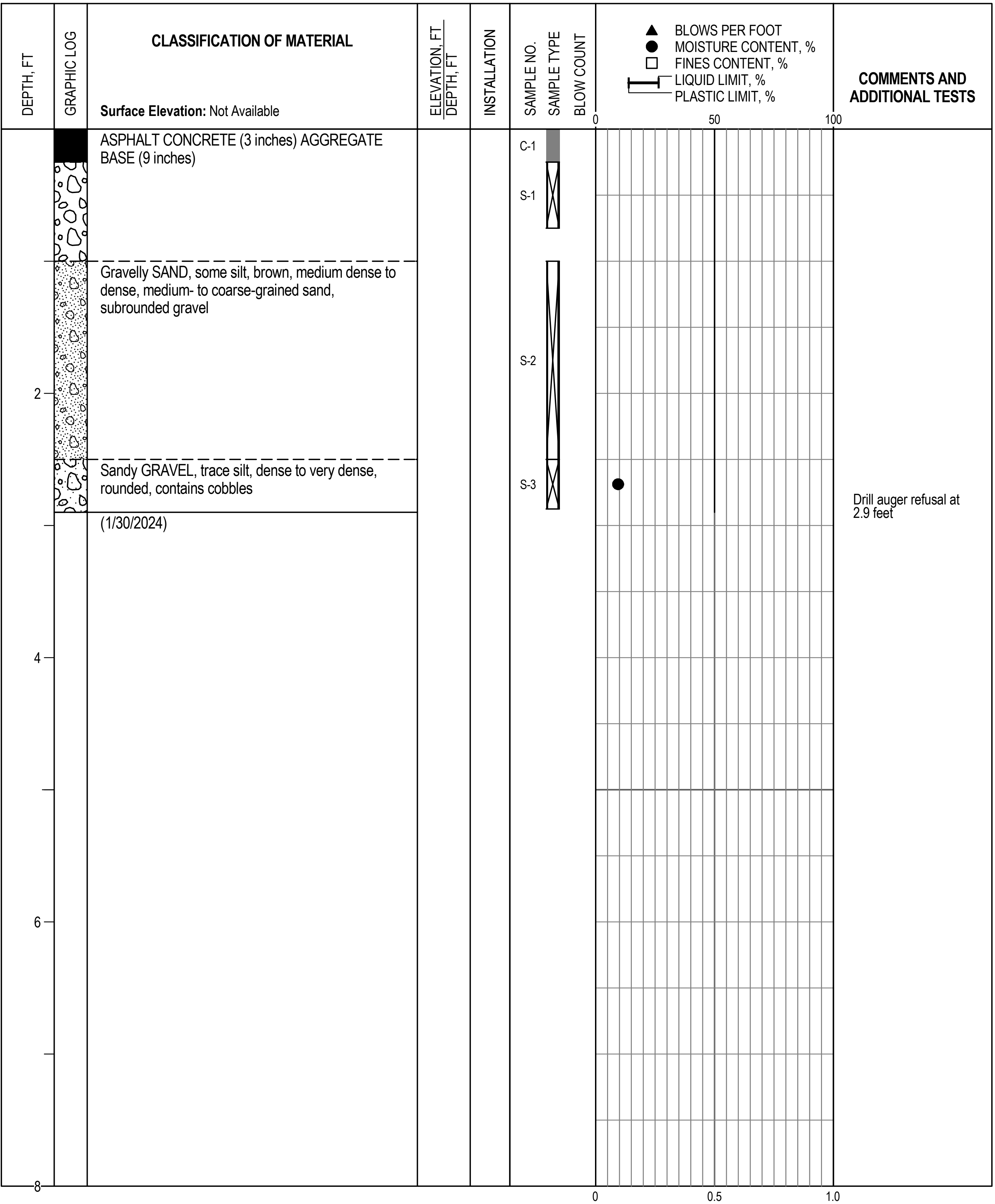
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24
Coordinates: 44.138224° N 121.349971° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

GRI

BORING PB-8

DEC. 2024 JOB NO. 6894-A FIG. 9A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3 inches) AGGREGATE BASE (9 inches)

Gravelly SAND, some silt, brown, medium dense to dense, medium- to coarse-grained sand, subrounded gravel

Sandy GRAVEL, trace silt, dense to very dense, rounded, contains cobbles

(1/30/2024)

COMMENTS AND ADDITIONAL TESTS

Drill auger refusal at 2.9 feet

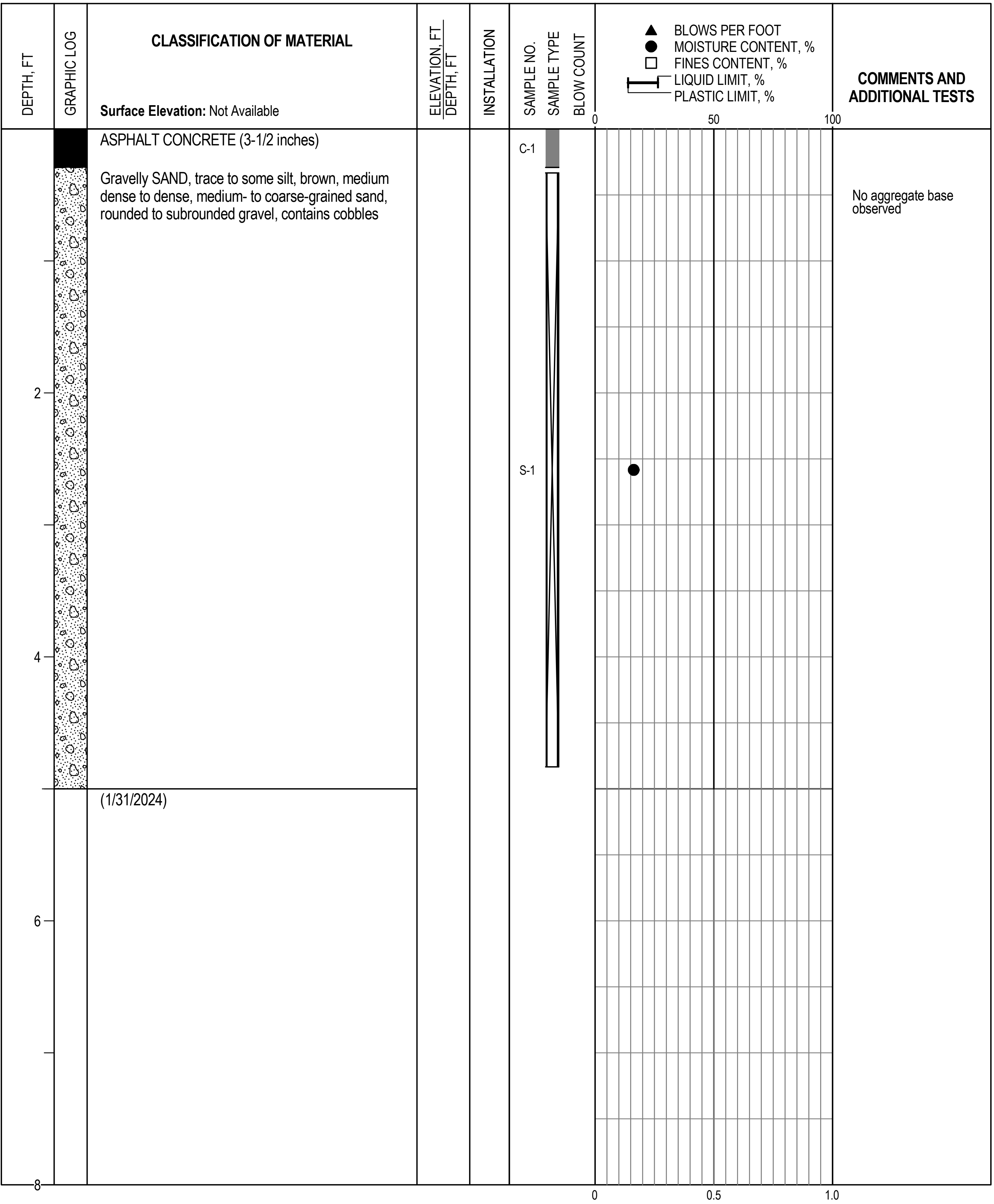
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

GRI BORING LOG (LAT/LONG) - 16' PP GRI DATA TEMPLATE.GDT 12/12/24

Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/30/24
Coordinates: 44.137055° N 121.343295° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

BORING PB-9

DEC. 2024 JOB NO. 6894-A FIG. 10A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3-1/2 inches)

Gravelly SAND, trace to some silt, brown, medium dense to dense, medium- to coarse-grained sand, rounded to subrounded gravel, contains cobbles

(1/31/2024)

COMMENTS AND ADDITIONAL TESTS

No aggregate base observed

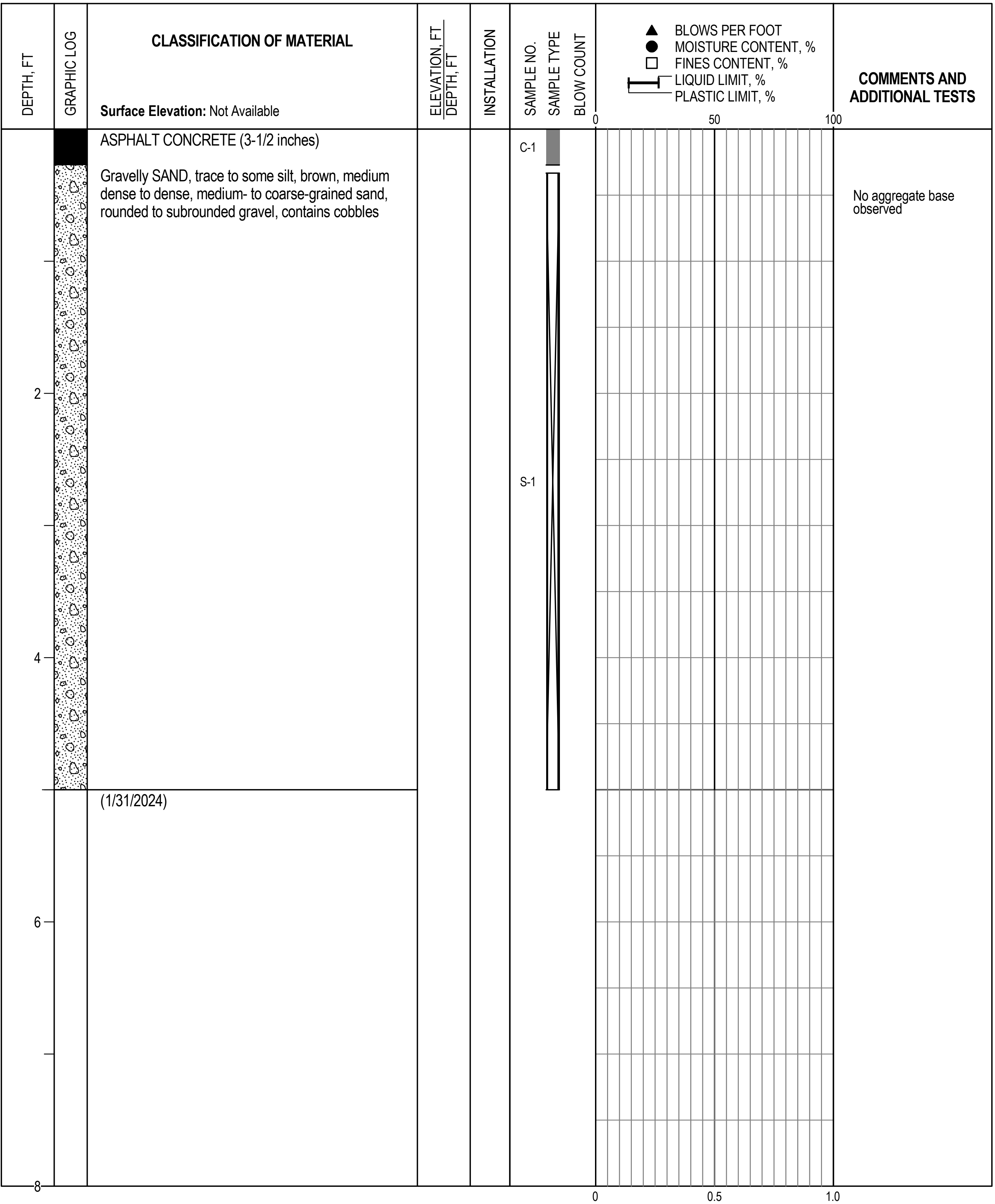
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/31/24
Coordinates: 44.1336647° N 121.340967° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

GRI

BORING PB-10

DEC. 2024 JOB NO. 6894-A FIG. 11A



CLASSIFICATION OF MATERIAL

Surface Elevation: Not Available

ASPHALT CONCRETE (3-1/2 inches)

Gravelly SAND, trace to some silt, brown, medium dense to dense, medium- to coarse-grained sand, rounded to subrounded gravel, contains cobbles

(1/31/2024)

COMMENTS AND ADDITIONAL TESTS

No aggregate base observed

◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

GRI BORING LOG (LAT/LONG) - 16' PP GRI DATA TEMPLATE.GDT 12/12/24

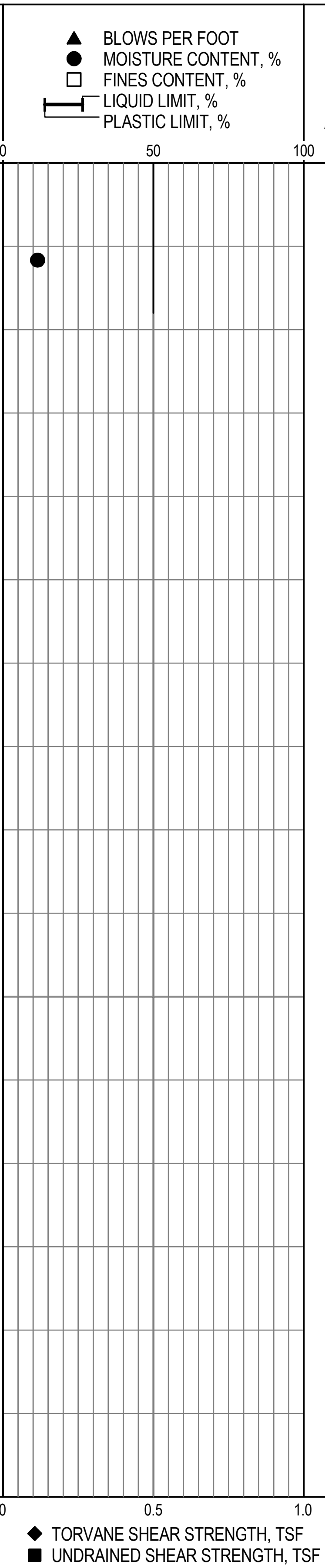
Logged By: S. Sreedhar	**Drilled by:** Dan J. Fischer Excavating, Inc.
Date Started: 1/31/24	**Coordinates:** 44.133675° N 121.337692° W (WGS 84)
Drilling Method: Solid-Stem Auger **Equipment:** Buck Rogers 160 Trailer-Mounted Rig **Hole Diameter:** 5 in.	**Hammer Type:** Cat Head **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** Not Available
Note: See Legend for Explanation of Symbols	

GRI

BORING PB-11

DEC. 2024 JOB NO. 6894-A FIG. 12A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: Not Available	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	■	ASPHALT CONCRETE (3-1/2 inches)			C-1	▨		
		Gravelly SAND, some silt, brown, medium dense to dense, medium- to coarse-grained, rounded to subrounded gravel, contains cobbles			S-1	☒		No aggregate base observed
		(1/31/2024)						Drill auger refusal at .9 feet
2								
4								
6								
8								



Logged By: S. Sreedhar
Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 1/31/24
Coordinates: 44.132274° N 121.332644° W (WGS 84)
Drilling Method: Solid-Stem Auger
Equipment: Buck Rogers 160 Trailer-Mounted Rig
Hole Diameter: 5 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Cat Head
Weight: 140 lb
Drop: 30 in.
Energy Ratio: Not Available

GRI

BORING PB-12

DEC. 2024 JOB NO. 6894-A FIG. 13A

a. Boring PB-1 Location

b. Core PB-1 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 14A

a. Boring PB-2 Location

b. Core PB-2 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 15A

a. Boring PB-3 Location

b. Core PB-3 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 16A

a. Boring PB-4 Location

b. Core PB-4 Sample

GRI

BORING LOCATION AND PAVEMENT
CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 17A

a. Boring PB-5 Location

b. Core PB-5 Sample

GRI

BORING LOCATION AND PAVEMENT
CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 18A

a. Boring PB-6 Location

b. Core PB-6 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

a. Boring PB-7 Location

b. Core PB-7 Sample

GRI

BORING LOCATION AND PAVEMENT
CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 20A

a. Boring PB-8 Location

b. Core PB-8 Sample

GRI

BORING LOCATION AND PAVEMENT
CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 21A

a. Boring PB-9 Location

b. Core PB-9 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 22A

a. Boring PB-10 Location

b. Core PB-10 Sample

a. Boring PB-11 Location

b. Core PB-11 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

DEC. 2024 JOB NO. 6894-A FIG. 24A

a. Boring PB-12 Location

b. Core PB-12 Sample

GRI

BORING LOCATION AND PAVEMENT CORE PHOTOGRAPHS

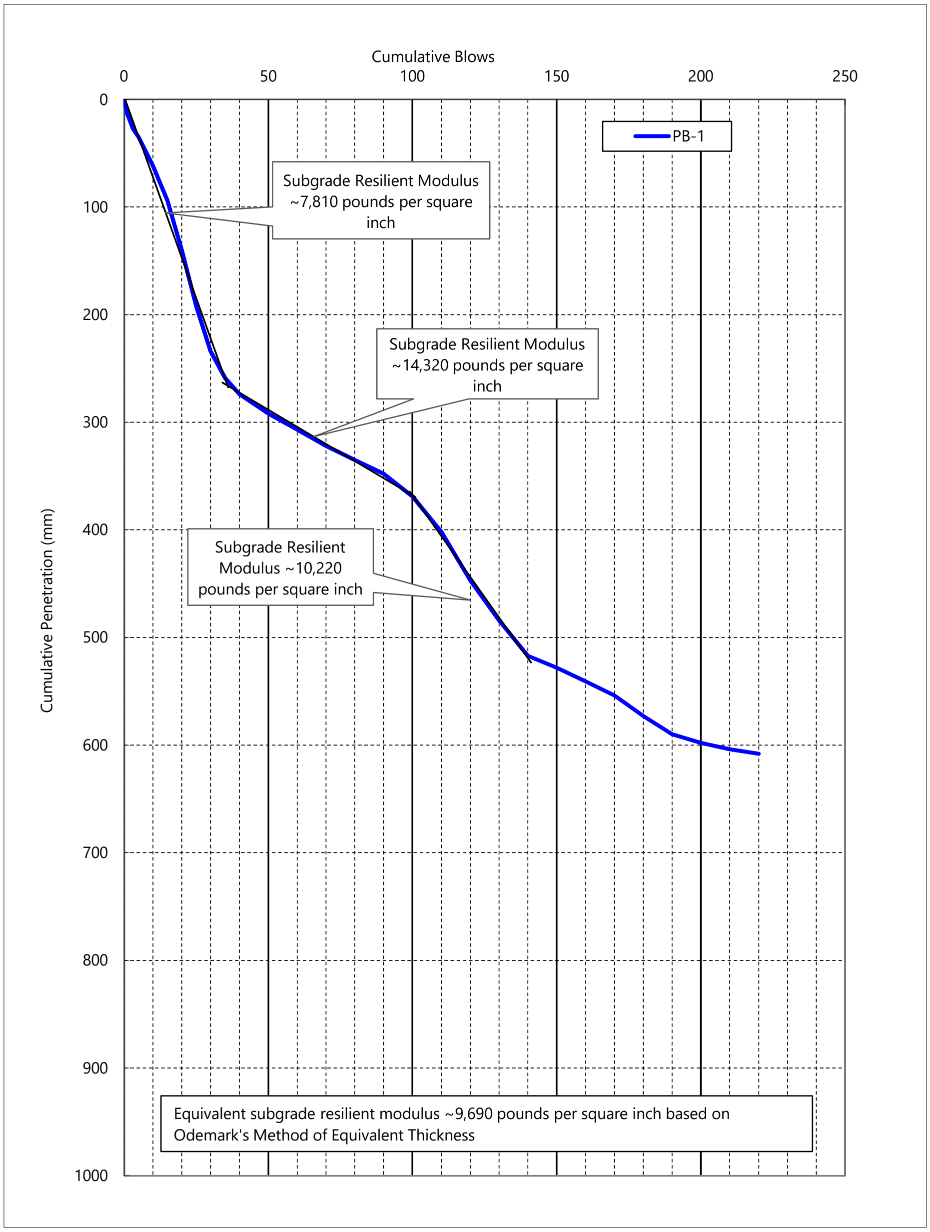
DEC. 2024	JOB NO. 6894-A	FIG. 25A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

Test Number PB-1
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.5	13	1
1.1	27	3
1.4	35	5
2.4	62	10
3.7	94	15
5.5	140	20
7.6	192	25
9.2	234	30
10.2	259	35
10.8	274	40
11.5	292	50
12.1	307	60
12.7	322	70
13.2	335	80
13.7	348	90
14.5	369	100
15.8	402	110
17.6	447	120
19.1	484	130
20.4	517	140
20.8	528	150
21.3	541	160
21.8	554	170
22.6	573	180
23.2	590	190
23.5	598	200
23.8	604	210
23.9	608	220
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~7,810 pounds per square inch

Subgrade Resilient Modulus ~14,320 pounds per square inch

Subgrade Resilient Modulus ~10,220 pounds per square inch

Equivalent subgrade resilient modulus ~9,690 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

DEC. 2024 JOB NO. 6894-A FIG. 26A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

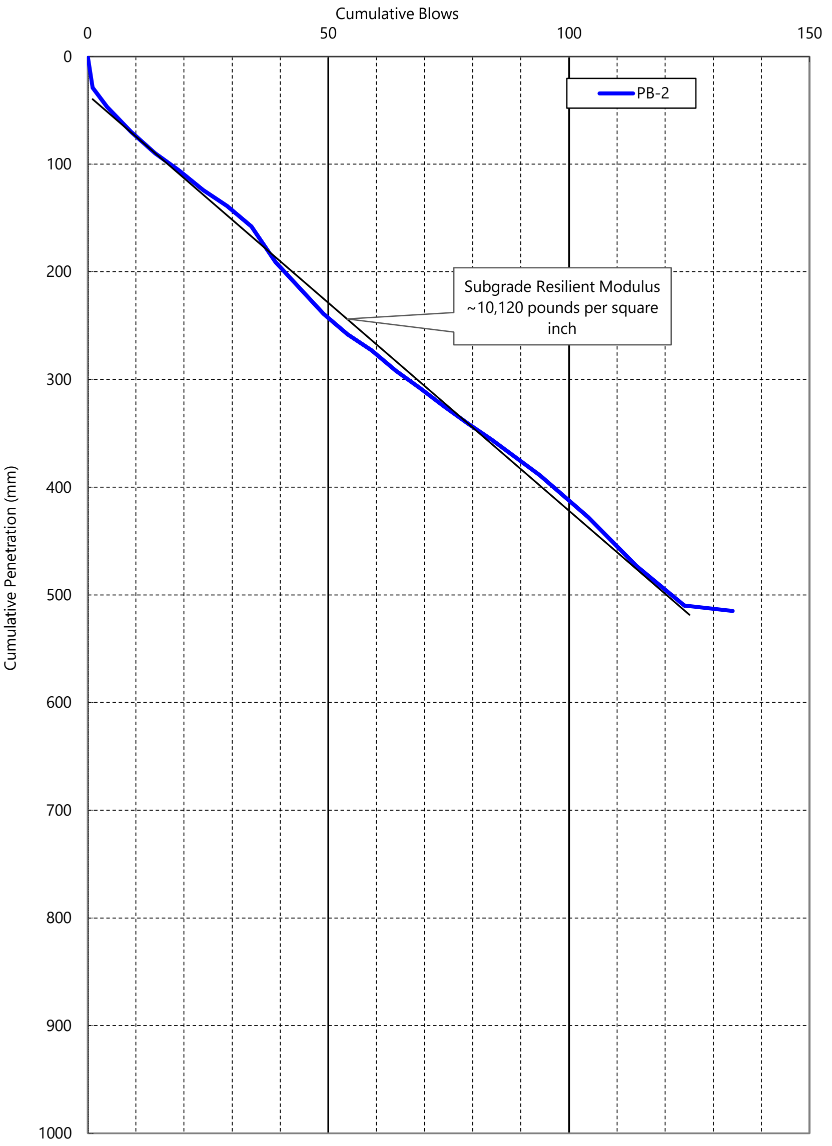
Test Number PB-2

Location Tumalo Reservoir Road

Surface Type Asphalt Concrete

Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
1.1	29	1
1.9	47	4
2.8	70	9
3.5	90	14
4.2	106	19
4.9	124	24
5.5	139	29
6.2	158	34
7.5	191	39
8.5	215	44
9.4	239	49
10.2	258	54
10.7	273	59
11.5	292	64
12.1	308	69
12.8	325	74
13.4	341	79
14.0	356	84
15.3	389	94
16.9	428	104
18.6	473	114
20.1	510	124
20.3	515	134
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



DYNAMIC CONE PENETROMETER

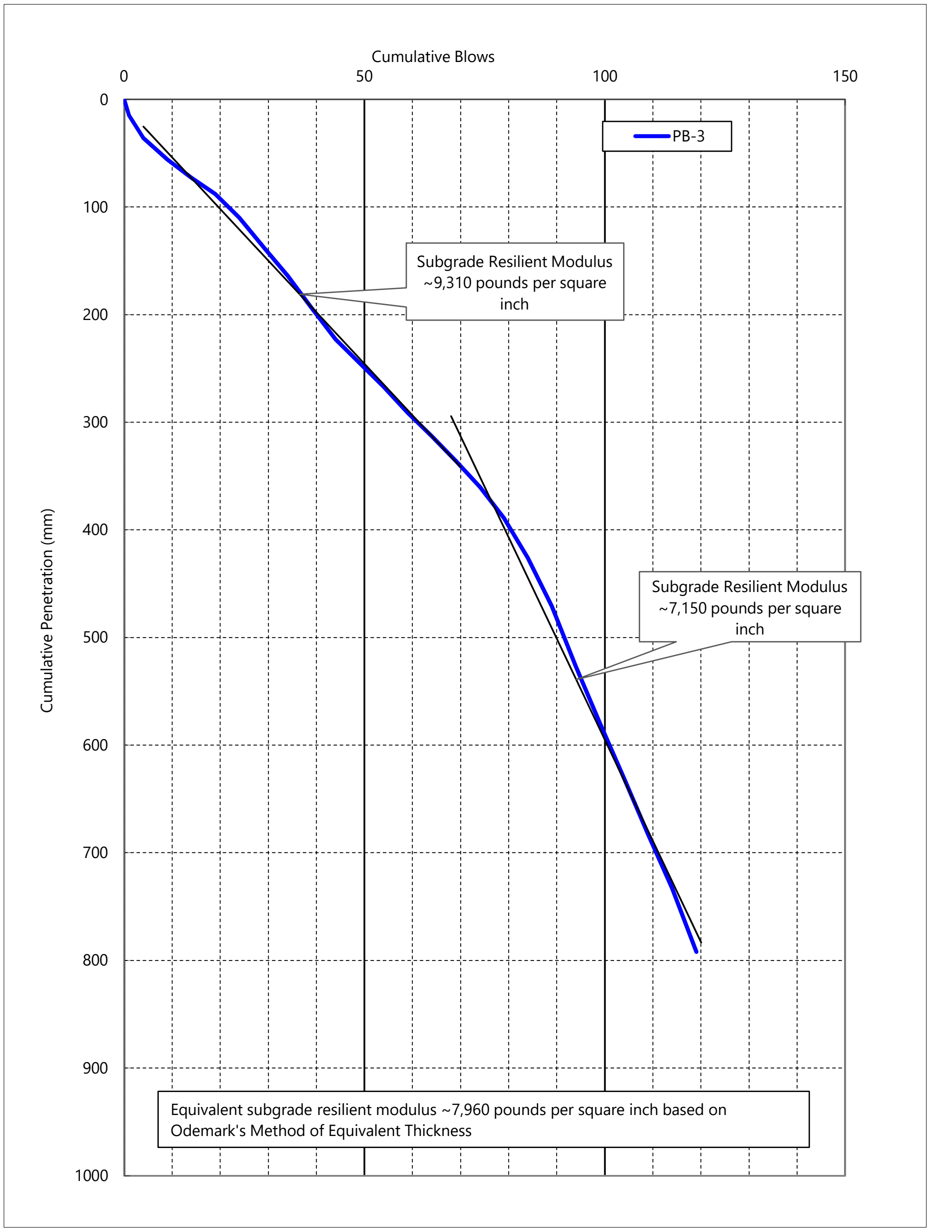
DEC. 2024 JOB NO. 6894-A FIG. 27A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A
DRAWN BY SS
TESTING DATE 1/30/2024

Test Number PB-3
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.6	15	1
1.4	36	4
2.2	56	9
2.9	73	14
3.5	88	19
4.3	110	24
5.4	137	29
6.5	164	34
7.6	194	39
8.8	223	44
9.6	245	49
10.5	267	54
11.5	291	59
12.3	313	64
13.2	336	69
14.2	360	74
15.3	389	79
16.8	426	84
18.5	471	89
20.7	527	94
22.8	580	99
24.8	631	104
26.9	683	109
28.9	733	114
31.2	792	119
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~9,310 pounds per square inch

Subgrade Resilient Modulus ~7,150 pounds per square inch

Equivalent subgrade resilient modulus ~7,960 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

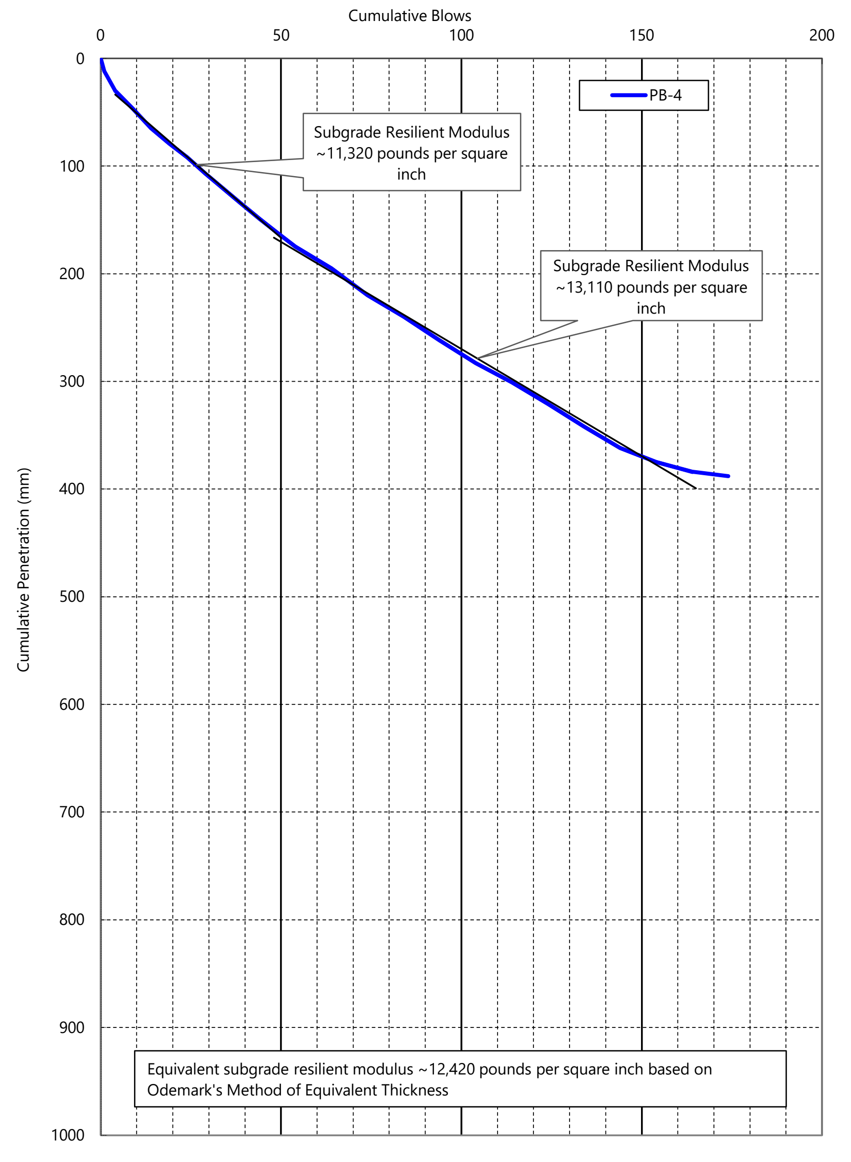
DEC. 2024 JOB NO. 6894-A FIG. 28A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

Test Number	PB-4	Surface Type	Asphalt Concrete
Location	Tumalo Reservoir Road	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.5	12	1
1.2	30	4
1.9	47	9
2.6	65	14
3.1	79	19
3.6	92	24
4.2	107	29
4.8	121	34
5.3	135	39
5.9	149	44
6.4	162	49
6.9	175	54
7.7	195	64
8.7	220	74
9.4	240	84
10.3	262	94
11.1	283	104
11.9	301	114
12.6	321	124
13.5	342	134
14.3	362	144
14.8	375	154
15.1	384	164
15.3	388	174
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~11,320 pounds per square inch

Subgrade Resilient Modulus ~13,110 pounds per square inch

Equivalent subgrade resilient modulus ~12,420 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

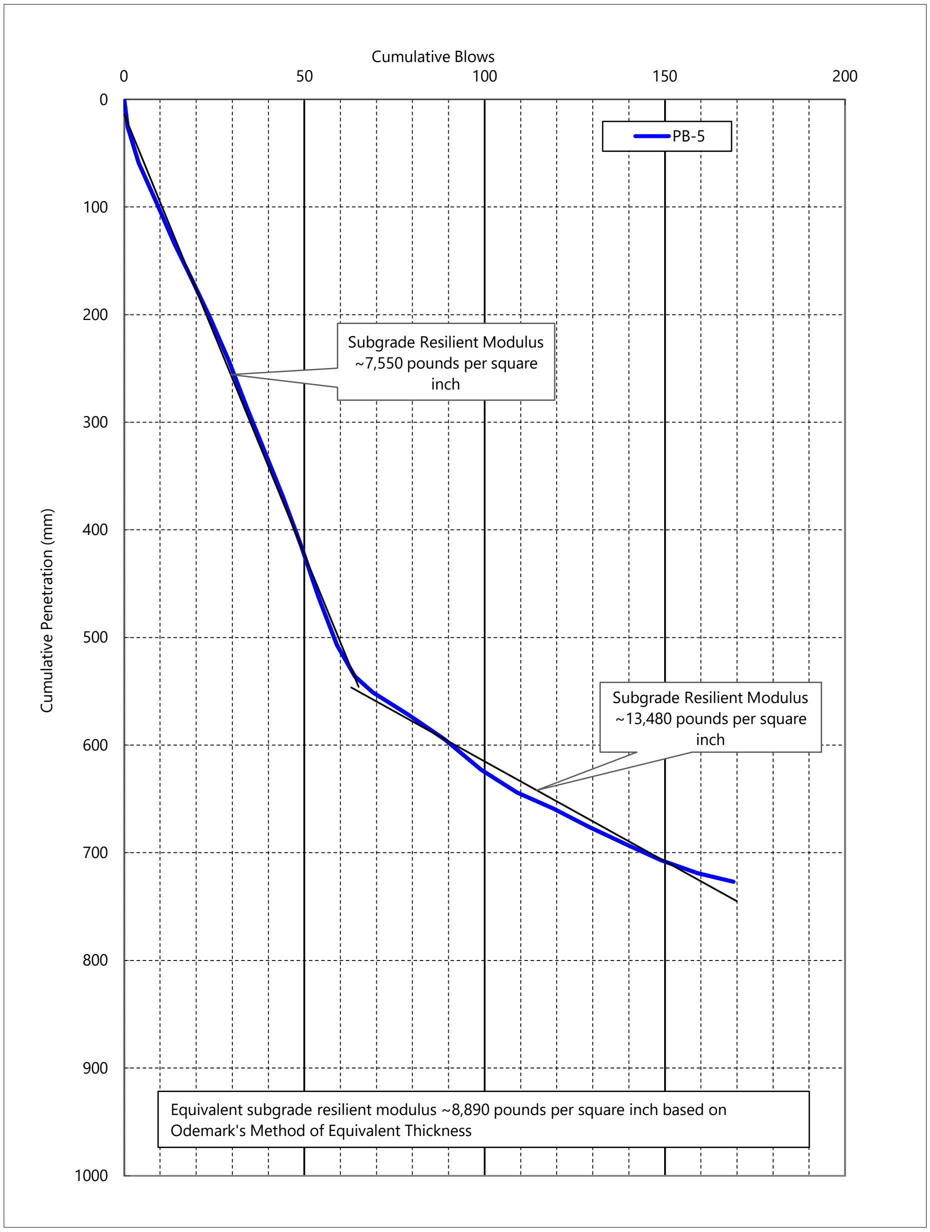
DYNAMIC CONE PENETROMETER

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

Test Number PB-5
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
1.0	26	1
2.3	59	4
3.8	96	9
5.3	134	14
6.7	169	19
8.0	204	24
9.6	243	29
11.3	286	34
12.9	327	39
14.5	369	44
16.3	414	49
18.2	463	54
20.0	507	59
21.1	536	64
21.7	551	69
22.5	572	79
23.4	595	89
24.5	623	99
25.4	644	109
25.9	659	119
26.6	676	129
27.2	692	139
27.8	707	149
28.3	719	159
28.6	727	169
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~7,550 pounds per square inch

Subgrade Resilient Modulus ~13,480 pounds per square inch

Equivalent subgrade resilient modulus ~8,890 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

DEC. 2024 JOB NO. 6894-A FIG. 30A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

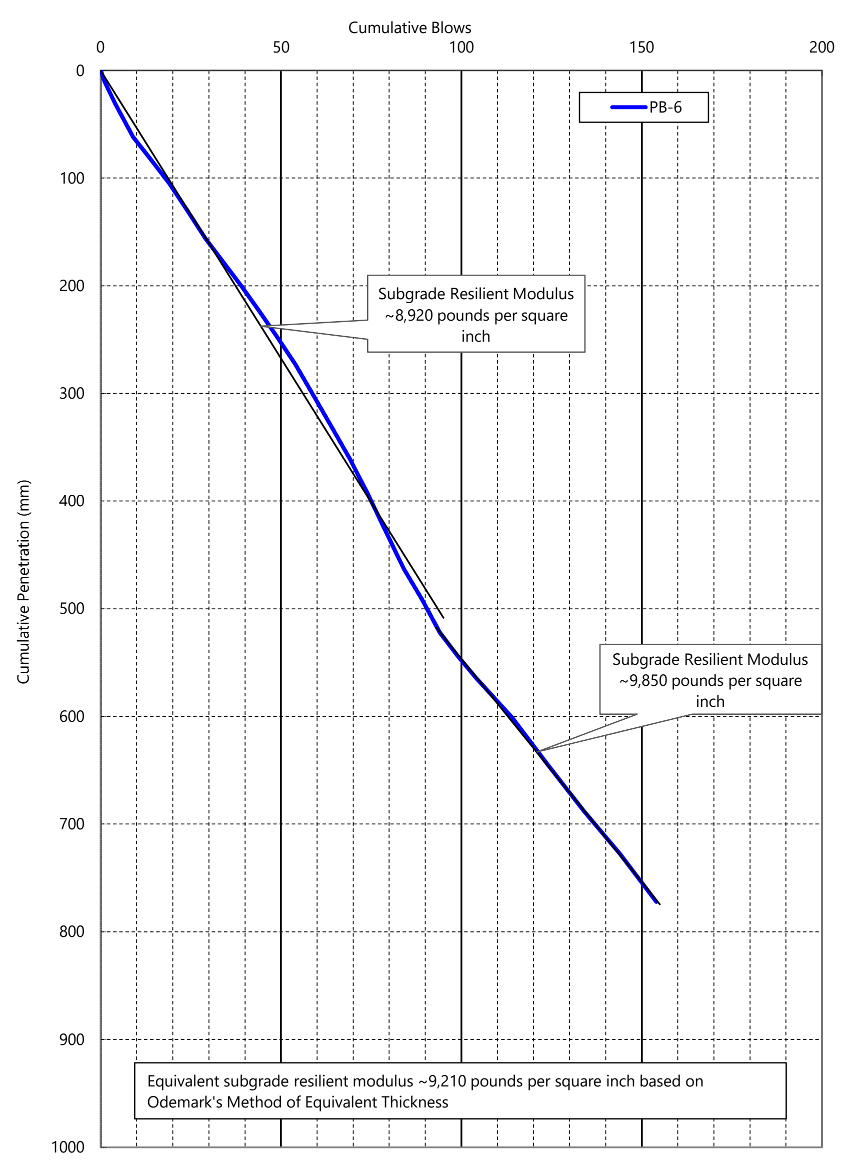
Test Number PB-6

Location Tumalo Reservoir Road

Surface Type Asphalt Concrete

Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.4	10	1
1.2	31	4
2.4	62	9
3.3	83	14
4.1	105	19
5.1	130	24
6.1	156	29
7.0	178	34
7.9	200	39
8.8	224	44
9.8	248	49
10.7	273	54
11.9	302	59
13.0	331	64
14.2	360	69
15.5	393	74
16.9	428	79
18.2	463	84
19.3	491	89
20.6	522	94
21.4	544	99
22.2	564	104
23.7	601	114
25.4	645	124
27.1	688	134
28.7	728	144
30.4	772	154
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~8,920 pounds per square inch

Subgrade Resilient Modulus ~9,850 pounds per square inch

Equivalent subgrade resilient modulus ~9,210 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

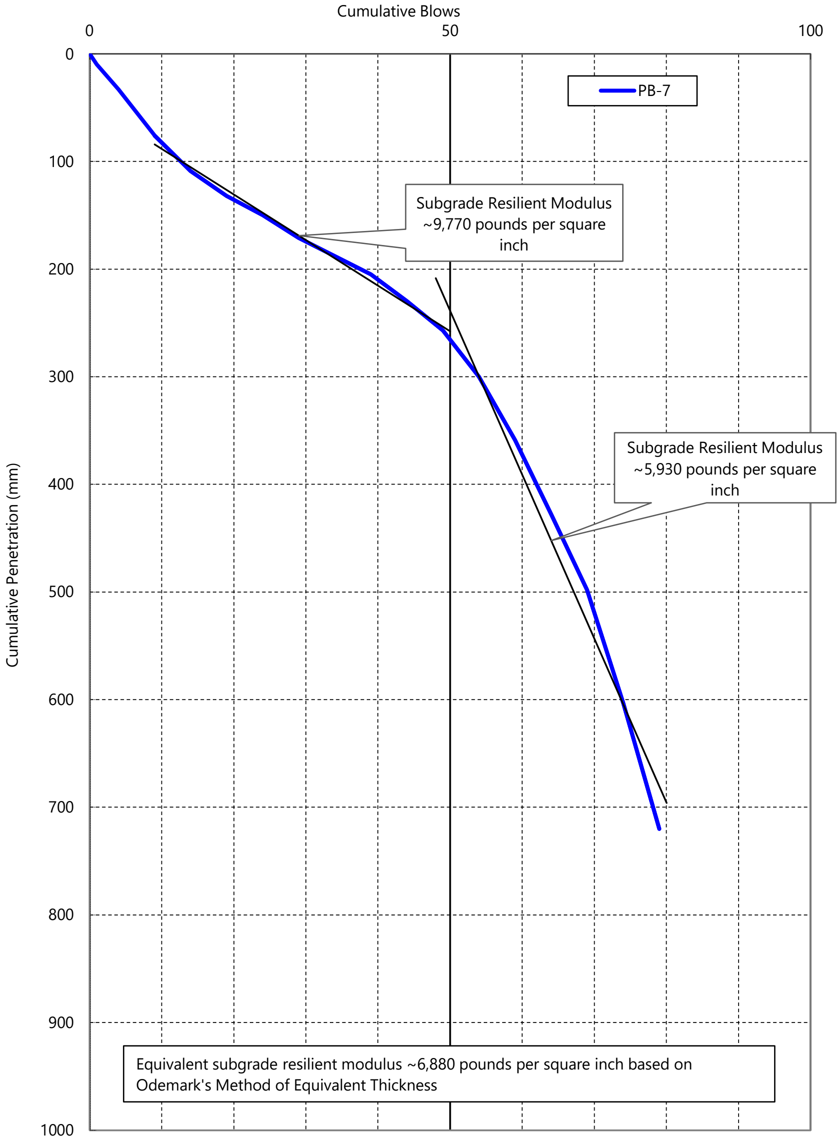
DEC. 2024 JOB NO. 6894-A FIG. 31A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

Test Number PB-7 Surface Type Asphalt Concrete
Location Tumalo Reservoir Road Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.4	10	1
1.3	33	4
3.0	76	9
4.3	109	14
5.2	132	19
5.9	150	24
6.7	171	29
7.4	188	34
8.1	205	39
9.1	230	44
10.1	257	49
11.8	300	54
14.1	359	59
16.9	428	64
19.6	498	69
23.7	603	74
28.3	720	79
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~9,770 pounds per square inch

Subgrade Resilient Modulus ~5,930 pounds per square inch

Equivalent subgrade resilient modulus ~6,880 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

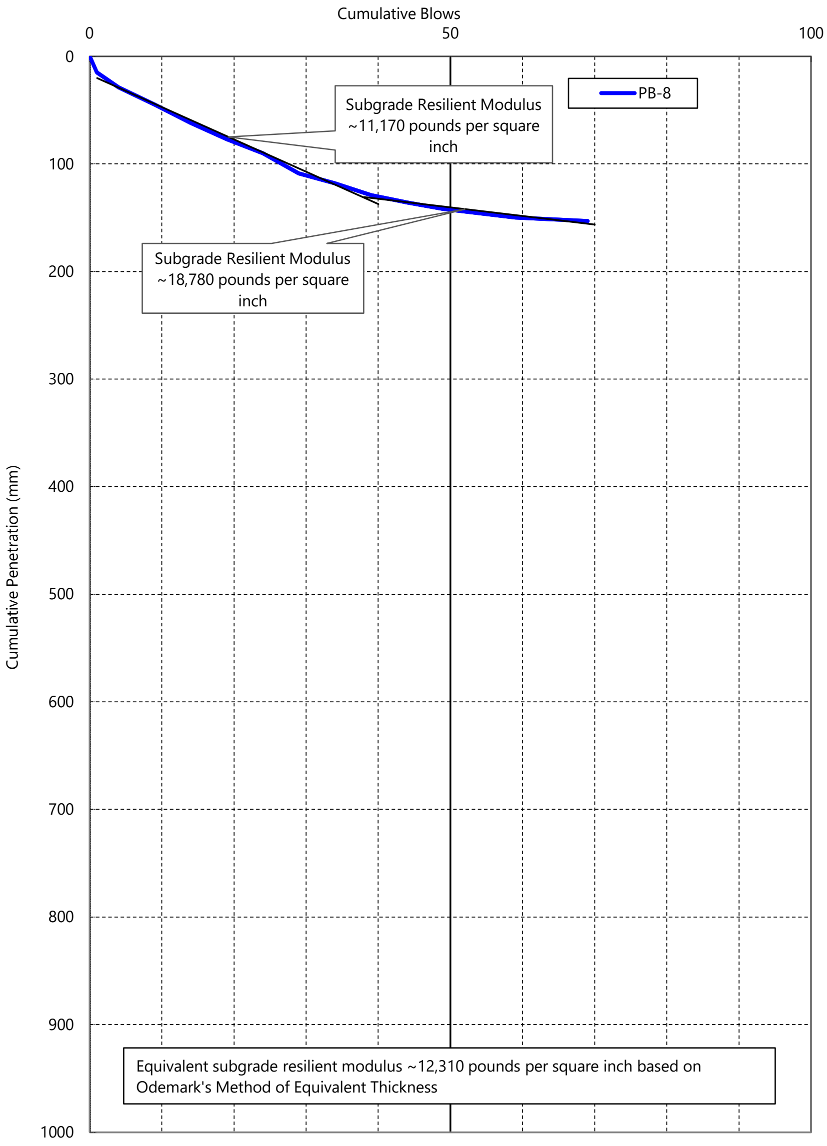
DEC. 2024 JOB NO. 6894-A FIG. 32A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A DRAWN BY SS TESTING DATE 1/30/2024

Test Number	PB-8	Surface Type	Asphalt Concrete
Location	Tumalo Reservoir Road	Hammer	17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.6	15	1
1.1	29	4
1.8	45	9
2.4	62	14
3.0	77	19
3.5	90	24
4.3	109	29
4.6	118	34
5.1	129	39
5.4	136	44
5.6	142	49
5.9	150	59
6.0	153	69
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~11,170 pounds per square inch

Subgrade Resilient Modulus ~18,780 pounds per square inch

Equivalent subgrade resilient modulus ~12,310 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

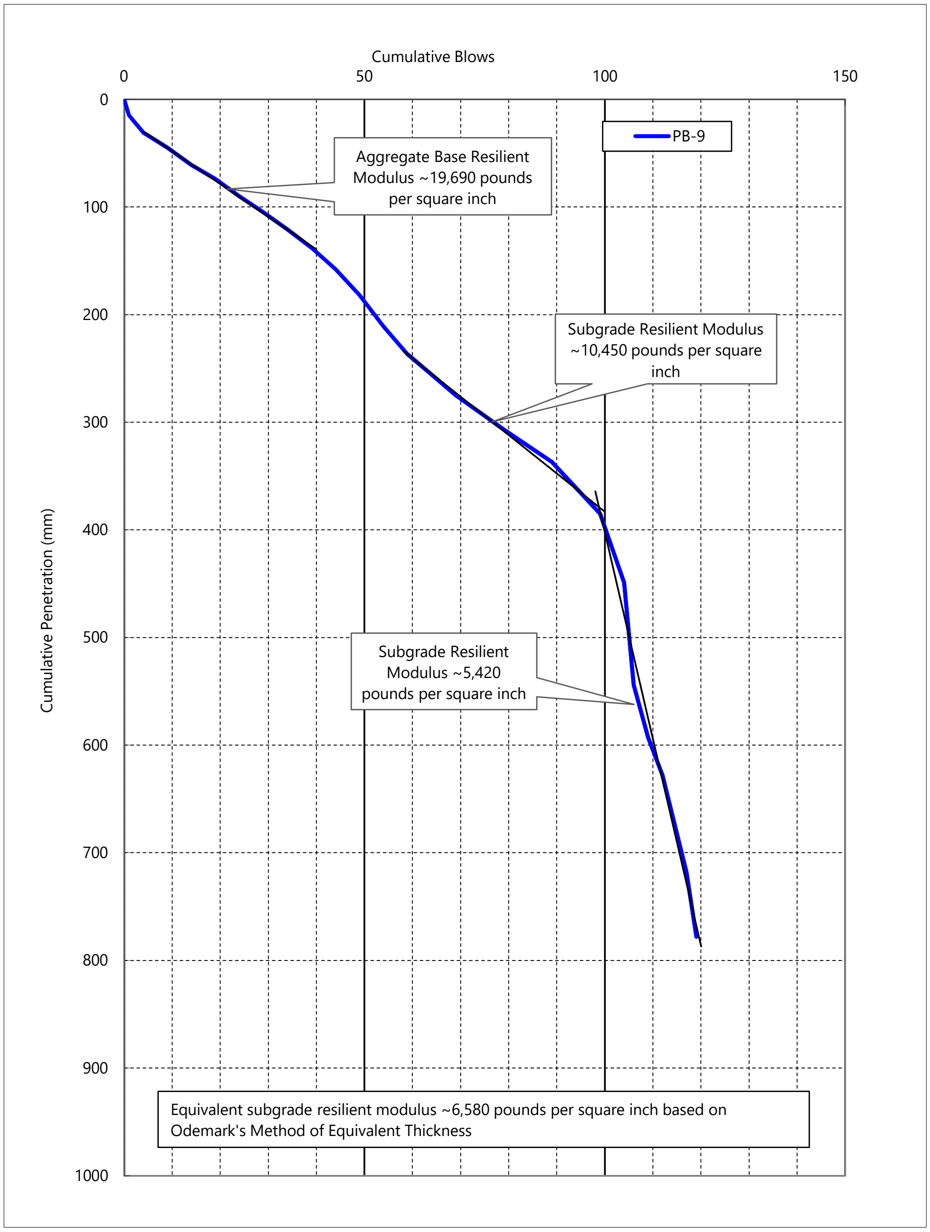
DEC. 2024 JOB NO. 6894-A FIG. 33A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A
DRAWN BY SS
TESTING DATE 1/30/2024

Test Number PB-9
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.6	15	1
1.2	31	4
1.8	45	9
2.4	61	14
2.9	74	19
3.5	90	24
4.1	105	29
4.8	121	34
5.4	138	39
6.2	158	44
7.2	182	49
8.3	211	54
9.3	237	59
10.1	256	64
10.8	275	69
12.1	307	79
13.3	337	89
15.2	385	99
17.7	449	104
21.4	544	106
23.3	593	109
24.7	628	112
26.9	682	115
28.3	718	117
30.6	778	119
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Aggregate Base Resilient Modulus ~19,690 pounds per square inch

Subgrade Resilient Modulus ~10,450 pounds per square inch

Subgrade Resilient Modulus ~5,420 pounds per square inch

Equivalent subgrade resilient modulus ~6,580 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

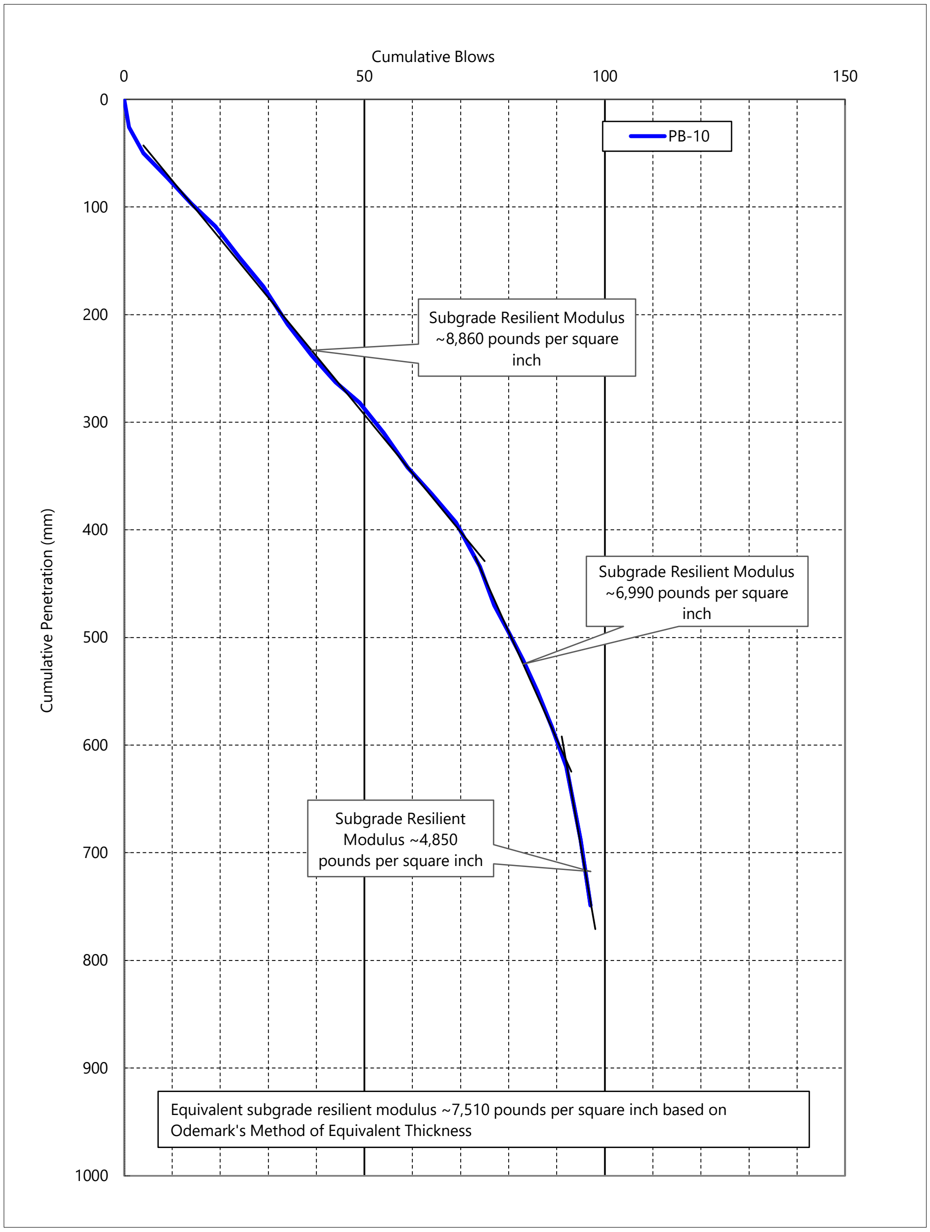
DEC. 2024 JOB NO. 6894-A FIG. 34A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A
DRAWN BY SS
TESTING DATE 1/30/2024

Test Number PB-10
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
1.0	26	1
2.0	50	4
2.9	73	9
3.8	97	14
4.6	118	19
5.8	147	24
6.9	174	29
8.2	209	34
9.4	238	39
10.4	263	44
11.1	282	49
12.2	310	54
13.5	342	59
14.4	367	64
15.5	393	69
17.1	434	74
18.5	470	77
19.5	495	80
20.5	521	83
21.7	550	86
23.0	583	89
24.4	620	92
27.1	688	95
29.5	749	97
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~8,860 pounds per square inch

Subgrade Resilient Modulus ~6,990 pounds per square inch

Subgrade Resilient Modulus ~4,850 pounds per square inch

Equivalent subgrade resilient modulus ~7,510 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

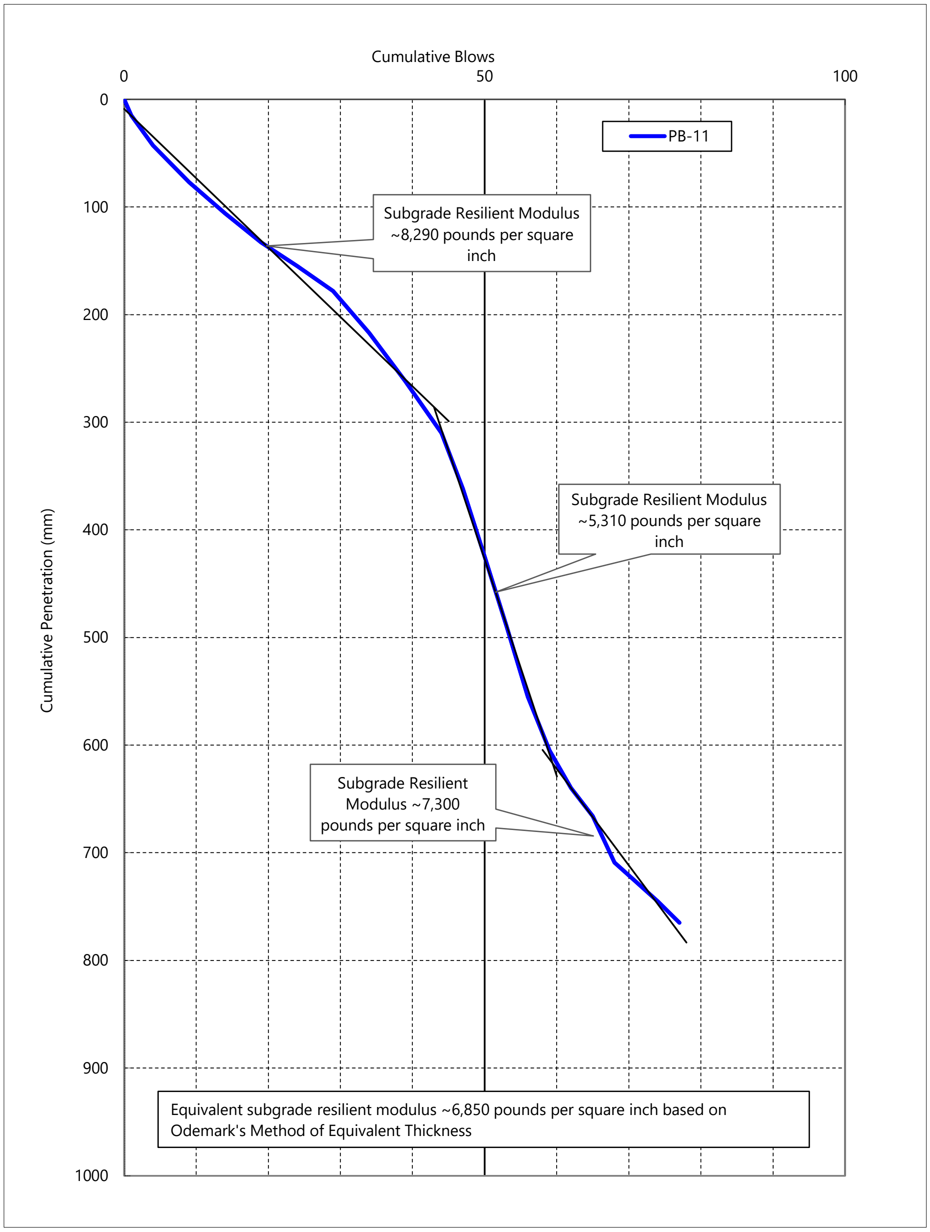
DEC. 2024 JOB NO. 6894-A FIG. 35A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A
DRAWN BY SS
TESTING DATE 1/30/2024

Test Number PB-11
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
0.6	15	1
1.7	43	4
3.0	77	9
4.2	106	14
5.2	133	19
6.1	155	24
7.0	178	29
8.5	217	34
10.3	262	39
12.2	310	44
14.3	362	47
16.7	425	50
19.3	489	53
21.9	555	56
23.8	605	59
25.2	640	62
26.2	666	65
27.9	709	68
28.6	727	71
29.3	745	74
30.1	765	77
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



Subgrade Resilient Modulus ~8,290 pounds per square inch

Subgrade Resilient Modulus ~5,310 pounds per square inch

Subgrade Resilient Modulus ~7,300 pounds per square inch

Equivalent subgrade resilient modulus ~6,850 pounds per square inch based on Odemark's Method of Equivalent Thickness

GRI

DYNAMIC CONE PENETROMETER

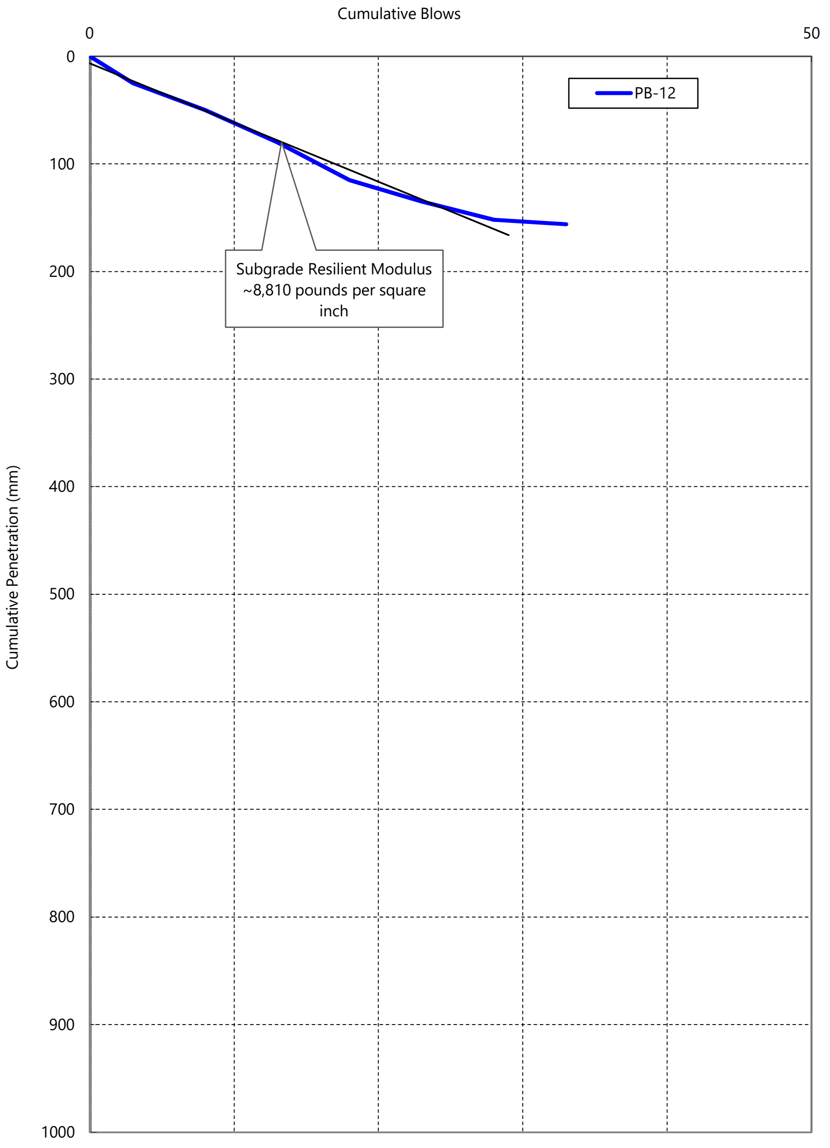
DEC. 2024 JOB NO. 6894-A FIG. 36A

KESSLER DYNAMIC CONE PENETROMETER LOG

JOB NO. 6894-A
DRAWN BY SS
TESTING DATE 1/30/2024

Test Number PB-12
Location Tumalo Reservoir Road
Surface Type Asphalt Concrete
Hammer 17.6 pounds

Depth, inches	Depth, millimeters	Cumulative Blows
0.0	0	0
1.0	25	3
2.0	50	8
3.1	80	13
4.5	115	18
5.3	135	23
6.0	152	28
6.1	156	33
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---
---	---	---



DYNAMIC CONE PENETROMETER

DEC. 2024 JOB NO. 6894-A FIG. 37A

July 12, 2024

GRI
16520 SW Upper Boones Ferry Rd Suite 100
Portland, OR 97224

Attn: Shashwath Sreedhar, Project Engineer
RE: Foamed Asphalt Stabilized Full-Depth Reclamation Mix Design
Central Oregon
AET Report No. P-0032918

Dear Mr. Sreedhar,

American Engineering Testing, Inc., (AET) is pleased to present the stabilized full-depth reclamation (SFDR) mix design, using foamed asphalt as the stabilization agent, for the SFDR project in central Oregon. This cover letter to our mix design report summarizes our understanding of the project materials, the specification, and our laboratory procedures.

PROJECT INFORMATION AND PROVIDED MATERIALS

A 4.5-mile section of roadway in central Oregon will be reconstructed using SFDR. Specifications from the Juntura Cut-Off Road Reconstruction Project and its guidelines for Cold In-Place Recycled Asphalt Concrete Pavement – Expanded Asphalt Method (CIR – EAM) (Section 00722) will be used as the guiding specification, however AET understands that specifications for the project have not been determined. AET understands that the SFDR layer will be composed of 50% recycled asphalt pavement (RAP) and 50% existing aggregate base. GRI provided the core and base samples to AET. AET processed cores and base samples on receipt. The mix design utilizes PG 68-24 asphalt from Albina Asphalt, which GRI provided to AET.

FOAMING CHARACTERIZATION

We performed foaming tests using our Wirtgen WLB-10S Foamed Asphalt Laboratory on the binder in general accordance with the Wirtgen procedure. Results and conclusions from those foaming tests, which are documented in the attached Foaming Characterization Report, are summarized below. Wirtgen procedure states a minimum expansion ratio of 8 and a minimum half-life of 6 seconds. According to the Specification, an expansion ratio of 10 and a half-life of 8 seconds are suitable.

1. The binder met Specification performance limits for expansion ratio (ER) and half-life (HL) for 150°C at 1.5%, 2.0%, and 2.5% water contents, 160°C at 1.0% and 1.5% water contents, and 170°C at 1.5% and 2.0% water contents.

2. According to Wirtgen procedure, the binder met the minimum expansion ratio and half-life at each temperature and water content.
3. Based on foaming tests, we recommend that foaming temperatures do not exceed 170°C and a working range of 1.5% to 2.0% for foaming water.

MIX DESIGN PROCEDURE

The mix design was developed in general accordance with the Juntura Cut-Off Road Reconstruction Project and its guidelines for Cold In-Place Recycled Asphalt Concrete Pavement – Expanded Asphalt Method (CIR – EAM) (Section 00722). The following summary describes the mix design process.

- The pavement cores were processed to achieve a gradation as defined by the Specification.
- Tests of unstabilized blended reclaimed materials were performed, including modified Proctor tests (ASTM D1557).
- Prior to mixing the blended reclaimed material with the emulsion, 8.7% water was added to the 2.0%, 2.5%, and 3.0% mixes to account for the moisture content that is expected to be encountered in the field.
- SFDR mixtures were developed at foamed asphalt addition rates of 2.0%, 2.5%, and 3.0% at a 50/50 blend of RAP/base. An additional mix at 2.5% foamed asphalt with 1.0% cement was developed. Specimens were prepared with 30 gyrations compared to the specification of 25 gyrations.
- SFDR mixtures were developed to create samples for tests that include indirect tensile strength (ITS) (AASHTO T 283), Hveem cohesiometer (ASTM D1560), and resilient modulus (ASTM D7369). Volumetric tests of samples were performed to provide bulk/maximum specific gravity and air void information (ASTM D6752 and D2401).

More details on the tests and test results are provided in the sections below.

MIX DESIGN TEST RESULTS

The following items summarize important information from the SFDR Mix Design report attached to this cover letter. Laboratory performance is discussed in terms of the specification cited above, which was used as a guide for the design.

- The blended reclaimed material had an optimum moisture content of 11.5% and maximum dry density of 115.5 pcf according to ASTM D1557 Method C.
- The conditioned ITS values of each mixture did not meet the Specification requirements of 40 psi. The conditioned ITS values were 4.7 psi, 5.5 psi, 6.8 psi, and 12.7 psi for foamed asphalt contents (FAC) of 2.0%, 2.5%, 3.0%, and 2.5%

with 1.0% cement, respectively. Dry ITS values were 32.0 psi, 34.7 psi, 41.1 psi, and 36.8 psi for foamed asphalt contents of 2.0%, 2.5%, 3.0%, and 2.5% with 1.0% cement, respectively.

- The resilient modulus (MR) testing, performed according to ASTM D7369, yielded average values of 237 ksi, 166 ksi, 117 ksi, and 158 ksi at 2.0%, 2.5%, 3.0%, and 2.5% with 1.0% cement FAC, respectively.
- The short-term strength testing, performed according to ASTM D1560, yielded average values of 78.5 g/25 mm, 104.9 g/25 mm, 156.7 g/25 mm and 176.4 g/25mm after 1 hour. Additional short term strength samples at 2.0% and 2.5% FAC were tested after two hours.
- These and other test results, including mix volumetrics, are reported in our standard mix design report, which is attached to this letter report.

MIX DESIGN DISCUSSION

Based on the results of laboratory tests, specifically low conditioned and dry ITS values, we recommend performing additional testing utilizing additional materials or stabilizing agents. This may include crushed rock, cement, or lime. The materials and blends tested do not meet the mix design parameters supplied.

REMARKS

We thank you for the opportunity to assist you in this project. Please contact us if you have questions or require additional information.

Sincerely,
American Engineering Testing

Kristen Hanson, EIT
Engineer II
khanson@teamaet.com
651-328-3078

Jacob O. Michalowski, PE (MN)
Pavement Group Manager
jmichalowski@teamaet.com
651-283-2481

Attachments:

- Foamed Bitumen SFDR Mix Design, AET Mix Design Report (4 Pages)
- Foaming Characterization Results at 150°C, 160°C, and 170°C (3 Pages)
- Proctor Curve (1 Page)

AMERICAN ENGINEERING TESTING

AET P-0032918

SFDR MIX DESIGN SUMMARY

Client	**GRI**	**Attn**	Shashwath Sreedhar, Project Engineer
		AET Contact	Jake Michalowski

Project	**Central Oregon**	**From**	**Not Given**
		To	**Not Given**

Target Foamed Emulsion Content	***NA***
Gal/SY (Assumes 6 in depth)	***NA***
Target Moisture Content	***NA***

Relevant Specification *Juntura Cut-Off Road Reconstruction Project (CIR-EAM Section 00722)*

Materials

The asphalt used was manufactured and supplied by Albina Asphalt, and was graded as PG 64-28. Bituminous cores and base samples were obtained from the roadway by GRI and provided to AET. The SFDR mix was composed of 50% RAP (produced by crushing frozen cores) and 50% existing base material. AET foamed the asphalt using our Wirtgen Foamed Asphalt Laboratory (Model WLB-10S).

Mix Preparation

Sampling and testing was performed in general accordance with the specification for SFDR mix designs using foamed asphalt using the Juntura Cut-Off Road Reconstruction Project Specifications as a guidline. AET crushed cores to to resemble a medium gradation. SFDR specimens were prepared using a gyratory compactor at internal compaction angle of 1.16 degrees and 30 gyrations.

Comments from Testing

Tests presume bitumen foaming temperature of 160C and 1.0% baseline water added content. 8.7% water was added to the 50/50 blend. If you have any questions concerning this report please contact us.

Special Notes

Field adjustments to the foamed asphalt content may be required:

1) The foamed asphalt content was determined based on the laboratory manufactured gradation. Reclaiming operations should be adjusted to create field materials resembling the target lab gradation. Please contact AET to discuss adjustments to foamed asphalt content if field gradation deviates from specified limits (more than 30% material over 1-1/2" or more than 15% material passing #200)

2) If the temperature of the existing pavement surface during the reclaiming operation is above 100 deg F, the foamed asphalt content may need to be reduced to maintain workability.

3) We recommend that a modified Proctor of the material after the pre-grind process to verify optimum moisture content.

4) The "target moisture content" indicated above is moisture added to processed millings in our lab procedure, which assumed “free” or pre-wet water of 8.7%. In the field, this added water would correspond with water added at the milling head.

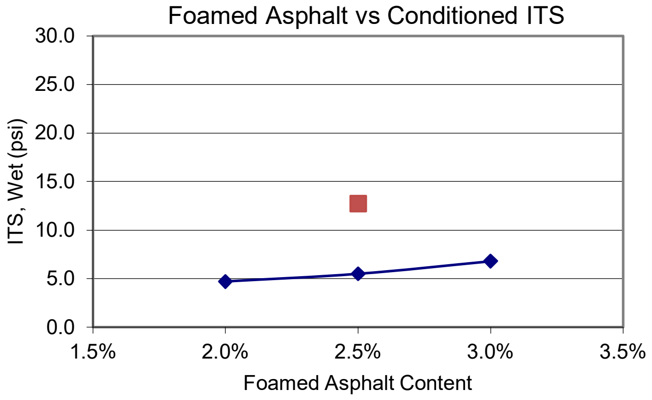
AET P-0032918	**GRI Central Oregon**	**FOAMED ASPHALT SFDR MIX DESIGN TEST RESULTS**

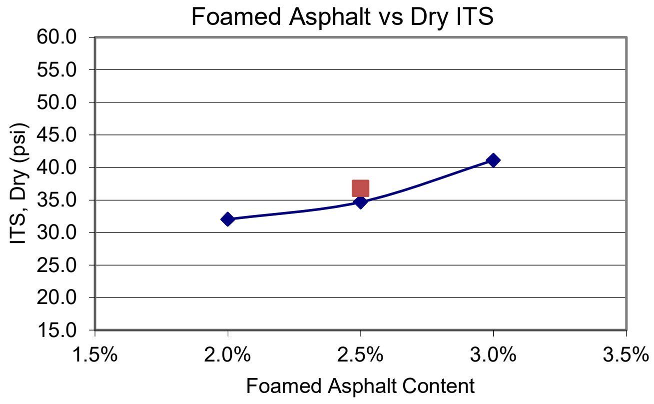
Sample number Central Oregon

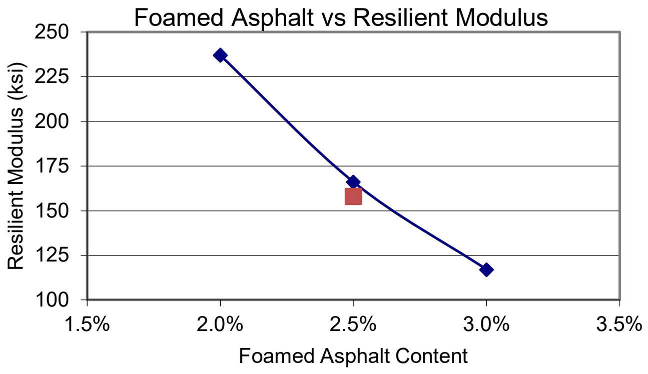
Date 7/1/2024

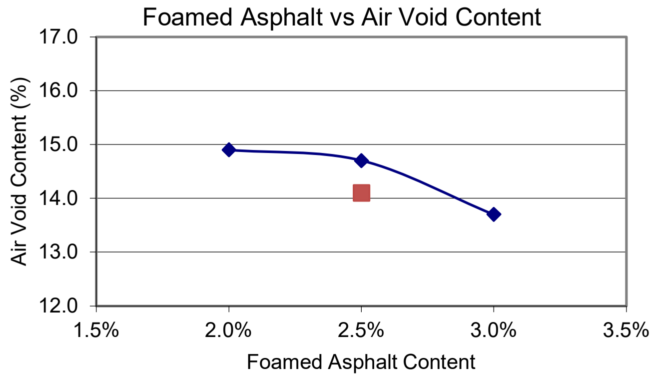
Material	**RAP**	**Base**	**Bitumen**	**Filler**
Location / Source	Road Cores	Aggregate Base	Albina Asphalt	*Cement*
Description	--	--	PG 64-28	
Prewet Water (%)	8.7			

Foamed asphalt treated material characteristics						***Comments***
Foamed Asphalt content	2.0%	2.5%	3.0%	2.5%		
Filler added	0.0%	0.0%	0.0%	1.0%		
Gradation	*Med*	*Med*	*Med*	*Med*		*Specification target blend*
Bulk Density, lb/ft3	120.9	120.4	121.1	121.2		
Bulk Spec Grav (Gmb)	1.941	1.933	1.944	1.946		
Theo Max Spec Grav (Gmm)	2.280	2.266	2.252	2.266		
Air voids (%)	14.9	14.7	13.7	14.1		
ITS, soaked (psi)	4.7	5.5	6.8	12.7		*Min 40*
ITS, dry (psi)	32.0	34.7	41.1	36.8		
Tensile Strength Ratio (TSR)	0.15	0.16	0.17	0.35		*Min 70%*
Cohesiometer (g/25 mm) (after 1 hr)	78.5	104.9	156.7	176.4		
Cohesiometer (g/25 mm) (after 2 hr)	90.2	118.1	--	--		
Resilient Modulus (ksi)	237	166	117	158		


Foamed Asphalt vs Conditioned ITS


Foamed Asphalt vs Dry ITS


Foamed Asphalt vs Resilient Modulus


Foamed Asphalt vs Air Void Content

P-0032918

SFDR SAND EQUIVALENCE, SIEVE, AND PROCTOR ANALYSIS

Client	GRI
Project	Central Oregon

Sample No.		1	2	3	
Description		Processed Cores (RAP)	Base Aggregate	Cement Filler	**Blend**
% of Blend		50	50	0	
Sieve size		**Percent Passing (ASTM D422)**			
mm	**inch**				
53.0	**2**	100.0	100.0	100	100.0
37.5	**1½**	100.0	100.0	100	100.0
25.0	**1**	100.0	99.0	100	99.5
19.0	**¾**	93.0	98.0	100	95.5
12.5	**½**	70.0	97.0	100	83.5
9.5	**⅜**	60.0	95.0	100	77.5
4.75	**# 4**	45.0	86.5	100	65.8
2.36	**# 8**	14.3	80.0	100	47.2
2.00	**# 10**	12.0	78.0	100	45.0
1.18	**# 16**	7.4	72.0	100	39.7
0.600	**# 30**	3.9	63.0	100	33.5
0.425	**# 40**	2.9	58.0	100	30.5
0.300	**# 50**	2.2	51.0	100	26.6
0.150	**# 100**	1.3	37.0	100	19.2
0.075	**# 200**	0.9	27.8	100	14.4

Sample No.	**1**	**2**	**3**	**Blend**
Sand Equiv (D2419)	95	22	--	51.8

Proctor Tests of Reclaimed Blend (ASTM D1557, Method C)

Point	**Moisture Content**	**Max Dry Density**
1	7.9	113.4
2	10.7	114.9
3	11.4	115.5
4	13.3	113.2

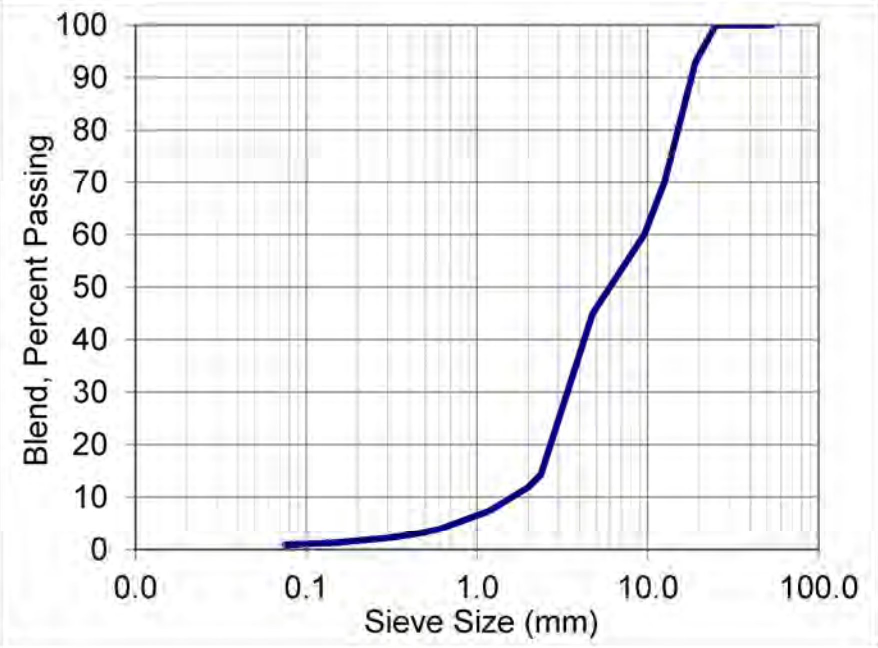
Notes:

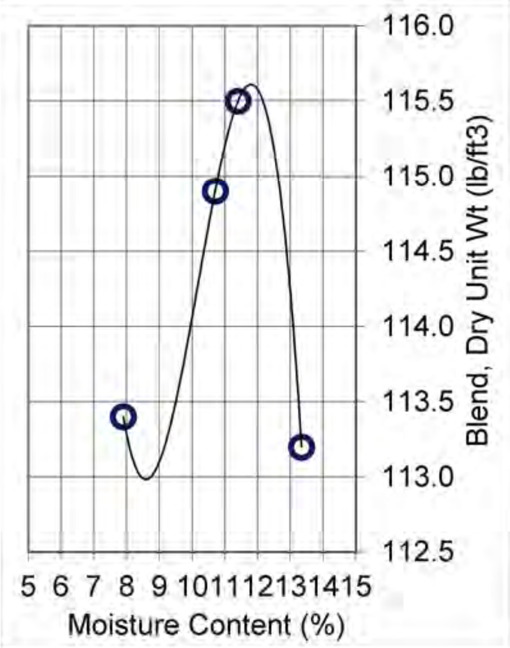
Optimum Moisture Content

11.5%

Maximum Dry Density (at Optimum Moisture Content)

115.5 pcf





AET P-0032918

FOAMING CHARACTERISTICS OF BITUMEN

(Wirtgen Cold Recycling Manual)

BITUMEN	**Source**	Albina Asphalt
	Type	PG 64-28

Bitumen Temperature

160°C

MACHINE SETTINGS (WLB-10S)

Bitumen pump

Calibration	1	2	3	4
Timer setting (sec)	1.0	3.0	5.0	7.0

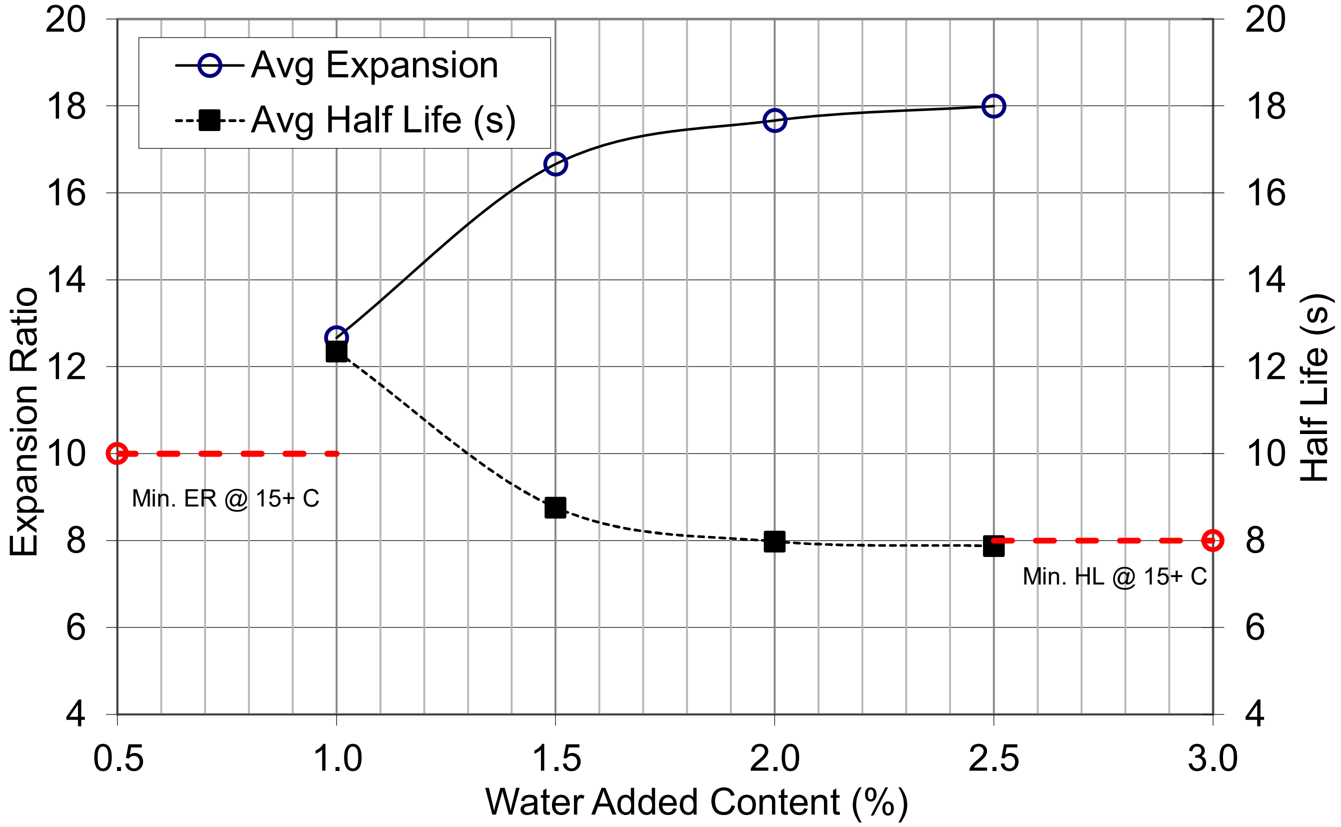
Setting

Quantity required (g)	100	300	500
Pump output (g/s)	100	300	500
Timer setting (s)	1.0	1.0	1.0

Water

Quantity required (%)	1.0	1.5	2.0	2.5
Flow meter setting (l/h)	3.6	5.4	7.2	9.0

Water Content	**Trial 1**		**Trial 2**		**Trial 3**		**Avg Expansion**	**Avg Half Life (s)**
	EX	**T 1/2**	**EX**	**T 1/2**	**EX**	**T 1/2**		
1.0	12	12.50	12	12.40	14	12.16	12.7	12.35
1.5	16	9.56	18	8.46	16	8.27	16.7	8.76
2.0	17	7.79	18	8.25	18	7.91	17.7	7.98
2.5	18	8.05	18	8.06	18	7.53	18.0	7.88



BASELINE WATER ADDED CONTENT (%) **1.0**

AET P-0032918	**FOAMING CHARACTERISTICS OF BITUMEN** ***(Wirtgen Cold Recycling Manual)***

BITUMEN	**Source**	Albina Asphalt
	Type	64-28

Bitumen Temperature (C)

150

Test Date **6/4/2024**

MACHINE SETTINGS (WLB-10S)

Bitumen pump

Calibration	1	2	3	4
Timer setting (sec)	1.0	3.0	5.0	7.0

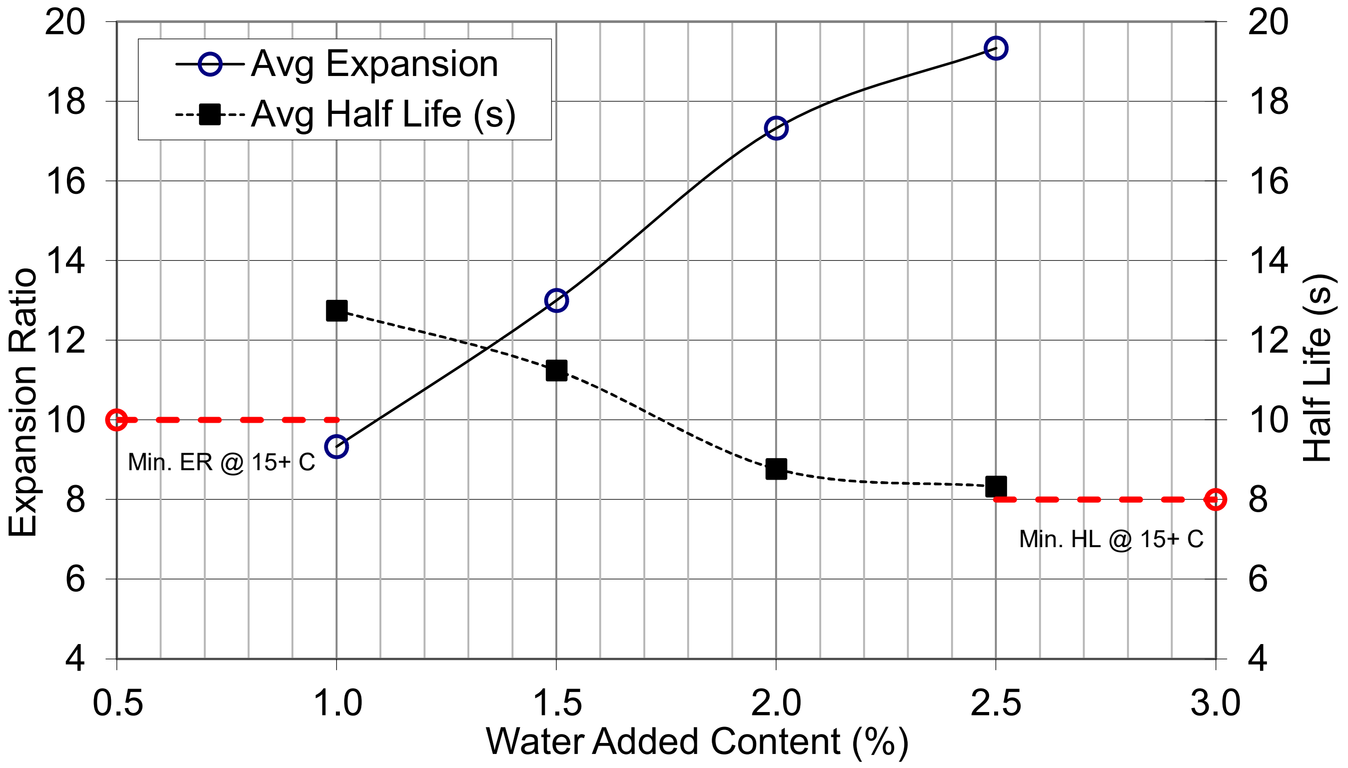
Setting

Quantity required (g)	100	300	500
Pump output (g/s)	100	300	500
Timer setting (s)	1.0	1.0	1.0

Water

Quantity required (%)	1.0	1.5	2.0	2.5
Flow meter setting (l/h)	3.6	5.4	7.2	9.0

Water Content	**Trial 1**		**Trial 2**		**Trial 3**		**Avg Expansion**	**Avg Half Life (s)**
	EX	**T 1/2**	**EX**	**T 1/2**	**EX**	**T 1/2**		
1.0	8	12.75	10	12.65	10	12.85	9.3	12.75
1.5	13	11.08	13	12.22	13	10.44	13.0	11.25
2.0	18	8.02	16	9.80	18	8.49	17.3	8.77
2.5	18	8.59	20	8.08	20	8.32	19.3	8.33



BASELINE WATER ADDED CONTENT (%) ***n/a***

AET P-0032918

FOAMING CHARACTERISTICS OF BITUMEN

(Wirtgen Cold Recycling Manual)

BITUMEN	**Source**	Albina Asphalt
	Type	64-28

Bitumen Temperature (C)

160

Test Date **6/4/2024**

MACHINE SETTINGS (WLB-10S)

Bitumen pump

Calibration	1	2	3	4
Timer setting (sec)	1.0	3.0	5.0	7.0

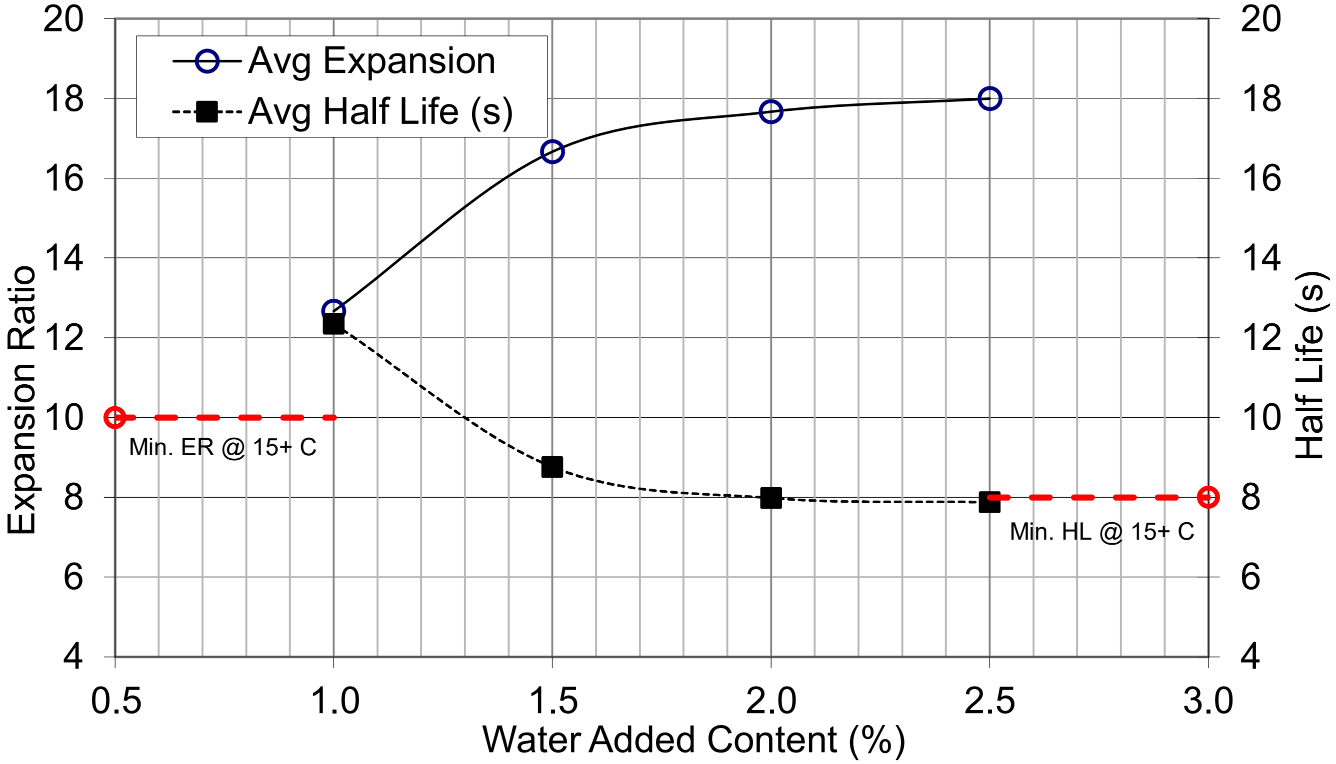
Setting

Quantity required (g)	100	300	500
Pump output (g/s)	100	300	500
Timer setting (s)	1.0	1.0	1.0

Water

Quantity required (%)	1.0	1.5	2.0	2.5
Flow meter setting (l/h)	3.6	5.4	7.2	9.0

Water Content	**Trial 1**		**Trial 2**		**Trial 3**		**Avg Expansion**	**Avg Half Life (s)**
	EX	**T 1/2**	**EX**	**T 1/2**	**EX**	**T 1/2**		
1.0	12	12.50	12	12.40	14	12.16	12.7	12.35
1.5	16	9.56	18	8.46	16	8.27	16.7	8.76
2.0	17	7.79	18	8.25	18	7.91	17.7	7.98
2.5	18	8.05	18	8.06	18	7.53	18.0	7.88



BASELINE WATER ADDED CONTENT (%) ***n/a***

AET P-0032918

FOAMING CHARACTERISTICS OF BITUMEN

(Wirtgen Cold Recycling Manual)

BITUMEN	**Source**	Albina Asphalt
	Type	64-28

Bitumen Temperature (C)

170

Test Date **6/4/2024**

MACHINE SETTINGS (WLB-10S)

Bitumen pump

Calibration	1	2	3	4
Timer setting (sec)	1.0	3.0	5.0	7.0

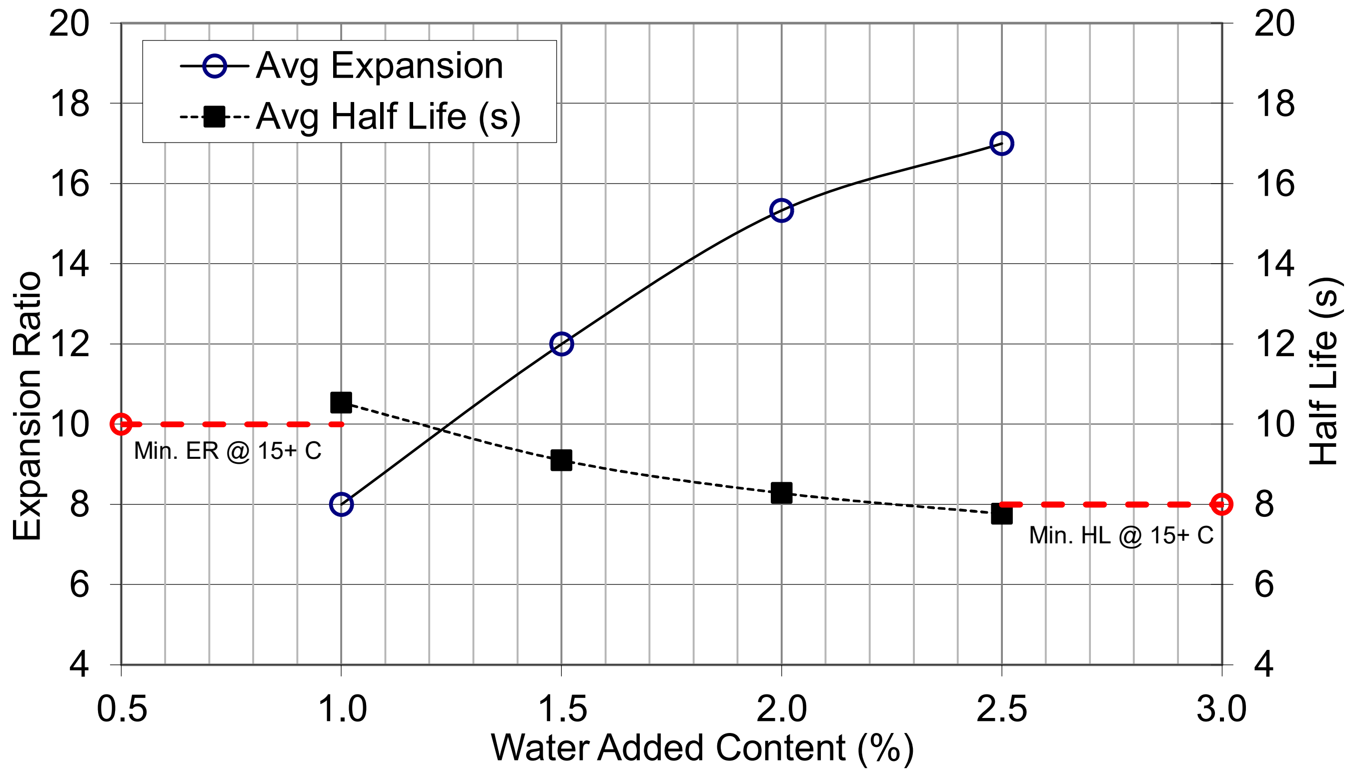
Setting

Quantity required (g)	100	300	500
Pump output (g/s)	100	300	500
Timer setting (s)	1.0	1.0	1.0

Water

Quantity required (%)	1.0	1.5	2.0	2.5
Flow meter setting (l/h)	3.6	5.4	7.2	9.0

Water Content	**Trial 1**		**Trial 2**		**Trial 3**		**Avg Expansion**	**Avg Half Life (s)**
	EX	**T 1/2**	**EX**	**T 1/2**	**EX**	**T 1/2**		
1.0	8	10.86	8	10.56	8	10.20	8.0	10.54
1.5	12	8.78	12	9.01	12	9.52	12.0	9.10
2.0	14	7.67	16	8.82	16	8.36	15.3	8.28
2.5	17	7.49	17	7.88	17	7.94	17.0	7.77



BASELINE WATER ADDED CONTENT (%) ***n/a***

American Engineering Testing, Inc.
St. Paul Construction Services
550 Cleveland Ave N
St. Paul, MN 55114
(651) 659-9001
www.teamAET.com

Proctor Report

Report No: PTR:AET-161586-S1
Issue No: 1

Client: Geotechnical Resources Inc. (GRI)

CC:

Project: GRI Oregon SFDR Mix Design

Unknown   OR

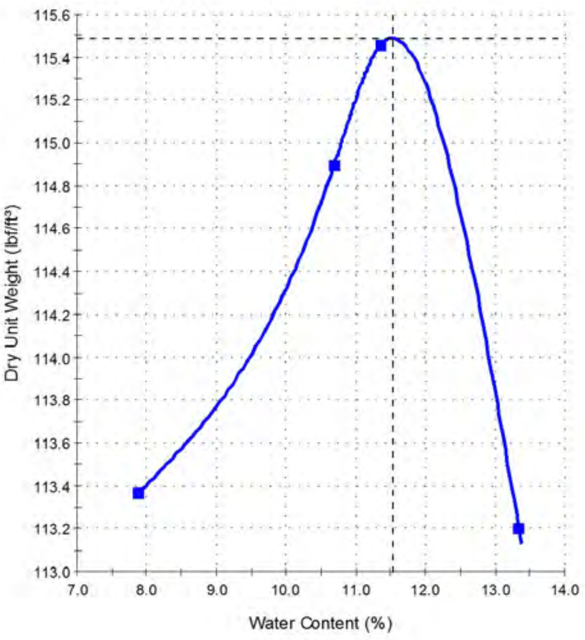
Job No: P-0032918

Date of Issue: 6/12/2024
Reviewed By: Kristen Hanson
Field Engineer

Sample Details

Sample ID: AET-161586-S1
Date Sampled: 6/6/2024
Location:
Sampled By: Kristen Hanson

Dry Unit Weight - Water Content Relationship



Test Results

ASTM D 1557

Maximum Dry Unit Weight (lbf/ft³): **115.5**
Optimum Water Content (%): **11.5**
Method: C
Preparation Method: Moist
Tested By: Rel Seykora
Date Tested: 6/7/2024

Comments

APPENDIX B

Ground-Penetrating Radar

APPENDIX B

GROUND-PENETRATING RADAR

B.1 GENERAL

We conducted a ground-penetrating radar (GPR) survey of the project street segment to determine the continuous asphalt concrete (AC) thicknesses and identity potential bedrock depth within the project limits.

B.2 BACKGROUND

GPR is a geophysical technique used for detecting subsurface features such as rebar in concrete, pavement-surfacing thickness, soil strata boundaries and bedrock depth, and underground storage tanks and utilities. Our GPR system transmits high-frequency electromagnetic pulses (waveforms) into the ground and records the time between transmission and receipt of the waveforms reflected from buried features or from stratigraphic boundaries. Reflections of the waveforms occur at boundaries of electrically dissimilar materials, such as at the interface between aggregate backfill and the top of a metal pipe. More specifically, reflections of the transmitted pulse occur at locations where a change in dielectric permittivity occurs. In simplified terms, dielectric permittivity is a unitless measure of the capacity of a material to hold an electric charge when exposed to an electric field. Given that dielectric permittivity varies among materials, it was normalized to air through the dielectric constant, where the constant for air has been defined as unity (one). Materials that are denser than air and/or contain moisture have a dielectric constant greater than that of air. Given that the dielectric constant of a given material is directly related to the velocity of the electromagnetic pulse traveling through the material, the dielectric constant is used to relate time of waveform travel through the material to the depth (distance) at which a reflection occurs. In this way, and based on the chosen or assumed dielectric constant, GPR data can be used to estimate the depth at which waveforms are reflected off subsurface features.

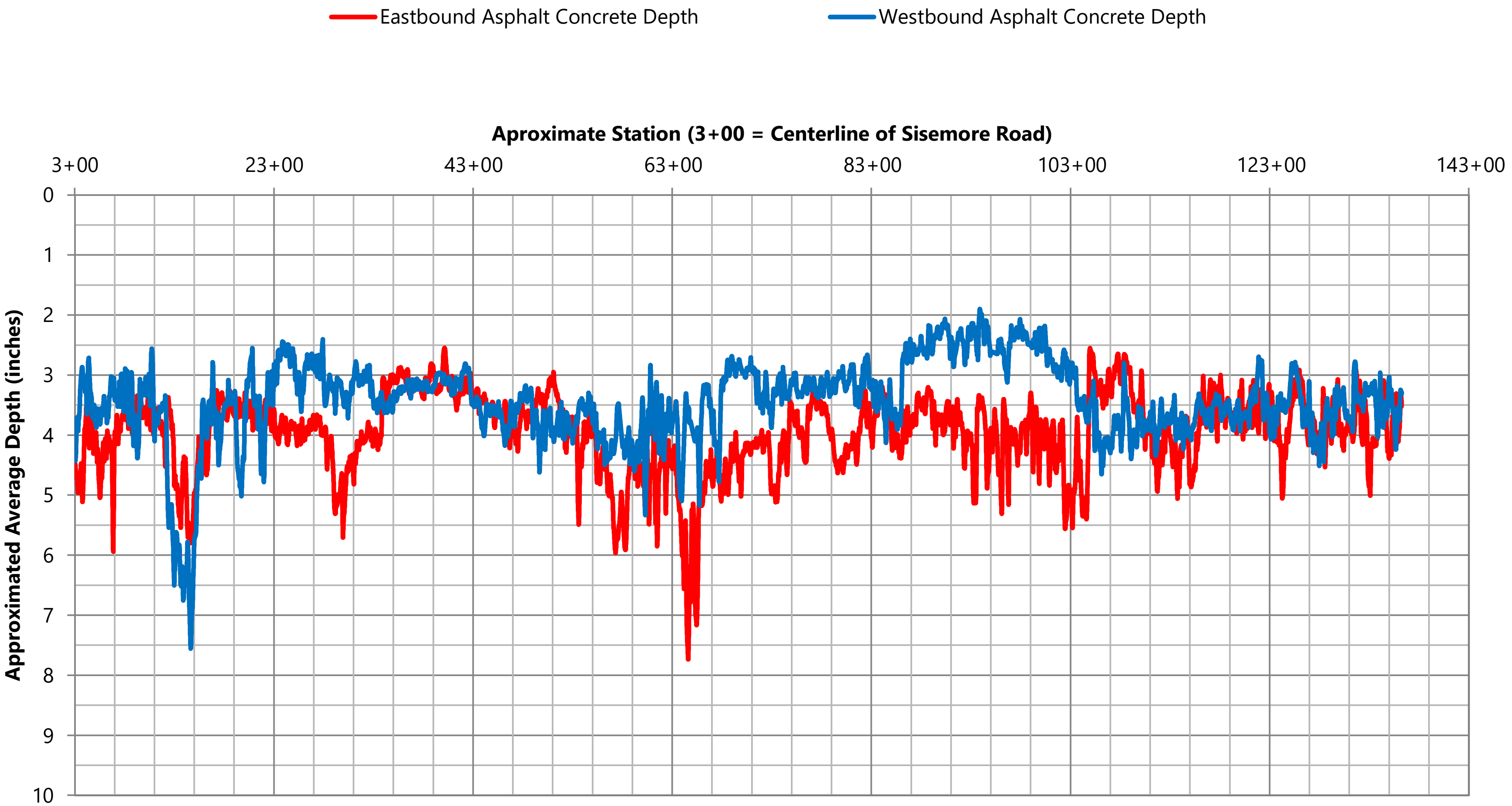
B.3 GROUND-PENETRATING RADAR DATA COLLECTION

We conducted a longitudinal GPR survey along the roadway segment (i.e., parallel to the roadway centerline) for the purposes of estimating pavement surfacing depth and depths to potential bedrock. We conducted the survey using a 2-gigahertz truck-mounted horn antenna and our 350-megahertz (MHz) truck-mounted antenna, Model 42000S, manufactured by Geophysical Survey Systems, Inc., along the outside wheel tracks of the travel lanes in each direction on January 29, 2024.

B.4 DATA PROCESSING AND RESULTS

We analyzed the GPR data using RADAN 7 to identify AC depths. We adjusted the depths to ground-truth information obtained from the pavement cores (i.e., pavement surfacing thickness and delamination depths, when present, at core locations) to account for differences between the assumed dielectric constant used during data collection and the calculated dielectric constant based on actual depths to reflections. Plots showing the continuous AC thicknesses along the GPR test lines for each project design segment are shown on Figures 1B through 3B.

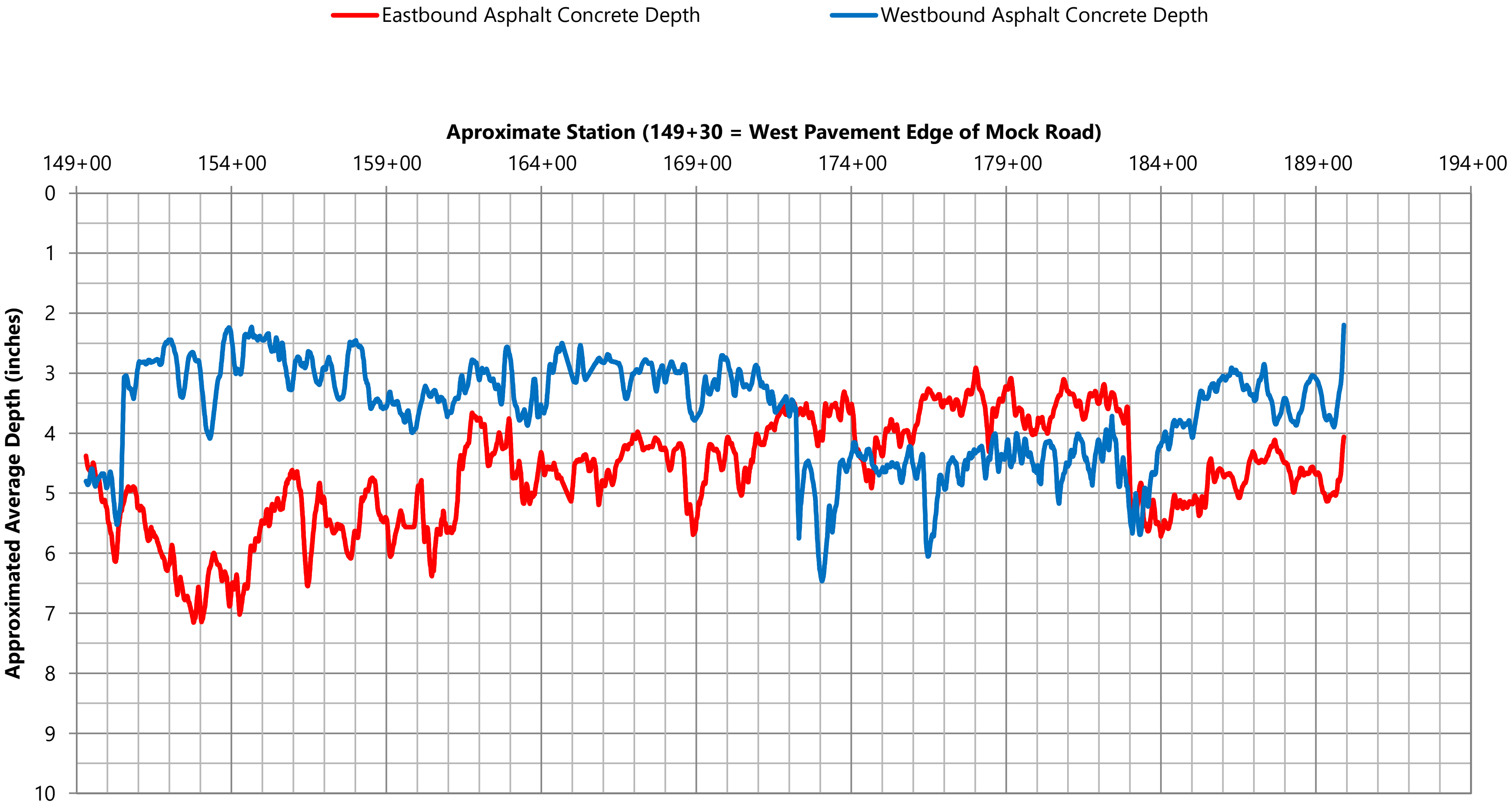
We also completed a 350 MHz survey along the project limits to potentially identify the presence and depth of bedrock. Based on the GPR data, we generally did not encounter bedrock except near O.B. Riley Road, as shown on Figure 4B in this appendix.



GRI

GROUND PENETRATING RADAR
DESIGN SEGMENT - 1

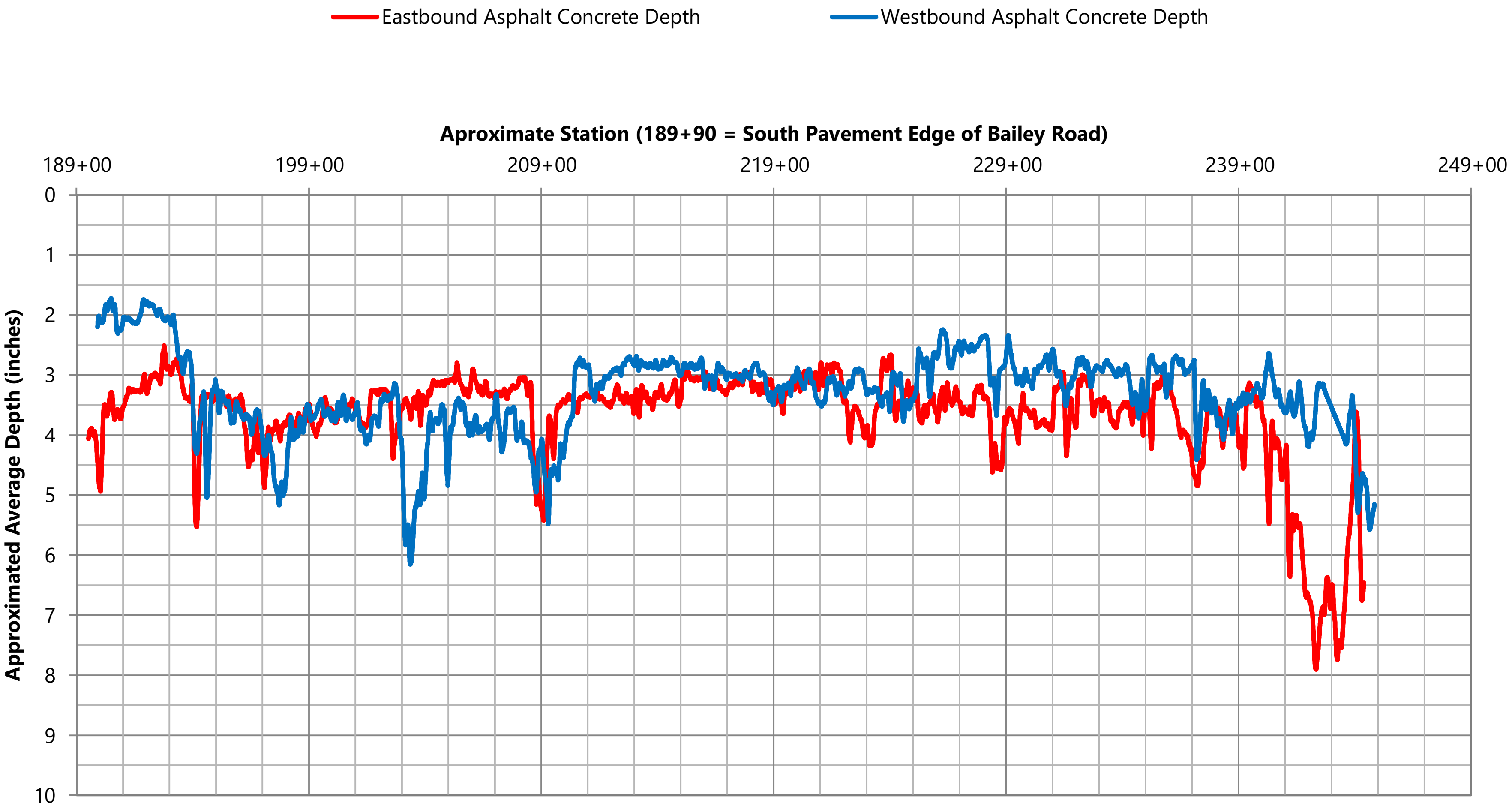
DEC. 2024 JOB NO. 6894-A FIG. 1B



GRI

GROUND PENETRATING RADAR
DESIGN SEGMENT - 2

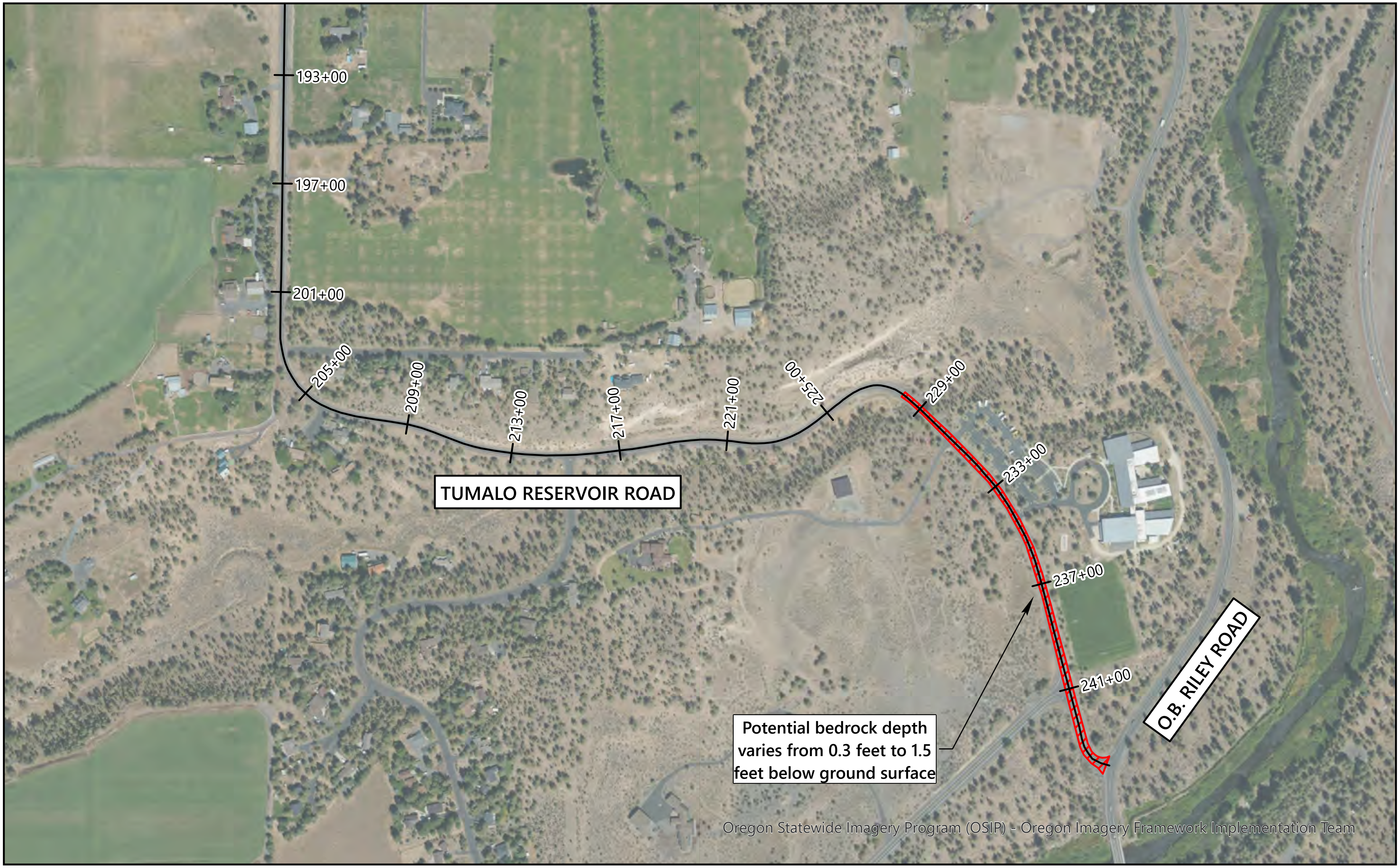
DEC. 2024 JOB NO. 6894-A FIG. 2B



GRI

GROUND PENETRATING RADAR
DESIGN SEGMENT - 3

DEC. 2024 JOB NO. 6894-A FIG. 3B

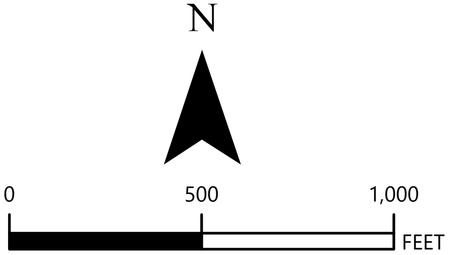


Potential bedrock depth varies from 0.3 feet to 1.5 feet below ground surface

Aerial Imagery Source: Oregon Statewide Imagery Program, OSIP 2022 (Accessed December 2023)

LEGEND

▨ POTENTIAL SHALLOW BEDROCK AREA



GRI

POTENTIAL SHALLOW BEDROCK AREA

DEC. 2024 JOB NO. 6894-A FIG. 4B

APPENDIX C

Traffic Analysis Worksheets

APPENDIX C

TRAFFIC ANALYSIS WORKSHEETS

C.1 GENERAL

GRI used the methodology presented in the Oregon Department of Transportation (ODOT) *Pavement Design Guide* (PDG) to approximate cumulative 18-kip Equivalent Single Axle Load (ESAL) repetitions (traffic loading) over the 20-year design period for flexible pavement designs. We obtained 48-hour vehicle classification counts from the County for three locations within the project segment as follows:

1. Tumalo Reservoir Road, 900 feet west of Mock Road
2. Tumalo Reservoir Road, 600 feet west of Bailey Road
3. Tumalo Reservoir Road, 0.03 miles east of Tumalo Rim Road

We based our traffic-loading approximations on vehicle classification counts for Federal Highway Administration (FHWA) Class 4 through 13 vehicles. We used these data to forecast traffic over the 20-year period, assuming construction will occur in 2025. Additional details of our analysis methodology and our approximations for future traffic loading are presented below.

C.2 ANNUAL EQUIVALENT SINGLE AXLE LOAD REPETITIONS

We converted the FHWA Class 4 through 13 volumes obtained from our 48-hour approximation into annual ESAL repetitions using the ESAL conversion factors provided in the 2019 ODOT PDG.

C.3 TRAFFIC GROWTH

Based on our discussions with the County, we used an annual compound growth rate of 1.5% to forecast the annual ESALs over time.

C.4 DESIGN EQUIVALENT SINGLE-AXLE LOADS

Our approximations of cumulative ESAL repetitions (traffic loading) for the 20-year design period for flexible pavements are shown in Tables 1C and 2C for combined travel directions for design Segment 1 on May 29 and 30, 2024, respectively, in Tables 3C and 4C for combined travel directions for design Segment 2 on May 29 and 30, 2024, respectively, and in Tables 5C and 6C for combined travel directions for design Segment 3 on May 29 and 30, 2024, respectively. For design Segment 1, we used the greater of the two values for the 20-year ESALs shown in Table 1C as the design ESAL value. For design Segment 2, we used the greater of the two values for the 20-year ESALs shown in Table 3C as the design ESAL value. For design Segment 3, we used the greater of the two values for the 20-year ESALs shown in Table 5C as the design ESAL value.

C.5 REFERENCES

Oregon Department of Transportation (ODOT), 2019, ODOT pavement design guide: Pavement Services Unit, Salem, Oregon.

Table 1C: TRAFFIC ANALYSIS WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 1 - BETWEEN SISEMORE ROAD AND MOCK ROAD

Project:	**Tumalo Reservoir Road Improvements**
Effective Date:	**5/29/2024**
Source of Traffic Volume Data:	**Deschutes County**
Count Location:	**Tumalo Reservoir Road, 900 feet West of Mock Road**
One-Way or Two-Way Volumes?	**Two-Way**
Year of Traffic Volume Count Data:	**2024**
Project Construction Year:	**2025**
Years between Count & Construction:	**1**
Directional Factor:	**0.50**
Lane Distribution Factor:	**1.00**
Annual Compound Growth Rate:	**1.50%**
Pavement Type:	**Flexible**
Agency for ESAL Conversion Factors:	**Oregon Department of Transportation**

	FHWA Vehicle Class and Corresponding Oregon Department of Transportation Flexible Pavement Two-Way ESAL Conversion Factor																
FHWA Vehicle Class	1	2	3	4T	4	5	6	7	8	9	10	11	12	13			
Two-Way ESAL Conversion Factors	0	0	0	0	246	104	284	757	253	466	561	603	546	1037			
Vehicle Classification Description	**Motor-cycles**	**Cars**	**Light Pickups**	**Transit Buses (single)**	**Other Buses (single)**	**2-axle, 6-tire (single)**	**3-axle (single)**	**4-axle (single)**	**<5-axle (double)**	**5-axle (double)**	**>6-axle (double)**	**<6-axle (multi)**	**6-axle (multi)**	**>6-axle (multi)**	**Total 24-hour Volume**	**Percent Trucks**	**Annual ESALs During Count Year**	**Annual ESALs During Construction Year**
	Annual Average Daily Traffic Volume																	
Count Year Data	21	337	137	0	4	106	9	10	3	4	1	2	0	0	634	21.9%	13,262	13,461

Annual and Cumulative ESALs														
Year	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**
2026 (1)	13,663	13,663	2036 (11)	15,856	162,086	2046 (21)	18,402	334,337	2056 (31)	21,356	534,241	2066 (41)	24,785	766,238
2027 (2)	13,868	27,531	2037 (12)	16,094	178,180	2047 (22)	18,678	353,015	2057 (32)	21,676	555,918	2067 (42)	25,156	791,395
2028 (3)	14,076	41,606	2038 (13)	16,336	194,516	2048 (23)	18,958	371,973	2058 (33)	22,002	577,919	2068 (43)	25,534	816,929
2029 (4)	14,287	55,893	2039 (14)	16,581	211,096	2049 (24)	19,242	391,215	2059 (34)	22,332	600,251	2069 (44)	25,917	842,845
2030 (5)	14,501	70,395	2040 (15)	16,829	227,925	2050 (25)	19,531	410,746	2060 (35)	22,667	622,918	2070 (45)	26,306	869,151
2031 (6)	14,719	85,113	2041 (16)	17,082	245,007	2051 (26)	19,824	430,570	2061 (36)	23,007	645,924	2071 (46)	26,700	895,851
2032 (7)	14,940	100,053	2042 (17)	17,338	262,345	2052 (27)	20,121	450,692	2062 (37)	23,352	669,276	2072 (47)	27,101	922,952
2033 (8)	15,164	115,217	2043 (18)	17,598	279,943	2053 (28)	20,423	471,115	2063 (38)	23,702	692,978	2073 (48)	27,507	950,459
2034 (9)	15,391	130,608	2044 (19)	17,862	297,805	2054 (29)	20,730	491,845	2064 (39)	24,058	717,035	2074 (49)	27,920	978,378
2035 (10)	15,622	146,230	2045 (20)	18,130	315,935	2055 (30)	21,041	512,885	2065 (40)	24,418	741,454	2075 (50)	28,339	1,006,717

Design (Cumulative) ESALs (Rounded up to the next 1,000 ESALs)									
1-Year ESALs	**2-Year ESALs**	**5-Year ESALs**	**8-Year ESALs**	**10-Year ESALs**	**15-Year ESALs**	**20-Year ESALs**	**30-Year ESALs**	**40-Year ESALs**	**50-Year ESALs**
14,000	**28,000**	**71,000**	**116,000**	**147,000**	**228,000**	**316,000**	**513,000**	**742,000**	**1,007,000**

Abbreviations: FHWA = Federal Highway Administration; ESAL = Equivalent Single Axle Load (ESALs is plural); 4T = Class 4 Transit Buses

Table 2C: TRAFFIC ANALYSIS WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 1 - BETWEEN SISEMORE ROAD AND MOCK ROAD

Project:	**Tumalo Reservoir Road Improvements**
Effective Date:	**5/30/2024**
Source of Traffic Volume Data:	**Deschutes County**
Count Location:	**Tumalo Reservoir Road, 900 feet West of Mock Road**
One-Way or Two-Way Volumes?	**Two-Way**
Year of Traffic Volume Count Data:	**2024**
Project Construction Year:	**2025**
Years between Count & Construction:	**1**
Directional Factor:	**0.50**
Lane Distribution Factor:	**1.00**
Annual Compound Growth Rate:	**1.50%**
Pavement Type:	**Flexible**
Agency for ESAL Conversion Factors:	**Oregon Department of Transportation**

	FHWA Vehicle Class and Corresponding Oregon Department of Transportation Flexible Pavement Two-Way ESAL Conversion Factor														Total 24-hour Volume	Percent Trucks	Annual ESALs During Count Year	Annual ESALs During Construction Year
FHWA Vehicle Class	1	2	3	4T	4	5	6	7	8	9	10	11	12	13				
Two-Way ESAL Conversion Factors	0	0	0	0	246	104	284	757	253	466	561	603	546	1037				
Vehicle Classification Description	**Motor-cycles**	**Cars**	**Light Pickups**	**Transit Buses (single)**	**Other Buses (single)**	**2-axle, 6-tire (single)**	**3-axle (single)**	**4-axle (single)**	**<5-axle (double)**	**5-axle (double)**	**>6-axle (double)**	**<6-axle (multi)**	**6-axle (multi)**	**>6-axle (multi)**				
	Annual Average Daily Traffic Volume																	
Count Year Data	22	359	127	0	5	105	18	6	1	2	0	0	0	0	645	21.2%	11,495	11,667

Annual and Cumulative ESALs

Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs
2026 (1)	11,842	11,842	2036 (11)	13,743	140,484	2046 (21)	15,949	289,778	2056 (31)	18,510	463,040	2066 (41)	21,481	664,118
2027 (2)	12,020	23,861	2037 (12)	13,949	154,433	2047 (22)	16,189	305,967	2057 (32)	18,788	481,828	2067 (42)	21,804	685,921
2028 (3)	12,200	36,061	2038 (13)	14,158	168,591	2048 (23)	16,431	322,398	2058 (33)	19,069	500,897	2068 (43)	22,131	708,052
2029 (4)	12,383	48,444	2039 (14)	14,371	182,962	2049 (24)	16,678	339,076	2059 (34)	19,355	520,252	2069 (44)	22,463	730,515
2030 (5)	12,569	61,013	2040 (15)	14,586	197,549	2050 (25)	16,928	356,004	2060 (35)	19,646	539,898	2070 (45)	22,800	753,314
2031 (6)	12,757	73,770	2041 (16)	14,805	212,354	2051 (26)	17,182	373,186	2061 (36)	19,940	559,838	2071 (46)	23,142	776,456
2032 (7)	12,948	86,718	2042 (17)	15,027	227,381	2052 (27)	17,440	390,626	2062 (37)	20,239	580,078	2072 (47)	23,489	799,945
2033 (8)	13,143	99,861	2043 (18)	15,253	242,634	2053 (28)	17,701	408,327	2063 (38)	20,543	600,621	2073 (48)	23,841	823,786
2034 (9)	13,340	113,201	2044 (19)	15,481	258,115	2054 (29)	17,967	426,294	2064 (39)	20,851	621,472	2074 (49)	24,199	847,985
2035 (10)	13,540	126,741	2045 (20)	15,714	273,829	2055 (30)	18,236	444,530	2065 (40)	21,164	642,636	2075 (50)	24,562	872,546

Design (Cumulative) ESALs (Rounded up to the next 1,000 ESALs)

1-Year ESALs	2-Year ESALs	5-Year ESALs	8-Year ESALs	10-Year ESALs	15-Year ESALs	20-Year ESALs	30-Year ESALs	40-Year ESALs	50-Year ESALs
12,000	**24,000**	**62,000**	**100,000**	**127,000**	**198,000**	**274,000**	**445,000**	**643,000**	**873,000**

Abbreviations: FHWA = Federal Highway Administration; ESAL = Equivalent Single Axle Load (ESALs is plural); 4T = Class 4 Transit Buses

Table 3C: TRAFFIC ANALYSIS WORKSHEET
TUMALO RESERVOIR ROAD - SEGMENT 2 - BETWEEN BAILEY ROAD AND MOCK ROAD

Project: **Tumalo Reservoir Road Improvements**
Effective Date: **5/29/2024**
Source of Traffic Volume Data: **Deschutes County**
Count Location: **Tumalo Reservoir Road, 600 feet west of Bailey Road**
One-Way or Two-Way Volumes? **Two-Way**
Year of Traffic Volume Count Data: **2024**
Project Construction Year: **2025**
Years between Count & Construction: **1**
Directional Factor: **0.50**
Lane Distribution Factor: **1.00**
Annual Compound Growth Rate: **1.50%**
Pavement Type: **Flexible**
Agency for ESAL Conversion Factors: **Oregon Department of Transportation**

	FHWA Vehicle Class and Corresponding Oregon Department of Transportation Flexible Pavement Two-Way ESAL Conversion Factor														Total 24-hour Volume	Percent Trucks	Annual ESALs During Count Year	Annual ESALs During Construction Year
FHWA Vehicle Class	1	2	3	4T	4	5	6	7	8	9	10	11	12	13				
Two-Way ESAL Conversion Factors	0	0	0	0	246	104	284	757	253	466	561	603	546	1037				
Vehicle Classification Description	**Motorcycles**	**Cars**	**Light Pickups**	**Transit Buses (single)**	**Other Buses (single)**	**2-axle, 6-tire (single)**	**3-axle (single)**	**4-axle (single)**	**<5-axle (double)**	**5-axle (double)**	**>6-axle (double)**	**<6-axle (multi)**	**6-axle (multi)**	**>6-axle (multi)**				
	Annual Average Daily Traffic Volume																	
Count Year Data	3	513	228	0	4	174	10	0	12	11	1	1	0	0	957	22.3%	15,623	15,857

Annual and Cumulative ESALs														
Year	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**	**Year**	**Annual ESALs**	**Cumulative ESALs**
2026 (1)	16,095	16,095	2036 (11)	18,679	190,942	2046 (21)	21,678	393,858	2056 (31)	25,158	629,351	2066 (41)	29,197	902,650
2027 (2)	16,337	32,432	2037 (12)	18,959	209,901	2047 (22)	22,003	415,861	2057 (32)	25,535	654,886	2067 (42)	29,635	932,285
2028 (3)	16,582	49,014	2038 (13)	19,244	229,145	2048 (23)	22,333	438,194	2058 (33)	25,919	680,805	2068 (43)	30,079	962,364
2029 (4)	16,830	65,844	2039 (14)	19,532	248,677	2049 (24)	22,668	460,862	2059 (34)	26,307	707,112	2069 (44)	30,531	992,895
2030 (5)	17,083	82,927	2040 (15)	19,825	268,502	2050 (25)	23,008	483,871	2060 (35)	26,702	733,814	2070 (45)	30,989	1,023,884
2031 (6)	17,339	100,266	2041 (16)	20,123	288,625	2051 (26)	23,353	507,224	2061 (36)	27,102	760,916	2071 (46)	31,453	1,055,337
2032 (7)	17,599	117,865	2042 (17)	20,425	309,050	2052 (27)	23,704	530,927	2062 (37)	27,509	788,425	2072 (47)	31,925	1,087,262
2033 (8)	17,863	135,728	2043 (18)	20,731	329,781	2053 (28)	24,059	554,986	2063 (38)	27,922	816,347	2073 (48)	32,404	1,119,666
2034 (9)	18,131	153,859	2044 (19)	21,042	350,823	2054 (29)	24,420	579,406	2064 (39)	28,340	844,687	2074 (49)	32,890	1,152,557
2035 (10)	18,403	172,263	2045 (20)	21,358	372,180	2055 (30)	24,786	604,193	2065 (40)	28,766	873,453	2075 (50)	33,384	1,185,940

Design (Cumulative) ESALs (Rounded up to the next 1,000 ESALs)									
1-Year ESALs	**2-Year ESALs**	**5-Year ESALs**	**8-Year ESALs**	**10-Year ESALs**	**15-Year ESALs**	**20-Year ESALs**	**30-Year ESALs**	**40-Year ESALs**	**50-Year ESALs**
17,000	**33,000**	**83,000**	**136,000**	**173,000**	**269,000**	**373,000**	**605,000**	**874,000**	**1,186,000**

Abbreviations: FHWA = Federal Highway Administration; ESAL = Equivalent Single Axle Load (ESALs is plural); 4T = Class 4 Transit Buses

Table 4C: TRAFFIC ANALYSIS WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 2 - BETWEEN BAILEY ROAD AND MOCK ROAD

Project:	**Tumalo Reservoir Road Improvements**
Effective Date:	**5/30/2024**
Source of Traffic Volume Data:	**Deschutes County**
Count Location:	**Tumalo Reservoir Road, 600 feet west of Bailey Road**
One-Way or Two-Way Volumes?	**Two-Way**
Year of Traffic Volume Count Data:	**2024**
Project Construction Year:	**2025**
Years between Count & Construction:	**1**
Directional Factor:	**0.50**
Lane Distribution Factor:	**1.00**
Annual Compound Growth Rate:	**1.50%**
Pavement Type:	**Flexible**
Agency for ESAL Conversion Factors:	**Oregon Department of Transportation**

	FHWA Vehicle Class and Corresponding Oregon Department of Transportation Flexible Pavement Two-Way ESAL Conversion Factor														**Total 24-hour Volume**	**Percent Trucks**	**Annual ESALs During Count Year**	**Annual ESALs During Construction Year**
FHWA Vehicle Class	1	2	3	4T	4	5	6	7	8	9	10	11	12	13				
Two-Way ESAL Conversion Factors	0	0	0	0	246	104	284	757	253	466	561	603	546	1037				
Vehicle Classification Description	**Motor-cycles**	**Cars**	**Light Pickups**	**Transit Buses (single)**	**Other Buses (single)**	**2-axle, 6-tire (single)**	**3-axle (single)**	**4-axle (single)**	**<5-axle (double)**	**5-axle (double)**	**>6-axle (double)**	**<6-axle (multi)**	**6-axle (multi)**	**>6-axle (multi)**				
	Annual Average Daily Traffic Volume																	
Count Year Data	6	543	222	0	5	184	11	1	4	5	3	0	0	0	984	21.6%	14,636	14,856

Annual and Cumulative ESALs

Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs
2026 (1)	15,078	15,078	2036 (11)	17,499	178,879	2046 (21)	20,308	368,976	2056 (31)	23,569	589,591	2066 (41)	27,352	845,624
2027 (2)	15,305	30,383	2037 (12)	17,762	196,640	2047 (22)	20,613	389,589	2057 (32)	23,922	613,513	2067 (42)	27,763	873,387
2028 (3)	15,534	45,917	2038 (13)	18,028	214,668	2048 (23)	20,922	410,511	2058 (33)	24,281	637,794	2068 (43)	28,179	901,566
2029 (4)	15,767	61,684	2039 (14)	18,298	232,967	2049 (24)	21,236	431,747	2059 (34)	24,645	662,440	2069 (44)	28,602	930,168
2030 (5)	16,004	77,688	2040 (15)	18,573	251,539	2050 (25)	21,555	453,301	2060 (35)	25,015	687,455	2070 (45)	29,031	959,199
2031 (6)	16,244	93,931	2041 (16)	18,851	270,391	2051 (26)	21,878	475,179	2061 (36)	25,390	712,845	2071 (46)	29,466	988,665
2032 (7)	16,487	110,419	2042 (17)	19,134	289,525	2052 (27)	22,206	497,385	2062 (37)	25,771	738,616	2072 (47)	29,908	1,018,573
2033 (8)	16,735	127,153	2043 (18)	19,421	308,946	2053 (28)	22,539	519,925	2063 (38)	26,158	764,773	2073 (48)	30,357	1,048,930
2034 (9)	16,986	144,139	2044 (19)	19,713	328,659	2054 (29)	22,877	542,802	2064 (39)	26,550	791,323	2074 (49)	30,812	1,079,743
2035 (10)	17,240	161,380	2045 (20)	20,008	348,667	2055 (30)	23,220	566,022	2065 (40)	26,948	818,272	2075 (50)	31,275	1,111,017

Design (Cumulative) ESALs (Rounded up to the next 1,000 ESALs)

1-Year ESALs	2-Year ESALs	5-Year ESALs	8-Year ESALs	10-Year ESALs	15-Year ESALs	20-Year ESALs	30-Year ESALs	40-Year ESALs	50-Year ESALs
16,000	**31,000**	**78,000**	**128,000**	**162,000**	**252,000**	**349,000**	**567,000**	**819,000**	**1,112,000**

Abbreviations: FHWA = Federal Highway Administration; ESAL = Equivalent Single Axle Load (ESALs is plural); 4T = Class 4 Transit Buses

Table 5C: TRAFFIC ANALYSIS WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 3 - BETWEEN O.B. RILEY ROAD AND BAILEY ROAD

Project:	**Tumalo Reservoir Road Improvements**
Effective Date:	**5/29/2024**
Source of Traffic Volume Data:	**Deschutes County**
Count Location:	**0.03 mile East of Tumalo Rim Road**
One-Way or Two-Way Volumes?	**Two-Way**
Year of Traffic Volume Count Data:	**2024**
Project Construction Year:	**2025**
Years between Count & Construction:	**1**
Directional Factor:	**0.50**
Lane Distribution Factor:	**1.00**
Annual Compound Growth Rate:	**1.50%**
Pavement Type:	**Flexible**
Agency for ESAL Conversion Factors:	**Oregon Department of Transportation**

	FHWA Vehicle Class and Corresponding Oregon Department of Transportation Flexible Pavement Two-Way ESAL Conversion Factor														Total 24-hour Volume	Percent Trucks	Annual ESALs During Count Year	Annual ESALs During Construction Year
FHWA Vehicle Class	1	2	3	4T	4	5	6	7	8	9	10	11	12	13				
Two-Way ESAL Conversion Factors	0	0	0	0	246	104	284	757	253	466	561	603	546	1037				
Vehicle Classification Description	**Motorcycles**	**Cars**	**Light Pickups**	**Transit Buses (single)**	**Other Buses (single)**	**2-axle, 6-tire (single)**	**3-axle (single)**	**4-axle (single)**	**<5-axle (double)**	**5-axle (double)**	**>6-axle (double)**	**<6-axle (multi)**	**6-axle (multi)**	**>6-axle (multi)**				
	Annual Average Daily Traffic Volume																	
Count Year Data	13	401	92	0	2	80	9	2	3	3	0	0	0	1	606	16.5%	8,038	8,159

Annual and Cumulative ESALs

Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs
2026 (1)	8,281	8,281	2036 (11)	9,610	98,239	2046 (21)	11,153	202,639	2056 (31)	12,944	323,800	2066 (41)	15,022	464,411
2027 (2)	8,405	16,686	2037 (12)	9,755	107,994	2047 (22)	11,321	213,960	2057 (32)	13,138	336,938	2067 (42)	15,247	479,659
2028 (3)	8,531	25,217	2038 (13)	9,901	117,894	2048 (23)	11,490	225,450	2058 (33)	13,335	350,273	2068 (43)	15,476	495,134
2029 (4)	8,659	33,877	2039 (14)	10,049	127,944	2049 (24)	11,663	237,113	2059 (34)	13,535	363,808	2069 (44)	15,708	510,842
2030 (5)	8,789	42,666	2040 (15)	10,200	138,144	2050 (25)	11,838	248,950	2060 (35)	13,738	377,546	2070 (45)	15,944	526,786
2031 (6)	8,921	51,587	2041 (16)	10,353	148,497	2051 (26)	12,015	260,966	2061 (36)	13,944	391,490	2071 (46)	16,183	542,969
2032 (7)	9,055	60,641	2042 (17)	10,508	159,005	2052 (27)	12,195	273,161	2062 (37)	14,153	405,643	2072 (47)	16,425	559,394
2033 (8)	9,191	69,832	2043 (18)	10,666	169,671	2053 (28)	12,378	285,539	2063 (38)	14,366	420,009	2073 (48)	16,672	576,066
2034 (9)	9,328	79,160	2044 (19)	10,826	180,497	2054 (29)	12,564	298,103	2064 (39)	14,581	434,590	2074 (49)	16,922	592,988
2035 (10)	9,468	88,629	2045 (20)	10,988	191,486	2055 (30)	12,752	310,856	2065 (40)	14,800	449,390	2075 (50)	17,176	610,164

Design (Cumulative) ESALs (Rounded up to the next 1,000 ESALs)

1-Year ESALs	2-Year ESALs	5-Year ESALs	8-Year ESALs	10-Year ESALs	15-Year ESALs	20-Year ESALs	30-Year ESALs	40-Year ESALs	50-Year ESALs
9,000	**17,000**	**43,000**	**70,000**	**89,000**	**139,000**	**192,000**	**311,000**	**450,000**	**611,000**

Abbreviations: FHWA = Federal Highway Administration; ESAL = Equivalent Single Axle Load (ESALs is plural); 4T = Class 4 Transit Buses

Table 6C: TRAFFIC ANALYSIS WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 3 - BETWEEN O.B. RILEY ROAD AND BAILEY ROAD

Project:	**Tumalo Reservoir Road Improvements**
Effective Date:	**5/30/2024**
Source of Traffic Volume Data:	**Deschutes County**
Count Location:	**0.03 mile East of Tumalo Rim Road**
One-Way or Two-Way Volumes?	**Two-Way**
Year of Traffic Volume Count Data:	**2024**
Project Construction Year:	**2025**
Years between Count & Construction:	**1**
Directional Factor:	**0.50**
Lane Distribution Factor:	**1.00**
Annual Compound Growth Rate:	**1.50%**
Pavement Type:	**Flexible**
Agency for ESAL Conversion Factors:	**Oregon Department of Transportation**

	FHWA Vehicle Class and Corresponding Oregon Department of Transportation Flexible Pavement Two-Way ESAL Conversion Factor														Total 24-hour Volume	Percent Trucks	Annual ESALs During Count Year	Annual ESALs During Construction Year
FHWA Vehicle Class	1	2	3	4T	4	5	6	7	8	9	10	11	12	13				
Two-Way ESAL Conversion Factors	0	0	0	0	246	104	284	757	253	466	561	603	546	1037				
Vehicle Classification Description	Motor-cycles	Cars	Light Pickups	Transit Buses (single)	Other Buses (single)	2-axle, 6-tire (single)	3-axle (single)	4-axle (single)	<5-axle (double)	5-axle (double)	>6-axle (double)	<6-axle (multi)	6-axle (multi)	>6-axle (multi)				
	Annual Average Daily Traffic Volume																	
Count Year Data	23	418	84	0	5	98	4	1	0	0	0	0	0	0	633	17.1%	6,658	6,757

Annual and Cumulative ESALs

Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs	Year	Annual ESALs	Cumulative ESALs
2026 (1)	6,859	6,859	2036 (11)	7,960	81,367	2046 (21)	9,238	167,837	2056 (31)	10,721	268,188	2066 (41)	12,442	384,650
2027 (2)	6,962	13,820	2037 (12)	8,079	89,446	2047 (22)	9,376	177,213	2057 (32)	10,882	279,070	2067 (42)	12,628	397,279
2028 (3)	7,066	20,886	2038 (13)	8,200	97,646	2048 (23)	9,517	186,730	2058 (33)	11,045	290,114	2068 (43)	12,818	410,097
2029 (4)	7,172	28,058	2039 (14)	8,323	105,970	2049 (24)	9,660	196,389	2059 (34)	11,210	301,325	2069 (44)	13,010	423,107
2030 (5)	7,280	35,338	2040 (15)	8,448	114,418	2050 (25)	9,805	206,194	2060 (35)	11,379	312,703	2070 (45)	13,205	436,312
2031 (6)	7,389	42,727	2041 (16)	8,575	122,993	2051 (26)	9,952	216,146	2061 (36)	11,549	324,253	2071 (46)	13,403	449,716
2032 (7)	7,500	50,226	2042 (17)	8,704	131,697	2052 (27)	10,101	226,246	2062 (37)	11,723	335,975	2072 (47)	13,604	463,320
2033 (8)	7,612	57,839	2043 (18)	8,834	140,531	2053 (28)	10,252	236,499	2063 (38)	11,898	347,874	2073 (48)	13,809	477,129
2034 (9)	7,726	65,565	2044 (19)	8,967	149,498	2054 (29)	10,406	246,905	2064 (39)	12,077	359,950	2074 (49)	14,016	491,144
2035 (10)	7,842	73,407	2045 (20)	9,101	158,599	2055 (30)	10,562	257,467	2065 (40)	12,258	372,208	2075 (50)	14,226	505,370

Design (Cumulative) ESALs (Rounded up to the next 1,000 ESALs)

1-Year ESALs	2-Year ESALs	5-Year ESALs	8-Year ESALs	10-Year ESALs	15-Year ESALs	20-Year ESALs	30-Year ESALs	40-Year ESALs	50-Year ESALs
7,000	**14,000**	**36,000**	**58,000**	**74,000**	**115,000**	**159,000**	**258,000**	**373,000**	**506,000**

Abbreviations: FHWA = Federal Highway Administration; ESAL = Equivalent Single Axle Load (ESALs is plural); 4T = Class 4 Transit Buses

GRI

APPENDIX D

Pavement Design Analysis

APPENDIX D

PAVEMENT DESIGN ANALYSIS

D.1 GENERAL

We accomplished the pavement design analysis in general accordance with the guidelines given in the 1993 American Association of State Highway and Transportation Officials *AASHTO Guide for Design of Pavement Structures* (AASHTO Guide), and the 2019 Oregon Department of Transportation *Pavement Design Guide*. Our pavement design analysis is based on our field explorations and DCP testing results provided in Appendix A, GPR testing results provided in Appendix B, and our approximated and assumed traffic loading.

D.2 REHABILITATION ANALYSIS

We calculated the structural requirement for each project segment to adequately support the approximated 20-year design traffic. The pavement design worksheets for rehabilitation and partial-depth reconstruction are provided in Tables 1D through 3D and Tables 4D through 6D, respectively, in this appendix.

We used the procedures outlined in the AASHTO Guide to calculate the overlay or inlay thickness required for each segment based on the structural deficiency of the existing pavement structure based on the backcalculated subgrade moduli, estimated effective structural number (SN_{eff}), and results of the visual condition survey. We used the following design equation from the AASHTO Guide Part III, Section 5.4.5, to calculate the overlay/inlay thicknesses to support the approximated 20-year design traffic:

$$D_{ol} = \frac{\Delta SN}{a_{ol}}$$

where:

D_{ol} = Overlay thickness or inlay depth, inch

ΔSN = Structural deficiency = SN_f - SN_{eff}

SN_f = Structural number required for the design traffic loading

SN_{eff} = Backcalculated effective structural number of the existing pavement

a_{ol} = Structural Coefficient for the asphalt concrete (AC) overlay (0.5)

D.3 FLEXIBLE PAVEMENT DESIGN ANALYSIS

We completed full-depth reconstruction and/or widening pavement design analysis for each design segment within the project scope using flexible pavement and in-place full-depth reclamation of existing AC and subgrade materials without stabilizing agents. We used the methods described by Giroud and Han (2004) to design the aggregate depth placed over a geotextile required to support construction traffic prior to designing the AC surfacing layer(s). Design parameters used in the analysis and the design pavement structure are shown in the flexible pavement design worksheets (Tables 7D through 9D) in this appendix.

D.4 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 1993, AASHTO guide for design of pavement structures: Washington, D.C.

Giroud, J. P., and Han, J., 2004, Design method for geogrid-reinforced unpaved roads. I. Development of design method and design method for geogrid-reinforced unpaved roads. II. Calibration and applications, *Journal of Geotechnical Engineering,* vol. 130, iss. 8, pp. 775–797.

Oregon Department of Transportation (ODOT), 2019, ODOT pavement design guide: Pavement Services Unit, Salem, Oregon.

Table 1D - PAVEMENT DESIGN WORKSHEET
TUMALO RESERVOIR ROAD - SEGMENT 1: REHABILITATION WITH AC OVERLAY

Flexible Pavement Overlay Design

Project Segment: TUMALO RESERVOIR ROAD - SEGMENT 1

AASHTO Design Parameters:		**Notes**	
Design Period, years:	20		**Denotes user data field**
Cumulative Equivalent Single Axle Load (ESAL) Repetitions:	316,000	based on traffic classification count data provided by Deschutes County	**Denotes calculated field**
Design Reliability:	80	per ODOT Pavement Design Guide for Rural Minor Collector	
Overall Standard Deviation, S_o:	0.49	per ODOT Pavement Design Guide	
Initial Serviceability, P_o:	4.2	per ODOT Pavement Design Guide	
Terminal Serviceability, P_t:	2.5	per ODOT Pavement Design Guide	
New Asphalt Concrete (AC) Layer Coefficient:	0.42	per ODOT Pavement Design Guide	

Existing Pavement Conditions:		
Average Existing AC Thickness, inches:	3.50	based on field explorations
Average Layer Coefficient of Existing AC:	0.35	based on surface condition & AASHTO 93 Part III Table 5.2
Aggregate Base (AB), inches:	0.00	based on field explorations
Average Modulus of Aggregate Base Material below AC, psi:	20,000	based on layer coefficient & AASHTO 93 Part II Figure 2.6
Average Layer Coefficient of AB Material:	0.10	based on surface condition & AASHTO 93 Part III Table 5.2
Estimated Effective Structural Number SNeff:	1.23	based on AC thickness and existing AC layer coefficient
Subgrade Mr, psi:	9,600	based on Dynamic Cone Penetrometer data

Calculated Values:	
Subgrade M_r, psi:	9,600
Total Structural Number (SN) required above subgrade:	2.45
Total SN Deficiency:	1.23
AC SN required above base layer:	1.84
Effective AC SN:	1.23
AC SN Deficiency:	0.61
AC Thickness Deficiency, inches:	2.93

Overlay Design:	**Thickness, inches**	**Layer Coeff.**	**SN**	
AC overlay above existing pavement surface:	3.00	0.42	1.26	
AC inlay below existing pavement surface:	0.00	0.42	0.00	
Existing AC removed by inlay:	0.00	0.35	0	
Existing AB removed by inlay:	0.00	0.10	0	
Net SN above existing base :			2.49	>1.84 required above base - OK
Net Total SN:			2.49	>2.45 required above subgrade - OK

Table 2D - PAVEMENT DESIGN WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 2: REHABILITATION WITH AC OVERLAY

Flexible Pavement Overlay Design

Project Segment: TUMALO RESERVOIR ROAD - SEGMENT 2

Denotes user data field

Denotes calculated field

AASHTO Design Parameters:		**Notes**
Design Period, years:	20	
Cumulative Equivalent Single Axle Load (ESAL) Repetitions:	373,000	based on traffic classification count data provided by Deschutes County
Design Reliability:	80	per ODOT Pavement Design Guide for Rural Minor Collector
Overall Standard Deviation, S_o:	0.49	per ODOT Pavement Design Guide
Initial Serviceability, P_o:	4.2	per ODOT Pavement Design Guide
Terminal Serviceability, P_t:	2.5	per ODOT Pavement Design Guide
New Asphalt Concrete (AC) Layer Coefficient:	0.42	per ODOT Pavement Design Guide

Existing Pavement Conditions:		
Average Existing AC Thickness, inches:	3.50	based on field explorations
Average Layer Coefficient of Existing AC:	0.35	based on surface condition & AASHTO 93 Part III Table 5.2
Aggregate Base (AB), inches:	0.00	based on field explorations
Average Modulus of Aggregate Base Material below AC, psi:	20,000	based on layer coefficient & AASHTO 93 Part II Figure 2.6
Average Layer Coefficient of AB Material:	0.10	based on surface condition & AASHTO 93 Part III Table 5.2
Estimated Effective Structural Number SNeff:	1.23	based on AC thickness and existing AC layer coefficient
Subgrade Mr, psi:	9,600	based on Dynamic Cone Penetrometer data

Calculated Values:	
Subgrade M_r, psi:	9,600
Total Structural Number (SN) required above subgrade:	2.52
Total SN Deficiency:	1.30
AC SN required above base layer:	1.90
Effective AC SN:	1.23
AC SN Deficiency:	0.67
AC Thickness Deficiency, inches:	3.09

Overlay Design:	**Thickness, inches**	**Layer Coeff.**	**SN**	
AC overlay above existing pavement surface:	3.50	0.42	1.47	
AC inlay below existing pavement surface:	0.00	0.42	0.00	
Existing AC removed by inlay:	0.00	0.35	0	
Existing AB removed by inlay:	0.00	0.10	0	
Net SN above existing base :			2.70	>1.90 required above base - OK
Net Total SN:			2.70	>2.52 required above subgrade - OK

Table 3D - PAVEMENT DESIGN WORKSHEET
TUMALO RESERVOIR ROAD - SEGMENT 3: REHABILITATION WITH AC OVERLAY

Flexible Pavement Overlay Design

Project Segment: TUMALO RESERVOIR ROAD - SEGMENT 3

Denotes user data field

Denotes calculated field

AASHTO Design Parameters:		**Notes**
Design Period, years:	20	
Cumulative Equivalent Single Axle Load (ESAL) Repetitions:	192,000	based on traffic classification count data provided by Deschutes County
Design Reliability:	80	per ODOT Pavement Design Guide for Rural Minor Collector
Overall Standard Deviation, S_o:	0.49	per ODOT Pavement Design Guide
Initial Serviceability, P_o:	4.2	per ODOT Pavement Design Guide
Terminal Serviceability, P_t:	2.5	per ODOT Pavement Design Guide
New Asphalt Concrete (AC) Layer Coefficient:	0.42	per ODOT Pavement Design Guide

Existing Pavement Conditions:		
Average Existing AC Thickness, inches:	3.25	based on field explorations
Average Layer Coefficient of Existing AC:	0.35	based on surface condition & AASHTO 93 Part III Table 5.2
Aggregate Base (AB), inches:	0.00	based on field explorations
Average Modulus of Aggregate Base Material below AC, psi:	20,000	based on layer coefficient & AASHTO 93 Part II Figure 2.6
Average Layer Coefficient of AB Material:	0.10	based on surface condition & AASHTO 93 Part III Table 5.2
Estimated Effective Structural Number SNeff:	1.14	based on AC thickness and existing AC layer coefficient
Subgrade Mr, psi:	7,400	based on Dynamic Cone Penetrometer data

Calculated Values:	
Subgrade M_r, psi:	7,400
Total Structural Number (SN) required above subgrade:	2.49
Total SN Deficiency:	1.36
AC SN required above base layer:	1.69
Effective AC SN:	1.14
AC SN Deficiency:	0.55
AC Thickness Deficiency, inches:	3.23

Overlay Design:	**Thickness, inches**	**Layer Coeff.**	**SN**	
AC overlay above existing pavement surface:	3.50	0.42	1.47	
AC inlay below existing pavement surface:	0.00	0.42	0.00	
Existing AC removed by inlay:	0.00	0.35	0	
Existing AB removed by inlay:	0.00	0.10	0	
Net SN above existing base :			2.61	>1.69 required above base - OK
Net Total SN:			2.61	>2.49 required above subgrade - OK

Table 4D - PAVEMENT DESIGN WORKSHEET
TUMALO RESERVOIR ROAD - SEGMENT 1: PARTIAL-DEPTH (SURFACE) RECONSTRUCTION

Flexible Pavement Overlay Design

Project Segment: TUMALO RESERVOIR ROAD - SEGMENT 1

Denotes user data field

Denotes calculated field

AASHTO Design Parameters:		Notes
Design Period, years:	20	
Cumulative Equivalent Single Axle Load (ESAL) Repetitions:	316,000	estimated ESALs for Partial-Depth Reconstruction (Remove & replace AC)
Design Reliability:	80	per ODOT Pavement Design Guide for Rural Minor Collector
Overall Standard Deviation, S_o:	0.49	per ODOT Pavement Design Guide
Initial Serviceability, P_o:	4.2	per ODOT Pavement Design Guide
Terminal Serviceability, P_t:	2.5	per ODOT Pavement Design Guide
New Asphalt Concrete (AC) Layer Coefficient:	0.42	per ODOT Pavement Design Guide

Existing Pavement Conditions:		
Average Existing AC Thickness, inches:	3.50	based on field explorations
Average Layer Coefficient of Existing AC:	0.35	based on surface condition & AASHTO 93 Part III Table 5.2
Aggregate Base (AB), inches:	0.00	based on field explorations
Average Modulus of Aggregate Base Material below AC, psi:	20,000	based on layer coefficient & AASHTO 93 Part II Figure 2.6
Average Layer Coefficient of AB Material:	0.10	based on surface condition & AASHTO 93 Part III Table 5.2
Estimated Effective Structural Number SNeff:	1.23	based on AC thickness and existing AC layer coefficient
Subgrade Mr, psi:	9,600	based on Dynamic Cone Penetrometer data

Calculated Values:	
Subgrade M_r, psi:	9,600
Total Structural Number (SN) required above subgrade:	2.45
Total SN Deficiency:	1.23
AC SN required above base layer:	1.84
Effective AC SN:	1.23
AC SN Deficiency:	0.61
AC Thickness Deficiency, inches:	2.93

Overlay Design:	Thickness, inches	Layer Coeff.	SN	
AC overlay above existing pavement surface:	2.50	0.42	1.05	
AC inlay below existing pavement surface:	3.50	0.42	1.47	
Existing AC removed by inlay:	3.50	0.35	-1.225	
Existing AB removed by inlay:	0.00	0.10	0	
Net SN above existing base :			2.52	>1.84 required above base - OK
Net Total SN:			2.52	>2.45 required above subgrade - OK

GRI

Table 5D - PAVEMENT DESIGN WORKSHEET
TUMALO RESERVOIR ROAD - SEGMENT 2: PARTIAL-DEPTH (SURFACE) RECONSTRUCTION

Flexible Pavement Overlay Design

Project Segment: TUMALO RESERVOIR ROAD - SEGMENT 2

Denotes user data field

Denotes calculated field

AASHTO Design Parameters:		**Notes**
Design Period, years:	20	
Cumulative Equivalent Single Axle Load (ESAL) Repetitions:	373,000	estimated ESALs for Partial-Depth Reconstruction (Remove & replace AC)
Design Reliability:	80	per ODOT Pavement Design Guide for Rural Minor Collector
Overall Standard Deviation, S_o:	0.49	per ODOT Pavement Design Guide
Initial Serviceability, P_o:	4.2	per ODOT Pavement Design Guide
Terminal Serviceability, P_t:	2.5	per ODOT Pavement Design Guide
New Asphalt Concrete (AC) Layer Coefficient:	0.42	per ODOT Pavement Design Guide

Existing Pavement Conditions:		
Average Existing AC Thickness, inches:	3.50	based on field explorations
Average Layer Coefficient of Existing AC:	0.35	based on surface condition & AASHTO 93 Part III Table 5.2
Aggregate Base (AB), inches:	0.00	based on field explorations
Average Modulus of Aggregate Base Material below AC, psi:	20,000	based on layer coefficient & AASHTO 93 Part II Figure 2.6
Average Layer Coefficient of AB Material:	0.10	based on surface condition & AASHTO 93 Part III Table 5.2
Estimated Effective Structural Number SNeff:	1.23	based on AC thickness and existing AC layer coefficient
Subgrade Mr, psi:	9,600	based on Dynamic Cone Penetrometer data

Calculated Values:	
Subgrade M_r, psi:	9,600
Total Structural Number (SN) required above subgrade:	2.52
Total SN Deficiency:	1.30
AC SN required above base layer:	1.90
Effective AC SN:	1.23
AC SN Deficiency:	0.67
AC Thickness Deficiency, inches:	3.09

Overlay Design:	**Thickness, inches**	**Layer Coeff.**	**SN**	
AC overlay above existing pavement surface:	2.50	0.42	1.05	
AC inlay below existing pavement surface:	3.50	0.42	1.47	
Existing AC removed by inlay:	3.50	0.35	-1.225	
Existing AB removed by inlay:	0.00	0.10	0	
Net SN above existing base :			2.52	>1.90 required above base - OK
Net Total SN:			2.52	approx. equal 2.52 required above subgrade - OK

GRI

Table 6D - PAVEMENT DESIGN WORKSHEET
TUMALO RESERVOIR ROAD - SEGMENT 3: PARTIAL-DEPTH (SURFACE) RECONSTRUCTION

Flexible Pavement Overlay Design

Project Segment: TUMALO RESERVOIR ROAD - SEGMENT 3

Denotes user data field

Denotes calculated field

AASHTO Design Parameters:		**Notes**
Design Period, years:	20	
Cumulative Equivalent Single Axle Load (ESAL) Repetitions:	192,000	estimated ESALs for Partial-Depth Reconstruction (Remove & replace AC)
Design Reliability:	80	per ODOT Pavement Design Guide for Rural Minor Collector
Overall Standard Deviation, S_o:	0.49	per ODOT Pavement Design Guide
Initial Serviceability, P_o:	4.2	per ODOT Pavement Design Guide
Terminal Serviceability, P_t:	2.5	per ODOT Pavement Design Guide
New Asphalt Concrete (AC) Layer Coefficient:	0.42	per ODOT Pavement Design Guide

Existing Pavement Conditions:		
Average Existing AC Thickness, inches:	3.25	based on field explorations
Average Layer Coefficient of Existing AC:	0.35	based on surface condition & AASHTO 93 Part III Table 5.2
Aggregate Base (AB), inches:	0.00	based on field explorations
Average Modulus of Aggregate Base Material below AC, psi:	20,000	based on layer coefficient & AASHTO 93 Part II Figure 2.6
Average Layer Coefficient of AB Material:	0.10	based on surface condition & AASHTO 93 Part III Table 5.2
Estimated Effective Structural Number SNeff:	1.14	based on AC thickness and existing AC layer coefficient
Subgrade Mr, psi:	7,400	based on Dynamic Cone Penetrometer data

Calculated Values:	
Subgrade M_r, psi:	7,400
Total Structural Number (SN) required above subgrade:	2.49
Total SN Deficiency:	1.36
AC SN required above base layer:	1.69
Effective AC SN:	1.14
AC SN Deficiency:	0.55
AC Thickness Deficiency, inches:	3.23

Overlay Design:	**Thickness, inches**	**Layer Coeff.**	**SN**	
AC overlay above existing pavement surface:	2.50	0.42	1.05	
AC inlay below existing pavement surface:	3.50	0.42	1.47	
Existing AC removed by inlay:	3.25	0.35	-1.1375	
Existing AB removed by inlay:	0.25	0.10	-0.025	
Net SN above existing base :			2.52	>1.69 required above base - OK
Net Total SN:			2.50	>2.49 required above subgrade - OK

Table 7D: ASPHALT CONCRETE PAVEMENT DESIGN WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 1: IN-PLACE FULL-DEPTH RECLAIMATION FOR 20-YEAR DESIGN PERIOD

AASHTO Design Parameters & Input Values		Notes
Design Period, years	20	per ODOT PDG
Cumulative Equivalent Single-Axle Load (ESAL) Repetitions	316,000	
Design Reliability, %	80	per ODOT PDG
Overall Standard Deviation, S_o	0.49	per ODOT PDG
Initial Serviceability, p_o	4.2	per ODOT PDG
Terminal Serviceability, p_t	2.5	per ODOT PDG
Effective Subgrade Resilient Modulus (M_R), pounds per square inch (psi)	9,600	approximated from dynamic cone penetration (DCP) testing
New Aggregate Base (AB) Modulus, psi	20,000	per ODOT PDG
New Asphalt Concrete (AC) Layer Coefficient	0.42	per ODOT PDG
New AB Layer Coefficient	0.10	per ODOT PDG
New AB Drainage Coefficient	1.00	per ODOT PDG
Structural Number (SN) required above AB	1.84	
SN required above subgrade	2.45	

Pavement Section

Layer Description	Thickness, inches	Layer Coefficient	SN	SN Subtotals	Notes
Level 2, ½-inch Dense ACP, PG 58-22	2.00	0.42	0.84	0.84	
Level 2, ½-inch Dense ACP, PG 58-22	2.50	0.42	1.05	1.89	>=1.84 required above aggregate base - OK
¾-inch-0 Aggregate Base	4.00	0.10	0.40	2.29	>=1.68 required above aggregate subbase - OK
In-place pulverization of existing AC and SG	8.00	0.08	0.64	2.93	>=2.45 required above subgrade - OK
Total Depth	16.50				

Notes:

Denotes user defined value

Denotes calculated value

We recommend a FDR depth such that the blended material has 50% or less of AC material.

Table 8D: ASPHALT CONCRETE PAVEMENT DESIGN WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 2: IN-PLACE FULL-DEPTH RECLAIMATION FOR 20-YEAR DESIGN PERIOD

AASHTO Design Parameters & Input Values		Notes
Design Period, years	20	per ODOT PDG
Cumulative Equivalent Single-Axle Load (ESAL) Repetitions	373,000	
Design Reliability, %	80	per ODOT PDG
Overall Standard Deviation, S_o	0.49	per ODOT PDG
Initial Serviceability, p_o	4.2	per ODOT PDG
Terminal Serviceability, p_t	2.5	per ODOT PDG
Effective Subgrade Resilient Modulus (M_R), pounds per square inch (psi)	9,600	approximated from dynamic cone penetration (DCP) testing
New Aggregate Base (AB) Modulus, psi	20,000	per ODOT PDG
New Asphalt Concrete (AC) Layer Coefficient	0.42	per ODOT PDG
New AB Layer Coefficient	0.10	per ODOT PDG
New AB Drainage Coefficient	1.00	per ODOT PDG
Structural Number (SN) required above AB	1.90	
SN required above subgrade	2.52	

Pavement Section

Layer Description	Thickness, inches	Layer Coefficient	SN	SN Subtotals	Notes
Level 2, ½-inch Dense ACP, PG 58-22	2.00	0.42	0.84	0.84	
Level 2, ½-inch Dense ACP, PG 58-22	3.00	0.42	1.26	2.10	>=1.90 required above aggregate base - OK
¾-inch-0 Aggregate Base	4.00	0.10	0.40	2.50	>=1.72 required above aggregate subbase - OK
In-place pulverization of existing AC and SG	8.00	0.08	0.64	3.14	>=2.52 required above subgrade - OK
Total Depth	17.00				

Notes:

Denotes user defined value

Denotes calculated value

We recommend a FDR depth such that the blended material has 50% or less of AC material.

Table 9D: ASPHALT CONCRETE PAVEMENT DESIGN WORKSHEET

TUMALO RESERVOIR ROAD - SEGMENT 3: IN-PLACE FULL-DEPTH RECLAIMATION FOR 20-YEAR DESIGN PERIOD

AASHTO Design Parameters & Input Values		Notes
Design Period, years	20	per ODOT PDG
Cumulative Equivalent Single-Axle Load (ESAL) Repetitions	192,000	
Design Reliability, %	80	per ODOT PDG
Overall Standard Deviation, S_o	0.49	per ODOT PDG
Initial Serviceability, p_o	4.2	per ODOT PDG
Terminal Serviceability, p_t	2.5	per ODOT PDG
Effective Subgrade Resilient Modulus (M_R), pounds per square inch (psi)	7,400	approximated from dynamic cone penetration (DCP) testing
New Aggregate Base (AB) Modulus, psi	20,000	per ODOT PDG
New Asphalt Concrete (AC) Layer Coefficient	0.42	per ODOT PDG
New AB Layer Coefficient	0.10	per ODOT PDG
New AB Drainage Coefficient	1.00	per ODOT PDG

Structural Number (SN) required above AB	1.69
SN required above subgrade	2.49

Pavement Section

Layer Description	Thickness, inches	Layer Coefficient	SN	SN Subtotals	Notes
Level 2, ½-inch Dense ACP, PG 58-22	2.00	0.42	0.84	0.84	
Level 2, ½-inch Dense ACP, PG 58-22	2.50	0.42	1.05	1.89	>=1.69 required above aggregate base - OK
¾-inch-0 Aggregate Base	4.00	0.10	0.40	2.29	>=1.71 required above aggregate subbase - OK
In-place pulverization of existing AC and SG	8.00	0.08	0.64	2.93	>=2.49 required above subgrade - OK
Total Depth	16.50				

Notes:

Denotes user defined value

Denotes calculated value