



Department Memorandum

Idaho Transportation Department

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DATE: 3/5/2025

Program Number(s) A021(860)

TO: Todd Hubbard P.E.
D5 District Engineer

Key Number(s) 21860

FROM: Nikolai Greer P.E.
D5 Materials Engineer

Program ID, County, Etc. US-91, Park Lawn to
Siphon Rd

RE: US-91, Park Lawn to Siphon Rd Materials Report

Your approval of this Roadway Materials Report is requested.

This report presents the geotechnical findings for US-91 starting at the Park Lawn Ave intersection at MP 81.2 to the Siphon Rd intersection at MP 81.7.

Recommended by:

Nikolai Greer P.E.

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ROADWAY MATERIALS REPORT

US-91, Park Lawn to Siphon Rd

CHUBBUCK, IDAHO

ITD KEY NO. 21860

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Submitted To: Kimley-Horn
1100 W. Idaho St., Suite 210
Boise, Id. 83702
Attn: Robert Beckman, PE

Subject: ROADWAY MATERIALS REPORT
ITD KN 21860
US-91, PARK LAWN TO SIPHON RD
CHUBBUCK, IDAHO

Shannon & Wilson prepared this report and participated in this project as a subconsultant to Kimley-Horn. Our scope of services was specified in Project Order Number 093937002-1 with Kimley-Horn dated 12/16/2022. This report presents the results of the field exploration, analyses, and design recommendations for the Roadway Materials Report and was prepared by the undersigned in accordance with the ITD Materials Manual.

Shannon & Wilson has included the document "Important Information About Your Roadway Materials Report" following this report to assist you and others in understanding the use and limitations of our reports.

We appreciate the opportunity to be of service to you on this project. If you have questions concerning this report, or we may be of further service, please contact us.

Sincerely,

SHANNON & WILSON



Mart E. Earl, WAQTC
Geotechnical Technician

MEE/MJS



Michael J. Santi, PE
Pavement Engineer

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Important Information about your Roadway Materials Report

240.00 ROADWAY MATERIALS REPORT

240.01 Introduction

This roadway widening project is located in the City of Chubbuck, Idaho, on US-91 (a.k.a. Yellowstone Ave), beginning at 180 ft north of the intersection of Park Lawn Avenue (MP 81.20) and ending at Southside Way (MP 81.70). The project length is about 0.50 miles and involves both travel directions for the full width of the roadway. The intersection of US-91 and about 400 ft of Siphon Rd / New Day Parkway will also be reconstructed.

The functional classification of the roadway is a Principal Arterial. The roadway has one lane in each direction, with a center turn lane. The current width of the roadway is about 40-ft with 12-ft lanes and 2-ft paved outside shoulders. The existing roadway has been constructed in different stages. The original roadway was constructed with Portland Cement Concrete (PCC) and was widened using flexible pavement with several Asphalt Concrete (AC) overlays added over time. The PCC layer is near the center turn lane, as identified in a GPR Memorandum prepared by American Geotechnics on August 30, 2021. The route speed limit is 35 MPH.

The proposed roadway will have four 12-ft lanes and a 14-ft two-way left turn lane (TWLTL). A 5-ft sidewalk with curb and gutter will extend the length of the project on the west side of US-91. A 10-ft multi-use path with a 15-ft buffer zone will be added along the east side of US-91. A new northbound right turn lane from US-91 onto New Day Parkway is planned. A new northbound right turn lane from US-91 into the Legacy Development adjacent to Briscoe Rd is also planned. This project includes short segments of Siphon Road and New Day Parkway at the intersection with US-91.

The project development primarily consists of the following:

- Pavement reconstruction and/or rehabilitation
- Widening

In collaboration with the Idaho Transportation Department (ITD), Shannon & Wilcon (S&W) selected the following design alternatives for feasibility evaluation and life cycle cost comparison.

- Alternative 1 – Mill/Overlay with Flexible Construction Widening.
- Alternative 2 – AC Removal and HMA Overlay with Flexible Reconstruction.
- Alternative 3 – Flexible Reconstruction.

- Alternative 4 – Rigid Reconstruction.

The proposed construction year is 2026.

240.02 Vicinity Map

A Vicinity Map is shown in Appendix B.

240.03 Soils Profile

This project involves widening and reconstruction along an existing alignment, such that soils profile drawings are not needed.

Ten roadway borings were advanced through the existing pavement structure to a depth of 6 ft, as shown on the Exploration Map in Appendix C. The boring logs were updated to include laboratory ASTM D2487 (USCS) soils classification information. Laboratory test reports are in Appendix D. Subgrade soils classified as Lean Clay (CL), and Silty Clay (CL-ML), Silty Gravel with Sand (GM). The subsurface explorations are further discussed in Section 540.03 Existing Pavement Structure – Materials and Thicknesses.

The following table summarizes the subgrade soil characteristics throughout the project.

Table 240.03-1: Summary of Subgrade Soil Laboratory Test Results

Sample		Water Content (%)	Atterberg Limits			Particle Size			USCS
Location	Depth (ft)		LL (%)	PL (%)	PI	Gravel (%)	Sand (%)	Fine (%)	
B-01	2.0-4.0	22.5	29	21	8	2	6	92	CL
B-02	4.0-6.0	20.4	28	22	6	3	11	86	CL-ML
B-03	4.0-6.0	20.4	27	20	7	2	11	87	CL-ML
B-05	2.2-2.9	--	23	20	3	1	10	89	ML
B-06	4.0-6.0	21.5	32	21	11	0	8	93	CL
B-07	2.0-4.0	22.7	28	19	9	1	6	93	CL
B-09	2.0-4.0	18.8	28	20	8	12	17	71	CL
B-11	2.0-4.0	8.2	--	--	--	38	23	39	GM

Acronyms:

“—” = Indicates the test was not completed

The moisture content is typically at or above the plastic limit, which indicates that Excavation and Repair of Soft Spot (205.03.D) of fine-grained subgrade soils may be necessary.

Contaminated soils were not identified.

240.04 Soil Report Summary

This project involves widening and reconstruction along an existing alignment; therefore, a Soil Report Summary Form ITD-944 was not prepared.

240.05 Total Design Pavement Thickness

All pavement design evaluations were completed using AASHTOWare Pavement ME design software, using procedures outlined in the ITD Materials Manual.

A review of the four pavement design strategies shown above, indicate.

- Alternative 1 – Mill/Overlay with Flexible Construction Widening does not appear feasible as the mill/overlay section fails in total pavement permanent deformation at about year 12.
- Alternative 2 – AC Removal and HMA Overlay with Flexible Reconstruction & Widening appears to meet the requirements for a 20-year design life. However, concerns for the potential of reflective cracking along the edges of the buried PCC layer, difficulty when excavating through and replacing in kind for any utility work, and not having a uniform cross section makes this option viable but not recommended.
- Alternative 3 – Flexible Reconstruction will remove the existing flexible pavement and the buried PCC layer and will create a uniform section across the roadway. This option meets the criteria for a 20-year design life and allows for a single construction event over this short roadway segment. For these reasons, Alternative 3 is the preferred design strategy and is summarized in the following table.

Table 240.05-2: –Alternative 3 - Flexible Reconstruction

Pavement Layer	Thickness (ft)
HMA	0.45
Untreated Aggregate Base	0.75
Granular Subbase	1.00
Total	2.20

- Alternative 4 – Rigid Reconstruction has the highest initial project cost, net present worth and equivalent uniform annual cost in the Life Cycle Cost Analysis (LCCA) of all the alternatives.

240.06 Sub-subgrading

Sub-subgrading is not required.

240.07 Grade Pointing

Grade pointing is not planned.

240.08 Special Placement

Soft Spot Repair

Soft spots may be anticipated when the moisture content is near the plastic limit.

Excavation of fine-grained subgrade soils may be necessary.

Excavation and Repair of Soft Spot (205.03.E.)

- Aggregate for Granular Subbase (703.11)
- Subgrade Separation Geotextile, Type III (718.07)
- Biaxial Geogrid, Type I (641)

240.09 Compaction

Compact roadway materials in accordance with ITD Standard Specifications – Section 205.03.G and current supplemental specifications.

240.10 Slope Design Summary

The roadway profile will not change; therefore, a slope design summary is not needed.

240.11 Slope Design

All slopes will conform to ITD standards.

240.12 Embankment Foundation

Embankment foundations are not planned.

240.13 Surface and Subsurface Water

Surface run-off and run-on from precipitation will be collected via curb and gutter. A roadside ditch on the east side of the roadway will be impacted by the widening. The ditch is expected to be piped prior to roadway construction in accordance with current ITD Standard Specifications for Highway Construction

Ground water was not encountered in the roadway borings. The depth to groundwater is expected to be at greater than 25 ft below the pavement surface.

240.14 Drainage

A stormwater drainage outfall is planned at the southwest corner of US-91 and Siphon Rd on State-purchased property. Further evaluation of the planned drainage facilities was not included in this evaluation. Additional materials recommendations can be made after further observations and analysis are scheduled and completed.

240.15 Geosynthetics

The subgrade soils typically have more than 50% passing the No. 200 sieve and a plasticity index near or greater than 10. For subgrade separation, show a Subgrade Separation Geotextile, Type III (718.07) immediately below the pavement structure.

For Sub-subgrading, and Repair of Soft Spot, specify Subgrade Separation Geotextile - Type III (718.07) together with Biaxial Geogrid, Type 1 (641).

240.16 Existing Roadway Material

Pulverized asphalt and existing base materials from required project excavations may be reused as Granular Subbase so long as the pulverized asphalt and existing base meets the material requirements for Granular Subbase (301.03.D).

240.17 Rock Subgrade

Exposed rock subgrades are not anticipated. However, the contractor should use care in excavating to the top of and along the sides of the buried PCC layer. The buried PCC layer is approximately 1 ft below the roadway surface. A GPR Memo dated August 30, 2021 by American Geotechnics shows the location of the buried PCC throughout the project.

240.18 Topsoil

All topsoil required on the project must be provided by the Contractor from Contractor Furnished Sources.

240.19 Pipe

All pipes are planned to be extended or replaced within the project limits. Culverts should be replaced with like materials and diameters.

The following table summarizes the soil corrosion data test result.

Table 240.19-3: Summary of Soil Corrosion Test Results

Sample Location	pH	Resistivity (ohm-cm)	Chloride (mg/kg)	Sulfate (mg/kg)	Bed Load ¹
CV-12	7.7	3,000	49	24	N

240.20 Riprap

Riprap is not required.

240.21 Staged Construction

Staged construction for time-rate consolidation of embankment foundation is not required.

240.22 Pavement Data

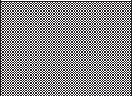
Flexible Pavement

For the US-91, Park Lawn to Siphon Rd widening project, the recommended pavement type is Superpave Hot Mix Asphalt, Class SP-3 (405) using PG 64-34 binder. Specify Schedule II Surface Smoothness (405.03.P).

Typical Sections

The following table summarize the typical section recommended for this project.

Table 240.22-4: Flexible Reconstruction and Widening Typical Section

US-91, Park Lawn to Siphon Rd			
	Thickness (ft)	Layer	Materials
	0.45	Superpave Hot Mix Asphalt, Class SP-3 (405); 2 equal lifts	Aggregate for Superpave HMA Pavement, 1/2-inch (703.05) Asphalt, PG 64-34 (702.01)
	0.75	Aggregate Base (303)	Aggregate for Untreated Base, 3/4-inch Type B (703.04)
	1.00	Granular Subbase (301)	Aggregate for Granular Subbase (703.11)
		Geotextile Interlayer	Subgrade Separation Geotextile, Type III (718.07)

240.23 Base

Geotextile on Subgrade

Subgrade Separation Geotextile, Type III (718.07)

Granular Subbase (301)

Aggregate for Granular Subbase (703.11)

Granular Subbase (301) with RAP

Aggregate for Granular Subbase (703.11) mixed with less than 50% Recycled Asphalt Pavement (RAP), (720.07) per 301.03.D.

Aggregate Base (303)

Aggregate for Untreated Base, ¾-inch Type B (703.04)

Tack Coat on New HMA

Emulsified Asphalt, CSS-1 (702.03) diluted (1:1 ratio) asphalt applied at a rate of 0.10 gal/sy (residual rate of 0.03 gal/sy estimated).

Tack Coat on Old PCC

Emulsified Asphalt, CSS-1 (702.03) diluted (1:1 ratio) asphalt applied at a rate of 0.15 gal/sy (residual rate of 0.05 gal/sy estimated) for existing PCC surfaces.

240.24 Surface Treatment

A surface treatment (404) is not anticipated.

240.25 Paving

Flexible Pavement

Aggregate for Superpave HMA Pavement, ½-inch (703.05)

Asphalt, PG 64-34 (702.01) at 5.6% by weight of mix (estimated)

Anti-Stripping Additive (702.04) at 0.5% by weight of asphalt binder (estimated)

240.26 Seal

A seal coat is not planned.

240.27 Dust Abatement

Water for Dust Abatement is estimated at 1,584 MG of water for dust abatement, base on the following equation from the 2023 Materials Manual.

$$((17,600 \text{ SY (app)}) \times (3 \text{ (app) day}) \times (60 \text{ days}) \times (0.5 \text{ gal SY}))/1000 = 1,584 \text{ MG}$$

240.28 Aggregate Estimating Data

Superpave Hot Mix Asphalt (405)

Aggregate for Superpave HMA Pavement at 148 lb/cf, including asphalt (estimated)

Aggregate Base (303)

Aggregate for Untreated Base at 146 lb/cf, including 7% water (estimated)

Granular Subbase (301)

Aggregate for Granular Subbase at 138 lb/cf, including 7% water (estimated)

Soft Spot Repair (205) (304)

Combined areas of soft spot repair are estimated to be about 300 sy with 2 ft of sub-excavation (estimated).

Disclaimer

The unit weights in this estimating basis are provided to the designer to develop approximate project quantities. The actual quantities will vary depending on the Contractor-provided sources, crushing operations, and mix designs. The Contractor is solely responsible for determining actual unit weights based on the methods of production and providing adequate materials for the project plus any losses due to stockpile operations, out of specification (rejected) materials, or other wastes.

240.29 Aggregate Sources

Source Identification

Approved Contractor-furnished sources are specified for all aggregates.

Designated Sources

Designated sources are not identified for this project.

Contractor Provided Sources

The Contractor shall furnish approved sources(s) for all materials to be embanked or processed for placement. A list of State-owned or State-controlled sources is available at the ITD District office. Written approval of the Contractor's source operation plan will be required prior to accepting materials or using State-owned or State-controlled sources.

Cost

The Contractor shall be responsible for all costs incurred in obtaining approval for the use of source(s).

240.30 Current Specifications and Minimum Testing Requirements

The following documents are applicable:

- Idaho Transportation Department (ITD). 2020. Materials Manual.
- Idaho Transportation Department (ITD). 2019. Quality Assurance Manual.
- Idaho Transportation Department (ITD). 2023. Standard Specifications for Highway Construction.

240.31 Modification of Standard Specifications

There are no materials-related modifications to the Standard Specifications.

240.32 Special Provisions

There are no Special Provisions.

240.33 Notes to Contractor

Estimating Basis

The unit weights in the estimating basis were estimated from area history and past project experience. This information is provided to assist the designer in developing reasonable project quantities. The actual quantities will vary dependent on Contractor furnished source, crushing operations, and mix designs. The Contractor is responsible for determining actual unit weights based on the material produced and providing adequate materials for the project, plus any losses to stockpile operations or other wastes.

Soft Subgrade Soils

The Contractor should anticipate soft and moisture-sensitive subgrade soils which could occur throughout this project. These soils will be prone to rutting or pumping under construction equipment, especially if they become wetter than optimum moisture content at the time of construction.

The Contractor is to protect these soils during construction activities, and the Contractor is to determine how best to achieve this requirement. No separate measurement of payment will be made for any excavation or replacement of excavated material below subgrade elevation made necessary from construction activities.

Excess Material Sites

Excess material sites will conform to the requirements of ITD Standard Specifications Subsection 205.03.A – General. All excess or unsuitable material removed from the project becomes the property of the Contractor.

240.34 Notes to Resident Engineer

There are no notes to the Resident Engineer.

240.35 Notes to Designer

Revision of This Roadway Materials Report

Delay of project advertisement or project changes that occur after the final design package is issued often necessitate revisions to the Roadway Materials Report. The Roadway Materials Report must be reviewed and revised as necessary when any of the following occur after the original Roadway Materials Report is issued and before project advertisement:

- New standard specifications or supplemental specifications are released and are to be used on the project.
- Revised Minimum Testing Requirements (MTRs) are released.
- Additional bid items are added to the project, and design changes are made that have an impact on materials specification.

Geotechnical/Materials Review After Final Design

In the ITD “Consultant Agreement Specifications” document, the policy states that

“the Consultant must ensure that any Subconsultant performing geotechnical, and materials work be involved in the final design review. This does not mean that the geotechnical materials consultant must attend the actual final design review meeting, but does mean that the Subconsultant, will at a minimum, participate in the final design plan and proposal review to assure that all geotechnical and materials recommendations/issues it raised concerning the project have been addressed, or notify the Consultant of any outstanding issues.” (2019)

540.00 PAVEMENT STRUCTURE ANALYSIS

540.01 Methodology

AASHTOWare Pavement Mechanistic-Empirical (ME) Design is ITD's method (ITD 2020 Materials manual Section 520) for analyzing the existing pavement structure and designing the recommended pavement strategies for the US-91, Park Lawn to Siphon Road project.

AASHTO 1993 design procedures were used to develop layer thickness for seed values Pavement ME evaluation.

The performance criteria and reliability levels for the ME approach are listed in the calculation summaries in Appendix F.

Existing Pavement Conditions

The last known rehabilitation consisted of sealcoat, which occurred in 2014.

Visual Pavement Distress Survey

Shannon & Wilson performed a pavement distress survey for the project in January 2023, in general accordance with the FHWA Distress Identification Manual for Long-Term Pavement Performance Program (FHWA 2014) The following tables present the dominant distresses observed throughout the project.

Table 540.02-1: Observed Pavement Distresses of AC Pavement

Distress Type	Severity	Notes
Fatigue (Alligator) Cracking	Low	< 5%-wheel path average
Transverse Cracking	Low	Estimated less than 300 ft/mi
Longitudinal Cracking	Low	< 5%-wheel path average
Block Cracking	Low	< 5%-in north bound lane
Edge Cracking		None
Rutting	Low	Average Depth < 0.10 inch
Patch/Patch Deterioration	Low	Utility patch
Potholes		None
Shoving		None
Bleeding	Low	About 25% of the roadway

1 NOTES:

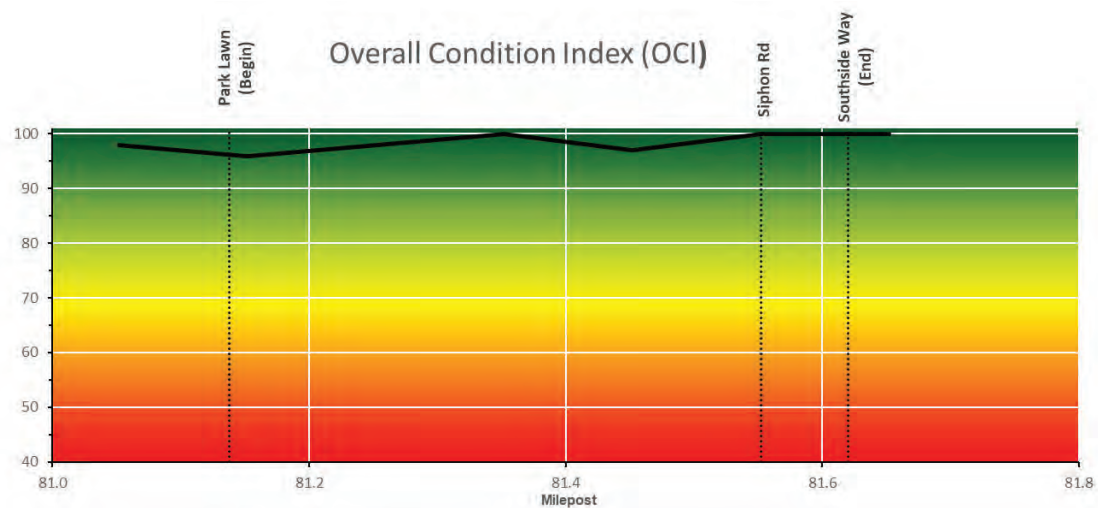
2 Pavement Distresses noted in accordance with 2014 FHWA Distress Identification Manual for the Long-Term pavement performance Program.

Based on the visual pavement distresses and Tables 520.07.07.1 and 520.07.07.2 in the ITD Materials manual, the existing pavement is rated in “Good” condition.

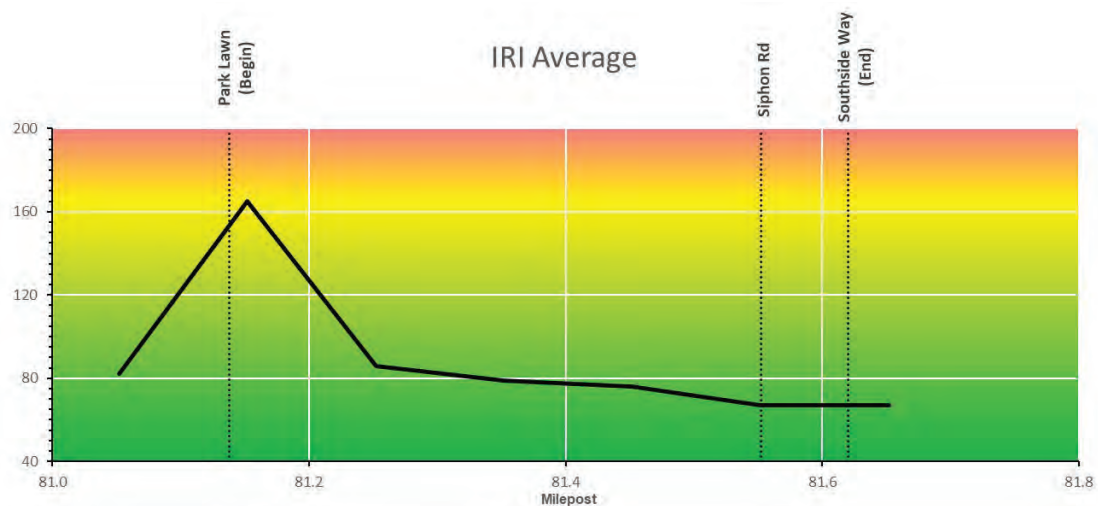
540.02 ITD Pavement Condition Data

The ITD asset management group provided pavement performance data from July 2022 consisting of three measurements related to cracking: the international roughness index (IRI), rutting depth, and an overall condition index (OCI) obtained from the ITD profiler van measurements. Values for fatigue cracking and transverse cracking were also included, which is pertinent input for Pavement ME analysis. The following graphs and table summarize the measured ITD pavement condition parameters from 2022.

Graph 540.02-2: Summary of ITD 2022 Overall Condition Index (OCI) Values



Graph 540.02-3: Summary of ITD 2022 International Roughness Index (IRI) Values



Graph 540.02-4: Summary of ITD 2022 Rutting Values

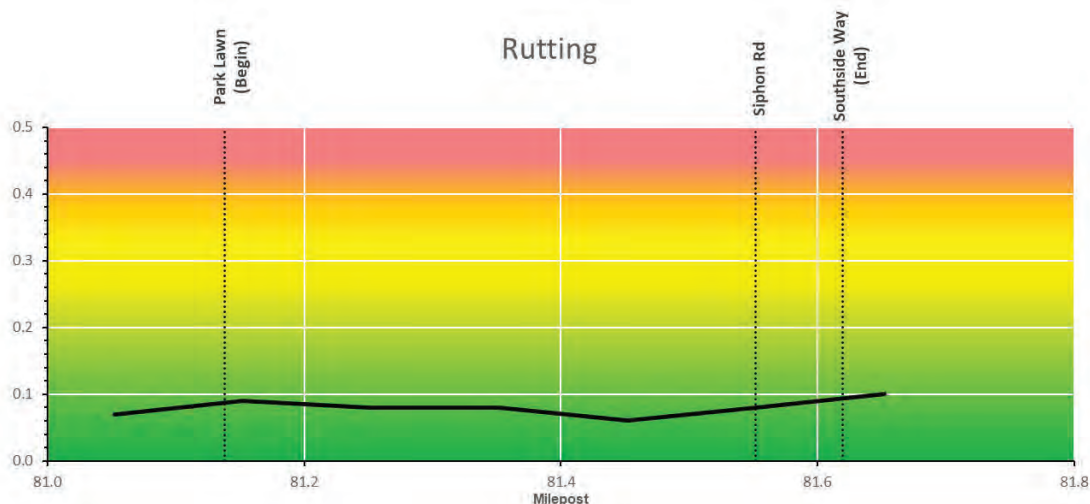


Table 540.02-5: Summary of ITD Pavement Condition

Average OCI	Average IRI	Weighted Average Rutting (inches)	Avg Condition State (OCI, IRI, Rutting)
98.45	90	0.08	Fair to good

540.03 Existing Pavement Structure – Materials and Thicknesses

Borings

10 roadway borings were advanced through the existing pavement structure to a depth of 6 ft as shown on the Exploration Map in Appendix C. The boring logs were updated to include laboratory ASTM D2487 (USCS) soils classification information. Laboratory test reports are in Appendix D. Subgrade soils classified as Lean Clay (CL), and Silty Clay (CL-ML), Silty Gravel with Sand (GM).

GPR

Existing pavement structure layers were evaluated by reviewing ground penetrating radar (GPR) data with the pavement borings through the ballast layers.

Shannon & Wilson collected GPR data to supplement recent boring explorations using a short-pulse GPR imaging system in general accordance with ASTM D4748. The components of the Shannon & Wilson GPR system include a GSSI SIR-30 controller and two antennas. The 2 GHz, air-coupled antenna is especially suited for collecting detailed data collection in the upper 24 inches of the pavement structure. The 400 MHz, ground-coupled antenna collected data to about 5 ft below the pavement surface for project-level analysis.

The GPR data was post processed using GSSI© RADAN7™ software and facilitated a substantial understanding of the variability of the roadway pavement structure layers. Pavement structure layer imaging was developed from scans obtained at 4-inch intervals along the length of the roadway and 512 samples per scan interval. In all, about 3.8 million discrete GPR data points were collected for use on this project. GPR layers profiles and statistics are in Appendix C.

The following tables shows the thicknesses of the existing pavement structure for each lane on US-91 and Siphon Road/New Day Pkwy.

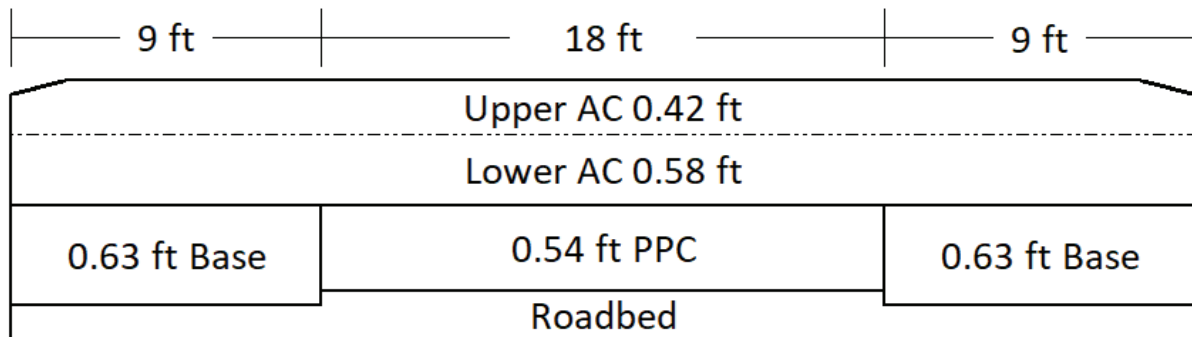
Table 540.03-6: Existing Pavement Layer Thickness Summary (US-91)

Existing Pavement Layer	Statistic	Layer Thicknesses in Ft		
		SB Lane	Center Turn Lane	NB Lane
Existing AC	Average	1.08	0.97	0.95
	Minimum	0.80	0.74	0.69
	Maximum	1.42	1.27	1.25
	Std. Dev.	0.12	0.08	0.11
Buried PCC	Average	---	0.54	---
	Minimum	---	0.13	---
	Maximum	---	0.98	---
	Std. Dev.	---	0.14	---
Existing BASE	Average	0.64	---	0.61
	Minimum	0.22	---	0.20
	Maximum	1.25	---	1.04
	Std. Dev.	0.17	---	0.17

Table 540.03-7: Existing Pavement Layer Thickness Summary (Siphon Rd / New Day Pkwy)

Existing Pavement Layer	Statistic	Layer Thicknesses in Ft	
		Siphon Rd (WB)	New Day Pkwy (EB)
Existing AC	Average	0.33	0.30
	Minimum	0.23	0.16
	Maximum	0.54	0.48
	Std. Dev.	0.05	0.08
Existing BASE	Average	0.38	1.05
	Minimum	0.19	0.54
	Maximum	0.58	1.62
	Std. Dev.	0.08	0.19

Figure 540.03-8: Existing Cross Section of US-91



Groundwater was not encountered at the time of drilling.

The boring logs were updated to include laboratory ASTM D2487 (USCS) soils classification information. Laboratory test reports are in Appendix D. Subgrade soils classified as Lean Clay (CL), and Silty Clay (CL-ML), Silty Gravel with Sand (GM). The soils have F4 frost susceptibility characteristics, as classified by the US Army Corps of Engineers (USACE 2001).

540.04 Traffic Load

The ITD roadway data section provided traffic data. The following table summarizes the project design parameters for traffic loading.

Table 540.04-9: Traffic Data Summary for Pavement ME

Traffic Data Summary	Design Parameter
Commercial Traffic (CADTT)	297
Number of Lanes in Design Direction	2
Percent Trucks in the Design Direction	60%
Percent Trucks in the Design Lane	100%
20-Year Flexible ESALS (TI) ¹	3,070,681 (10.3)
40-Year Rigid ESALS ¹	14,948,582

Notes:

1 ITD traffic projections calculated from the ITD projected commercial and 18,000 ESAL loadings.

The following is the assumed FHWA vehicle class truck traffic distribution used for design, as defined by ITD in 520.05.02.5 for a Primary Arterial roadway with similar conditions.

Table 540.04-10: FHWA Vehicle Class Truck Traffic Distribution

FHWA Vehicle Class		AADTT Volume (%)
4. Buses		0.8
5. Two-Axle, Six-Tire, Single-Unit Trucks		30.8
6. Three-Axle Single-Unit Trucks		6.9
7. Four or More Axle Single-Unit Trucks		0.1
8. Four or Fewer Axle Single-Trailer Trucks		7.8
9. Five-Axle Single-Trailer Trucks		37.5
10. Six or More Axle Single-Trailer Trucks		3.7
11. Five or Fewer Axle Multi-Trailer Trucks		1.2
12. Six-Axle Multi-Trailer Trucks		4.5
13. Seven or More Axle Multi-Trailer Trucks		6.7

Load spectra data used in the AASHTOWare Pavement ME design analysis was adjusted to match ESALs provided by ITD.

540.05 Climate

For ME analysis, local weather stations within the project climate zone and near the project elevation provided MERRA2 for flexible and NARR for rigid climate data to predict the temperature or moisture content of the various pavement structure layers. Specific weather station(s) used are identified in the Pavement ME Reports located in Appendix F.

Frost Depth

A design frost depth of 36 inches was selected for this part of Bannock County. Based on the Soil classifications, the subgrade frost group is "F4" per the US Army Corps Engineers (USACE 2001). For "F4" soils, it is recommended the pavement structure be at least 70% of the frost depth (25 inches).

540.06 Deflections and Layer Moduli

Shannon & Wilson obtained pavement deflection measurements every 200 ft along the north and south bound lanes and the center of the turn lane on April 26, 2023. The testing was performed using a Dynatest 8002-158 Falling Weight Deflectometer (FWD), in accordance with ASTM D4694 (ASTM International 2015). The FWD had nine deflection sensors capable of 100-mil deflections located at 0", 8", 12", 18", 24", 30", 36", 48", and 60". The plate diameter was 5.91". Each test location included two targeted 9,000-lb load drops and two 12,000-lb drops. The measurements were located with a Trimble AG 332 GPS survey instrument for subsequent correlation with GPR layer thicknesses. At each test location, infrared pavement surface temperature and air temperature were measured. The FWD equipment annual reference calibration certificate and monthly relative calibrations were up to date.

After reviewing the deflection data and anticipated truck load limits, Shannon & Wilson selected the second 12,000-lb drop load from each test sequence for analysis. All deflections were normalized to the 12,000-lb target load. The following plot shows US-91 normalized 12,000-lb average FWD deflections measured for the D(0) plate sensor and the D(48) sensor.

Figure 540.06-11: Normalized 12,000 lb drop FWD Surface Deflection for US-91

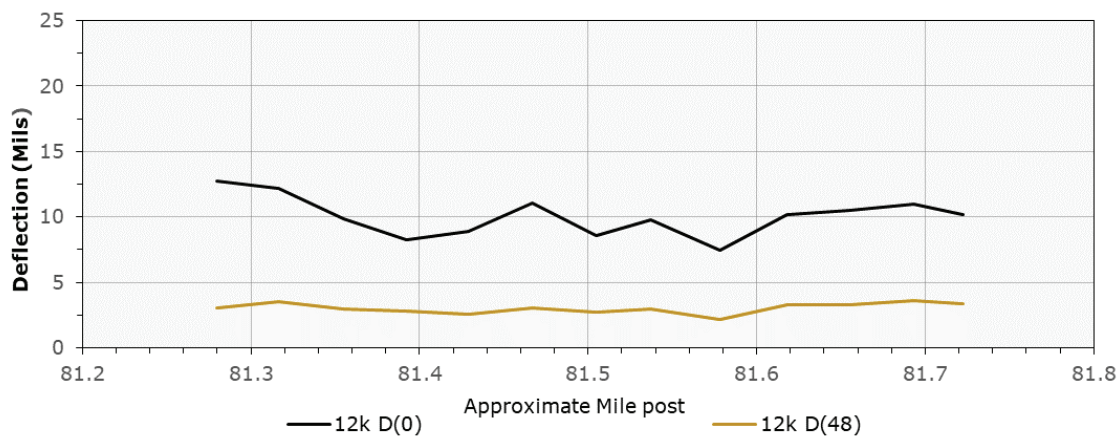
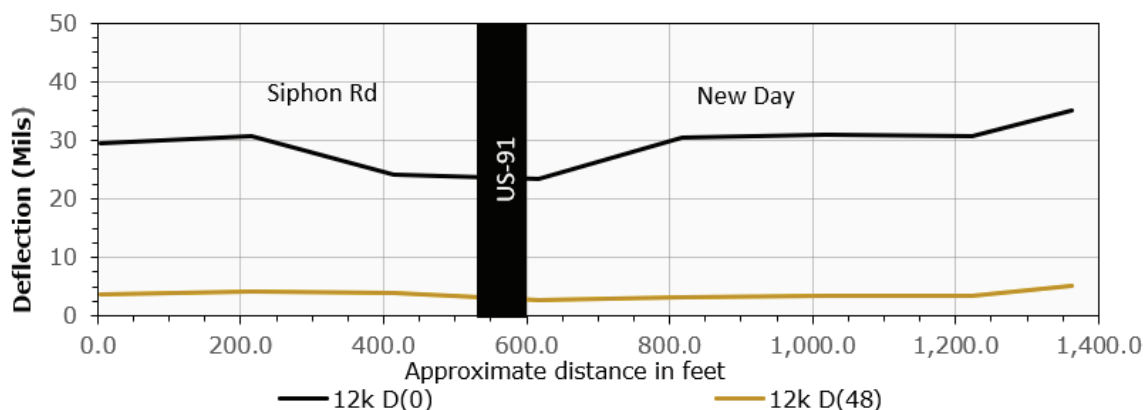


Figure 540.06-12: Normalized 12,000 lb drop FWD Surface Deflection for Siphon Rd and New Day Pkwy



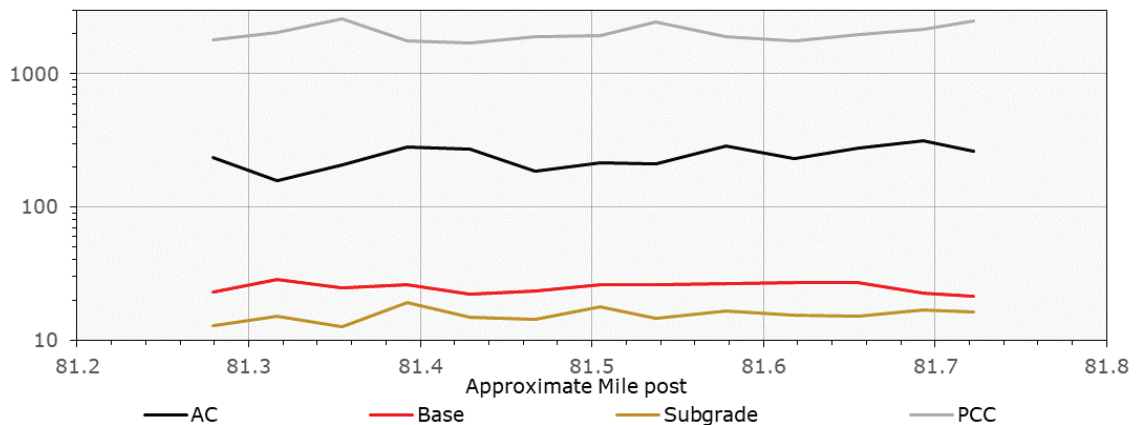
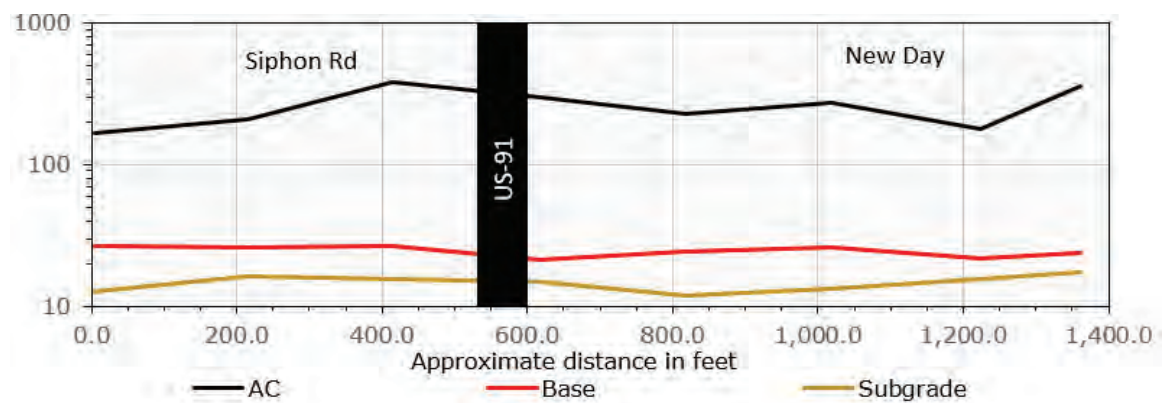
The D(0) sensor is a surface response, and the D(48) sensor is an indication of subgrade response. Summaries of FWD data and backcalculation results are included in Appendix C.

Layer Moduli

The stiffness or elastic modulus of the asphalt concrete (AC) surface course is sensitive to temperature. Elastic modulus back-calculation for the AC layer stiffness was adjusted to a reference temperature of 70°F using the BELLS method and the previous average daily temperature (PADT), in accordance with ASTM D7228 (ASTM International 2006). The PADT was 51°F on April 25, 2023.

Elastic moduli back-calculation is also sensitive to the thickness of the pavement structure layers. Constructed roadway pavement structure layers may vary significantly. For each FWD drop location, layer thicknesses measured from the GPR imaging were correlated via submeter accurate GPS for true multipoint analyses.

The “deflection basin fit” method was used to back-calculate layer elastic moduli, and ELMOD6 facilitated the back-calculation of elastic moduli of the layered ballast (Dynatest International 2018). The following graph(s) and table(s) summarize(s) the back-calculated elastic moduli at each FWD drop location.

Figure 540.06-13: Back-Calculated Elastic Moduli (E_{FWD}) for Existing Pavement Layers (US-91)¹Figure 540.04-14: Back-Calculated Elastic Moduli (E_{FWD}) for Existing Pavement Layers (Siphon Rd and New Day Pkwy)¹Table 540.06-15: Summary of Back-Calculated Elastic Moduli (E_{FWD}) for Existing Pavement Layers (US-91 and Siphon Rd/New Day Pkwy)¹

Pavement Layer	Statistic	US-91 Backcalculated Elastic Moduli (E_{FWD}) Values by Lane (ksi)			
		SB	CTL	NB	Ave
AC	Mean E_{FWD} (ksi)	230.3 ²	206.5 ²	253.0 ²	229.9 ²
	Std. Deviation	55.1	61.3	48.5	55.0
PCC	Mean E_{FWD} (ksi)	--	1987.8	---	1987.8
	Std. Deviation	--	240.9	---	240.9
Existing Base	Mean E_{FWD} (ksi)	24.7	25.5	23.6	24.6
	Std. Deviation	3.5	7.3	4.4	5.1
Subgrade	Mean E_{FWD} (ksi)	15.6	15.4	15.2	15.4
	Std. Deviation	2.2	2.2	2.7	2.4

Pavement Layer	Statistic	Siphon/New Day Backcalculated Elastic Moduli (E_{FWD}) Values by Lane (ksi)		
		East Bound	West Bound	Ave
AC	Mean E_{FWD} (ksi)	255.3 ²	207.5 ²	231.4 ²
	Std. Deviation	59.1	91.3	75.2
Existing Base	Mean E_{FWD} (ksi)	25.3	23.2	24.3
	Std. Deviation	4.2	2.8	3.5
Subgrade	Mean E_{FWD} (ksi)	14.5	14.3	14.4
	Std. Deviation	1.3	2.6	2.0

NOTES:

- 1 Back-calculation results were computed using Dynatest ELMOD6™ Software.
- 2 Adjusted to Reference Condition (70 ° F)

C-Value and Resilient Moduli for Existing Pavement Layers

AASHTO Pavement ME analysis is performed on Resilient Modulus (M_R), input for unbound materials. Therefore, E_{FWD} values are converted to resilient moduli using the following correlation: $M_R = \text{C-Value} \times E_{FWD}$.

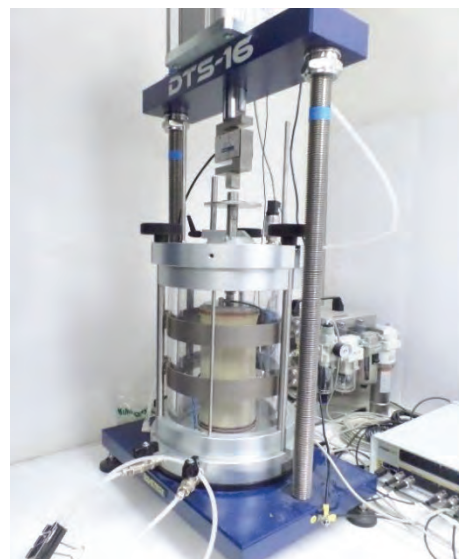
AASHTO (AASHTO 2020) analyses account for data quality according to the following:

- **Level 1:** Project Site-Specific Input
- **Level 2:** Local Vicinity Input
- **Level 3:** National Default Input
- The Level 3 C-Value for subgrade soils beneath an unbound aggregate base is 0.35. For aggregate base materials beneath an existing AC layer, the Level 3 C-Value is 0.62 (AASHTO 2020).

Improving data quality can lead to a more cost-effective design solution. A higher C-Value may be justified when AASTHO T 307 resilient modulus testing is performed.

One subgrade resilient modulus test was performed on an undisturbed subgrade sample obtained using a 4-inch diameter tube. The resilient modulus test report is in Appendix D.

AASHTO T 307 test load sequence 13 (TRB 2003) was used to develop a design resilient modulus for subgrade soils.



The following are the design resilient moduli and C-values used for this project.

Table 540.06-16: Summary of C-Values for Existing Unbound Pavement Layers

Layer	Location	M_r	E_{FWD}	C-Factor	Data Quality
Subgrade	Boring SW-05	4,832	14,433 ¹	0.33	Level 1
Existing Aggregate Base	---	N/A	24600	0.62	Level 3

NOTE:

- 1 Average of nearby subgrade E_{FWD} modulus values.

Table 540.06-17: Design Resilient Moduli (M_r) for Existing Pavement Layers

Layer	Design M_r (ksi)
AC	229,900
PCC	1,987,800
Base	15,300 ¹
Subgrade	4,800

NOTE:

1. Average existing base E_{FWD} modulus (24,600) X 0.62.

Design Moduli for New Layers

The following table shows the design moduli assumed for new layers in the design analyses.

Table 540.06-18: Design Resilient Moduli (M_r) for New Pavement Layers

Layer	Design M_r (ksi)
Aggregate for Untreated Base	40
Aggregate for Granular Subbase	30

Dynamic Modulus of New HMA

The dynamic modulus of the new HMA layer is dependent on truck speed, tire load and pressure, and the thickness of the HMA layer.

A review of the ITD ME Database V3.0 was made but an appropriate HMA mix for this project for Level 1 design analysis was not available.

Layer Material Properties for ME Analysis

For the AASHTOWare Pavement ME design method, the calculation summaries in Appendix F provide a full list of the material properties and associated calibration factors for the various pavement layers.

540.07 Analyses and Designs

Evaluation of Pavement Design Alternatives

For flexible pavement, 20 years of service is specified. For rigid pavement, 40 years of service is required. The traffic opening date is assumed to be 2026.

Analysis strategies included the following:

- Alternative 1* – Mill/Overlay with Flexible Construction Widening.
- Alternative 2* – AC Removal and HMA Overlay with Flexible Reconstruction Widening
- Alternative 3 – Flexible Reconstruction and Widening.
- Alternative 4 – Rigid Reconstruction and Widening.

* Alternatives 1 and 2 are for the rehabilitation of the existing roadway. Widening will include new flexible construction.

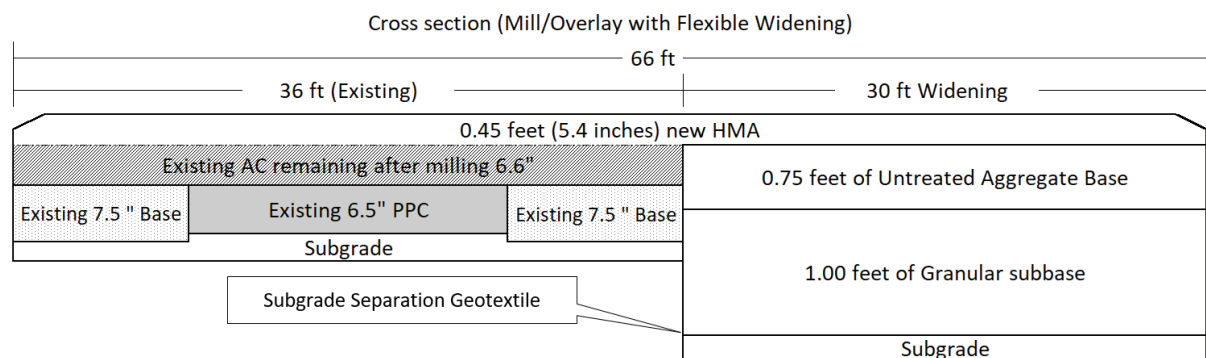
Appendix F contains the pavement analysis results.

Mill/Overlay with Flexible Construction Widening

A 0.45 ft mill/overlay strategy was analyzed using the AASHTOWare Pavement ME design method. This strategy was not deemed feasible as rut depth and IRI failure is predicted at year 12 and 18.

The following figure shows the cross section for the mill/overlay with flexible widening.

Figure 540.07-19: Cross section of US-91, (Mill/Overlay with Flexible Construction Widening.)



AC Removal and HMA Overlay with Flexible Reconstruction Widening

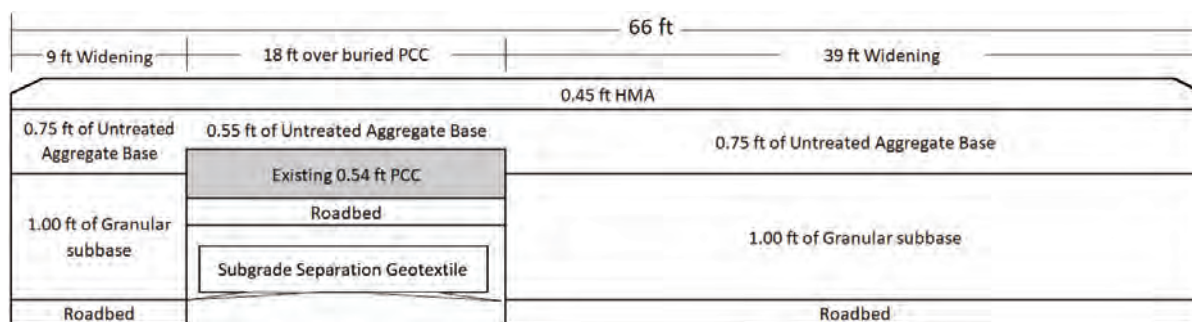
This strategy includes the following activities:

- Remove all existing AC and base along the sides and top of the buried, existing PCC layer.
- Excavate 2.20 ft the width of the roadway to be reconstructed and widened.
- Place a subgrade separation geotextile on the prepared subgrade for the reconstruction and widening.
- Place 1.00 ft of Granular Subbase for the reconstruction and widening areas.
- Place 0.75 ft of Aggregate for Untreated Base for the reconstruction and widening areas and 0.55 ft of Aggregate for Untreated Base on the existing PCC.
- Place 0.45 ft of new HMA across the entire width of the roadway.

Based on the AASHTOWare Pavement ME design method, this strategy meets performance criteria for 20 years of service.

The following figure shows the cross section for the AC removal and HMA Overlay with flexible reconstruction widening.

Figure 540.07-20 Cross section of US-91, (AC removal with flexible reconstruction and widening)



Flexible Reconstruction

This strategy includes the following activities:

- Excavate 2.20 ft width of the roadway.
- Place a subgrade separation geotextile on the prepared subgrade.
- Place 1.00 ft Granular Subbase.
- Place 0.75 ft Aggregate for Untreated Base.
- Place a 0.45 ft Hot Mix Asphalt (HMA).

Note: This process will maintain the existing roadway profile, while meeting the minimum frost depth criteria for the shoulder widening.

The following table shows the proposed pavement layer structure for Flexible Reconstruction design alternative.

Table 540.07-21: Design Results for the Flexible Reconstruction

Pavement Layer	Thickness (ft)
HMA	0.45
New Aggregate Base	0.75
New Granular Subbase	1.00
Subgrade Separation Geotextile	Recommended
Total	2.20
Meets Minimum Frost Depth Criteria?	Yes

Based on the AASHTOWare Pavement ME design method, this strategy meets performance criteria for 20 years of service.

Rigid Reconstruction

This strategy includes the following activities:

- Excavate 16.4 inches (1.37 ft) full width of the roadway and remove the existing PCC lanes.
- Place a subgrade separation geotextile on the prepared subgrade.
- Place 6.0 inches (0.50 ft) Aggregate for Untreated Base.
- Place 2.4 inches (0.20 ft) Hot Mix Asphalt (HMA).
- Place 10.0 inches of Jointed Plain Concrete Pavement (JPCP)

The following table shows the proposed rigid pavement layer structure.

Table 540.07-22: Design Results for the Rigid Reconstruction

Pavement Layer	Thickness (inches)
JPCP	10.0
HMA Leveling Course	2.4
New Aggregate Base	6.0
Subgrade Separation Geotextile	Required
Total	16.4

Based on the AASHTO Pavement ME design method, this strategy meets performance criteria for 40 years of service.

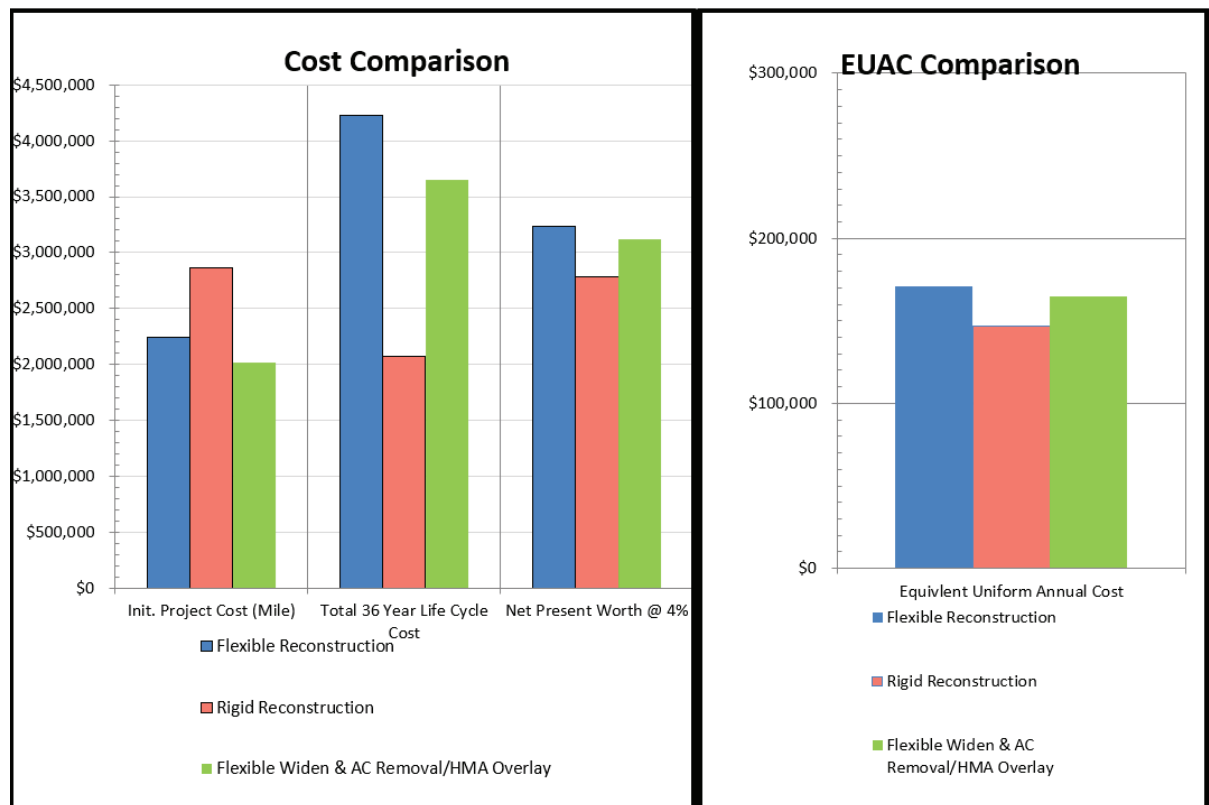
540.08 Economic Comparison of Alternatives

For the mainline, a Life-Cycle Cost Analysis (LCCA) was performed for the following feasible strategies:

- AC Removal and HMA Overlay with Flexible Reconstruction and Widening.
- Flexible Reconstruction and Widening.
- Rigid Reconstruction and Widening.

The following table summarizes the LCCA results. The LCCA output is in Appendix G.

Graph 540.08-23: Life-Cycle Cost Analysis Results^{1,2}



Pavement Design Alternative	EUAC Init. Project Cost (Mile)	Total 36 Year Life Cycle Cost	Net Present Worth @ 4%	EUAC
Flexible Reconstruction	\$2,243,000	\$4,226,000	\$3,233,000	\$174,000
Rigid Reconstruction	\$2,861,000	\$2,070,000	\$2,779,000	\$147,000
AC Removal and HMA Overlay with Flexible Reconstruction and Widening	\$2,021,000	\$3,647,000	\$3,119,000	\$165,000

Notes

-
- 1 The LCCA uses unit costs provided by ITD. The LCCA costs are for comparison purposes only.
 - 2 Does not include all costs that are common to each alternative.

The LCCA results indicate the AC Removal and HMA Overlay with Flexible Reconstruction and Widening strategy and the Flexible Reconstruction strategy have comparable Equivalent Uniform Annual Cost (EUAC), Net Present Worth, and Initial Project Cost.

540.09 Recommendations

Based on the Pavement ME calculations and ITD's concerns, the *Flexible Reconstruction* is the preferred strategy. Other pavement design alternatives are viable, as discussed previously.

Appendix A: References

Appendix A

References

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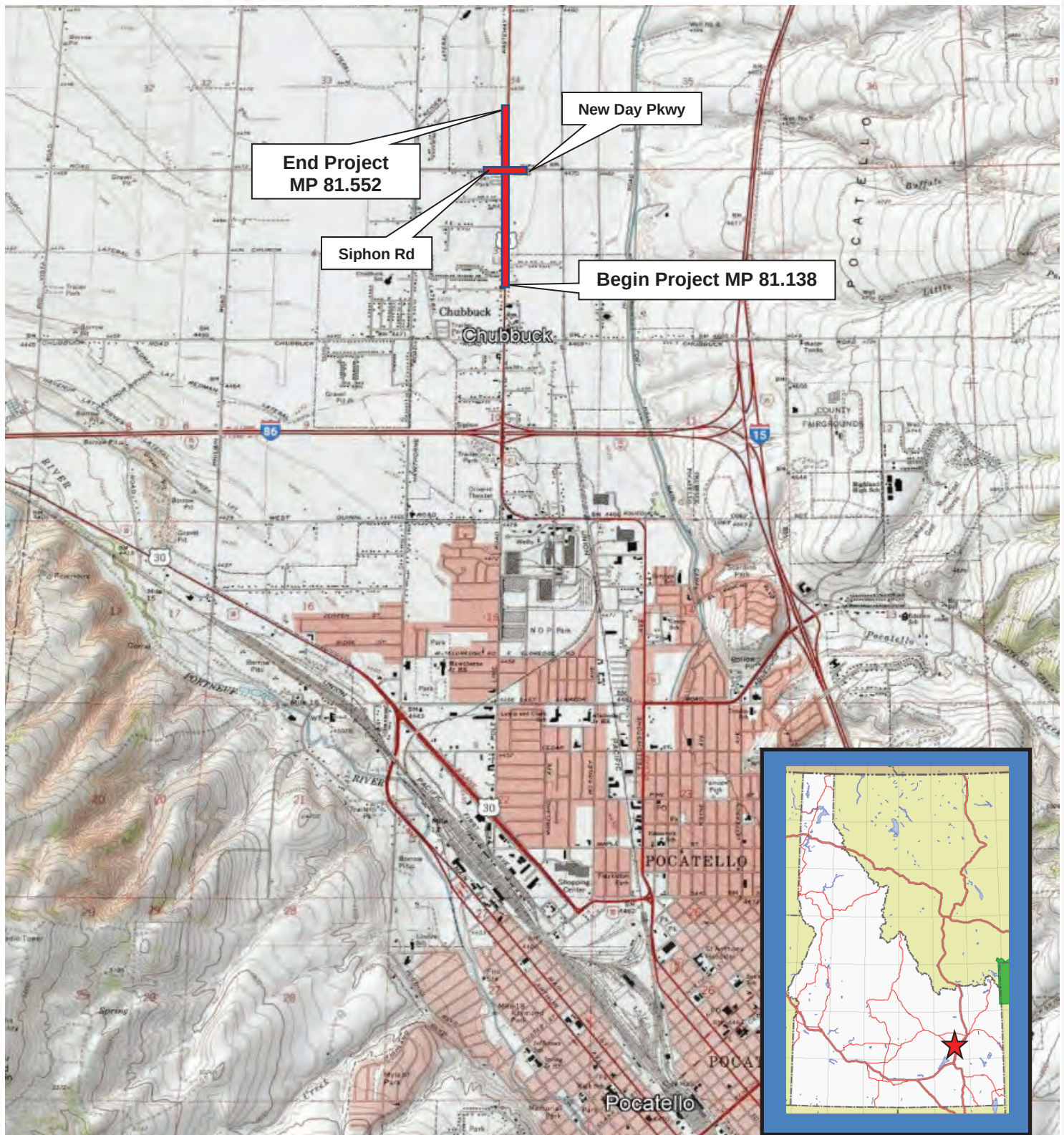
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- Von Quintus, H., and B. Killingsworth. 1997. Design Pamphlet for the Determination of Design Subgrade in Support of the AASHTO Guide for the Design of Pavement Structures. Report No. FHWA-RD-97-083. Federal Highway Administration. McLean, VA. September 30.

Appendix B

Site Information & Data

CONTENTS

- Vicinity Map (Figure 1)
- Site Photographs
- Visual Pavement Distress Survey Photographs



NOT TO SCALE

US-91, Roadway Widening, Park Lawn to
Siphon Rd
MP 81.138 to MP 81.552

VICINITY MAP

February 17, 2023,

71-109216



Photo 1: Looking north from beginning of project (Park Lawn).



Photo 2: Looking south from end of project (Southside Way).



Photo 1: From boring location B-01



Photo 2: From boring location B-01



Photo 3: From boring location B-04



Photo 4: From boring location B-04



Photo 3: From boring location **B-03**



Photo 4: From boring location **B-03**

Appendix C

Subsurface Exploration and Data

CONTENTS

- Exploration Location Map (Figure 2)
- Boring Logs
- Core Photographs
- GPR Profiles and Statistics
- FWD Data and Statistics



NOT TO SCALE

US-91, Roadway Widening, Park Lawn to
Southside Way
MP 81.138 to MP 81.620

EXPLORATION MAP

March 15, 2023

71-109216



NOT TO SCALE

US-91, Roadway Widening, Park Lawn to
Southside Way
MP 81.20 to MP 81.70

EXPLORATION MAP

March 15, 2023

71-109216

SHANNON & WILSON

FIG. 2 of 3

By: MEE

QC: mjs



NOT TO SCALE

US-91, Roadway Widening, Park Lawn to
Southside Way
MP 81.20 to MP 81.70

EXPLORATION MAP

March 15, 2023

71-109216

SHANNON & WILSON

FIG. 3 of 3

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/12/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-01

GROUNDWATER:

Groundwater not encountered on 1/12/2023

LATITUDE: 42.9309401774°
LONGITUDE: -112.4664735673°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-01	100		Asphalt Concrete- Lift Interface @ 0.18', 0.34', 0.49', 0.61'; Core Recovery = 0.79'; Voids from 0.67' to 0.79'.	0.79	0.79	Boring located approximately 4.5' from fogline in northbound lane. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0				Poorly Graded Sand with Silt and Gravel (SP-SM)- (BASE) About 50% fine to coarse, subrounded to subangular sand; about 40% fine, subrounded to subangular gravel to 3/4"; about 10% nonplastic fines; wet (from coring); brown.	0.74	1.53	
1.5				Lean Clay (CL)- 92% fines; LL =29, PL =21, PI =8 6% fine to medium sand; 2% gravel; w = 22.5%; brown.			
2.0							
2.5							
3.0	SS-02	75					
3.5							
4.0							
4.5							
5.0	ST-03	100					
5.5							
						5.80	

Bottom of Boring at 5.8 ft on 1/12/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/12/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-02

GROUNDWATER:

Groundwater not encountered on 1/12/2023

LATITUDE: 42.9328725375°
LONGITUDE: -112.4664791042°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-04	96		Asphalt Concrete- Lift Interface @ 0.22', 0.39', 0.50', 0.67'; Core Recovery = 0.79'; Voids from 0.67' to 0.79'.	0.85	0.85	Boring located approximately 48" from fogline in northbound lane. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0	GB-05			Silty Gravel with Sand (GM)- 43% fine, subrounded to sunangular gravel to 3/4"; 30% fine to coarse, subrounded to subangular sand; 27% nonplastic fines; Wet from coring; brown.	0.74		
1.5						1.59	
2.0	SS-06	79		Silt (ML)- (NATIVE) About 95% nonplastic fines; about 5% fine to medium sand; moist; brown.	2.41	4.00	
2.5							
3.0							
4.0	SS-07	71		Silty Clay (CL-ML)- 86% fines; LL =29, PL =21, PI =8 11% fine sand; 3% gravel; w=20.4%; brown.	2.00		
4.5							
5.0							
5.5						6.00	

Bottom of Boring at 6.0 ft on 1/12/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/13/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-03

GROUNDWATER:

Groundwater not encountered on 1/13/2023

LATITUDE: 42.9363818533°
LONGITUDE: -112.4665099942°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-28	100		Asphalt Concrete- Lift Interface @ 0.22', 0.37', 0.50', 0.68', 0.83; Core Recovery = 1.02'; Voids increasing with depth starting at from 0.50'.	1.03	1.03	Boring located approximately 35" from fogline in northbound lane. To east of road, 3' embankment drop to field. To west of road, flat past shoulder for 5' then drop into a canal.
1.0							
1.5				Clayey Sand with Gravel (SC)- (BASE) About 40% low plasticity fines; about 35% fine to coarse, subrounded to angular sand; about 25% fine, subrounded to subangular gravel to 3/4"; moist; brown.	1.97	3.00	Splitspoon sent to sample had 0" of recovery. Took grab bag sample instead. Driller noted that base material seemed to end around 3'.
2.0							
2.5							Pocket Penetrometer = 2 to 2.75 TSF
3.0	GB-29			Silty Clay (CL-ML)- (NATIVE)	3.00	6.00	
3.5							
4.0							
4.5							
5.0	SS-30	75					
5.5							
6.0							

Bottom of Boring at 6.0 ft on 1/13/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/12/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-04

GROUNDWATER:

Groundwater not encountered on 1/12/2023

LATITUDE: 42.930945576°
LONGITUDE: -112.4665017591°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-08	89		Asphalt Concrete- Lift Interface @ 0.22', 0.35', 0.49' (delaminated), 0.61' (delaminated, fragmented); Core Recovery = 0.82'; Light fragmentation from 0.35' to 0.49', moderate fragmentation from 0.49' to 0.82'	0.92	0.92	Boring located in turning lane. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0	CR-09	110		Portland Cement Concrete- Intact core.	0.42	1.34	
1.5				Clayey Sand (SC)- (NATIVE) About 55% fine sand; about 45% low plasticity fines; wet from coring; brown.			
2.0							Pocket Penetrometer = 4.0 TSF
2.5							
3.0	SS-10	67					
3.5							Pocket Penetrometer = 4.0 TSF
4.0				As above. except moist.			
4.5							
5.0	SS-11	79					
5.5							
6.0						6.00	

Bottom of Boring at 6.0 ft on 1/12/2023.



SHANNON & WILSON

BORING NO. B-05

Groundwater not encountered on 1/12/2023

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-12	77		Asphalt Concrete- Lift Interface @ 0.21', 0.35' (delamination), 0.55' (delamination, fragmented) ; Core Recovery = 0.73'; Fragmented and stripping from 0.35' to 0.73'.	0.95		Boring located in turning lane. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0	CR-13A	100		Portland Cement Concrete- Intact core.	0.60	0.95	
1.5						1.55	
2.0				SILT (ML)- (NATIVE) 89% fines; LL =23, PL =20, PI =3 10% Sand; 1% Gravel;		4.45	Pocket Penetrometer = 2.0 TSF
2.5							
3.0	ST-14						
3.5							
4.0							
4.5							
5.0	SS-15	50					
5.5							
6.0						6.00	

Bottom of Boring at 6.0 ft on 1/12/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/13/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-06

GROUNDWATER:

Groundwater not encountered on 1/13/2023

LATITUDE: 42.9363869766°
LONGITUDE: -112.4665459272°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-31	82		Asphalt Concrete- Lift Interface @ 0.21', 0.41' (delamination, fragmented); Core Recovery = 0.73'; Fragmented and stripping from 0.41' to 0.73'.	0.89	0.89	Boring located in turning lane, 69" from east centerline, 73" from west centerline. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0	CR-32	100		Portland Cement Concrete- Intact core; light fragmentation on bottom.	0.59	1.48	
1.5				Lean Clay (CL)- (NATIVE) 93% fines; LL =32, PL =21, PI =11 7% fine to medium sand; w=21.5%; brown.			Pocket Penetrometer = 1.75 to 3.0 TSF
2.0							
2.5							
3.0	SS-33	58					
3.5							
4.0				As above, except moist.			Pocket Penetrometer = 3.5 TSF
4.5							
5.0	SS-34	75					
5.5							
6.0						6.00	

Bottom of Boring at 6.0 ft on 1/13/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/12/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-07

GROUNDWATER:

Groundwater not encountered on 1/12/2023

LATITUDE: 42.9309394946°
LONGITUDE: -112.4665553242°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-19	68		Asphalt Concrete- Lift Interface @ 0.34' (delamination, stripped); Core Recovery = 0.69'; Bottom of core is fragmented.	1.02	1.02	Boring located in southbound lane approximately 48" from fogline. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0	GB-20			SILTY GRAVEL with SAND (GM)- (BASE) 49% fine, subrounded to subangular gravel to 3/4"; 35% fine to coarse, subrounded to subangular sand; 16% nonplastic fines; wet; brown.	0.49	1.51	
1.5				LEAN CLAY (CL)- (NATIVE) 93% fines; LL =28, PL =19, PI =9 6% fine sand; 1% gravel; w=22.7%; brown.			
2.0							Pocket Penetrometer = 1.25 to 1.5 TSF
2.5							
3.0	SS-21	75					
3.5							
4.0							
4.5							Pocket Penetrometer = 1.0 to 2.5 TSF
5.0	SS-22	100					
5.5							
6.0						6.00	

Bottom of Boring at 6.0 ft on 1/12/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/12/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-08

GROUNDWATER:

Groundwater not encountered on 1/12/2023

LATITUDE: 42.9328749758°
LONGITUDE: -112.4665863007°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-16	85		Asphalt Concrete- Lift Interface @ 0.32', 0.59', and 0.85' (delaminated and fragmented); Core Recovery = 0.85'; Intact core to 0.85' second smaller piece of asphalt concrete recovered from below CR-16.	1.00	1.00	Boring located in southbound lane approximately 48" from fogline. To east of road, 3' embankment drop to ditch. To west of road, flat for 10' then drop to ditch.
1.0				Poorly Graded Sand with Silt and Gravel (SP-SM)- (BASE) About 50% fine to coarse, subrounded to subangular sand; about 40% fine, subrounded to subangular gravel to 3/4"; about 10% nonplastic fines; wet (from coring); brown.	0.55	1.55	
1.5				Clayey Sand (SC)- (NATIVE) About 80% fine sand; about 20% low plasticity; trace fine, subrounded gravel to 1/2"; moist; gray.			Pocket Penetrometer = 1.75 to 2 TSF
2.0							
2.5							
3.0	SS-17	79					
3.5							
4.0							
4.5							
5.0	SS-18	67					
5.5							
6.0						6.00	

Bottom of Boring at 6.0 ft on 1/12/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/13/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-09

GROUNDWATER:

Groundwater not encountered on 1/13/2023

LATITUDE: 42.9363850974°
LONGITUDE: -112.4666177881°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
0.5	CR-35	96		Asphalt Concrete- Lift Interface @ 0.26', 0.43', 0.66', 0.80'; Core Recovery = 0.93'; From 0.74' and below is slightly fragmented.	0.97	0.97	Boring located approximately 43" from fogline in southbound lane. To east of road, 3' embankment drop to field. To west of road, flat past shoulder for 5' then drop into a canal.
1.0	GB-36			Poorly Graded Sand with Silt and Gravel (SP-SM)- (BASE) About 50% fine to coarse, subrounded to subangular sand; about 40% fine, subrounded to subangular gravel to 3/4"; about 10% nonplastic fines; wet (from coring); brown.	2.03	3.00	Unable to visually identify base layer depth, driller indicated layer change around 3'.
1.5							
2.0							
2.5							
3.0	SS-37	88		LEAN CLAY with SAND (CL)- (NATIVE) 71% fines; LL =28, PL =20, PI =8; 17% fine to medium sand; 12% fine, subrounded to rounded gravel to 1/2"; w=18.8%; brown.	2.80	5.80	Pocket Penetrometer = 1.0 to 1.5 TSF
3.5							
4.0							
4.5	ST-38	100					
5.0							
5.5							

Bottom of Boring at 5.8 ft on 1/13/2023.

PROJECT: US-91, Park Lawn to Southside Way
LOCATION: Chubbuck, Idaho



METHOD: Hollow Stem Auger/HQ-3 Diamond Core
DATE LOGGED: 1/12/2023
LOGGED BY: Austin Madsen, EI

BORING NO. B-11

GROUNDWATER:

Groundwater not encountered on 1/12/2023

LATITUDE: 42.9349539055°
LONGITUDE: -112.4651389404°

DEPTH (ft)	TYPE - No.	RECOVERY %	LITHOLOGY	MATERIAL DESCRIPTION (Stratification lines represent approximate boundaries between materials)	LAYER THICKNESS (ft.)	DEPTH (ft)	REMARKS
	CR-23			Asphalt Concrete- Single lift, no voids; Core Recovery = 0.24';	0.24	0.24	Boring located in eastbound lane approximately 74" from shoulder. To north and south of roadway is flat.
0.5	GB-26			Poorly Graded Gravel (GP)- (BASE) 95% fine to coarse, rounded to subangular gravel to 3"; 3% sand; 2% fines;	1.13		
1.0						1.37	
1.5				SILTY GRAVEL with SAND (GM)- (NATIVE) 39% fines; LL =19, PL =4, PI =2; 38% fine, rounded to subrounded gravel to 3/4"; 23% fine to coarse, subrounded to subangular sand; w=8.2%; brown.			
2.0							
2.5					2.63		
3.0	SS-25	50					
3.5							
4.0						4.00	
4.5				Silty Sand (SM)- About 75% fine to medium sand; about 15% nonplastic to low plasticity fines; about 5% fine, subrounded to subangular gravel to 1/2"; moist; brown.			
5.0	SS-27	58			2.00		
5.5							
6.0						6.00	

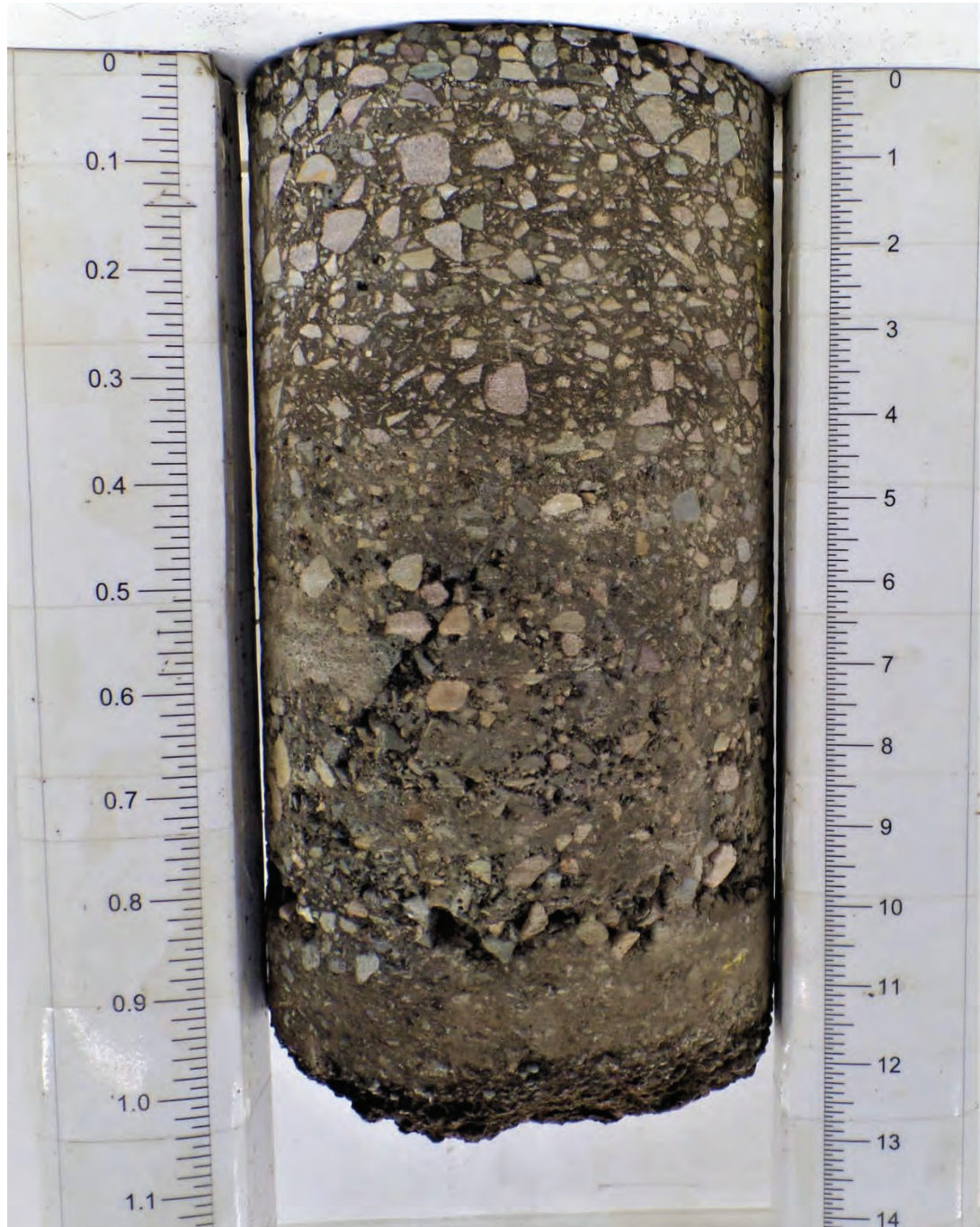
Bottom of Boring at 6.0 ft on 1/12/2023.



Core Photo 1: B-01, CR-01; 0.0'-0.79'



Core Photo 2: B-02, CR-04; 0.0'-0.79'



Core Photo 3: B-03, CR-28; 0.0'-1.02'



Core Photo 4: B-04, CR-08; 0.0'-0.92'



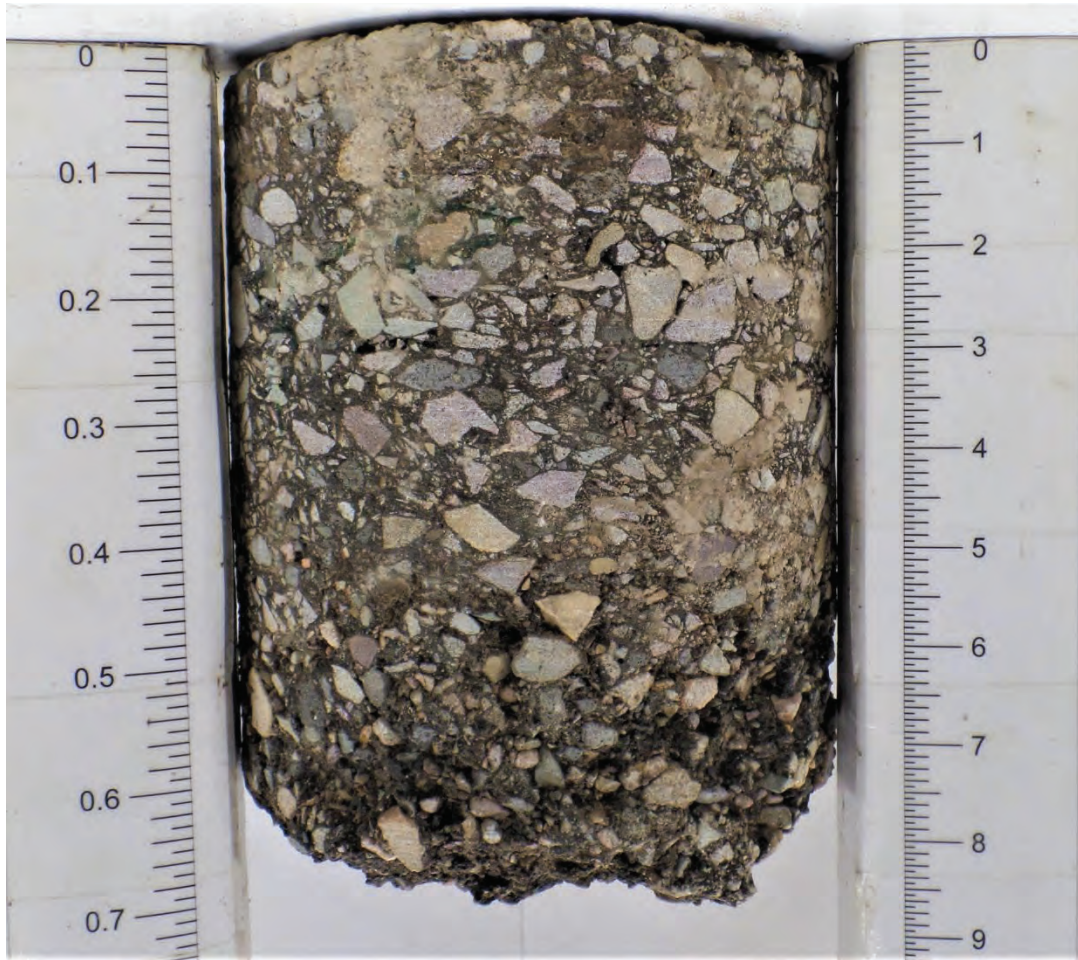
Core Photo 5: B-04, CR-09; 0.92'-1.34'



Core Photo 6: B-05, CR-12; 0.0'-0.73'



Core Photo 7: B-05, CR-13A; 0.95'-1.55'



Core Photo 8: B-06, CR-31; 0.0'-0.73'



Core Photo 9: B-06, CR-32; 0.89'-1.48'



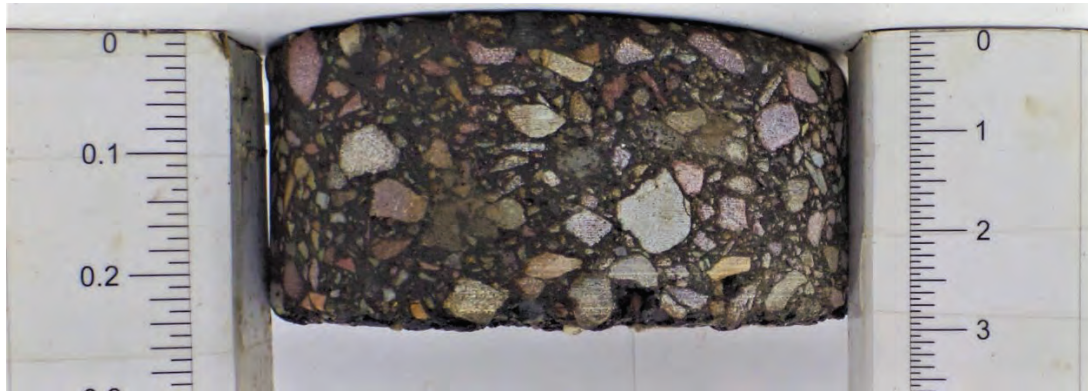
Core Photo 10: B-07, CR-19; 0.0'-0.69'



Core Photo 11: B-08, CR-16; 0.0'-1.0'



Core Photo 12: B-09, CR-35; 0.0'-0.97'



Core Photo 13: B-11, CR-23; 0.0'-0.24'

File No: 109216

ITD Key No. 21860

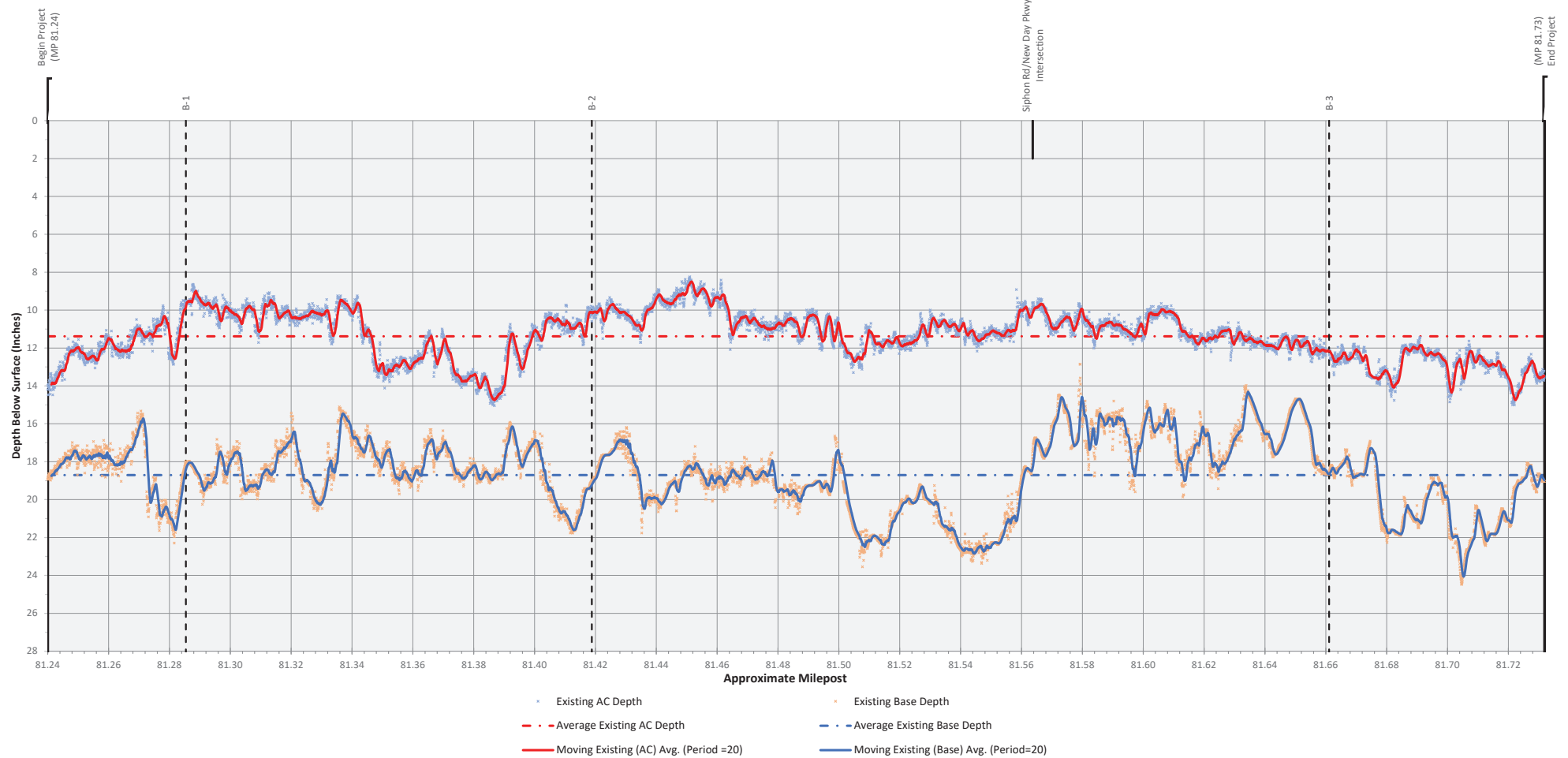
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Existing Pavement Layer Depths

US-91 Park Lawn to Siphon

US-91; Milepost 81.24 to 81.73

(North Bound, Lane 0, Right Wheel Path)



Note: GPR distance scale along the x-axis may not correspond exactly with project stationing.

Existing AC Depth/Thickness Statistics

File No: 109216

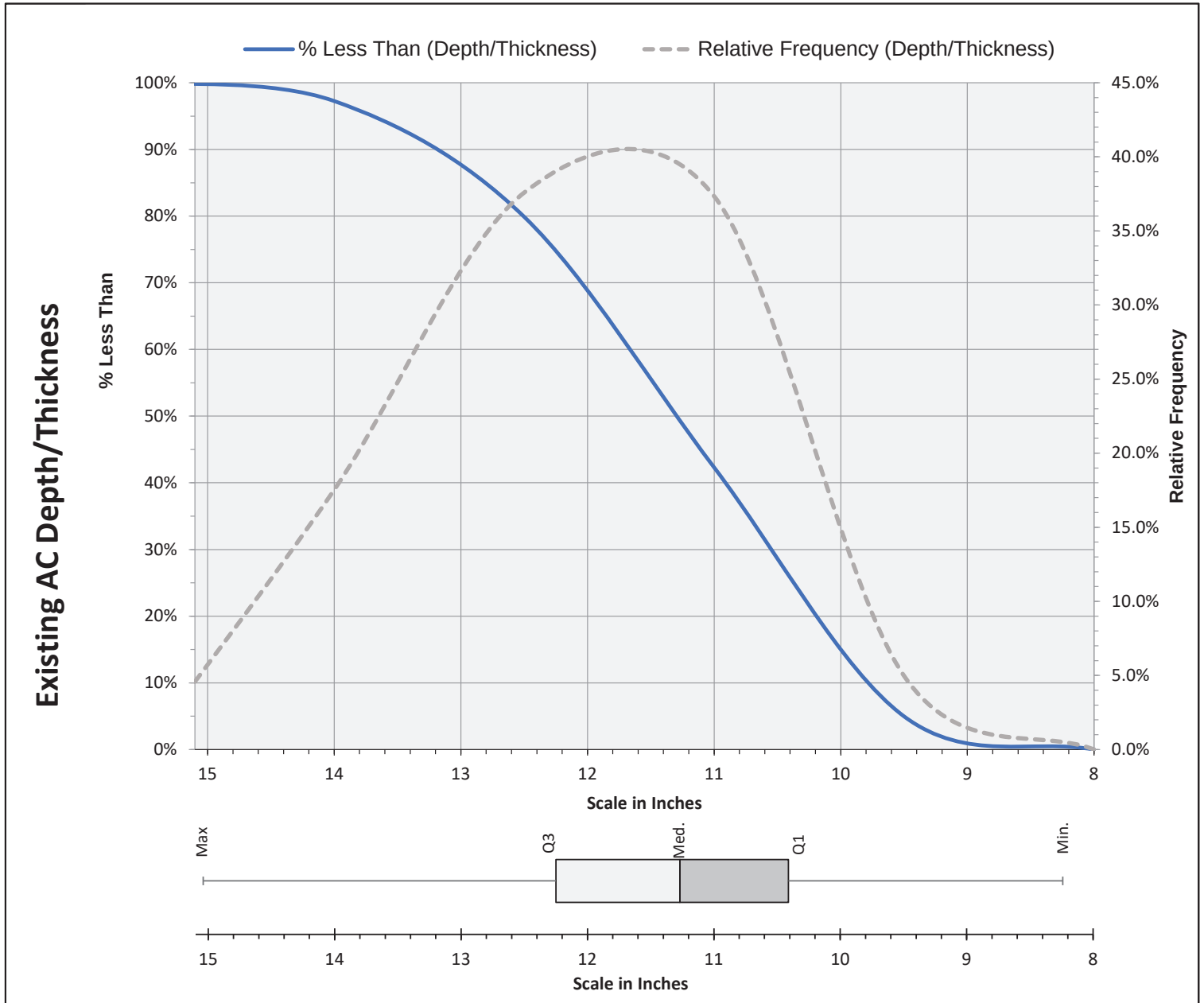
ITD Key No: 21860

Scan Date: 1/14/2023

US-91 Park Lawn to Siphon

US-91; Milepost 81.24 to 81.73

(North Bound, Lane 0, Right Wheel Path)



Existing AC Depth/Thickness Statistics

Average= 11.4 in. (0.95 ft.)
 Max= 15 in. (1.25 ft.)
 Min= 8.2 in. (0.69 ft.)
 SD= 1.3 in. (0.11 ft.)
 Median= 11.3 in. (0.94 ft.)
 Q1= 10.4 in. (0.87 ft.)
 Q3= 12.3 in. (1.02 ft.)

Total Number of Scans= 7793

Existing Base Depth And Thickness Statistics



File No: 109216

ITD Key No: 21860

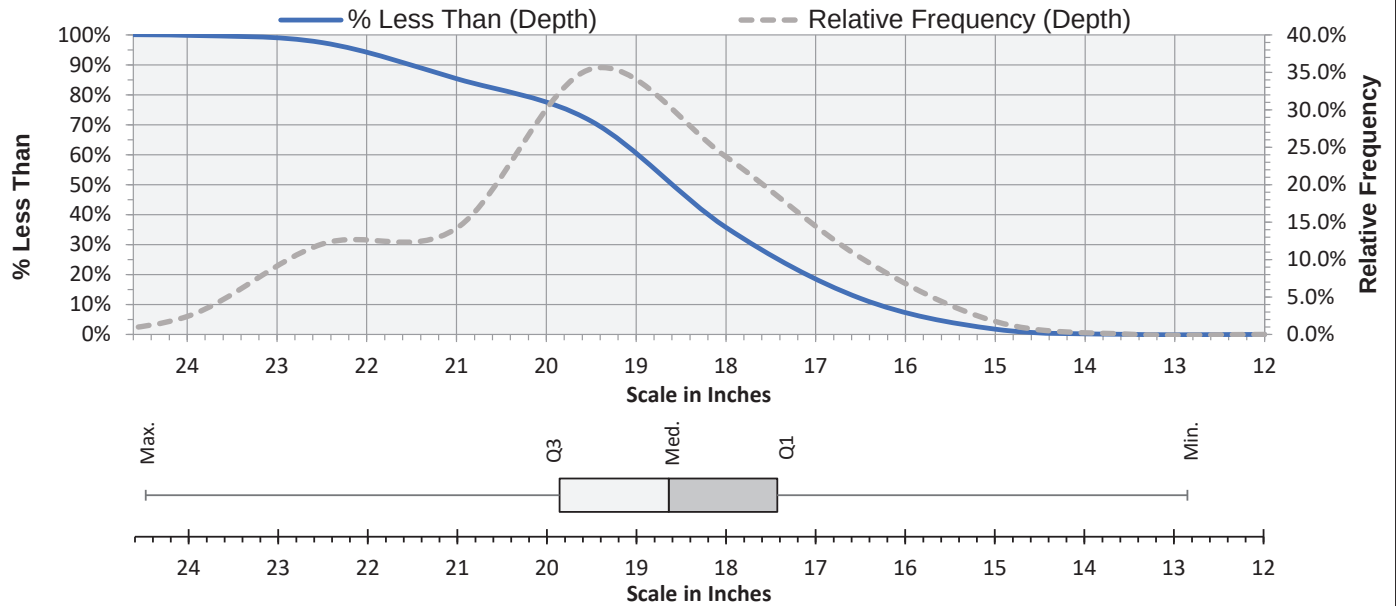
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US-91 Park Lawn to Siphon

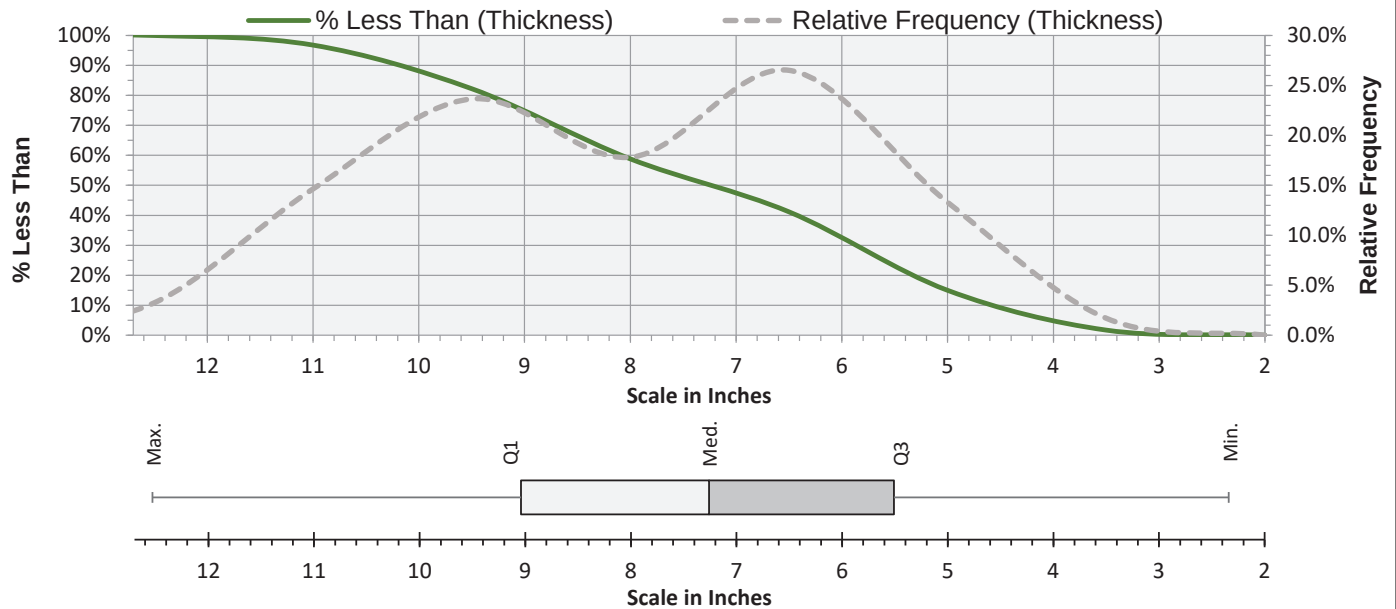
US-91; Milepost 81.24 to 81.73

(North Bound, Lane 0, Right Wheel Path)

Existing Base Depth



Existing Base Thickness



Existing Base Depth Statistics

Average= 18.7 in. (1.56 ft.)
 Max= 24.5 in. (2.04 ft.)
 Min= 12.9 in. (1.07 ft.)
 SD= 1.9 in. (0.16 ft.)
 Median= 18.6 in. (1.55 ft.)
 Q1= 17.4 in. (1.45 ft.)
 Q3= 19.9 in. (1.66 ft.)

Existing Base Thickness Statistics

Average= 7.3 in. (0.61 ft.)
 Max= 12.5 in. (1.04 ft.)
 Min= 2.3 in. (0.2 ft.)
 SD= 2.1 in. (0.17 ft.)
 Median= 7.3 in. (0.61 ft.)
 Q1= 5.5 in. (0.46 ft.)
 Q3= 9 in. (0.75 ft.)

Total Number of Scans= 7793

File No: 109216

ITD Key No. 21860

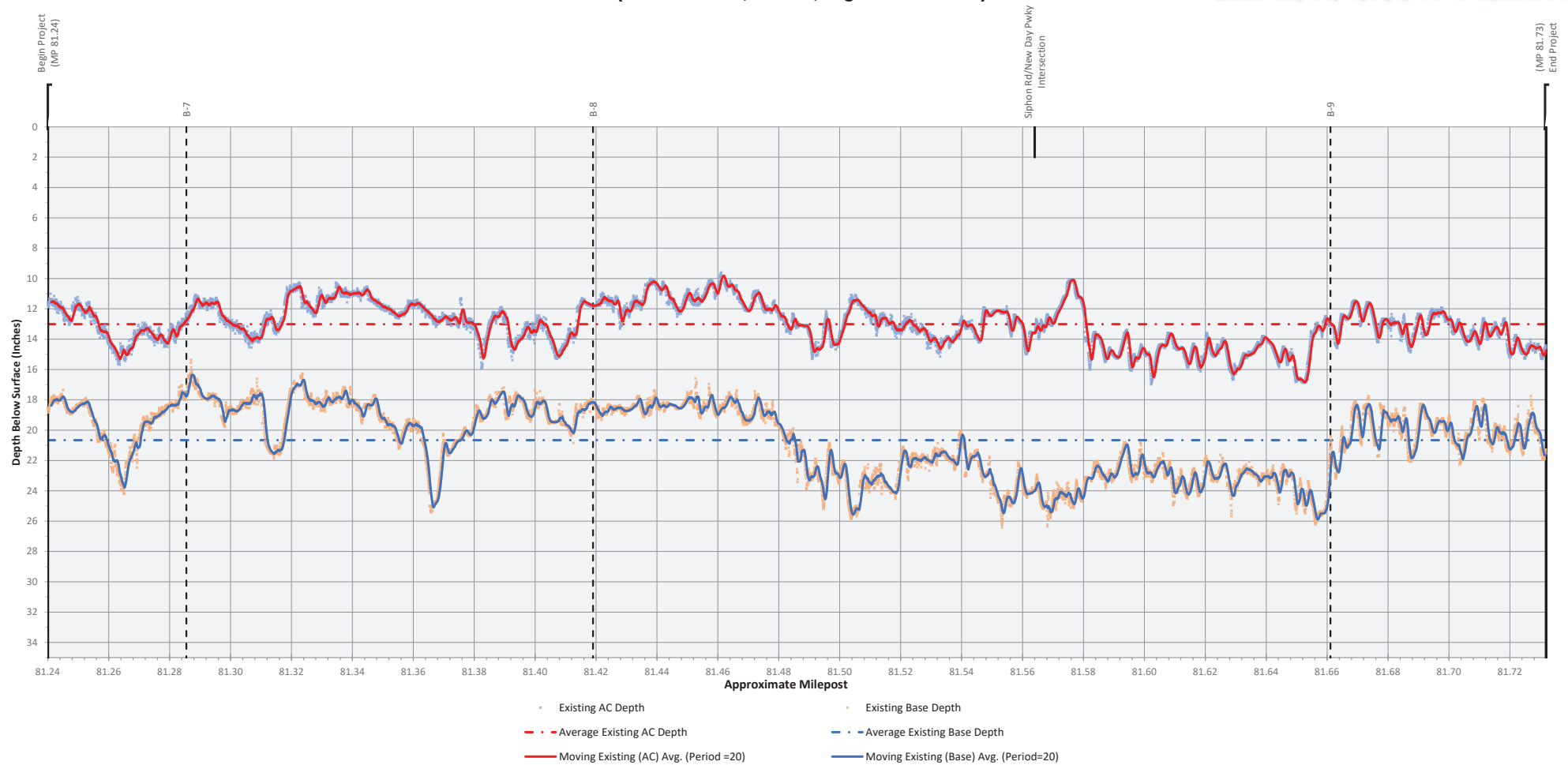
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Existing Pavement Layer Depths

US-91 Park Lawn to Siphon

US-91; Milepost 81.24-81.73

(South Bound, Lane 0, Right Wheel Path)



Note: GPR distance scale along the x-axis may not correspond exactly with project stationing.

Existing AC Depth/Thickness Statistics

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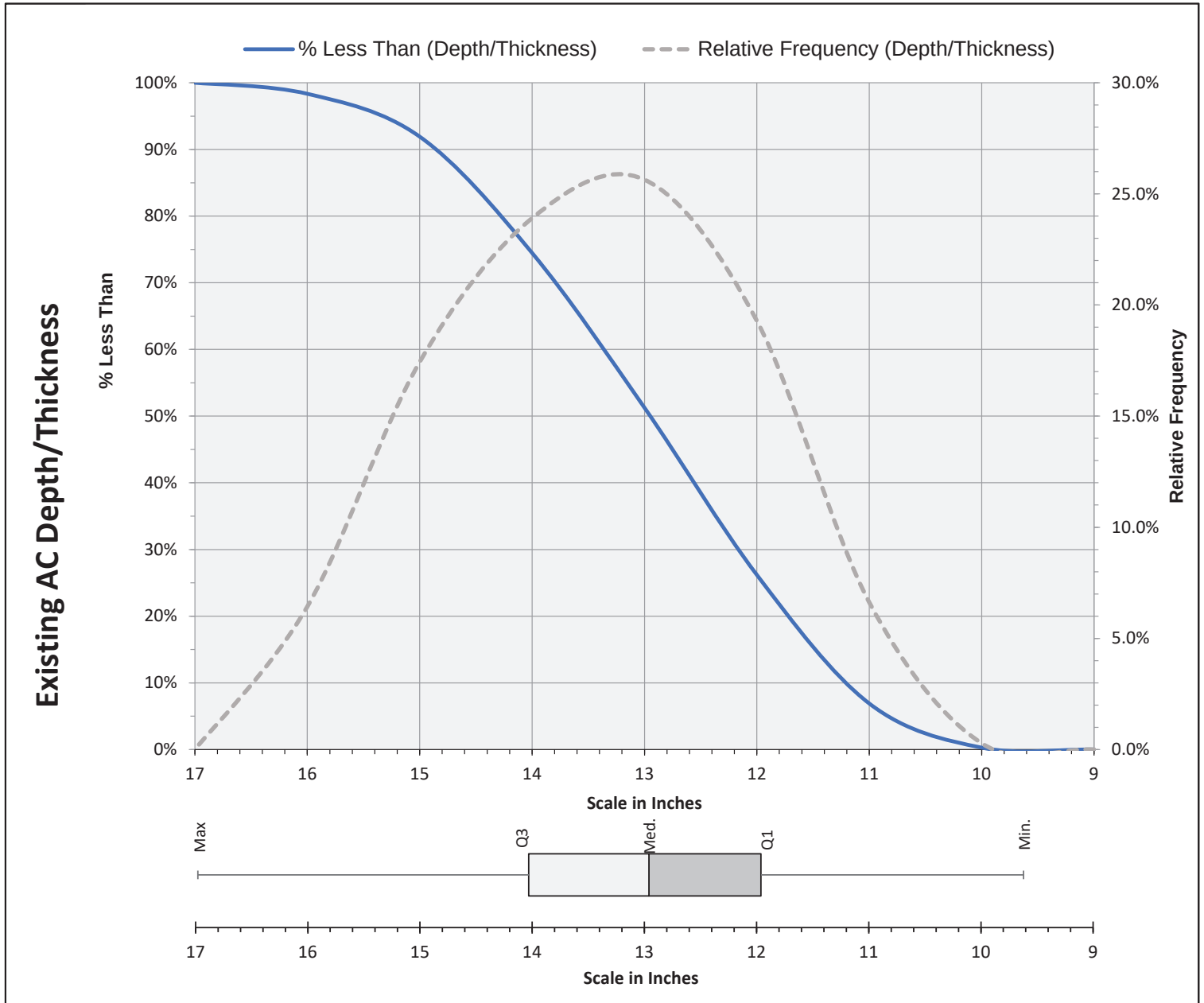
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Scan Date: 1/14/2023

US-91 Park Lawn to Siphon

US-91; Milepost 81.24-81.73

(South Bound, Lane 0, Right Wheel Path)



Existing AC Depth/Thickness Statistics

Average= 13 in. (1.08 ft.)
 Max= 17 in. (1.42 ft.)
 Min= 9.6 in. (0.8 ft.)
 SD= 1.4 in. (0.12 ft.)
 Median= 13 in. (1.08 ft.)
 Q1= 12 in. (1 ft.)
 Q3= 14 in. (1.17 ft.)

Total Number of Scans= 7793

Existing Base Depth And Thickness Statistics



File No: 109216

ITD Key No: 21860

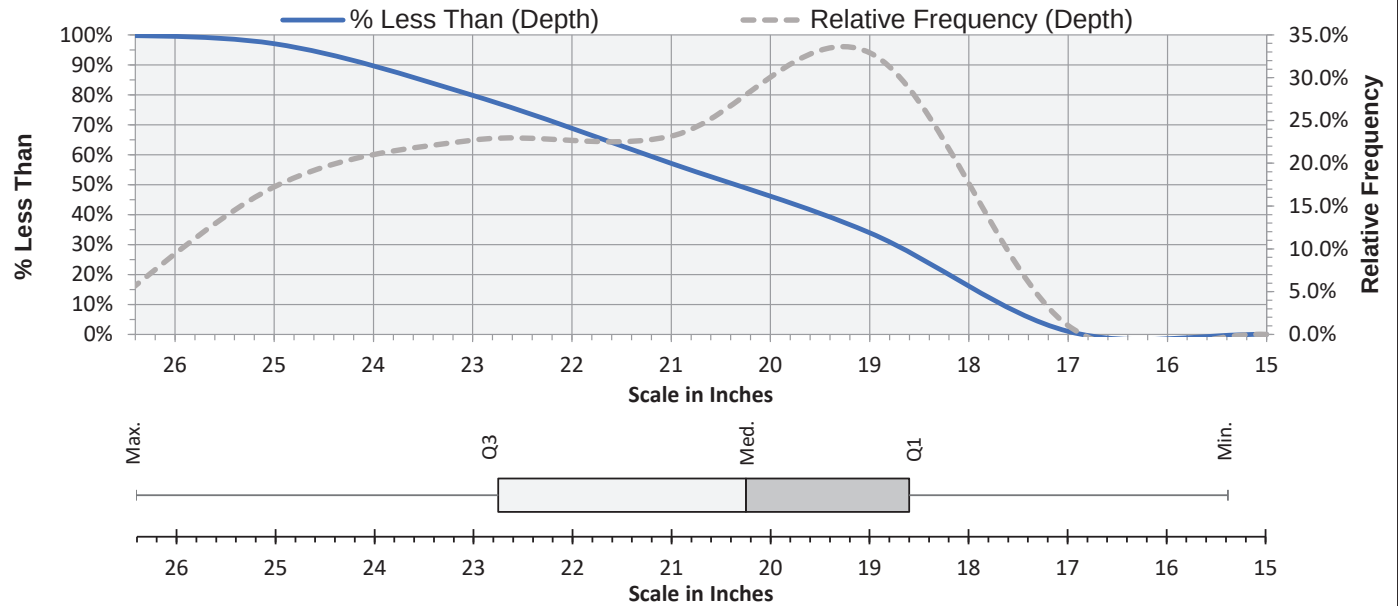
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US-91 Park Lawn to Siphon

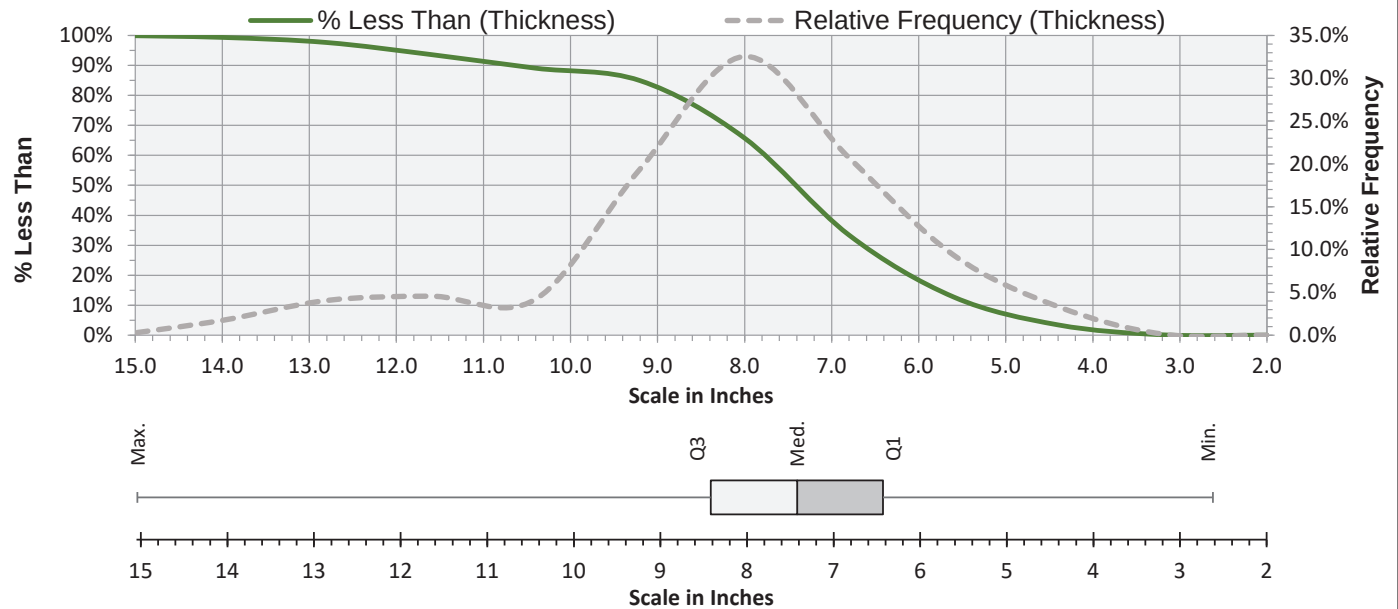
US-91; Milepost 81.24-81.73

(South Bound, Lane 0, Right Wheel Path)

Existing Base Depth



Existing Base Thickness



Existing Base Depth Statistics

Average= 20.7 in. (1.72 ft.)
 Max= 26.4 in. (2.2 ft.)
 Min= 15.4 in. (1.28 ft.)
 SD= 2.3 in. (0.19 ft.)
 Median= 20.3 in. (1.69 ft.)
 Q1= 18.6 in. (1.55 ft.)
 Q3= 22.8 in. (1.9 ft.)

Existing Base Thickness Statistics

Average= 7.6 in. (0.64 ft.)
 Max= 15 in. (1.25 ft.)
 Min= 2.6 in. (0.22 ft.)
 SD= 2 in. (0.17 ft.)
 Median= 7.4 in. (0.62 ft.)
 Q1= 6.4 in. (0.54 ft.)
 Q3= 8.4 in. (0.7 ft.)

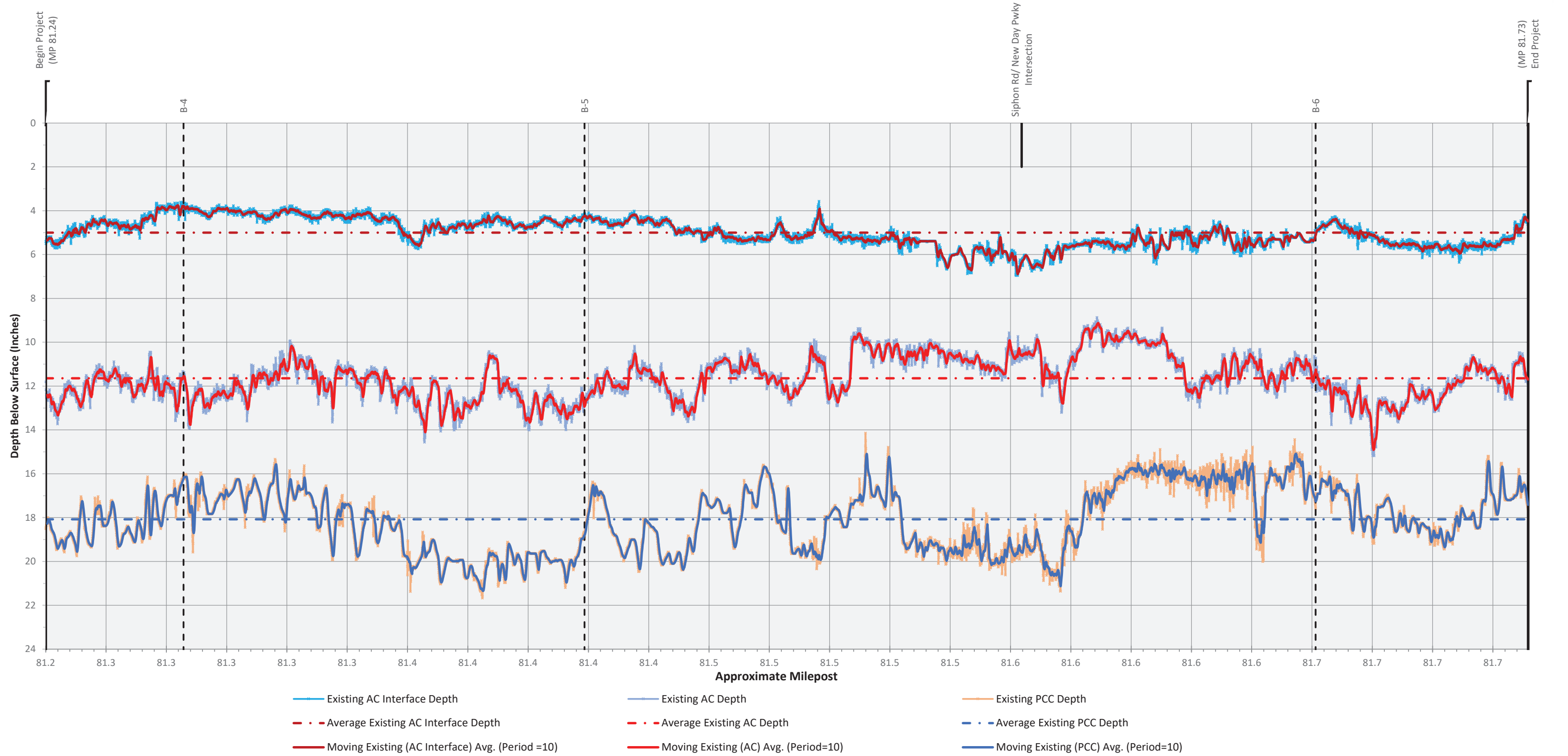
Total Number of Scans= 7793

Existing Pavement Layer Depths

US-91 Park Lawn to Siphon

US-91; Milepost 81.24 to 81.73

(NB Center Lane, Right Wheel Path)



Note: GPR distance scale along the x-axis may not correspond exactly with project stationing.

Existing AC Interface Depth/Thickness Statistics



File No: 109216

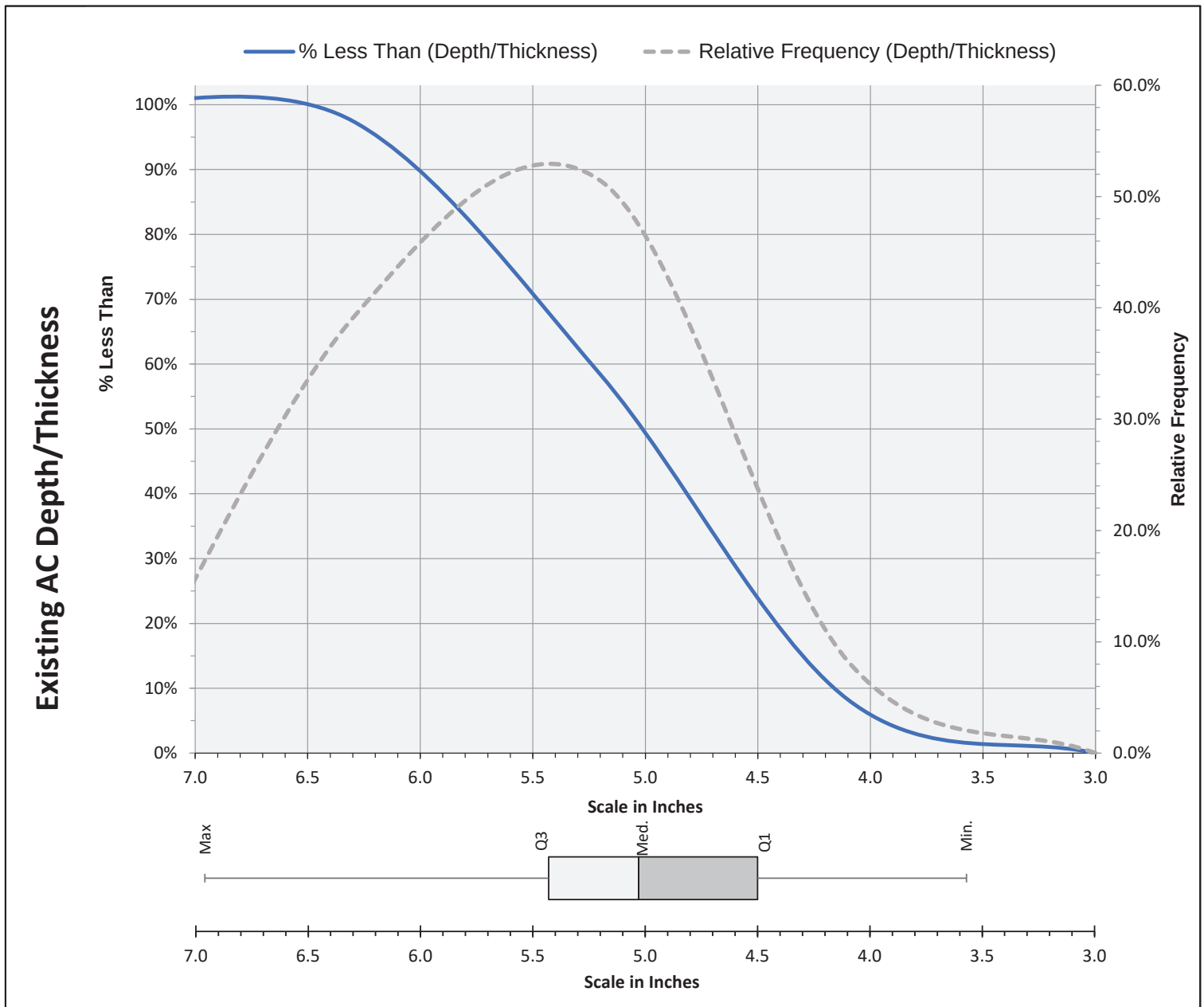
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Scan Date: 1/14/2023

US-91 Park Lawn to Siphon

US-91; Milepost 81.24 to 81.73

(NB Center Lane, Right Wheel Path)



Existing AC Interface Depth/Thickness Statistics

Average=	5 in.	(0.42 ft.)
Max=	7 in.	(0.58 ft.)
Min=	3.6 in.	(0.3 ft.)
SD=	0.6 in.	(0.05 ft.)
Median=	5 in.	(0.42 ft.)
Q1=	4.5 in.	(0.38 ft.)
Q3=	5.4 in.	(0.45 ft.)
Total Number of Scans= 7789		

Existing AC Depth And Thickness Statistics



File No: 109216

ITD Key No: 21860

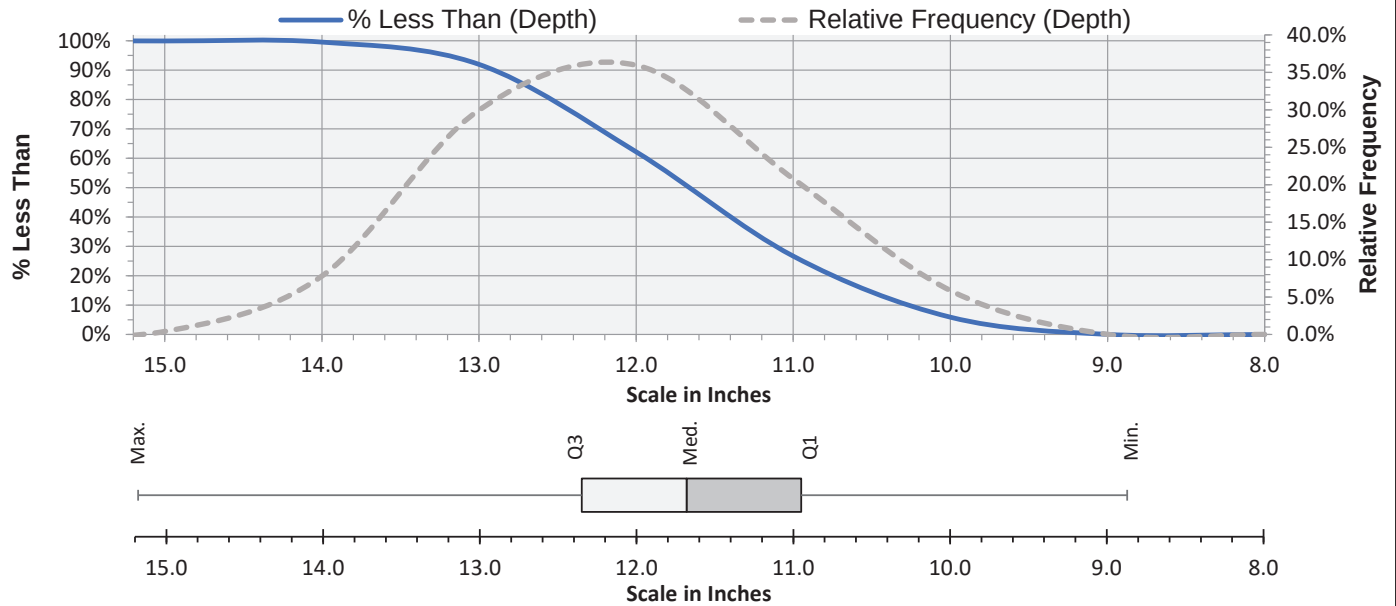
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US-91 Park Lawn to Siphon

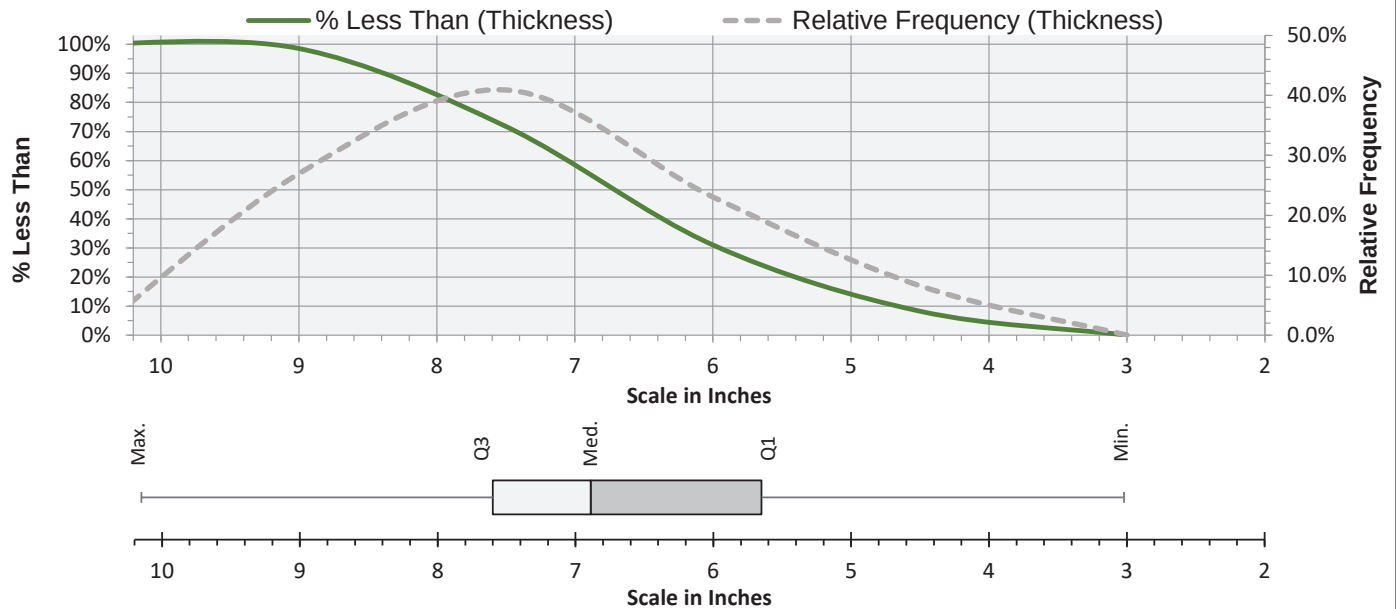
US-91; Milepost 81.24 to 81.73

(NB Center Lane, Right Wheel Path)

Existing AC Depth



Existing AC Thickness



Existing AC Depth Statistics

Average= 11.6 in. (0.97 ft.)
 Max= 15.2 in. (1.27 ft.)
 Min= 8.9 in. (0.74 ft.)
 SD= 1 in. (0.08 ft.)
 Median= 11.7 in. (0.97 ft.)
 Q1= 11 in. (0.91 ft.)
 Q3= 12.4 in. (1.03 ft.)

Existing AC Thickness Statistics

Average= 6.6 in. (0.55 ft.)
 Max= 10.2 in. (0.85 ft.)
 Min= 3 in. (0.25 ft.)
 SD= 1.3 in. (0.11 ft.)
 Median= 6.9 in. (0.57 ft.)
 Q1= 5.7 in. (0.47 ft.)
 Q3= 7.6 in. (0.63 ft.)

Total Number of Scans= 7789

Existing PCC Depth And Thickness Statistics

File No: 109216

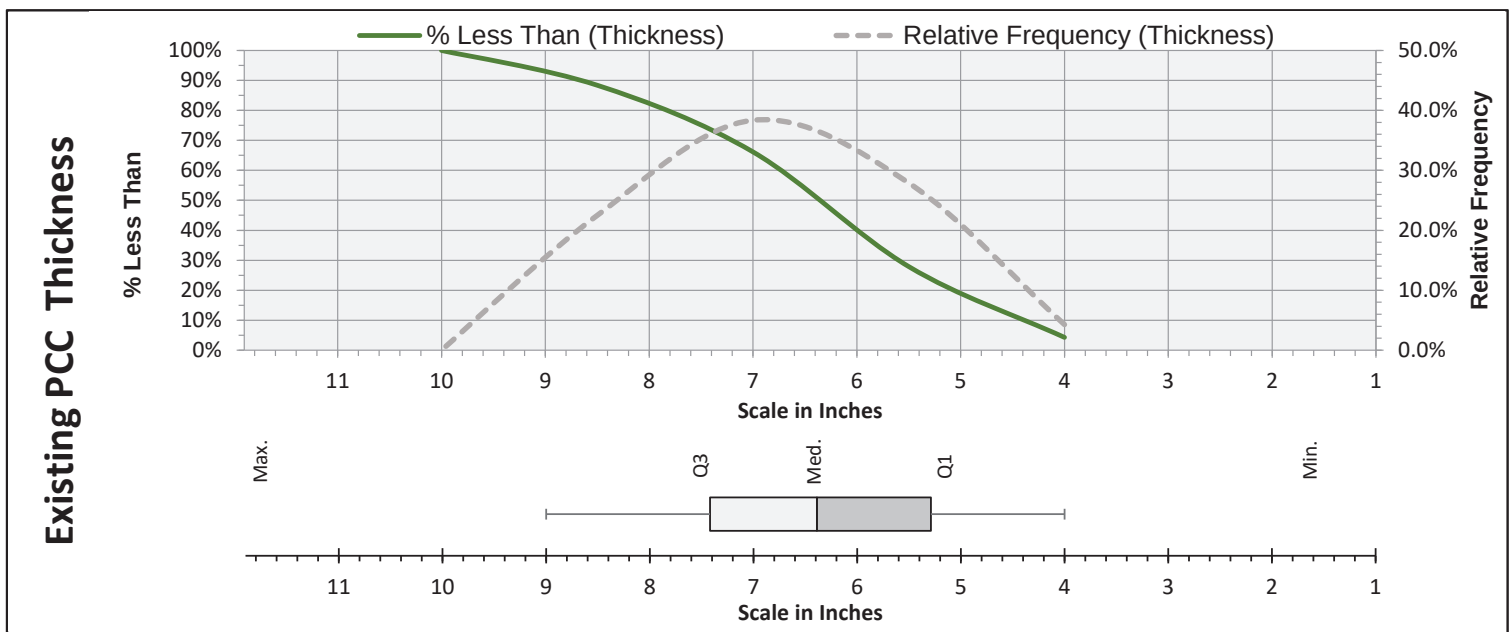
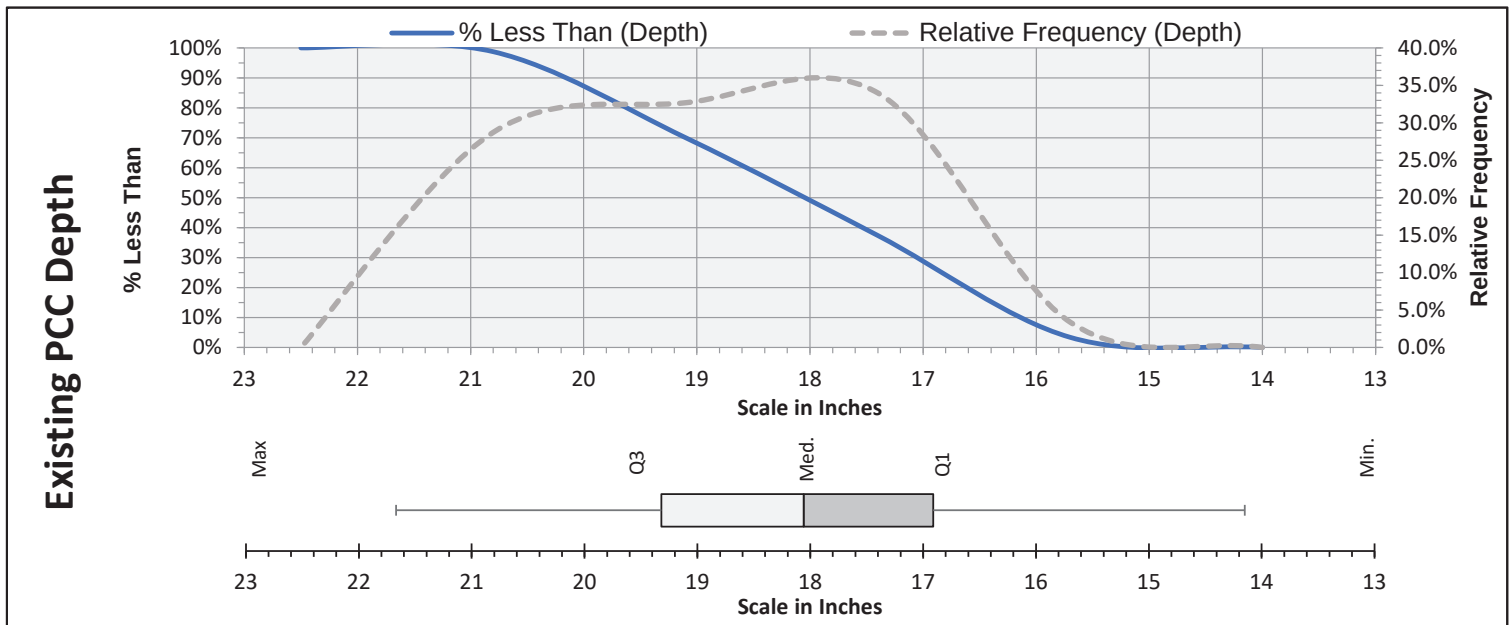
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Scan Date: 1/14/2023

US-91 Park Lawn to Siphon

US-91; Milepost 81.24 to 81.73

(NB Center Lane, Right Wheel Path)



Existing Base Depth Statistics

Average= 18.1 in. (1.51 ft.)
 Max= 21.7 in. (1.81 ft.)
 Min= 14.2 in. (1.18 ft.)
 SD= 1.4 in. (0.12 ft.)
 Median= 18.1 in. (1.51 ft.)
 Q1= 16.9 in. (1.41 ft.)
 Q3= 19.3 in. (1.61 ft.)

Existing Base Thickness Statistics

Average= 6.4 in. (0.54 ft.)
 Max= 9 in. (0.75 ft.)
 Min= 4 in. (0.33 ft.)
 SD= 1.4 in. (0.12 ft.)
 Median= 6.4 in. (0.53 ft.)
 Q1= 5.3 in. (0.44 ft.)
 Q3= 7.4 in. (0.62 ft.)

Total Number of Scans= 7789

Existing PCC Depth And Thickness Statistics

File No: 109216

ITD Key No: 21860

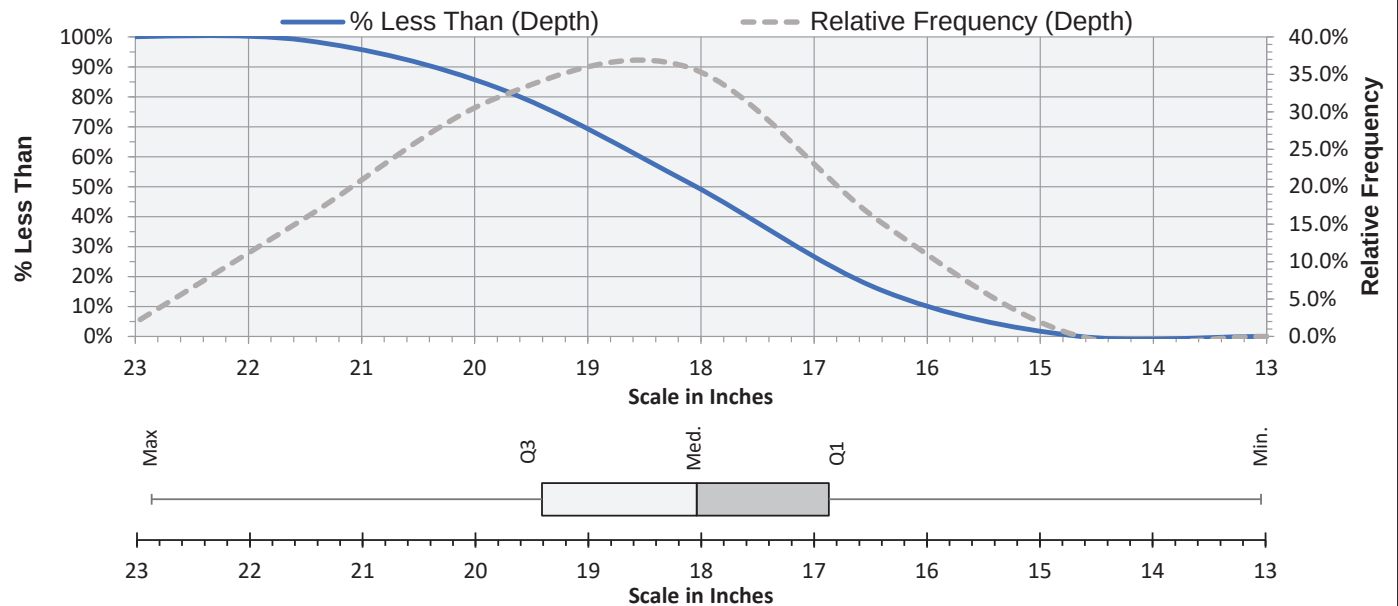
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US-91 Park Lawn to Siphon

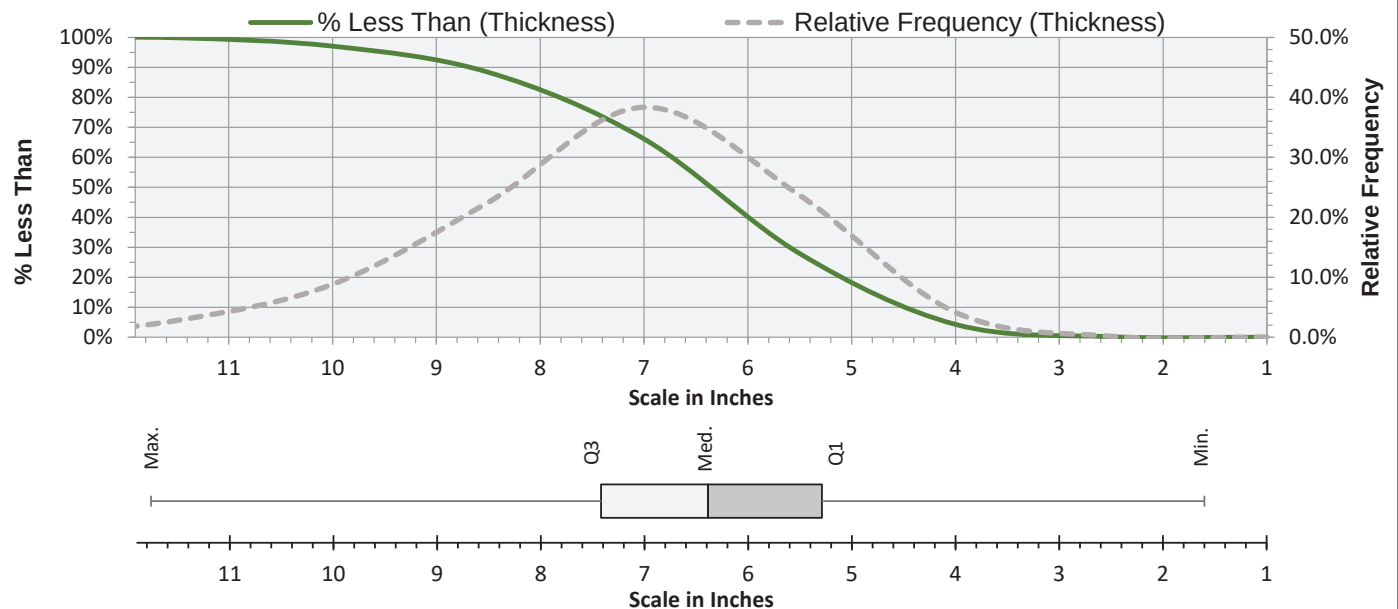
US-91; Milepost 81.24 to 81.73

(NB Center Lane, Right Wheel Path)

Existing PCC Depth



Existing PCC Thickness



Existing PCC Depth Statistics

Average= 18.1 in. (1.51 ft.)
 Max= 22.9 in. (1.91 ft.)
 Min= 13 in. (1.09 ft.)
 SD= 1.6 in. (0.13 ft.)
 Median= 18 in. (1.5 ft.)
 Q1= 16.9 in. (1.41 ft.)
 Q3= 19.4 in. (1.62 ft.)

Existing PCC Thickness Statistics

Average= 6.5 in. (0.54 ft.)
 Max= 11.8 in. (0.98 ft.)
 Min= 1.6 in. (0.13 ft.)
 SD= 1.6 in. (0.14 ft.)
 Median= 6.4 in. (0.53 ft.)
 Q1= 5.3 in. (0.44 ft.)
 Q3= 7.4 in. (0.62 ft.)

Total Number of Scans= 7789

File No: 109216

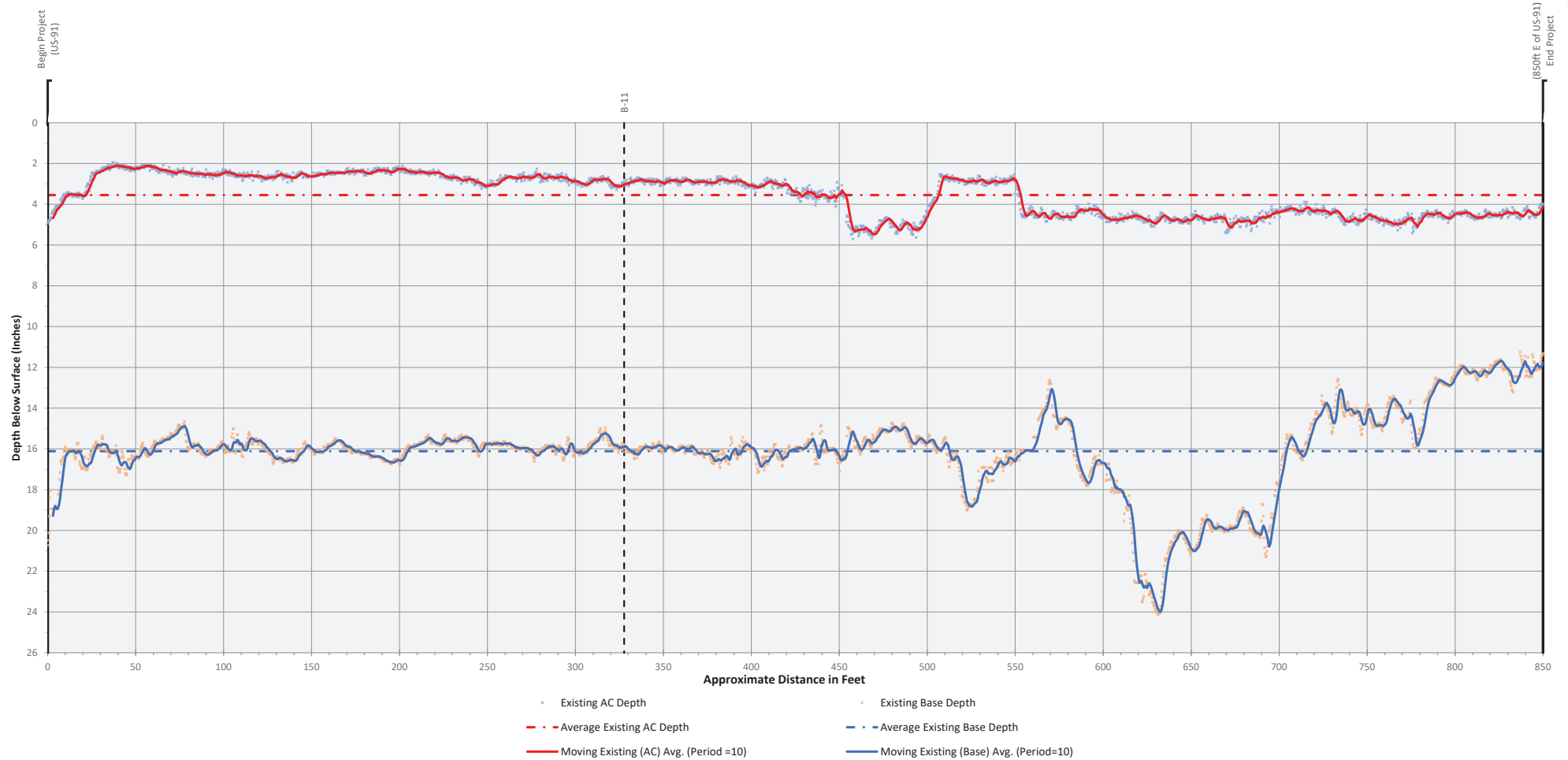
ITD Key No. 21860

Scan Date: 1/14/2023

Existing Pavement Layer Depths

US-91 Park Lawn to Siphon

New Day Pkwy; US-91 to 850ft East of US-91
(East Bound, Lane 0, Right Wheel Path)



Note: GPR distance scale along the x-axis may not correspond exactly with project stationing.

Existing AC Depth/Thickness Statistics



File No: 109216

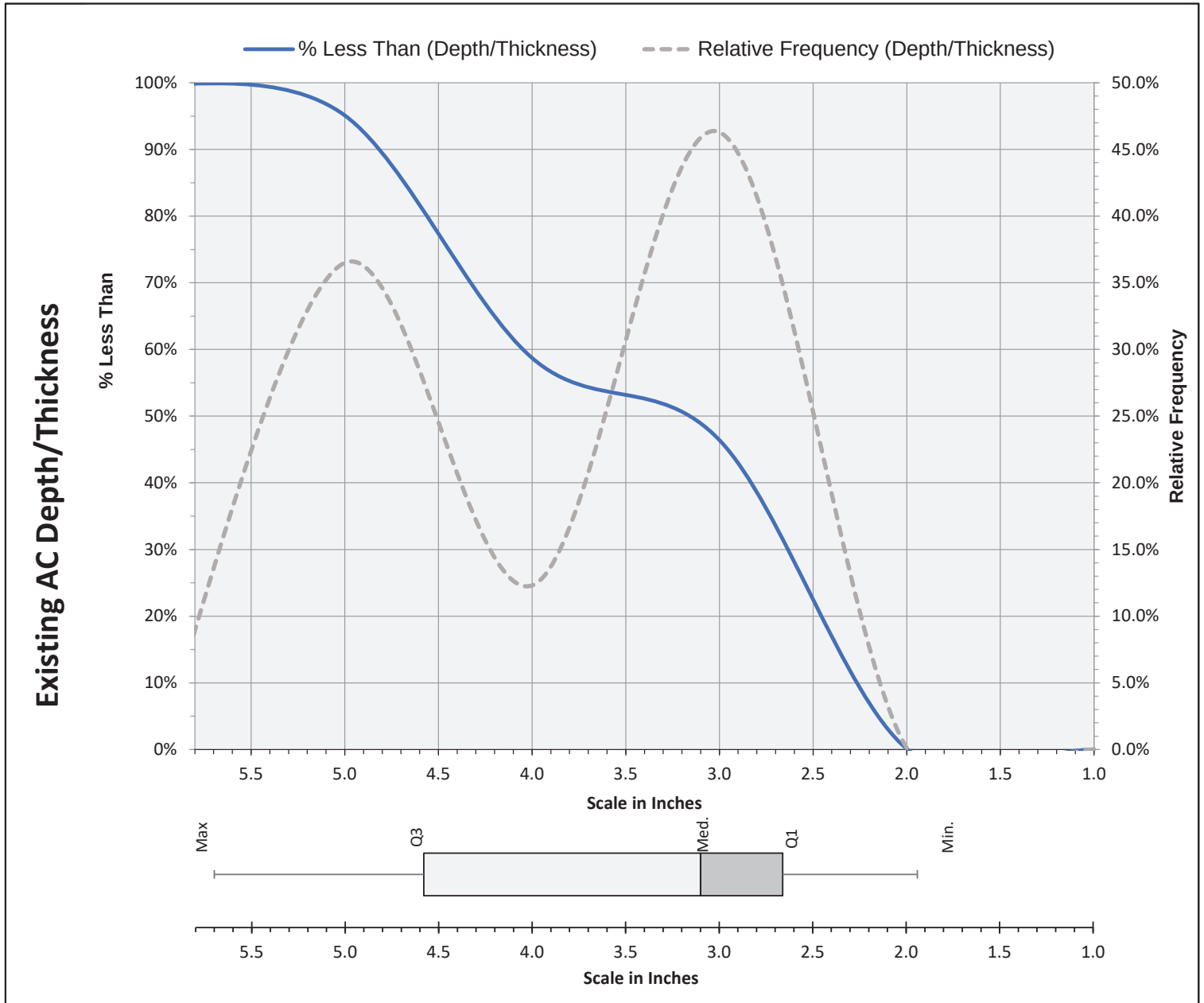
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Scan Date: 1/14/2023

US-91 Park Lawn to Siphon

New Day Pkwy; US-91 to 850ft East of US-91

(East Bound, Lane 0, Right Wheel Path)



Existing AC Depth/Thickness Statistics

Average=	3.5 in.	(0.3 ft.)
Max=	5.7 in.	(0.48 ft.)
Min=	1.9 in.	(0.16 ft.)
SD=	1 in.	(0.08 ft.)
Median=	3.1 in.	(0.26 ft.)
Q1=	2.7 in.	(0.22 ft.)
Q3=	4.6 in.	(0.38 ft.)

Total Number of Scans= 2551

Existing Base Depth And Thickness Statistics



File No: 109216

ITD Key No: 21860

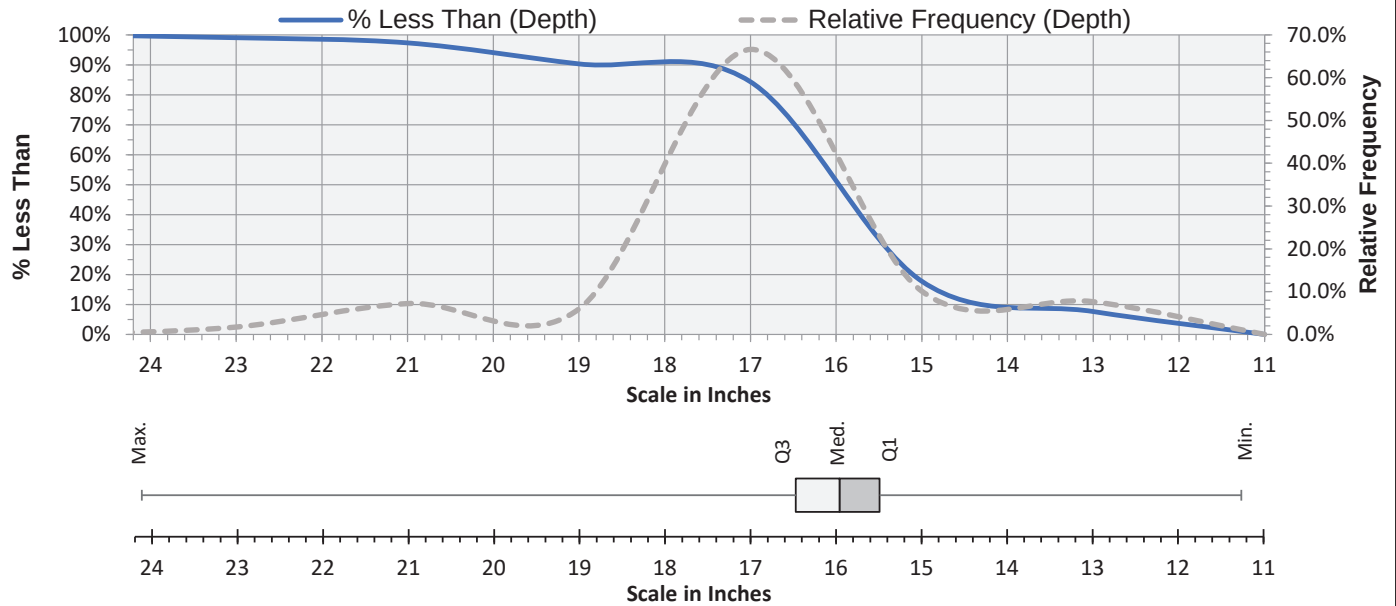
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US-91 Park Lawn to Siphon

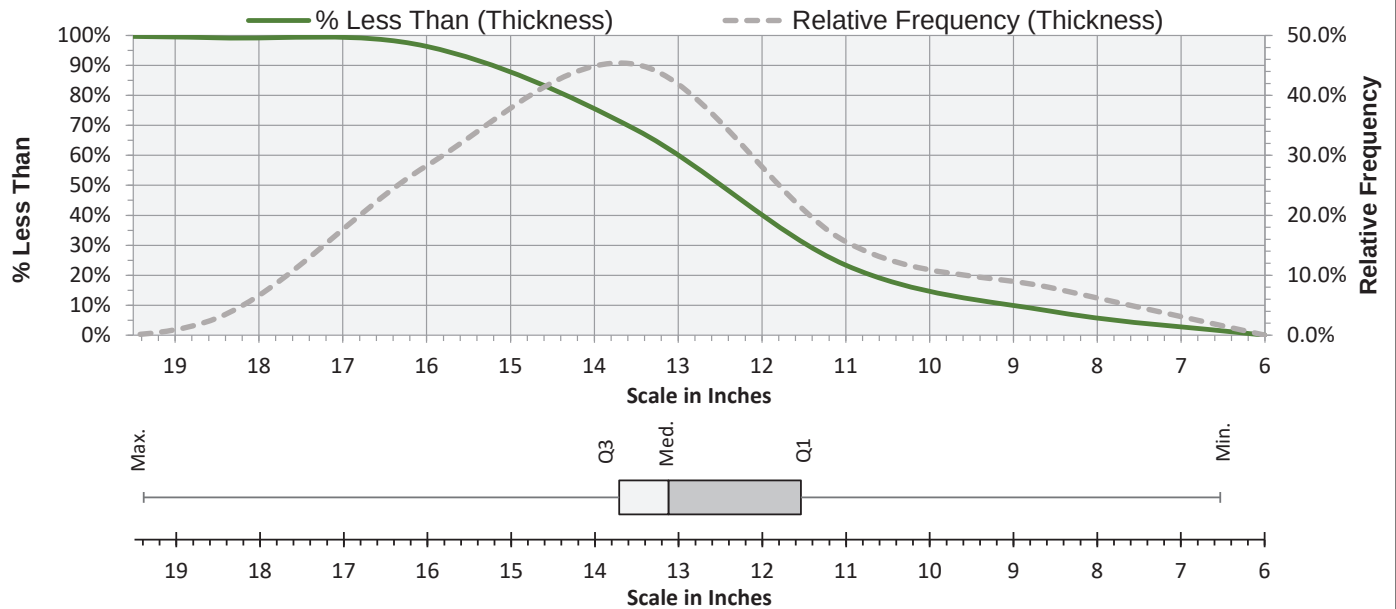
New Day Pkwy; US-91 to 850ft East of US-91

(East Bound, Lane 0, Right Wheel Path)

Existing Base Depth



Existing Base Thickness



Existing Base Depth Statistics

Average= 16.1 in. (1.34 ft.)
 Max= 24.1 in. (2.01 ft.)
 Min= 11.3 in. (0.94 ft.)
 SD= 2 in. (0.17 ft.)
 Median= 16 in. (1.33 ft.)
 Q1= 15.5 in. (1.29 ft.)
 Q3= 16.5 in. (1.37 ft.)

Existing Base Thickness Statistics

Average= 12.6 in. (1.05 ft.)
 Max= 19.4 in. (1.62 ft.)
 Min= 6.5 in. (0.54 ft.)
 SD= 2.2 in. (0.19 ft.)
 Median= 13.1 in. (1.09 ft.)
 Q1= 11.5 in. (0.96 ft.)
 Q3= 13.7 in. (1.14 ft.)

Total Number of Scans= 2551

File No: 109216

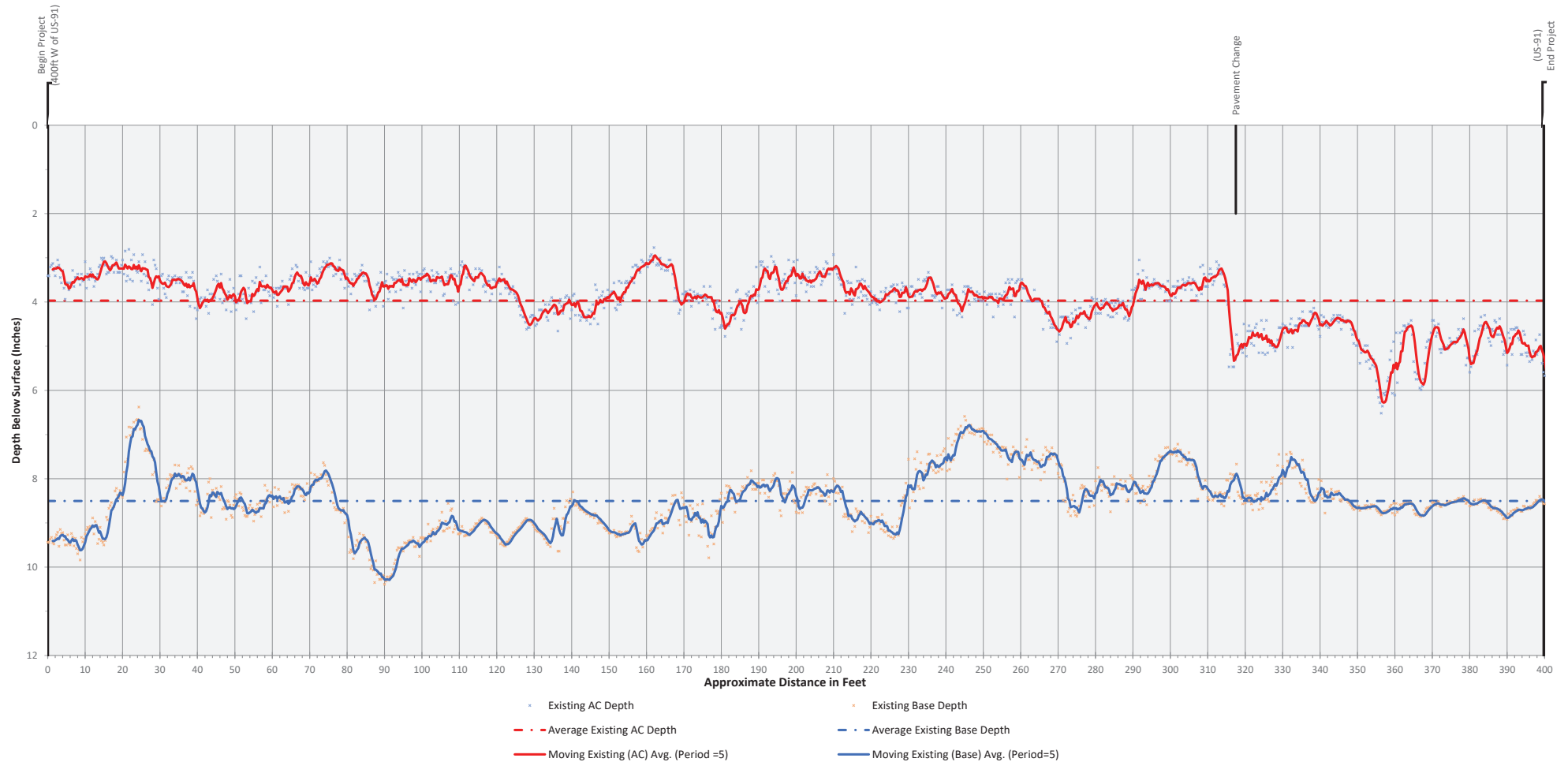
ITD Key No. 21860

Scan Date: 1/14/2023

Existing Pavement Layer Depths

US-91 Park Lawn to Siphon

Siphon Rd; 400ft West of US-91 to US-91
(West Bound, Lane 0, Right Wheel Path)



Note: GPR distance scale along the x-axis may not correspond exactly with project stationing.

Existing AC Depth/Thickness Statistics

File No: 109216

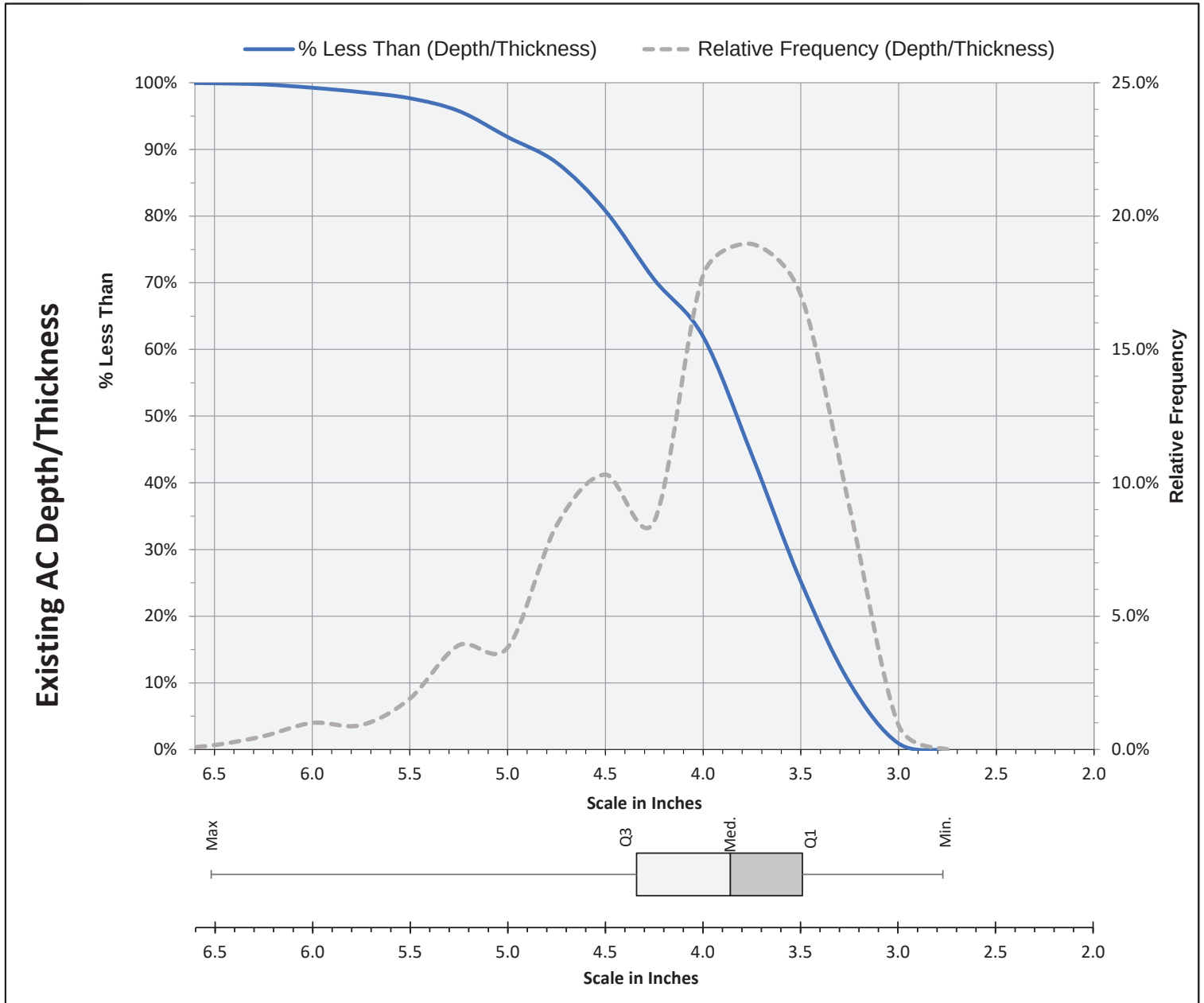
ITD Key No: 21860

Scan Date: 1/14/2023

US-91 Park Lawn to Siphon

Siphon Rd; 400ft West of US-91 to US-91

(West Bound, Lane 0, Right Wheel Path)



Existing AC Depth/Thickness Statistics

Average= 4 in. (0.33 ft.)
 Max= 6.5 in. (0.54 ft.)
 Min= 2.8 in. (0.23 ft.)
 SD= 0.6 in. (0.05 ft.)
 Median= 3.9 in. (0.32 ft.)
 Q1= 3.5 in. (0.29 ft.)
 Q3= 4.3 in. (0.36 ft.)

Total Number of Scans= 1203

Processed by AAC

Checked by KRB

Page 2 of 3

Existing Base Depth And Thickness Statistics

File No: 109216

ITD Key No: 21860

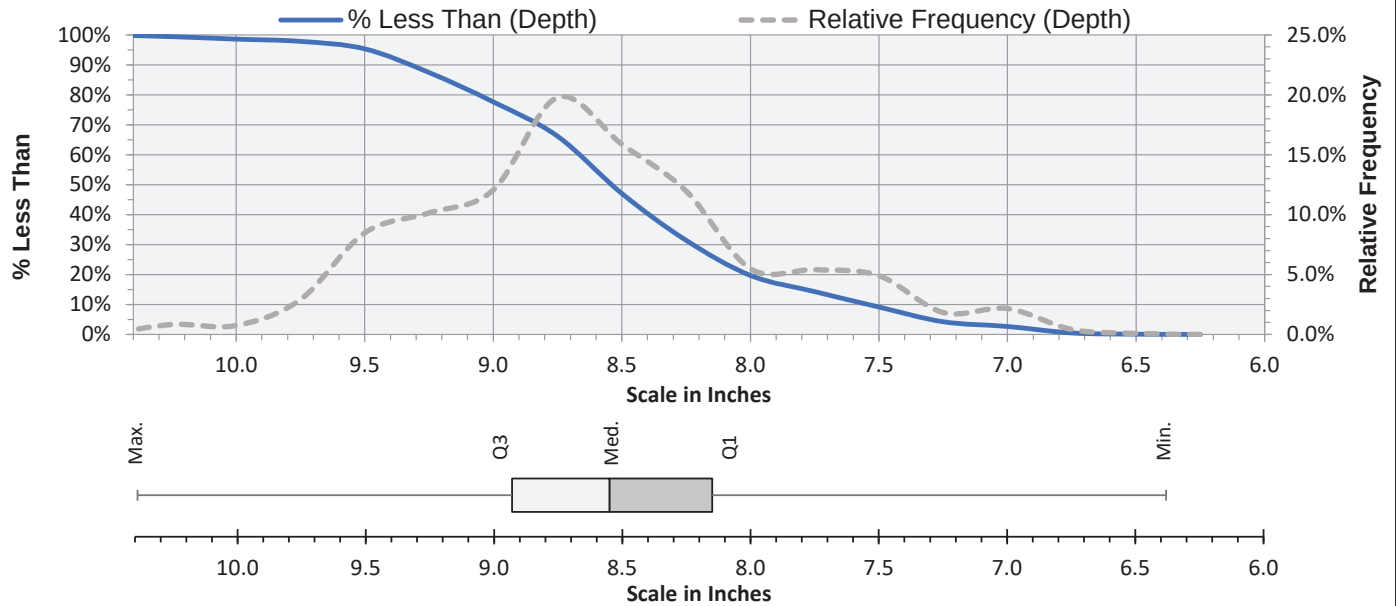
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US-91 Park Lawn to Siphon

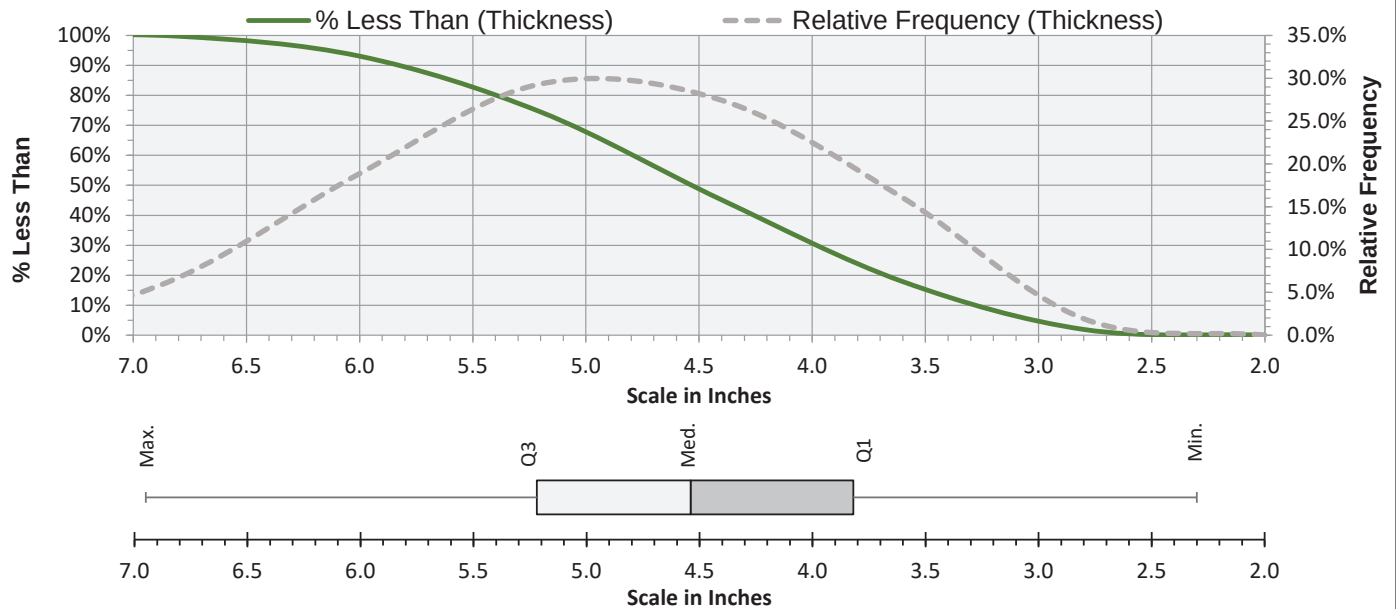
Siphon Rd; 400ft West of US-91 to US-91

(West Bound, Lane 0, Right Wheel Path)

Existing Base Depth



Existing Base Thickness



Existing Base Depth Statistics

Average= 8.5 in. (0.71 ft.)
 Max= 10.4 in. (0.87 ft.)
 Min= 6.4 in. (0.53 ft.)
 SD= 0.7 in. (0.06 ft.)
 Median= 8.6 in. (0.71 ft.)
 Q1= 8.2 in. (0.68 ft.)
 Q3= 8.9 in. (0.74 ft.)

Existing Base Thickness Statistics

Average= 4.5 in. (0.38 ft.)
 Max= 7 in. (0.58 ft.)
 Min= 2.3 in. (0.19 ft.)
 SD= 0.9 in. (0.08 ft.)
 Median= 4.5 in. (0.38 ft.)
 Q1= 3.8 in. (0.32 ft.)
 Q3= 5.2 in. (0.44 ft.)

Total Number of Scans= 1203

Summary of FWD Data and Backcalculation Results

(ELMOD6 version 6.1.86)



Project Name: **US-91, Park Lawn to Siphon Rd**
 Segment: **Park Lawn to Southside way**
 Direction: **Northbound**

Calc. Date: 5/2/2023
 File No.: 109216

Summary of Input Data

Date of FWD Testing: **April 26, 2023**
 PDAT used for Backcalculation (BELLS): **51°F**
 FWD Plate Radius: **5.905"**

Summary of Backcalculated Moduli			
AC	Base	Subgrade	RMS (%)
253.0	23.6	15.2	1.9
48.5	4.4	2.7	0.8

Geometric Mean:	253.0	23.6	15.2	1.9
Standard Deviation:	48.5	4.4	2.7	0.8

Approx. Station	Pavement Deflections in Mils at (12,000 Lbs.) (inches from load plate)									Temperatures (Deg. F)		Layer Thickness (inches)		Backcalculated Elastic Modulus, E _{FWD} (ksi)			
	D(0)	D(8)	D(12)	D(18)	D(24)	D(30)	D(36)	D(48)	D(60)	Asphalt BELLS	Air	AC	Base	AC	Base	Subgrade	RMS (%)
81.276	10.08	9.51	8.89	8.17	7.26	6.28	5.34	3.69	2.43	55.2	47.6	10.8	9.4	219.3	15.9	12.4	1.7
81.315	13.53	12.12	11.17	10.00	8.62	7.45	6.50	4.78	3.67	56.4	48.3	10.3	7.2	178.9	25.1	11.9	0.8
81.354	11.31	10.35	10.32	8.64	7.71	6.80	5.87	3.96	2.95	56.9	49.1	12.9	5.9	221.0	17.1	11.3	2.7
81.392	8.15	7.91	7.46	6.99	6.34	5.60	4.94	3.77	2.91	56.1	50.1	11.3	4.9	334.6	31.2	21.9	3.1
81.427	9.21	8.34	7.46	6.67	5.85	5.02	4.32	3.26	2.54	57.6	50.1	10.1	6.8	284.0	23.7	15.4	1.1
81.467	12.18	11.37	10.43	9.46	8.43	7.31	6.38	4.70	3.52	57.5	50.9	10.5	8.3	228.1	26.1	13.0	1.7
81.504	9.60	8.82	8.09	7.42	6.75	5.98	5.33	4.11	3.24	58.3	50.8	12.6	8.4	195.3	20.2	15.9	2.7
81.532	10.74	10.36	9.39	8.50	7.57	6.59	5.79	4.40	3.41	58.5	51.3	10.8	9.9	226.0	23.5	14.3	2.8
81.616	8.63	7.87	7.28	6.79	6.22	5.57	5.01	3.99	3.13	65.5	57.0	11.5	6.1	296.8	28.3	15.2	0.9
81.653	10.26	9.34	8.66	8.04	7.32	6.56	5.89	4.62	3.61	65.7	56.9	11.7	4.0	340.7	25.6	18.3	1.2
81.691	11.07	10.09	9.38	8.67	7.74	6.89	6.15	4.72	3.60	65.6	58.2	11.9	9.2	264.6	22.6	17.9	1.5
81.717	8.79	8.11	7.59	7.07	6.45	5.77	5.16	3.94	3.13	65.7	58.6	12.9	8.2	310.5	28.9	17.8	2.7

Summary of FWD Data and Backcalculation Results

(ELMOD6 version 6.1.86)



Project Name: **US-91, Park Lawn to Siphon Rd**
 Segment: **Park Lawn to Southside way**
 Direction: **Southbound**

Calc. Date: 5/2/2023
 File No.: 109216

Summary of Input Data

Date of FWD Testing: **April 26, 2023**
 PDAT used for Backcalculation (BELLS): **51°F**
 FWD Plate Radius: **5.905"**

Summary of Backcalculated Moduli			
AC	Base	Subgrade	RMS (%)
230.3	24.7	15.6	2.6
55.1	3.5	2.2	1.2

Geometric Mean:	230.3	24.7	15.6	2.6
Standard Deviation:	55.1	3.5	2.2	1.2

Approx. Station	Pavement Deflections in Mils at (12,000 Lbs.) (inches from load plate)									Temperatures (Deg. F)		Layer Thickness (inches)		Backcalculated Elastic Modulus, E _{FWD} (ksi)			
	D(0)	D(8)	D(12)	D(18)	D(24)	D(30)	D(36)	D(48)	D(60)	Asphalt BELLS	Air	AC	Base	AC	Base	Subgrade	RMS (%)
81.285	21.54	18.79	16.15	13.63	11.35	9.36	7.79	5.34	4.07	60.8	55.0	12.7	4.9	204.0	20.6	13.6	2.3
81.317	14.01	12.52	11.19	9.92	8.61	7.39	6.45	4.80	3.59	61.3	55.2	12.7	8.1	168.0	20.8	17.2	2.7
81.356	11.34	9.95	8.86	7.90	6.93	5.97	5.28	4.07	3.16	59.7	55.5	12.4	8.4	212.6	25.4	14.4	1.5
81.394	7.70	6.94	6.32	5.80	5.22	4.69	4.23	3.44	2.82	60.5	55.3	14.4	3.5	366.1	29.7	21.3	1.7
81.431	9.96	8.81	7.85	7.06	6.26	5.50	4.89	3.86	3.09	60.3	55.2	12.0	6.6	296.7	26.7	13.4	1.5
81.468	13.02	11.53	10.05	8.85	7.62	6.42	5.43	3.96	3.07	59.9	55.4	11.7	7.4	192.5	26.8	15.8	1.8
81.507	8.91	7.84	6.91	6.16	5.38	4.64	4.03	3.07	2.38	60.2	55.6	11.7	12.6	278.8	33.3	17.9	1.8
81.546	10.63	9.26	8.18	7.19	6.21	5.38	4.68	3.47	2.61	61.2	55.1	14.0	8.0	185.4	23.8	14.1	2.9
81.582	14.09	12.84	11.43	10.09	8.60	7.26	6.21	4.46	3.33	68.2	60.8	14.9	8.2	161.3	24.0	17.8	5.3
81.622	13.15	12.01	10.88	9.82	8.71	7.42	6.44	4.81	3.70	67.6	59.1	14.8	8.1	191.8	26.3	15.8	4.7
81.657	10.79	9.74	8.81	8.00	7.11	6.17	5.41	4.08	3.11	68.3	59.4	13.2	12.4	306.0	20.4	12.3	2.4
81.697	13.28	12.27	11.28	10.29	9.13	7.92	6.97	5.31	4.11	67.7	59.3	12.2	7.2	298.2	22.0	15.4	2.3
81.732	13.22	11.93	10.88	9.90	8.80	7.66	6.68	5.02	3.88	66.9	59.4	14.6	6.9	209.6	18.8	15.8	3.1

Summary of FWD Data and Backcalculation Results

(ELMOD6 version 6.1.86)



Project Name: **US-91, Park Lawn to Siphon Rd**
 Segment: **Park Lawn to Siphon**
 Direction: **Center Turn Lane**

Calc. Date: **5/2/2023**
 File No.: **109216**

Summary of Input Data

Date of FWD Testing: **April 26, 2023**

PDAT used for Backcalculation (BELLS): **51°F**

FWD Plate Radius: **5.905"**

Summary of Backcalculated Moduli

	AC	PCC	Base	Subgrade	RMS (%)
Geometric Mean:	206.5	1987.8	25.5	15.4	2.6
Standard Deviation:	61.3	240.9	7.3	2.2	0.6

Approx. Station	Pavement Deflections in Mils at (12,000 Lbs.) (inches from load plate)									Temperatures (Deg. F)		Layer Thickness (inches)			Backcalculated Elastic Modulus, E _{FWD} (ksi)				
	D(0)	D(8)	D(12)	D(18)	D(24)	D(30)	D(36)	D(48)	D(60)	Asphalt BELLS	Air	AC	PCC	PCC	AC	PCC	PCC	Subgrade	RMS (%)
81.277	6.57	5.98	5.48	5.12	4.68	4.25	3.88	3.17	2.56	57.2	57.8	3.9	8.1	6.0	282.5	1814.3	32.0	12.2	1.7
81.317	8.94	7.62	6.77	6.20	5.72	5.25	4.84	4.04	3.39	57.5	57.2	4.1	7.3	5.0	127.8	2064.4	39.1	16.0	2.6
81.354	6.81	5.81	5.28	4.92	4.53	4.14	3.83	3.24	2.74	59.2	55.5	4.4	7.5	6.4	192.1	2585.9	31.6	12.3	1.9
81.392	8.81	7.51	6.52	5.82	5.11	4.50	3.98	3.20	2.63	59.2	56.2	4.4	7.5	8.5	150.7	1773.6	17.7	14.0	3.0
81.429	7.49	6.40	5.58	5.00	4.24	3.49	3.04	2.53	2.12	59.3	54.9	4.6	7.4	6.9	230.9	1718.9	15.9	15.3	2.2
81.467	7.90	6.56	5.72	5.12	4.60	4.14	3.79	3.18	2.62	58.3	56.4	5.2	5.9	6.9	136.4	1918.5	17.7	14.5	3.5
81.505	7.34	6.17	5.43	4.99	4.56	4.14	3.79	3.16	2.64	58.6	56.8	5.2	6.9	6.3	166.2	1925.3	25.1	19.6	2.9
81.534	7.99	6.99	6.32	5.82	5.36	4.90	4.48	3.63	2.95	60.1	55.8	5.4	4.8	9.0	218.4	2458.3	30.2	15.6	2.3
81.578	3.75	3.26	3.02	2.85	2.66	2.41	2.19	1.79	1.49	65.8	60.7	5.7	6.5	7.1	355.5	1896.6	23.8	20.2	1.5
81.617	8.70	7.42	6.67	6.12	5.58	5.07	4.64	3.79	3.10	66.0	59.9	5.2	5.9	4.9	203.7	1762.0	26.2	15.5	2.7
81.654	10.35	8.68	7.60	6.82	6.13	5.51	4.99	4.08	3.27	66.5	59.8	5.2	5.8	4.3	180.9	1974.1	34.9	14.9	3.1
81.693	8.69	7.24	6.35	5.82	5.33	4.90	4.52	3.79	3.21	64.8	60.1	5.5	6.6	6.3	383.6	2151.4	22.9	17.3	3.4
81.720	8.44	7.39	6.55	5.93	5.35	4.83	4.42	3.73	3.17	66.1	59.7	5.6	5.7	5.6	270.9	2488.9	16.3	14.6	2.9

Summary of FWD Data and Backcalculation Results

(ELMOD6 version 6.1.86)



Project Name: **US-91, Park Lawn to Siphon Rd**
 Segment: **Siphon/New Day**
 Direction: **Eastbound Lane**

Calc. Date: 5/5/2023
 File No.: 109216

Summary of Input Data

Date of FWD Testing: **April 26, 2023**
 PDAT used for Backcalculation (BELLS): **51°F**
 FWD Plate Radius: **5.905"**

Summary of Backcalculated Moduli			
AC	Base	Subgrade	RMS (%)
255.3	25.3	14.5	1.8
59.1	4.2	1.3	0.5

Geometric Mean:	255.3	25.3	14.5	1.8
Standard Deviation:	59.1	4.2	1.3	0.5

Approx. Station	Pavement Deflections in Mils at (12,000 Lbs.) (inches from load plate)									Temperatures (Deg. F)		Layer Thickness (inches)		Backcalculated Elastic Modulus, E _{FWD} (ksi)			
	D(0)	D(8)	D(12)	D(18)	D(24)	D(30)	D(36)	D(48)	D(60)	Asphalt BELLS	Air	AC	Base	AC	Base	Subgrade	RMS (%)
10.0	25.22	18.15	13.07	9.04	6.08	4.10	3.00	1.87	1.56	55.9	52.0	3.7	12.9	208.7	30.4	13.2	1.9
219.3	28.97	23.47	18.35	14.18	10.94	8.65	7.16	5.28	4.15	55.8	53.1	2.5	13.2	245.5	26.3	13.8	1.4
418.0	31.25	22.40	16.50	12.19	9.28	7.46	6.40	5.06	4.17	56.6	53.5	3.1	13.2	160.8	28.1	14.9	1.2
615.4	30.27	22.58	15.81	11.42	8.44	6.58	5.52	4.07	3.08	61.7	57.2	3.1	13.1	268.8	24.3	14.9	1.9
816.8	31.29	22.80	15.76	10.69	7.21	5.40	4.53	3.54	2.72	59.3	56.3	2.9	13.1	266.3	25.0	13.4	2.0
1016.2	28.18	21.39	15.85	11.62	8.40	6.39	5.28	4.04	3.24	61.6	56.0	3.0	13.1	354.5	30.0	13.3	1.4
1219.6	31.76	23.28	14.76	9.67	7.08	5.64	4.81	3.70	3.20	60.9	55.7	3.0	13.1	241.3	17.2	15.8	3.0
1361.7	35.12	29.58	23.35	17.93	13.13	9.74	7.56	5.16	4.07	61.2	55.0	3.0	13.1	357.8	23.8	17.3	1.7

Summary of FWD Data and Backcalculation Results

(ELMOD6 version 6.1.86)



Project Name: **US-91, Park Lawn to Siphon Rd**
 Segment: **Siphon/New Day**
 Direction: **Westbound Lane**

Calc. Date: 5/5/2023
 File No.: 109216

Summary of Input Data

Date of FWD Testing: **April 26, 2023**
 PDAT used for Backcalculation (BELLS): **51°F**
 FWD Plate Radius: **5.905"**

Summary of Backcalculated Moduli			
AC	Base	Subgrade	RMS (%)
207.5	23.2	14.3	2.1
91.3	2.8	2.6	0.3

Geometric Mean:	207.5	23.2	14.3	2.1
Standard Deviation:	91.3	2.8	2.6	0.3

Approx. Station	Pavement Deflections in Mils at (12,000 Lbs.) (inches from load plate)									Temperatures (Deg. F)		Layer Thickness (inches)		Backcalculated Elastic Modulus, E _{FWD} (ksi)			
	D(0)	D(8)	D(12)	D(18)	D(24)	D(30)	D(36)	D(48)	D(60)	Asphalt BELLS	Air	AC	Base	AC	Base	Subgrade	RMS (%)
0.0	33.60	26.76	20.44	15.43	11.79	9.09	7.52	5.66	4.56	56.4	Air	4.8	3.9	123.8	23.2	12.4	1.7
211.0	32.29	25.50	19.11	14.18	10.04	7.18	5.34	3.27	2.43	55.1	53.3	4.6	4.0	168.9	25.8	18.8	2.1
409.9	17.01	14.65	12.25	9.85	7.59	5.68	4.41	2.75	1.96	59.0	54.5	5.3	3.3	596.8	24.9	16.3	1.8
618.0	16.40	11.93	8.40	5.79	3.96	2.77	2.09	1.33	1.10	62.0	54.9	4.6	3.9	325.3	18.1	14.8	2.6
819.4	29.63	22.01	15.49	10.78	7.34	5.26	4.15	3.11	2.53	61.2	58.7	4.1	4.8	188.4	23.9	10.2	2.3
1020.5	33.85	23.94	15.85	10.46	6.97	5.22	4.33	3.12	2.43	61.1	58.5	4.9	3.7	192.5	21.5	13.4	2.2
1226.4	29.56	21.10	14.22	9.44	6.54	4.84	3.98	3.02	2.41	61.5	58.4	4.8	3.8	112.6	26.3	15.6	1.8

Appendix D

Laboratory Test Results

CONTENTS

- Summary of Laboratory Test Results
- Sand Equivalent Test Results
- Atterberg Limits Test Results
- Particle Size Distribution Reports
- Chloride & Sulfate Corrosion Testing Results
- Resilient Modulus Test Results

Project Information

Report to: Kimley Horn
Project: US-91, Park Lawn to Siphon
Report Date: 2/14/2023
File No.: 109216

Material Information

Date Sampled: 1/12/2023
Sampled By: S&W
Date Received: 1/24/2023
Date Tested: 1/24 - 2/13/2023

SUMMARY OF LABORATORY RESULTS

Lab Number	Borehole	Sample Type	Depth (ft)	Water Content (%)	% Passing #200 Sieve	Liquid Limit (%)	Plasticity Index	Soil Type	Remarks
23-0149	B-01	SS-02	2.0'-4.0'	22.5	91.5	29	8	CL	--
23-0150	B-02	GB-05	0.9'-1.6'	--	27.3	--	--	GM	--
23-0151	B-02	SS-07	4.0'-6.0'	20.4	86.3	28	6	CL-ML	--
23-0152	B-03	SS-30	4.0'-6.0'	20.4	87.4	27	7	CL-ML	--
23-0153	B-05	ST-14	2.2'-2.9'	--	89.4	23	3	ML	--
23-0138	B-06	SS-34	4.0'-6.0'	21.5	92.5	32	11	CL	--
23-0139	B-07	GB-20	1.0'-1.5'	--	16.3	--	--	GM	--
23-0140	B-07	SS-21	2.0'-4.0'	22.7	92.8	28	9	CL	--
23-0141	B-09	SS-37	2.0'-4.0'	18.8	71.2	28	8	CL	--
23-0143	B-11	GB-26	0.3'-1.4'	--	2.0	23	4	GP	--
23-0142	B-11	SS-25	2.0'-4.0'	8.2	38.8	--	--	GM	Hydro, -#40 mtl. used.

Prepared By: Kelli Browning

Project Information

Report to: Kimley Horn
Project: US-91, Park Lawn to Siphon
Report Date: 2/14/2023
File No.: 109216

Material Information

Date Sampled: 1/12/2023
Sampled By: S&W
Date Received: 1/24/2023
Date Tested: 1/24 - 2/13/2023

Sand Equivalent Test AASHTO T-176

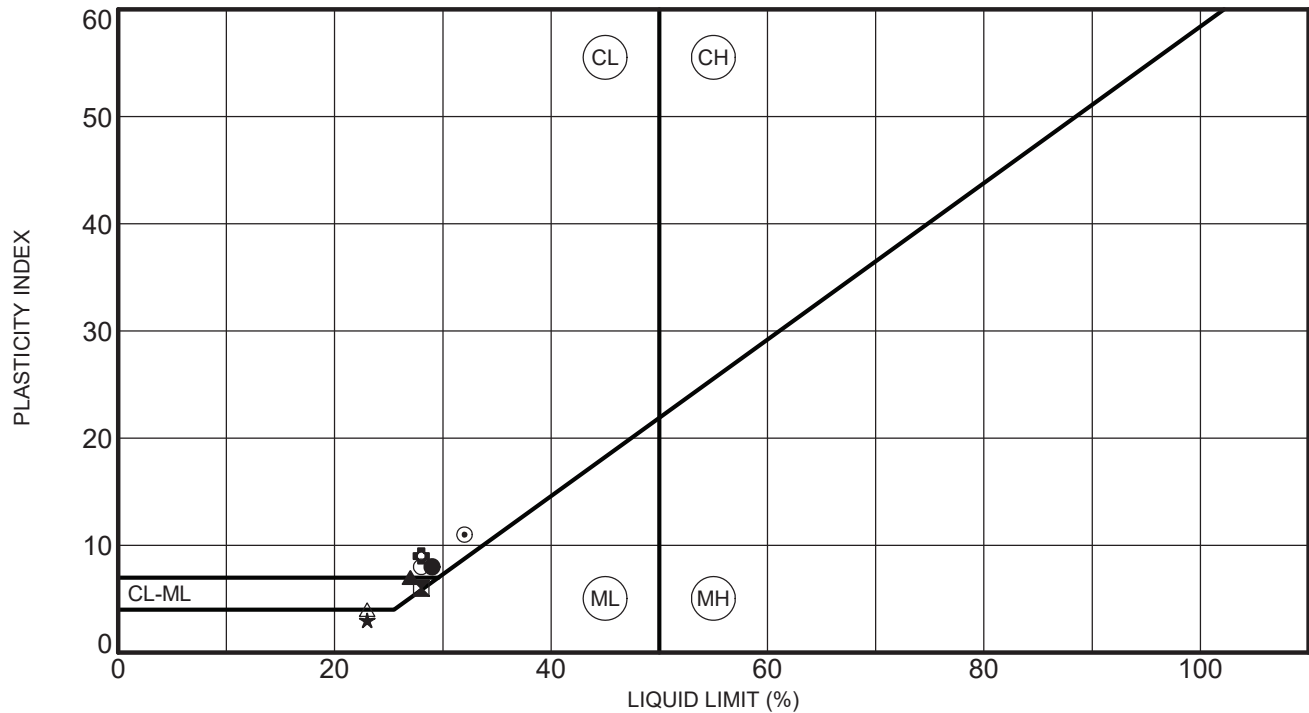
Lab Number	Location	Sample Type	Depth (ft)	Sand Equivalent	Remarks
23-0150	B-02	GB-05	0.9'-1.6'	14	--

Prepared By: Kelli Browning

ATTERBERG LIMITS REPORT

CLIENT: Kimley Horn
FILE NUMBER: 109216

PROJECT NAME: US-91, Park Lawn to Siphon
PROJECT LOCATION: Chubbuck, Idaho



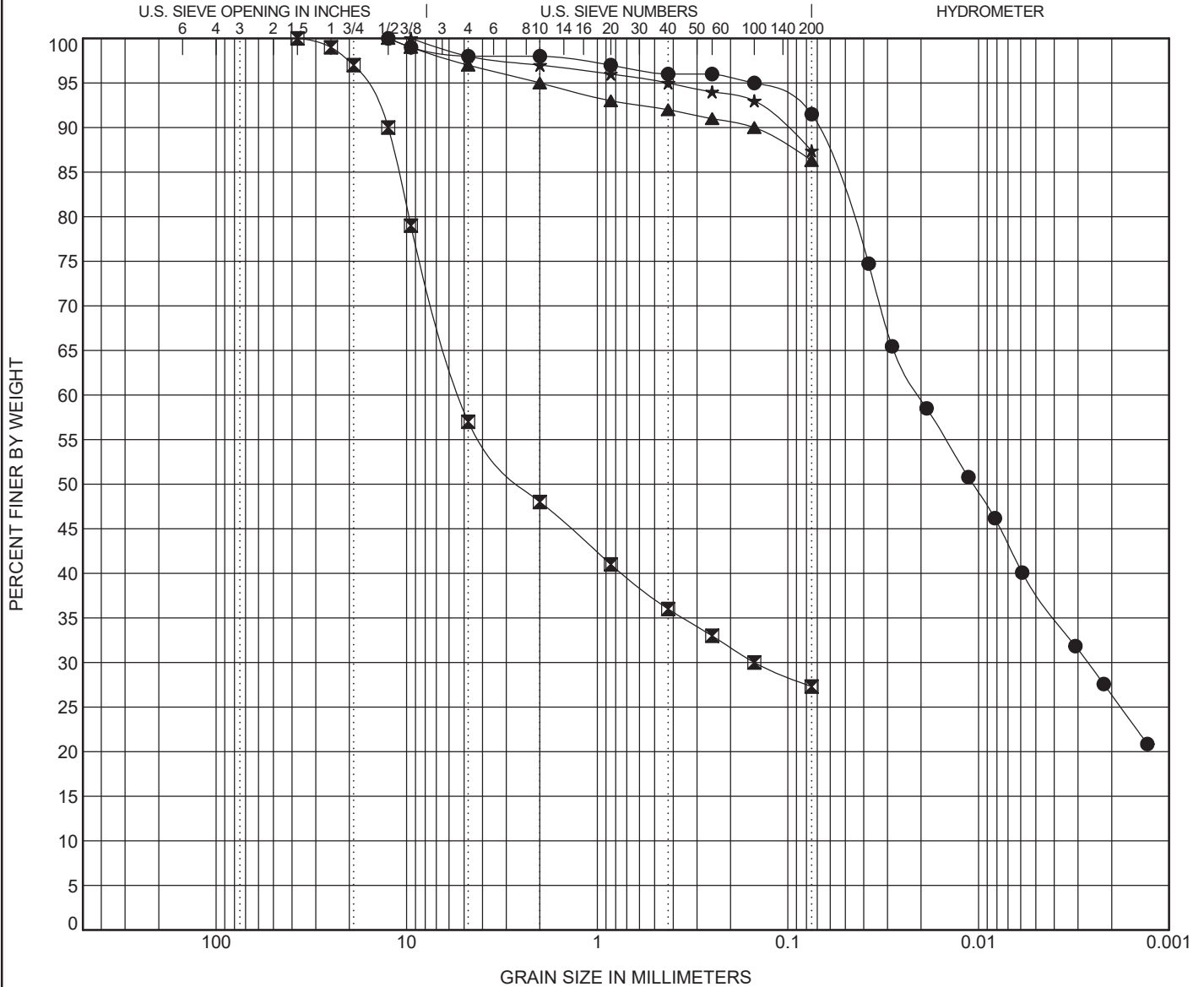
Specimen Identification				MC	LL	PL	PI	Fines	Classification
●	B-01	SS-02	2.0	22.5	29	21	8	92	LEAN CLAY (CL)
▣	B-02	SS-07	4.0	20.4	28	22	6	86	SILTY CLAY (CL-ML)
▲	B-03	SS-30	4.0	20.4	27	20	7	87	SILTY CLAY (CL-ML)
★	B-05	ST-14	2.2	--	23	20	3	89	SILT (ML)
⊙	B-06	SS-34	4.0	21.5	32	21	11	93	LEAN CLAY (CL)
⊕	B-07	SS-21	2.0	22.7	28	19	9	93	LEAN CLAY (CL)
○	B-09	SS-37	2.0	18.8	28	20	8	71	LEAN CLAY with SAND (CL)
△	B-11	GB-26	0.3	--	23	19	4	2	POORLY GRADED GRAVEL (GP)
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	
		-		--				--	

PARTICLE-SIZE DISTRIBUTION REPORT



CLIENT: Kimley Horn
FILE NUMBER: 109216

PROJECT NAME: US-91, Park Lawn to Siphon
PROJECT LOCATION: Chubbuck, Idaho



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification				Classification	D10	D30	D60
●	B-01	SS-02	2.0	LEAN CLAY (CL)	--	0.003	0.02
☒	B-02	GB-05	0.9	SILTY GRAVEL with SAND (GM)	--	0.15	5.221
▲	B-02	SS-07	4.0	SILTY CLAY (CL-ML)	--	--	--
★	B-03	SS-30	4.0	SILTY CLAY (CL-ML)	--	--	--

Specimen Identification				%Gravel	%Sand	%Fines	D15	D50	D85	Cc	Cu	MC	LL	PI
●	B-01	SS-02	2.0	2.0	6.5	91.5	--	0.011	0.057	--	--	22.5	29	8
☒	B-02	GB-05	0.9	43.0	29.7	27.3	--	2.424	11.034	--	--	--	--	--
▲	B-02	SS-07	4.0	3.0	10.7	86.3	--	--	--	--	--	20.4	28	6
★	B-03	SS-30	4.0	2.0	10.6	87.4	--	--	--	--	--	20.4	27	7

Prepared By: Kelli Browning

QC:TT

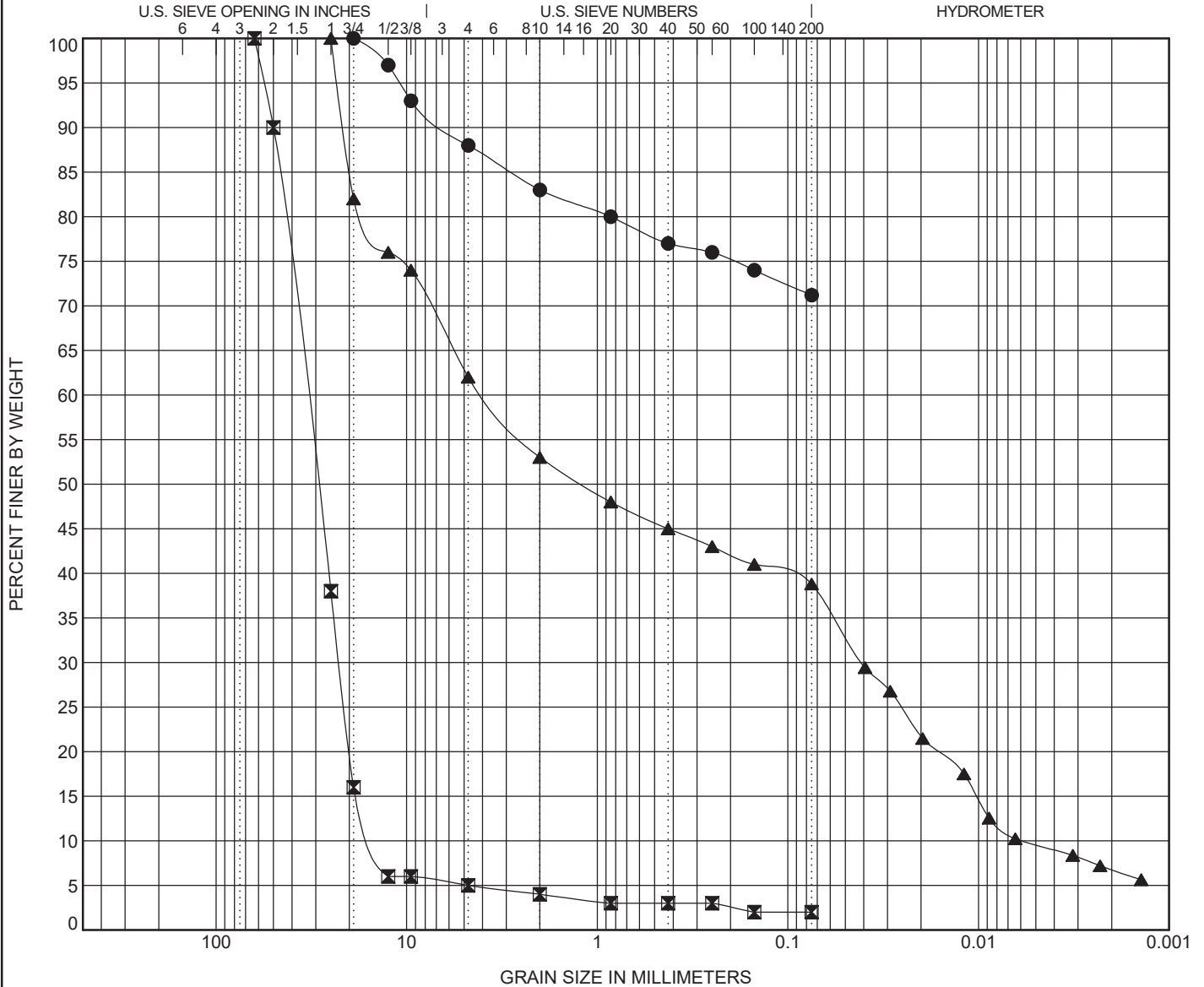
Shannon & Wilson

PARTICLE-SIZE DISTRIBUTION REPORT



CLIENT: Kimley Horn
FILE NUMBER: 109216

PROJECT NAME: US-91, Park Lawn to Siphon
PROJECT LOCATION: Chubbuck, Idaho



Client Name: Kimley Horn
Project Name: US-91 Park Lawn to Siphon KN(21860)
Project No: 109216
Report Date: 2/14/2023

Material Information

Boring/Sample ID: B-05 ST-14	Lab Number: 23-0153
Material Type: Type-2 (Subgrade)	AASHTO Classification: A4
Type of Sample: 4" Dia Undisturbed	Depth of Specimen (ft.): 2.6'
Dry Density (pcf): 103.5 In-situ	Date Sampled: 1/12/2023
Specimen WC (%): 15.6 In-situ	Date Tested: 2/7/2023

Test Results

Resilient Modulus Test (AASHTO T-307)

Sequence No	Confining Stress	Total Axial Stress	Bulk Stress	Octahedral Shear Stress	Measured Resilient Modulus	Predicted Resilient Modulus
	σ_3	σ_d	θ	τ_{oct}	M_r	Pred. M_r
	psi	psi	psi	psi	psi	psi
1	6.00	2.04	20.06	0.96	9036	9029
2	6.01	4.18	22.20	1.97	8466	8428
3	6.01	6.12	24.14	2.89	7728	7928
4	6.00	8.13	26.14	3.83	7604	7453
5	6.01	10.12	28.14	4.77	7627	7023
6	4.00	2.05	14.06	0.97	7364	6989
7	4.00	4.12	16.13	1.94	6391	6726
8	4.00	6.07	18.08	2.86	5997	6460
9	4.00	8.08	20.09	3.81	6052	6184
10	4.00	10.08	22.09	4.75	6253	5913
11	2.00	2.06	8.07	0.97	5342	4687
12	2.00	4.06	10.07	1.91	4595	4813
13	2.00	6.06	12.06	2.86	4416	4832
14	2.00	8.05	14.06	3.80	4596	4792
15	2.00	10.05	16.05	4.74	4833	4707

Resilient Modulus Equation

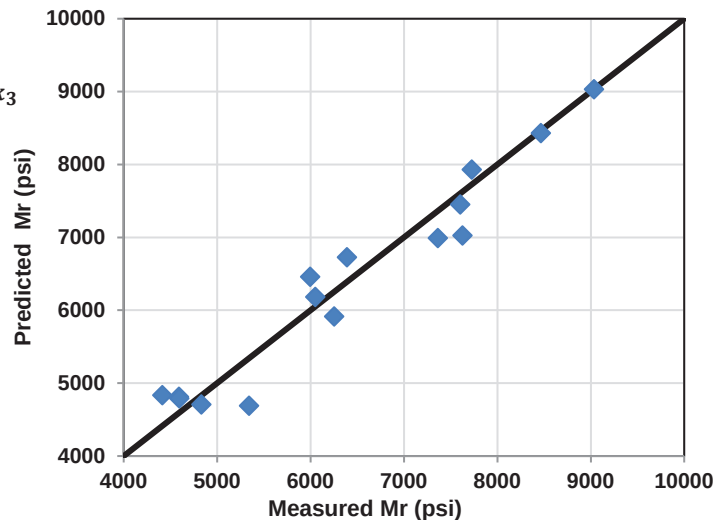
$$M_r = k_1 * P_a * \left(\frac{\theta}{P_a} \right)^{k_2} * \left(\frac{\zeta_{oct}}{P_a} + 1 \right)^{k_3}$$

Resilient Modulus Model Parameters

$$k_1 = \underline{567.639}$$

$$k_2 = \underline{0.719}$$

$$k_3 = \underline{-2.273}$$



Tested By: KB

Reviewed By: TT

Shannon & Wilson
5260 Chinden Blvd.
Boise, Idaho 83714
Phone: (208) 658-8700
Fax: (208) 658-8703



Report to: Kimley Horn
Report Date: 3/8/2023
Project No.: 109216
Project: US-91 Park Lawn to Siphon

Material Information

Date Sampled: 1/23/2023
Sampled By: Shannon & Wilson
Date Received: 1/26/2023
Date Tested: 1/30/2023

Test Results

Soil Resistivity and pH for Corrosion Testing
AASHTO T-288, T-289

**Minimum
Resistivity**

Lab Number	Sample ID	Ohm-cm	pH	@ Temp, F°
23-0144	CV-12, BK-39	3,000	7.7	67.2

Reviewed By: Paul Clawges



1804 N. 33rd Street
Boise, Idaho 83703
Phone (208) 342-5515

www.analyticallaboratories.com
Lab Federal ID# ID00020

Laboratory Analysis Report

Report To: TRAVIS THOMSEN
SHANNON & WILSON
5260 CHINDEN BLVD
BOISE, ID 83714

Phone: (208) 658-8700 Copy:
e-mail: tthomsen@shanwil.com
Date Received: 01/30/2023
Collection Date/Time: 01/24/2023 0:00

Lab/Sample Number: 2301888-01
Sample Location: US-91; PARK LAWN TO SIPHON; PROJECT
#109216; 23-0144; CV-12, BK-39

Date Printed: 02/10/2023 7:28
Collector's Name:
Transported By: PAUL CLAWGES
Temp C Received at Lab:

Field Measurements

pH: Total Chlorine mg/L: DO mg/L:
Temp C: Free Chlorine mg/L: Flow g/min:

Analyte	Result	Units	MRL	MDL	MCL	Analyzed	Analyst	Method	Notes
Inorganics									
Chloride, Cl	49	mg/kg	10	0.6		2/7/23 16:35	NC	EPA 300.0	
Sulfate, SO ₄	24	mg/kg	10	0.4		2/7/23 16:35	NC	EPA 300.0	

Authorized Signature,

James Hibbs, Client Manager

This report shall not be reproduced except in full, without the written approval of the laboratory
The results reported related only to the samples indicated.

ND - Non Detect
MCL - Maximum Contaminant Level
MDL - Method Detection Limit
MRL - Method Reporting Limit

Appendix E

Pavement Design Data and Considerations

CONTENTS

- Traffic Loading
- LTPPBind Report

Projected Commercial and 18,000 Equivalent Single Axle Loadings (ESALS)				
Project Number:	A021(860)	Key Number:	21860	
County:	Bannock	District:	5	
Route:	US-091	From Measure:	80.878	
RouteID:	02350AU5091	To Measure:	81.219	
Last year with data:	2021			
Starting to Cumulate in:	2026	Requested By:	Mart Earl	
Cumulating ESALs up to:	2066	Email:	mart.earl@sharwil.com	

				2021: Base Year Values			Truck Density	Projection Year	Projection ADTs			Rigid Pavement ESALs (in 1000s)				Flexible Pavement ESALs (in 1000s)				
RouteID	From Measure	To Measure	Description From	Description To	AADT	PassengerAADT			CommercialAADT	Total (AADT)	Passenger (PAADT)	Commercial (CAADT)	Both Directions		50% Direction of Travel		Both Directions		50% Direction of Travel	
											rigid_year value	rigid_cumulative	rigid_50percent_year value	rigid_50percent_cumulative	flexible_year value	flexible_cumulative	flexible_50percent_year value	flexible_50percent_cumulative		
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2026	11039	10742	297	235	235	118	118	128	64	64	
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2027	11146	10844	302	243	477	122	239	131	259	66	130
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2028	11254	10946	308	249	727	125	364	134	393	67	197
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2029	11362	11048	313	257	983	129	492	138	531	69	266
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2030	11469	11151	319	265	1248	133	624	143	674	72	337
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2031	11577	11253	324	272	1520	136	760	146	820	73	410
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2032	11685	11355	329	280	1800	140	900	150	970	75	485
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2033	11792	11458	335	287	2086	144	1043	154	1124	77	562
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2034	11900	11560	340	295	2382	148	1191	159	1282	80	641
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2035	12008	11666	346	304	2685	152	1344	162	1444	81	722
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2036	12116	11765	351	311	2996	156	1498	166	1611	83	806
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2037	12223	11867	356	320	3316	160	1658	170	1781	85	891
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2038	12331	11969	362	328	3644	164	1822	175	1956	88	978
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2039	12439	12079	368	336	3980	168	1990	179	2135	90	1068
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2040	12546	12174	373	345	4325	173	2163	183	2318	92	1159
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2041	12654	12276	378	353	4678	177	2339	187	2505	94	1253
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2042	12762	12378	383	362	5040	181	2520	193	2698	97	1349
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2043	12869	12481	389	371	5411	186	2706	197	2895	99	1448
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2044	12977	12583	394	379	5790	190	2895	201	3095	101	1548
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2045	13085	12685	400	389	6179	195	3090	205	3301	103	1651
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2046	13193	12788	405	399	6578	200	3289	211	3511	106	1756
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2047	13300	12890	410	407	6985	204	3493	215	3727	108	1864
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2048	13408	12992	416	417	7401	209	3701	219	3946	110	1973
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2049	13516	13094	421	427	7828	214	3914	224	4170	112	2085
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2050	13623	13197	427	435	8264	218	4132	230	4400	115	2200
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2051	13731	13299	432	446	8709	223	4355	234	4634	117	2317
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2052	13839	13401	437	456	9165	228	4583	239	4873	120	2437
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2053	13946	13504	443	466	9632	233	4816	245	5118	123	2559
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2054	14054	13606	448	477	10109	239	5055	250	5368	125	2684
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2055	14162	13708	454	488	10596	244	5298	254	5622	127	2811
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2056	14270	13811	459	499	11095	250	5548	259	5881	130	2941
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2057	14377	13913	464	511	11606	256	5803	264	6145	132	3073
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2058	14485	14015	470	521	12127	261	6064	270	6415	135	3208
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2059	14593	14117	475	532	12659	266	6330	275	6690	138	3345
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2060	14700	14220	481	543	13202	272	6601	280	6970	140	3485
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2061	14808	14322	486	555	13756	278	6878	285	7255	143	3628
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2062	14916	14424	491	566	14322	283	7161	290	7545	145	3773
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2063	15023	14532	497	578	14900	289	7450	295	7840	148	3920
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2064	15131	14629	502	589	15489	295	7745	300	8139	150	4070
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2065	15239	14731	508	601	16091	301	8046	305	8444	153	4222
02350AU5091	80.87824507	81.2191238	ADAMS ST	SIPHON RD	10500	10230	270	2 - Medium	2066	15347	14834	513	613	16704	307	8352	310	8754	155	4377

Traffic Projection Worksheet

Project: **US-91, Park Lawn to Siphon Road**

Date: **February 19, 2023**

Flexible Pavement --> Beginning Year: **2026**

Ending Year: **2046**

Analysis **20**

Rigid Pavement --> Beginning Year: **2026**

Ending Year: **2066**

Period: **40**

		Roadway Segment					
		US-91					
<u>Desired Reliability</u>	% Reliability, R	0.5128					
	Overall Standard Deviation, S _o	90%					
	Standard Normal Deviate, Z _R	0.40					
		-1.282					
<u>Lane Information</u>	No. of Lanes in Design Direction	2					
	% Split of Trucks in Design Direction	60%					
	% of Trucks in Design Lane	100%					
From ITD's AADT Projection Report	<u>Total Traffic - Both Directions</u>						
	2026 AADT						
	2046 AADT						
	AADT for the Analysis Period						
	<u>Truck Traffic - Both Directions</u>						
	% Truck Traffic						
	AADTT						
	Truck Density (H, M, L)						
	<u>Design Lane</u>						
	AADTT						
From ITD's ESAL Projection Report	<u>Flexible ESAL Projections - Both Directions</u>						
	2026 Yearly and Cumulative ESALS	128,000					
	2046 Cumulative ESALS	3,511,000					
	<u>Design Lane</u>						
	Flexible Design ESALS (with reliability)	3,070,681					
	Traffic Index, TI	10.3					
	<u>Rigid ESAL Projections - Both Directions</u>						
	2026 Yearly and Cumulative ESALS	235,000					
	2066 Cumulative ESALS	16,704,000					
	<u>Design Lane</u>						
	Rigid Design ESALS (with reliability)	14,948,582					

Flexible

Rigid

Park Lawn to Southside Way

LTPPBind V3.1 PG Binder Selection Report (Date: 3/4/2023)

Parameter	A=8 km	B=11 km	C=12 km
Station ID	ID7208	ID7211	ID3297
Elevation, m	4488	4137	4148
Degree-Days >10 C	2645	2667	2637
Low Air Temperature, C	-22.5	-25.9	-26.5
Low Air Temp. Std Dev	3.9	5.1	4.7

Input Data

Latitude, Degree	42.96
Yearly Degree-Days>10C	2650
Lowest Yearly Air Temp., Deg. C	-25.0
Low Temp. Std. Dev., Deg. C	4.6
Base HT PG	58

Traffic Adjustments for HT

Desired Reliability, Percent	98
Traffic Loading, Million ESAL	3 to 10 M. ESAL
Traffic Speed	Slow
High Temp. Adjustment	9.5

PG Temperature	HIGH	LOW
PG Temp. at 50% Reliability	53.6	-18.2
PG Temp. at Desired Reliability	56.6	-26.3
Adjustments for Traffic	9.5	
Adjustments for Depth	0.0	0.0
Adjusted PG Temperature	66.1	-26.3
Selected PG Binder Grade	70	-28
PG 64-34 is recommended		

LTPPBind Report

Binder Selection using LTPPBind Software

Introduction

Superpave asphalt binders were selected using the Performance Grade (PG) methodology described in Section 560 of the ITD Materials Manual (ITD 2020) for each of the strategies that required Superpave HMA.

Methodology

Shannon & Wilson used LTPPBind Version 3.1 and guidance from the ITD Materials Manual, Section 560 to select PG Binder Grade of the asphalt binder.

The PG Binder grade was determined for US-91 HMA paving.

Temperature adjustment for 98% desired reliability was selected.

High temperature adjustments for slow traffic speed and 3 to 10 million ESAL for US-91 Flexible Pavement Strategy was selected.

Weather Stations selected in this analysis were:

- Pocatello 2NE, ID7208.
- Fort Hall 1NNE, ID3297.
- Pocatello Municipal Airport, ID7211.

LTPPBind predicts a PG binder grade of PG 66.1-26.3. Adjustments to this prediction are recommended. The high PG temperature should be adjusted to PG 64. The low temperature should be adjusted to -34 because of predictions made by AASHTOWare Pavement ME.

Recommendation

Shannon & Wilson recommends the following PG Binder Grade:

- Use PG 64-34 for all HMA paving on the project.
-

Appendix F

AASHTOWare Pavement ME Calculation Reports

Contents

- o Mill/Overlay with Flexible Construction Widening
- o AC Removal and HMA Overlay with Flexible Reconstruction Widening
- o AASHTO 1993
- o Flexible Reconstruction
- o Rigid Reconstruction



US-91, Mill-Overlay with flexible widening

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, Mill-Overlay with flexible widening.dgpx



Design Inputs

Design Life: 20 years Existing construction: May, 1950 Climate Data 43, -112.5
Design Type: AC_AC_INTERLAYER Pavement construction: June, 2026 Sources (Lat/Lon)
Traffic opening: September, 2026

Design Structure

Layer type	Material Type	Thickness (in)
Flexible (OL + interlayer)	HMA (PG 64-34)	5.4
Flexible (existing)	Existing AC	6.6
NonStabilized	Existing Aggregate Base	7.5
Subgrade	Subgrade	Semi-infinite

Volumetric at Construction:

Effective binder content (%)	11.6
Air voids (%)	7.0

Traffic

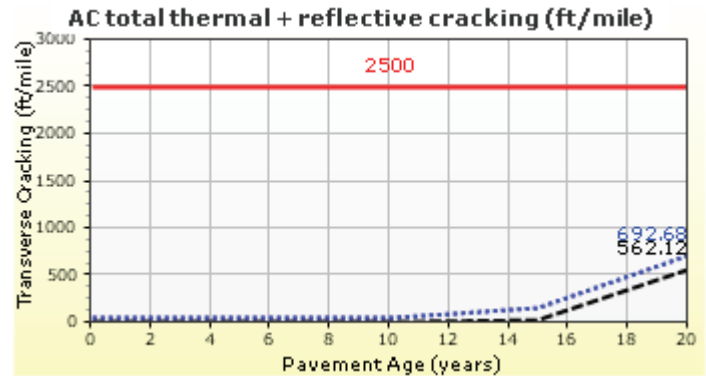
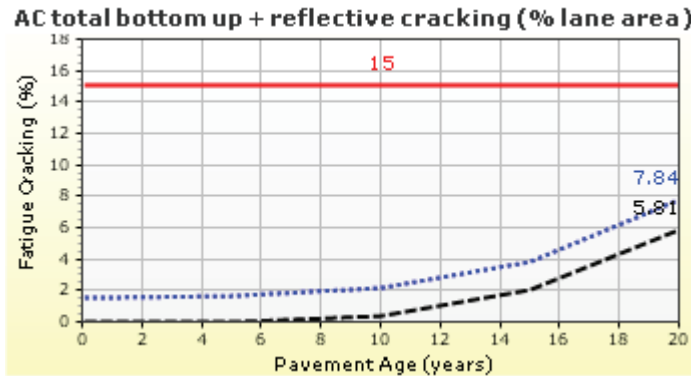
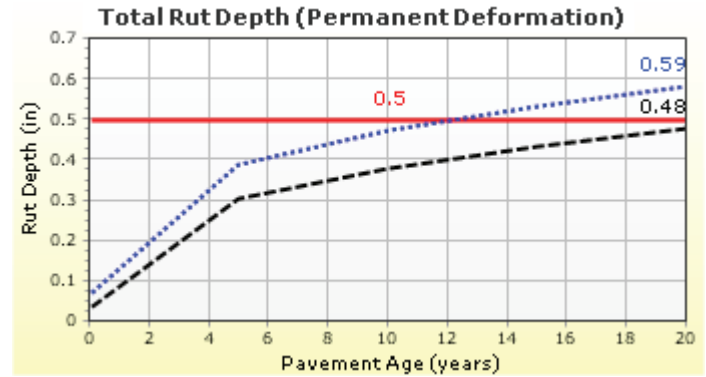
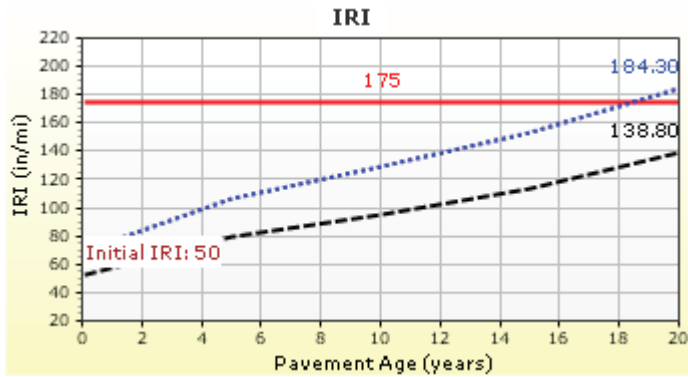
Age (year)	Heavy Trucks (cumulative)
2026 (initial)	297
2036 (10 years)	729,201
2046 (20 years)	1,662,640

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	175.00	184.28	90.00	84.62	Fail
Permanent deformation - total pavement (in)	0.50	0.59	90.00	59.99	Fail
AC total fatigue cracking: bottom up + reflective (% lane area)	15.00	7.84	90.00	100.00	Pass
AC total transverse cracking: thermal + reflective (ft/mile)	2500.00	692.68	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.50	0.05	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	0.19	50.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	1.00	50.00	100.00	Pass

Distress Charts



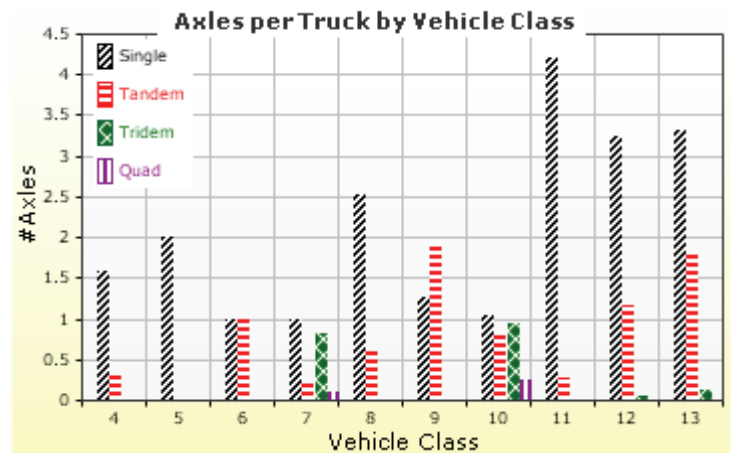
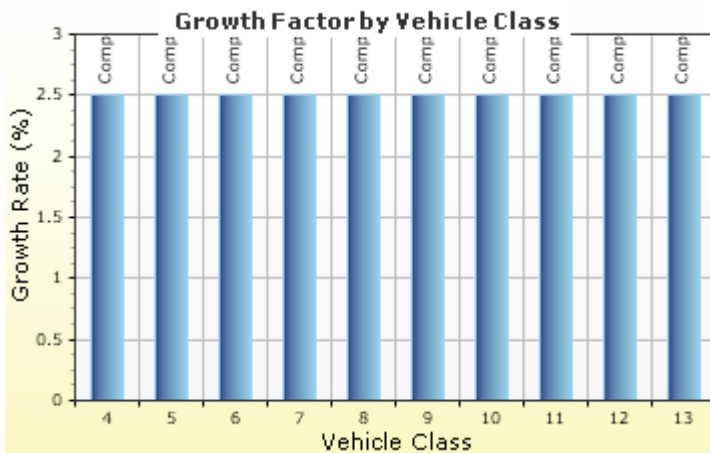
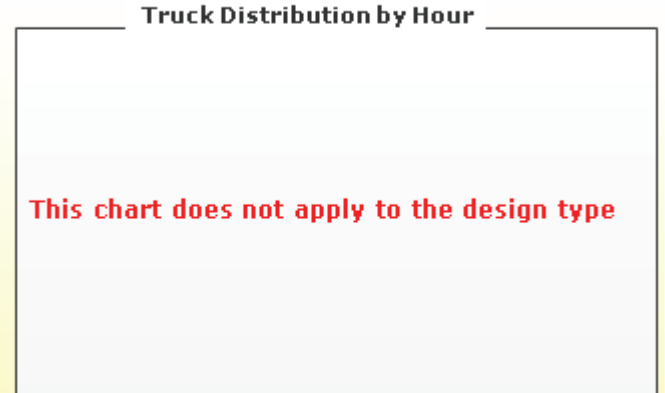
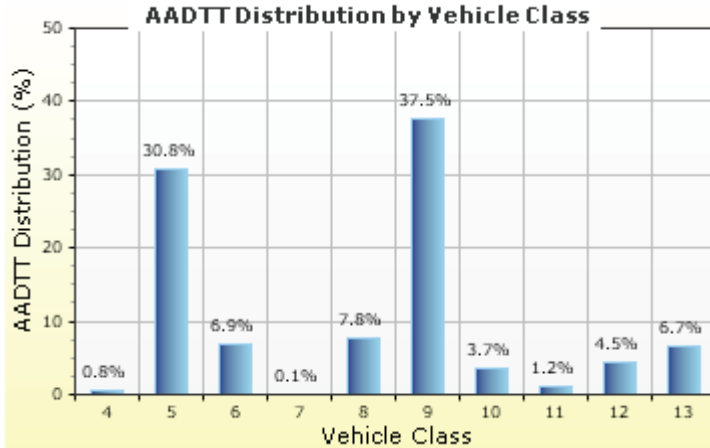
— Threshold Value @ Specified Reliability --- @ 50% Reliability

Traffic Inputs

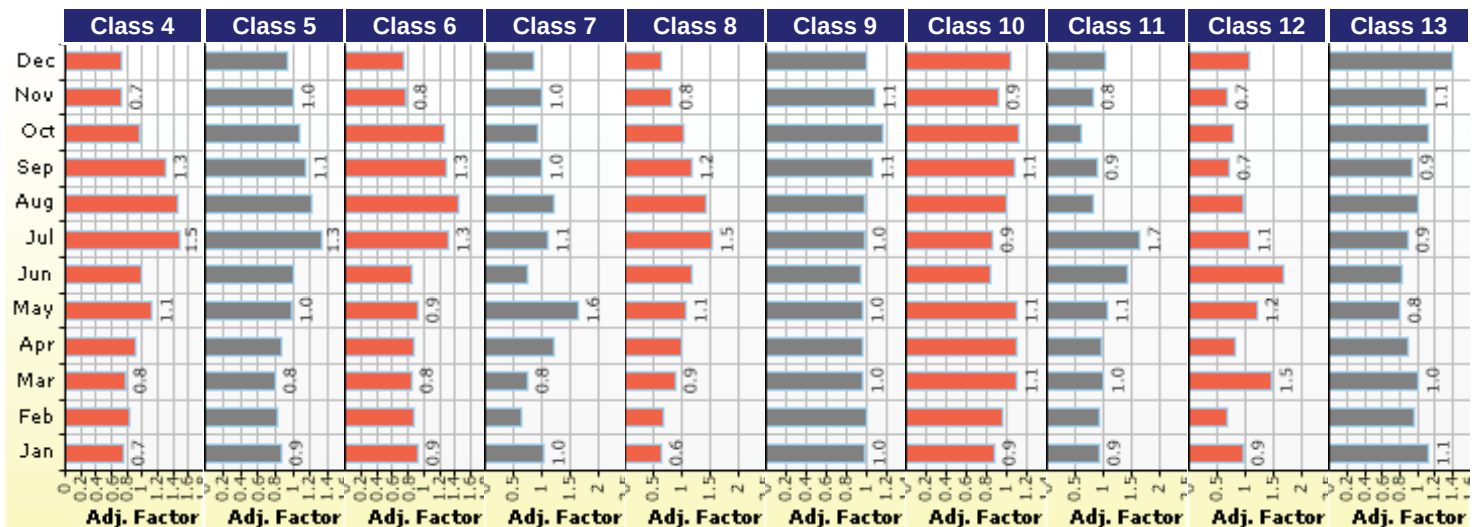
Graphical Representation of Traffic Inputs

Initial two-way AADTT: 297
Number of lanes in design direction: 2

Percent of trucks in design direction (%): 60.0
Percent of trucks in design lane (%): 100.0
Operational speed (mph): 35.0



Traffic Volume Monthly Adjustment Factors





US-91, Mill-Overlay with flexible widening

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Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.7	0.9	0.9	1.0	0.6	1.0	0.9	0.9	0.9	1.1
February	0.8	0.8	0.9	0.6	0.7	1.0	1.0	0.9	0.7	1.0
March	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.0	1.5	1.0
April	0.9	0.9	0.9	1.2	1.0	1.0	1.1	0.9	0.8	0.9
May	1.1	1.0	0.9	1.6	1.1	1.0	1.1	1.1	1.2	0.8
June	1.0	1.0	0.8	0.7	1.2	0.9	0.8	1.4	1.7	0.8
July	1.5	1.3	1.3	1.1	1.5	1.0	0.9	1.7	1.1	0.9
August	1.5	1.2	1.5	1.2	1.4	1.0	1.0	0.8	1.0	1.0
September	1.3	1.1	1.3	1.0	1.2	1.1	1.1	0.9	0.7	0.9
October	0.9	1.1	1.3	0.9	1.0	1.2	1.1	0.6	0.8	1.1
November	0.7	1.0	0.8	1.0	0.8	1.1	0.9	0.8	0.7	1.1
December	0.7	0.9	0.7	0.9	0.6	1.0	1.0	1.0	1.1	1.4

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.8%	2.5%	Compound
Class 5	30.8%	2.5%	Compound
Class 6	6.9%	2.5%	Compound
Class 7	0.1%	2.5%	Compound
Class 8	7.8%	2.5%	Compound
Class 9	37.5%	2.5%	Compound
Class 10	3.7%	2.5%	Compound
Class 11	1.2%	2.5%	Compound
Class 12	4.5%	2.5%	Compound
Class 13	6.7%	2.5%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander		Axle Configuration	
Mean wheel location (in)	18.0	Average axle width (ft)	8.5
Traffic wander standard deviation (in)	10.0	Dual tire spacing (in)	12.0
Design lane width (ft)	12.0	Tire pressure (psi)	120.0

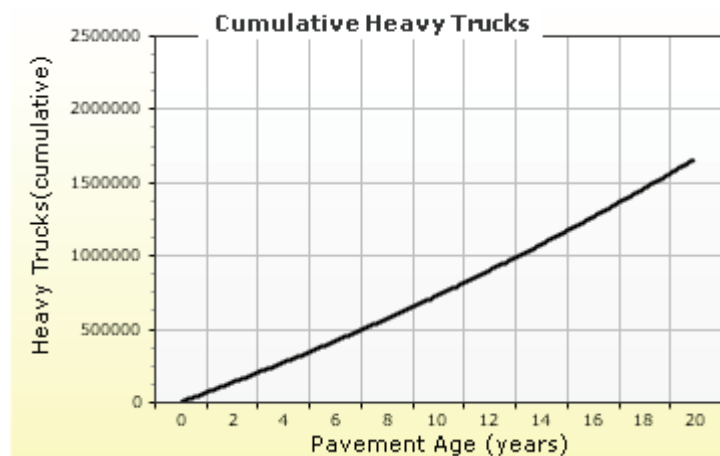
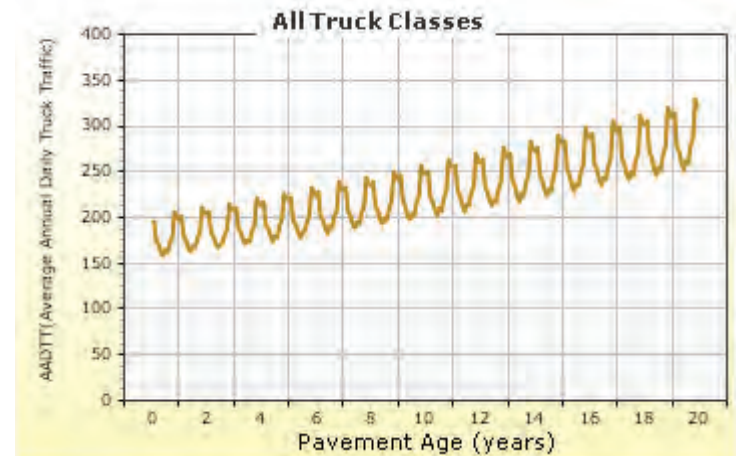
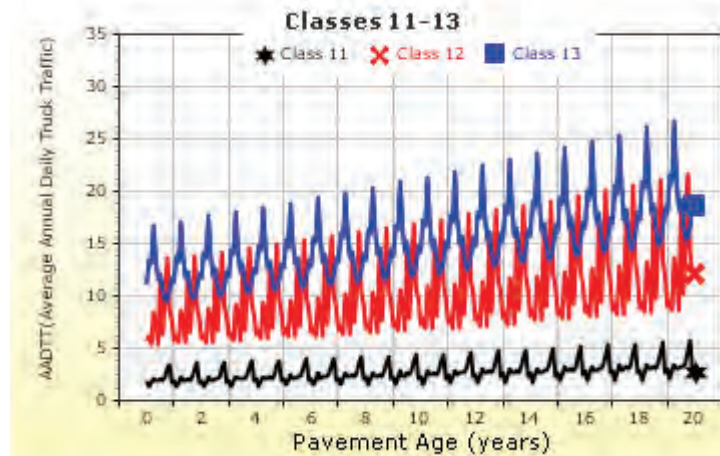
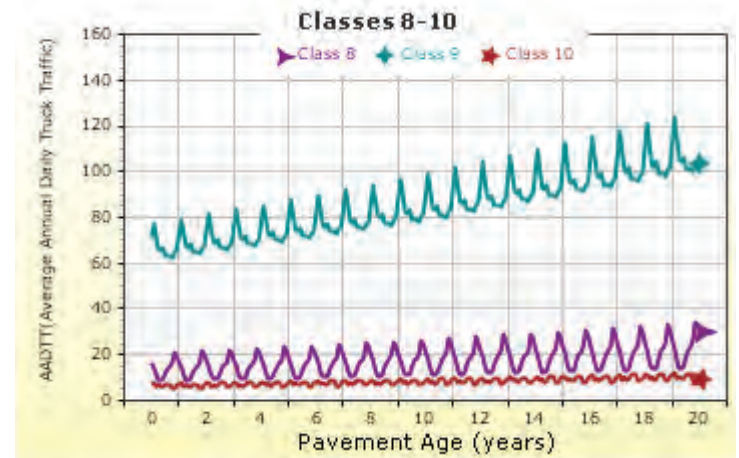
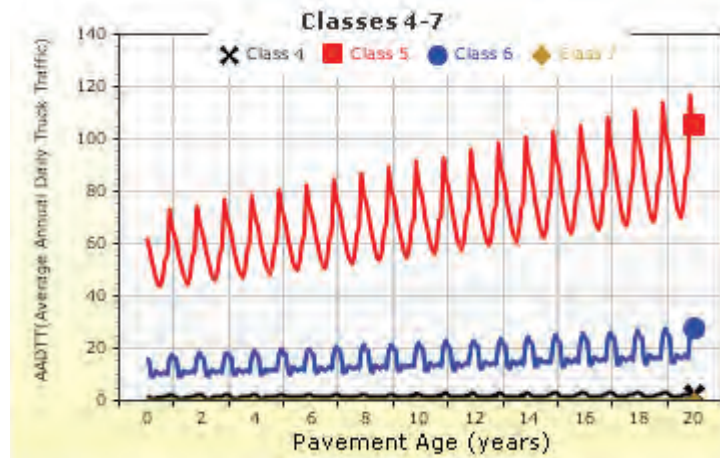
Average Axle Spacing		Wheelbase				
Tandem axle spacing (in)	51.6	Value Type	Axle Type	Short	Medium	Long
Tridem axle spacing (in)	49.2	Average spacing of axles (ft)		12.0	15.0	18.0
Quad axle spacing (in)	49.2	Percent of Trucks (%)		17.0	22.0	61.0

Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.59	0.34	0	0
Class 5	2	0	0	0
Class 6	1	1	0	0
Class 7	1	0.22	0.83	0.1
Class 8	2.52	0.6	0	0
Class 9	1.25	1.87	0	0
Class 10	1.03	0.85	0.95	0.26
Class 11	4.21	0.29	0.01	0
Class 12	3.24	1.16	0.07	0.01
Class 13	3.32	1.79	0.14	0.02

AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced





US-91, Mill-Overlay with flexible widening

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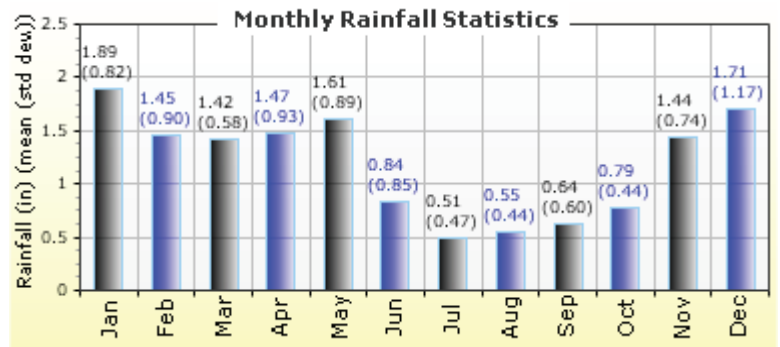
Climate Inputs

Climate Data Sources:

Climate Station Cities: Location (lat lon elevation(ft))
US, ID 43.00000 -112.50000 4431

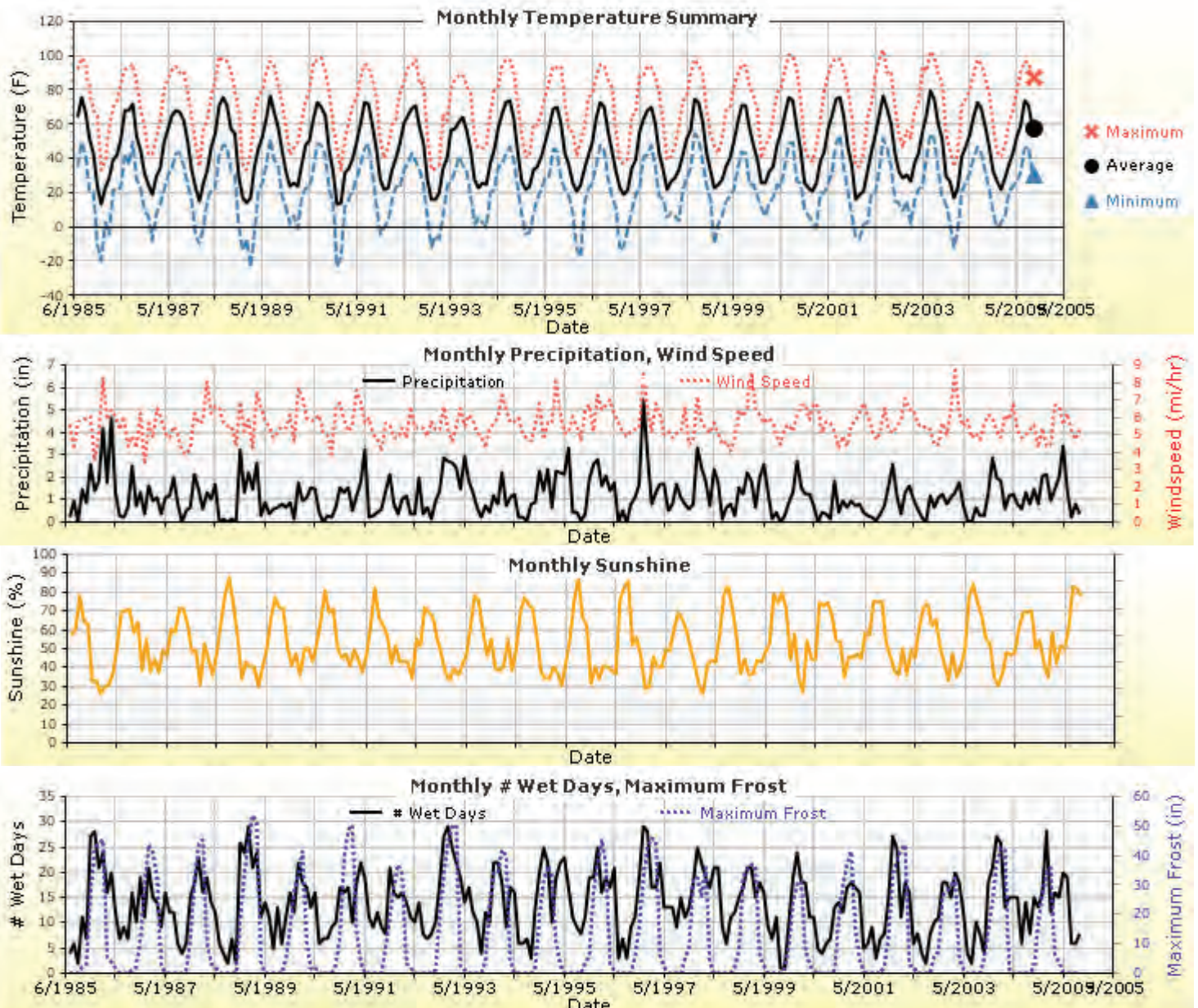
Annual Statistics:

Mean annual air temperature (°F) 46.30
Mean annual precipitation (in) 14.20
Freezing index (°F - days) 882.14
Average annual number of freeze/thaw cycles: 123.71



Water table depth (ft) 10.00

Monthly Climate Summary:



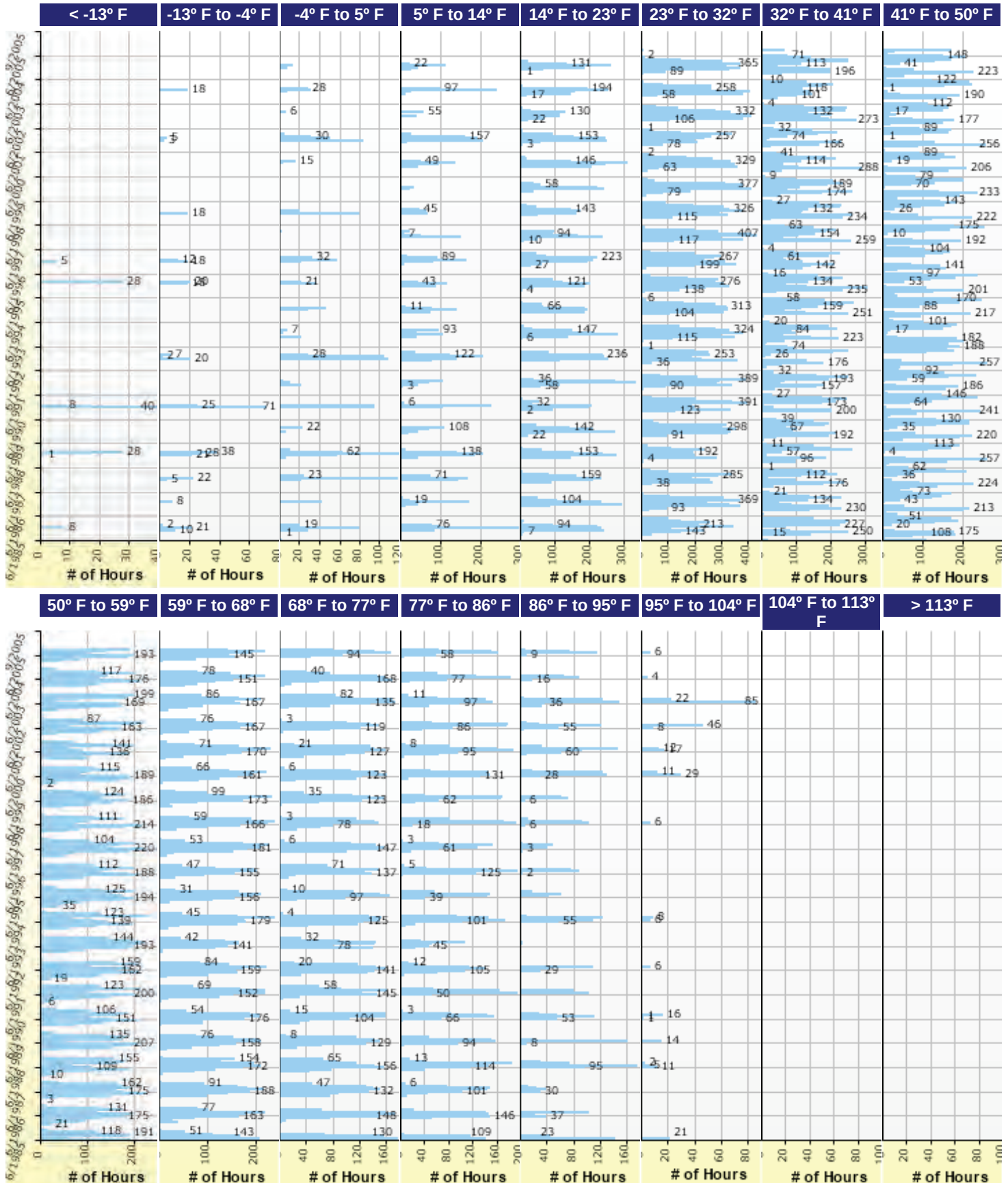


US-91, Mill-Overlay with flexible widening

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Hourly Air Temperature Distribution by Month:





US-91, Mill-Overlay with flexible widening

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Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : HMA (PG 64-34) (with interlayer)	Flexible (1)	1.00
Layer 2 Flexible : Existing AC (existing)	Flexible (1)	1.00
Layer 3 Non-stabilized Base : Existing Aggregate Base	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : Subgrade	Subgrade (5)	-

HMA Rehabilitation (Input Level: 1)

Milled thickness (in)	5.40
Fatigue cracking severity	Medium
Fatigue cracking LTE	0.4
Transverse cracking amount (ft/mile)	750.00
Transverse cracking severity	Medium
Transverse cracking LTE	0.4
Total rut depth (in)	-

Layer Name	Layer Type	Rut Depth (in)
Layer 1 Flexible : HMA (PG 64-34)	Flexible (1)	-
Layer 2 Flexible : Existing AC (existing)	Flexible (1)	0.07
Layer 3 Non-stabilized Base : Existing Aggregate Base	Non-stabilized Base (4)	0.01
Layer 4 Subgrade : Subgrade	Subgrade (5)	0.03

Thermal Cracking

Thermal Contraction

Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	18.6

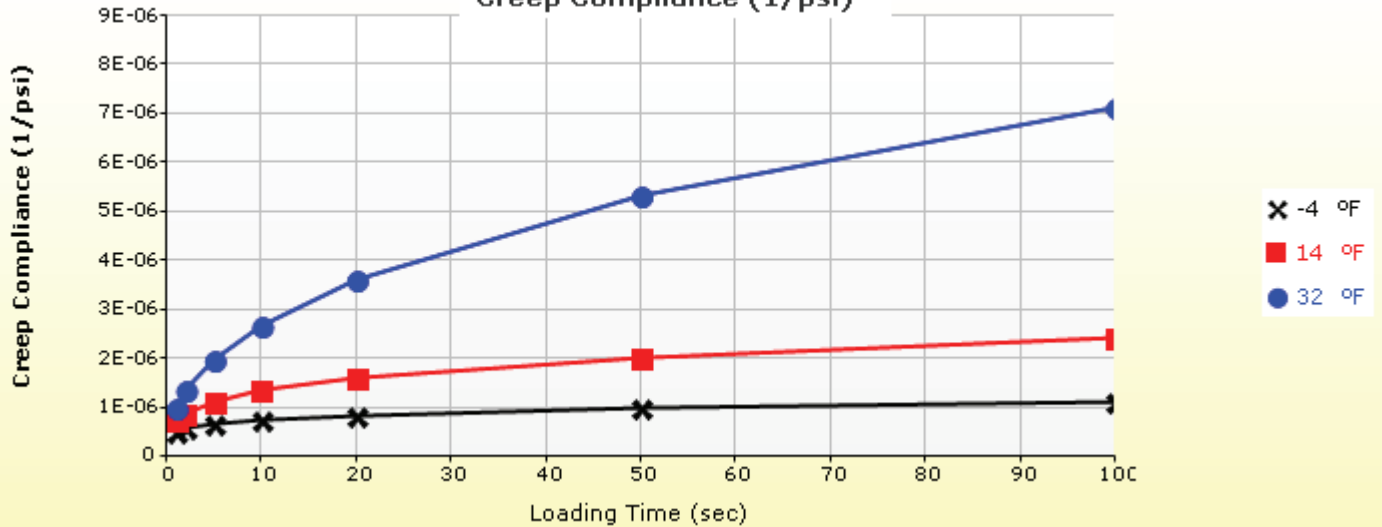
Indirect Tensile Strength (Input Level: 3)

Test Temperature (°F)	Indirect Tensile Strength (psi)
14.0	482.38

Creep Compliance (1/psi) (Input Level: 3)

Loading time (sec)	-4 °F	14 °F	32 °F
1	5.18e-007	7.48e-007	1.01e-006
2	5.82e-007	8.94e-007	1.35e-006
5	6.77e-007	1.13e-006	2.00e-006
10	7.60e-007	1.35e-006	2.68e-006
20	8.53e-007	1.61e-006	3.60e-006
50	9.94e-007	2.04e-006	5.32e-006
100	1.12e-006	2.44e-006	7.14e-006

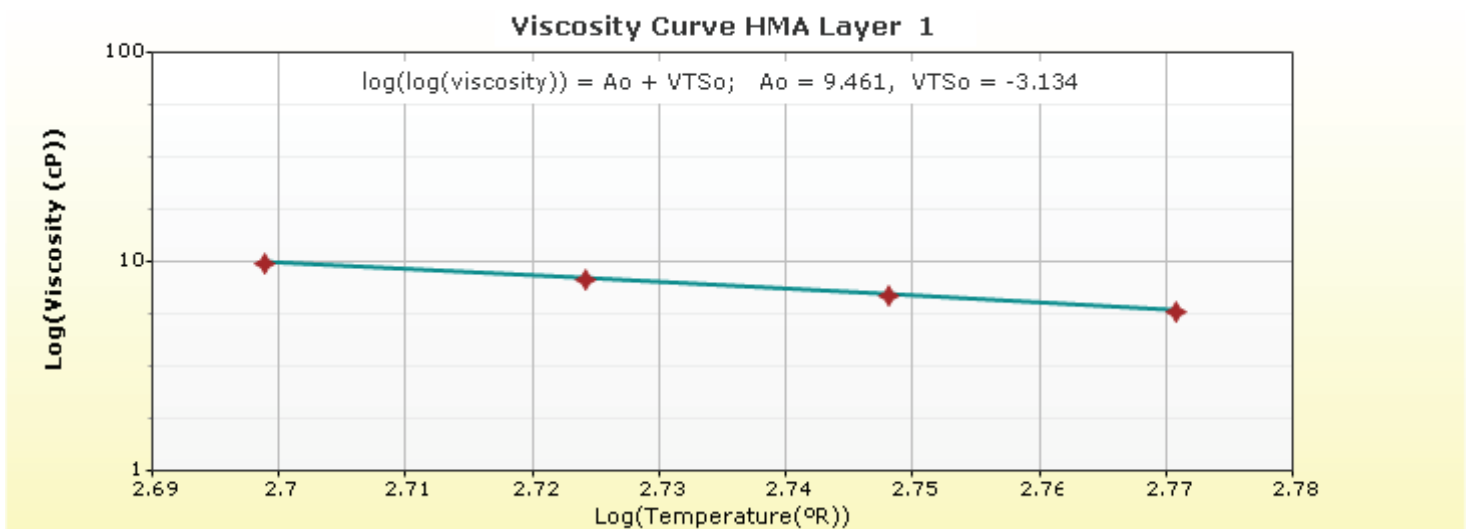
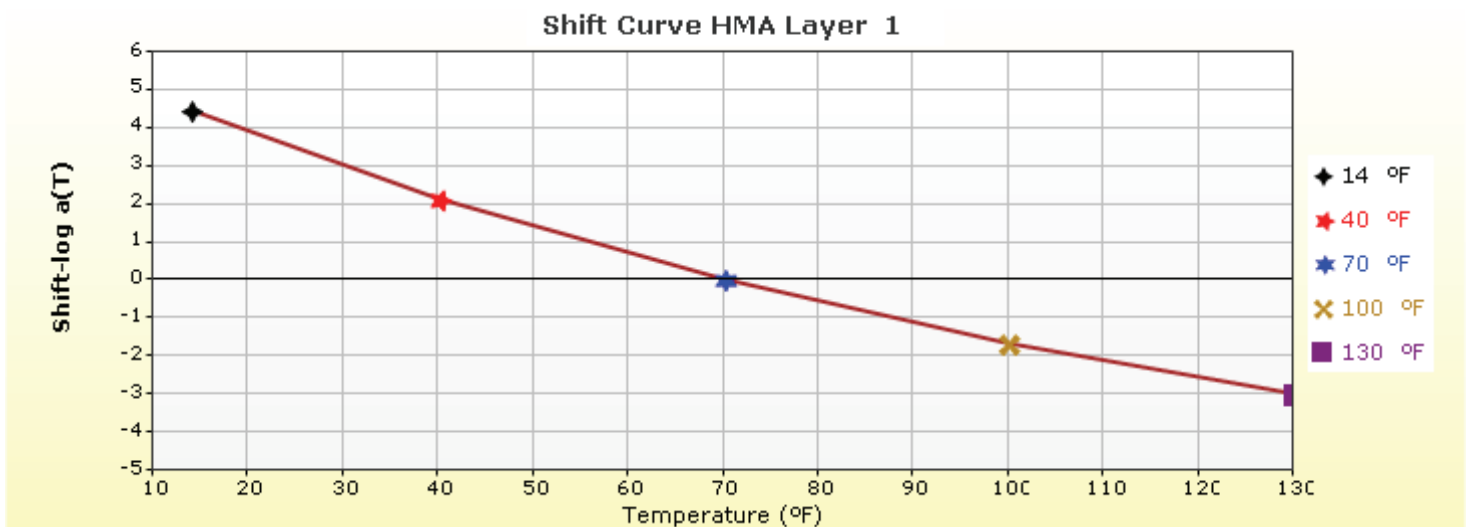
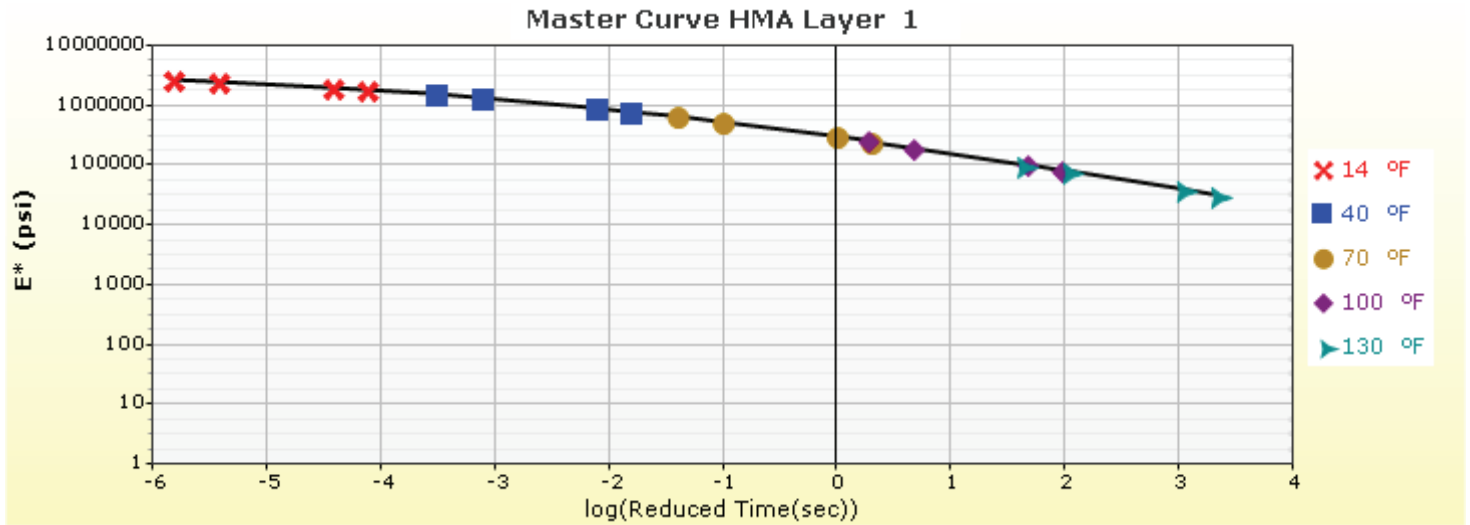
Creep Compliance (1/psi)



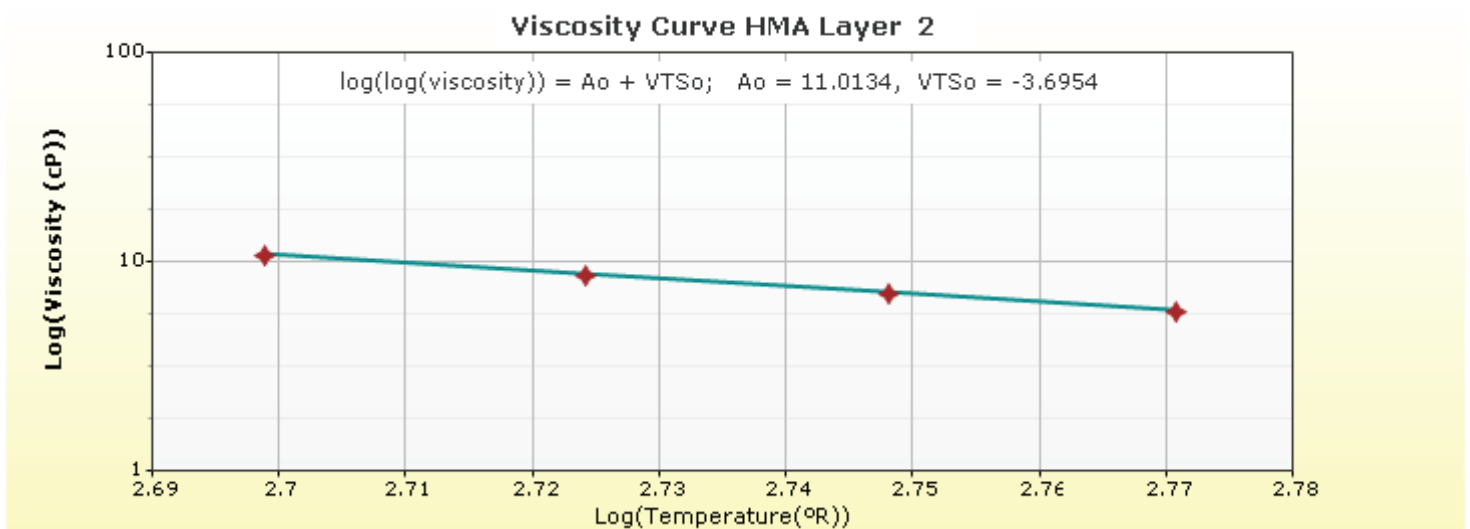
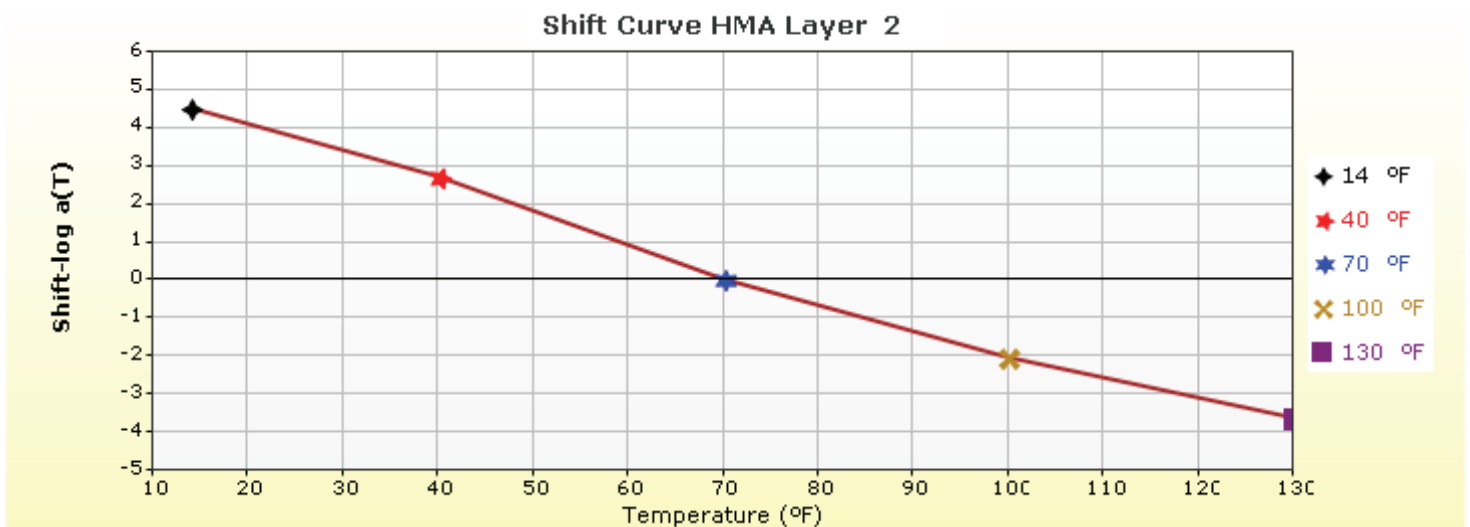
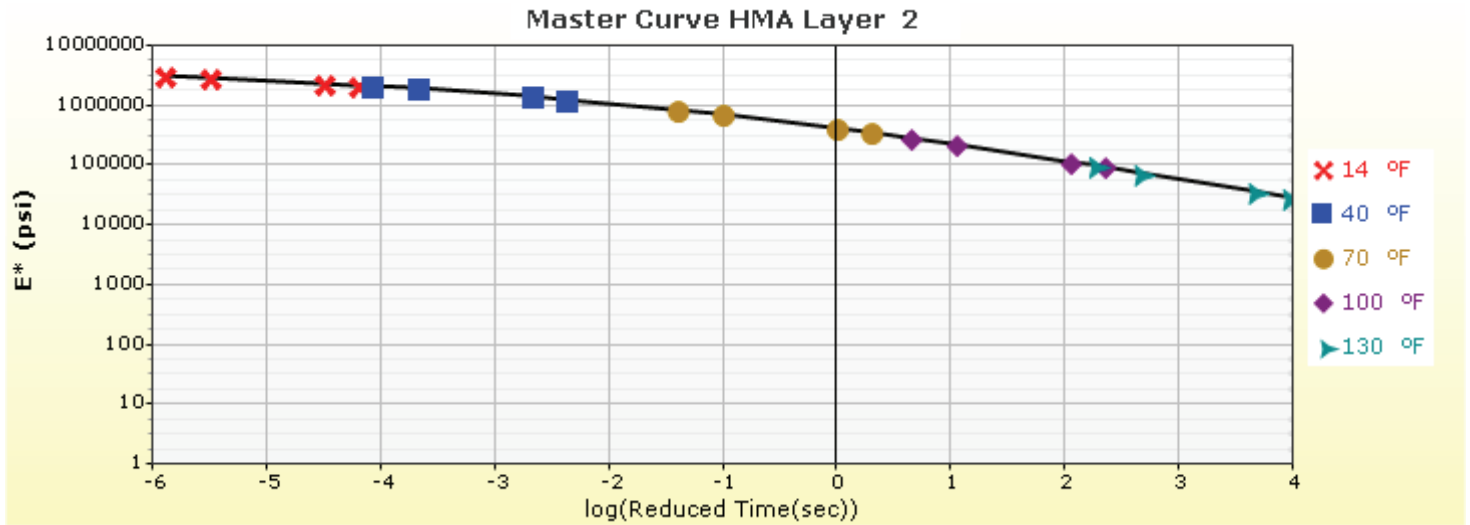
Indirect Tensile Strength, psi

There is no or empty series

HMA Layer 1: Layer 1 Flexible : HMA (PG 64-34)



HMA Layer 2: Layer 2 Flexible : Existing AC(existing)



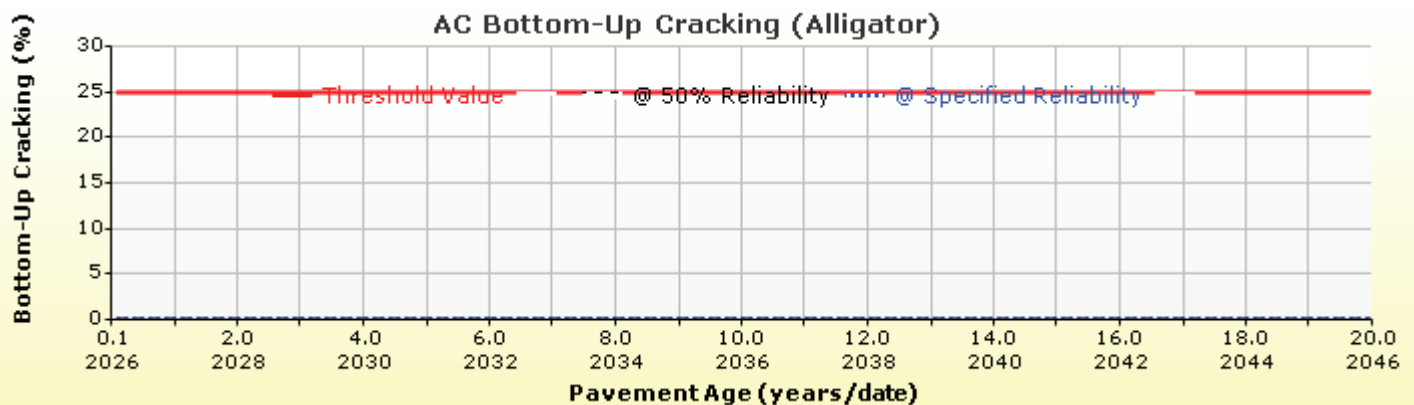
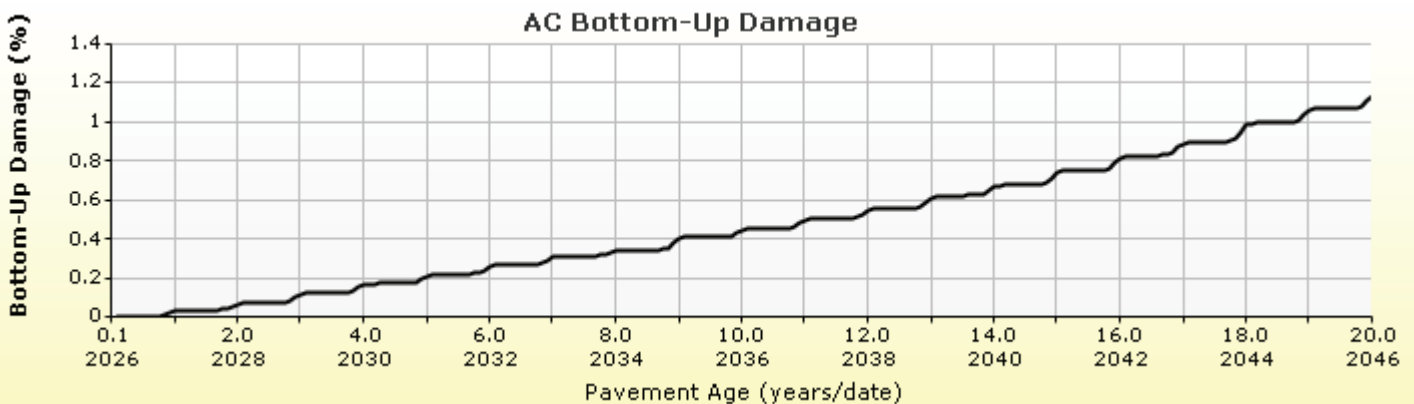
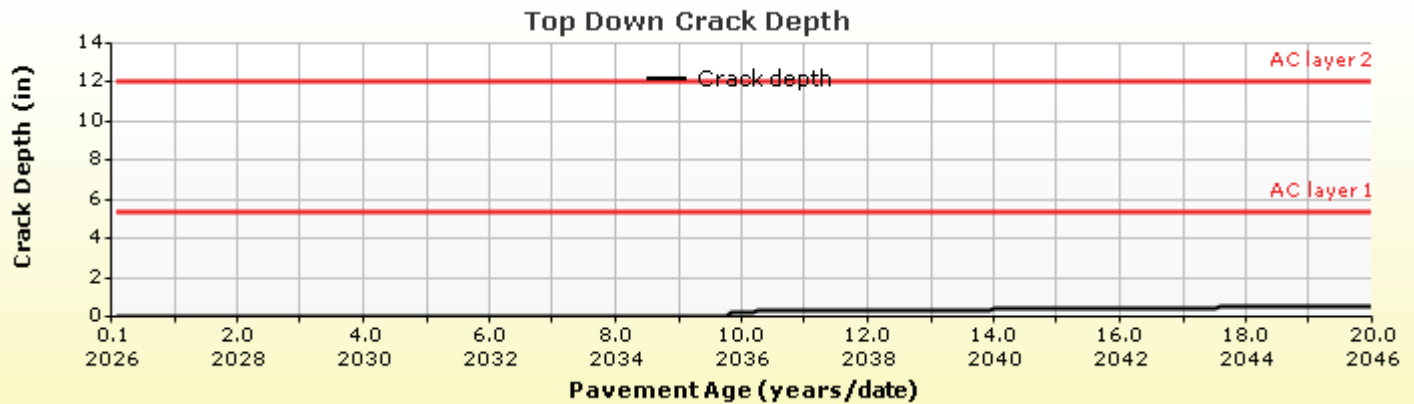
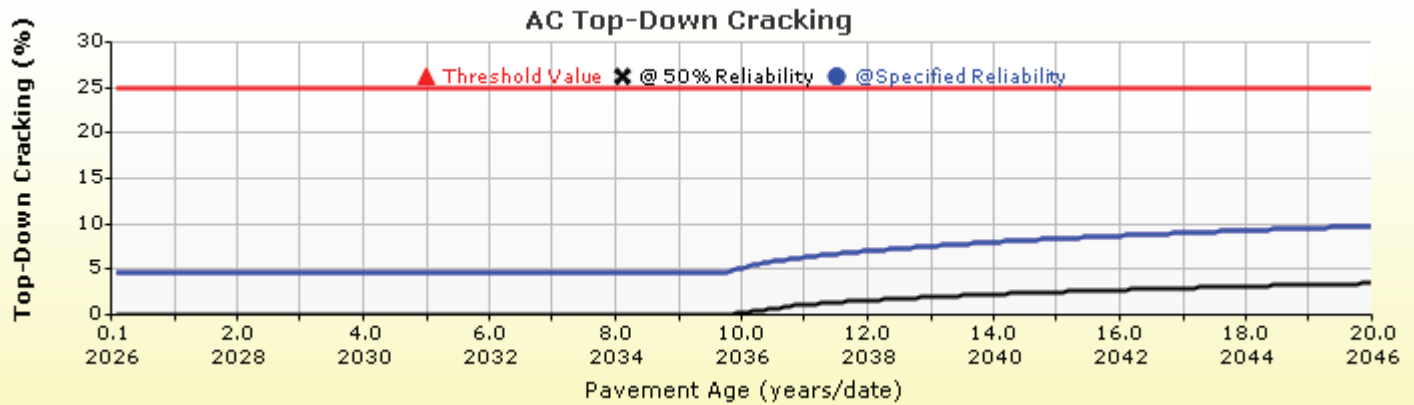


US-91, Mill-Overlay with flexible widening

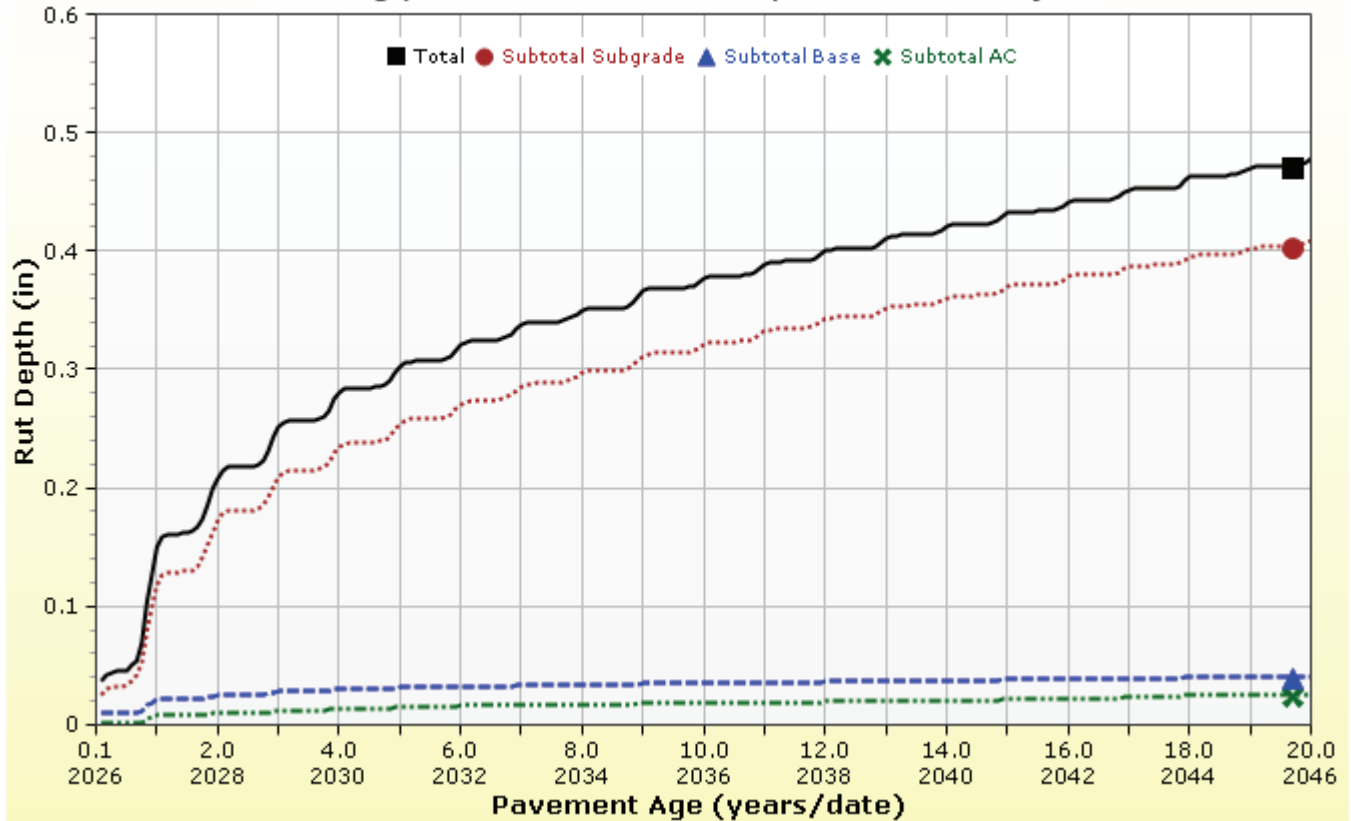
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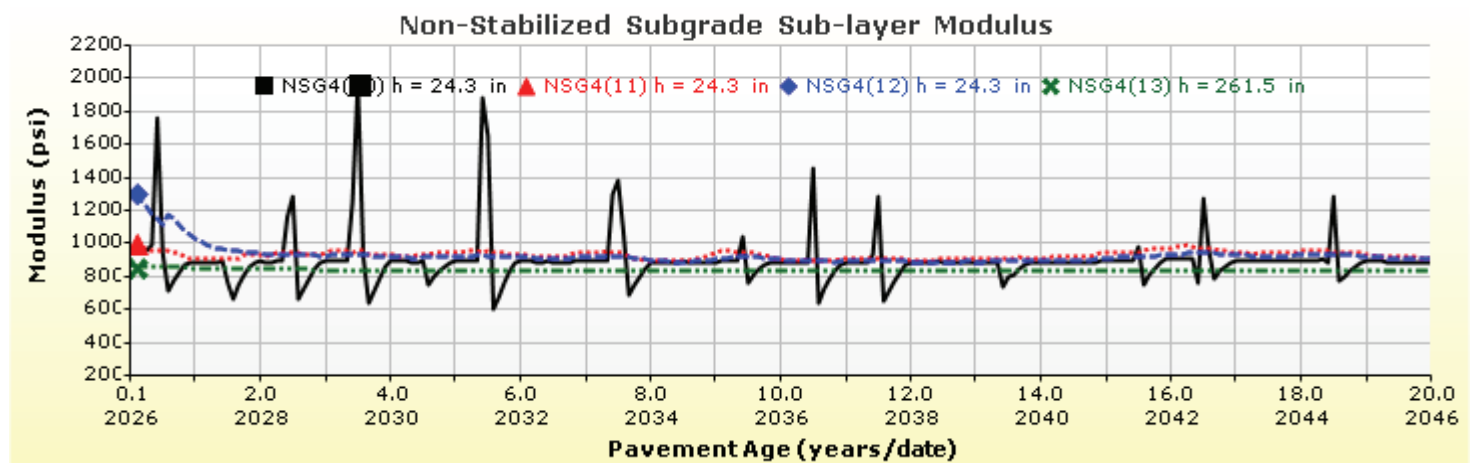
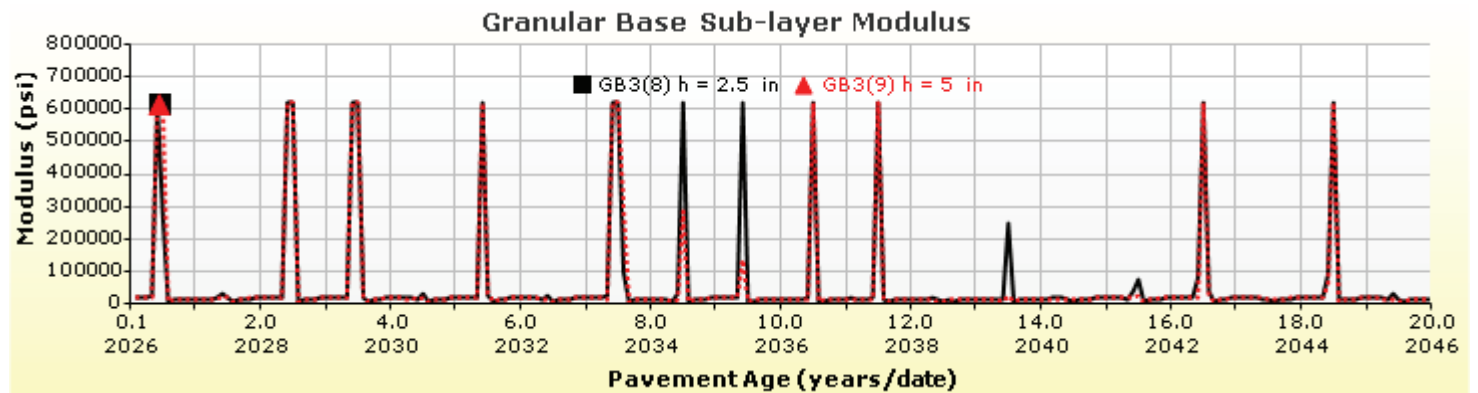
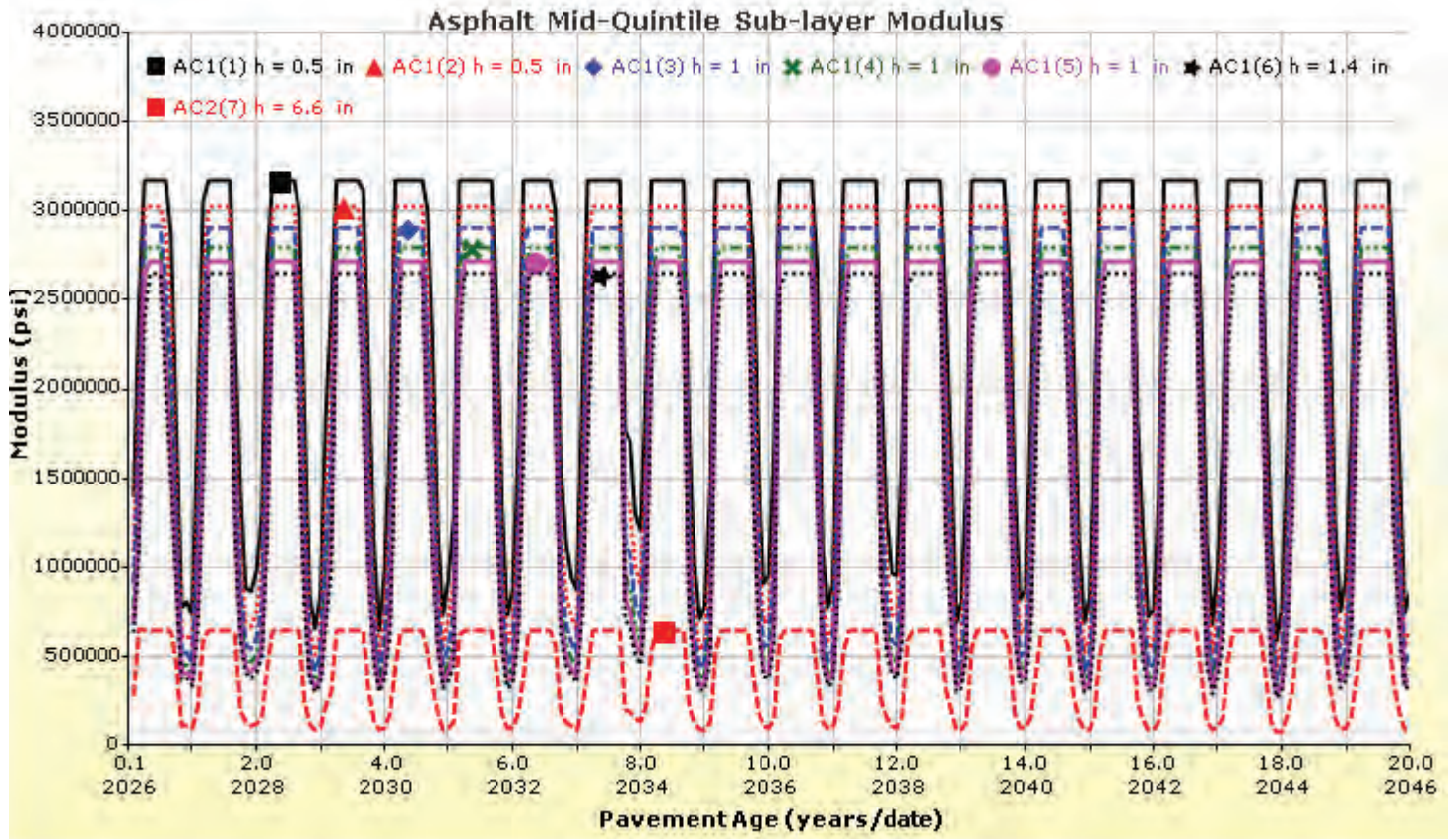


Analysis Output Charts



Rutting (Permanent Deformation) at 50% Reliability







US-91, Mill-Overlay with flexible widening

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Layer Information

Layer 1 Flexible : HMA (PG 64-34) (interlayer)

Asphalt		
Thickness (in)	5.4	
Unit weight (pcf)	144.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-34
A	9.461
VTs	-3.134

General Info

Name	Value
Reference temperature (°F)	70
Effective binder content (%)	11.6
Air voids (%)	7
Thermal conductivity (BTU/hr-ft-°F)	0.67
Heat capacity (BTU/lb-°F)	0.23
Asphalt content by weight (%)	4.5
Aggregate parameter	0.4021

Identifiers

Field	Value
Display name/identifier	HMA (PG 64-34)
Description of object	
Author	MEE
Date Created	3/3/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0



US-91, Mill-Overlay with flexible widening

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Layer 2 Flexible : Existing AC(existing)

Asphalt		
Thickness (in)	6.6	
Unit weight (pcf)	144.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Modulus of existing AC layer obtained from NDT testing

NDT Modulus (psi)	Frequency (Hz)	Temperature (°F)
229900	20	70.0

Asphalt Binder

Parameter	Value
Grade	Viscosity Grade
Binder Type	AC 10
A	11.0134
VTs	-3.6954

General Info

Name	Value
Reference temperature (°F)	70
Effective binder content (%)	11.6
Air voids (%)	7
Thermal conductivity (BTU/hr-ft-°F)	0.67
Heat capacity (BTU/lb-°F)	0.23
Asphalt content by weight (%)	-
Aggregate parameter	-

Identifiers

Field	Value
Display name/identifier	Existing AC
Description of object	
Author	MEE
Date Created	3/2/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0



US-91, Mill-Overlay with flexible widening

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Layer 3 Non-stabilized Base : Existing Aggregate Base

Unbound

Layer thickness (in)	7.5
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

15300.0

Use Correction factor for NDT modulus?	False
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Existing Aggregate Base
Description of object	Existing Untreated Aggregate Base
Author	MEE
Date Created	2/2/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	126
Saturated hydraulic conductivity (ft/hr)	False	8.77e-03
Specific gravity of solids	False	2.7
Water Content (%)	False	8.2

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	1.7748
bf	2.2297
cf	0.6927
hr	116.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.0
#100	
#80	
#60	
#50	
#40	
#30	20.0
#20	
#16	
#10	
#8	40.0
#4	60.0
3/8-in.	
1/2-in.	95.0
3/4-in.	100.0
1-in.	
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	



US-91, Mill-Overlay with flexible widening

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Layer 4 Subgrade : Subgrade

Unbound

Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

4800.0

Use Correction factor for NDT modulus?	False
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Subgrade
Description of object	Default material
Author	MEE
Date Created	3/2/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	33.0
Plasticity Index	16.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	107.9
Saturated hydraulic conductivity (ft/hr)	False	1.95e-05
Specific gravity of solids	False	2.7
Water Content (%)	False	17.1

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	108.4091
bf	0.6801
cf	0.2161
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	63.2
#100	
#80	73.5
#60	
#50	
#40	82.4
#30	
#20	
#16	
#10	90.2
#8	
#4	93.5
3/8-in.	96.4
1/2-in.	97.4
3/4-in.	98.4
1-in.	99.0
1 1/2-in.	99.5
2-in.	99.8
2 1/2-in.	
3-in.	
3 1/2-in.	100.0

Calibration Coefficients

AC Fatigue

$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\epsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$	k1: 3.75
$C = 10^M$	k2: 2.87
$M = 4.84 \left(\frac{V_b}{V_a + V_b} - 0.69\right)$	k3: 1.46
	Bf1: (5.014 * Pow(hac,-3.416)) * 1 + 0
	Bf2: 1.38
	Bf3: 0.88

AC Rutting

$\frac{\epsilon_p}{\epsilon_r} = k_z \beta_{r1} 10^{k_1 T} k_2 \beta_{r2} N^{k_3 \beta_{r3}}$ $k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$ $C_1 = -0.1039 * H_a^2 + 2.4868 * H_a - 17.342$ $C_2 = 0.0172 * H_a^2 - 1.7331 * H_a + 27.428$ Where: H_{ac} = total AC thickness(in)	ϵ_p = plastic strain(in/in) ϵ_r = resilient strain(in/in) T = layer temperature(°F) N = number of load repetitions
---	---

acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22	Br1:0.3 Br2:0.52 Br3:1.36
AC Layer 2	K1:-2.45 K2:3.01 K3:0.22	Br1:0.4 Br2:0.52 Br3:1.36

Thermal Fracture

$C_f = \beta_{t1} N \left[\frac{1}{\sigma_d} \log \left(\frac{C}{h_{AC}} \right) \right]$ $\Delta C = A(\Delta K)^n$ $A = k_t \beta_t 10^{[4.389 - 2.52 \log(E_{HMA} \sigma_m n)]}$	C_f = Observed amount of thermal cracking, ft. / 500ft. β_{t1} = Regression coefficient determined through global calibration (400) $N[z]$ = Standard normal distribution evaluated at [z] σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in. C = Crack depth, in. h_{AC} = Thickness of asphalt layer, in. ΔC = Change in the crack depth due to a cooling cycle ΔK = Change in the stress intensity factor due to a cooling cycle A, n = Fracture parameters for the asphalt mixture E = Asphalt mixture stiffness, MPa σ_m = Undamaged mixture tensile strength, MPa k_t = Regression coefficient determined through field calibration β_t = Calibration parameter
Level 1 K: ((3 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	
Level 2 K: ((2.591 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	
Level 3 K: ((3 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	

CSM Fatigue

$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r} \right)}{k_2 \beta_{c2}} \right)}$		$N_f = \text{number of repetitions to fatigue cracking}$ $\sigma_s = \text{Tensile stress(psi)}$ $M_r = \text{modulus of rupture(psi)}$	
k1: 0.972	k2: 0.0825	Bc1: 1	Bc2:1

Unbound Layer Rutting			
$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r} \right) \left e^{-\left(\frac{\rho}{N} \right)^\beta} \right $		δ_a = permanent deformation for the layer N = number of repetitions ε_v = average vertical strain(in/in) $\varepsilon_0, \beta, \rho$ = material properties ε_r = resilient strain(in/in)	
Base Rutting		Subgrade Rutting	
k1: 0.965	Bs1: 0.86	k1: 0.965	Bs1: 0.736
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking					
AC Top Down Cracking			AC Bottom Up Cracking		
$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{1 - C_3 t_a} \right)^{C_2 \beta}}$ $t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0 / 2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$			$FC = \left(\frac{6000}{1 + e^{(C_1 * C'_1 + C_2 * C'_2 \log_{10}(D * 100))}} \right) * \left(\frac{1}{60} \right)$ $C'_2 = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$ $C'_1 = -2 * C'_2$		
c1: 2.5219	c2: 0.8069	c3: 1	c1: 1.31	c2: (0.867 + 0.2583 * hac) * 1	c3: 6000
kL1: 64271618	kL2: 0.2855	kL3: 0.011	acCrackingBottomStandardDeviation		
kL4: 0.01488	kL5: 3.266		1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))		
acCrackingTopStandardDeviation					
0.3657 * TOP + 3.6563					

CSM Cracking				IRI Flexible Pavements			
$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(\text{Damage})}}$				C1 - Rutting C3 - Transverse Crack C2 - Fatigue Crack C4 - Site Factors			
C1: 0	C2: 75	C3: 2	C4: 2	C1: 80	C2: 0.6	C3: 0.008	C4: 0.02
csmCrackingStandardDeviation							
CTB*11							

Reflective Cracking

$$\Delta C = k_1 \Delta_{\text{bending}} + k_2 \Delta_{\text{shearing}} + k_3 \Delta_{\text{thermal}}$$

$$\Delta D = \frac{C_1 k_1 \Delta_{\text{bending}} + C_2 k_2 \Delta_{\text{shearing}} + C_3 k_3 \Delta_{\text{thermal}}}{h_{OL}}$$

$$\Delta_{\text{Bending}} = A(\text{SIF})_B^n$$

$$\Delta_{\text{Shearing}} = A(\text{SIF})_S^n$$

$$\Delta_{\text{Thermal}} = A(\text{SIF})_T^n$$

$$D = \sum_{i=1}^N \Delta D$$

$$\text{RCR} = \left(\frac{100}{C_4 + e^{C_5 \log D}} \right) * \text{EX_CRK}$$

Where

ΔC	=	Crack length increment, in
ΔD	=	Incremental damage ratio
$k_1, k_2, k_3, C_1, C_2, C_3, C_4, C_5$	=	Calibration factors (local and global)
$\Delta_{\text{bending}}, \Delta_{\text{shearing}}, \Delta_{\text{thermal}}$	=	Crack length increments caused by bending, shearing, and thermal loading
A, n	=	HMA material fracture properties
N	=	Total number of days
$(\text{SIF})_B, (\text{SIF})_S, (\text{SIF})_T$	=	Stress intensity factors caused by bending, shearing, and thermal loading
D	=	Damage ratio
h_{OL}	=	Overlay thickness, in
RCR	=	Cracks in the underlying layers reflected, %
EX_CRK	=	Transverse cracking in underlying pavement layers, ft/mile (transverse cracking) Alligator cracking in underlying pavement layers, % lane area (alligator cracking)

Pavement Type	Distress Type	k1	k2	k3	C1	C2	C3	C4	C5	Standard Deviation
AC over AC (interlayer)	Transverse	0.012	0.005	1	3.22	25.7	0.1	133.4	-72.4	70.98 * Pow (TRANSVERSE, 0.2994) + 30.12
AC over AC (interlayer)	Fatigue	0.012	0.005	1	0.38	1.66	2.72	105.4	-7.02	1.1097 * Pow (FATIGUE, 0.6804) + 1.23



US-91, AC and Base Removal (PCC in place)

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Design Inputs

Design Life: 20 years

Design Type: FLEXIBLE

Base construction: July, 2026

Pavement construction: August, 2026

Traffic opening: September, 2026

Climate Data 43, -112.5

Sources (Lat/Lon)

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	HMA (PG 64-34)	5.4
NonStabilized	Untreated Aggregate Base	6.6
NonStabilized	Existing PCC	6.5
Subgrade	Subgrade	Semi-infinite

Volumetric at Construction:

Effective binder content (%)	11.6
Air voids (%)	7.5

Traffic

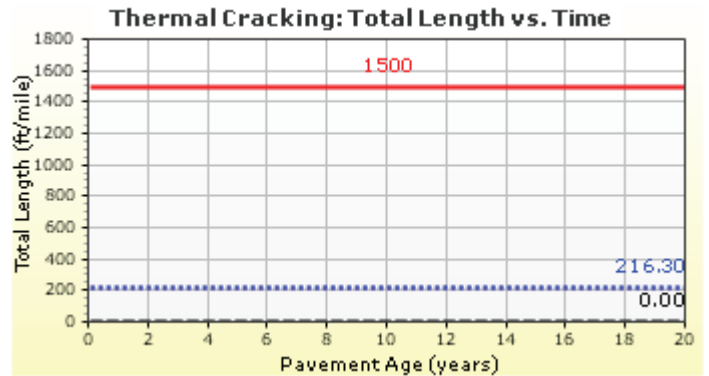
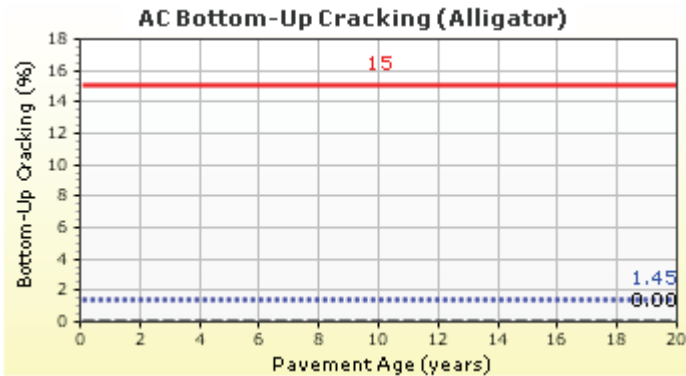
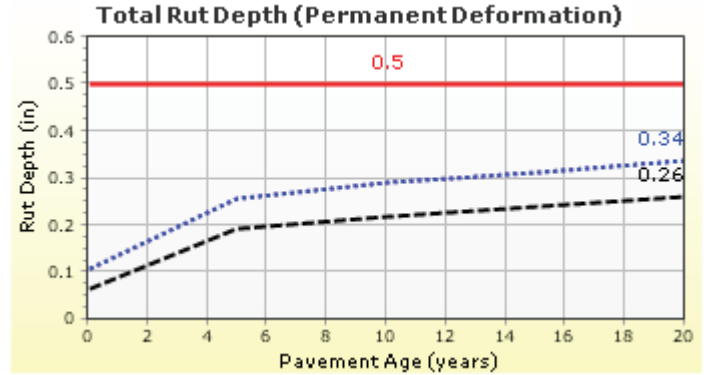
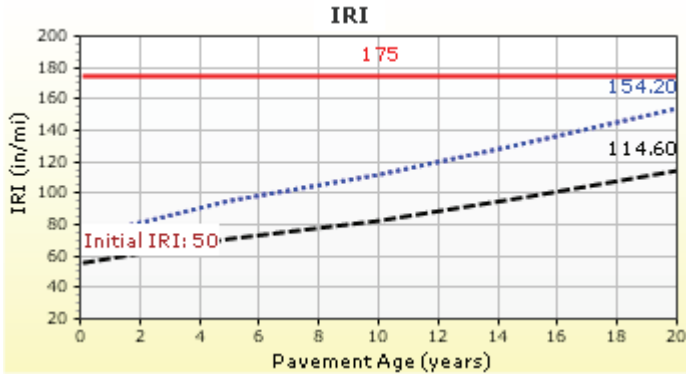
Age (year)	Heavy Trucks (cumulative)
2026 (initial)	297
2036 (10 years)	729,201
2046 (20 years)	1,662,640

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	175.00	154.17	90.00	97.48	Pass
Permanent deformation - total pavement (in)	0.50	0.34	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	15.00	1.45	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	216.30	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.50	0.11	90.00	100.00	Pass

Distress Charts



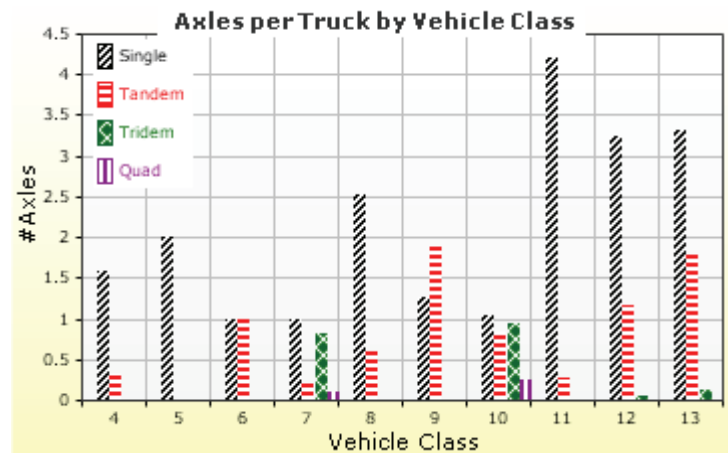
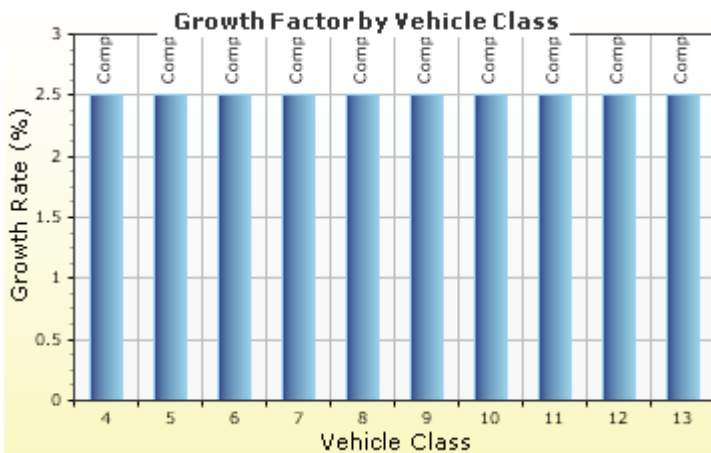
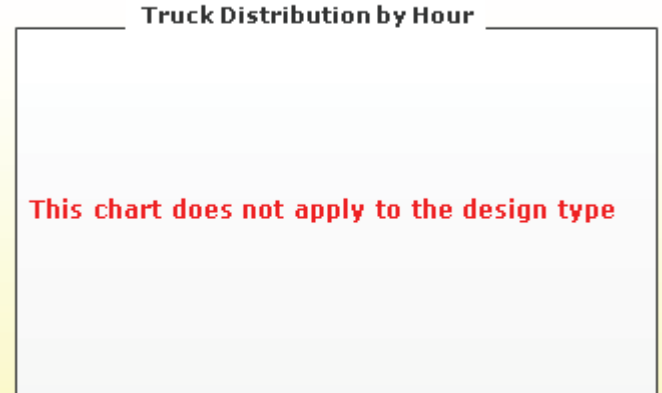
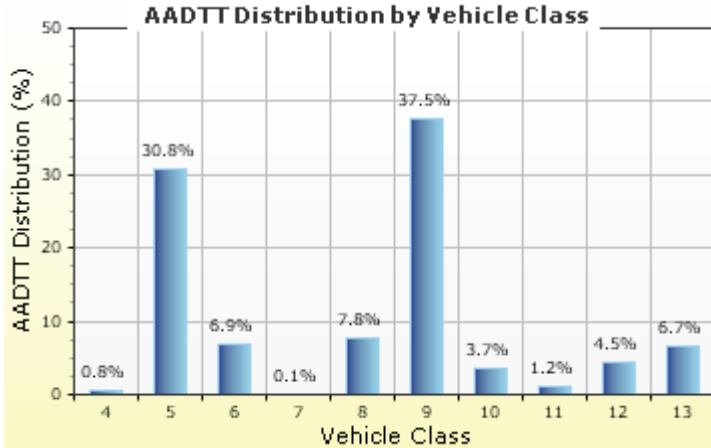
— Threshold Value @ Specified Reliability --- @ 50% Reliability

Traffic Inputs

Graphical Representation of Traffic Inputs

Initial two-way AADTT: 297
Number of lanes in design direction: 2

Percent of trucks in design direction (%): 60.0
Percent of trucks in design lane (%): 100.0
Operational speed (mph): 35.0



Traffic Volume Monthly Adjustment Factors





US-91, AC and Base Removal (PCC in place)

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Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.7	0.9	0.9	1.0	0.6	1.0	0.9	0.9	0.9	1.1
February	0.8	0.8	0.9	0.6	0.7	1.0	1.0	0.9	0.7	1.0
March	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.0	1.5	1.0
April	0.9	0.9	0.9	1.2	1.0	1.0	1.1	0.9	0.8	0.9
May	1.1	1.0	0.9	1.6	1.1	1.0	1.1	1.1	1.2	0.8
June	1.0	1.0	0.8	0.7	1.2	0.9	0.8	1.4	1.7	0.8
July	1.5	1.3	1.3	1.1	1.5	1.0	0.9	1.7	1.1	0.9
August	1.5	1.2	1.5	1.2	1.4	1.0	1.0	0.8	1.0	1.0
September	1.3	1.1	1.3	1.0	1.2	1.1	1.1	0.9	0.7	0.9
October	0.9	1.1	1.3	0.9	1.0	1.2	1.1	0.6	0.8	1.1
November	0.7	1.0	0.8	1.0	0.8	1.1	0.9	0.8	0.7	1.1
December	0.7	0.9	0.7	0.9	0.6	1.0	1.0	1.0	1.1	1.4

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.8%	2.5%	Compound
Class 5	30.8%	2.5%	Compound
Class 6	6.9%	2.5%	Compound
Class 7	0.1%	2.5%	Compound
Class 8	7.8%	2.5%	Compound
Class 9	37.5%	2.5%	Compound
Class 10	3.7%	2.5%	Compound
Class 11	1.2%	2.5%	Compound
Class 12	4.5%	2.5%	Compound
Class 13	6.7%	2.5%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander		Axle Configuration	
Mean wheel location (in)	18.0	Average axle width (ft)	8.5
Traffic wander standard deviation (in)	10.0	Dual tire spacing (in)	12.0
Design lane width (ft)	12.0	Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

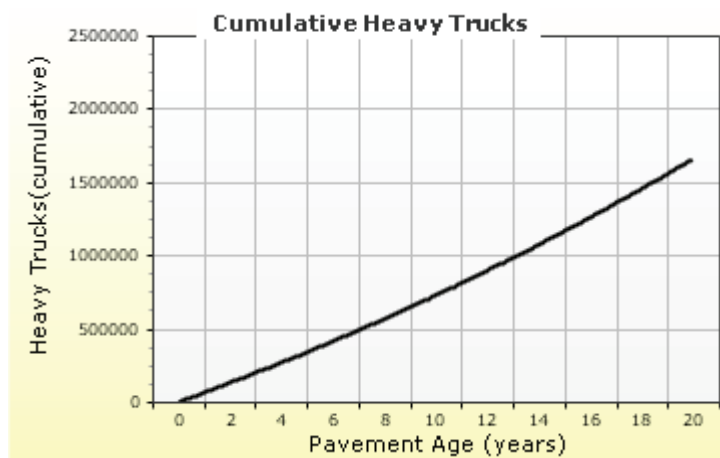
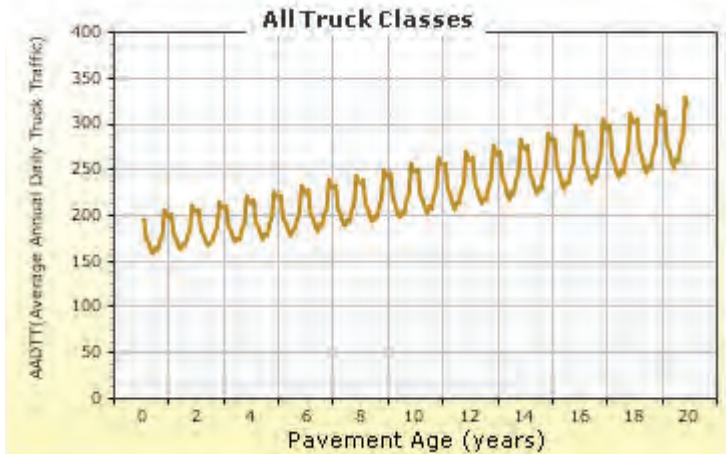
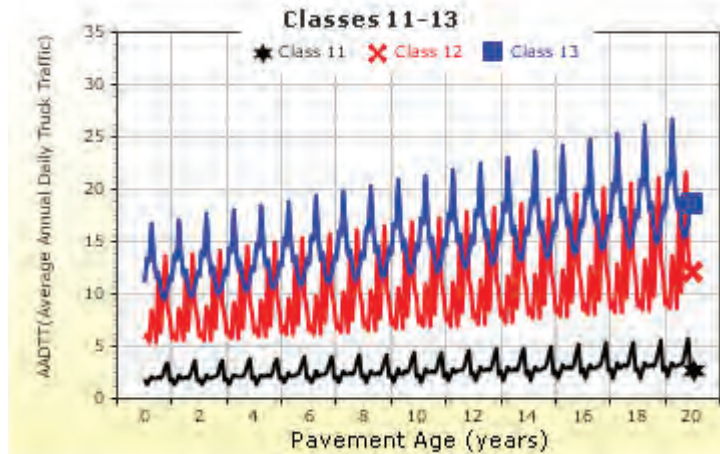
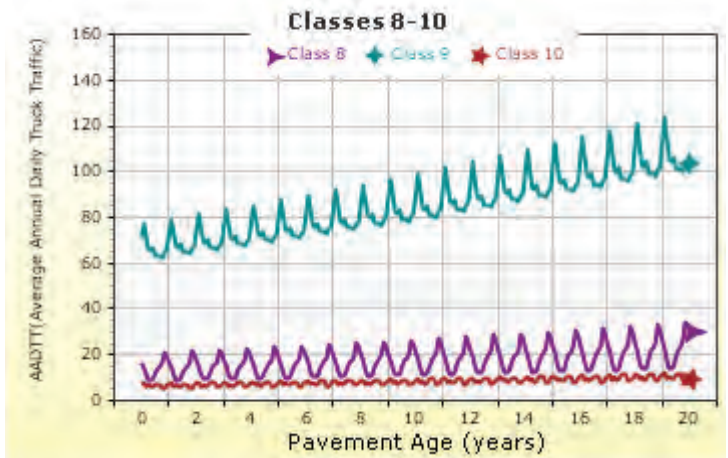
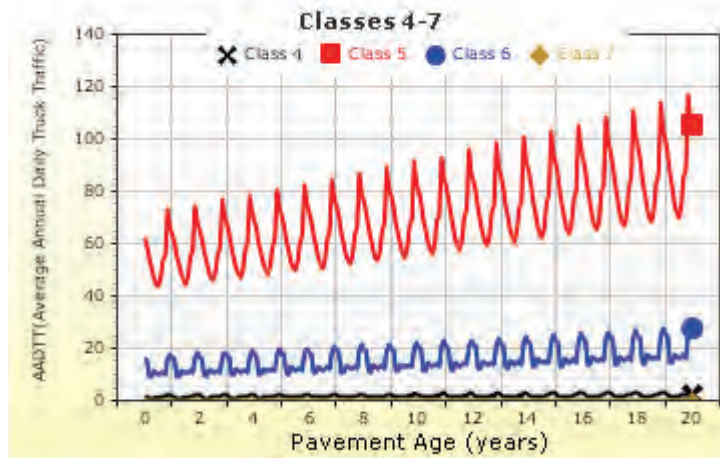
Wheelbase does not apply

Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.59	0.34	0	0
Class 5	2	0	0	0
Class 6	1	1	0	0
Class 7	1	0.22	0.83	0.1
Class 8	2.52	0.6	0	0
Class 9	1.25	1.87	0	0
Class 10	1.03	0.85	0.95	0.26
Class 11	4.21	0.29	0.01	0
Class 12	3.24	1.16	0.07	0.01
Class 13	3.32	1.79	0.14	0.02

AADTT (Average Annual Daily Truck Traffic) Growth

* Traffic cap is not enforced





US-91, AC and Base Removal (PCC in place)

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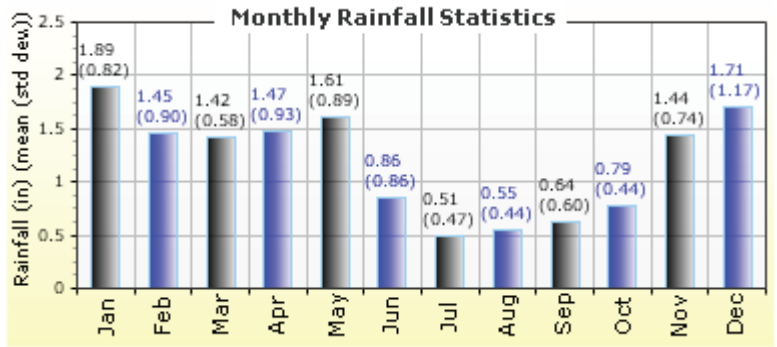
Climate Inputs

Climate Data Sources:

Climate Station Cities: Location (lat lon elevation(ft))
US, ID 43.00000 -112.50000 4431

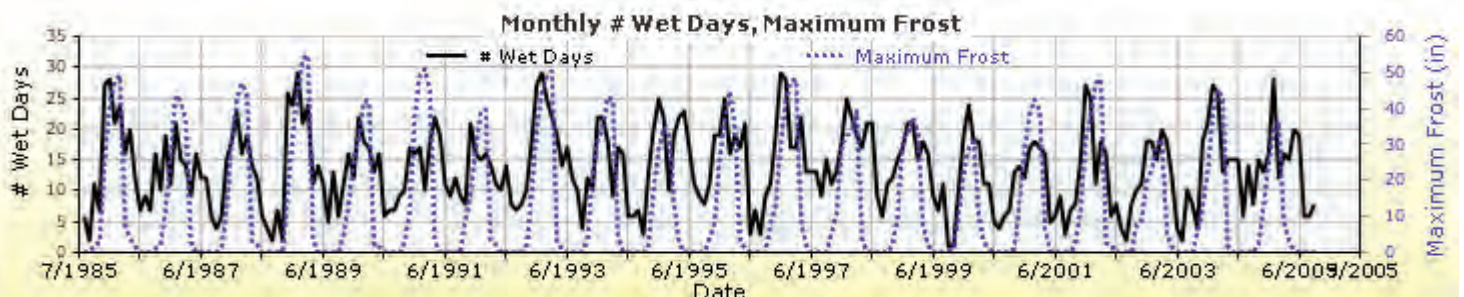
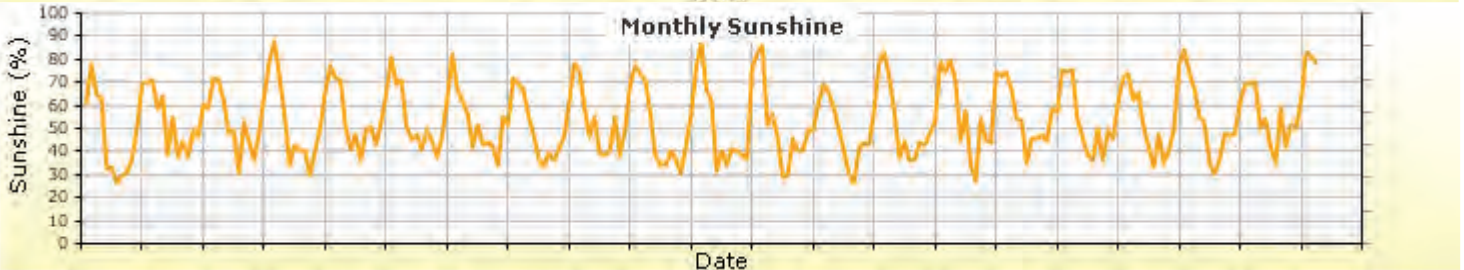
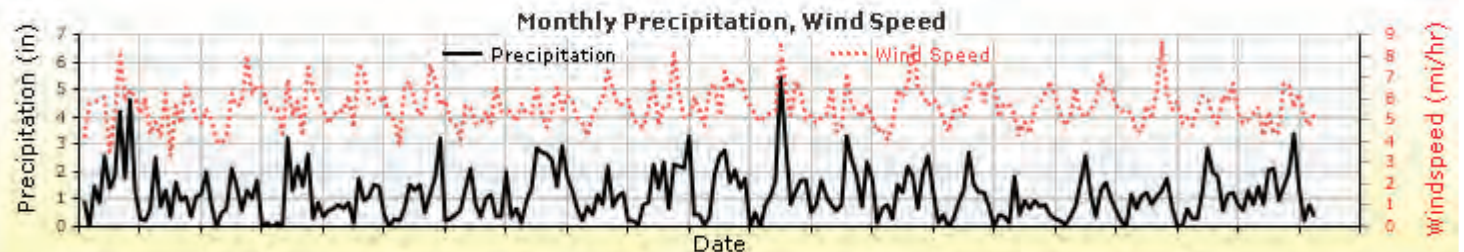
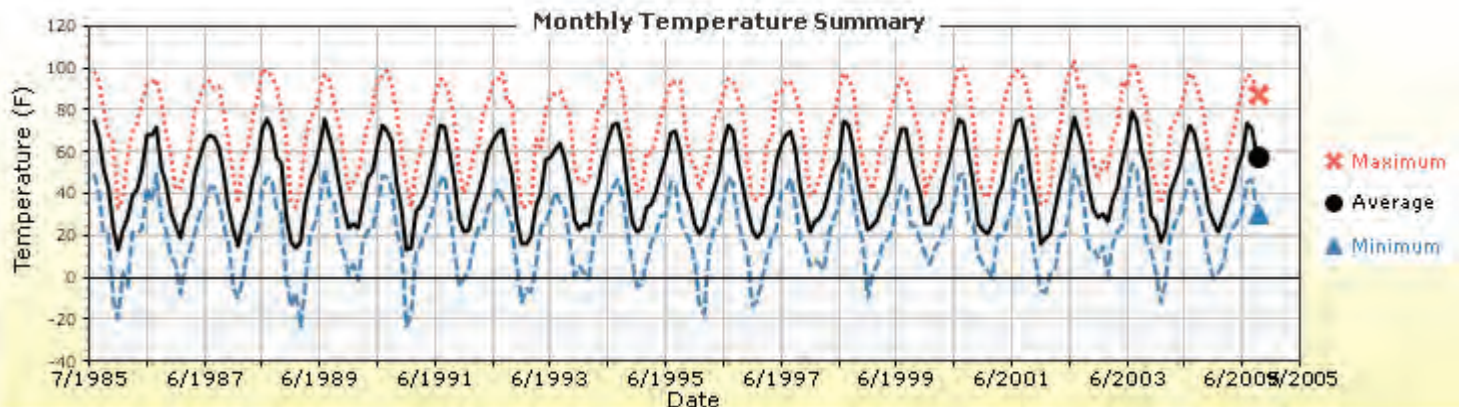
Annual Statistics:

Mean annual air temperature (°F) 46.21
Mean annual precipitation (in) 14.24
Freezing index (°F - days) 887.39
Average annual number of freeze/thaw cycles: 121.65



Water table depth (ft) 10.00

Monthly Climate Summary:



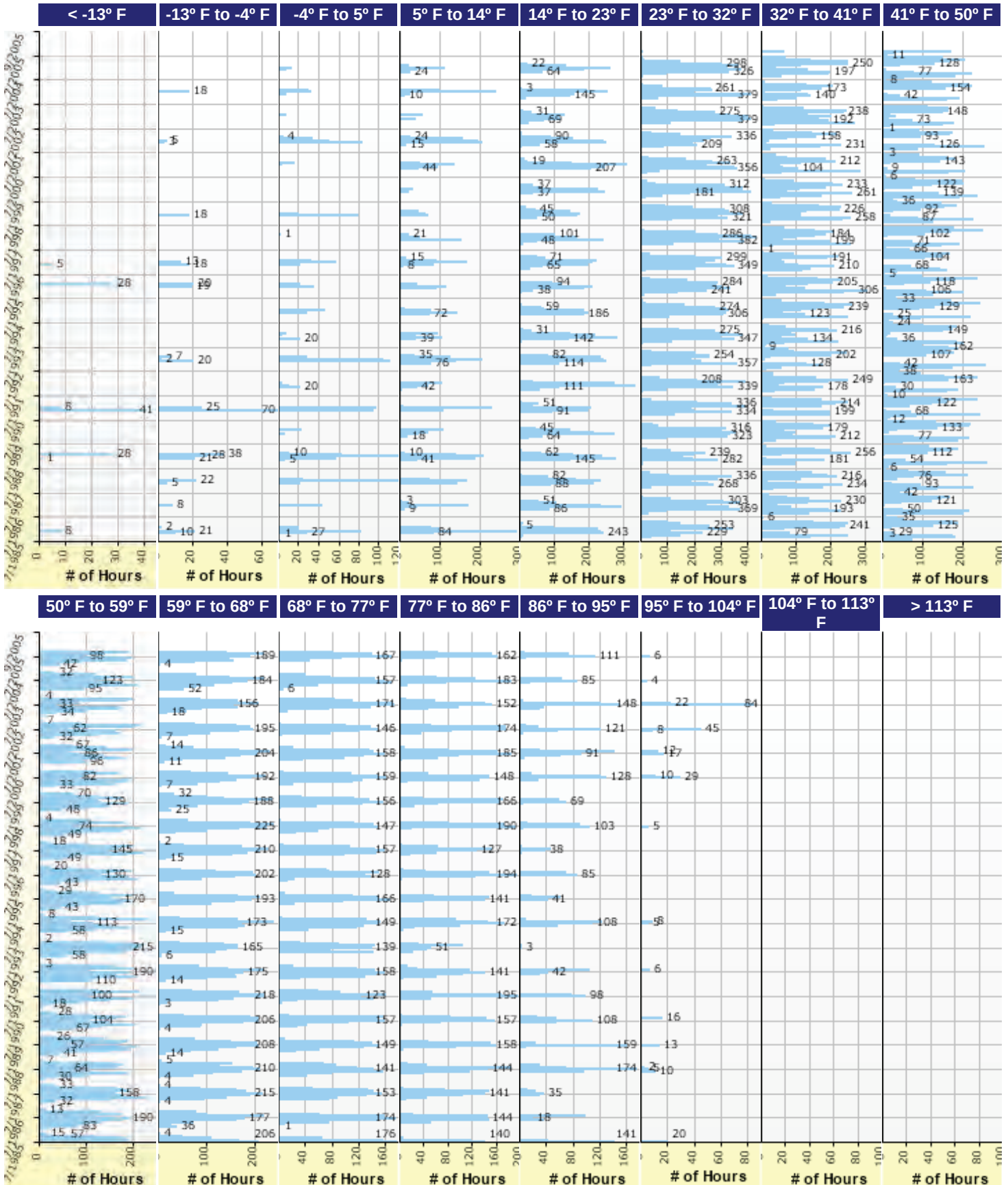


US-91, AC and Base Removal (PCC in place)

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Hourly Air Temperature Distribution by Month:





Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False	Layer Name	Layer Type	Interface Friction
Using G* based model (not nationally calibrated)	False	Layer 1 Flexible : HMA (PG 64-34)	Flexible (1)	1.00
Is NCHRP 1-37A HMA Rutting Model Coefficients	True	Layer 2 Non-stabilized Base : Untreated Aggregate Base	Non-stabilized Base (4)	1.00
Endurance Limit	-	Layer 3 Non-stabilized Base : Existing PCC	Non-stabilized Base (4)	1.00
Use Reflective Cracking	True	Layer 4 Subgrade : Subgrade	Subgrade (5)	-
Structure - ICM Properties				
AC surface shortwave absorptivity	0.85			

Thermal Cracking

Thermal Contraction

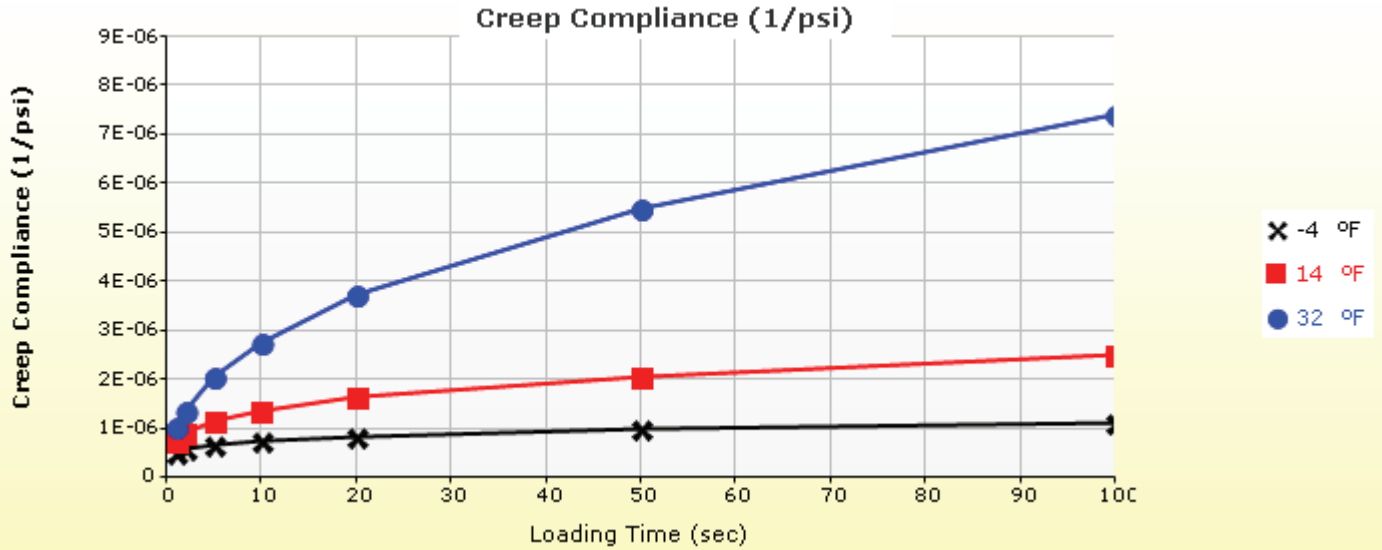
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	19.1

Indirect Tensile Strength (Input Level: 3)

Test Temperature (°F)	Indirect Tensile Strength (psi)
14.0	479.50

Creep Compliance (1/psi) (Input Level: 3)

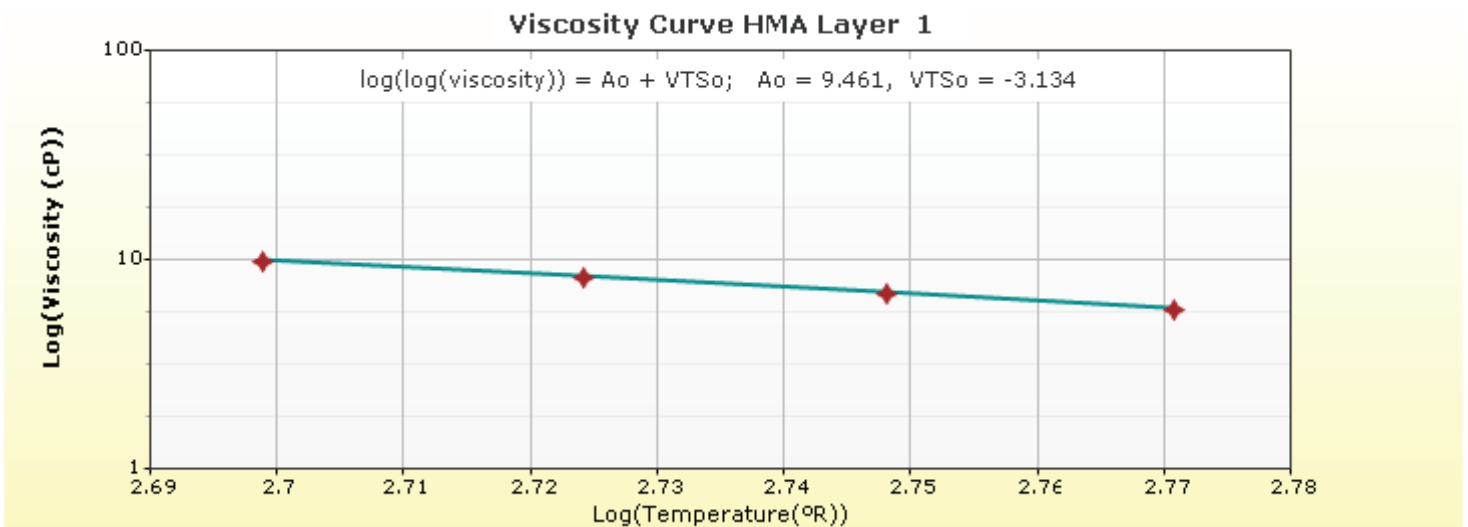
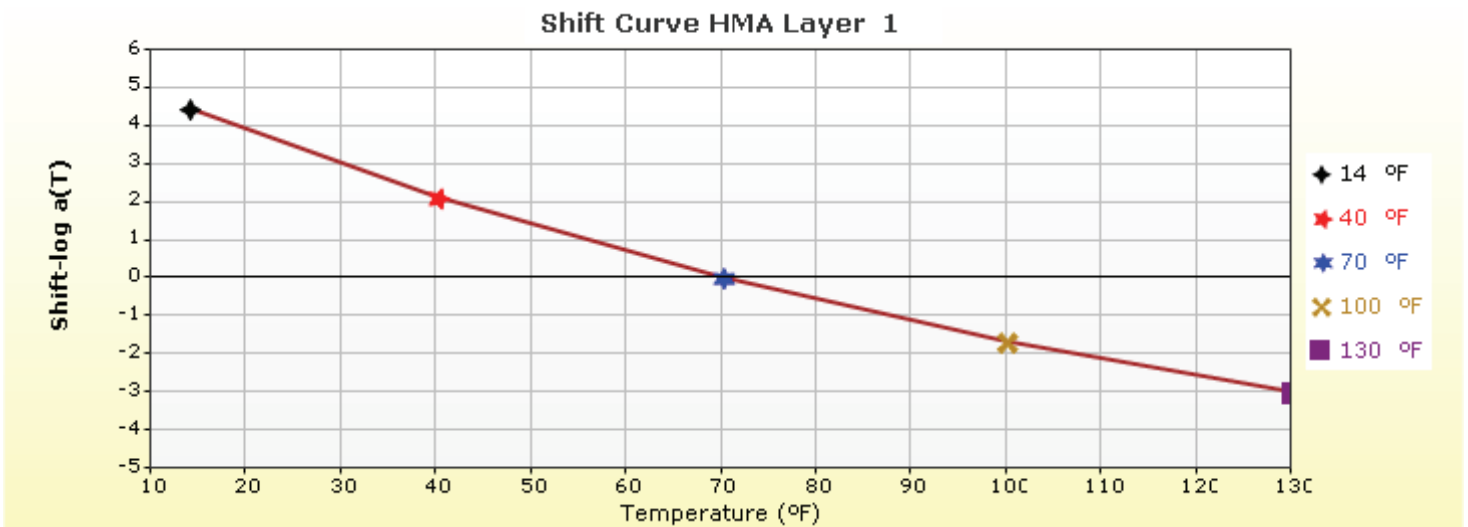
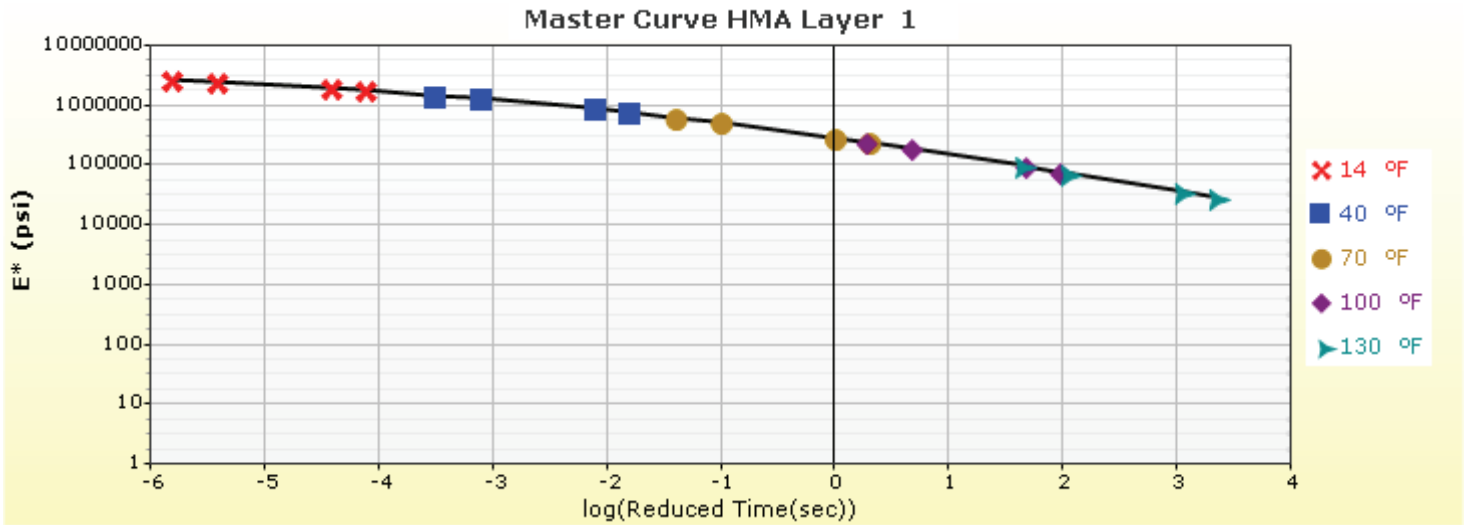
Loading time (sec)	-4 °F	14 °F	32 °F
1	5.11e-007	7.57e-007	1.03e-006
2	5.74e-007	9.06e-007	1.39e-006
5	6.71e-007	1.15e-006	2.06e-006
10	7.54e-007	1.37e-006	2.77e-006
20	8.48e-007	1.65e-006	3.73e-006
50	9.90e-007	2.09e-006	5.51e-006
100	1.11e-006	2.50e-006	7.42e-006



Indirect Tensile Strength, psi

There is no or empty series

HMA Layer 1: Layer 1 Flexible : HMA (PG 64-34)



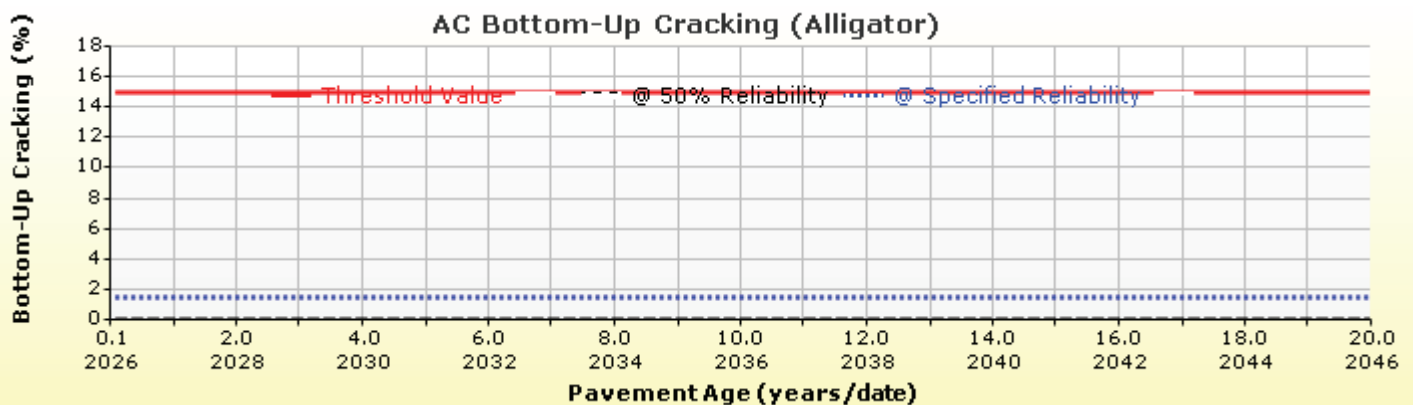
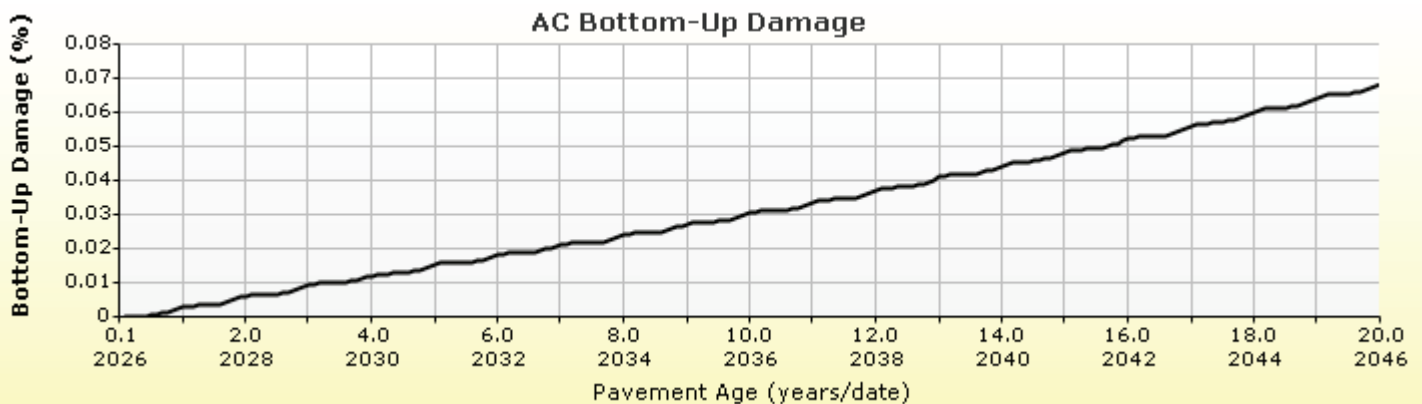
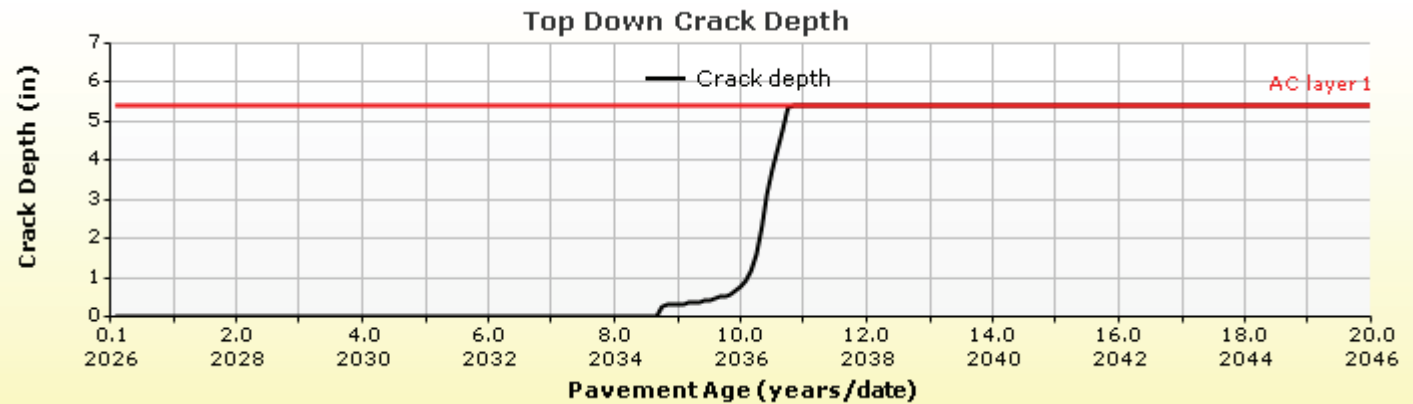
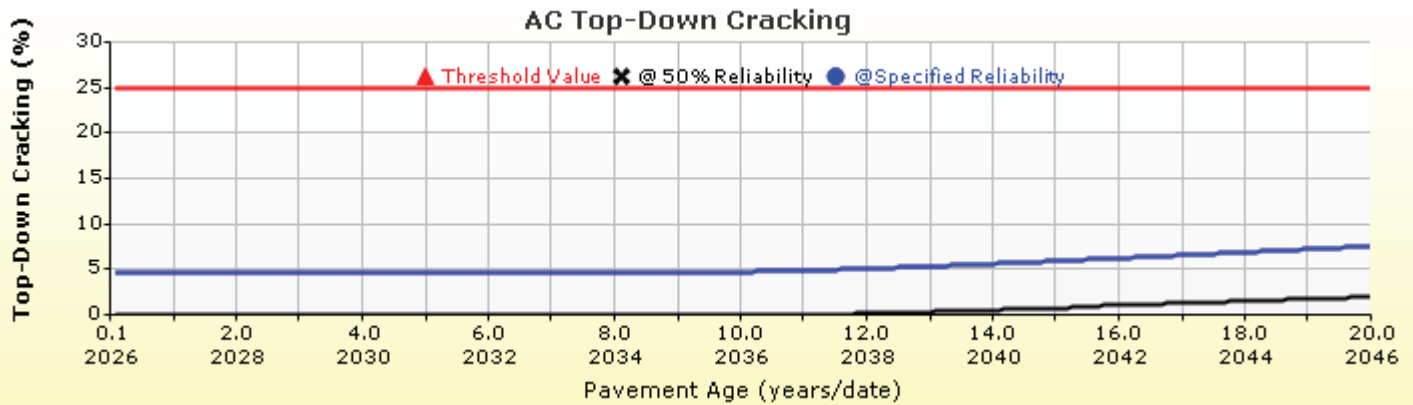


US-91, AC and Base Removal (PCC in place)

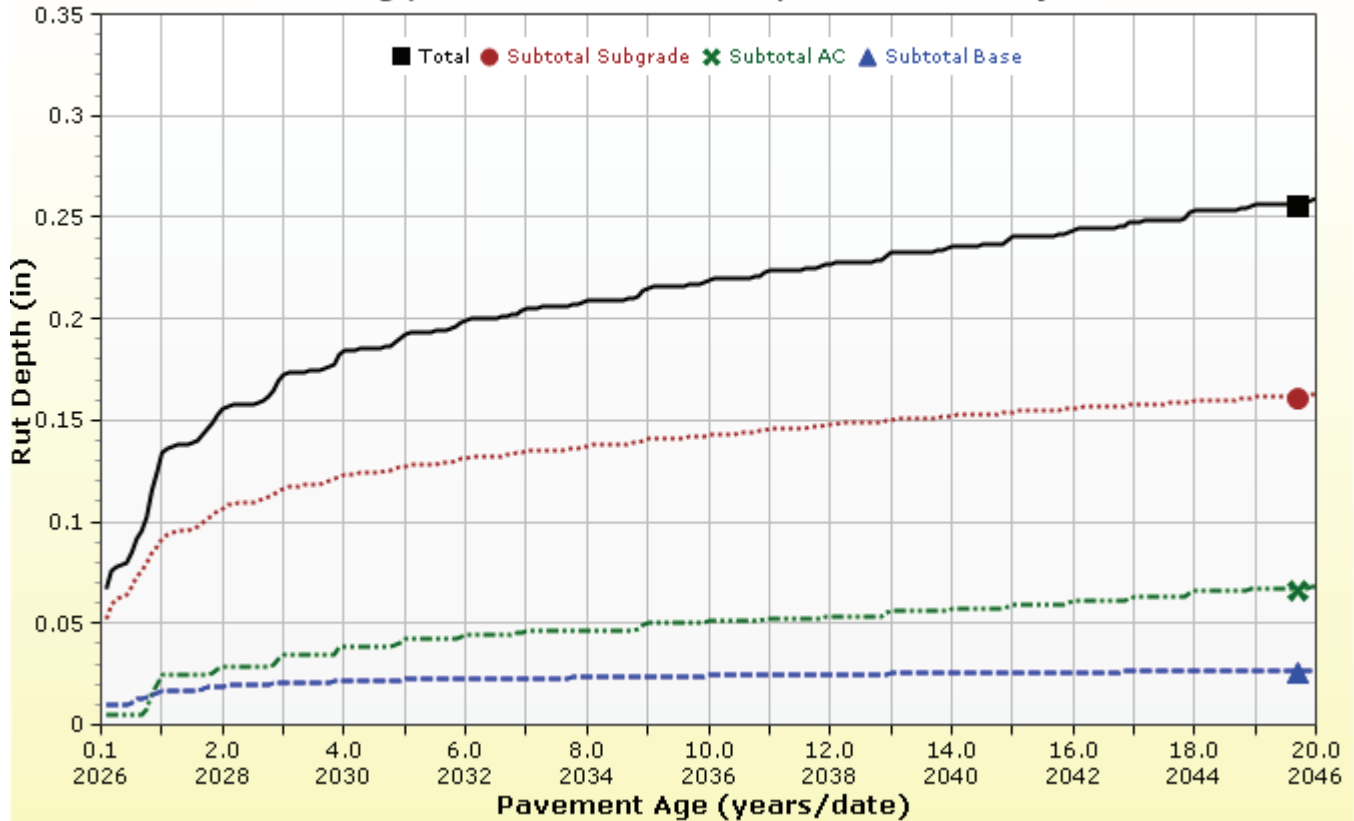
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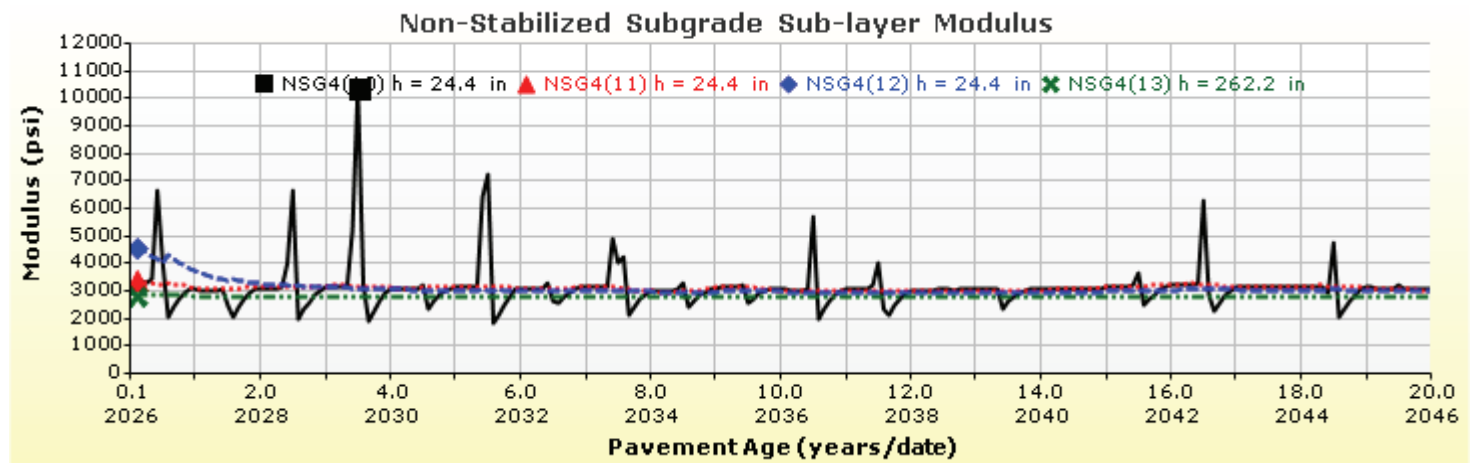
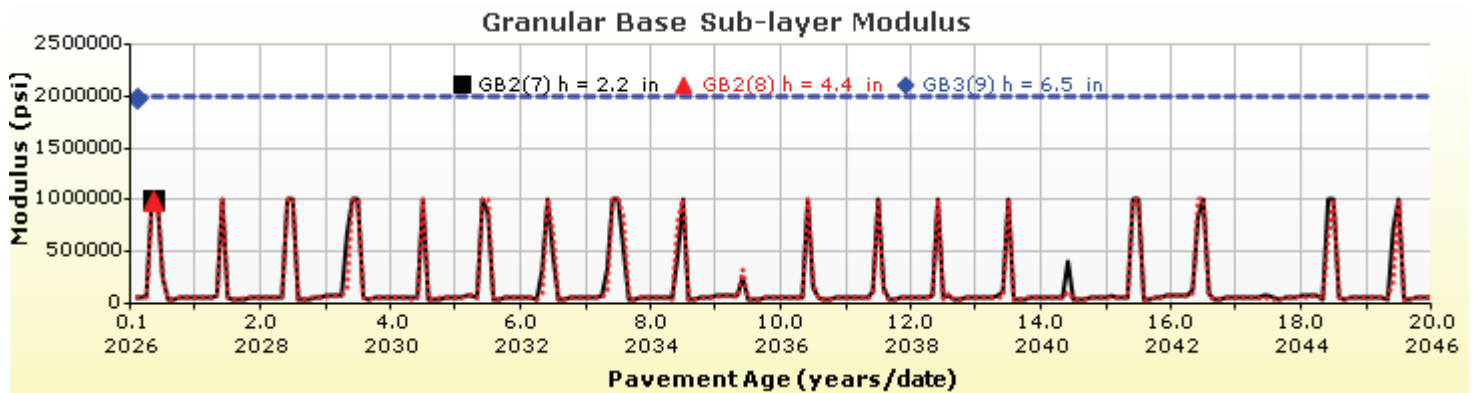
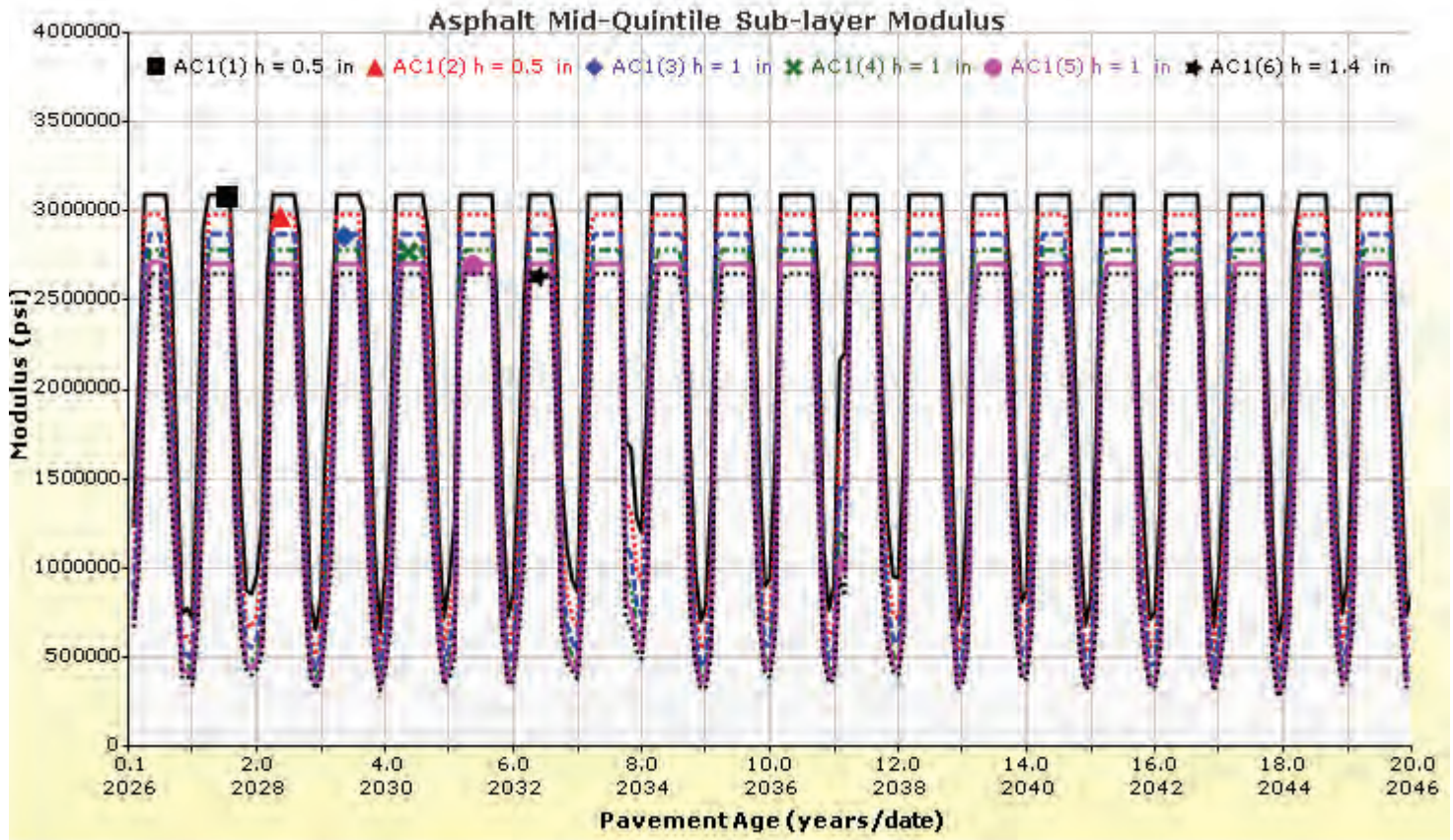


Analysis Output Charts



Rutting (Permanent Deformation) at 50% Reliability







US-91, AC and Base Removal (PCC in place)

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Layer Information

Layer 1 Flexible : HMA (PG 64-34)

Asphalt

Thickness (in)	5.4	
Unit weight (pcf)	144.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-34
A	9.461
VTs	-3.134

General Info

Name	Value
Reference temperature (°F)	70
Effective binder content (%)	11.6
Air voids (%)	7.5
Thermal conductivity (BTU/hr-ft-°F)	0.67
Heat capacity (BTU/lb-°F)	0.23
Asphalt content by weight (%)	4.5
Aggregate parameter	0.4021

Identifiers

Field	Value
Display name/identifier	HMA (PG 64-34)
Description of object	New Superpave Hot Mix Asphalt
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0



US-91, AC and Base Removal (PCC in place)

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, AC and Base Removal (PCC in place).dgp



Layer 2 Non-stabilized Base : Untreated Aggregate Base

Unbound

Layer thickness (in)	6.6
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

40000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Untreated Aggregate Base
Description of object	New Untreated Aggregate Base
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
Saturated hydraulic conductivity (ft/hr)	False	1.907e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.6

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	5.1359
bf	2.0746
cf	0.7463
hr	112.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	6.0
#100	
#80	
#60	
#50	
#40	
#30	
#20	
#16	
#10	
#8	40.0
#4	55.0
3/8-in.	
1/2-in.	
3/4-in.	95.0
1-in.	100.0
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	



US-91, AC and Base Removal (PCC in place)

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, AC and Base Removal (PCC in place).dgp



Layer 3 Non-stabilized Base : Existing PCC

Unbound

Layer thickness (in)	6.5
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Annual representative values
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

1987800.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Existing PCC
Description of object	New Granular Subbase
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.5
Saturated hydraulic conductivity (ft/hr)	False	2.635e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	9.9487
bf	1.1708
cf	0.9577
hr	115.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	7.5
#100	
#80	
#60	
#50	
#40	
#30	
#20	
#16	
#10	
#8	
#4	52.5
3/8-in.	
1/2-in.	
3/4-in.	
1-in.	
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	95.0
3 1/2-in.	100.0



US-91, AC and Base Removal (PCC in place)

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, AC and Base Removal (PCC in place).dgp



Layer 4 Subgrade : Subgrade

Unbound

Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

4800.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Subgrade
Description of object	Default material
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	32.0
Plasticity Index	11.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	108.5
Saturated hydraulic conductivity (ft/hr)	False	1.606e-05
Specific gravity of solids	False	2.7
Water Content (%)	False	17.2

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	108.7900
bf	0.6776
cf	0.2136
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	93.0
#100	97.0
#80	
#60	
#50	
#40	99.0
#30	
#20	100.0
#16	
#10	
#8	
#4	
3/8-in.	
1/2-in.	
3/4-in.	
1-in.	
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	

Calibration Coefficients

AC Fatigue

$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\epsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$	k1: 3.75
$C = 10^M$	k2: 2.87
$M = 4.84 \left(\frac{V_b}{V_a + V_b} - 0.69\right)$	k3: 1.46
	Bf1: (5.014 * Pow(hac,-3.416)) * 1 + 0
	Bf2: 1.38
	Bf3: 0.88

AC Rutting

$\frac{\epsilon_p}{\epsilon_r} = k_z \beta_{r1} 10^{k_1 T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}}$ $k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$ $C_1 = -0.1039 * H_a^2 + 2.4868 * H_a - 17.342$ $C_2 = 0.0172 * H_a^2 - 1.7331 * H_a + 27.428$ Where: H_{ac} = total AC thickness(in)	ϵ_p = plastic strain(in/in) ϵ_r = resilient strain(in/in) T = layer temperature(°F) N = number of load repetitions
acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22 Br1:0.3 Br2:0.52 Br3:1.36

Thermal Fracture

$C_f = \beta_{t1} N \left[\frac{1}{\sigma_d} \log \left(\frac{C}{h_{AC}} \right) \right]$ $\Delta C = A(\Delta K)^n$ $A = k_t \beta_t 10^{[4.389 - 2.52 \log(E_{HMA} \sigma_m n)]}$	C_f = Observed amount of thermal cracking, ft. / 500ft. β_{t1} = Regression coefficient determined through global calibration (400) $N[z]$ = Standard normal distribution evaluated at [z] σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in. C = Crack depth, in. h_{AC} = Thickness of asphalt layer, in. ΔC = Change in the crack depth due to a cooling cycle ΔK = Change in the stress intensity factor due to a cooling cycle A, n = Fracture parameters for the asphalt mixture E = Asphalt mixture stiffness, MPa σ_m = Undamaged mixture tensile strength, MPa k_t = Regression coefficient determined through field calibration β_t = Calibration parameter
Level 1 K: ((3 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	Level 1 Standard Deviation: 0.14 * THERMAL + 168
Level 2 K: ((2.591 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	Level 2 Standard Deviation: 0.20 * THERMAL + 168
Level 3 K: ((3 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	Level 3 Standard Deviation: 0.289 * THERMAL + 168

CSM Fatigue

$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r} \right)}{k_2 \beta_{c2}} \right)}$	N_f = number of repetitions to fatigue cracking σ_s = Tensile stress(psi) M_r = modulus of rupture(psi)
k1: 0.972	k2: 0.0825
Bc1: 1	Bc2:1

Unbound Layer Rutting			
$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r} \right) \left e^{-\left(\frac{\rho}{N} \right)^\beta} \right $		δ_a = permanent deformation for the layer N = number of repetitions ε_v = average vertical strain(in/in) $\varepsilon_0, \beta, \rho$ = material properties ε_r = resilient strain(in/in)	
Base Rutting		Subgrade Rutting	
k1: 0.965	Bs1: 0.86	k1: 0.965	Bs1: 0.736
Standard Deviation (BASERUT) 0.1477 * Pow(BASERUT,0.6711) + 0.001		Standard Deviation (BASERUT) 0.1235 * Pow(SUBRUT,0.5012) + 0.001	

AC Cracking					
AC Top Down Cracking			AC Bottom Up Cracking		
$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{1 - C_3' a} \right)^{C_2 \beta}}$ $t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0 / 2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$			$FC = \left(\frac{6000}{1 + e^{(C_1 * C_1' + C_2 * C_2' \log_{10}(D * 100))}} \right) * \left(\frac{1}{60} \right)$ $C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$ $C_1' = -2 * C_2'$		
c1: 2.5219	c2: 0.8069	c3: 1	c1: 1.31	c2: (0.867 + 0.2583 * hac) * 1	c3: 6000
kL1: 64271618	kL2: 0.2855	kL3: 0.011	acCrackingBottomStandardDeviation		
kL4: 0.01488	kL5: 3.266		1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))		
acCrackingTopStandardDeviation					
0.3657 * TOP + 3.6563					

CSM Cracking				IRI Flexible Pavements			
$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(\text{Damage})}}$				C1 - Rutting C3 - Transverse Crack C2 - Fatigue Crack C4 - Site Factors			
C1: 0	C2: 75	C3: 2	C4: 2	C1: 80	C2: 0.6	C3: 0.008	C4: 0.02
csmCrackingStandardDeviation							
CTB*1							

Flexible Pavement Design - AASHTO 1993 Method

Project Name: US-91, Park Lawn to Siphon Rd

Segment: All

Project No.: 71-109216

Date: March 7, 2023

Performance Criteria

Initial Serviceability, p_o :	4.2	85
Terminal Serviceability, p_t :	2.5	
Reliability Level R:	85%	
Overall Standard Deviation, S_o :	0.49	
Performance Period:	20	

years

Design Traffic Load

Traffic Index, TI: - or - ESALs:

Design Subgrade Resistance

CBR: - or - Resilient Modulus, M_r : psi

Layered Thickness Design

Required Structural Number, SN_r : 4.89

Layer No.	Layer Name	Thickness (inches)	Structural Coefficient	Drainage Coefficient	Structural Number, SN
1	Plant Mix	5.40	0.45	n.a.	2.43
2	Base	9.00	0.15	1.00	1.35
3	Subbase	12.00	0.10	1.00	1.20
4					
5					

Total SN Provided: 4.98

Acceptable



US-91, Flexible Reconstruction

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, Flexible Reconstruction.dgpx



Design Inputs

Design Life: 20 years Base construction: July, 2026 Climate Data 43, -112.5
Design Type: FLEXIBLE Pavement construction: August, 2026 Sources (Lat/Lon)
Traffic opening: September, 2026

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	HMA (PG 64-34)	5.4
NonStabilized	Untreated Aggregate Base	9.0
NonStabilized	Granular Subbase	12.0
Subgrade	Subgrade	Semi-infinite

Volumetric at Construction:

Effective binder content (%)	11.6
Air voids (%)	7.5

Traffic

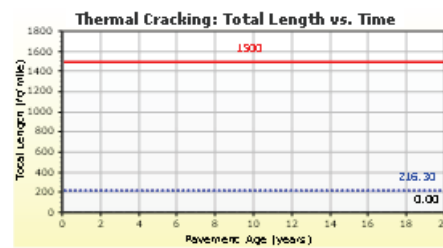
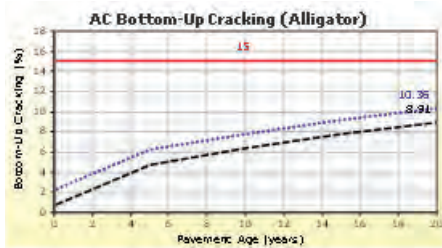
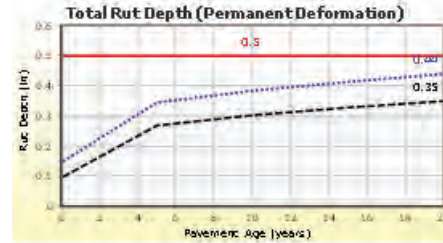
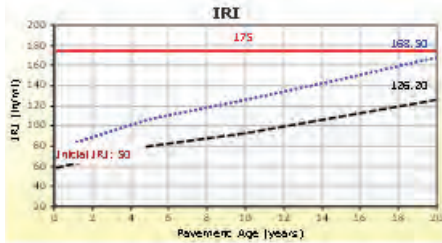
Age (year)	Heavy Trucks (cumulative)
2026 (initial)	297
2036 (10 years)	729,201
2046 (20 years)	1,662,640

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	175.00	168.50	90.00	93.03	Pass
Permanent deformation - total pavement (in)	0.50	0.44	90.00	98.36	Pass
AC bottom-up fatigue cracking (% lane area)	15.00	10.36	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	216.30	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.50	0.10	90.00	100.00	Pass

Distress Charts

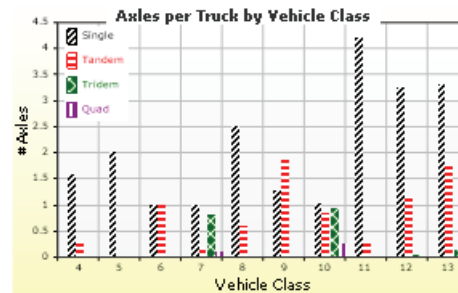
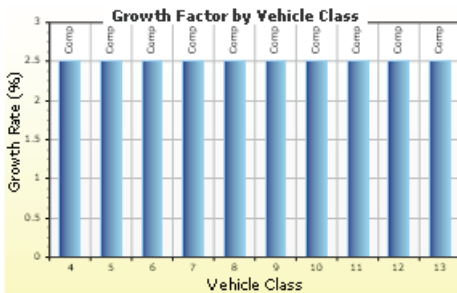
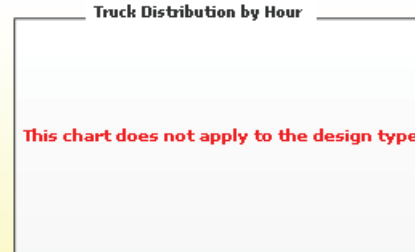
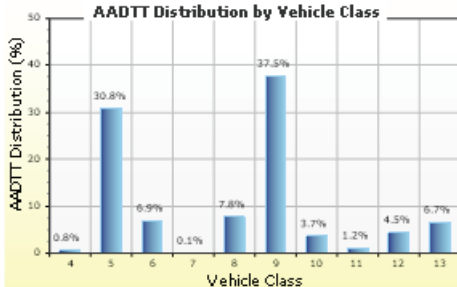


— Threshold Value @ Specified Reliability --- @ 50% Reliability

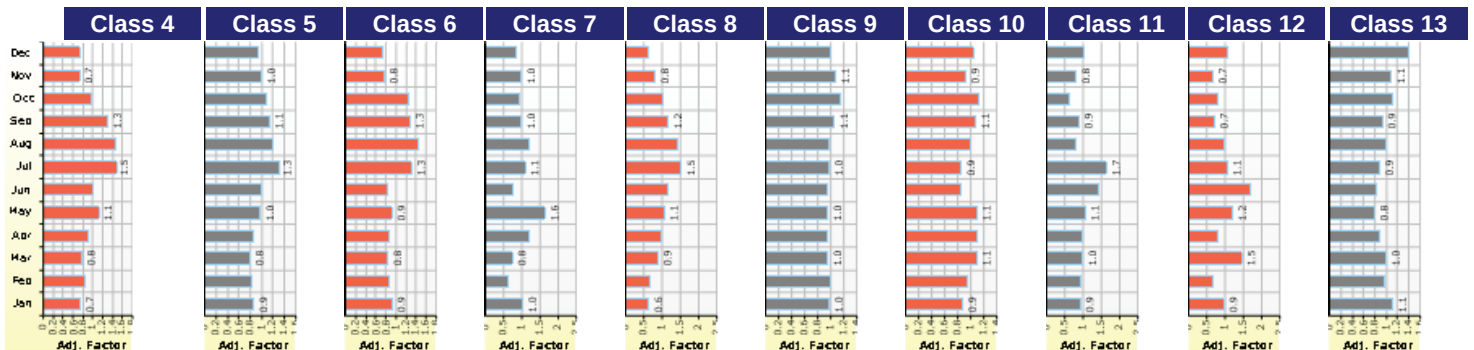
Traffic Inputs

Graphical Representation of Traffic Inputs

Initial two-way AADTT:	297	Percent of trucks in design direction (%):	60.0
Number of lanes in design direction:	2	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	35.0



Traffic Volume Monthly Adjustment Factors



Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.7	0.9	0.9	1.0	0.6	1.0	0.9	0.9	0.9	1.1
February	0.8	0.8	0.9	0.6	0.7	1.0	1.0	0.9	0.7	1.0
March	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.0	1.5	1.0
April	0.9	0.9	0.9	1.2	1.0	1.0	1.1	0.9	0.8	0.9
May	1.1	1.0	0.9	1.6	1.1	1.0	1.1	1.1	1.2	0.8
June	1.0	1.0	0.8	0.7	1.2	0.9	0.8	1.4	1.7	0.8
July	1.5	1.3	1.3	1.1	1.5	1.0	0.9	1.7	1.1	0.9
August	1.5	1.2	1.5	1.2	1.4	1.0	1.0	0.8	1.0	1.0
September	1.3	1.1	1.3	1.0	1.2	1.1	1.1	0.9	0.7	0.9
October	0.9	1.1	1.3	0.9	1.0	1.2	1.1	0.6	0.8	1.1
November	0.7	1.0	0.8	1.0	0.8	1.1	0.9	0.8	0.7	1.1
December	0.7	0.9	0.7	0.9	0.6	1.0	1.0	1.0	1.1	1.4

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.8%	2.5%	Compound
Class 5	30.8%	2.5%	Compound
Class 6	6.9%	2.5%	Compound
Class 7	0.1%	2.5%	Compound
Class 8	7.8%	2.5%	Compound
Class 9	37.5%	2.5%	Compound
Class 10	3.7%	2.5%	Compound
Class 11	1.2%	2.5%	Compound
Class 12	4.5%	2.5%	Compound
Class 13	6.7%	2.5%	Compound

Truck Distribution by Hour does not apply

Axle Configuration

Traffic Wander	
Mean wheel location (in)	18.0
Traffic wander standard deviation (in)	10.0
Design lane width (ft)	12.0

Axle Configuration	
Average axle width (ft)	8.5
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	51.6
Tridem axle spacing (in)	49.2
Quad axle spacing (in)	49.2

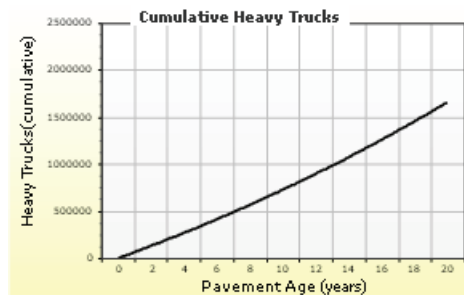
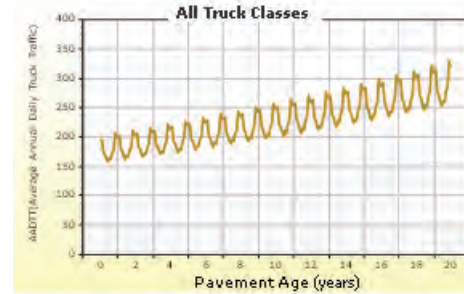
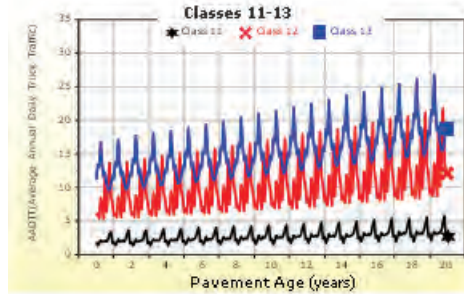
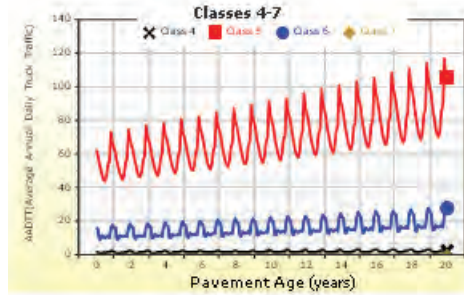
Wheelbase does not apply	
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Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.59	0.34	0	0
Class 5	2	0	0	0
Class 6	1	1	0	0
Class 7	1	0.22	0.83	0.1
Class 8	2.52	0.6	0	0
Class 9	1.25	1.87	0	0
Class 10	1.03	0.85	0.95	0.26
Class 11	4.21	0.29	0.01	0
Class 12	3.24	1.16	0.07	0.01
Class 13	3.32	1.79	0.14	0.02

AADTT (Average Annual Daily Truck Traffic) Growth

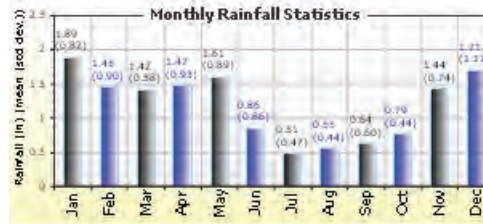
* Traffic cap is not enforced



Climate Inputs

Climate Data Sources:

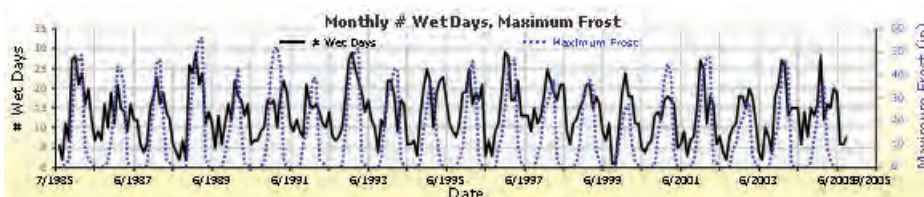
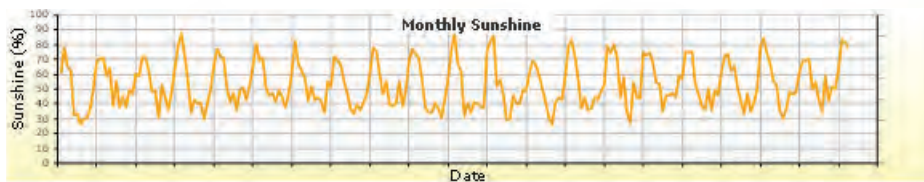
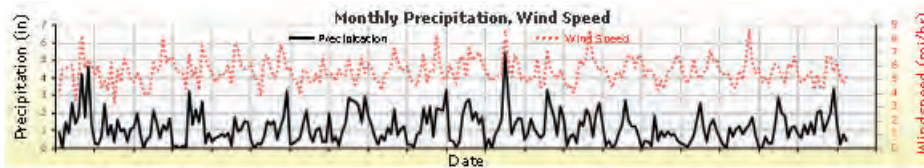
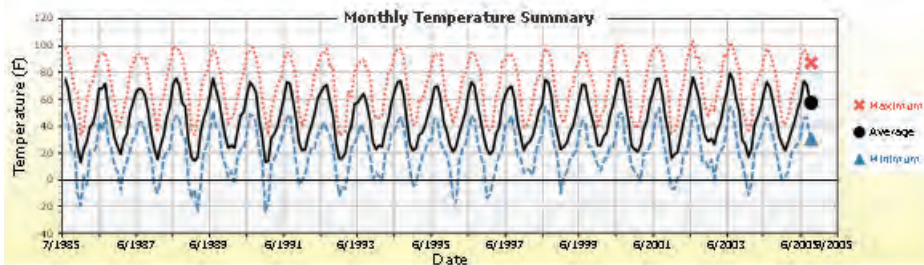
Climate Station Cities: Location (lat lon elevation(ft))
US, ID 43.00000 -112.50000 4431



Annual Statistics:

Mean annual air temperature (°F)	46.21	
Mean annual precipitation (in)	14.24	
Freezing index (°F - days)	887.39	
Average annual number of freeze/thaw cycles:	121.66	Water table depth (ft) 10.00

Monthly Climate Summary:



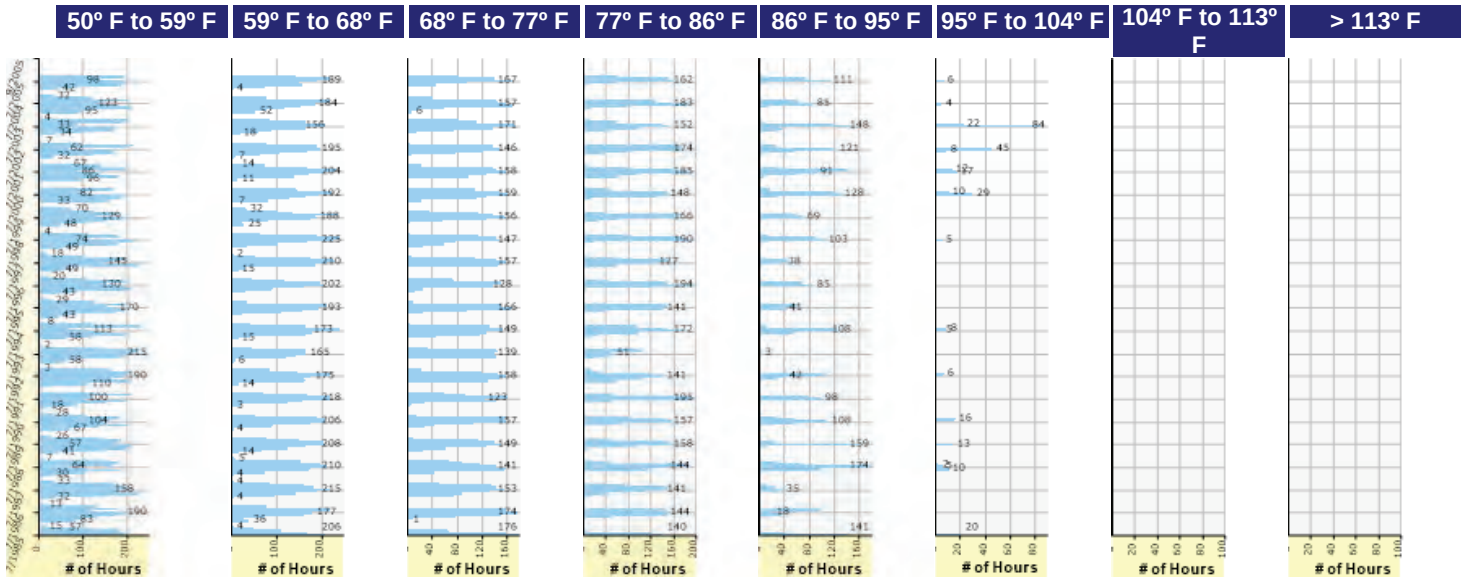
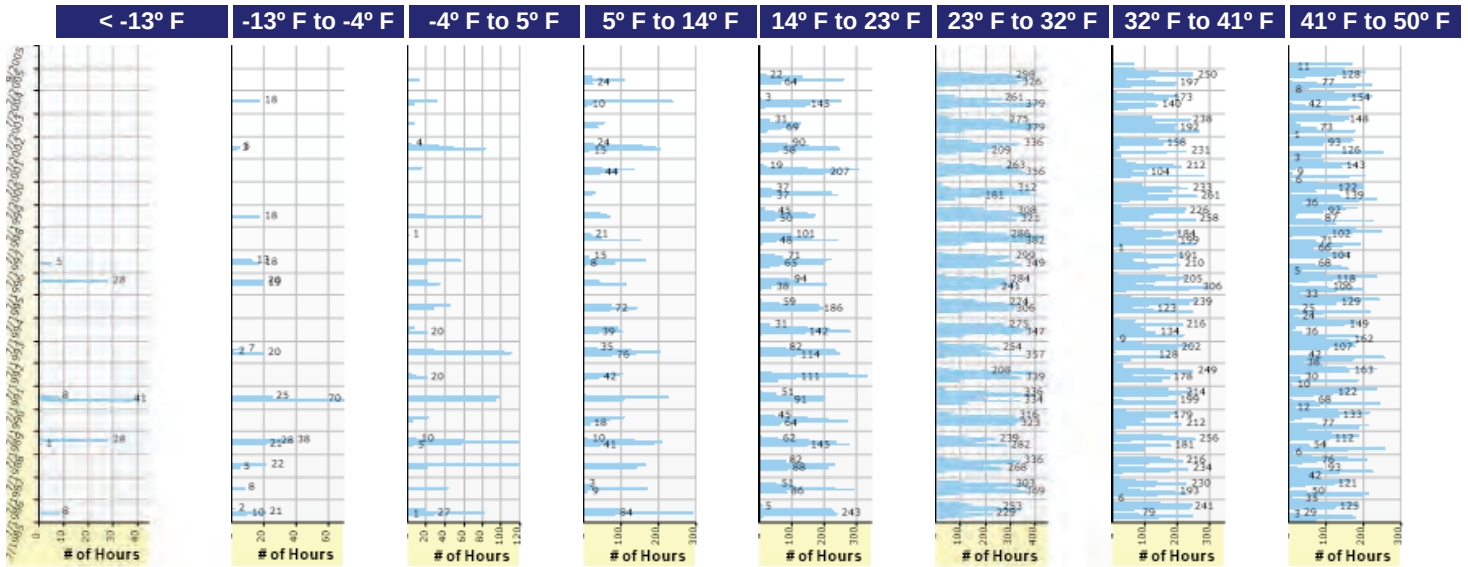


US-91, Flexible Reconstruction

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, Flexible Reconstruction.dgp



Hourly Air Temperature Distribution by Month:





US-91, Flexible Reconstruction

File Name: C:\Users\mee\Desktop\US-91 Park Lawn\US-91, Flexible Reconstruction.dgpx



Design Properties

HMA Design Properties

Use Multilayer Rutting Model	False
Using G* based model (not nationally calibrated)	False
Is NCHRP 1-37A HMA Rutting Model Coefficients	True
Endurance Limit	-
Use Reflective Cracking	True

Structure - ICM Properties	
AC surface shortwave absorptivity	0.85

Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : HMA (PG 64-34)	Flexible (1)	1.00
Layer 2 Non-stabilized Base : Untreated Aggregate Base	Non-stabilized Base (4)	1.00
Layer 3 Non-stabilized Base : Granular Subbase	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : Subgrade	Subgrade (5)	-

Thermal Cracking

Thermal Contraction

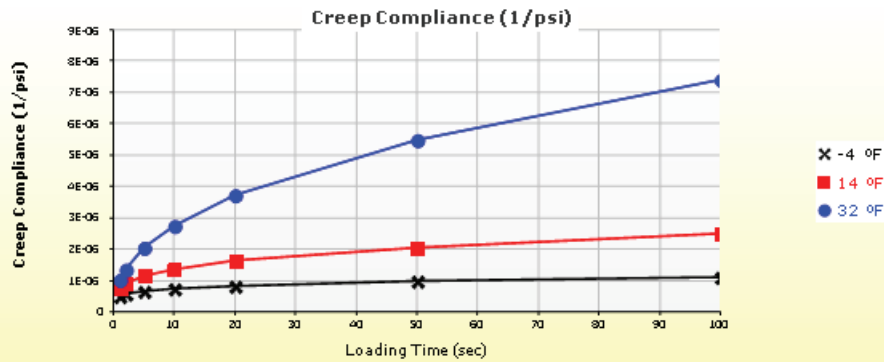
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/°F)	-
Aggregate coefficient of thermal contraction (in/in/°F)	5.0e-006
Voids in Mineral Aggregate (%)	19.1

Indirect Tensile Strength (Input Level: 3)

Test Temperature (°F)	Indirect Tensile Strength (psi)
14.0	479.50

Creep Compliance (1/psi) (Input Level: 3)

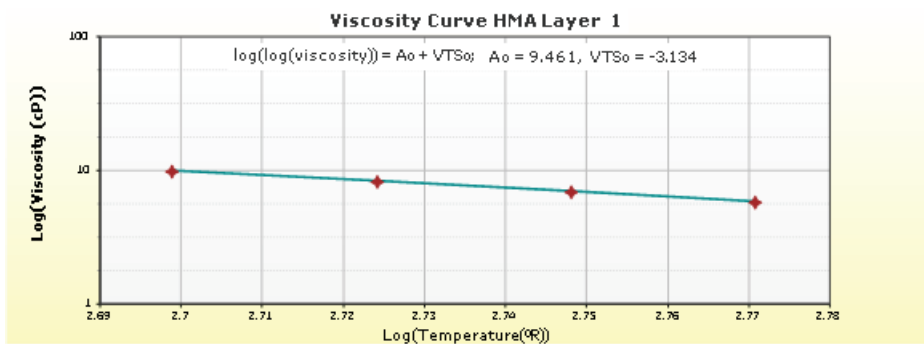
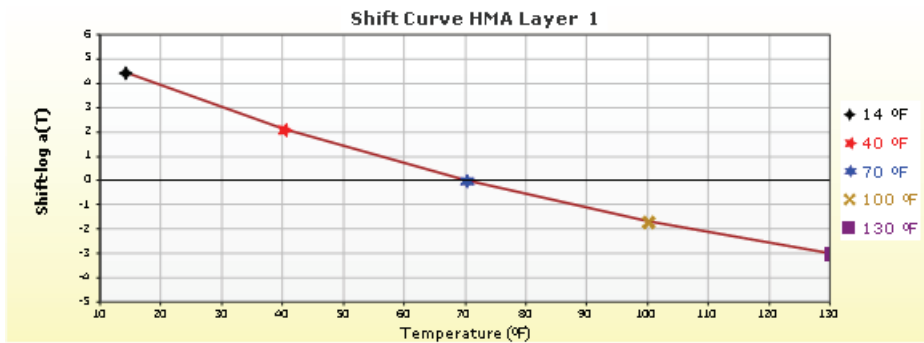
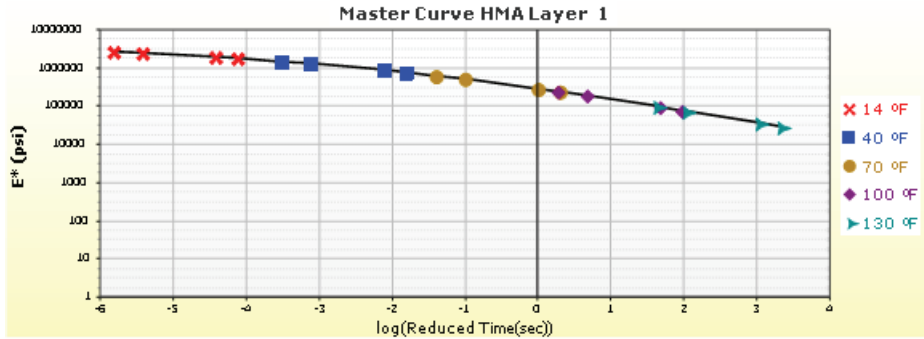
Loading time (sec)	-4 °F	14 °F	32 °F
1	5.11e-007	7.57e-007	1.03e-006
2	5.74e-007	9.06e-007	1.39e-006
5	6.71e-007	1.15e-006	2.06e-006
10	7.54e-007	1.37e-006	2.77e-006
20	8.48e-007	1.65e-006	3.73e-006
50	9.90e-007	2.09e-006	5.51e-006
100	1.11e-006	2.50e-006	7.42e-006



Indirect Tensile Strength, psi

There is no or empty series

HMA Layer 1: Layer 1 Flexible : HMA (PG 64-34)



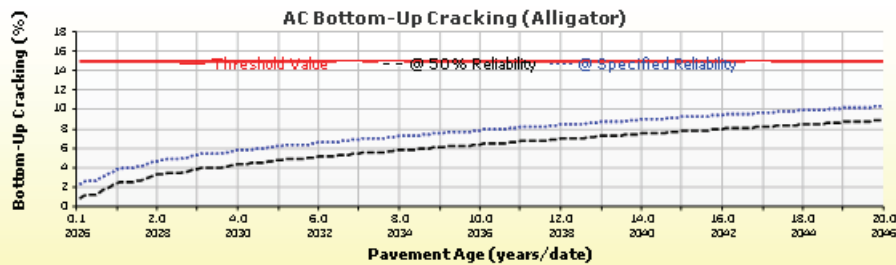
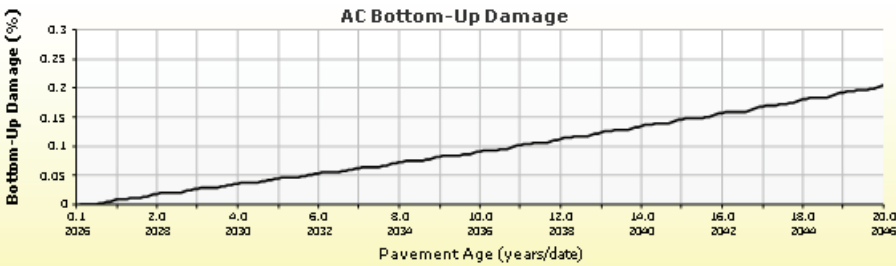
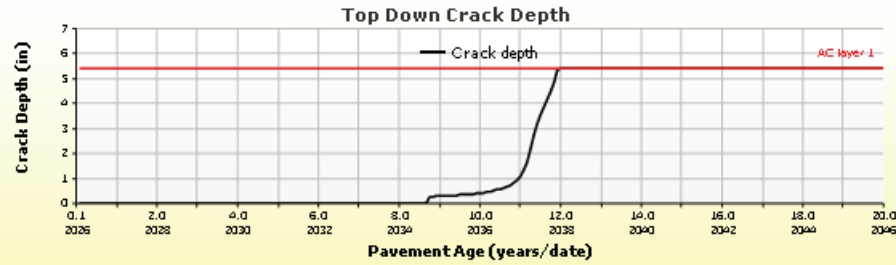
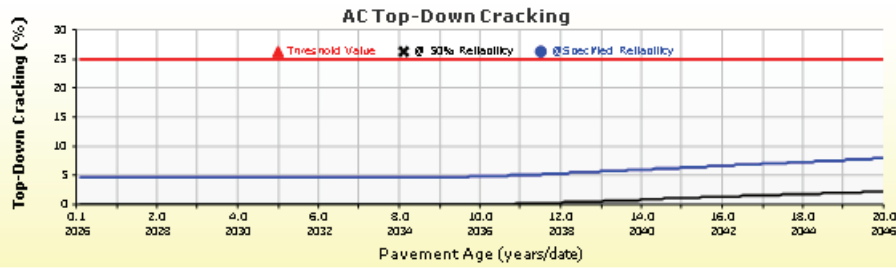


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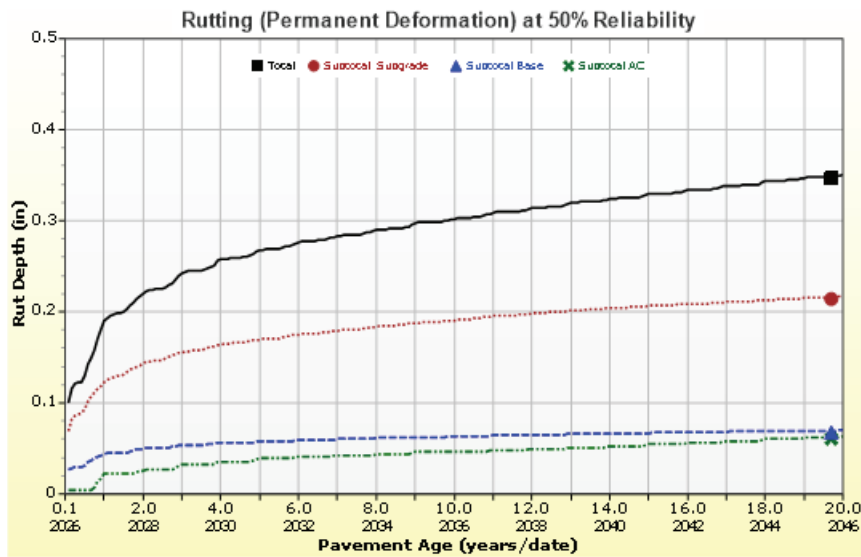
Analysis Output Charts

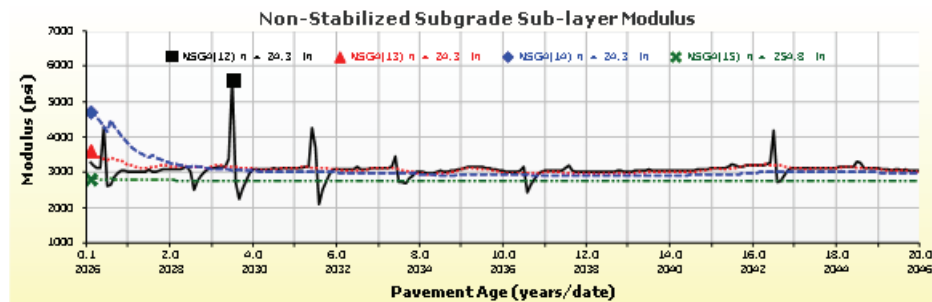
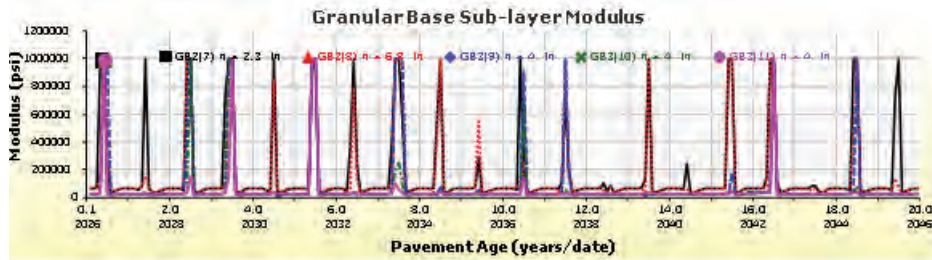
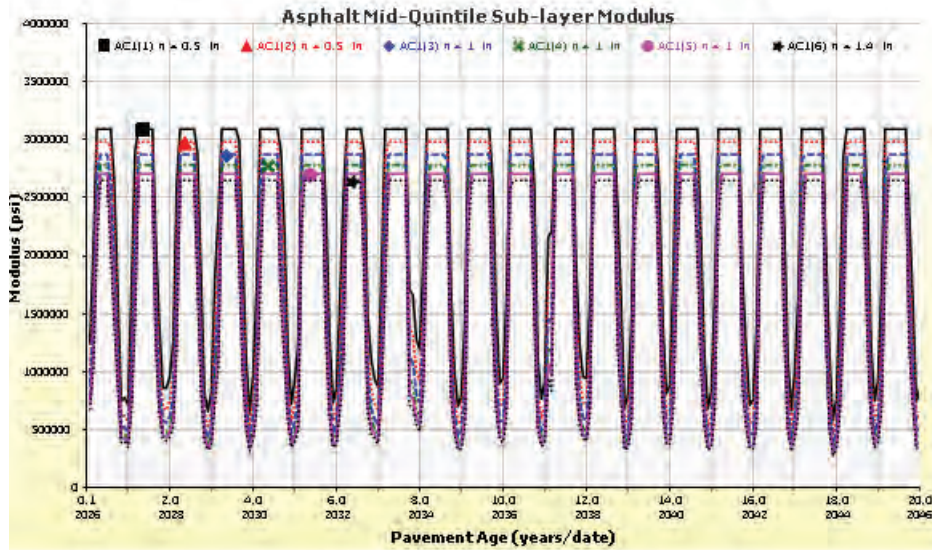




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Layer Information

Layer 1 Flexible : HMA (PG 64-34)

Asphalt		
Thickness (in)	5.4	
Unit weight (pcf)	144.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	64-34
A	9.461
VTs	-3.134

General Info

Name	Value
Reference temperature (°F)	70
Effective binder content (%)	11.6
Air voids (%)	7.5
Thermal conductivity (BTU/hr-ft-°F)	0.67
Heat capacity (BTU/lb-°F)	0.23
Asphalt content by weight (%)	4.5
Aggregate parameter	0.4021

Identifiers

Field	Value
Display name/identifier	HMA (PG 64-34)
Description of object	New Superpave Hot Mix Asphalt
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/23
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Non-stabilized Base : Untreated Aggregate Base

Unbound

Layer thickness (in)	9.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

40000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Untreated Aggregate Base
Description of object	New Untreated Aggregate Base
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
Saturated hydraulic conductivity (ft/hr)	False	1.907e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.6

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	5.1359
bf	2.0746
cf	0.7463
hr	112.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	6.0
#100	
#80	
#60	
#50	
#40	
#30	
#20	
#16	
#10	
#8	40.0
#4	55.0
3/8-in.	
1/2-in.	
3/4-in.	95.0
1-in.	100.0
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	



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Layer 3 Non-stabilized Base : Granular Subbase

Unbound

Layer thickness (in)	12.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

25000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Granular Subbase
Description of object	New Granular Subbase
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.5
Saturated hydraulic conductivity (ft/hr)	False	2.635e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.4

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	9.9487
bf	1.1708
cf	0.9577
hr	115.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	7.5
#100	
#80	
#60	
#50	
#40	
#30	
#20	
#16	
#10	
#8	
#4	52.5
3/8-in.	
1/2-in.	
3/4-in.	
1-in.	
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	95.0
3 1/2-in.	100.0



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Layer 4 Subgrade : Subgrade

Unbound

Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

4800.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Subgrade
Description of object	Default material
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	32.0
Plasticity Index	11.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	108.5
Saturated hydraulic conductivity (ft/hr)	False	1.606e-05
Specific gravity of solids	False	2.7
Water Content (%)	False	17.2

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	108.7900
bf	0.6776
cf	0.2136
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	93.0
#100	97.0
#80	
#60	
#50	
#40	99.0
#30	
#20	100.0
#16	
#10	
#8	
#4	
3/8-in.	
1/2-in.	
3/4-in.	
1-in.	
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	

Calibration Coefficients

AC Fatigue

$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\epsilon_1} \right)^{k_2 \beta_{f2}} \left(\frac{1}{E} \right)^{k_3 \beta_{f3}}$ $C = 10^M$ $M = 4.84 \left(\frac{V_b}{V_a + V_b} - 0.69 \right)$	k1: 3.75
	k2: 2.87
	k3: 1.46
	Bf1: (5.014 * Pow(hac,-3.416)) * 1 + 0
	Bf2: 1.38
	Bf3: 0.88

AC Rutting

$\frac{\epsilon_p}{\epsilon_r} = k_z \beta_{r1} 10^{k_1 T^{k_2 \beta_{r2} N^{k_3 \beta_{r3}}}}$ $k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$ $C_1 = -0.1039 * H_a^2 + 2.4868 * H_a - 17.342$ $C_2 = 0.0172 * H_a^2 - 1.7331 * H_a + 27.428$ Where: H_{ac} = total AC thickness(in)	ϵ_p = plastic strain(in/in) ϵ_r = resilient strain(in/in) T = layer temperature(°F) N = number of load repetitions
acRuttingStandardDeviation	0.24 * Pow(RUT,0.8026) + 0.001
AC Layer 1	K1:-2.45 K2:3.01 K3:0.22 Br1:0.3 Br2:0.52 Br3:1.36

Thermal Fracture

$C_f = \beta_{t1} N \left[\frac{1}{\sigma_d} \log \left(\frac{C}{h_{AC}} \right) \right]$ $\Delta C = A(\Delta K)^n$ $A = k_t \beta_t 10^{[4.389 - 2.52 \log(E_{HMA} \sigma_m n)]}$	C_f = Observed amount of thermal cracking, ft. / 500ft. β_{t1} = Regression coefficient determined through global calibration (400) $N[z]$ = Standard normal distribution evaluated at [z] σ_d = Standard deviation of the logarithm of crack depth in the pavement (0.769), in. C = Crack depth, in. h_{AC} = Thickness of asphalt layer, in. ΔC = Change in the crack depth due to a cooling cycle ΔK = Change in the stress intensity factor due to a cooling cycle A, n = Fracture parameters for the asphalt mixture E = Asphalt mixture stiffness, MPa σ_m = Undamaged mixture tensile strength, MPa k_t = Regression coefficient determined through field calibration β_t = Calibration parameter
Level 1 K: ((3 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	Level 1 Standard Deviation: 0.14 * THERMAL + 168
Level 2 K: ((2.591 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	Level 2 Standard Deviation: 0.20 * THERMAL + 168
Level 3 K: ((3 * Pow(10,-7)) * Pow(MAAT,4.0319)) * 1 + 0	Level 3 Standard Deviation: 0.289 * THERMAL + 168

CSM Fatigue

$N_f = 10^{\left(\frac{k_1 \beta_{c1} \left(\frac{\sigma_s}{M_r} \right)}{k_2 \beta_{c2}} \right)}$	N_f = number of repetitions to fatigue cracking σ_s = Tensile stress(psi) M_r = modulus of rupture(psi)
k1: 0.972	k2: 0.0825
Bc1: 1	Bc2:1

Unbound Layer Rutting

$$\delta_a(N) = \beta_{s_1} k_1 \varepsilon_v h \left(\frac{\varepsilon_0}{\varepsilon_r} \right) \left| e^{-\left(\frac{\rho}{N} \right)^\beta} \right|$$

δ_a = permanent deformation for the layer
 N = number of repetitions
 ε_v = average vertical strain(in/in)
 $\varepsilon_0, \beta, \rho$ = material properties
 ε_r = resilient strain(in/in)

Base Rutting

k1: 0.965

Bs1: 0.86

Standard Deviation (BASERUT)

0.1477 * Pow(BASERUT,0.6711) + 0.001

Subgrade Rutting

k1: 0.965

Bs1: 0.736

Standard Deviation (BASERUT)

0.1235 * Pow(SUBRUT,0.5012) + 0.001

AC Cracking

AC Top Down Cracking

$$L(t) = L_{Max} e^{-\left(\frac{C_1 \rho}{1 - C_3 a} \right)^{C_2 \beta}}$$

$$t_0(\text{Days}) = \frac{k_{L1}}{1 + e^{(k_{L2} \times 100 \times a_0 / 2A_0) + (k_{L3} \times HT) + (k_{L4} \times LT) + (k_{L5} \times \log_{10} AADTT)}}$$

c1: 2.5219

c2: 0.8069

c3: 1

kL1: 64271618

kL2: 0.2855

kL3: 0.011

kL4: 0.01488

kL5: 3.266

acCrackingTopStandardDeviation

0.3657 * TOP + 3.6563

AC Bottom Up Cracking

$$FC = \left(\frac{6000}{1 + e^{(C_1 * C'_1 + C_2 * C'_2 \log_{10}(D * 100))}} \right) * \left(\frac{1}{60} \right)$$

$$C'_2 = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C'_1 = -2 * C'_2$$

c1: 0.31

c2: (0.867 + 0.2583 * hac) *
0.175

c3: 6000

acCrackingBottomStandardDeviation

1.13 + 13/(1+exp(7.57-15.5*LOG10(BOTTOM+0.0001)))

CSM Cracking

$$FC_{ctb} = C_1 + \frac{C_2}{1 + e^{C_3 - C_4 * \log_{10}(\text{Damage})}}$$

C1: 0

C2: 75

C3: 2

C4: 2

csmCrackingStandardDeviation

CTB*1

IRI Flexible Pavements

C1 - Rutting

C3 - Transverse Crack

C2 - Fatigue Crack

C4 - Site Factors

C1: 80

C2: 0.6

C3: 0.008

C4: 0.02



US-91, Rigid Reconstruction

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Design Inputs

Design Life: 40 years
Design Type: JPCP

Existing construction: -
Pavement construction: August, 2026
Traffic opening: September, 2026

Climate Data 42.92, -112.571
Sources (Lat/Lon)

Design Structure

Layer type	Material Type	Thickness (in)
PCC	JPCP	10.0
Flexible	HMA (PG 58-28)	2.4
NonStabilized	Untreated Aggregate Base	6.0
Subgrade	Subgrade	Semi-infinite

Joint Design:

Joint spacing (ft)	12.0
Dowel diameter (in)	1.50
Slab width (ft)	13.0 (w)

Traffic

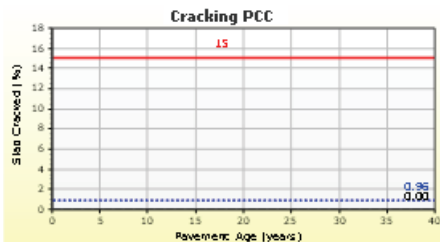
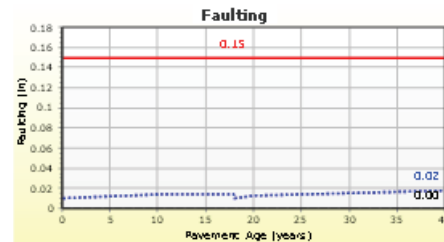
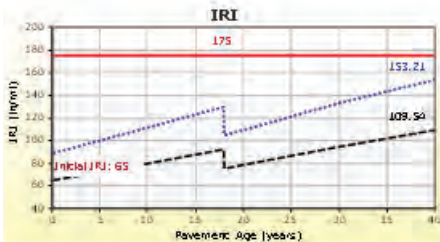
Age (year)	Heavy Trucks (cumulative)
2026 (initial)	297
2046 (20 years)	1,662,640
2066 (40 years)	4,387,070

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	175.00	153.21	90.00	97.26	Pass
Mean joint faulting (in)	0.15	0.02	90.00	100.00	Pass
JPCP transverse cracking (percent slabs)	15.00	0.96	90.00	100.00	Pass

Distress Charts



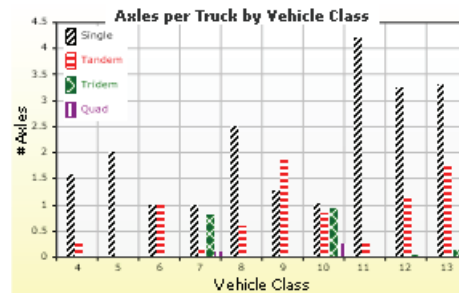
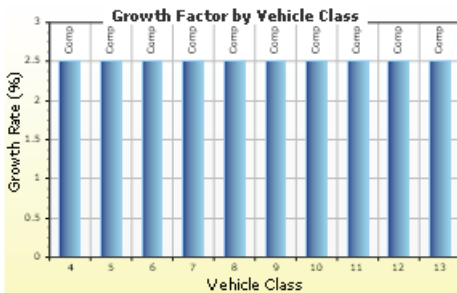
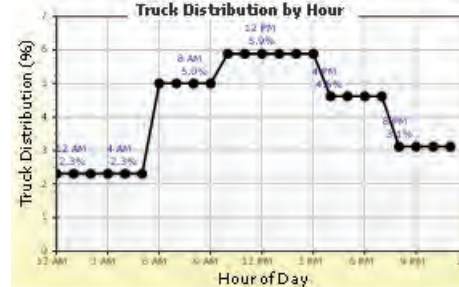
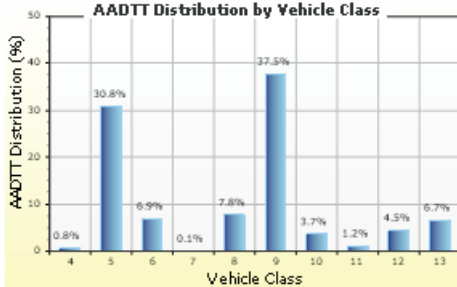
— Threshold Value @ Specified Reliability - - - @ 50% Reliability

Traffic Inputs

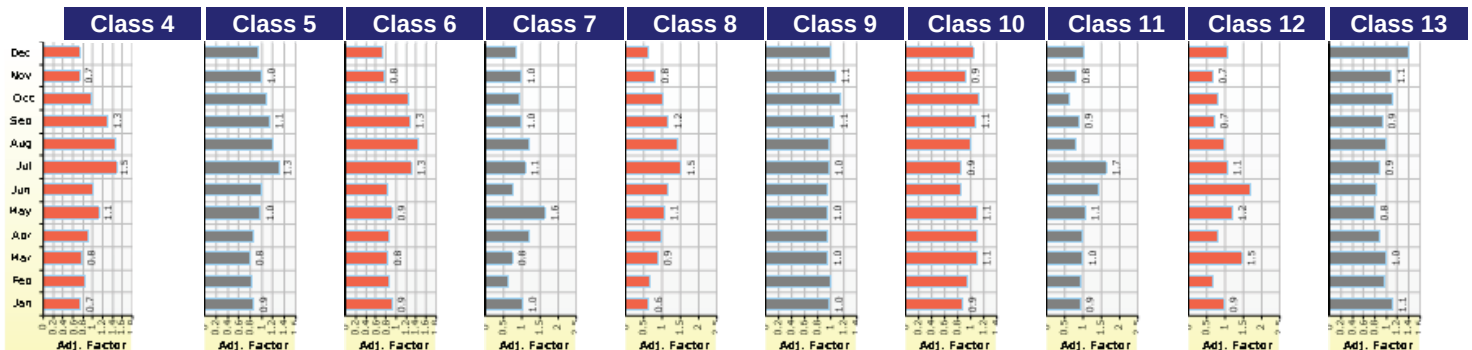
Graphical Representation of Traffic Inputs

Initial two-way AADTT: 297
Number of lanes in design direction: 2

Percent of trucks in design direction (%): 60.0
Percent of trucks in design lane (%): 100.0
Operational speed (mph): 35.0



Traffic Volume Monthly Adjustment Factors





US-91, Rigid Reconstruction

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Tabular Representation of Traffic Inputs

Volume Monthly Adjustment Factors

Level 3: Default MAF

Month	Vehicle Class									
	4	5	6	7	8	9	10	11	12	13
January	0.7	0.9	0.9	1.0	0.6	1.0	0.9	0.9	0.9	1.1
February	0.8	0.8	0.9	0.6	0.7	1.0	1.0	0.9	0.7	1.0
March	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.0	1.5	1.0
April	0.9	0.9	0.9	1.2	1.0	1.0	1.1	0.9	0.8	0.9
May	1.1	1.0	0.9	1.6	1.1	1.0	1.1	1.1	1.2	0.8
June	1.0	1.0	0.8	0.7	1.2	0.9	0.8	1.4	1.7	0.8
July	1.5	1.3	1.3	1.1	1.5	1.0	0.9	1.7	1.1	0.9
August	1.5	1.2	1.5	1.2	1.4	1.0	1.0	0.8	1.0	1.0
September	1.3	1.1	1.3	1.0	1.2	1.1	1.1	0.9	0.7	0.9
October	0.9	1.1	1.3	0.9	1.0	1.2	1.1	0.6	0.8	1.1
November	0.7	1.0	0.8	1.0	0.8	1.1	0.9	0.8	0.7	1.1
December	0.7	0.9	0.7	0.9	0.6	1.0	1.0	1.0	1.1	1.4

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0.8%	2.5%	Compound
Class 5	30.8%	2.5%	Compound
Class 6	6.9%	2.5%	Compound
Class 7	0.1%	2.5%	Compound
Class 8	7.8%	2.5%	Compound
Class 9	37.5%	2.5%	Compound
Class 10	3.7%	2.5%	Compound
Class 11	1.2%	2.5%	Compound
Class 12	4.5%	2.5%	Compound
Class 13	6.7%	2.5%	Compound

Truck Distribution by Hour

Hour	Distribution (%)	Hour	Distribution (%)
12 AM	2.3%	12 PM	5.9%
1 AM	2.3%	1 PM	5.9%
2 AM	2.3%	2 PM	5.9%
3 AM	2.3%	3 PM	5.9%
4 AM	2.3%	4 PM	4.6%
5 AM	2.3%	5 PM	4.6%
6 AM	5%	6 PM	4.6%
7 AM	5%	7 PM	4.6%
8 AM	5%	8 PM	3.1%
9 AM	5%	9 PM	3.1%
10 AM	5.9%	10 PM	3.1%
11 AM	5.9%	11 PM	3.1%
		Total	100%

Axle Configuration

Traffic Wander		Axle Configuration	
Mean wheel location (in)	18.0	Average axle width (ft)	8.5
Traffic wander standard deviation (in)	10.0	Dual tire spacing (in)	12.0
Design lane width (ft)	12.0	Tire pressure (psi)	120.0

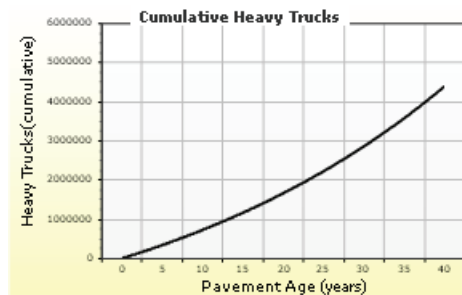
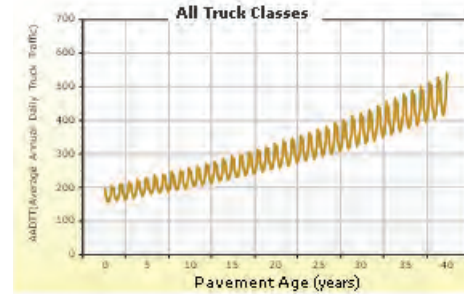
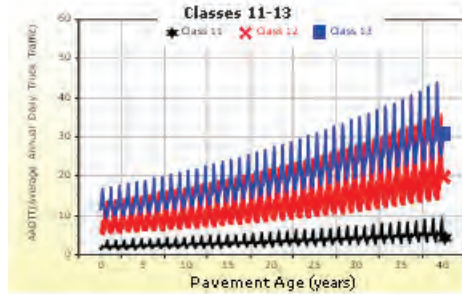
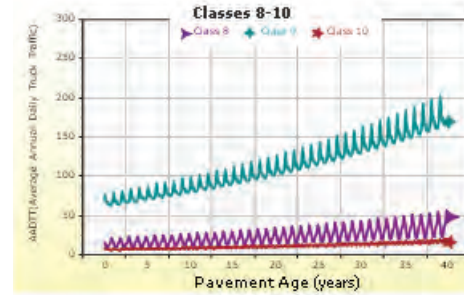
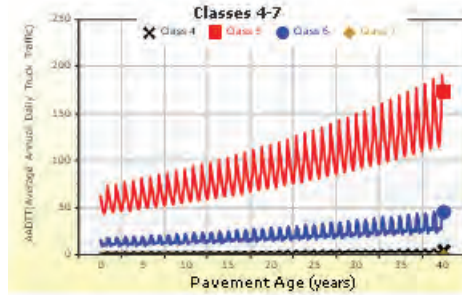
Average Axle Spacing		Wheelbase			
Value Type	Axle Type	Short	Medium	Long	
Tandem axle spacing (in)	51.6				
Tridem axle spacing (in)	49.2				
Quad axle spacing (in)	49.2				
Average spacing of axles (ft)		12.0	15.0	18.0	
Percent of Trucks (%)		17.0	22.0	61.0	

Number of Axles per Truck

Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.59	0.34	0	0
Class 5	2	0	0	0
Class 6	1	1	0	0
Class 7	1	0.22	0.83	0.1
Class 8	2.52	0.6	0	0
Class 9	1.25	1.87	0	0
Class 10	1.03	0.85	0.95	0.26
Class 11	4.21	0.29	0.01	0
Class 12	3.24	1.16	0.07	0.01
Class 13	3.32	1.79	0.14	0.02

AADTT (Average Annual Daily Truck Traffic) Growth

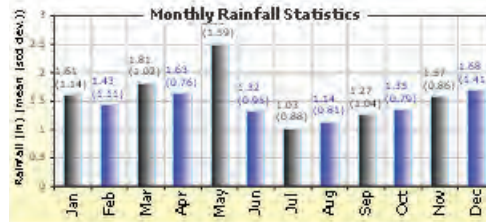
* Traffic cap is not enforced



Climate Inputs

Climate Data Sources:

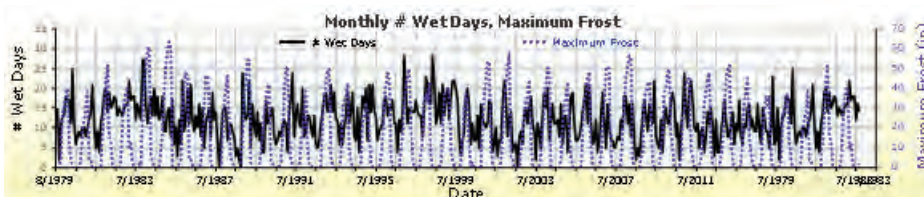
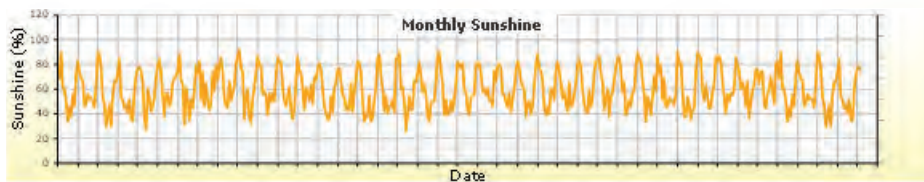
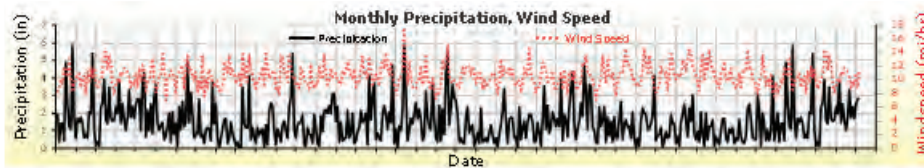
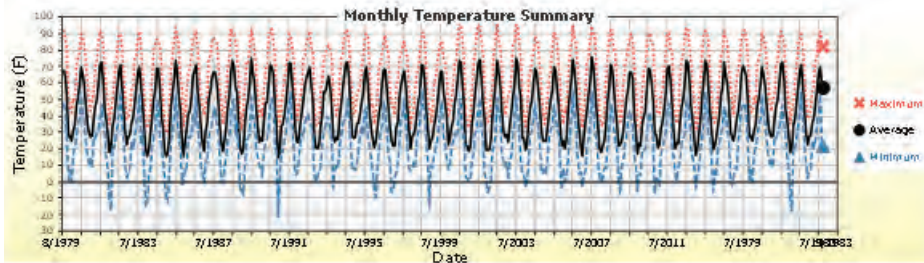
Climate Station Cities: Location (lat lon elevation(ft))
POCATELLO_NARR_GRI 42.92000 -112.57100 4440



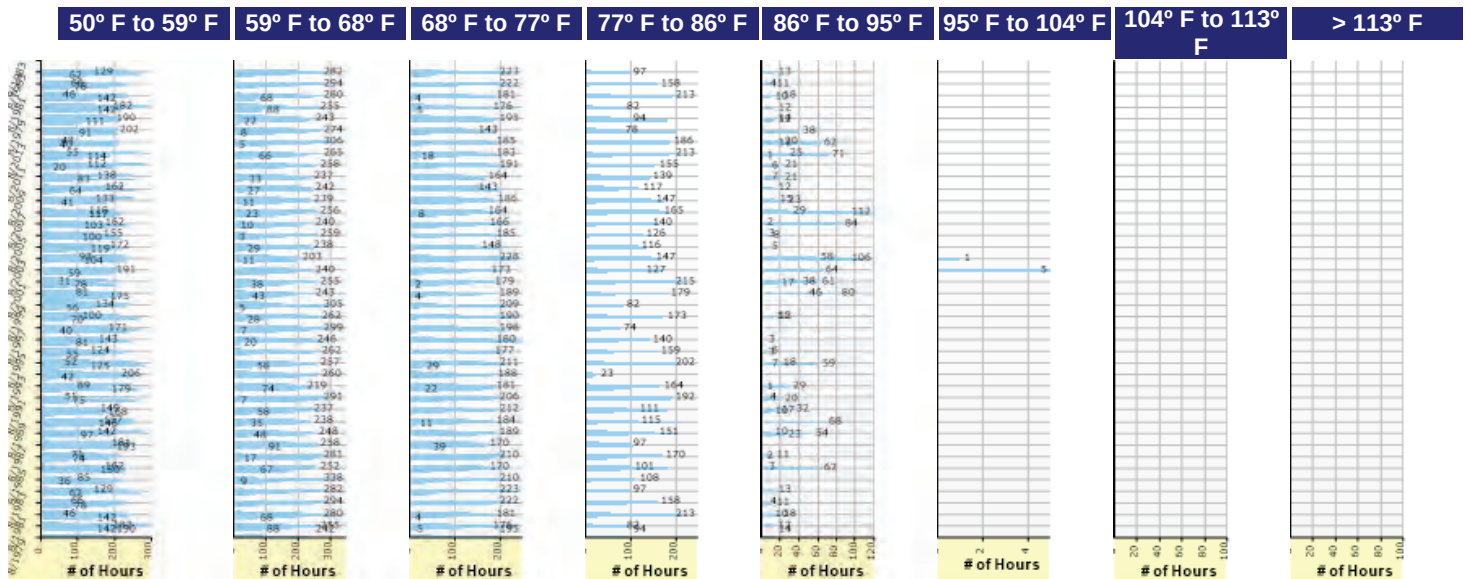
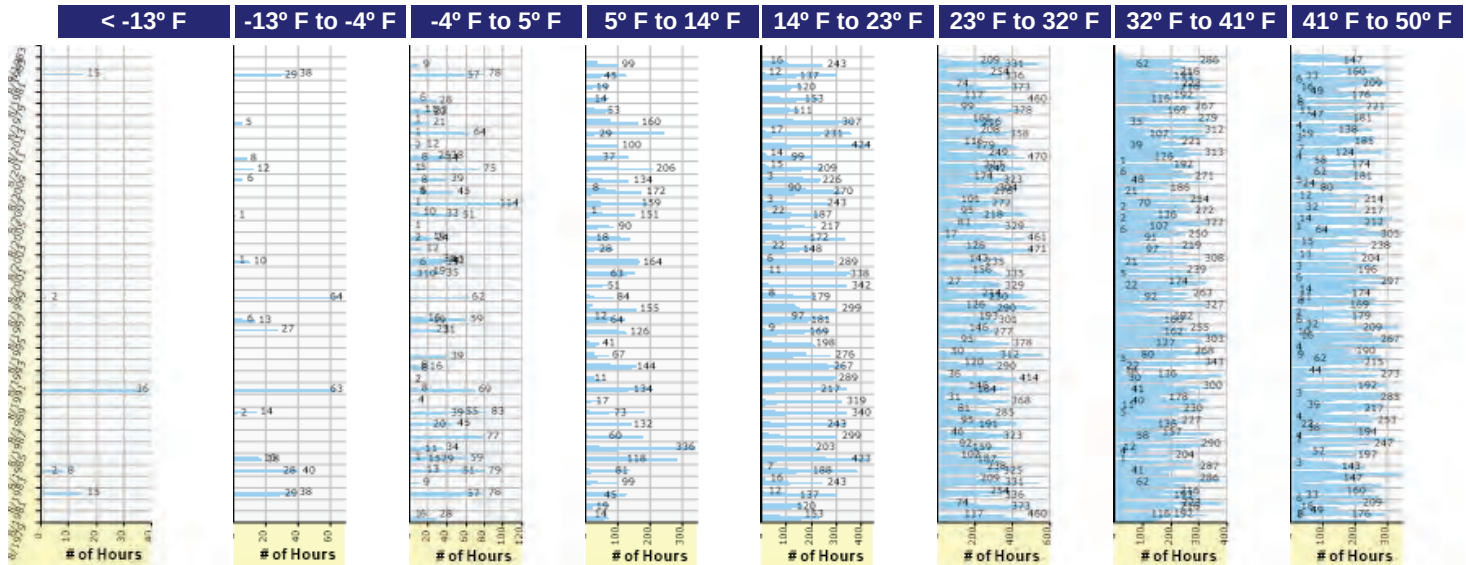
Annual Statistics:

Mean annual air temperature (°F)	44.78	
Mean annual precipitation (in)	18.33	
Freezing index (°F - days)	953.83	
Average annual number of freeze/thaw cycles:	72.03	Water table depth (ft) 10.00

Monthly Climate Summary:



Hourly Air Temperature Distribution by Month:





US-91, Rigid Reconstruction

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Design Properties

JPCP Design Properties

Structure - ICM Properties

PCC surface shortwave absorptivity	0.85
------------------------------------	------

PCC joint spacing (ft)

Is joint spacing random ?	False
Joint spacing (ft)	12.00

Doweled Joints

Is joint doweled ?	True
Dowel diameter (in)	1.50
Dowel spacing (in)	12.00

Widened Slab

Is slab widened ?	True
Slab width (ft)	13.00

Sealant type	Preformed
--------------	-----------

Tied Shoulders

Tied shoulders	True
Load transfer efficiency (%)	50.00

PCC-Base Contact Friction

PCC-Base full friction contact	True
Months until friction loss	240.00

Erodibility index	3
-------------------	---

Permanent curl/warp effective temperature difference (°F)	-10.00
---	--------

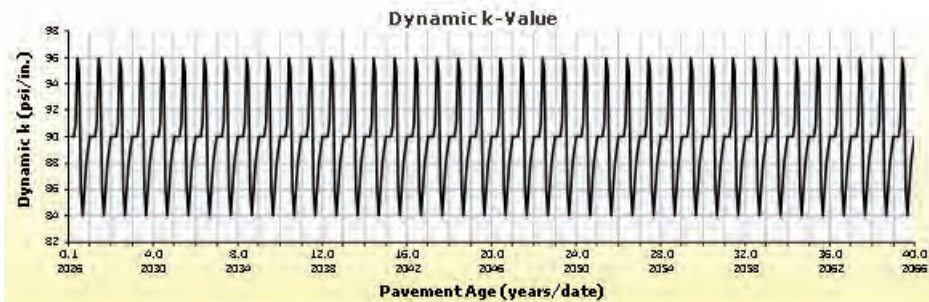
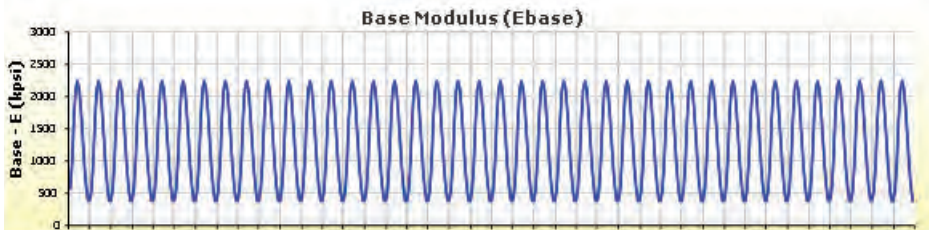
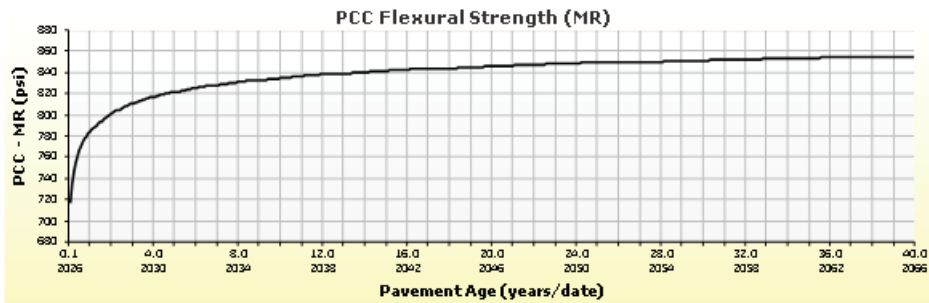
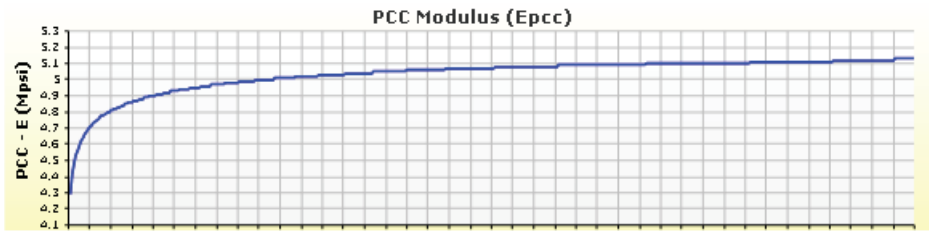


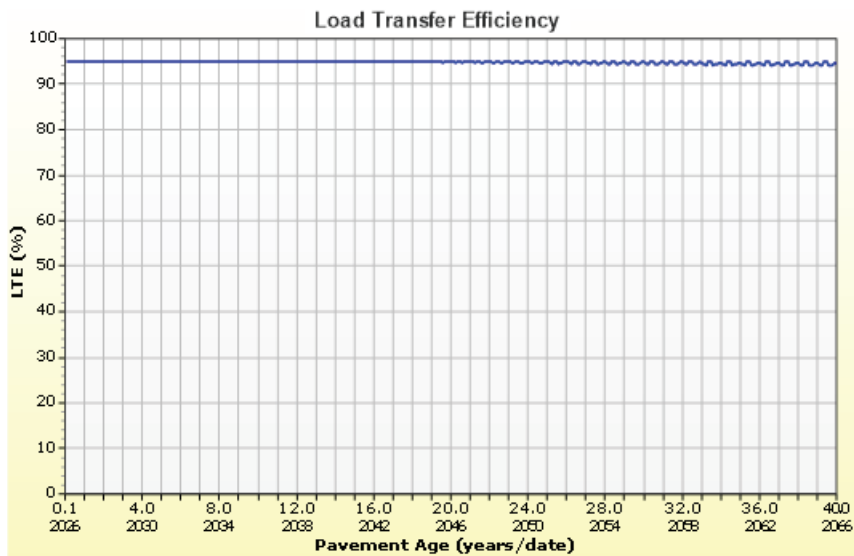
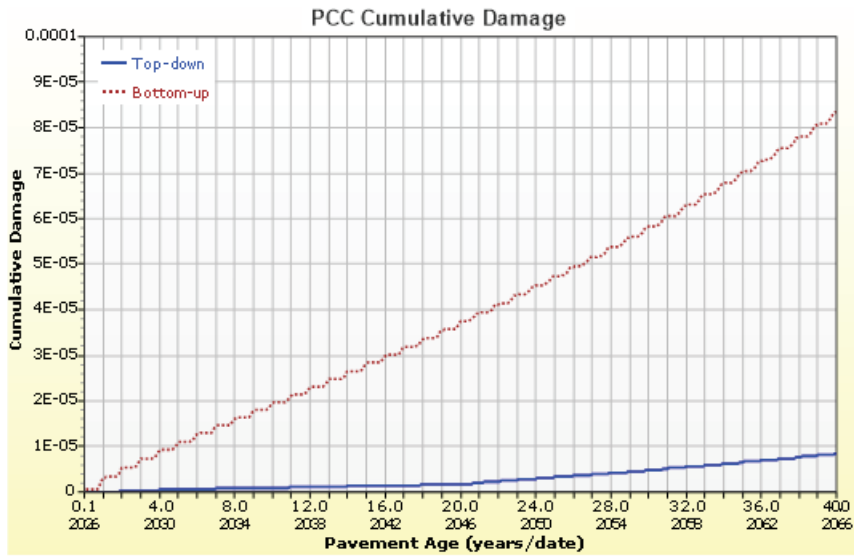
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Analysis Output Charts







US-91, Rigid Reconstruction

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Layer Information

Layer 1 PCC : JPCP

PCC	
Thickness (in)	10.0
Unit weight (pcf)	145.0
Poisson's ratio	0.2

Thermal	
PCC coefficient of thermal expansion (in/in/°F x 10 ⁻⁶)	4.7
PCC thermal conductivity (BTU/hr-ft-°F)	1.25
PCC heat capacity (BTU/lb-°F)	0.28

Mix		
Cement type		Type I (1)
Cementitious material content (lb/yd ³)		660
Water to cement ratio		0.42
Aggregate type		Granite (3)
PCC zero-stress temperature (°F)	Calculated Internally?	True
	User Value	-
	Calculated Value	104.4
Ultimate shrinkage (microstrain)	Calculated Internally?	True
	User Value	-
	Calculated Value	697.6
Reversible shrinkage (%)		50
Time to develop 50% of ultimate shrinkage (days)		35
Curing method		Curing Compound

PCC strength and modulus (Input Level: 3)

28-Day PCC modulus of rupture (psi)	700.0
28-Day PCC elastic modulus (psi)	4200000.0

Identifiers

Field	Value
Display name/identifier	JPCP
Description of object	Jointed Plain Concrete Pavement
Author	
Date Created	1/1/0001 12:00:00 AM
Approver	
Date approved	1/1/0001 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0



US-91, Rigid Reconstruction

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Layer 2 Flexible : HMA (PG 58-28)

Asphalt

Thickness (in)	2.4	
Unit weight (pcf)	144.0	
Poisson's ratio	Is Calculated?	False
	Ratio	0.35
	Parameter A	-
	Parameter B	-

Asphalt Dynamic Modulus (Input Level: 3)

Gradation	Percent Passing
3/4-inch sieve	100
3/8-inch sieve	77
No.4 sieve	60
No.200 sieve	6

Asphalt Binder

Parameter	Value
Grade	Superpave Performance Grade
Binder Type	58-28
A	11.01
VTs	-3.701

General Info

Name	Value
Reference temperature (°F)	70
Effective binder content (%)	11.6
Air voids (%)	7.5
Thermal conductivity (BTU/hr-ft-°F)	0.67
Heat capacity (BTU/lb-°F)	0.23
Asphalt content by weight (%)	-
Aggregate parameter	-

Identifiers

Field	Value
Display name/identifier	HMA (PG 58-28)
Description of object	New Superpave Hot Mix Asphalt
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0



US-91, Rigid Reconstruction

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Layer 3 Non-stabilized Base : Untreated Aggregate Base

Unbound

Layer thickness (in)	6.0
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

40000.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Untreated Aggregate Base
Description of object	New Untreated Aggregate Base
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
Saturated hydraulic conductivity (ft/hr)	False	1.907e-02
Specific gravity of solids	False	2.7
Water Content (%)	False	7.6

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	5.1359
bf	2.0746
cf	0.7463
hr	112.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	6.0
#100	
#80	
#60	
#50	
#40	
#30	
#20	
#16	
#10	
#8	40.0
#4	55.0
3/8-in.	
1/2-in.	
3/4-in.	95.0
1-in.	100.0
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	



US-91, Rigid Reconstruction

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Layer 4 Subgrade : Subgrade

Unbound

Layer thickness (in)	Semi-infinite
Poisson's ratio	0.35
Coefficient of lateral earth pressure (k0)	0.5

Modulus (Input Level: 3)

Analysis Type:	Modify input values by temperature/moisture
Method:	Resilient Modulus (psi)

Resilient Modulus (psi)

4800.0

Use Correction factor for NDT modulus?	-
NDT Correction Factor:	-

Identifiers

Field	Value
Display name/identifier	Subgrade
Description of object	Default material
Author	MEE
Date Created	2/19/2023 12:00:00 AM
Approver	MJS
Date approved	3/6/2023 12:00:00 AM
State	
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	
User defined field 2	
User defined field 3	
Revision Number	0

Sieve

Liquid Limit	32.0
Plasticity Index	11.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	107.7
Saturated hydraulic conductivity (ft/hr)	False	1.727e-05
Specific gravity of solids	False	2.7
Water Content (%)	False	17.2

User-defined Soil Water Characteristic Curve (SWCC)

Is User Defined?	False
af	108.7900
bf	0.6776
cf	0.2136
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	93.0
#100	97.0
#80	
#60	
#50	
#40	99.0
#30	
#20	100.0
#16	
#10	
#8	
#4	
3/8-in.	
1/2-in.	
3/4-in.	
1-in.	
1 1/2-in.	
2-in.	
2 1/2-in.	
3-in.	
3 1/2-in.	

Calibration Coefficients

PCC Faulting

$$C_{12} = C_1 + (C_2 * FR^{0.25})$$

$$C_{34} = C_3 + (C_4 * FR^{0.25})$$

$$FaultMax_0 = C_{12} * \delta_{curling} * \left[\log(1 + C_5 * 5.0^{EROD}) * \log\left(P_{200} * \frac{WetDays}{p_s}\right) \right]^{C_6}$$

$$FaultMax_i = FaultMax_0 + C_7 * \sum_{j=1}^m DE_j * \log(1 + C_5 * 5.0^{EROD})^{C_6}$$

$$\Delta Fault_i = C_{34} * (FaultMax_{i-1} - Fault_{i-1})^2 * DE_i$$

$$C_8 = DowelDeterioration$$

C1: 0.516	C2: 1.636	C3: 0.00217	C4: 0.00444
C5: 250	C6: 0.47	C7: 7.3	C8: 400

pccReliabilityFaultStandardDeviation

$$0.07162 * Pow(FAULT, 0.368) + 0.00806$$

IRI-jpcp

C1 - Cracking	C1: 0.845	C2: 0.4417
C2 - Spalling	C3: 1.4929	C4: 28.24
C3 - Faulting	Reliability Standard Deviation	
C4 - Site Factor	5.4	

PCC Cracking

$\log(N) = C1 * \left(\frac{MR}{\sigma}\right)^{C2}$	Fatigue Coefficients		Cracking Coefficients	
	C1: 2.366	C2: 1.22	C4: 0.52	C5: -2.17
$CRK = \frac{100}{1 + C4 * FD^{C5}}$	pccReliabilityCrackStandardDeviation			
	3.5522 * Pow(CRACK, 0.3415) + 0.75			

Appendix G

Life Cycle Cost Analysis (LCCA) Reports

Contents

- LCCA Analysis Reports

LCCA Analyses

Pavement Type Determination

Life cycle cost analyses are one component of a Pavement Type Determination. The Life Cycle Cost Analysis (LCCA) provides a standard of cost comparison for the pavement structure on projects involving new construction, reconstruction, or rehabilitation. However, there are secondary factors that should be considered when selecting the preferred pavement type. Some secondary factors to consider are:

- Performance of Similar Pavements in the Area
- Continuity of Pavement Type
- Conservation of Materials and Energy
- Construction Considerations
- Availability of Local Materials or Contractor Capabilities
- Traffic Safety
- Stimulation of Competition
- Municipal Preference, Participating Local Government Preference, and Recognition of Local Industry

Methodology

Shannon & Wilson used the LCCA method presented in the ITD Material Manual (ITD 2020). ITD Standard cost data was last published in 2018 and it was updated, as needed, with 2022 published ITD Average Unit Prices. The ITD LCCA method is based on a deterministic computational approach and work zone user costs are not considered.

From ITD: *“The purpose of a life cycle cost analysis (LCCA) is to assist the Engineer in the decision-making process as to which strategy is appropriate for the project in question. The purpose of the analysis is to identify which strategy can be assumed to be the most economical given known or assumed conditions at the time of the initial project reconnaissance. Factors which play into this decision include traffic, design requirements for various alternatives, construction traffic, construction funding amounts, desired project life, to name a few. Hence, the most economical alternative is usually, but not always the most viable.”*

Following this guidance, life cycle cost analyses were prepared for three feasible strategies for the US-91 mainline and were analyzed using the method described above. Once the costs were determined, SW considered the secondary factors as they applied to each strategy. A summary of LCCA is found in Section 540.08 Economic Comparison of Alternates. Worksheets for each strategy are included in this section.

- o AC Removal and HMA Overlay with Flexible Reconstruction Widening
- o Flexible Reconstruction
- o Rigid Reconstruction

LCCAs for alternates are included in this appendix.

Recommendations

Based on Pavement ME calculations and ITD's concerns, the *"Flexible Reconstruction"* is recommended as the Pavement Structure Design and is detailed in Section 540.09 Recommendations.

Designed By: mjs

5/4/2023

FLEXIBLE PAVEMENT WORKSHEET
Flexible Reconstruction

PROJECT NAME

US-91, Park Lawn to South Side Way

PROJECT NUMBER

A021(860)

KEY NUMBER

21860

Material	Depth	Haul	Width	Weight / ft ³	Cost
Hot Mix Asphalt (HMA)	0.45 ft	3.0 mile	67.35 ft	156.00 lb	60.00 / ton
Untreated Aggregate Base	0.75 ft	3.0 mile	69.60 ft	142.00 lb	15.00 / ton
Granular Subbase	1.00 ft	3.0 mile	72.60 ft	134.00 lb	17.00 / ton
Cold Mill					
Preservation Mill/Inlay	0.20 ft	3.0 mile	66.00 ft	145.00 lb	0.57 / sq. yard
Project Length	5,280 ft				
Travel Lane Width	60.00 ft				
Surface Width - Left Side	33.00 ft				
Surface Width - Right Side	33.00 ft				
Additional Borrow	cu.yard				
Traffic Cross Overs	Ea.				
Number of Edge Drains	Ea.				
Longitudinal Cracks	3 Ea.				
Transverse Cracks	165 / mile				
Foreslope Angle - Left	3 (H): 1(V)				
Foreslope Angle - Right	3 (H): 1(V)				
Excavation	2.20 ft				
Subgrade Sep. Fabric Layer	73.00 ft				
Pavement Geotextile	ft				

Designed By: mjs

LIFE CYCLE COST ANALYSIS

PROJECT NAME

US-91, Park Lawn to South Side Way
STANDARD TIME LINES

4-May-23

PROJECT NUMBER

A021(860)

36 YEAR LIFE CYCLE

KEY NUMBER

21860

UNIFORM PROJECT COSTS PER MILE
(English units)

Flexible Reconstruction

YEAR	WORK	COST	PRESENT WORTH FACTOR	CAPITAL RECOVERY FACTOR	EQUIVALENT UNIFORM ANNUAL COST
0 -->	Initial Cost	\$2,243,000	1.000	0.0529	\$118,700
- -->	Seal Coat Full Width	\$101,000	0.962	0.0529	\$5,100
-					
-					
5					
-					
- -->	Seal Coat Driving Lanes	\$92,000	0.731	0.0529	\$3,600
10					
- -->	Preservation at Year 12	\$528,000	0.625	0.0529	\$17,400
-					
15 -->	Seal Cracks	\$32,000	0.555	0.0529	\$900
-					
- -->	Seal Cracks	\$32,000	0.494	0.0529	\$800
- -->	Seal Coat Driving Lanes	\$92,000	0.475	0.0529	\$2,300
20					
- -->	Seal Cracks	\$32,000	0.439	0.0529	\$700
-					
- -->	Preserv. Mill & Inlay/Overlay-Year 24	\$886,000	0.390	0.0529	\$18,300
25					
- -->	Seal Cracks	\$32,000	0.347	0.0529	\$600
-					
30 -->	Seal Cracks	\$32,000	0.308	0.0529	\$500
-					
- -->	Seal Coat Driving Lanes	\$92,000	0.285	0.0529	\$1,400
- -->	Seal Cracks	\$32,000	0.274	0.0529	\$500
35					
- -->	End Life - Salvage Value	\$0	0.244	0.0529	\$0
TOTAL		\$4,226,000		EUAC ----->	\$171,000
Total Net Present Worth @ 4%					\$3,233,000

LIFE CYCLE COST ANALYSIS
US-91, Park Lawn to South Side Way
A021(860)
Flexible Reconstruction

COST PER MILE SUMMARY:

INITIAL CONSTRUCTION:

Hot Mix Asphalt (HMA)	\$805,000
Untreated Aggregate Base	\$382,000
Granular Subbase	\$553,000
	\$0
	\$0
	\$0
	\$0
Cold Mill	\$0
Traffic Cross Overs	\$0
Excavation	\$417,000
Additional Borrow	\$0
Edge Drains	\$0
Subgrade Sep. Fabric Layer	\$86,000
Pavement Geotextile	

TOTAL INITIAL COST **\$2,243,000**

PERIODIC MAINTENANCE

Seal Coat Full Width @ Yr 1	\$101,000
Seal Driving Lanes @ Yr 8, 19, & 32	\$276,000
Seal Cracks @ Yr 15, 18, 21, 27, 30, & 33	\$64,000

TOTAL PERIODIC MAINTENANCE **\$441,000**

PRESERVATION AT 12 YEARS:

Preservation Mill Travel Lanes	\$45,000
Hot Mix Asphalt Inlay	\$350,000
Seal Coat Full Width	\$101,000
Seal Cracks	\$32,000

TOTAL 12 YEAR PRESERVATION **\$528,000**

PRESERVATION AT 24 YEARS:

Preservation Mill Travel Lanes	\$45,000
Hot Mix Asphalt inlay	\$350,000
Pavement Geotextile	\$0
Overlay Full Width	\$0
Seal Coat Full Width	\$101,000
Seal Cracks	\$32,000

TOTAL 24 YEAR PRESERVATION **\$528,000**

TOTAL 36 YEAR LIFE CYCLE COST (from Time Line Chart) **\$3,740,000**

EQUIVALENT UNIFORM ANNUAL COST (euac) **\$171,000**

TOTAL NET PRESENT WORTH AT 4% INTREST **\$3,233,000**

Designed By: mjs

5/4/2023

RIGID PAVEMENT WORKSHEET
Rigid Reconstruction

PROJECT NAME	US-91, Park Lawn to South Side Way
PROJECT NUMBER	A021(860)
KEY NUMBER	21860

Material	Depth	Haul	Width	Weight / ft ³	Cost / sq.yd
Concrete Pavement (PCC) CY & SY	10.00 in	3.00 mile	66.00 ft	150.00 lb	126.00 / cu.yd
Hot Mix Asphalt (HMA)	2.40 in	3.00 mile	69.10 ft	156.00 lb	60.00 / ton
Untreated Aggregate Base	6.00 in	3.00 mile	70.60 ft	142.00 lb	15.00 / ton

Project Length	5,280 ft
Travel Lane Width	60.00 ft
Surface Width - Left Side	33.00 ft
Surface Width - Right Side	33.00 ft
Additional Borrow	cu.yd
Traffic Cross Overs	Ea.
Number of Edge Drains	Ea.
Longitudinal Joints	4 Ea.
Transverse Joints	350 / mile
Foreslope Angle - Left	3 (H): 1 (V)
Foreslope Angle - Right	3 (H): 1 (V)
Excavation	16.40 in
Subgrade Sep. Fabric Layer	71.00 ft

Designed By: mjs

LIFE CYCLE COST ANALYSIS

PROJECT NAME

US-91, Park Lawn to South Side Way

PROJECT NUMBER

A021(860)

KEY NUMBER

21860

STANDARD TIME LINES

4-May-23

36 YEAR LIFE CYCLE

UNIFORM PROJECT COSTS PER MILE
(English Units)

Rigid Reconstruction

YEAR	WORK	COST	PRESENT WORTH FACTOR	CAPITAL RECOVERY FACTOR	EQUIVALENT UNIFORM ANNUAL COST
0 -->	Initial Cost	\$2,861,000	1.000	0.0529	\$151,300
5					
10 -->	Seal Joints	\$107,000	0.703	0.0529	\$4,000
15					
20 -->	Rehab & Seal Joints	\$216,000	0.494	0.0529	\$5,600
25					
30 -->	Seal Joints	\$107,000	0.347	0.0529	\$2,000
35					
- ---->	End Life - Salvage Value	(\$1,221,000)	0.244	0.0529	(\$16,000)
TOTAL		\$2,070,000		EUAC ---->	\$147,000
Total Net Present Worth @ 4%					\$2,779,000

LIFE CYCLE COST ANALYSIS
US-91, Park Lawn to South Side Way
A021(860)
Rigid Reconstruction

COST PER MILE SUMMARY:
INITIAL CONSTRUCTION:

Concrete Pavement (PCC) CY & SY	\$1,903,000
Hot Mix Asphalt (HMA)	\$367,000
Untreated Aggregate Base	\$258,000
	\$0
	\$0
	\$0
	\$0
Traffic Cross Overs	\$0
Excavation	\$250,000
Additional Borrow	\$0
Edge Drains	\$0
Subgrade Sep. Fabric Layer	\$83,000
TOTAL INITIAL COST	\$2,861,000

REHABILITATION AT 9 YEARS:

Seal Longitudinal Joints	\$80,000
Seal Transverse Joints	\$27,000

TOTAL 9 YEAR PRESERVATION
\$107,000
PRESERVATION AT 18 YEARS:

Slab Replacement at 2%	\$39,000
Grinding Driving Lanes	\$70,000
Seal Longitudinal Joints	\$80,000
Seal Transverse Joints	\$27,000

TOTAL 18 YEAR PRESERVATION
\$216,000
REHABILITATION AT 27 YEARS:

Seal Longitudinal Joints	\$80,000
Seal Transverse Joints	\$27,000

TOTAL 27 YEAR PRESERVATION
\$107,000

TOTAL 36 YEAR LIFE CYCLE COST (from Time Line Chart)	\$2,070,000
EQUIVALENT UNIFORM ANNUAL COST (euac)	\$147,000
TOTAL NET PRESENT WORTH AT 4% INTREST	\$2,779,000
SALVAGE VALUE	(\$1,221,000)

Designed By: mjs

5/4/2023

FLEXIBLE PAVEMENT WORKSHEET
Flexible Widen & AC Removal/HMA Overlay

PROJECT NAME

US-91, Park Lawn to South Side Way

PROJECT NUMBER

A021(860)

KEY NUMBER

21860

	Material	Depth	Haul	Width	Weight / ft. ³	Cost
Overlay	Existing Pavement	1.00 ft.		18.00 ft.		
	Hot Mix Asphalt (HMA)	0.45 ft.	3.00 mile	67.35 ft.	156.00 lb	60.00 / ton
	Untreated Aggregate Base	0.55 ft.	3.00 mile	69.00 ft.	142.00 lb	15.00 / ton
Widen	Untreated Aggregate Base	0.20 ft.	3.00 mile	48.60 ft.	142.00 lb	15.00 / ton
	Granular Subbase	1.00 ft.	3.00 mile	51.60 ft.	134.00 lb	17.00 / ton
	Coldmill					
	Preservation Mill/Inlay	0.20 ft.	3.00 mile	66.00 ft.	145.00 lb	0.57 / sq. yard
	Project Length	5,280 ft.				
	Travel Lane Width	18.00 ft.				
	Surface Width - Left Side	9.00 ft.				
	Surface Width - Right Side	9.00 ft.				
	Widen Width - Left Side	9.00 ft.				
	Widen Width - Right Side	39.00 ft.				
	Additional Borrow	cu.yard				
	Traffic Cross Overs	Ea.				
	Number of Edge Drains	Ea.				
	Longitudinal Cracks	4 Ea.				
	Transverse Cracks	176 / mile				
	Foreslope Angle - Left	3 (H): 1(V)				
	Foreslope Angle - Right	3 (H): 1(V)				
	Excavation	2.20 ft.				
	Subgrade Sep. Fabric Layer	52.00 ft.				
	Pavement Geotextile	ft.				

Designed By: mjs

LIFE CYCLE COST ANALYSIS
PROJECT NAME
US-91, Park Lawn to South Side Way
PROJECT NUMBER
A021(860)
KEY NUMBER
21860
STANDARD TIME LINES
4-May-23
36 YEAR LIFE CYCLE
UNIFORM PROJECT COSTS PER
(English units)
Flexible Widen & AC Removal/HMA Overlay

YEAR	WORK	COST	PRESENT WORTH FACTOR	CAPITAL RECOVERY FACTOR	EQUIVALENT UNIFORM ANNUAL COST
0	--> Rehab W/Seal Initial Cost	\$2,021,000	1.000	0.0529	\$106,900
-					
-	--> Seal Cracks	\$39,000	0.889	0.0529	\$1,800
5					
-	--> Seal Cracks	\$39,000	0.790	0.0529	\$1,600
-	--> Seal Coat Driving Lanes	\$92,000	0.760	0.0529	\$3,700
-					
-	--> Seal Cracks	\$39,000	0.703	0.0529	\$1,400
10					
-	--> Preserv. Mill & InLay Year 12	\$535,000	0.625	0.0529	\$17,700
-					
15	--> Seal Cracks	\$39,000	0.555	0.0529	\$1,100
-					
-	--> Seal Cracks	\$39,000	0.494	0.0529	\$1,000
-	--> Seal Coat Driving Lanes	\$92,000	0.475	0.0529	\$2,300
20					
-	--> Seal Cracks	\$39,000	0.439	0.0529	\$900
-					
-	--> Year 24 Reconstruction	\$2,243,000	0.390	0.0529	\$46,300
25	--> Seal Coat Full Width	\$101,000	0.375	0.0529	\$2,000
-					
-					
-					
30					
-	--> Seal Coat Driving Lanes	\$92,000	0.285	0.0529	\$1,400
-					
35					
-	--> End Life - Salvage Value	(\$1,763,000)	0.244	0.0529	(\$23,000)
TOTAL		\$3,647,000		EUAC ----->	\$165,000
Total Net Present Worth @ 4%					\$3,119,000

LIFE CYCLE COST ANALYSIS
US-91, Park Lawn to South Side Way
A021(860)

Flexible Widen & AC Removal/HMA Overlay

COST PER SUMMARY:

INITIAL CONSTRUCTION:

Flexible Overlay: Hot Mix Asphalt (HMA)	\$805,000
Untreated Aggregate Base	\$277,000
	\$0
Flexible Widening: Untreated Aggregate Base	\$71,000
Granular Subbase	\$392,000
	\$0
Coldmill	\$0
Traffic Cross Overs	\$0
Excavation	\$314,000
Additional Borrow	\$0
Edge Drains	
Seal Coat @ Initial Construction	\$101,000
Subgrade Sep. Fabric Layer	\$61,000

TOTAL INITIAL COST **\$2,021,000**

PERIODIC MAINTENANCE

Seal Coat Full Width @ Yr 25	\$101,000
Seal Coat Driving Lanes @ Yr 8, 19, 32	\$276,000
Seal Cracks @ Yr 15, 18, 21, 27, 30, 33	\$234,000

TOTAL PERIODIC MAINTENANCE **\$510,000**

PRESERVATION AT 12 YEARS:

Coldmill Travel Lanes	\$45,000
Hot Mix Asphalt Inlay	\$350,000
Seal Coat Full Width	\$101,000
Seal Cracks	\$39,000

TOTAL 12 YEAR PRESERVATION **\$535,000**

RECONSTRUCT AT 24 YEARS: **\$2,021,000**

SALVAGE VALUE (79%) **(\$1,763,000)**

TOTAL 36 YEAR LIFE CYCLE COST (from Time Line Chart) **\$3,647,000**

EQUIVALENT UNIFORM ANNUAL COST (euac) **\$165,000**

TOTAL NET PRESENT WORTH AT 4% INTREST **\$3,119,000**

Important Information

About Your Roadway Materials Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change after the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected because of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps

prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

**The preceding paragraphs are based on information
provided by the GBA, Silver Spring, Maryland**