Geotechnical Investigation Report
Community Recreation Center at Matchett Park
Grand Junction, Colorado

Prepared for:

City of Grand Junction
244 N. 7th Street
Grand Junction, Colorado

Attention: Kirsten Armbruster, PE

Prepared by:

RockSol Consulting Group, Inc.

RockSol Consulting Group, Inc.
12076 Grant Street
Thornton, Colorado 80241

RockSol Project No. 599.84
July 27, 2023

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ATTACHMENTS

1.0 PROJECT PURPOSE AND DESCRIPTION

This report documents the geotechnical engineering investigation performed by RockSol Consulting Group, Inc. (RockSol) to assist with design of the proposed City of Grand Junction Community Recreation Center (CRC) at Matchett Park. Proposed construction includes a recreation center, access roadways, and paved parking areas. The proposed recreation center will be two stories and contain three aquatic pools, sports courts, meeting rooms, workout facilities, and locker rooms. A site layout plan and renderings for CRC upper and lower levels provided by the City of Grand Junction are included in Appendix A. Site grading plans have not yet been developed for this project.

The scope of work for this geotechnical investigation included:

- Preparing a drilling program to perform a subsurface investigation and implementing the program to collect soil samples for laboratory testing.
- Performing laboratory tests and analyzing the data.
- Preparing a geotechnical report presenting the field and laboratory data obtained, geological conditions, pavement thickness recommendations for flexible and rigid pavement design options, and geotechnical parameters and recommendations for the proposed recreation center building.

Surface and groundwater hydrology, hydraulic engineering, and environmental evaluation of site soils and groundwater for possible contaminant characterization were not included in RockSol's geotechnical scope of work.

Unless otherwise specified, all recommendations presented in this report are based on the Colorado Department of Transportation (CDOT) 2022 Standard Specifications for Road and Bridge Construction; the City of Grand Junction Standard Specifications for Road and Bridge Construction; and the City of Grand Junction Transportation Engineering Design Standards.

2.0 PROJECT LOCATION AND SITE CONDITIONS

The project site is located in Section 6, Township 1 South, Range 1, east of the Ute Meridian in the City of Grand Junction, Colorado. The project site is located within the farmer's field bounded to the south by Patterson Road, to the west by 28 ¼ Road, to the east by the residential properties along 28 ¾ Road, and to the north by the extension of Hawthorne Avenue. Developments within and surrounding the site vicinity include agricultural fields at the existing site as well as to the north and west, residential developments on the east, west and south sides, and limited businesses. Topography generally consists of flat slopes throughout the site vicinity. General site vicinity is shown in Figure 1 and the site layout can be found in Appendix A.

Figure 1 – Project Site Location Map (Google Earth)

3.0 SUBSURFACE EXPLORATION

On June 5, 2023 RockSol drilled eight boreholes to evaluate subsurface conditions at the project site. The borehole locations are identified as BH-1, BH-2, and BH-5 through BH-10, as shown on attached Appendix B, Borehole Location Map. Boreholes BH-3 and BH-4 were not completed due to agricultural activity at the time of drilling operations and will be completed at a future date, possibly in September or October, 2023. Boreholes BH-1, BH-2, BH-5, and BH-6 were drilled at the approximate location of the proposed access roadways connecting the community recreation center to 28 ¼ Road to the west and Patterson Road to the south. Boreholes BH-7 through BH-10 were drilled at the approximate location of the proposed recreation center building. Additionally, a test pit identified as TP-1 was completed at the approximate location of the proposed swimming pool for the purpose of identifying potential uplift due to swelling subgrades.

A truck mounted Simco 2800 drill rig was used for drilling and sampling. The boreholes were advanced using 4-inch outside diameter solid stem augers to maximum depths ranging from approximately 8 feet to 21 feet below existing grades. The boreholes were logged in the field by a representative of RockSol with the depth to groundwater noted at the time of drilling. Boreholes BH-7 and BH-8 were left open at the completion of drilling for 24-hour water table readings. All boreholes with the exception of BH-5 were backfilled with pea gravel at the completion of drilling and groundwater level readings. A piezometer was installed at borehole location BH-5 at the completion of drilling and sampling for subsequent water level monitoring.

A Linkbelt lbx160 Excavator was used to excavate Test Pit TP-1. The test pit was excavated to an approximate depth of 9 feet below existing grades. Test Pit TP-1 was backfilled immediately after obtaining samples and logging the soil profile of the test pit. Test pits were logged in the field by a representative of RockSol. Subsurface materials were obtained from the excavated material as the test pits were excavated. Excavated material was separated by a RockSol representative as the soil conditions changed with the depth of the excavation and samples were collected. Depths at which the samples were taken are shown on the Test Pit Log. The Individual RockSol Test Pit Soil Log is included in Appendix C. Photographs of the test pit and the excavated material are presented in Appendix D.

Subsurface materials were sampled and resistance of the soil to penetration of the sampler was performed using modified California barrel and standard split spoon samplers. The modified California barrel sampler has an outside diameter of approximately 2.5 inches and an inside diameter of 2 inches. The standard split spoon sampler used had an outside diameter of 2 inches and an inside diameter of 1⅜-inches. Brass tube liners were used with the modified California barrel sampler. Brass tube liners are not used with the standard split spoon sampler. Soils were logged in the field per ASTM D2488.

Penetration Tests were performed at selected intervals using an automatic hammer lift system. The standard split spoon sampling method is the Standard Penetration Test (SPT) described by ASTM Method D-1586. Penetration Tests were also performed using the modified California barrel sampler with a standard hammer weighing 140 pounds falling 30 inches per ASTM D3550. The modified California Barrel sampling method is similar to the SPT test with the difference being the sampler dimensions and the number of 6-inch intervals driven with the hammer. It is RockSol's experience that blow counts obtained with the modified California sampler tend to be slightly greater than a standard split spoon sampler. Penetration resistance values (blow counts) were recorded for each sampling event. Blow counts, when properly evaluated, indicate the relative density or consistency of the soils.

Depths at which the samples were taken, the type of sampler used, and the blow counts that were obtained are shown on the Boring Logs for each borehole. Individual Borehole Logs are included in Appendix C.

4.0 GEOLOGICAL SETTING

Based on information presented in the United States Geological Survey (USGS) Geologic Map (See Figure 2, *Site Geology Map*) of the Grand Junction Quadrangle, Mesa County, Colorado, by Roger B. Scott, Paul E. Carrara, William C. Hood, and Kyle E. Murray, dated 2002, the project site is predominantly underlain by alluvium and colluvium (Holocene and late Pleistocene) (Qac). Alluvium generally consists of silt, sand, and gravel. The colluvium generally consists of sandy silt, silty to clayey sand, and sandy clay. Mancos Shale bedrock (Km) is mapped at or near the surface on the south end of the project site and to the south and east of the project site. The materials identified by the USGS mapping were consistent with native soils and bedrock encountered during our geotechnical investigation.

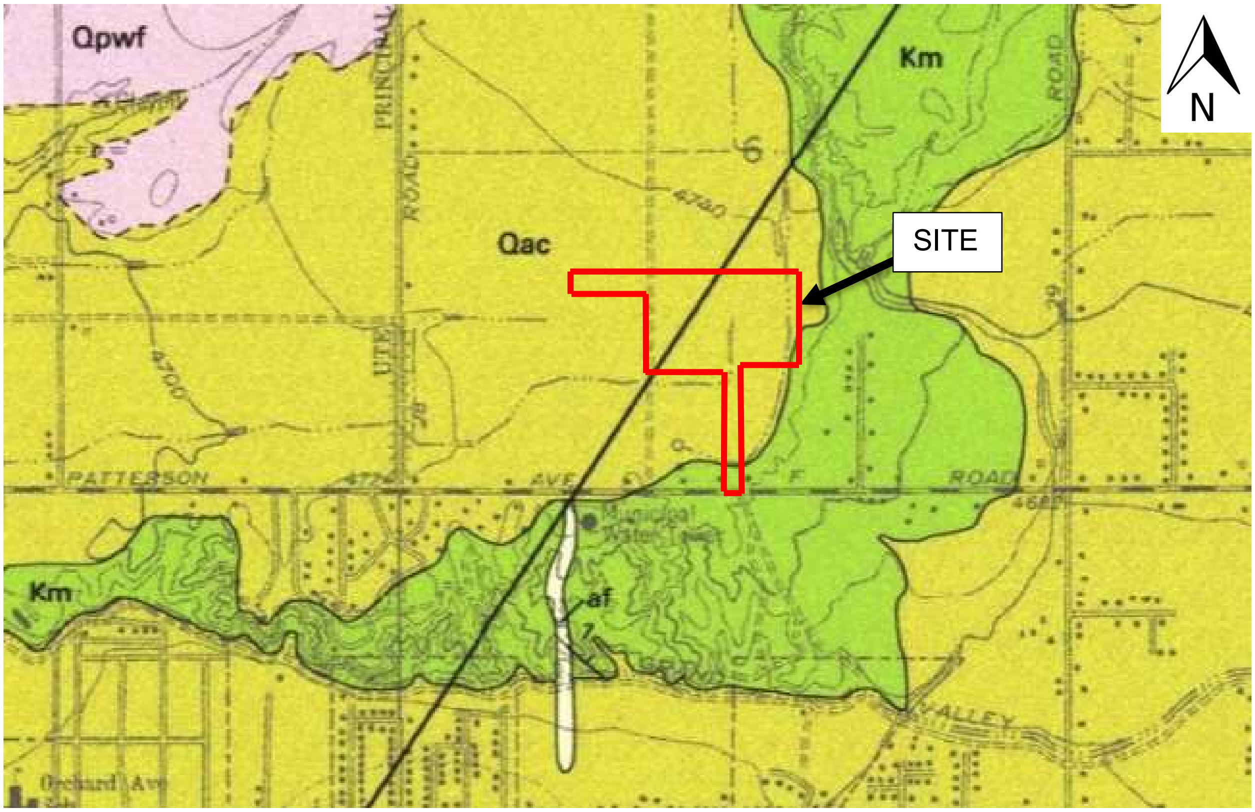


Figure 2 – Site Geology Map (USGS)

5.0 LABORATORY TESTING

Soil samples retrieved from the borehole locations were examined by the project geotechnical engineer in the RockSol laboratory. Selected samples were tested and classified according to the Unified Soil Classification System (USCS). The following laboratory tests were performed in accordance with the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and current local practices:

- Natural Moisture Content (ASTM D-2216)
- Percent Passing No. 200 Sieve (ASTM D-1140)
- Liquid and Plastic Limits (ASTM D-4318)
- Dry Density (ASTM D-2937)
- Soil Classification (ASTM D-2487 and AASHTO M145)
- Gradation (ASTM D6913)
- Water Soluble Sulfate Content (CDOT CP-L 2103)
- Water Soluble Chloride Content (CDOT CP-L 2104)
- Standard Test Method for pH of Soils (ASTM D4972-01)
- Soil Resistivity (ASTM G187 - Soil Box)
- Swell Test (Denver Swell Test, modified from ASTM D-4546)
- Resistance Value: (AASHTO T190

Laboratory test results were used to characterize the engineering properties of the subsurface material. For soil classification, RockSol conducted sieve analyses and Atterberg Limits tests. Lab testing was also performed on selected samples to determine the water-soluble sulfate content of subsurface materials to assist with cement type recommendations. R-Value testing was performed by CMT Technical Services. All other laboratory tests were performed by RockSol. Laboratory test results are presented in Appendix E and are also summarized on the Borehole Logs presented in Appendix C.

6.0 SUBGRADE CHARACTERIZATION

6.1 Subsurface Materials

Subsurface conditions generally consist of clay native soils overlying Mancos Shale sedimentary bedrock. Groundwater was encountered at approximate depths ranging from 8 feet to 12.5 feet below existing grades during drilling operations. See Table 1 for ground surface, groundwater, and bedrock elevations, where encountered. Descriptions of the surface and subsurface conditions encountered in the boreholes are provided below and are also summarized on the Borehole Logs presented in Appendix C.

Topsoil

Topsoil was encountered in each of the boreholes and test pits. Topsoil generally consisted of approximately 6 inches of brown sandy clay supporting moderate agricultural vegetation.

Native Soils

Native soils encountered generally consisted of soft to stiff, moist to wet, brown, silty clay. The thickness of the overburden clay layer is relatively thin near the CRC building site and gets thicker to the west.

Bedrock

Mancos Shale sedimentary bedrock was encountered beneath the native soils at Boreholes BH-5 through BH-10 and TP-1. Bedrock elevations ranged from approximately 4735.4 feet to 4728.3 feet. The bedrock generally consisted of hard to very hard Mancos Shale, with weathered layers overlying competent material. Plant roots were noted in fractures in the shale in Test Pit TP-1 (See Appendix D). Bedrock was not noted in Boreholes BH-1 or BH-2 to the maximum depths drilled, approximately 9 feet below existing grades.

Groundwater

Groundwater was encountered in Boreholes BH-5, BH-7, BH-9, BH-10, and TP-1 at depths ranging from approximately 8.2 feet to 12 feet (approximate elevations ranging from 4722 feet to 4725.1 feet) below existing grades. Groundwater was noted within the Mancos Shale, likely as a result of fractures and lamination joints within the bedrock.

Table 1 - Approximate Ground Surface, Top of Bedrock, and Groundwater Elevations

Borehole/ Test Pit No.	Ground Surface Elevation (ft)	Top of Bedrock Elevation (ft)	Initial (Note 1) Groundwater Elevation (ft)	Subsequent Groundwater Elevation (ft)	Maximum Depth Explored Elevation (ft)
BH-1	4731.9	NE	NE	--	4722.9
BH-2	4733.3	NE	NE	--	4724.3
BH-5	4731.3	4728.3	4723.1	4726.0 (6/23/23)	4712.3
BH-6	4738.5	4734.5	NE	--	4730.0
BH-7	4734.0	4731.0	4722.0	4725.5 (6/6/23)	4715.0
BH-8	4735.4	4734.9	NE	4725.3 (6/6/23)	4714.4
*BH-9	4733.0	4729.0	4724.5	--	4711.7
BH-10	4734.1	4734.1	4725.1	--	4713.1
TP-1	4734.0	4731.0	4725.0	--	4725.0

Note 1 – Recorded at the time of drilling – June 5, 2023
NE = None Encountered
*Location missed during survey. Elevation assumed based on interpolation between BH-5 and BH-10

6.2 Settlement and Expansive Soil Discussion

Based on the field and laboratory test data, a test of the native subgrade soils encountered 2 feet below the ground surface exhibits low swell potential (2.4 percent under 200 pounds per square foot (psf) surcharge pressure). Mancos Shale bedrock encountered 4 to 8 feet below the surface exhibits low to moderate swell potential (1.3 percent to 3.9 percent under a 500-psf surcharge pressure) while Mancos Shale bedrock encountered 9 feet below the surface exhibits high swell potential (8.0 percent under a 500-psf surcharge pressure). The elevated swell potential increases with depth into the Mancos Shale.

Further discussion of swell potential and mitigation recommendations are presented in later sections of this report.

6.3 Cement Type/Sulfate Resistance Discussion

Cementitious material requirements for concrete in contact with soils or groundwater are based on the percentage of water-soluble sulfate. Mix design requirements for concrete exposed to water-soluble sulfates in soils or water is considered by the Colorado Department of Transportation (CDOT) as shown in Table 2 and in the 2022 CDOT Standard Specifications for Road and Bridge Construction. Water-soluble Sulfate Testing Results are summarized in Table 3.

Table 2 – Requirements to Protect Against Damage to Concrete by Sulfate Attack from External Sources of Sulfate

Water-Soluble Sulfate (SO_4) in dry soil, percent	Water-Soluble Sulfate (SO_4) in water, ppm	Cementitious Material Requirements
0.00 to 0.10	0 to 150	Class 0
0.11 to 0.20	151 to 1,500	Class 1
0.21 to 2.0	1,501 to 10,000	Class 2
2.01 or greater	10,001 or greater	Class 3

Table 3 – Water-Soluble Sulfate Testing Summary

Borehole I.D.	Sample Depth (Feet)	Water-Soluble Sulfate (SO_4) in dry soil, percent	Cementitious Material Requirements
BH-1	2	0.10	Class 0
BH-2	4 – 8	1.02	Class 2
BH-5	2	0.06	Class 0
BH-7	4 – 9	1.56	Class 2
BH-7	9 – 14	1.50	Class 2
BH-8	4 – 9	1.18	Class 2
BH-10	4 – 9	1.47	Class 2
BH-10	9 – 14	0.34	Class 2
TP-1	4.5 – 5.5	1.90	Class 2
TP-1	7.5 – 8.5	1.02	Class 2

The concentration of water-soluble sulfates measured in soil samples obtained from RockSol's exploratory boreholes ranged from 0.06 percent to 1.90 percent by weight (See Appendices B and C). Based on the results of the water-soluble sulfate testing, Exposure Class 2 cementitious material requirements are considered appropriate for concrete in contact with subgrade materials for this project. Refer to CDOT's current Specifications in Section 601 for concrete mixtures that satisfy appropriate sulfate exposure Class 2 requirements.

6.4 Corrosion Resistance Discussion

Water soluble sulfate and chloride content, pH and electrical resistivity tests were performed and are summarized in Table 4. The electrical resistivity analyses were performed in the RockSol laboratory using the soil box method (ASTM G-187).

Table 4 – Corrosion Resistance Summary

Borehole Location	Sample Depth (ft)	Water Soluble Chloride (%)	Saturated Resistivity (ohm-cm) at Moisture content (%)	Water Soluble Sulfate (% by weight)	pH	CR Level
BH-1	2	--	--	**0.10**	--	CR 1
BH-2	4-8	--	--	0.02	--	CR 0
BH-5	2	--	--	**0.06**	--	CR 1
BH-7	4-9	0.030	--	**1.56**	7.6	CR 5
BH-7	9-14	--	--	**1.50**	--	CR 5
BH-8	4-9	--	--	**1.18**	--	CR 5
BH-10	4-9	0.014	750 @ 23.4	**1.47**	7.6	CR 5
BH-10	9-14	--	--	**0.34**	--	CR 3
TP-1	4.5-5.5	0.006	790 @ 28.8	**1.90**	7.7	CR 5
TP-1	8.5	--	--	**1.02**	--	CR 5

Comparison of the test results of the sulfate, chloride, and pH testing performed with *Table 1 - Guidelines for Selection of Corrosion Resistance Levels as presented in the CDOT Pipe Materials Selection Guide,* dated April 30, 2015, suggests corrosion resistance (CR) levels of CR 0, CR 1, CR 3, and CR 5 are present within the project limits. Additional testing at specific structure locations may be performed to provide structure specific corrosion resistance recommendations. Of the three variables (water soluble sulfate, water soluble chloride, and pH) that are used in determining the CR level, the water-soluble sulfate content appears to be the predominant component affecting the CR level selection. In Table 5.3, we have used "bold" text to identify the test result variable that is contributing to the CR Level above 0. Based on available data, the proposed project site should be considered as a CR 5 category site.

Based on the results of the electrical resistivity tests, the project site soils and bedrock should be considered as "aggressive" to unprotected metals.

7.0 SEISMICITY DISCUSSION

The City of Grand Junction uses the 2021 International Building Code (IBC-2018) for development of seismic design parameters. The IBC-2021 references the American Society of Civil Engineers 7-16 (ASCE 7-16) seismic design code. Based on the subsurface conditions encountered, it is our opinion that the location of the proposed building meets criteria for Seismic Site Class D. Shear wave velocity testing was not performed by RockSol. Seismic design parameters for Seismic Site Class D are discussed below.

7.1 Seismic Design Parameters

Seismic design parameters were obtained from the United States Geological Survey (USGS) Earthquake Design Maps using the 2021 International Building Code specifications which reference ASCE 7-16. Values were obtained using the USGS site: https://seismicmaps.org. Based on our understanding of the proposed building usage, it is our opinion that the CRC Building satisfies risk category III per Table 1604.5 of the IBC-2021 under the Nature of Occupancy description "Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300." Interpolated values for Peak Ground Acceleration Coefficient (PGA), Spectral Acceleration Coefficient at Period 0.2 sec (S_s), and Spectral Acceleration Coefficient at Period 1.0 sec (S_1) were obtained using the latitude and longitude for the site. The seismic acceleration coefficients obtained (data based on 0.05-degree grid spacing) are presented in Table 5.

Table 5 – Seismic Acceleration Coefficients (IBC 2021)

Proposed CRC Building (Latitude°/Longitude°)	Peak Ground Acceleration (PGA)	Spectral Acceleration Coefficient - S_s (Period 0.2 sec)	Spectral Acceleration Coefficient - S_1 (Period 1.0 sec)
39.094794 N, 108.524847 W	0.134	0.242	0.066

The acceleration coefficients are then used to obtain Site Factors F_a, and F_v based on the defined Site Class as shown in Tables 1613.2.3(1) and 1613.2.3(2) of the *IBC-2021*. A summary of the Site Factor values obtained are shown in Table 6.

Table 6 – Seismic Site Factor Values

Proposed CRC Building (Latitude°/Longitude°)	F_{pga} (at zero-period on acceleration spectrum)	F_a (for short period range of acceleration spectrum)	F_v (for long period range of acceleration spectrum)
39.094794 N, 108.524847 W	1.532	1.6	2.4

Table 7 summarizes the Seismic Zone determination and horizontal response spectral Acceleration Coefficients (S_{D1}) and (S_{DS}) obtained for the proposed structure. Seismic Performance Zone determination is based on the value of the horizontal response spectral Acceleration Coefficient at 1.0 Seconds, S_{D1}, as determined by *Eq. 16-23* of the IBC-2021 and the horizontal response spectral Acceleration Coefficient at 0.2 Seconds, S_{DS}, as determined by

Eq. 16-22. Values for S_1 and F_v are presented in Tables 5 and 6, shown above. The seismic performance zone was determined *IBC-2021* Tables 1613.2.5(1) and (2). Seismic Design output sheets are summarized in Appendix C.

Table 7 – Seismic Performance Zone

Proposed CRC Building (Latitude°/Longitude°)	Acceleration Coefficient at 1.0 seconds (S_{D1})	Acceleration Coefficient at 0.2 seconds (S_{DS})	Seismic Design Category (1)
39.094794 N, 108.524847 W	0.105	0.258	B

Note (1): Seismic Design Category C (For Risk Categories **I**, **II** or **III**) is assigned when *0.133g ≤* S_{D1} *< 0.20g and 0.33g ≤* S_{DS} *< 0.50g*

8.0 GEOTECHNICAL ANALYSIS AND RECOMMENDATIONS

Based on the subsurface conditions encountered, information obtained from the laboratory test results and the type of structure proposed, shallow foundation and deep foundation systems are feasible for the CRC Building. Site grading plans have not yet been developed for this project. However, due to the potential for heave-related movements, shallow foundations have a higher risk of differential movement depending the bearing elevation required and the minimum bearing pressure applied. A deep foundation system of drilled shafts is recommended if tight tolerances for allowable differential movement is required for the CRC Building. After site grading plans are developed, RockSol can work with the building designer to establish appropriate elevations and bearing resistances and minimum bearing pressures for shallow foundations.

Recommended geotechnical design parameters for the feasible foundation systems are based on information found in Boreholes BH-7 through BH-10 and Test Pit TP-1 and are presented in this report section.

8.1 Shallow Foundation Design Recommendations

Based on conditions encountered in the boreholes, bearing resistances are presented in Table 8 for shallow (footing) foundations for the proposed CRC Building. Values for AASHTO Load and Resistance Factor Design (LRFD) strength limit state, service limit state, and Allowable Strength Design (ASD) methodologies are presented. A resistance factor of 0.45 is used to determine the factored bearing resistance for LRFD strength limit state evaluation.

Table 8 – Preliminary Bearing Resistances (Shallow Foundation)

Bearing Material	**Strength Limit State (LRFD)**		**Service Limit State Bearing Resistance (LRFD) or Maximum Allowable Bearing Resistance (ASD) (ksf)**
	Ultimate (Nominal) Resistance (ksf)	**Factored Resistance (ksf)**	
CLAY, sandy (Native)	4.5	2.0	1.5 to 2.0 (Note 1)
Mancos Shale Bedrock	17.9	8.1	4.0 to 5.0 (Note 1)

Note 1: Depending on final site grading and interior floor elevations

Where shallow footings cannot be founded on the Mancos Shale Bedrock, subgrade improvement may be considered after site grading plans have been developed and building floor elevations established.

A minimum embedment of 30 inches below finished exterior grade is recommended for a shallow (concrete footing) foundation system.

RockSol estimates total “downward” movement for footings designed and constructed as discussed in this section will be less than 1-inch. Differential “downward” movements are estimated to be less than ½-inch.

Upward, or heave related movements, can occur depending on the location of the shallow footing foundation relative to the underlying Mancos Shale Bedrock surface. Estimates for potential heave can be provided better after overlot grading plans are developed and potential floor slab elevations are established.

8.2 Deep Foundation (Drilled Shafts) Design Recommendations

Drilled shafts will provide support by embedment into the Mancos Shale Bedrock encountered at the building location. Based on the subsurface conditions encountered, it is anticipated that hard to very hard Mancos Shale bedrock will be encountered at relatively shallow depths, depending on final overlot grading. Deep foundations are RockSol’s preferred foundation type for the proposed building based on site conditions and their ability to resist potential heave and minimize differential foundation movement.

Based on our evaluation, recommended nominal (unfactored) base resistance and nominal (unfactored) side resistance values for the bedrock material are presented in Table 9.

Table 9 - LRFD Base and Side Resistance Values for Drilled Shafts

Bearing Stratum	Ultimate (Nominal) Resistance		Service Resistance	
	Bearing (ksf)	Side (ksf)	Bearing (ksf)	Side (ksf)
Mancos Shale (Bedrock)	138	11.3	47.0	3.8

The side resistance is applicable to the portion of the shaft embedded in competent bedrock. When evaluating the side resistance of the drilled shaft, the lower 1.0-diameter length above the shaft tip should be ignored. Side resistance in the soil zone above the Mancos Shale should be neglected when calculating axial resistance. For LRFD strength limit state evaluation, a resistance factor of 0.50 is recommended for base/tip resistance and a resistance factor of 0.50 is recommended for side resistance evaluation for redundant single shafts based on AASHTO LRFD Table 10.5.5.2.4-1 side and tip resistance in rock. Per AASHTO LRFD (Section 10.5.5.2.4) the resistance factors for base/tip and side resistance should be reduced by 20 percent for non-redundant single shafts.

For drilled shafts, a minimum shaft length of 25 feet is recommended. Additional embedment may be necessary to satisfy axial bearing requirements and for lateral stability requirements as determined by the structural engineer. After overlot grading plans are developed and interior floor elevations are established, RockSol should review the plans and elevations to determine if the minimum shaft length should be increased.

Drilled shaft diameters shall be sufficient to satisfy axial, bending, and lateral load resistance requirements. In addition, the shaft diameters shall be sufficient to allow for use of casing, if required, and placement of reinforcement with adequate concrete cover.

Additional design and construction considerations for drilled shafts are presented below.

(a) The construction of the drilled shafts should follow the guidelines specified in the "CDOT Standard Specifications for Road and Bridge Construction (SSRBC), Section 503, 2022."

(b) During construction of drilled shafts, casing or slurry methods may be required to support the excavation where holes are unstable due to soil and groundwater conditions. Groundwater was encountered in Boreholes BH-7 through BH-10 and Test Pit TP-1 at an approximate elevation ranging from 4,722.0 feet to 4,725.5 feet during drilling and excavation operations and subsequent groundwater monitoring.

(c) Prior to the placement of the concrete, the drilled shaft excavation, including the bottom, should be cleaned of all loose material. For wet conditions (more than two inches of water), concrete placement by "tremie" methods should be used.

(d) Lateral load capacity of the drilled shafts should be evaluated. Geotechnical parameters for evaluation of lateral load capacity are provided in Table 10.

(e) All piers should be reinforced as required for resistance to axial, bending, lateral and uplift stresses.

(f) Drilled shafts should be constructed with spacing at least four shaft diameters center to center. For closely spaced drilled shafts, the axial and lateral capacities should be appropriately reduced. Group action of drilled shafts should be analyzed on an individual basis to assess the appropriate reduction.

Recommended lateral resistance parameters for drilled shafts are presented in Table 10. The parameters listed are for use with LPILE® or equivalent software. Material properties are based on SPT blow counts.

Table 10 - Drilled Shaft Lateral Resistance Parameters

Borehole Material	L-Pile Soil Type	Undrained Shear Strength (psf)	Angle of Internal Friction (degrees)	Subgrade Reaction Coefficient, (pci)	Strain Factor ε_{50} (%)	Unit Weight (pcf)
(Native) CLAY, with sand to sandy above water table	Stiff clay w/o free water (#3)	750	0	500	0.01	120 (Total)
Mancos Shale Bedrock	Stiff clay w/o free water	8,000	0	2,000	0.004	125 (Total)

The total unit weight indicated in Table 10 includes soil plus moisture content. Where the soil is above the water table the total unit weight is the unsaturated condition (soil+water+air voids). Where below the water table, the total unit weight is the saturated condition (soil+all voids filled with water). Depths at which groundwater was encountered are indicated on the attached borehole logs in Appendix C.

8.3 Aquatic Pools Discussion

Groundwater was encountered at relatively shallow depths in the test pit and boreholes completed within the proposed building footprint. Hydrostatic uplift must be considered for the various aquatic pools, when they are empty. In addition, depending on the final elevation of the pools, the underlying Mancos Shale Bedrock poses a heave risk. RockSol recommends establishing the bottom of pool elevations above the Mancos Shale Bedrock. As facility elevations are established RockSol can provide recommendations for support of the proposed pools. Overexcavation and replacement of subgrade soils may be required, or structurally supported pools may be required.

8.4 Recreation Center Slab-on-Grade Construction Discussion

Based on the swell test results, slab-on-grade construction is considered appropriate for the proposed CRC Building provided the bottom of the slab is a minimum of 4 feet above the Mancos Shale Bedrock. with subgrade moisture conditioning or soil replacement to a depth of at least three feet below the slab-on-grade. As facility elevations are established RockSol can provide recommendations for support of the proposed floor slabs. Overexcavation and replacement of subgrade soils may be required, or structurally supported floors may be required.

9.0 ROADWAY SURFACING AND PAVEMENT DESIGN RECOMMENDATIONS

Recreation center improvements will include the construction of a paved parking lot on the west side to accomidate about 370 parking stalls, a paved parking lot on the south side to accomidate about 175 parking stalls, an entrance road from 28 ¼ Road, and an entrance road from Patterson Road. In this report Hot Mix Asphalt (HMA) pavement is identified as flexible pavement. Portland Cement Concrete (PCC) pavement is identified as rigid pavement. CDOT Mechanistic- Empirical (M-E) Pavement Design Methodology is not applicable to parking lot pavement design, so RockSol has prepared flexible pavement design recommendations using the Colorado Asphalt Pavement Association's manual entitled "A Guideline for the Design and Construction of Asphalt Parking Lots in Colorado" dated January 2006, which recommends the use of PAVEXpress software that uses AASHTO 1993 methodology. RockSol also prepared rigid pavement design recommendations using the American Concrete Pavement Association's (ACPA) PavementDesigner.org program for parking lots which emulates the 1998 version of the AASHTO Guide for the Design of Pavement Structures.

Flexible and rigid pavement thickness evaluations for the entrance roads from 28 ¼ Road and from Patterson Road were performed in accordance with *Subsection 29.32 – Pavements and Truck Routes* in the City of Grand Junction Municipal Code as passed in Ordinance 5136 on March 15, 2023

For the flexible pavement designs, RockSol used CDOT's 2021 M-E Pavement Design Manual as modified in 2022 which uses Version 2.3.1 of AASHTO's Pavement Mechanistic-Empirical Design (PMED) software, and a spreadsheet developed by RockSol to replicate the 1993 AASHTO flexible pavement design as recommended in 29.32.040(a).

For the rigid pavement designs, RockSol used CDOT's 2021 M-E Pavement Design Manual as modified in 2022 which uses Version 2.3.1 of AASHTO's Pavement Mechanistic-Empirical Design (PMED) software, and the 1998 AASHTO rigid pavement design as recommended in 29.32.040(b).

9.1 Traffic Loading

Primary vehicle usage of the proposed parking lots will be passenger cars with infrequent light-duty trucks. For pavement design purposes, RockSol recommends the use of 18,000-pound Equivalent Axle Loads (18-kip ESALs) for a 30-year design life in accordance with Subsection 29.32.030 of the City of Grand Junction Transportation Engineering Design Standards (TEDS) for the approximate 370 and 170 space parking facilities. A compound growth rate of 2.2 percent over a 30-year design life was used to develop the flexibile pavement 18,000-pound equivalent single axle loads (ESAL's) from the PAVExpress calculated value. The 30-year flexible pavement 18-kip ESAL's were estimated to be 103,000 and the 30-year rigid pavement 18-kip ESAL's were estimated to be 161,000.

Traffic loading for the entance roads was estimated for a 30-year flexible pavement design life and 30-year rigid pavement design life in accordance with the City of Grand Junction Municipal Code (Subsection 29.32.030). RockSol included the estimated traffic loading for a 20-year flexible pavement design life since it is recommended in CDOT's Pavement Design Manual for reconstruction using flexible pavement. RockSol estimates average daily traffic (ADT) for the Community Recreational Center at Matchett Park to be 1,000 comprised mostly of cars and light duty trucks with some busses, delivery trucks, and trash trucks.The Average Annual Daily Truck Traffic (AADTT) has a significant effect on the predicted pavement performance as compared to cars and pick-up trucks. For this project, RockSol estimates that about 2 percent of the ADT on the entrance roads will be predominately Class 4 through 8 vehicles when using the Federal Highway vehicle type classification system. A compound growth rate of 2.2 percent over a 20-year and 30-year design life was used. The 20-year flexible 18-kip ESAL's were estimated to be 130,000 and the 30-year flexible and rigid 18-kip ESAL's were estimated to be 210,000 and 260,000 respectively from the PMED calculated value. Site specific truck percentages will be used to model the truck traffic in the PMED software as shown in Table 13.

Table 13 – Vehicle Class Distribution and Growth

Vehicle Class	Distribution (%)	Growth Rate (%)	Growth Function
Class 4	35	2.2	Compound
Class 5	30	2.2	Compound
Class 6	10	2.2	Compound
Class 7	10	2.2	Compound
Class 8	15	2.2	Compound
Class 9	0	2.2	Compound
Class 10	0	2.2	Compound
Class 11	0	2.2	Compound
Class 12	0	2.2	Compound
Class 13	0	2.2	Compound
Total	100		

9.2 Pavement Subgrade Characterization

To assist with pavement design recommendations, RockSol obtained bulk samples of on-site soils at the borehole locations. Classification testing indicates that the subgrade soils generally consist of a plastic, CLAY soil with an AASHTO soil classification ranging from an A-4 to an A-7-6.

To test the subgrade support characteristics, two R-Value laboratory test was performed on in accordance with American Association of State Highway Transportation Officials (AASHTO) T-190 on a combined sample of material obtained within 2 to 4 feet of the surface from Borehole BH-2 and BH-6 . An R-Value of 15 was obtained from the sample at BH-2 and and R-Value of 14 was obtained from the sample at BH-6. The R-Value test results are attached to this report in Appendix E. Based on R-Value testing, a conservative R-Value of 10 will be used for new pavement constructed on the existing site soils. The R-Value of 10 converts to a resilient modulus of 6,482 psi when using equation 4-1 from CDOT's 2021 Mechanistic-Empirical Pavement Design Manual as modified in 2022.

9.3 Pavement Design Parameter Summary

A summary of the pavement design input parameters used to evaluate the pavement thickness requirements for the proposed parking lots are presented below.

Table 14 - Pavement Design Parameters

Pavement Design Parameter	Value
30-Year HMA Design Life ESAL's	103,000
30-Year PCC Design Life ESAL's	161,000
Subgrade Resilient Modulus, M_R	6,482 psi
Serviceability Loss, (ΔPSI)	2.5
Overall Standard Deviation, S_O	0.44
Reliability, (R)	90%
Structural Coefficient of HMA	0.44
Structural Coefficient of Class 6 ABC	0.12
Structural Coefficient of Class 2 or 3 ABC	0.11

9.4 Pavement Section Thickness Evaluation (Parking Lots)

A summary of the pavement section thickness obtained from PAVExpress and PavementDesigner.org is presented in Table 15. The pavement design calculation sheet are presented in Appendix G and H.

Table 15 – Parking Lot Section Thickness Evaluation

Pavement Location	Design ESALs (30 year)	Pavement Section (inches)	Appendix
East and West Parking Lots	103,000	4.0 HMA Grading SX(75) PG 64-22 6.0 Class 6 Aggregate Base Course 6.0 Class 2 or 3 Aggregate Base Course	G
	161,000	5.75 Class P PCC 8.0 Class 6 Aggregate Base Course	H

The recommended pavement section for the parking areas is two two-inch thick lifts of CDOT's Grading SX mix with 75 design gyrations using a PG 64-22 performance graded binder. The top layer of aggregate base course should be a minimum of eight inches of CDOT Class 6 material and the bottom layer of aggregate base course should be a minimum of eight inches of CDOT Class 2 or 3 material.

9.5 Pavement Section Thickness Evaluation (Entrance Roads)

A summary of the PMED minimum pavement section thickness using a 20 and 30-year design life for flexible pavement is presented in Table 15 and the pavement design output sheets are included in Appendices I.

Table 15 – PMED Flexible Pavement Section Minimum Thickness Recommendations

Pavement Location	Material Type	20-Year Design Life Pavement Thickness (inches)	30-Year Design Life Pavement Thickness (inches)
28 ¼ Road and Patterson Road Entrances	HMA SX(75) PG 64-22	4.0	4.0
	Aggregate Base Course Class 6	6.0	6.0
	Aggregate Base Course Class 2 or 3	6.0	6.0

A summary of the AASHTO 1993 minimum pavement section thickness using a 20 and 30-year design life for flexible pavement is presented in Table 16 and the pavement design output sheets are included in Appendices J.

Table 16 – AASHTO 93 Flexible Pavement Section Minimum Thickness Recommendations

Pavement Location	Material Type	20-Year Design Life Pavement Thickness (inches)	30-Year Design Life Pavement Thickness (inches)
28 ¼ Road and Patterson Road Entrances	HMA SX(75) PG 64-22	3.0	3.5
	Aggregate Base Course Class 6	6.0	6.0
	Aggregate Base Course Class 2 or 3	6.0	6.0

A summary of the PMED minimum pavement section thickness using a 30-year design life for rigid pavement is presented in Table 17 and the pavement design output sheets are included in Appendices K.

Table 17 – PMED Rigid Pavement Section Minimum Thickness Recommendations

Pavement Location	Material Type	Thickness (inches)
28 ¼ Road and Patterson Road Entrances	CDOT Class P PCC	7.0
	Aggregate Base Course Class 6	8.0

A summary of the AASHTO 1998 minimum pavement section thickness using a 30-year design life for rigid pavement is presented in Table 18 and the pavement design output sheets are included in Appendices L.

Table 18 – AASHTO 1998 Rigid Pavement Section Minimum Thickness Recommendations

Pavement Location	Material Type	Thickness (inches)
28 ¼ Road and Patterson Road Entrances	PCC	7.0 (Note 1)
	ABC Class 6	8.0

Note 1: Minimum recommended thickness by AASHTO and CDOT is 7.0 inches for rigid pavement design.

RockSol recommends the pavement thicknesses shown in Table 15 for the 20-year design life or Table 17 be used since the PMED software accounts for site specific variables that AASHTO 1993 and 1998 do not. The 20-year design life is recommended since the top layer of most HMA pavements will require rehabilitation within 20 years after construction that should remove the top-down fatigue cracking along with other surface defects and there is no significant difference between the 20 and 30-year design lives for the predicted rutting and bottom-up fatigue cracking. HMA or rigid pavement shall consist of CDOT-approved mix designs. The bottom layer of HMA should consist of Grading SX(75) PG 64-22. Aggregate base course should consist of material meeting CDOT Class 6 Aggregate Base Course and pit run should consist of material meeting CDOT Class 2 or 3 Aggregate Base Course per CDOT 703.03. If the rigid pavement is selected, Rocksol recommends a CDOT Class P concrete meeting the requirements for Class 2 sulfate resistance. Welded wire fabric is recommended to be placed in the bottom third of the pavement. The welded wire fabric should be made with ¼ diameter wire spaced in a 6” by 6” pattern. The joint spacing should be 12 feet or less.

9.6 Other Park Hard Surfacing Recommendations

Interior Park hard surfacing improvements will be included for pedestrian walkways, maintenance vehicles and equipment trucks associated with Park events. The number of maintenance vehicles and event equipment trucks is anticipated to be very low when considered on a daily average basis.

All pavement (rigid and flexible pavement/flat-work materials) subgrade shall be properly compacted prior to placement of pavement sections. See Section 10.0 for compaction requirements.

Construction and materials for the proposed hard surfaces shall follow the designer guidelines and recommendations. At a minimum, the compaction and subgrade preparation recommendations presented in Sections 10.1 and 10.2 of this report should be considered.

Concrete paving for pedestrian-only use should be a minimum of 6-inches thick and should be constructed with a CDOT Class B concrete mix as modified by Section 601 of the current City Grand Junction Standard Specification for Road and Bridge Construction.

10.0 EMBANKMENT AND SITE GRADING

10.1 Compaction Specifications

Site grading plans have not yet been developed for this project. All embankment, backfill placement and subgrade preparation shall be performed in accordance with City of Grand Junction requirements, or as specified by recommendations in this report. The minimum compaction recommended for all soil classifications for this project by RockSol is presented in Table 19.

Table 19 – Compaction Specifications

AASHTO Classification (AASHTO M 145)	Relative Compaction Percent of Maximum	Moisture Content Deviation from Optimum
Clay Soils A-6 and A-7	95% Min. ASTM D698 (Standard Proctor Method)	0% to +3%
Sands, Gravels and Silts A-1, A-2, A-3, A-4 and A-5	90% Min. ASTM D1557 (Modified Proctor Method)	-2% to +2%

The soils encountered at this site are primarily A-6 and A-7 type soils. A representative of the geotechnical engineer should observe and test fill placement operations.

10.2 Subgrade Preparation

RockSol recommends moisture conditioning of the upper twelve inches of the existing soils in areas where sidewalks, pavement, and structures will be constructed. As grading plans are developed, this recommendation can be revisited. Vegetation, brush, sod, trash, and other deleterious substances shall not be placed in embankment, excavation backfill, or structural backfill.

10.3 Imported Fill

RockSol can provide import fill requirements after site grading plans are developed.

11.0 OTHER DESIGN AND CONSTRUCTION CONSIDERATIONS

Proper construction practices and adherence to project plans and specifications should be followed during site preparation, earthwork, excavations, and construction of utilities, pavements, and structures for the suitable long-term performance of the proposed improvements. Excavation support should be provided to maintain onsite safety and the stability of excavations and slopes. Excavations shall be constructed in accordance with local, state and federal regulations including OSHA guidelines. The contractor must provide a competent person to determine compliance with OSHA excavation requirements. For preliminary planning, existing fill material and native soils may be considered as OSHA Type C soils.

The actual subsurface conditions between boring locations may vary from the information obtained at specific boring locations and described in this report.

Surface drainage patterns may be altered during construction and surface drainage must be controlled to prevent water ponding and excessive moisture infiltration into the subgrade soils during and after construction.

12.0 LIMITATIONS

This geotechnical investigation was conducted in general accordance with the scope of work. The geotechnical practices are similar to that used in Colorado with similar soil conditions and our understanding of the proposed work.

The subsurface investigation program was conducted to obtain information on the subsurface soil, groundwater, and bedrock conditions at the proposed Community Recreation Center at Matchett Park site. Surface and groundwater hydrology, hydraulic engineering, and environmental studies including contaminant characterization were not included in RockSol's geotechnical scope of work.

This report has been prepared by RockSol for the City of Grand Junction exclusively for the project described in this report. The report is based on our exploratory boreholes and does not take into account variations in the subsurface conditions that may exist between boreholes. Additional investigation is required to address such variation. If during construction activities, materials or water conditions appear to be different from those described herein, RockSol should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. RockSol is not responsible for liability associated with interpretation of subsurface data by others.

APPENDIX A

SITE LAYOUT

AND

CRC UPPER AND LOWER PLAN RENDERINGS

ALTERNATIVE FUNDING

The City will look to secure additional funding sources to support the CRC, including but not limited to:

- Potential partnerships
- Grants e.g., Great Outdoors Colorado, El Pomar Foundation, Gates Family Foundation, Department of Energy Daniels Fund, Department of Local Affairs (DOLA), Anschutz Family Foundation, Boettcher Foundation, Bacon Family Foundation, Goodwin Foundation and others.

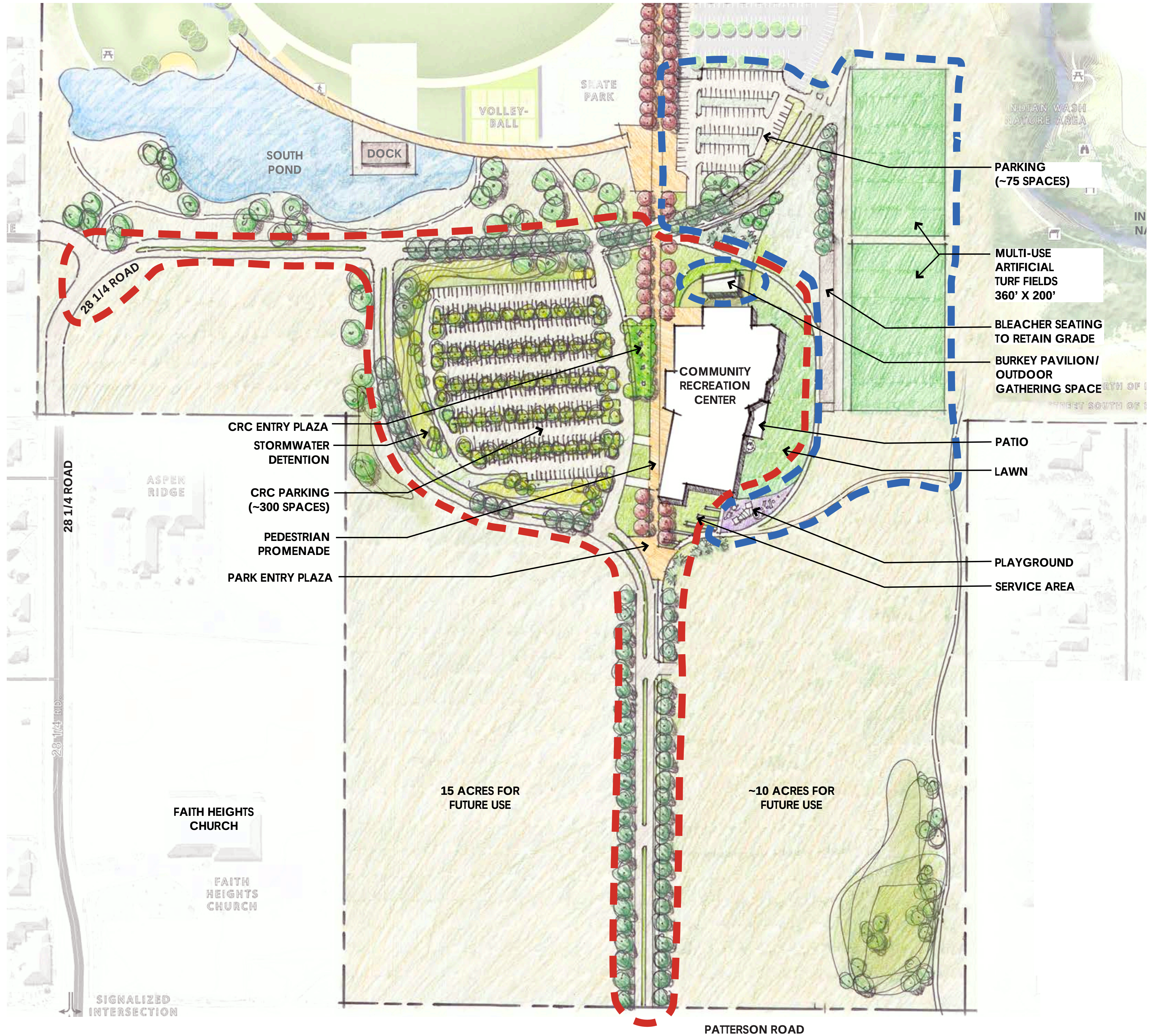
These funding sources can enhance the facility offerings or reduce the debt on the facility, but they typically provide less than 5% of the funding needed and are not guaranteed.

The City of Grand Junction, in partnership with the Grand Valley Parks and Recreation Foundation, is actively engaged with each of these organizations regarding a potential grant following the CRC election. Funders will often contribute after a project is approved by voters but not before.

Potential enhancements are shown dashed in blue on the site plan.

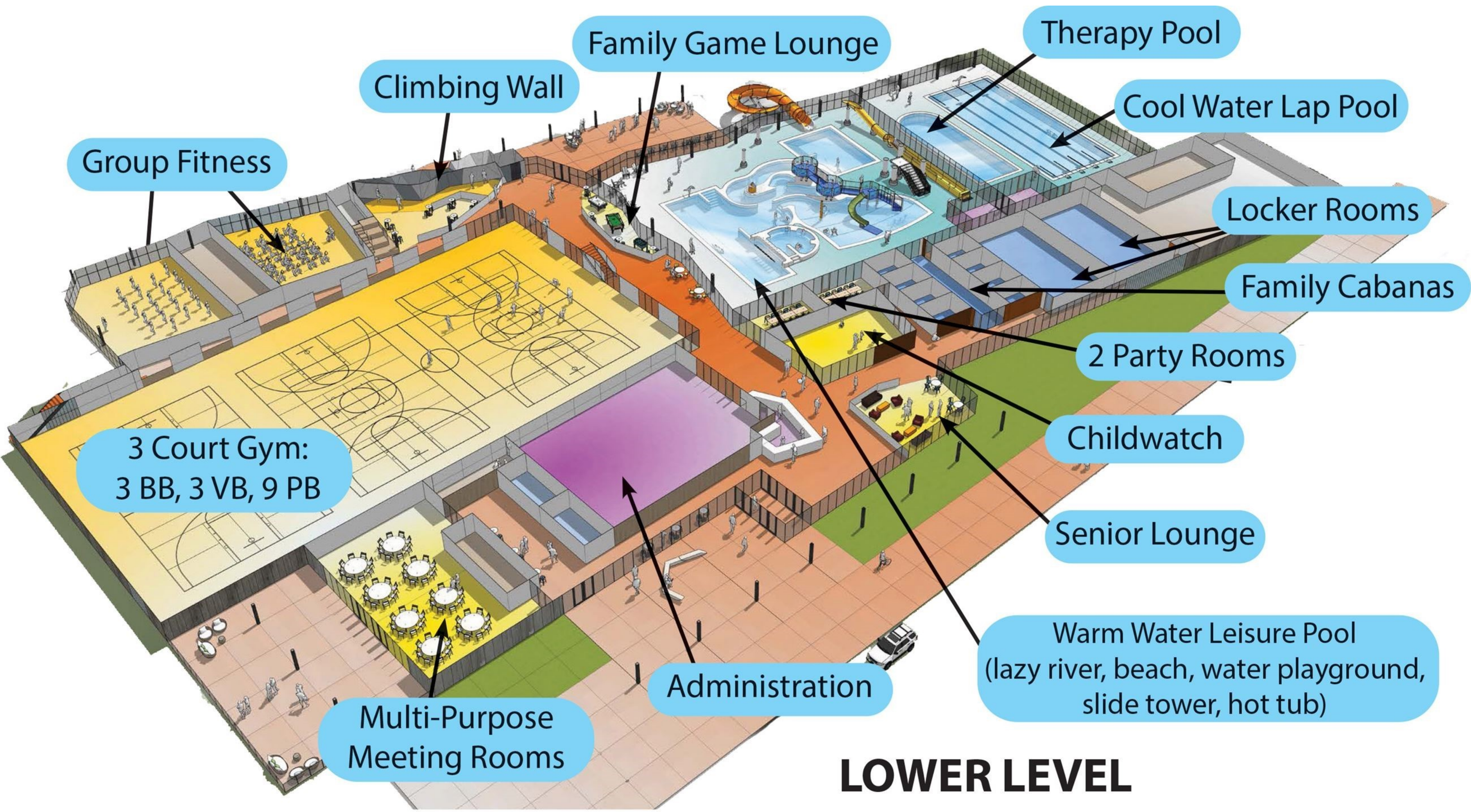
Notes:
These funding options do not include additional potential contributions from potential partners and grants.

These funding sources can reduce the debt and help pay it off earlier or enhance the facility. Because they are not guaranteed, these funding sources are not part of the funding plan.



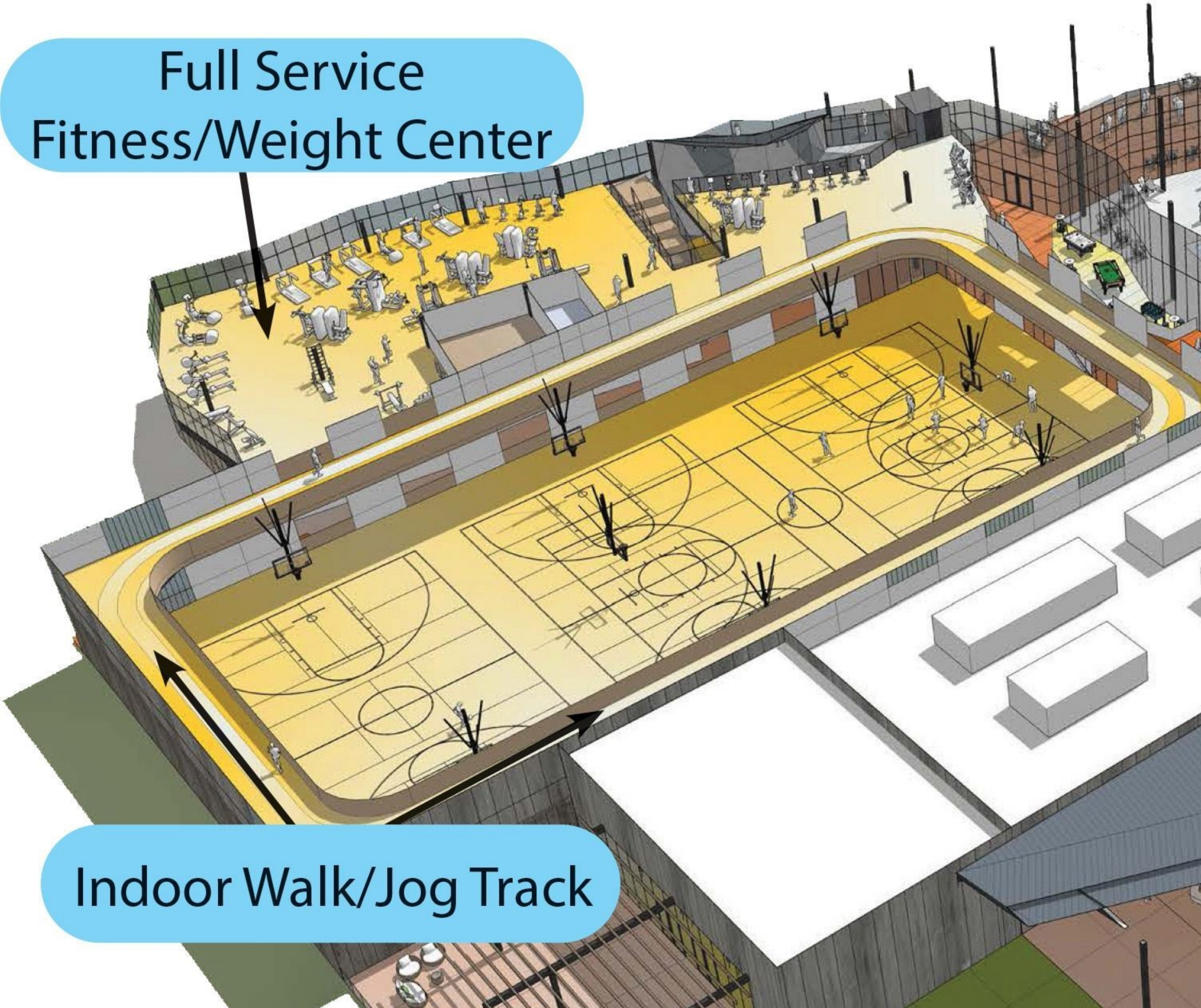
CRC BUILDING + INFRASTRUCTURE BASE PROJECT

OUTDOOR FACILITIES CONTINGENT ON ALTERNATIVE FUNDING


Family Game Lounge
Therapy Pool
Climbing Wall
Cool Water Lap Pool
Group Fitness
Locker Rooms
Family Cabanas
2 Party Rooms
Childwatch
3 Court Gym:
3 BB, 3 VB, 9 PB
Senior Lounge
Warm Water Leisure Pool
(lazy river, beach, water playground,
slide tower, hot tub)
Administration
Multi-Purpose
Meeting Rooms

LOWER LEVEL

UPPER LEVEL

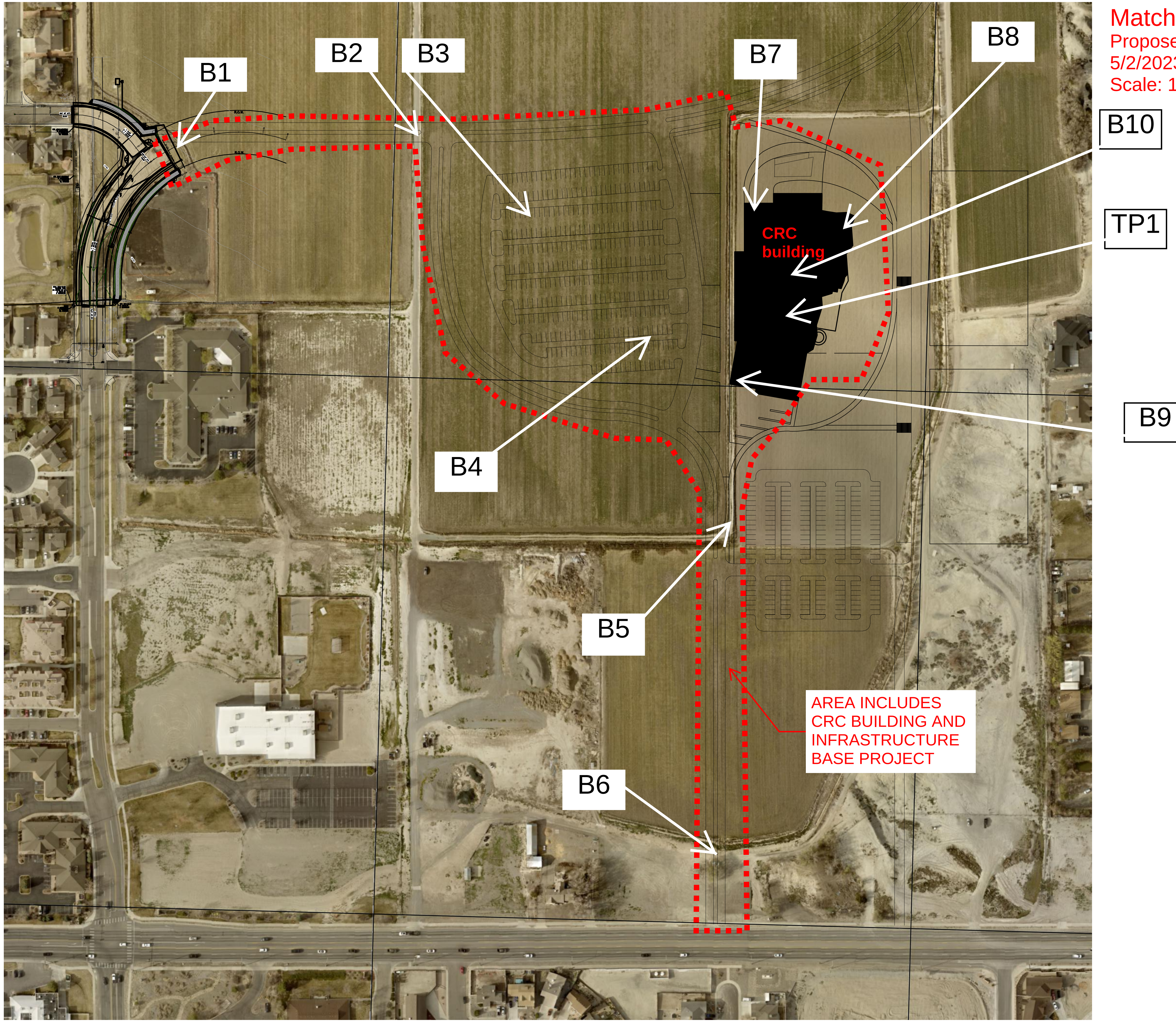


APPENDIX B

BOREHOLE LOCATION MAP

Matchett Park - CRC

Proposed Site Layout
5/2/2023
Scale: 1" = 200 ft



APPENDIX C

LEGEND AND INDIVIDUAL BOREHOLE AND TEST PIT LOGS

LEGEND

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado

LITHOLOGY

- **TOPSOIL**
- **Native - CLAY**
- **Native - CLAY, silty**
- **Native - CLAY, sandy**
- **Bedrock - MANCOS SHALE**

SAMPLE TYPE

- Auger Cuttings
- MODIFIED CALIFORNIA SAMPLER 2.5" O.D. AND 2" I.D. WITH BRASS LINERS INCLUDED
- SPLIT SPOON SAMPLER 2" O.D. AND 1 3/8" I.D. NO LINERS

Fines Content indicates amount of material, by weight, passing the US No 200 Sieve (%)

15/12 Indicates 15 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 12 inches.

50/11 Indicates 50 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 11 inches.

5,5,5 Indicates 5 blows, 5 blows, 5 blows of a 140 pound hammer falling 30 inches was required to drive the sampler 18 inches.

GROUND WATER LEVEL 1ST DEPTH
GROUND WATER LEVEL 2ND DEPTH
GROUND WATER LEVEL 3RD DEPTH

RockSol Consulting Group, Inc.

BORING : BH-1

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
GROUND ELEVATION 4731.9 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~0.3 mi N of Patterson Rd, ~160 ft E of 28 1/4 Rd
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Farmer's Field
WATER DEPTH None Encountered on 6/5/23

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4731.9	0.0	(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
		(Native) CLAY, sandy, moist, stiff, brown **Approximate Bulk Depth 0-2** Liquid Limit= 29 Plastic Limit= 18 Plasticity Index= 11 Fines Content= 55.9	BULK						29	18	11	55.9
4729.4	2.5	(Native) CLAY, sandy, wet, brown, medium stiff	MC	6/12		0.10						
		Approximate Bulk Depth 2-4 Liquid Limit= 28 Plastic Limit= 15 Plasticity Index= 13 Fines Content= 60.0	BULK						28	15	13	60.0
		(Native) CLAY, with sand, wet, brown, soft	MC	3/12			94.1	20.2				
4726.9	5.0	**Approximate Bulk Depth 4-8** Liquid Limit= 26 Plastic Limit= 17 Plasticity Index= 9 Fines Content= 83.1	BULK						26	17	9	83.1
4724.4	7.5		MC	3/12			92.5	23.8				
		Bottom of hole at 9.0 feet.										

BORING : BH-2

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
GROUND ELEVATION 4733.3 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~0.3 mi N of Patterson Rd, ~690 ft E of 28 1/4 Rd
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Farmer's Field
WATER DEPTH None Encountered on 6/5/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
4733.3	0.0		(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
			(Native) CLAY, with sand, moist, brown to tan **Approximate Bulk Depth 0-2** Liquid Limit= 28 Plastic Limit= 15 Plasticity Index= 13 Fines Content= 78.0	BULK						28	15	13	78.0
4730.8	2.5		(Native) CLAY, with sand, moist, tan, medium stiff to stiff	MC	8/12	2.4		109.8	10.4				
			Approximate Bulk Depth 2-4 Liquid Limit= 42 Plastic Limit= 20 Plasticity Index= 22 Fines Content= 81.5	BULK						42	20	22	81.5
			(Native) CLAY, silty, very moist, tan, soft to very soft	MC	2/12			96.1	17.5				
4728.3	5.0												
			Approximate Bulk Depth 4-8 Liquid Limit= 24 Plastic Limit= 18 Plasticity Index= 6 Fines Content= 87.5 Sulfate= 1.02	BULK			1.02			24	18	6	87.5
4725.8	7.5												
				MC	1/12			98.6	23.8				
			Bottom of hole at 9.0 feet.										

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado

DATE STARTED 6/5/23 **COMPLETED** 6/5/23

EXISTING ELEVATION 4731.3 ft **STATION NO.**

DRILLING CONTRACTOR Colorado Drilling and Sampling

NORTH **EAST**

DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"

BORING LOCATION: ~885 ft N of Patterson Rd, ~0.25 mi E of 28 1/4 Rd

LOGGED BY T. Woolley **HAMMER TYPE** Automatic

GROUND WATER LEVELS: 1ST DEPTH 8.2 ft on 6/5/23; 2ND DEPTH 7.7 ft on 5/6/23; 3RD DEPTH 5.3 ft on 6/23/23

NOTES Piezometer installed

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4731.3	0	(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
		(Native) CLAY, moist, reddish-brown, very stiff	BULK						41	22	19	88.2
			MC	18/12		0.06	104.5	14.2				
		(Bedrock) MANCOS SHALE, moist, light gray, hard **Approximate Bulk Depth 0-4** Liquid Limit= 41 Plastic Limit= 22 Plasticity Index= 19 Fines Content= 88.2	MC	82/12			116.2	11.1				
4726.3	5	**Approximate Bulk Depth 4-9** Liquid Limit= 35 Plastic Limit= 18 Plasticity Index= 17 Fines Content= 91.2	BULK						35	18	17	91.2
		(Bedrock) MANCOS SHALE, moist, gray, hard	SS	19/19/21								
4721.3	10	**Approximate Bulk Depth 9-14** Liquid Limit= 39 Plastic Limit= 18 Plasticity Index= 21 Fines Content= 88.2	BULK						39	18	21	88.2
		(Bedrock) MANCOS SHALE, gray, dry, very hard	SS	24/41/50								
4716.3	15	**Approximate Bulk Depth 14-21** Liquid Limit= 33 Plastic Limit= 19 Plasticity Index= 14 Fines Content= 83.2	BULK						33	19	14	83.2
			SS	50/6								74.4
		Bottom of hole at 19.5 feet.										

BORING : BH-6

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
GROUND ELEVATION 4738.5 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~180 ft N of Patterson Rd, ~0.25 mi E of 28 1/4 Rd
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Farmer's Field
WATER DEPTH None Encountered on 6/5/23

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
4738.5	0.0	(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
		(Native) CLAY, sandy, stiff, moist, light tan **Approximate Bulk Depth 0-2** Liquid Limit= 29 Plastic Limit= 17 Plasticity Index= 12 Fines Content= 66.1	BULK						29	17	12	66.1
4736.0	2.5	(Native) CLAY with sand, moist, light tan, stiff to very stiff	MC	15/12			103.7	11.9				
		Approximate Bulk Depth 2-4 Fines Content= 88.1	BULK									88.1
		(Bedrock) MANCOS SHALE, moist, light gray, hard	MC	56/12			113.1	13.5				
4733.5	5.0	**Approximate Bulk Depth 4-8** Liquid Limit= 35 Plastic Limit= 18 Plasticity Index= 17 Fines Content= 95.2	BULK						35	18	17	95.2
4731.0	7.5	(Bedrock) MANCOS SHALE, dry, light gray, very hard	MC	88/10	3.9		120.0	10.7				

Bottom of hole at 8.8 feet.

BORING : BH-7

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
EXISTING ELEVATION 4734.0 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~0.3 mi N of Patterson Rd, ~0.26 mi E of 28 1/4 Rd
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS: 1ST DEPTH 12.0 ft on 6/5/23
NOTES Farmer's Field
2ND DEPTH 8.5 ft on 5/6/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
4734.0	0		(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
			(Native) CLAY, moist, tan, medium stiff	BULK						33	17	16	92.2
				MC	7/12								
			(Bedrock) MANCOS SHALE, moist, light tan and white, hard **Approximate Bulk Depth 0-4** Liquid Limit= 33 Plastic Limit= 17 Plasticity Index= 16 Fines Content= 92.2	MC	59/12			109.4	13.3				
4729.0	5		**Approximate Bulk Depth 4-9** Liquid Limit= 37 Plastic Limit= 15 Plasticity Index= 22 Fines Content= 92.3 Sulfate= 1.56	BULK			1.56			37	15	22	92.3
			(Bedrock) MANCOS SHALE, moist, gray, very hard	MC	50/6	8.0		128.8	10.0				
4724.0	10		**Approximate Bulk Depth 9-14** Liquid Limit= 31 Plastic Limit= 16 Plasticity Index= 15 Fines Content= 66.7 Sulfate= 1.50	BULK			1.50			31	16	15	66.7
			(Bedrock) MANCOS SHALE, dry, dark gray, very hard	SS	50/6								45.7
4719.0	15		**Approximate Bulk Depth 14-19** Liquid Limit= 32 Plastic Limit= 16 Plasticity Index= 16 Fines Content= 76.1	BULK						32	16	16	76.1
				SS	50/4								62.2
			Bottom of hole at 19.3 feet.										

BORING : BH-8

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
EXISTING ELEVATION 4735.4 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~0.28 mi N of Patterson Rd, ~0.3 mi E of 28 1/4 Rd
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS: **1ST DEPTH** None Encountered on 6/5/23
NOTES Farmer's Field
▽ **2ND DEPTH** 10.1 ft on 5/6/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
4735.4	0		(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
			(Bedrock) MANOS SHALE, weathered, moist, yellowish tan, very stiff **Approximate Bulk Depth 0-4** Liquid Limit= 36 Plastic Limit= 18 Plasticity Index= 18 Fines Content= 89.9	BULK						36	18	18	89.9
				MC	27/12			109.3	16.7				
4730.4	5		(Bedrock) MANCOS SHALE, moist, tan to light brown, hard	MC	62/12			116.4	12.8				
			Approximate Bulk Depth 4-9 Liquid Limit= 39 Plastic Limit= 19 Plasticity Index= 20 Fines Content= 87.4 Sulfate= 1.18	BULK			1.18			39	19	20	87.4
4725.4	10	▽		SS	17/19/28								73.5
			Approximate Bulk Depth 9-14 Liquid Limit= 37 Plastic Limit= 20 Plasticity Index= 17 Fines Content= 87.8	BULK						37	20	17	87.8
4720.4	15		(Bedrock) MANCOS SHALE, dry, gray, very hard	SS	95/10								
			Approximate Bulk Depth 14-21 Liquid Limit= 38 Plastic Limit= 18 Plasticity Index= 20 Fines Content= 78.2	BULK						38	18	20	78.2
				SS	50/1								76.5
4715.4	20												
			Bottom of hole at 21.0 feet.										

BORING : BH-9

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado

DATE STARTED 6/5/23 **COMPLETED** 6/5/23

GROUND ELEVATION 4733.0 ft **STATION NO.**

DRILLING CONTRACTOR Colorado Drilling and Sampling

NORTH **EAST**

DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"

BORING LOCATION: ~0.23 mi N of Patterson Rd, ~0.25 mi E of 28 1/4 Rd

LOGGED BY T. Woolley **HAMMER TYPE** Automatic

GROUND WATER LEVELS:

NOTES Farmer's Field

WATER DEPTH 8.5 ft on 6/5/23

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4733.0	0	(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
		(Native) CLAY, with sand, moist, tan, very stiff										
		Approximate Bulk Depth 0-4 Liquid Limit= 37 Plastic Limit= 21 Plasticity Index= 16 Fines Content= 81.3	BULK						37	21	16	81.3
			MC	21/12			105.9	15.2				
		(Bedrock) MANCOS SHALE, weathered, moist, light gray, hard	MC	30/12	1.3		116.5	15.1				
4728.0	5	**Approximate Bulk Depth 4-9** Liquid Limit= 50 Plastic Limit= 27 Plasticity Index= 23 Fines Content= 94.2	BULK						50	27	23	94.2
4723.0	10	(Bedrock) MANCOS SHALE, moist, gray, very hard	SS	25/36/50								
		Approximate Bulk Depth 9-14 Liquid Limit= 37 Plastic Limit= 22 Plasticity Index= 15 Fines Content= 88.0	BULK						37	22	15	88.0
4718.0	15	(Bedrock) MANCOS SHALE, moist, dark gray, very hard	SS	50/6								50.4
		Approximate Bulk Depth 14-21 Liquid Limit= 38 Plastic Limit= 15 Plasticity Index= 23 Fines Content= 87.5	BULK						38	15	23	87.5
4713.0	20		SS	50/4								43.7
		Bottom of hole at 21.3 feet.										

RockSol Consulting Group, Inc.

BORING : BH-10

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
GROUND ELEVATION 4734.1 ft **STATION NO.**
DRILLING CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
DRILLING METHOD Solid Stem Auger **HOLE SIZE** 4.25"
BORING LOCATION: ~0.26 mi N of Patterson Rd, ~0.27 mi E of 28 1/4 Rd
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES Farmer's Field
WATER DEPTH 9.0 ft on 6/5/23

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES CONTENT (%)
4734.1	0	(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
		(Bedrock) MANCOS SHALE, weathered, moist, gray, very stiff	BULK						41	18	23	93.2
			MC	23/12			104.7	18.6				
		(Bedrock) MANCOS SHALE, dry, light gray, very hard **Approximate Bulk Depth 0-4** Liquid Limit= 41 Plastic Limit= 18 Plasticity Index= 23 Fines Content= 93.2										
4729.1	5		SS	16/21/32								46.9
		Approximate Bulk Depth 4-9 Fines Content= 71.6 Sulfate= 1.47	BULK			1.47						71.6
		(Bedrock) MANCOS SHALE, moist, light gray, very hard	SS	89/12								
4724.1	10	**Approximate Bulk Depth 9-14** Liquid Limit= 34 Plastic Limit= 18 Plasticity Index= 16 Fines Content= 74.2 Sulfate= 0.34	BULK			0.34			34	18	16	74.2
		(Bedrock) MANCOS SHALE, moist, gray, very hard	SS	50/4								
4719.1	15	**Approximate Bulk Depth 14-21** Liquid Limit= 30 Plastic Limit= 18 Plasticity Index= 12 Fines Content= 69.4	BULK						30	18	12	69.4
4714.1	20											
		Bottom of hole at 21.1 feet.	SS	50/1								48.2

TEST PIT : TP-1

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 6/5/23 **COMPLETED** 6/5/23
GROUND ELEVATION 4734.0 ft **STATION NO.**
EXCAVATION CONTRACTOR Colorado Drilling and Sampling
NORTH **EAST**
EXCAVATION METHOD Solid Stem Auger **TEST PIT SIZE** 4.25"
BORING LOCATION: Middle pool proposed building
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES
▼ **WATER DEPTH** 9.0 ft on 6/5/23

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS	SWELL POTENTIAL (%)	SULFATE (%)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4734.0	0.0		(Topsoil) CLAY, sandy, supporting moderate vegetation, approximately 6 inches thick										
			(Native) CLAY, brown, stiff, moist										
			Approximate Bulk Depth 0-3 Liquid Limit= 34 Plastic Limit= 21 Plasticity Index= 13 Fines Content= 92.0	B BULK						34	21	13	92.0
4731.5	2.5												
			(Bedrock) MANCOS SHALE, gray, very hard										
4729.0	5.0		**Approximate Bulk Depth 4.5-5.5** Liquid Limit= 39 Plastic Limit= 29 Plasticity Index= 10 Fines Content= 77.4 Sulfate= 1.90	B BULK			1.90			39	29	10	77.4
			(Bedrock) MANCOS SHALE, gray, very hard, calcareous										
			Approximate Bulk Depth 6-7 Liquid Limit= 40 Plastic Limit= 29 Plasticity Index= 11 Fines Content= 94.4	B BULK						40	29	11	94.4
4726.5	7.5												
			Approximate Bulk Depth 7.5-8.5 Sulfate= 1.02	B BULK			1.02						
		▼	Bottom of test pit at 9.0 feet.										

APPENDIX D

TEST PIT PHOTOGRAPHS

APPENDIX E

LABORATORY TEST RESULT SUMMARY

AND

TEST RESULT SHEETS

RockSol Consulting Group, Inc.

SUMMARY OF PHYSICAL & CHEMICAL TEST RESULTS

CLIENT City of Grand Junction

PROJECT NUMBER 599.84

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT LOCATION Grand Junction, Colorado

Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Swell Potential (%)	%<#200 Sieve	Classification		Water Content (%)	Dry Density (pcf)	Unconfined Compressive Strength (psi)	Sulfate (%)	Resistivity (ohm-cm)	pH	Chlorides (%)	Proctor S=Standard M=Modified		
							USCS	AASHTO								MDD	OMC	S/M
BH-1	0-2	29	18	11		56	CL	A-6 (3)										
BH-1	2-4	28	15	13		60	CL	A-6 (5)										
BH-1	2.01											0.10						
BH-1	4-8	26	17	9		83	CL	A-4 (6)										
BH-1	4.01								20.2	94.1								
BH-1	8								23.8	92.5								
BH-2	0-2	28	15	13		78	CL	A-6 (8)										
BH-2	2-4	42	20	22		81	CL	A-7-6 (18)										
BH-2	2.01				2.4				10.4	109.8								
BH-2	4-8	24	18	6		88	CL-ML	A-4 (3)				1.02						
BH-2	4.01								17.5	96.1								
BH-2	8								23.8	98.6								
BH-5	0-4	41	22	19		88	CL	A-7-6 (17)										
BH-5	2								14.2	104.5		0.06						
BH-5	4-9	35	18	17		91	CL	A-6 (15)										
BH-5	4.01								11.1	116.2								
BH-5	9-14	39	18	21		88	CL	A-6 (18)										
BH-5	14-19	33	19	14		83	CL	A-6 (11)										
BH-5	19					74												
BH-6	0-2	29	17	12		66	CL	A-6 (6)								110.8	15.9	S
BH-6	2-4					88												
BH-6	2.01								11.9	103.7								
BH-6	4-8	35	18	17		95	CL	A-6 (16)										
BH-6	4.01								13.5	113.1								
BH-6	8				3.9				10.7	120.0								
BH-7	0-4	33	17	16		92	CL	A-6 (14)										
BH-7	4-9	37	15	22		92	CL	A-6 (20)				1.56		7.6	0.0300			
BH-7	4.01								13.3	109.4								
BH-7	9-14	31	16	15		67	CL	A-6 (8)				1.50						
BH-7	9.01				8.0				10.0	128.8								

RockSol Consulting Group, Inc.

SUMMARY OF PHYSICAL & CHEMICAL TEST RESULTS

CLIENT City of Grand Junction

PROJECT NUMBER 599.84

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT LOCATION Grand Junction, Colorado

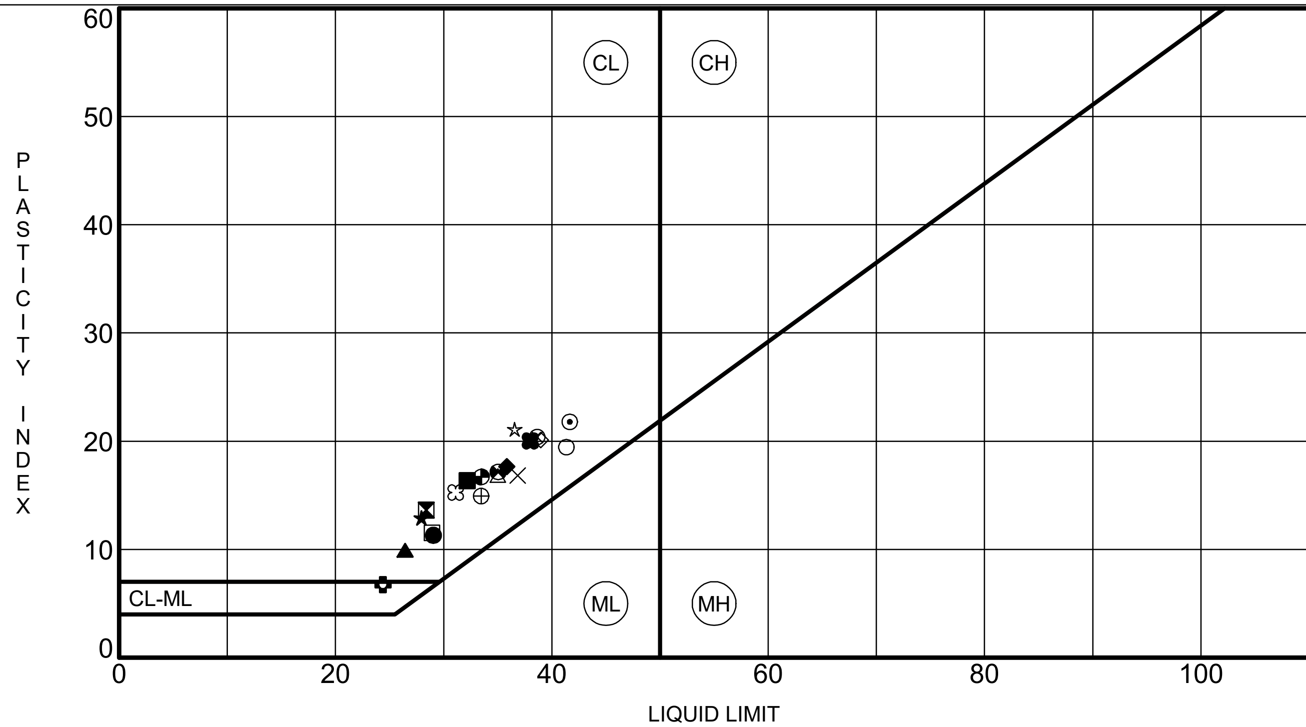
Borehole	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Swell Potential (%)	%<#200 Sieve	Classification		Water Content (%)	Dry Density (pcf)	Unconfined Compressive Strength (psi)	Sulfate (%)	Resistivity (ohm-cm)	pH	Chlorides (%)	Proctor S=Standard M=Modified		
							USCS	AASHTO								MDD	OMC	S/M
BH-7	14-19	32	16	16		76	CL	A-6 (10)										
BH-7	14.01					46												
BH-7	19					62												
BH-8	0-4	36	18	18		90	CL	A-6 (16)										
BH-8	2								16.7	109.3								
BH-8	4-9	39	19	20		87	CL	A-6 (17)				1.18						
BH-8	4.01								12.8	116.4								
BH-8	9-14	37	20	17		88	CL	A-6 (15)										
BH-8	9.01					74												
BH-8	14-21	38	18	20		78	CL	A-6 (14)										
BH-8	19					76												
BH-9	0-4	37	21	16		81	CL	A-6 (12)										
BH-9	2								15.2	105.9								
BH-9	4-9	50	27	23		94	CH	A-7-6 (25)										
BH-9	4.01				1.3				15.1	116.5								
BH-9	9-14	37	22	15		88	CL	A-6 (13)										
BH-9	14-21	38	15	23		88	CL	A-6 (20)										
BH-9	14.01					50												
BH-9	21					44												
BH-10	0-4	41	18	23		93	CL	A-7-6 (22)										
BH-10	2								18.6	104.7								
BH-10	4-9					72						1.47	750 @ 23.4%	7.6	0.0140			
BH-10	4.01					47												
BH-10	9-14	34	18	16		74	CL	A-6 (10)				0.34						
BH-10	14-21	30	18	12		69	CL	A-6 (6)										
BH-10	21					48												
TP-1	0-3	34	21	13		92	CL	A-6 (12)								106.0	17.5	S
TP-1	4.5-5.5	39	29	10		77	ML	A-4 (8)				1.90	790 @ 28.8%	7.7	0.0060			
TP-1	6-7	40	29	11		94	ML	A-6 (13)										
TP-1	7.5-8.5											1.02						

ATTERBERG LIMITS RESULTS
AASHTO T89 Method A/T90

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction **PROJECT NAME** Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



	Specimen Identification		LL	PL	PI	Fines	Classification
●	BH-1	0.0-2.0	29	18	11	55.9	SANDY LEAN CLAY (CL) (A-6)
⊠	BH-1	2.0-4.0	28	15	13	60.0	SANDY LEAN CLAY (CL) (A-6)
▲	BH-1	4.0-8.0	26	17	9	83.1	LEAN CLAY with SAND (CL) (A-4)
★	BH-2	0.0-2.0	28	15	13	78.0	LEAN CLAY with SAND (CL) (A-6)
⊙	BH-2	2.0-4.0	42	20	22	81.5	LEAN CLAY with SAND (CL) (A-7-6)
✿	BH-2	4.0-8.0	24	18	6	87.5	SILTY CLAY (CL-ML) (A-4)
○	BH-5	0.0-4.0	41	22	19	88.2	LEAN CLAY (CL) (A-7-6)
△	BH-5	4.0-9.0	35	18	17	91.2	LEAN CLAY (CL) (A-6)
⊗	BH-5	9.0-14.0	39	18	21	88.2	LEAN CLAY (CL) (A-6)
⊕	BH-5	14.0-19.0	33	19	14	83.2	LEAN CLAY with SAND (CL) (A-6)
□	BH-6	0.0-2.0	29	17	12	66.1	SANDY LEAN CLAY (CL) (A-6)
◉	BH-6	4.0-8.0	35	18	17	95.2	LEAN CLAY (CL) (A-6)
◕	BH-7	0.0-4.0	33	17	16	92.2	LEAN CLAY (CL) (A-6)
☆	BH-7	4.0-9.0	37	15	22	92.3	LEAN CLAY (CL) (A-6)
✤	BH-7	9.0-14.0	31	16	15	66.7	SANDY LEAN CLAY (CL) (A-6)
■	BH-7	14.0-19.0	32	16	16	76.1	LEAN CLAY with SAND (CL) (A-6)
◆	BH-8	0.0-4.0	36	18	18	89.9	LEAN CLAY (CL) (A-6)
◇	BH-8	4.0-9.0	39	19	20	87.4	LEAN CLAY (CL) (A-6)
×	BH-8	9.0-14.0	37	20	17	87.8	LEAN CLAY (CL) (A-6)
✖	BH-8	14.0-21.0	38	18	20	78.2	LEAN CLAY with SAND (CL) (A-6)

ATTERBERG LIMITS - STANDARD 599.84_GJ MATCHETT PARK AND CRC.GPJ ROCKSOL TEMPLATE.GDT 7/26/23

RockSol Consulting Group, Inc.

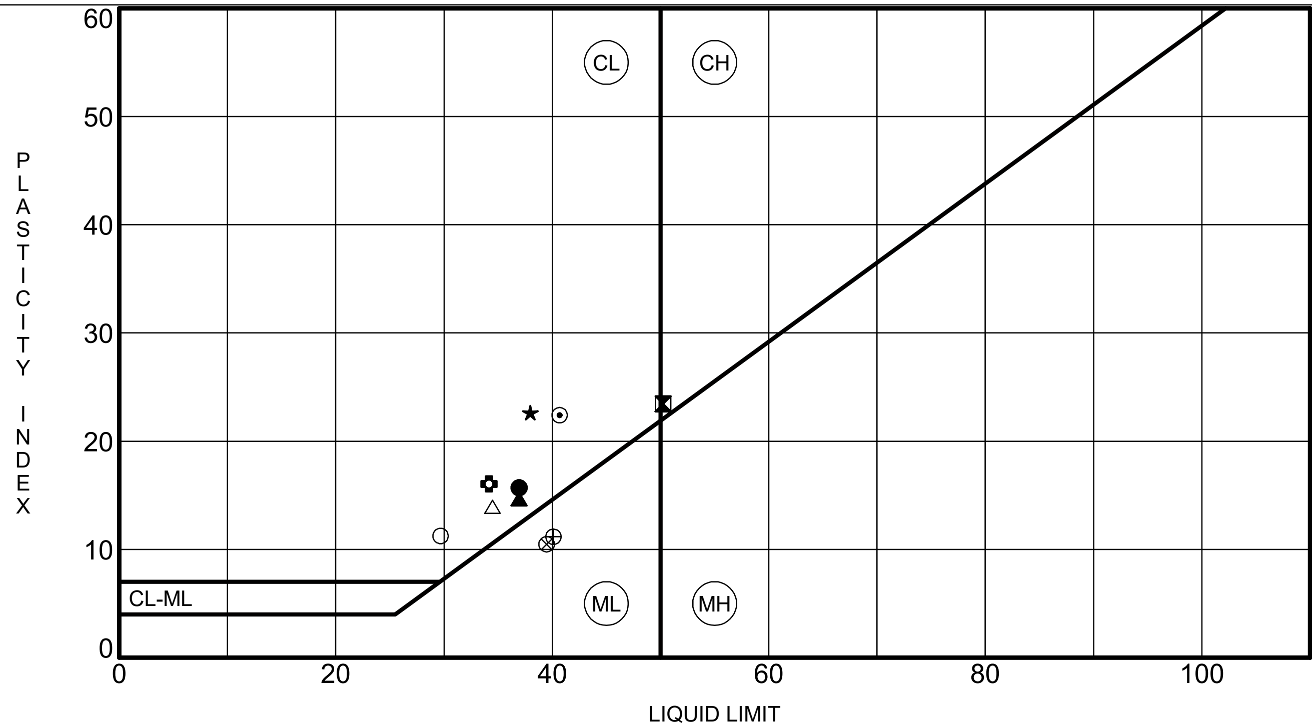
ATTERBERG LIMITS RESULTS
AASHTO T89 Method A/T90

CLIENT City of Grand Junction

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado

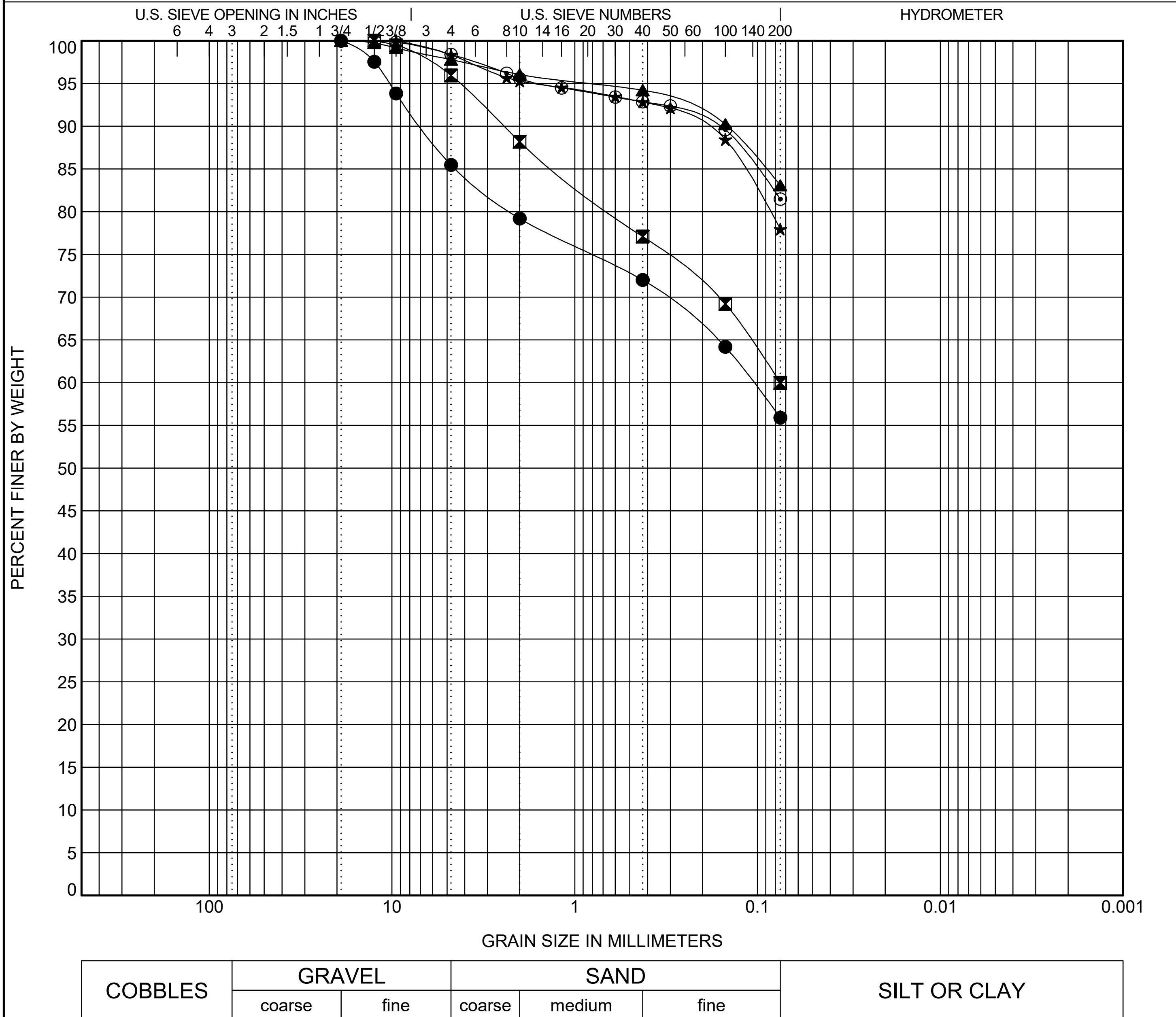


	Specimen Identification		LL	PL	PI	Fines	Classification
●	BH-9	0.0-4.0	37	21	16	81.3	LEAN CLAY with SAND (CL) (A-6)
⧗	BH-9	4.0-9.0	50	27	23	94.2	FAT CLAY (CH) (A-7-6)
▲	BH-9	9.0-14.0	37	22	15	88.0	LEAN CLAY (CL) (A-6)
★	BH-9	14.0-21.0	38	15	23	87.5	LEAN CLAY (CL) (A-6)
⊙	BH-10	0.0-4.0	41	18	23	93.2	LEAN CLAY (CL) (A-7-6)
✿	BH-10	9.0-14.0	34	18	16	74.2	LEAN CLAY with SAND (CL) (A-6)
○	BH-10	14.0-21.0	30	18	12	69.4	SANDY LEAN CLAY (CL) (A-6)
△	TP-1	0.0-3.0	34	21	13	92.0	LEAN CLAY (CL) (A-6)
⊗	TP-1	4.5-5.5	39	29	10	77.4	SILT with SAND (ML) (A-4)
⊕	TP-1	6.0-7.0	40	29	11	94.4	SILT (ML) (A-6)

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	**BH-1**	**0.0-2.0**	**SANDY LEAN CLAY (CL) (A-6)**	**29**	**18**	**11**		
⊠	**BH-1**	**2.0-4.0**	**SANDY LEAN CLAY (CL) (A-6)**	**28**	**15**	**13**		
▲	**BH-1**	**4.0-8.0**	**LEAN CLAY with SAND (CL) (A-4)**	**26**	**17**	**9**		
★	**BH-2**	**0.0-2.0**	**LEAN CLAY with SAND (CL) (A-6)**	**28**	**15**	**13**		
⊙	**BH-2**	**2.0-4.0**	**LEAN CLAY with SAND (CL) (A-7-6)**	**42**	**20**	**22**		

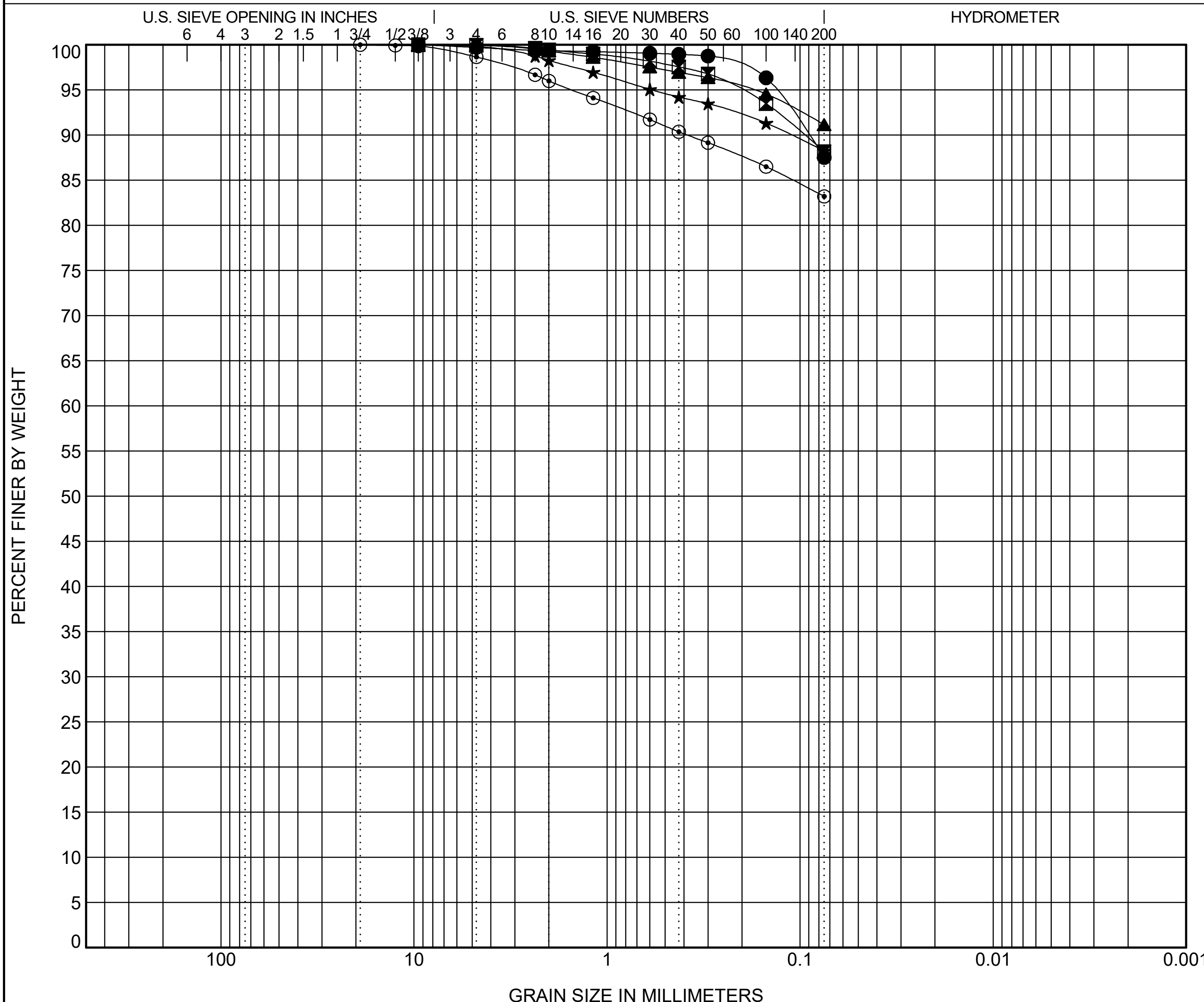
Specimen Identification			D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**BH-1**	**0.0-2.0**	**19**	**0.106**			**20.8**	**7.2**	**16.1**	**55.9**	
⊠	**BH-1**	**2.0-4.0**	**12.5**	**0.075**			**11.8**	**11.1**	**17.1**	**60.0**	
▲	**BH-1**	**4.0-8.0**	**19**				**4.0**	**1.8**	**11.1**	**83.1**	
★	**BH-2**	**0.0-2.0**	**9.5**				**4.7**	**2.5**	**14.9**	**78.0**	
⊙	**BH-2**	**2.0-4.0**	**12.5**				**4.4**	**2.7**	**11.4**	**81.5**	

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● BH-2	4.0-8.0	**SILTY CLAY (CL-ML) (A-4)**	24	18	6		
⌧ BH-5	0.0-4.0	**LEAN CLAY (CL) (A-7-6)**	41	22	19		
▲ BH-5	4.0-9.0	**LEAN CLAY (CL) (A-6)**	35	18	17		
★ BH-5	9.0-14.0	**LEAN CLAY (CL) (A-6)**	39	18	21		
⊙ BH-5	14.0-19.0	**LEAN CLAY with SAND (CL) (A-6)**	33	19	14		

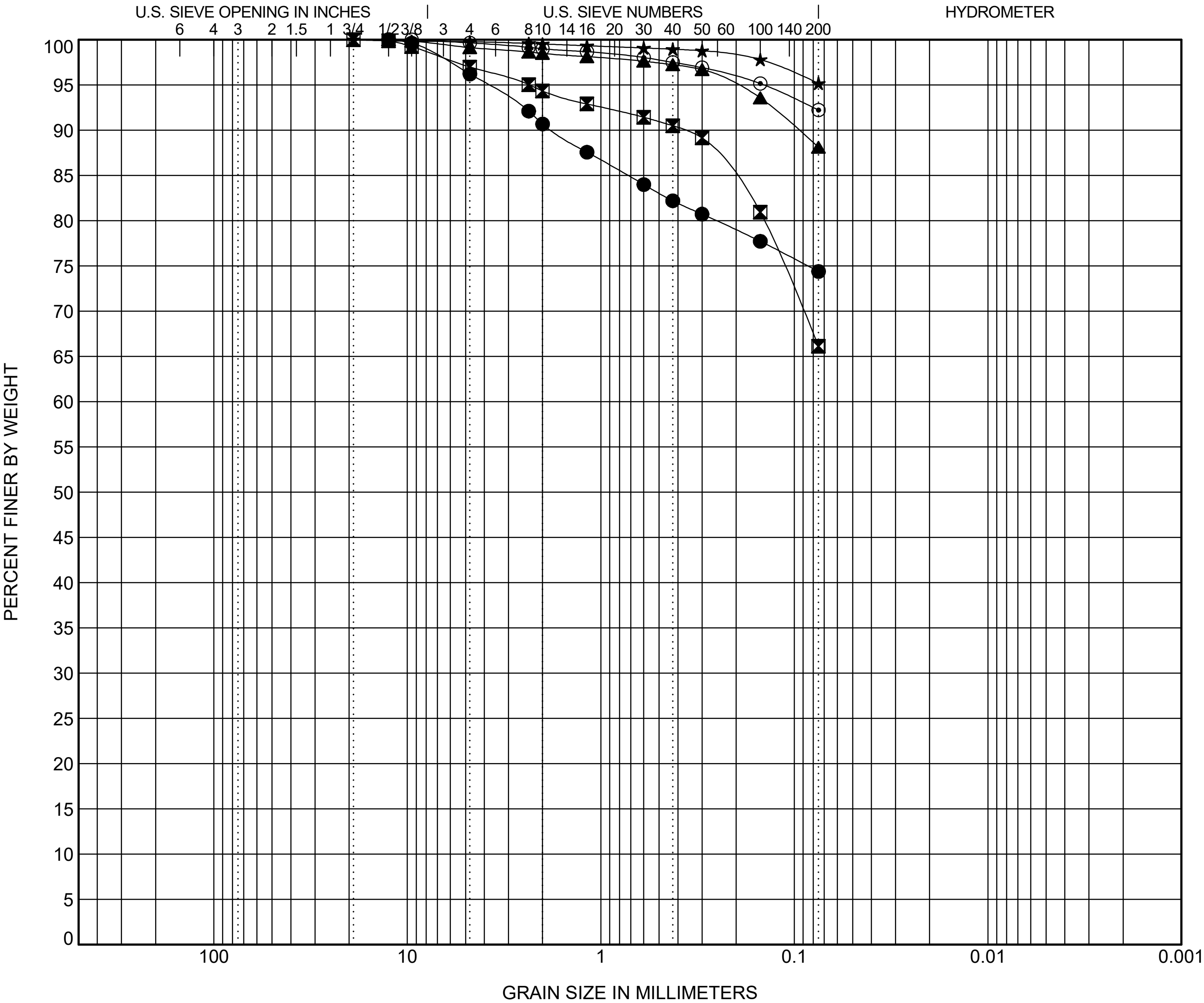
Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
● BH-2	4.0-8.0	9.5				0.7	0.4	11.4	87.5	
⌧ BH-5	0.0-4.0	9.5				0.6	1.9	9.4	88.2	
▲ BH-5	4.0-9.0	9.5				0.7	2.4	5.8	91.2	
★ BH-5	9.0-14.0	9.5				1.7	4.1	6.0	88.2	
⊙ BH-5	14.0-19.0	19				4.0	5.6	7.2	83.2	

GRADATION - STANDARD 599.84_GJ MATCHETT PARK AND CRC.GPJ ROCKSOL TEMPLATE.GDT 7/26/23

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction
PROJECT NAME Community Recreation Center at Matchett Park
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	BH-5	19.0	(Bedrock) MANCOS SHALE					
⧗	BH-6	0.0-2.0	SANDY LEAN CLAY (CL) (A-6)	29	17	12		
▲	BH-6	2.0-4.0	CLAY with SAND					
★	BH-6	4.0-8.0	LEAN CLAY (CL) (A-6)	35	18	17		
⊙	BH-7	0.0-4.0	LEAN CLAY (CL) (A-6)	33	17	16		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-5	19.0	12.5				9.3	8.5	7.8	74.4	
⧗	BH-6	0.0-2.0	19				5.7	3.8	24.4	66.1	
▲	BH-6	2.0-4.0	12.5				1.5	1.2	9.1	88.1	
★	BH-6	4.0-8.0	19				0.5	0.6	3.8	95.2	
⊙	BH-7	0.0-4.0	9.5				1.0	1.5	5.3	92.2	

GRADATION - STANDARD 599.84_GJ MATCHETT PARK AND CRC.GPJ ROCKSOL TEMPLATE.GDT 7/26/23

GRAIN SIZE DISTRIBUTION

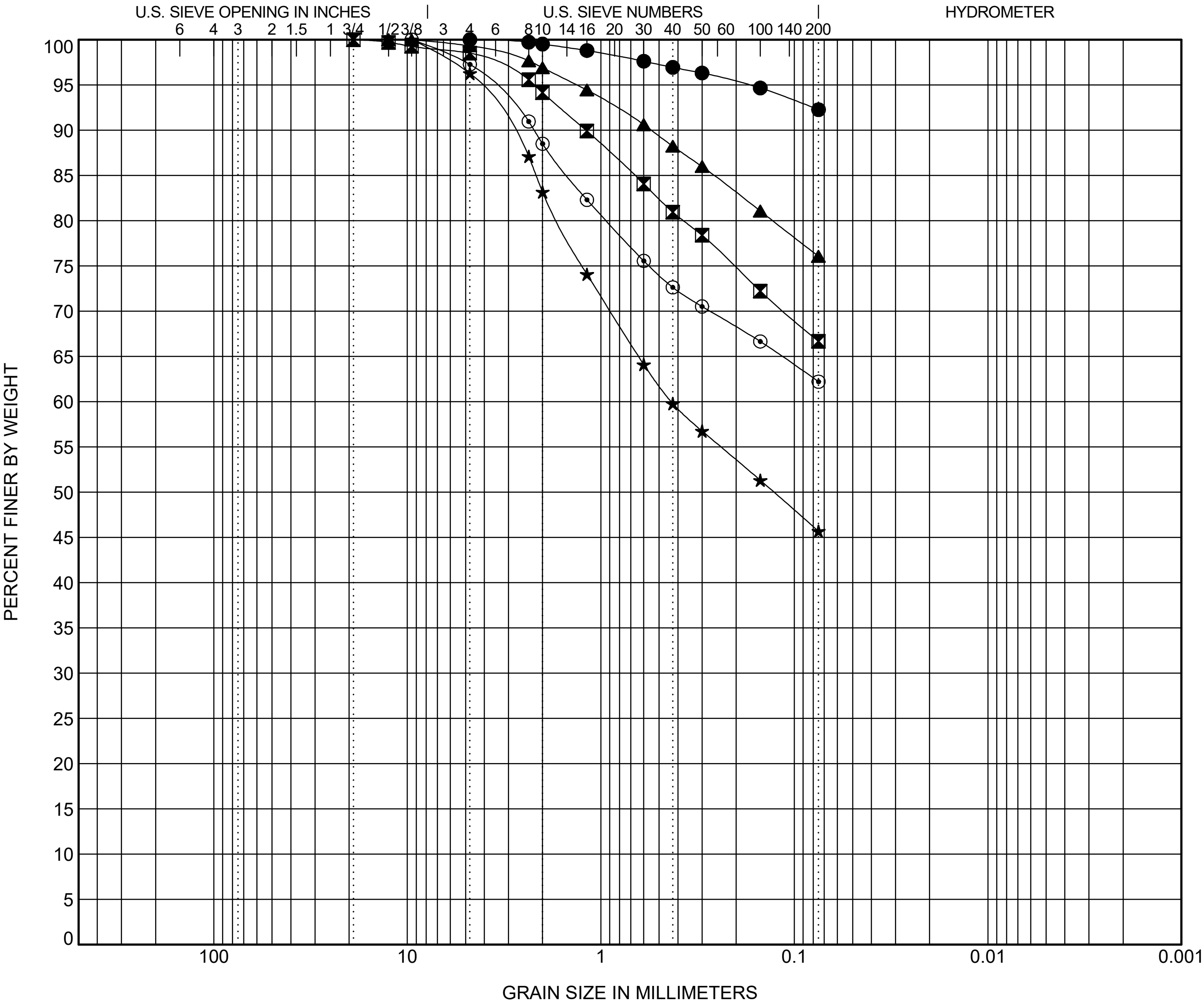
RockSol

CLIENT City of Grand Junction

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● BH-7	4.0-9.0	**LEAN CLAY (CL) (A-6)**	37	15	22		
⊠ BH-7	9.0-14.0	**SANDY LEAN CLAY (CL) (A-6)**	31	16	15		
▲ BH-7	14.0-19.0	**LEAN CLAY with SAND (CL) (A-6)**	32	16	16		
★ BH-7	14.0	**(Bedrock) MANCOS SHALE**					
⊙ BH-7	19.0	**(Bedrock) MANCOS SHALE**					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
● BH-7	4.0-9.0	4.75				0.5	2.6	4.7	92.3	
⊠ BH-7	9.0-14.0	19				5.8	13.2	14.3	66.7	
▲ BH-7	14.0-19.0	12.5				3.1	8.7	12.2	76.1	
★ BH-7	14.0	9.5	0.432			16.8	23.4	14.1	45.7	
⊙ BH-7	19.0	9.5				11.5	15.9	10.4	62.2	

GRAIN SIZE DISTRIBUTION

RockSol Consulting Group, Inc.

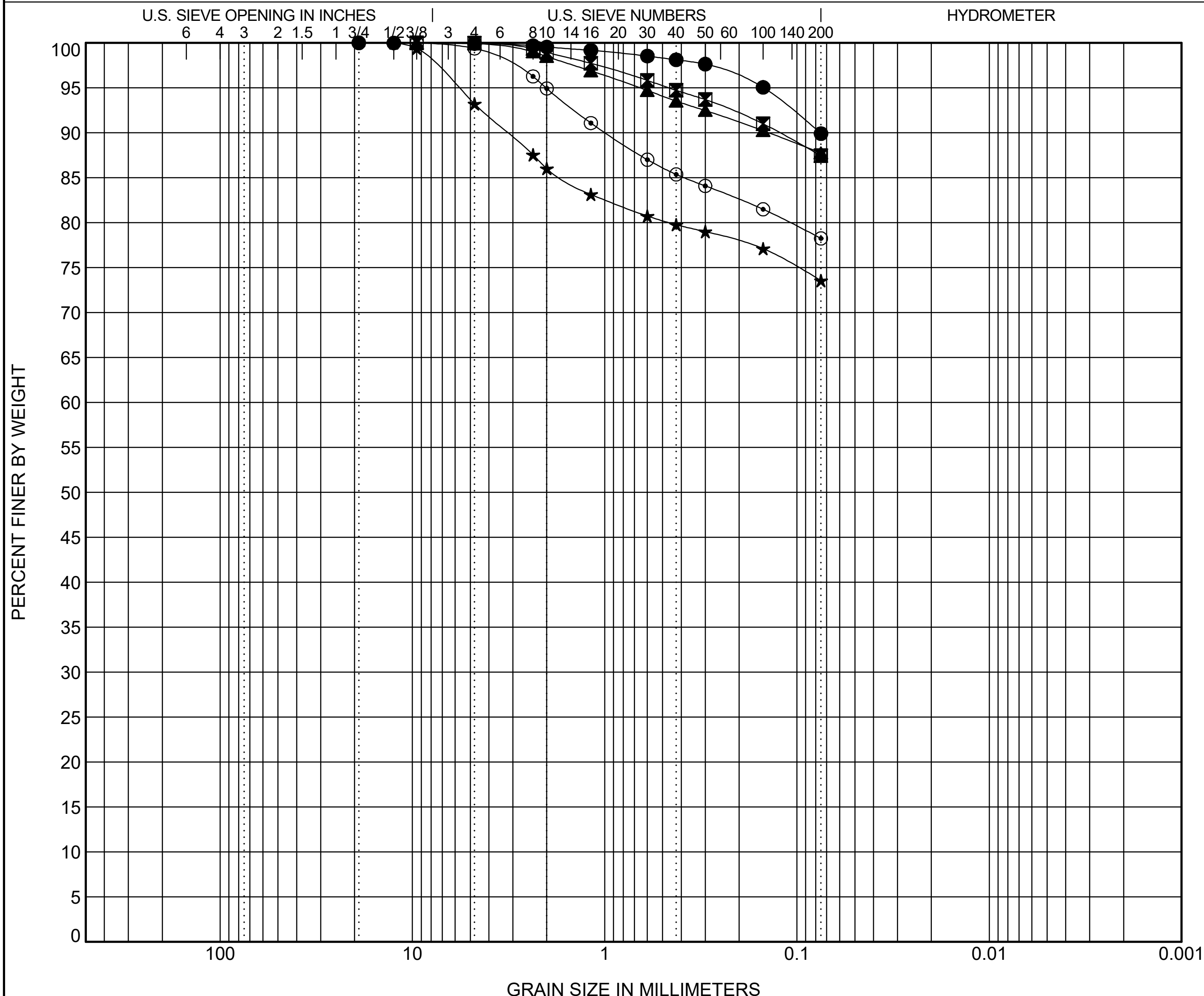
RockSol

CLIENT City of Grand Junction

PROJECT NAME Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	BH-8	0.0-4.0	**LEAN CLAY (CL) (A-6)**	36	18	18		
⧗	BH-8	4.0-9.0	**LEAN CLAY (CL) (A-6)**	39	19	20		
▲	BH-8	9.0-14.0	**LEAN CLAY (CL) (A-6)**	37	20	17		
★	BH-8	9.0	**(Bedrock) MANCOS SHALE**					
⊙	BH-8	14.0-21.0	**LEAN CLAY with SAND (CL) (A-6)**	38	18	20		

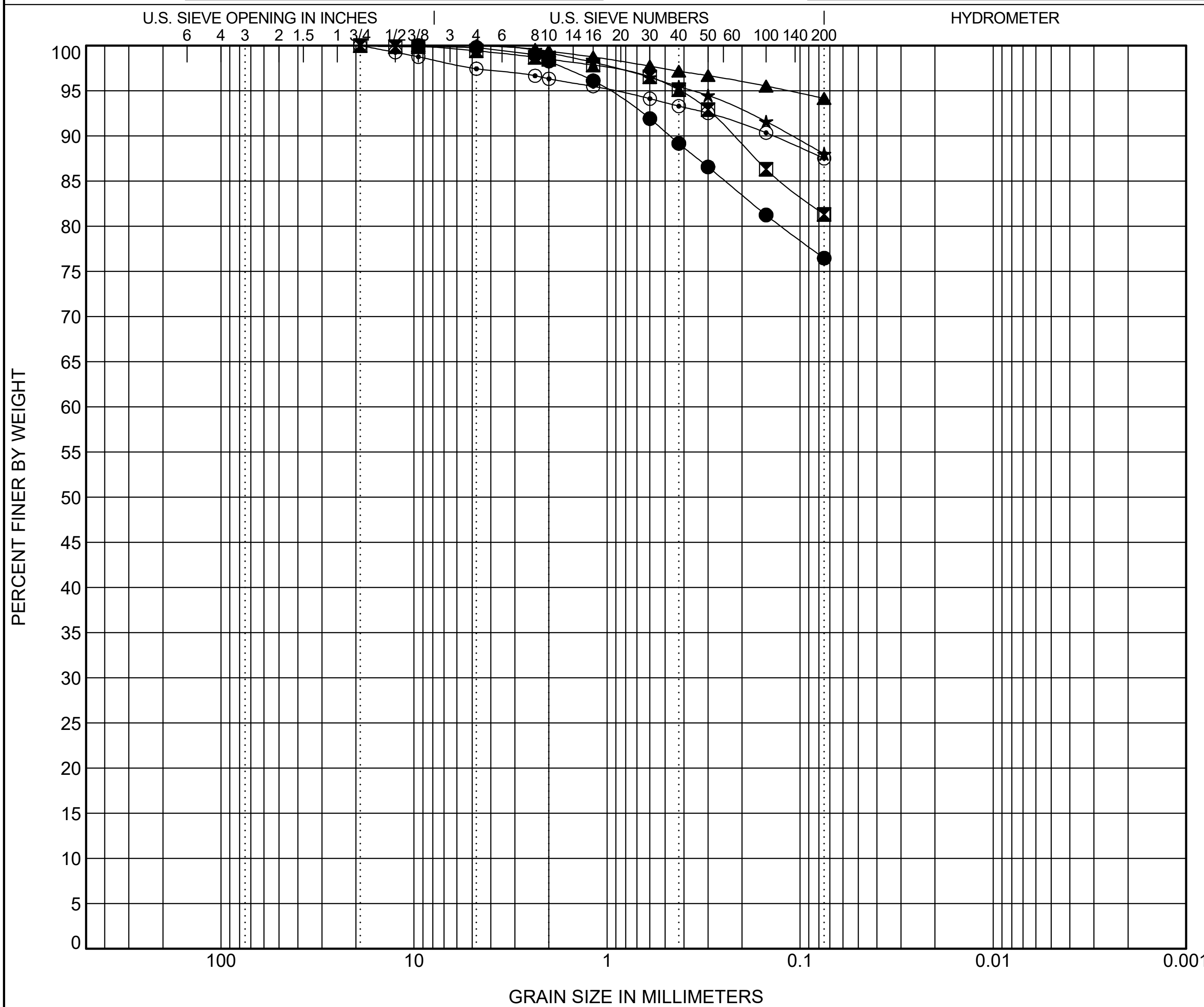
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-8	0.0-4.0	19				0.5	1.4	8.2	89.9	
⧗	BH-8	4.0-9.0	9.5				1.1	4.2	7.3	87.4	
▲	BH-8	9.0-14.0	9.5				1.5	5.0	5.8	87.8	
★	BH-8	9.0	12.5				14.0	6.2	6.2	73.5	
⊙	BH-8	14.0-21.0	9.5				5.1	9.6	7.1	78.2	

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



Specimen Identification			Classification	LL	PL	PI	Cc	Cu
●	BH-8	19.0	(Bedrock) MANCOS SHALE					
⊠	BH-9	0.0-4.0	LEAN CLAY with SAND (CL) (A-6)	37	21	16		
▲	BH-9	4.0-9.0	FAT CLAY (CH) (A-7-6)	50	27	23		
★	BH-9	9.0-14.0	LEAN CLAY (CL) (A-6)	37	22	15		
⊙	BH-9	14.0-21.0	LEAN CLAY (CL) (A-6)	38	15	23		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	BH-8	19.0	9.5				1.7	9.1	12.7	76.5	
⊠	BH-9	0.0-4.0	19				1.5	3.4	13.8	81.3	
▲	BH-9	4.0-9.0	9.5				0.6	2.2	3.0	94.2	
★	BH-9	9.0-14.0	9.5				0.8	3.7	7.5	88.0	
⊙	BH-9	14.0-21.0	19				3.7	3.0	5.8	87.5	

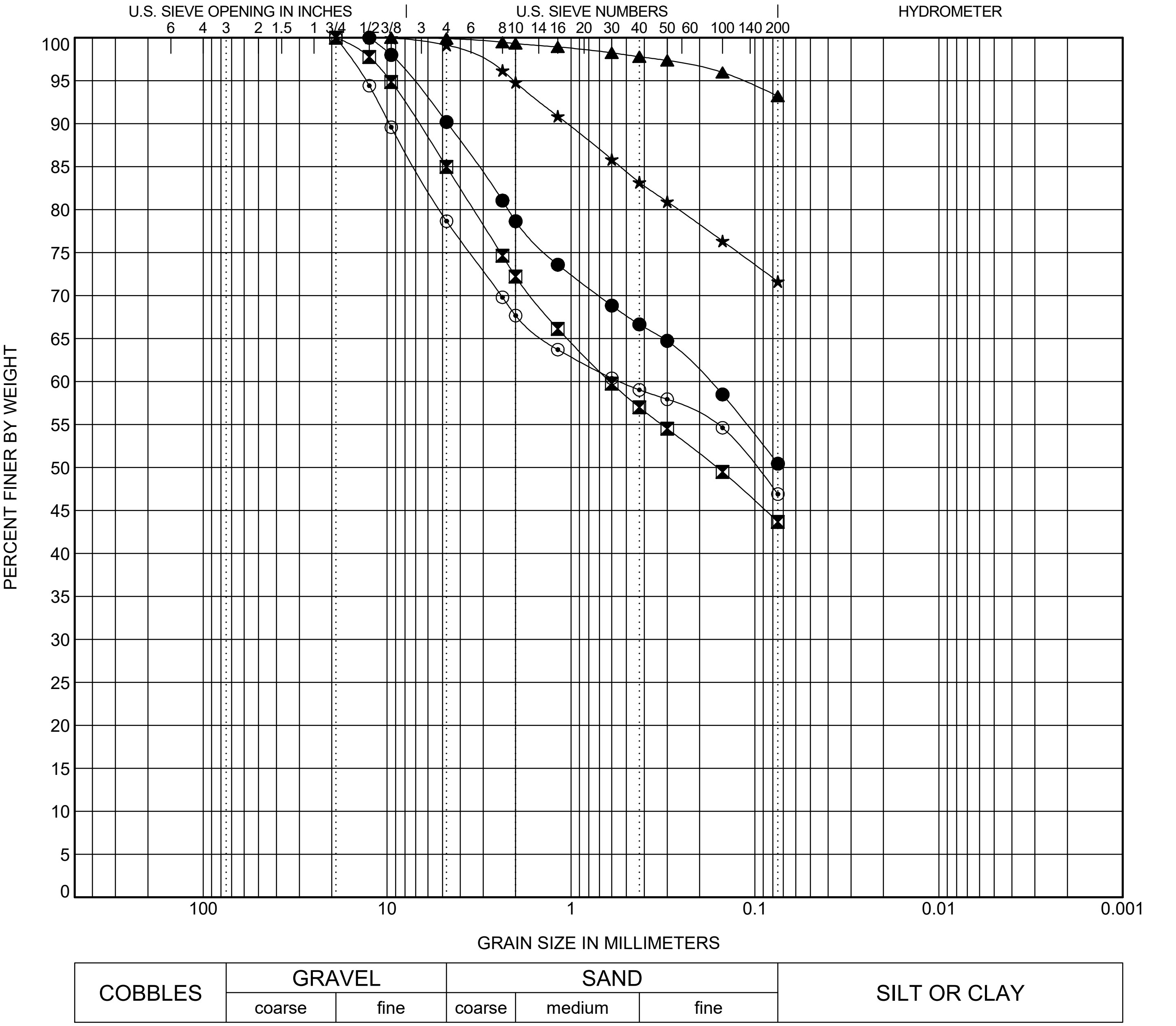
GRADATION - STANDARD 599.84_GJ MATCHETT PARK AND CRC.GPJ ROCKSOL TEMPLATE.GDT 7/26/23

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**BH-9**	**14.0**	**(Bedrock) MANCOS SHALE**					
⧗	**BH-9**	**21.0**	**(Bedrock) MANCOS SHALE**					
▲	**BH-10**	**0.0-4.0**	**LEAN CLAY (CL) (A-7-6)**	**41**	**18**	**23**		
★	**BH-10**	**4.0-9.0**	**(Bedrock) MANCOS SHALE, weathered**					
⊙	**BH-10**	**4.0**	**(Bedrock) MANCOS SHALE, weathered**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**BH-9**	**14.0**	**12.5**	**0.177**			**21.4**	**12.0**	**16.2**	**50.4**	
⧗	**BH-9**	**21.0**	**19**	**0.615**			**27.8**	**15.2**	**13.3**	**43.7**	
▲	**BH-10**	**0.0-4.0**	**9.5**				**0.7**	**1.5**	**4.6**	**93.2**	
★	**BH-10**	**4.0-9.0**	**12.5**				**5.2**	**11.6**	**11.5**	**71.6**	
⊙	**BH-10**	**4.0**	**19**	**0.545**			**32.3**	**8.6**	**12.1**	**46.9**	

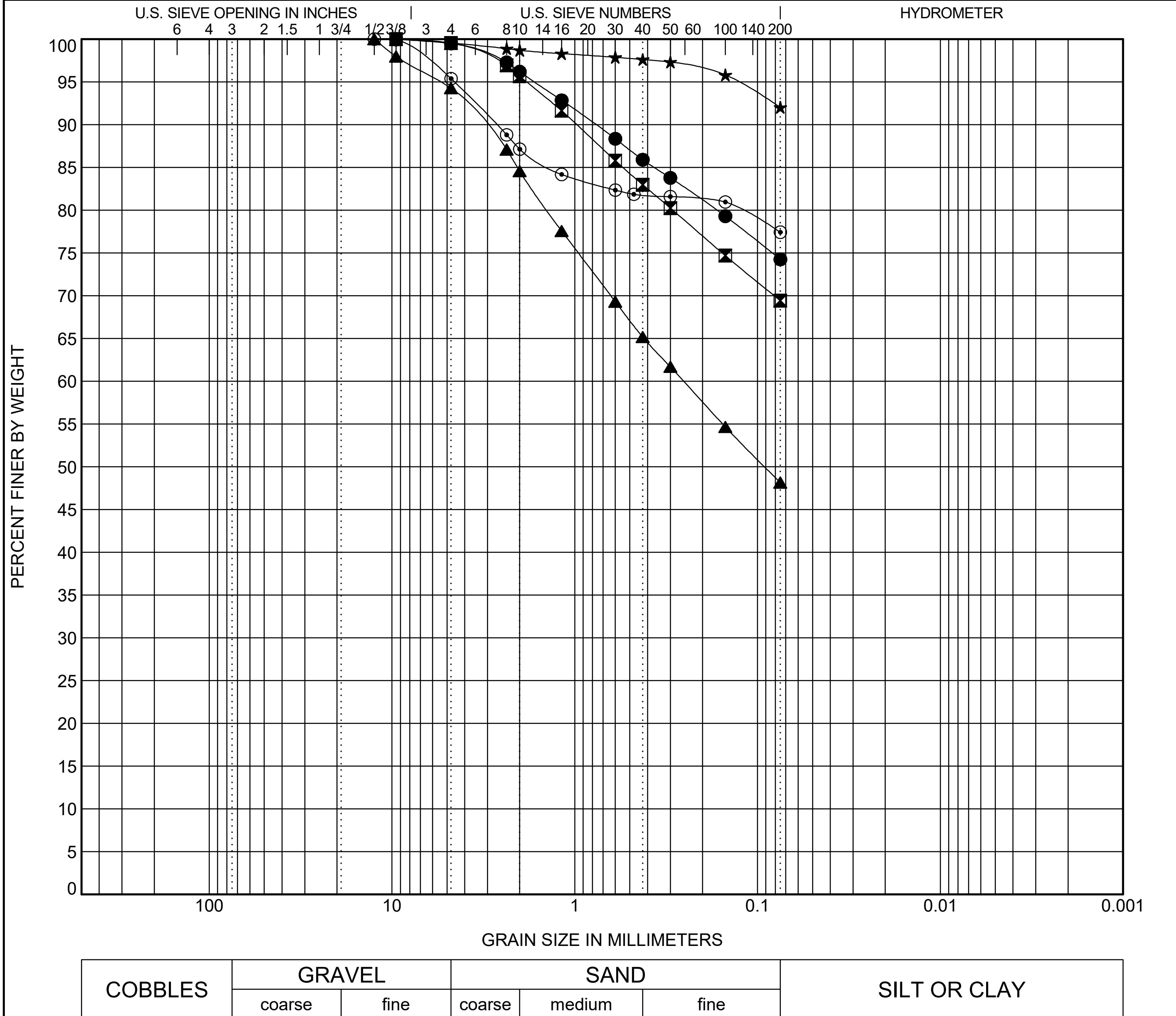
GRADATION - STANDARD 599.84_GJ MATCHETT PARK AND CRC.GPJ ROCKSOL TEMPLATE.GDT 7/26/23

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● BH-10	9.0-14.0	LEAN CLAY with SAND (CL) (A-6)	34	18	16		
⧗ BH-10	14.0-21.0	SANDY LEAN CLAY (CL) (A-6)	30	18	12		
▲ BH-10	21.0	(Bedrock) MANCOS SHALE					
★ TP-1	0.0-3.0	LEAN CLAY (CL) (A-6)	34	21	13		
⊙ TP-1	4.5-5.5	SILT with SAND (ML) (A-4)	39	29	10		

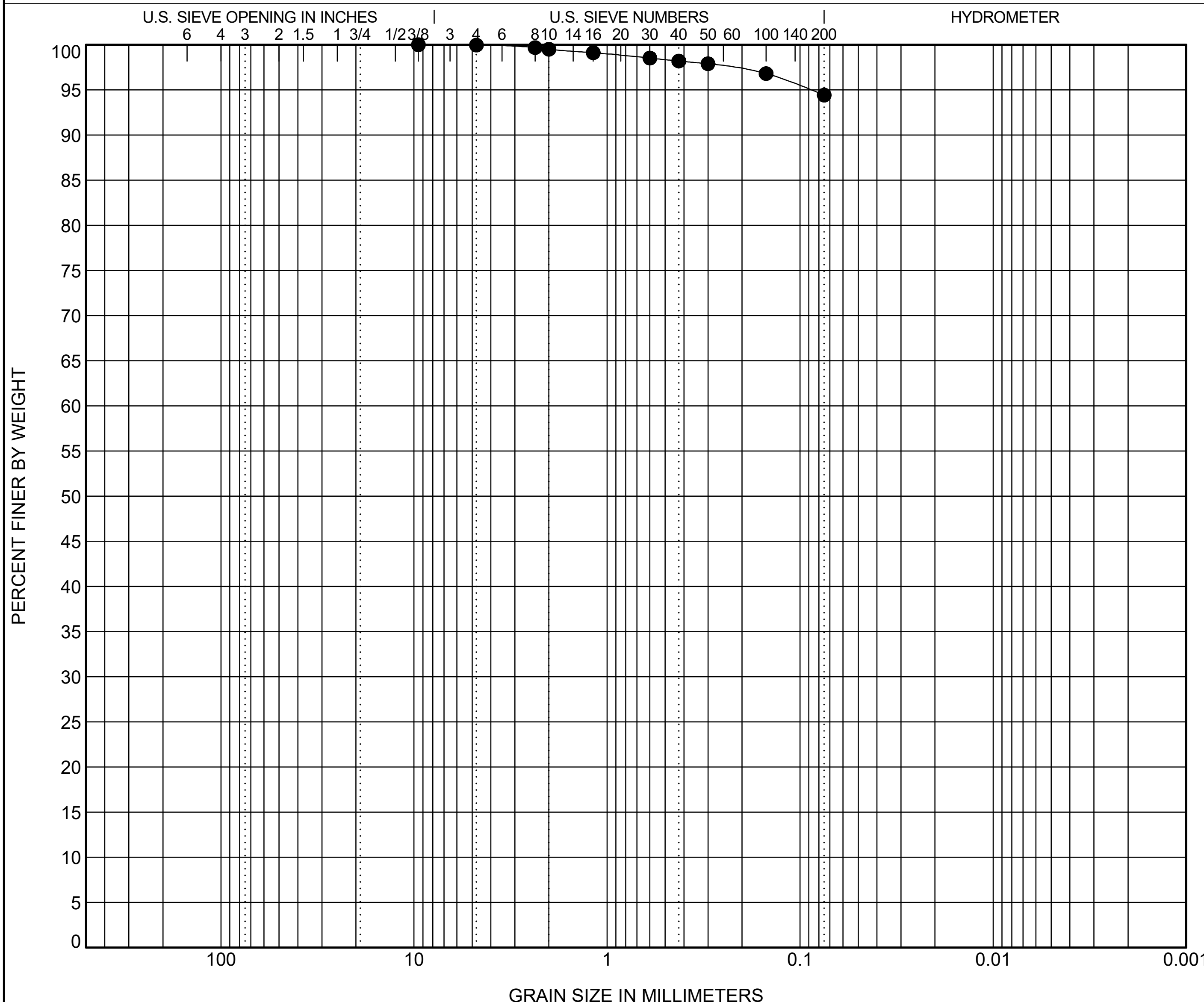
Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
● BH-10	9.0-14.0	9.5				3.8	10.3	11.7	74.2	
⧗ BH-10	14.0-21.0	9.5				4.3	12.7	13.6	69.4	
▲ BH-10	21.0	12.5	0.254			15.4	19.4	17.0	48.2	
★ TP-1	0.0-3.0	9.5				1.3	1.1	5.6	92.0	
⊙ TP-1	4.5-5.5	12.5				12.9	5.3	4.4	77.4	

GRAIN SIZE DISTRIBUTION

RockSol Consulting Group, Inc. RockSol

CLIENT City of Grand Junction **PROJECT NAME** Community Recreation Center at Matchett Park

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**TP-1**	**6.0-7.0**	**SILT (ML) (A-6)**	**40**	**29**	**11**		

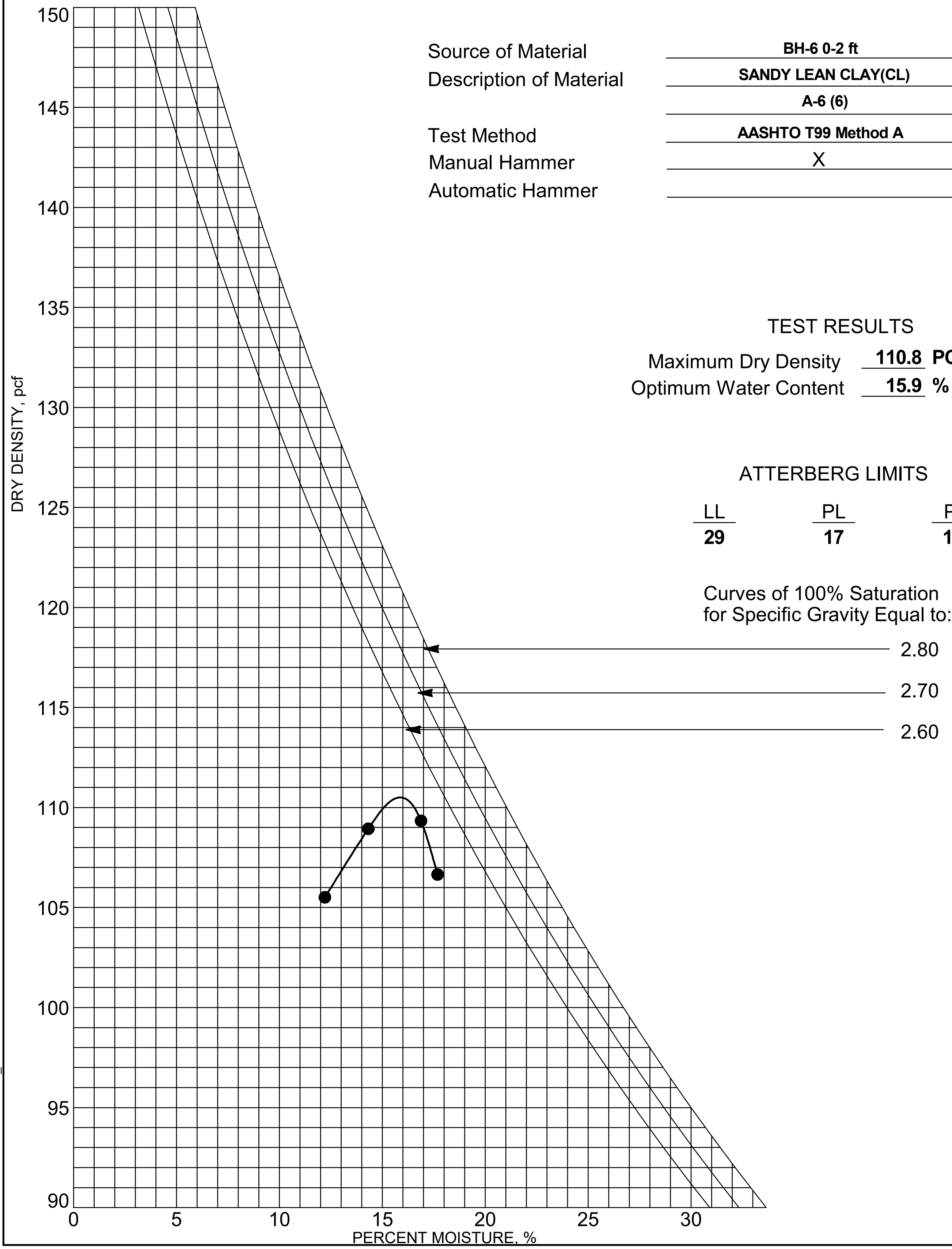
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**TP-1**	**6.0-7.0**	**9.5**				**0.5**	**1.3**	**3.8**	**94.4**	

GRADATION - STANDARD 599.84_GJ MATCHETT PARK AND CRC.GPJ ROCKSOL TEMPLATE.GDT 7/26/23

RockSol

CLIENT City of Grand Junction **PROJECT NAME** Matchett Park Community Recreation Center

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



Source of Material	BH-6 0-2 ft
Description of Material	SANDY LEAN CLAY(CL)
	A-6 (6)
Test Method	AASHTO T99 Method A
Manual Hammer	X
Automatic Hammer	

TEST RESULTS

Maximum Dry Density **110.8 PCF**

Optimum Water Content **15.9 %**

ATTERBERG LIMITS

LL	PL	PI
29	**17**	**12**

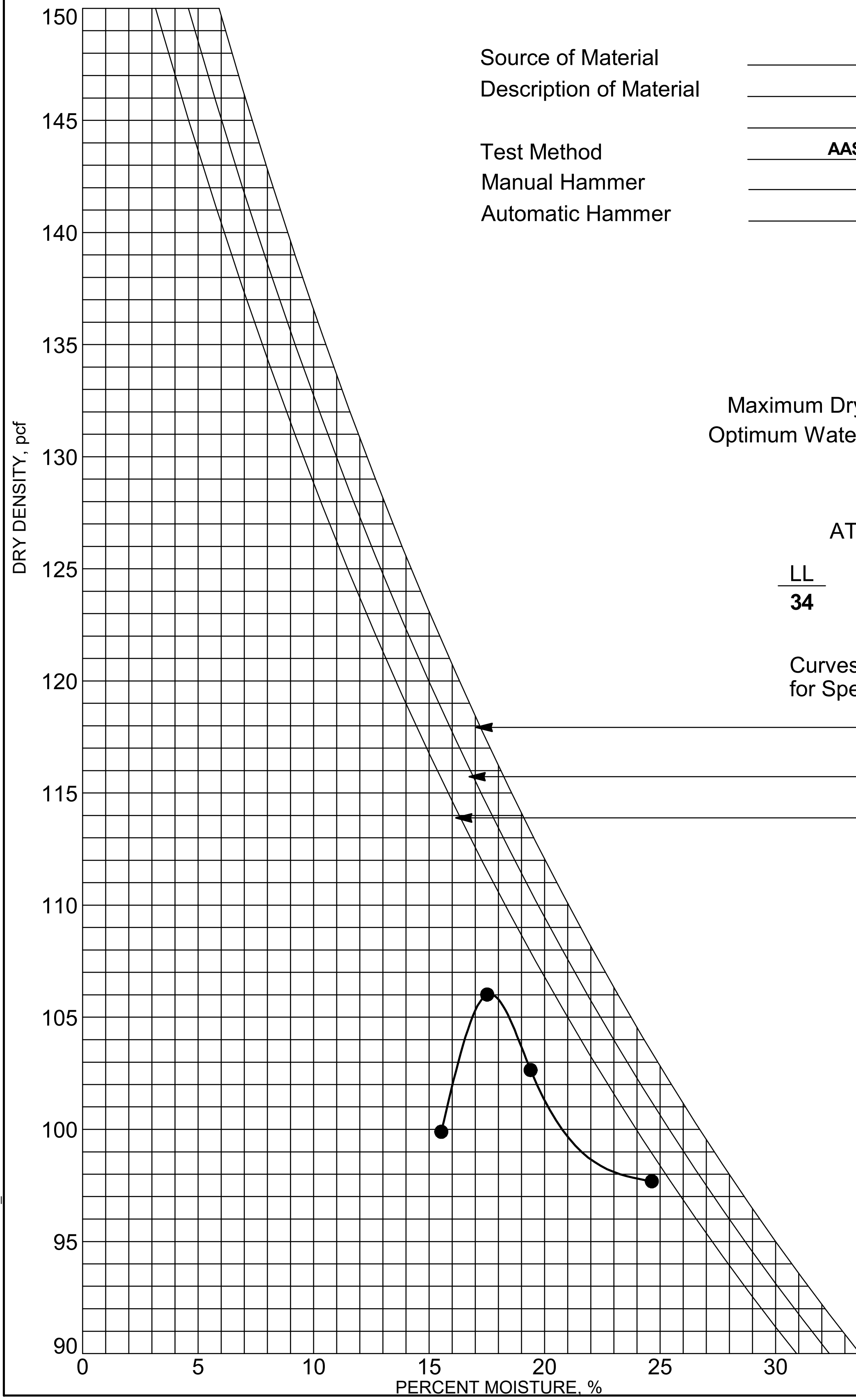
RockSol

CLIENT City of Grand Junction

PROJECT NAME Matchett Park Community Recreation Center

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado



Source of Material	TP-1 0-3 ft
Description of Material	LEAN CLAY(CL)
	A-6 (12)
Test Method	AASHTO T99 Method A
Manual Hammer	X
Automatic Hammer	

TEST RESULTS

Maximum Dry Density **106.0 PCF**

Optimum Water Content **17.5 %**

ATTERBERG LIMITS

LL	PL	PI
34	**21**	**13**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

SWELL - CONSOLIDATION TEST

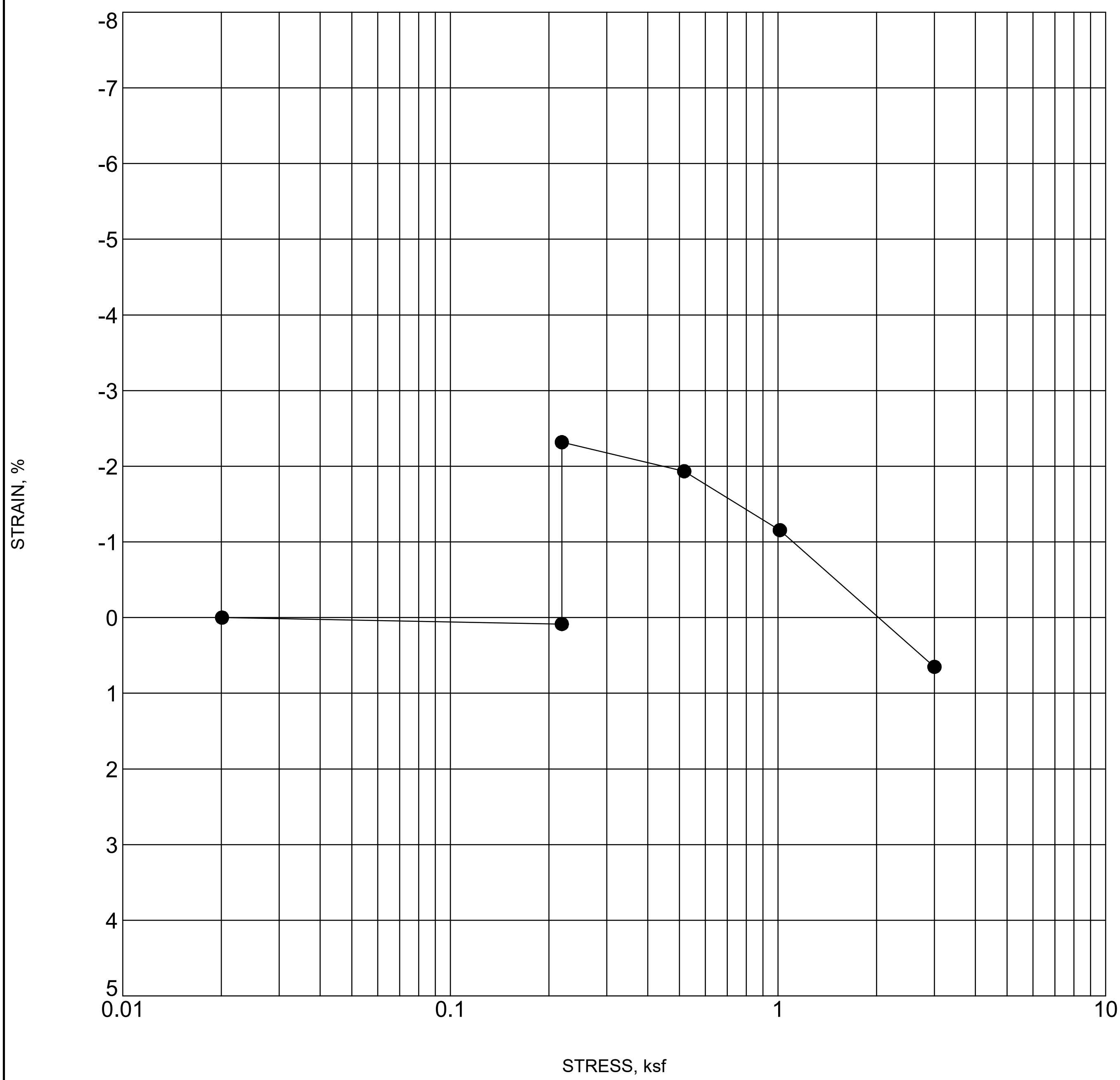
RockSol Consulting Group, Inc.

CLIENT City of Grand Junction

PROJECT NAME Matchett Park Community Recreation Center

PROJECT NUMBER 599.84

PROJECT LOCATION Grand Junction, Colorado



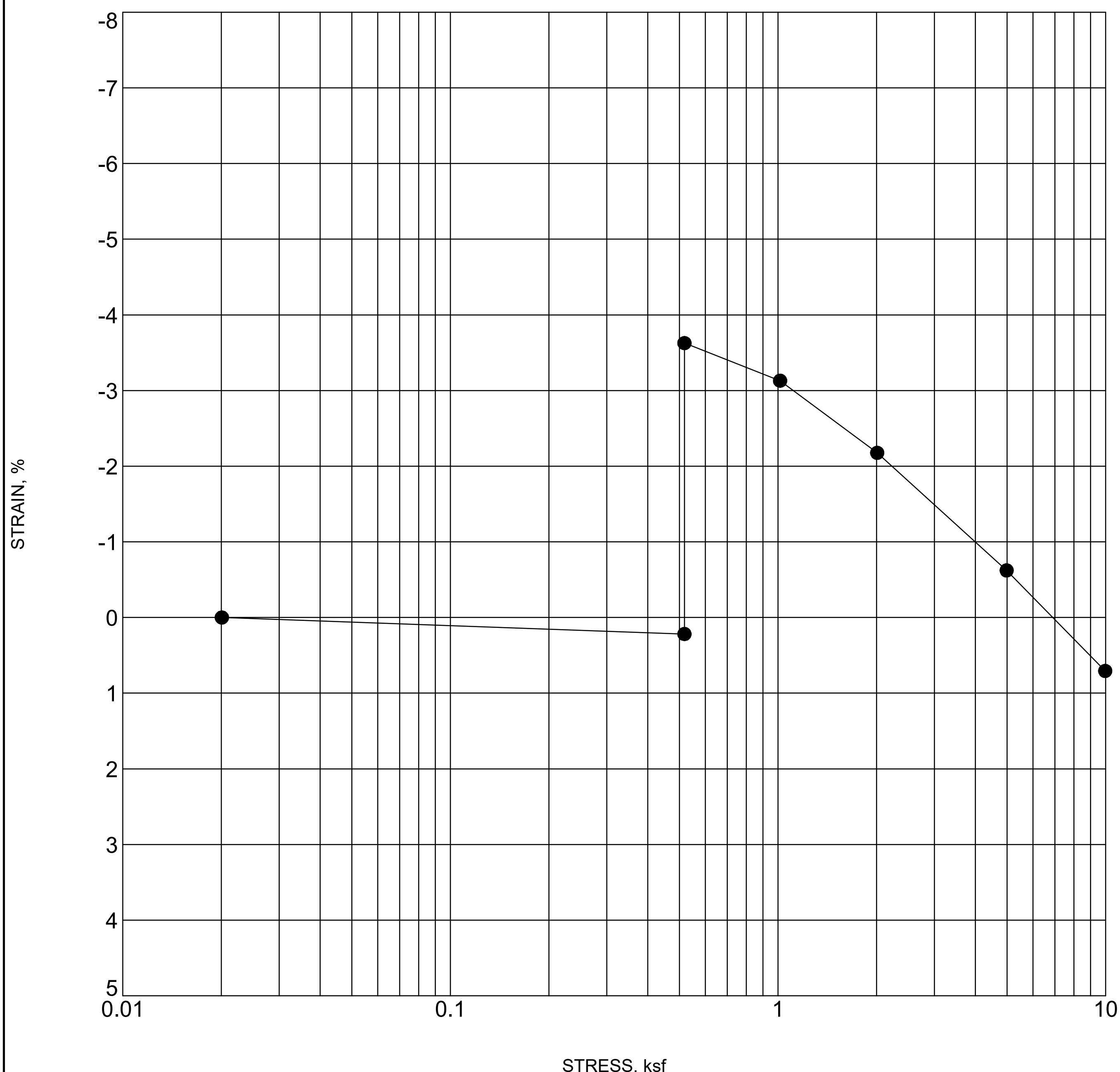
Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● BH-2	2	(Native) CLAY	2.4	109.8	10.4

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction **PROJECT NAME** Matchett Park Community Recreation Center

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado



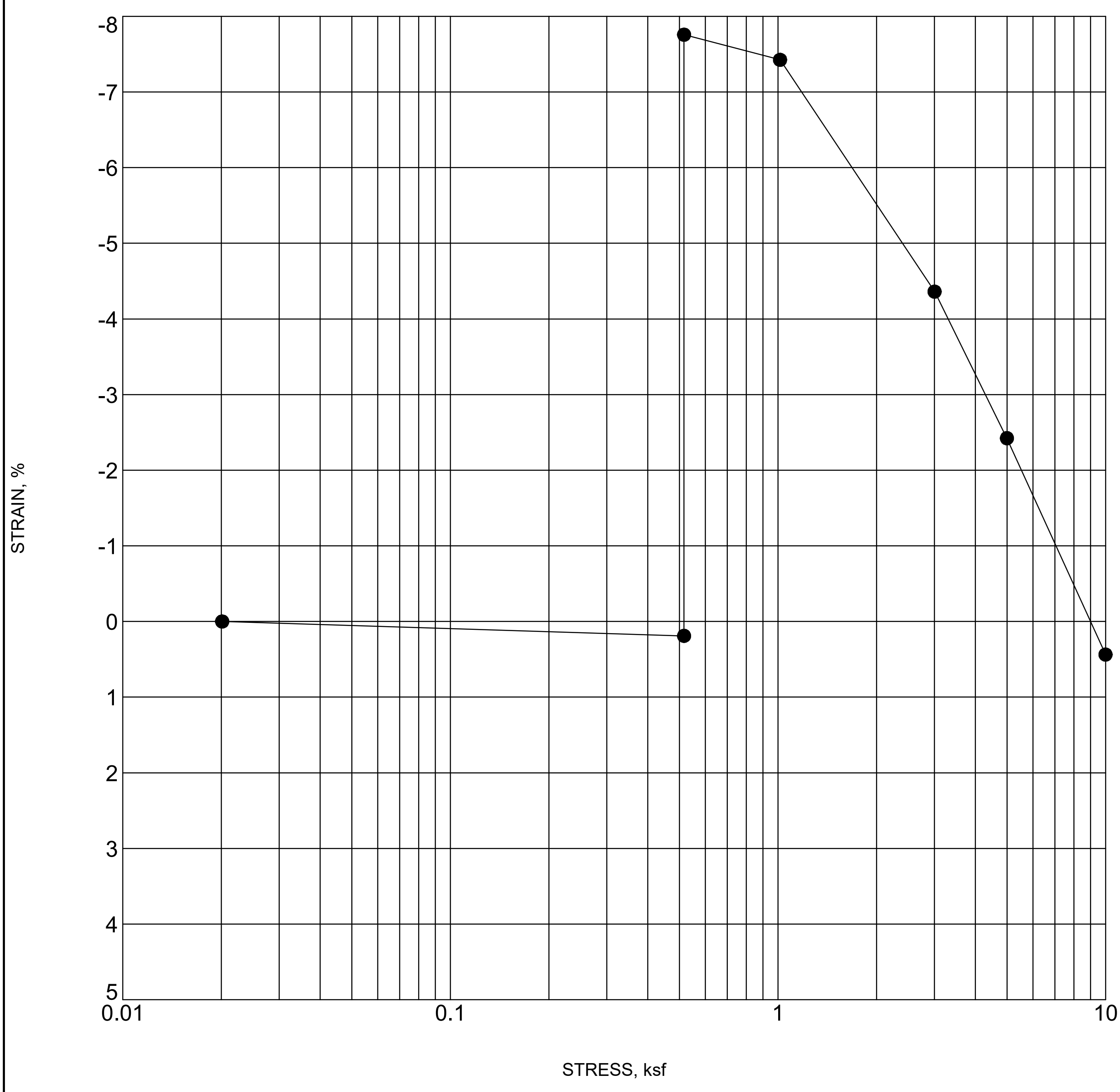
Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● BH-6	8	(Bedrock) CLAYSTONE	3.9	120.0	10.7

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction **PROJECT NAME** Matchett Park Community Recreation Center

PROJECT NUMBER 599.84 **PROJECT LOCATION** Grand Junction, Colorado

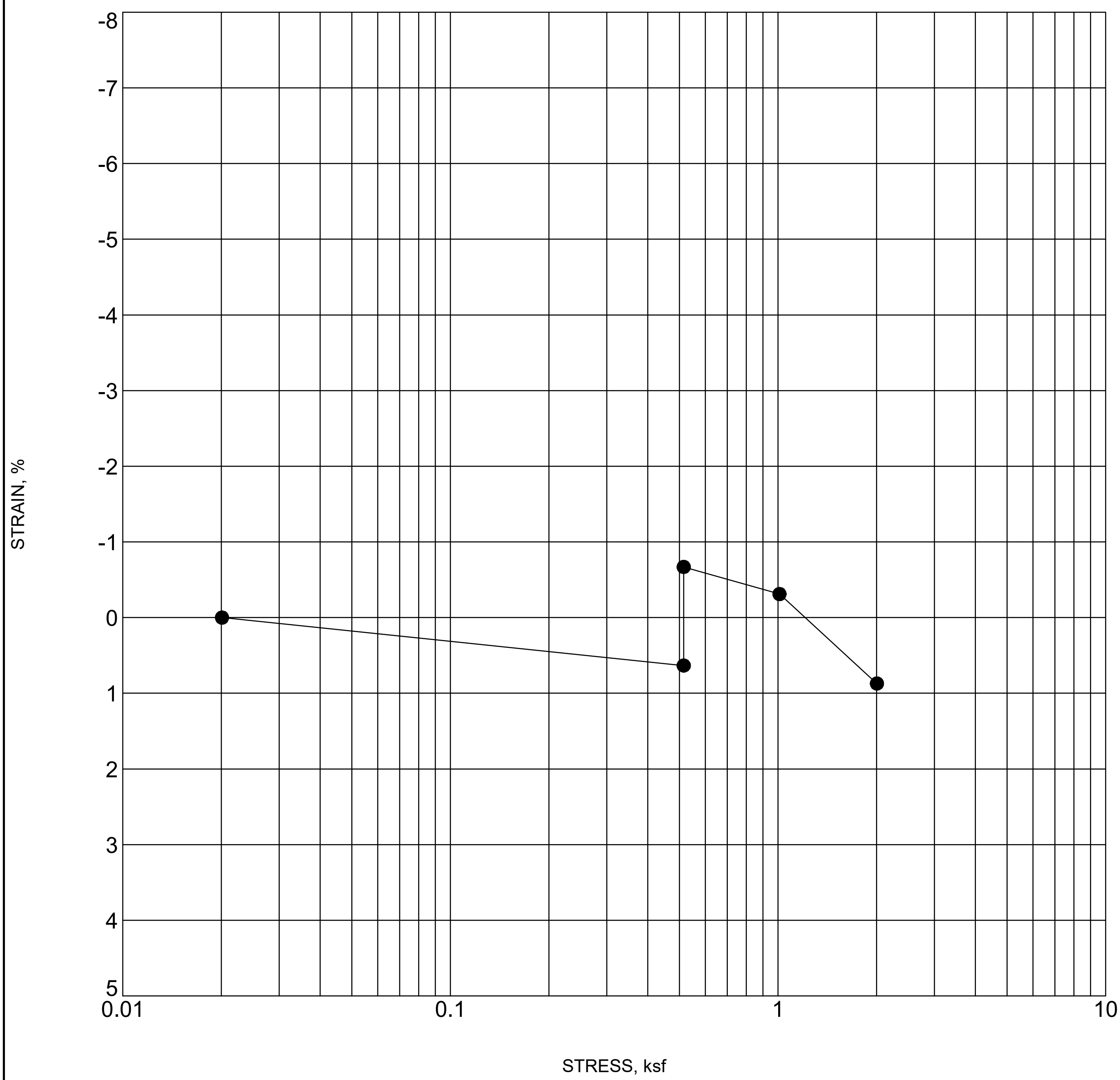


Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● BH-7	9	(Bedrock) SHALE	8.0	128.8	10.0

SWELL - CONSOLIDATION TEST

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Matchett Park Community Recreation Center
PROJECT NUMBER 599.84
PROJECT LOCATION Grand Junction, Colorado

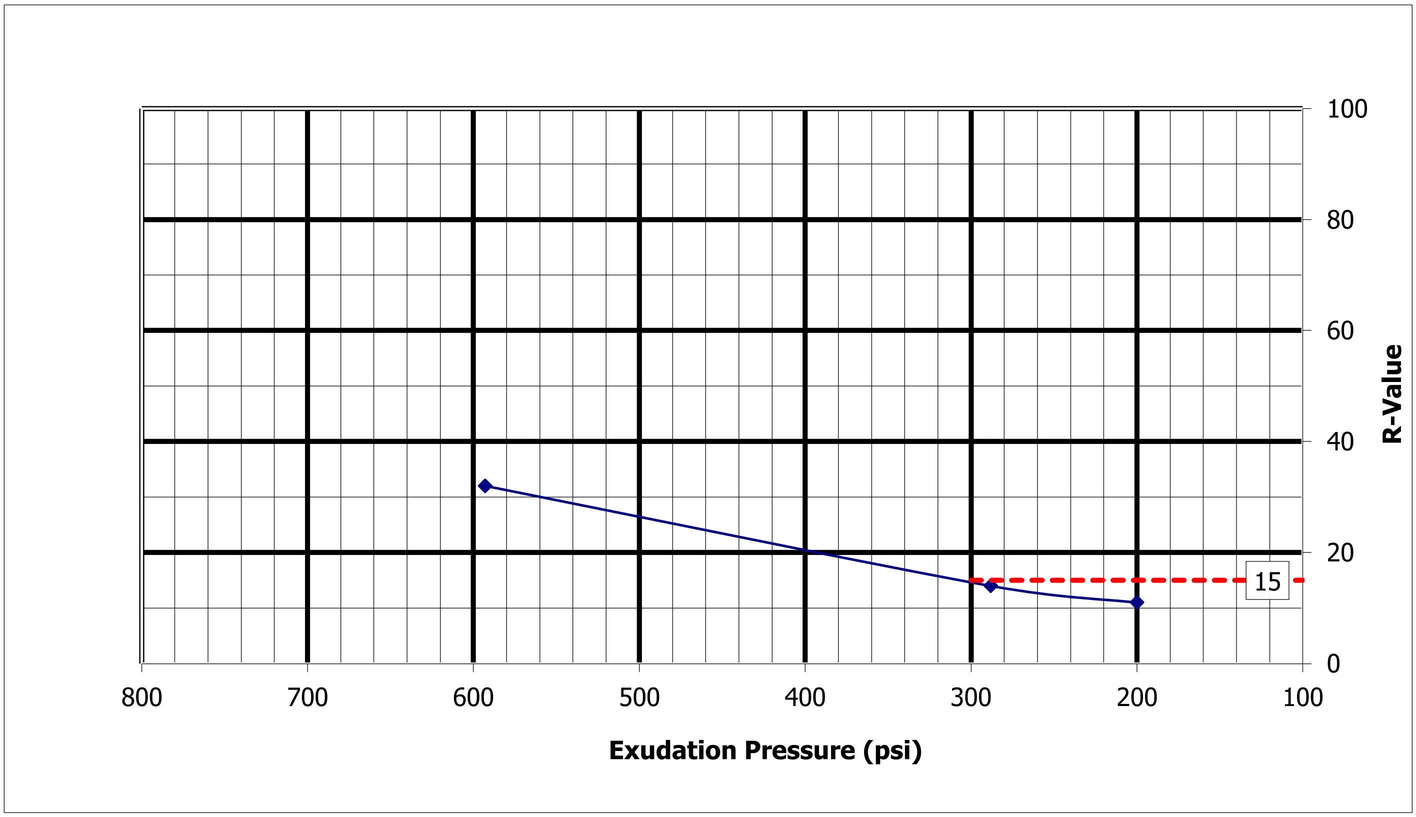


Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● **BH-9**	**4**	**(Bedrock) CLAYSTONE, weathered**	**1.3**	**116.5**	**15.1**

CMT TECHNICAL SERVICES

R-VALUE TEST GRAPH (AASHTO T190)

Project Number:	23.022, RockSol Consulting	Date:	06/21/23
Project Name:	City of GJ Marchett Park Rec Center (RockSol Project No. 599.84)	Technician:	J. De Los Santos
Lab ID Number:	232542	Reviewer:	G. Hoyos
Sample Location:	BH-2 at 2 to 4 feet		
Visual Description:	SAND, clayey, brown		



R-Value @ Exudation Pressure 300 psi: **15**

Specification:

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1 = 3.89**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R = 4,195**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

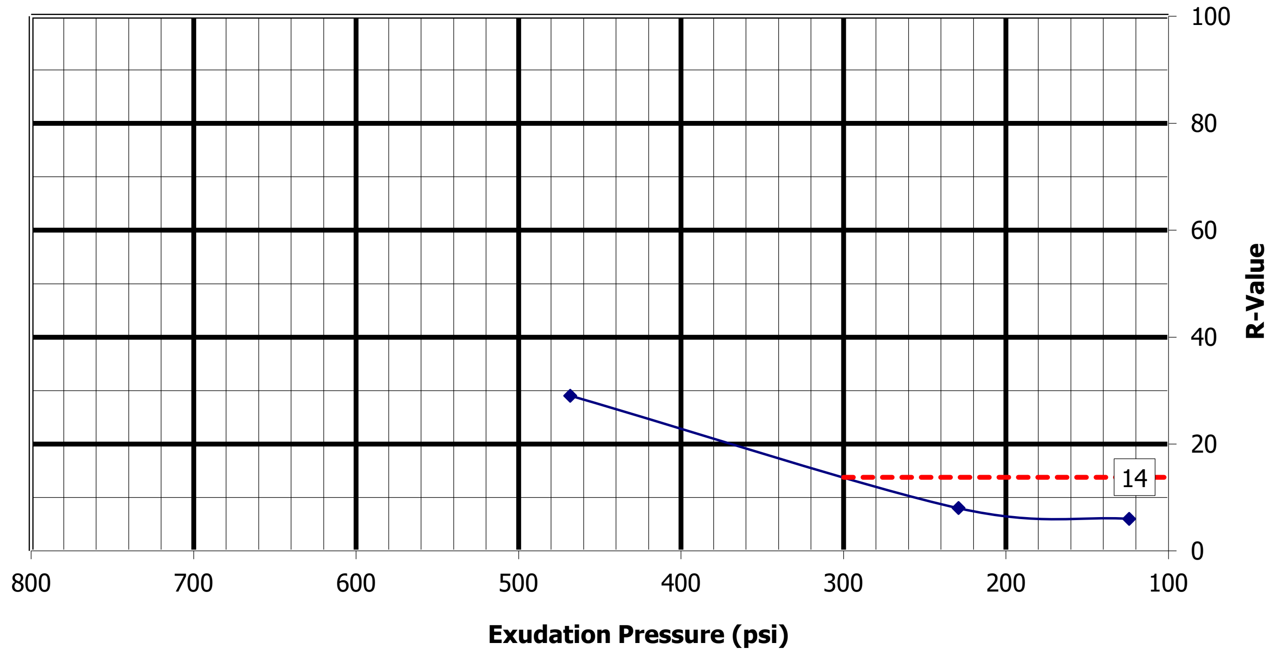
Test Specimen:	1	2	3
Moisture Content, %:	12.0	13.6	15.9
Expansion Pressure, psi:	0.44	0.39	0.09
Dry Density, pcf:	125.0	120.5	113.6
R-Value:	32	14	11
Exudation Pressure, psi:	593	288	200

Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

CMT TECHNICAL SERVICES

R-VALUE TEST GRAPH (AASHTO T190)

Project Number:	23.022, RockSol Consulting	Date:	06/21/23
Project Name:	City of GJ Marchett Park Rec Center (RockSol Project No. 599.84)	Technician:	J. De Los Santos
Lab ID Number:	232543	Reviewer:	G. Hoyos
Sample Location:	BH-6 at 2 to 4 feet		
Visual Description:	CLAY, with sand, brown		



R-Value @ Exudation Pressure 300 psi:	**14**
Specification:	

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1= 3.78**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R= 4,033**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

Test Specimen:	1	2	3
Moisture Content, %:	15.5	19.6	22.1
Expansion Pressure, psi:	1.27	1.06	0.52
Dry Density, pcf:	115.3	108.9	100.6
R-Value:	29	8	6
Exudation Pressure, psi:	468	229	124

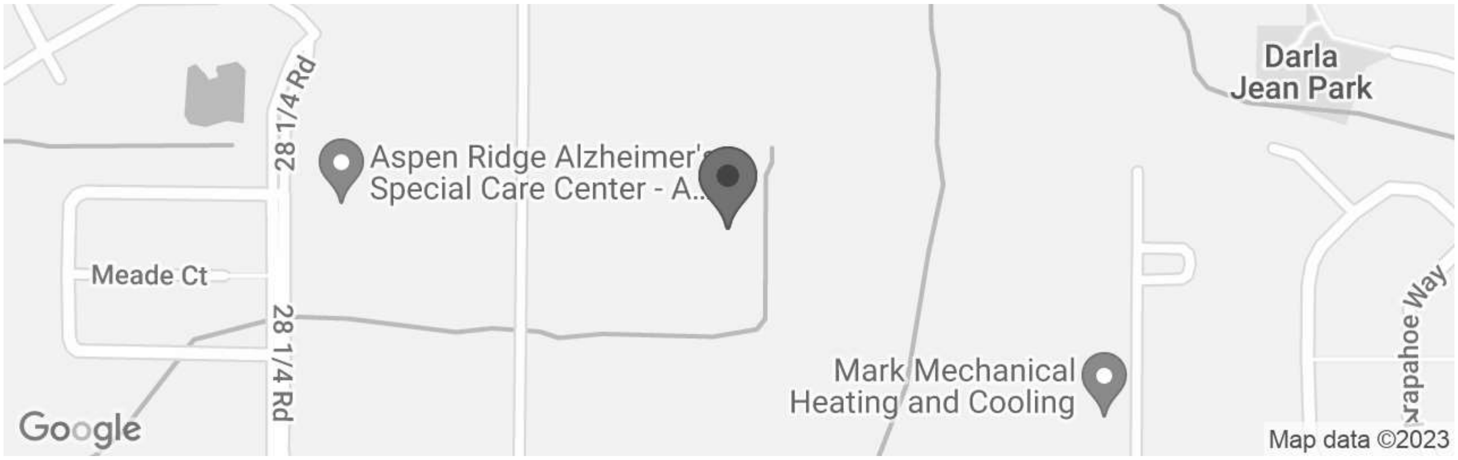
Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

APPENDIX F

SEISMIC COEFFICIENT OUTPUT SHEET

OSHPD

Latitude, Longitude: 39.09479453, -108.52484742



Date	7/18/2023, 12:13:50 PM
Design Code Reference Document	ASCE7-16
Risk Category	III
Site Class	D - Default (See Section 11.4.3)

Type	Value	Description
S_S	0.242	MCE_R ground motion. (for 0.2 second period)
S_1	0.066	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.387	Site-modified spectral acceleration value
S_{M1}	0.158	Site-modified spectral acceleration value
S_{DS}	0.258	Numeric seismic design value at 0.2 second SA
S_{D1}	0.105	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	B	Seismic design category
F_a	1.6	Site amplification factor at 0.2 second
F_v	2.4	Site amplification factor at 1.0 second
PGA	0.134	MCE_G peak ground acceleration
F_{PGA}	1.532	Site amplification factor at PGA
PGA_M	0.206	Site modified peak ground acceleration
T_L	4	Long-period transition period in seconds
SsRT	0.242	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.256	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.066	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.071	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.5	Factored deterministic acceleration value. (Peak Ground Acceleration)
PGA_{UH}	0.134	Uniform-hazard (2% probability of exceedance in 50 years) Peak Ground Acceleration
C_{RS}	0.946	Mapped value of the risk coefficient at short periods
C_{R1}	0.932	Mapped value of the risk coefficient at a period of 1 s
C_V	0.784	Vertical coefficient

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APPENDIX G

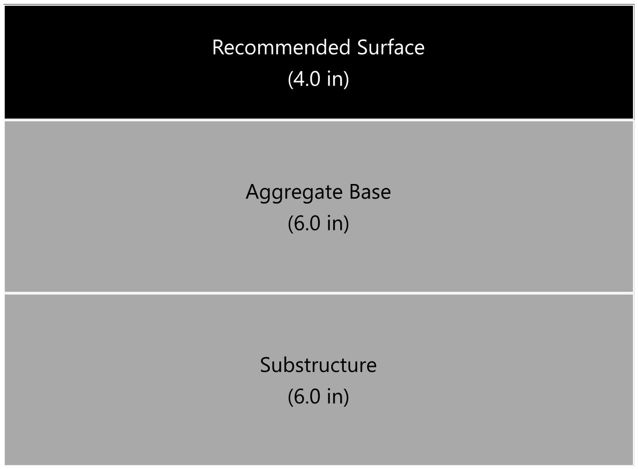
PAVEXPRESS FLEXIBLE PAVEMENT OUTPUT SHEET

Project: Matchett Park

Matchett Park and Community Recreation Center Parking Lots

AASHTO '93/'98: Flexible Pavement Design

Pavement Diagram



Required minimum design SN: 2.50

Layer Thicknesses (in)

Recommended Surface: 4.0 in
Aggregate Base: 6.0 in
Substructure: 6.0 in

Total SN: 3.00

⚠ *The Design SN exceeds the Required SN due to the layer protection check. A base layer thickness can be reduced; however, the reduction may create issues with construction. Therefore, care must be taken before adjusting the fixed or minimum thickness.*

Print

Details

Scenario: Matchett Park and Community Recreation Center Parking Lots

Created By: Jay Goldbaum, Goldbaum@RockSol.com

Last Modified: July 21, 2023 7:16:58 am

Design Parameters

Design Period: 30 years

Reliability Level (R): 90%

Combined Standard Error (S_0): 0.44

Initial Servicability Index (p_i): 4.5

Terminal Servicability Index (p_t): 2

Delta Servicability Index (ΔPSI): 2.5

Total Design ESALs (W_{18}): 103000

Layers

Recommended Surface - Asphalt

Thickness: 4 in

Aggregate Base - Base

Thickness: 6 in

Structural Coefficient: 0.12

Drainage Coefficient: 0.9

Substructure - Base

Thickness: 6 in

Structural Coefficient: 0.11

Drainage Coefficient: 0.9

APPENDIX H

PAVEMENTDESIGNER.ORG RIGID PAVEMENT OUTPUT SHEET

DESIGN SUMMARY REPORT FOR

CONCRETE PARKING LOT

DATE CREATED:

Thu Jul 20 2023 17:42:43 GMT-0600 (Mountain Daylight Time)

Project Description

Project Name:	Matchett Park	Owner:	City of Grand Junction	**Zip Code:**
Designer's Name:	Jay Goldbaum	**Route:**		
Project Description:	Parking Lots			

Design Summary

	Undoweled		Undoweled
Recommended Design Thickness:	5.75 in	Maximum Joint Spacing:	12 ft
Calculated Minimum Thickness:	5.60 in		

Pavement Structure

SUBBASE

User-Defined Composite K-Value of Substructure: 125 psi/in

CONCRETE

28-Day Flex Strength:	650 psi	Edge Support:	YES
Modulus of Elasticity:	4200000 psi		

SUBGRADE

CBR Value:	5.82 %
Calculated MRSG Value:	6482 psi

Project Level

TRAFFIC

Spectrum Type:	ACI 330 Traffic Spectrum D
Design Life:	30 years

USER DEFINED TRAFFIC

Trucks Per Day:	20

GLOBAL

Reliability:	90 %
% Slabs Cracked at End of Design Life:	7 %

Design Method

The PCA design methodology from StreetPave, was used to produce these results. Note: ACI 330 tables are generated using this same methodology.

APPENDIX I

PAVEMENT M-E DESIGN 20 AND 30-YEAR FLEXIBLE PAVEMENT OUTPUT SHEETS

Matchett Park New HMA (20-Year)

File Name: C:\Users\goldbaum\Documents\My PMED Designs\My ME Design\Projects\Matchett Park\Matchett Park New HMA (20-Year).dgpx

Design Inputs

Design Life: 20 years
Design Type: FLEXIBLE

Base construction: May, 2024
Pavement construction: July, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.134, -108.538

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R2 Level 1 SX(75) PG 64-22	4.0
NonStabilized	Crushed gravel	6.0
NonStabilized	River-run gravel	6.0
Subgrade	A-7-6	6.0
Subgrade	A-7-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.8
Air voids (%)	6.9

Traffic

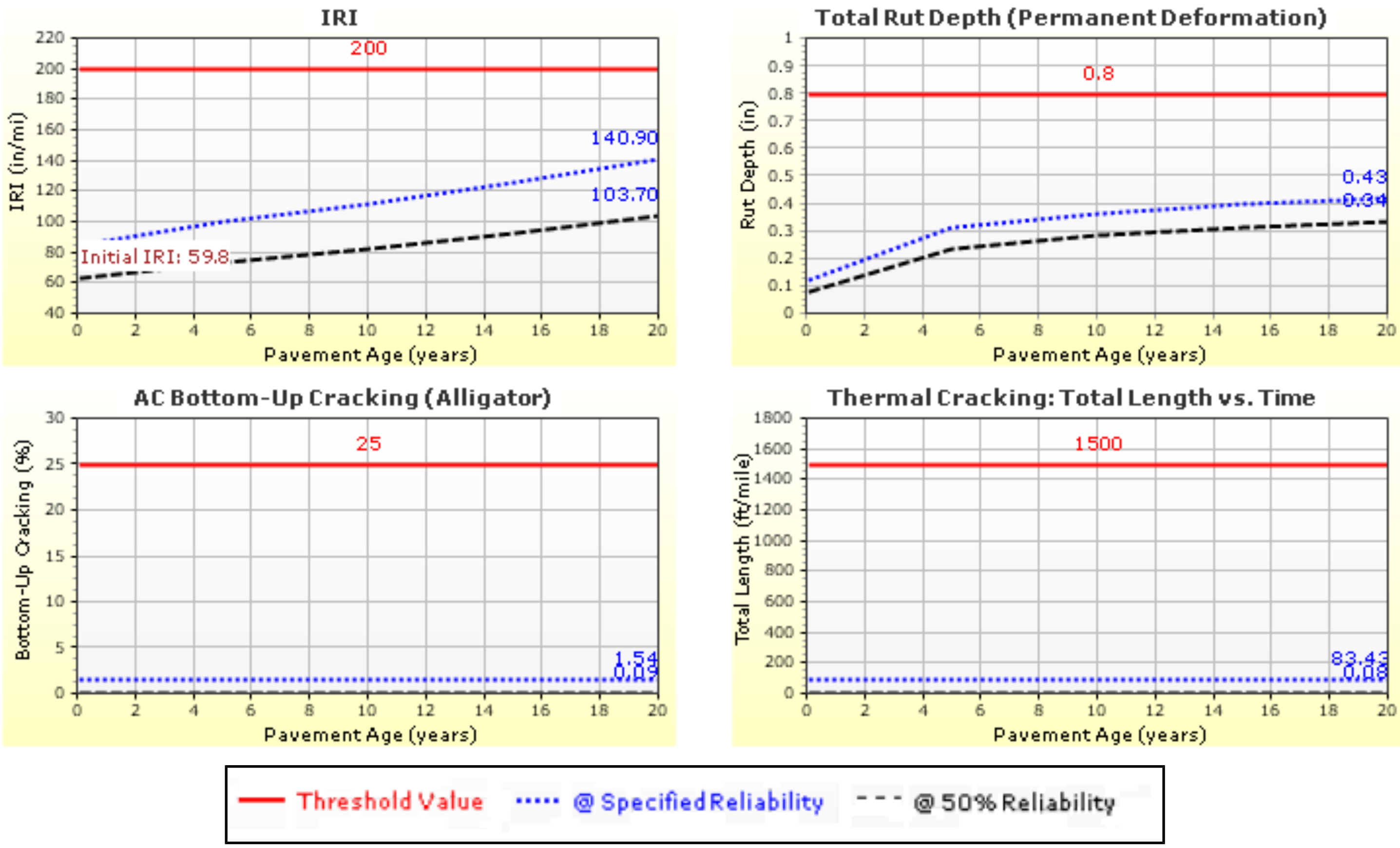
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	20
2034 (10 years)	80,723
2044 (20 years)	181,070

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	140.86	90.00	99.96	Pass
Permanent deformation - total pavement (in)	0.80	0.43	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	1.54	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	83.43	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	3000.00	392.00	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.65	0.03	90.00	100.00	Pass

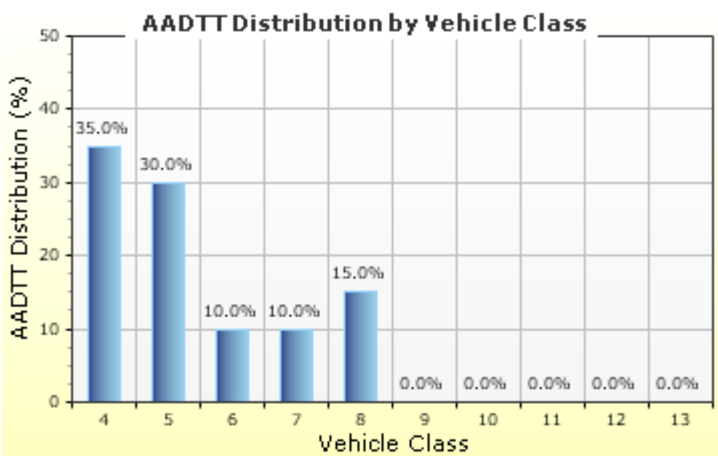
Distress Charts

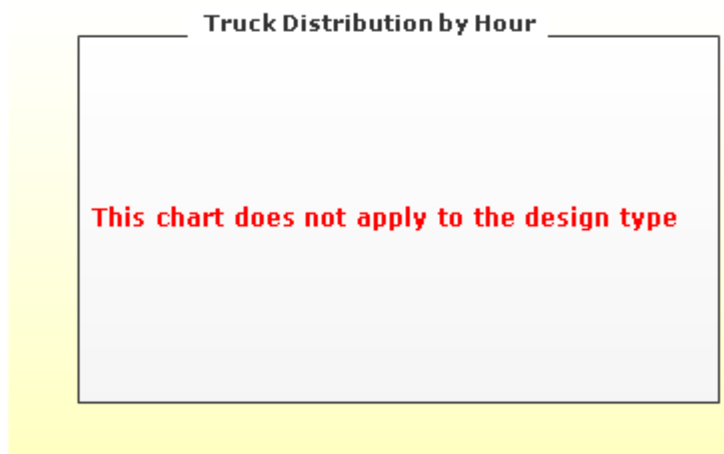


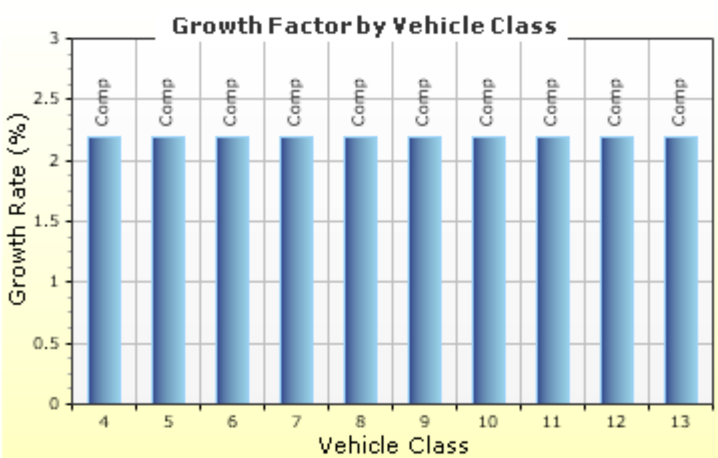
Traffic Inputs

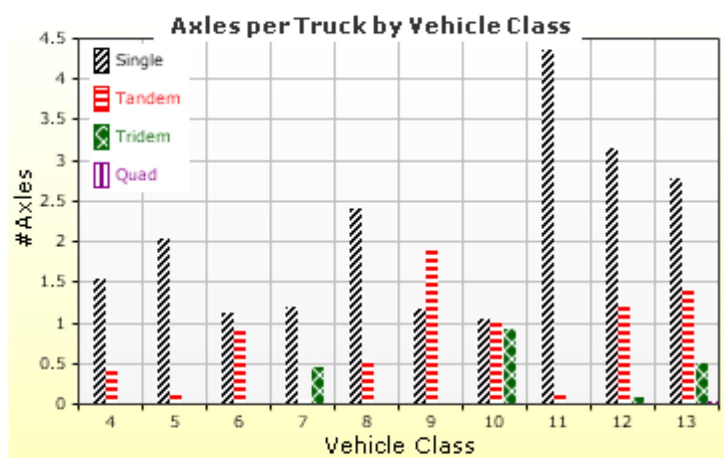
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	20	Percent of trucks in design direction (%):	100.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	25.0

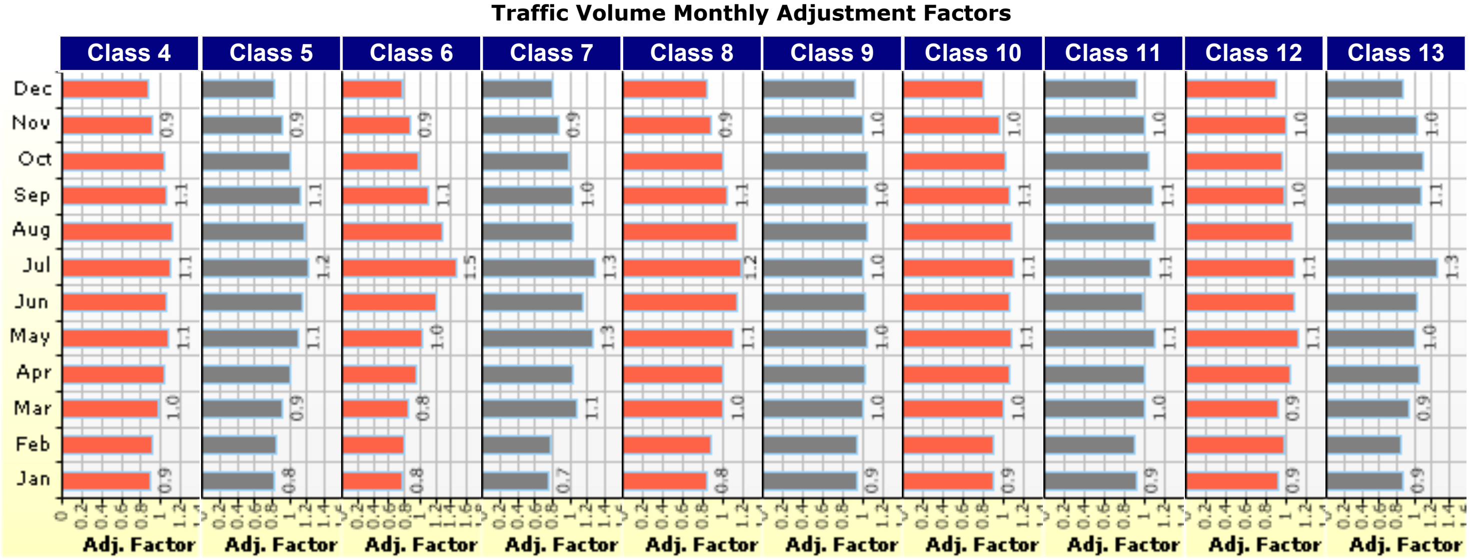








Traffic Volume Monthly Adjustment Factors



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	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	35%	2.2%	Compound
Class 5	30%	2.2%	Compound
Class 6	10%	2.2%	Compound
Class 7	10%	2.2%	Compound
Class 8	15%	2.2%	Compound
Class 9	0%	2.2%	Compound
Class 10	0%	2.2%	Compound
Class 11	0%	2.2%	Compound
Class 12	0%	2.2%	Compound
Class 13	0%	2.2%	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

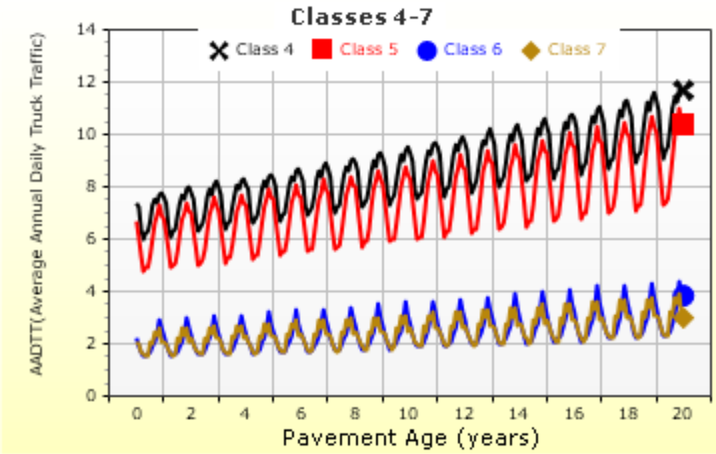
Wheelbase does not apply

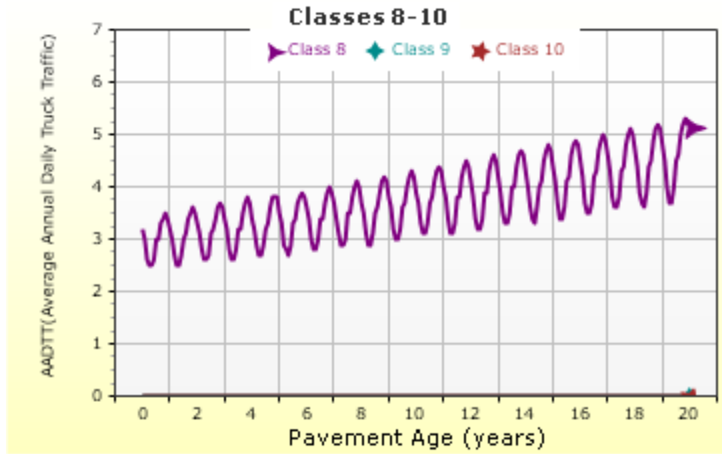
Number of Axles per Truck

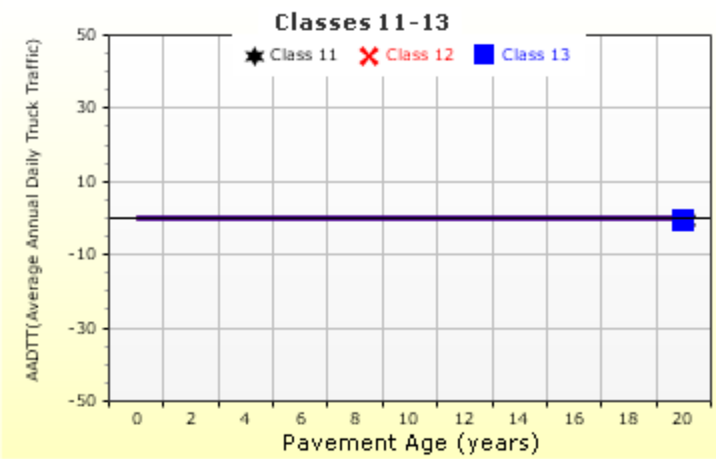
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

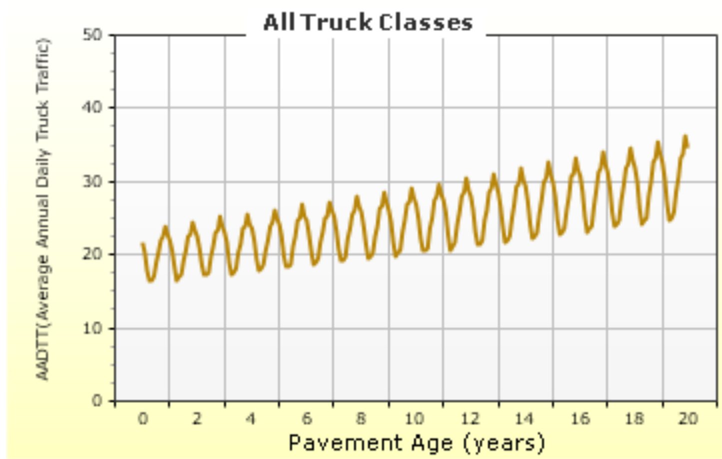
AADTT (Average Annual Daily Truck Traffic) Growth

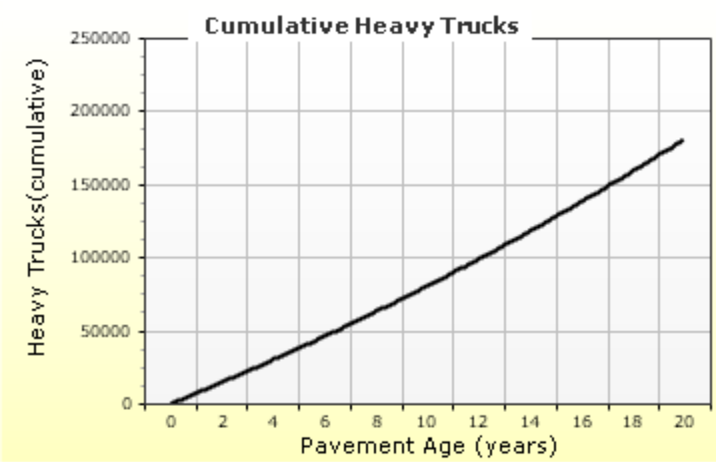
*** Traffic cap is not enforced**







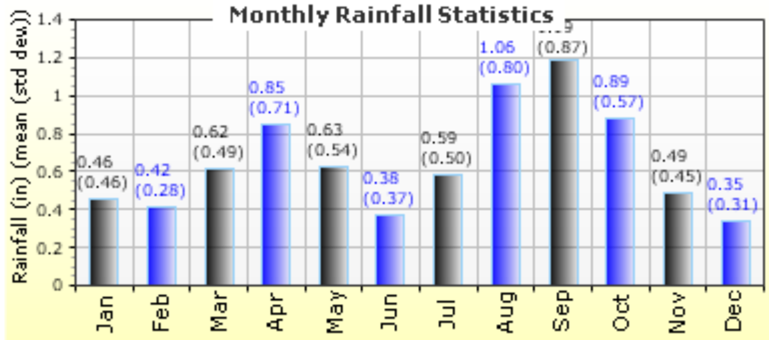




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
GRAND JUNCTION, CO	39.13400 -108.53800 4839

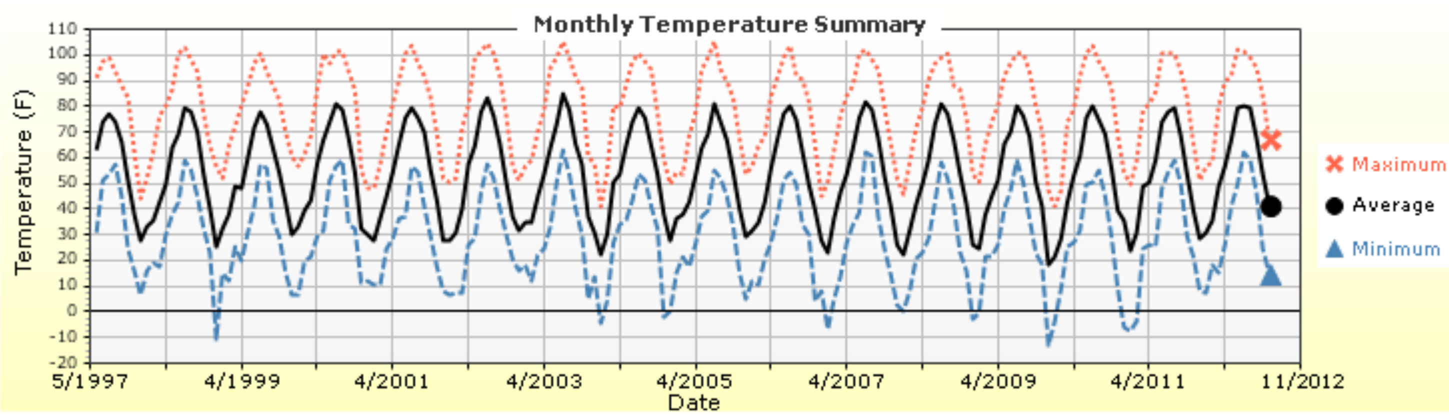


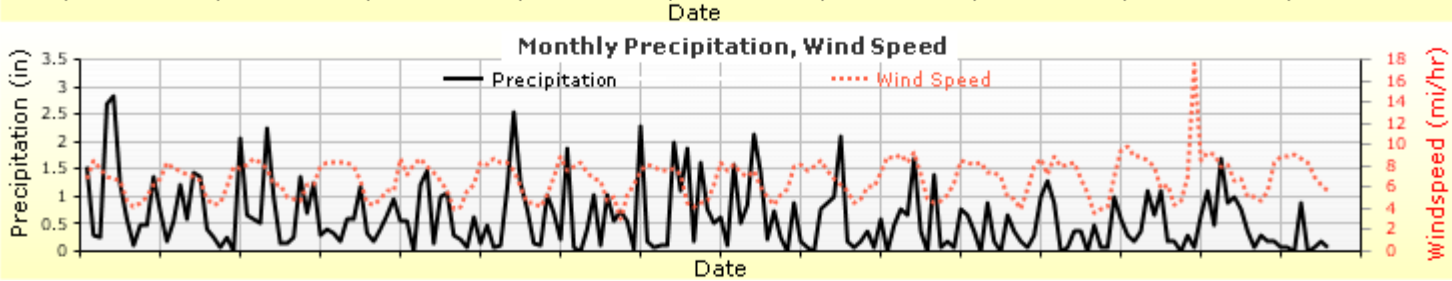
Annual Statistics:

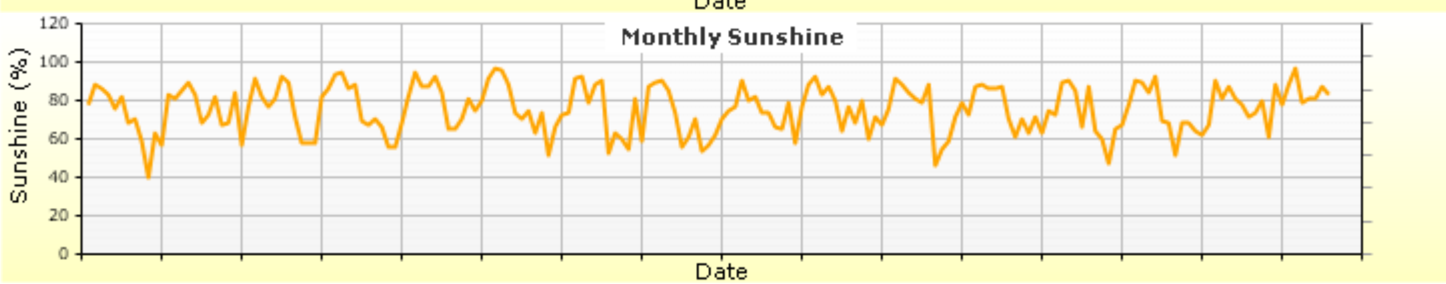
Mean annual air temperature (ºF)	53.75
Mean annual precipitation (in)	7.96
Freezing index (ºF - days)	360.58
Average annual number of freeze/thaw cycles:	111.77

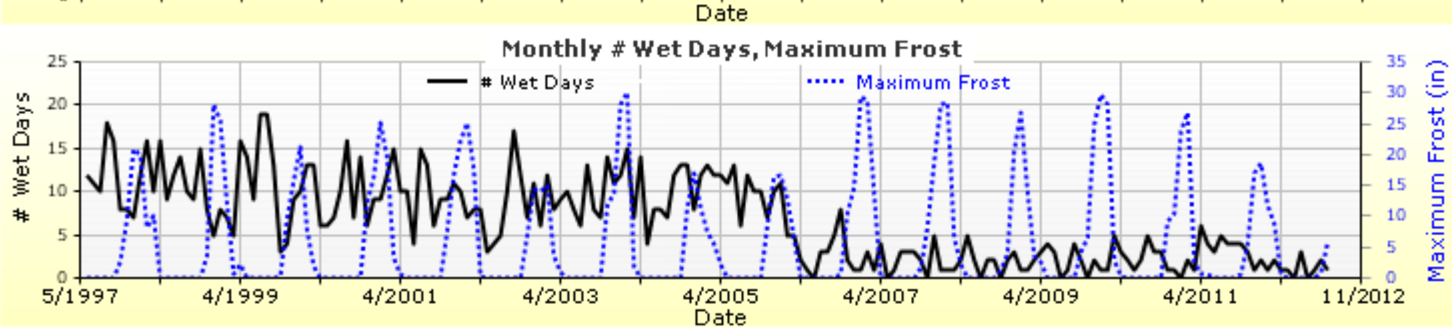
Water table depth (ft) 4.00

Monthly Climate Summary:





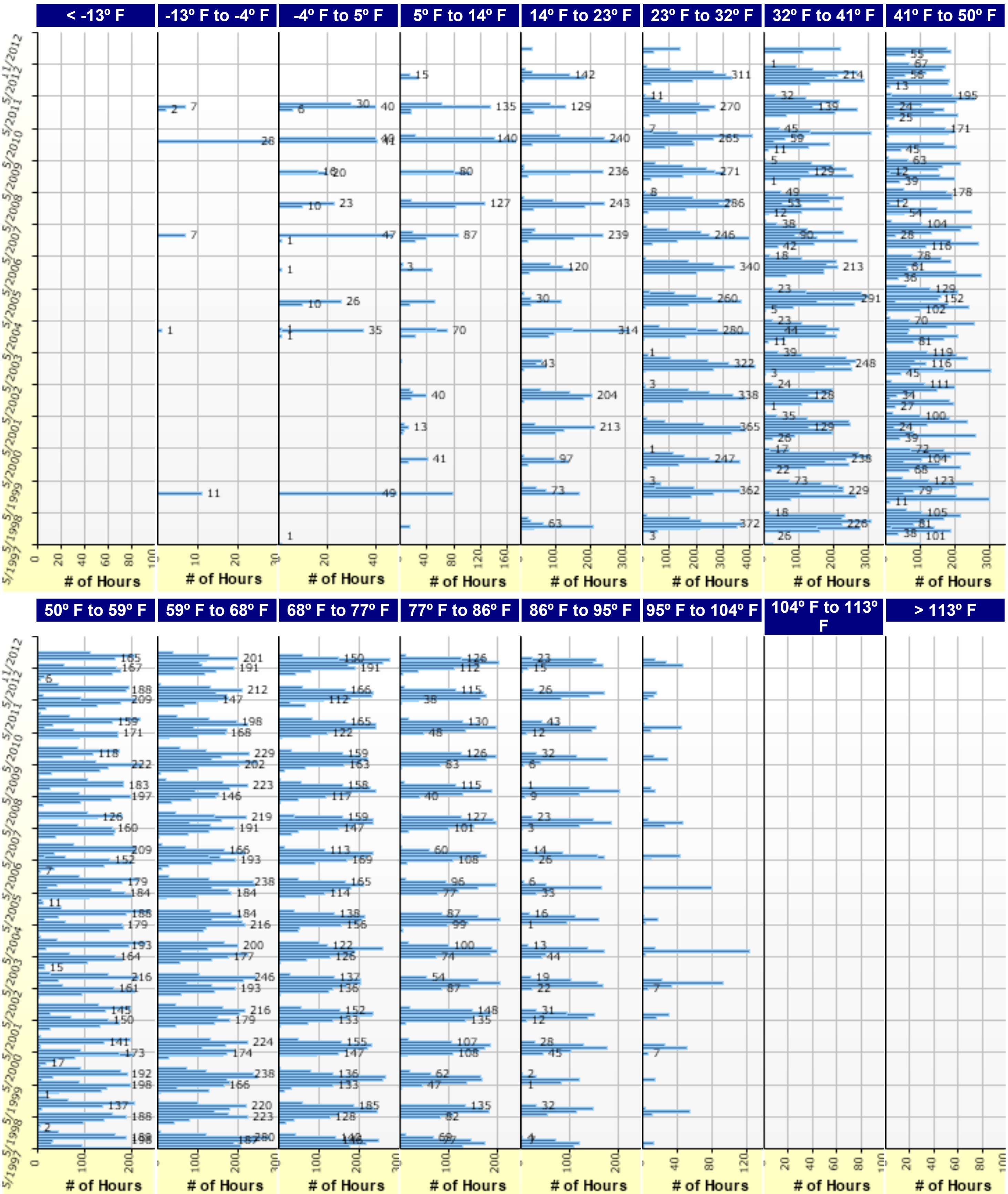




Matchett Park New HMA (20-Year)

File Name: C:\Users\goldbaum\Documents\My PMED Designs\My ME Design\Projects\Matchett Park\Matchett Park New HMA (20-Year).dgpx

Hourly Air Temperature Distribution by Month:



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

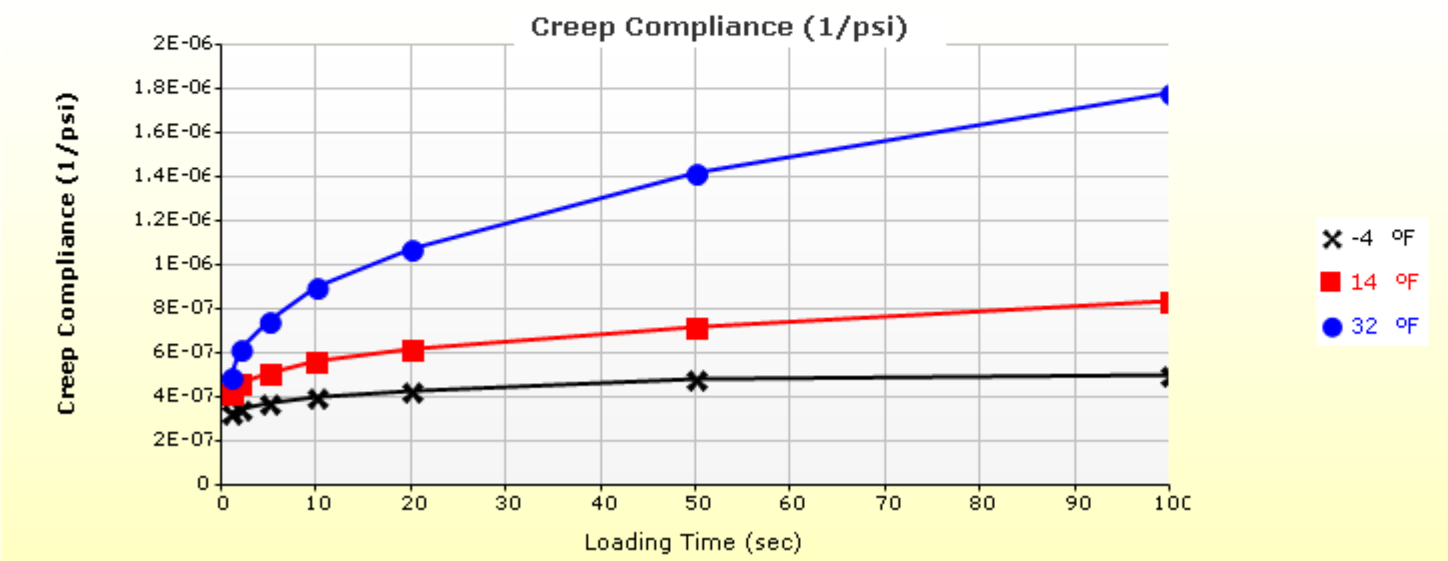
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : R2 Level 1 SX (75) PG 64-22	Flexible (1)	1.00
Layer 2 Non-stabilized Base : Crushed gravel	Non-stabilized Base (4)	1.00
Layer 3 Non-stabilized Base : River-run gravel	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : A-7-6	Subgrade (5)	1.00
Layer 5 Subgrade : A-7-6	Subgrade (5)	-

Thermal Cracking (Input Level: 1)

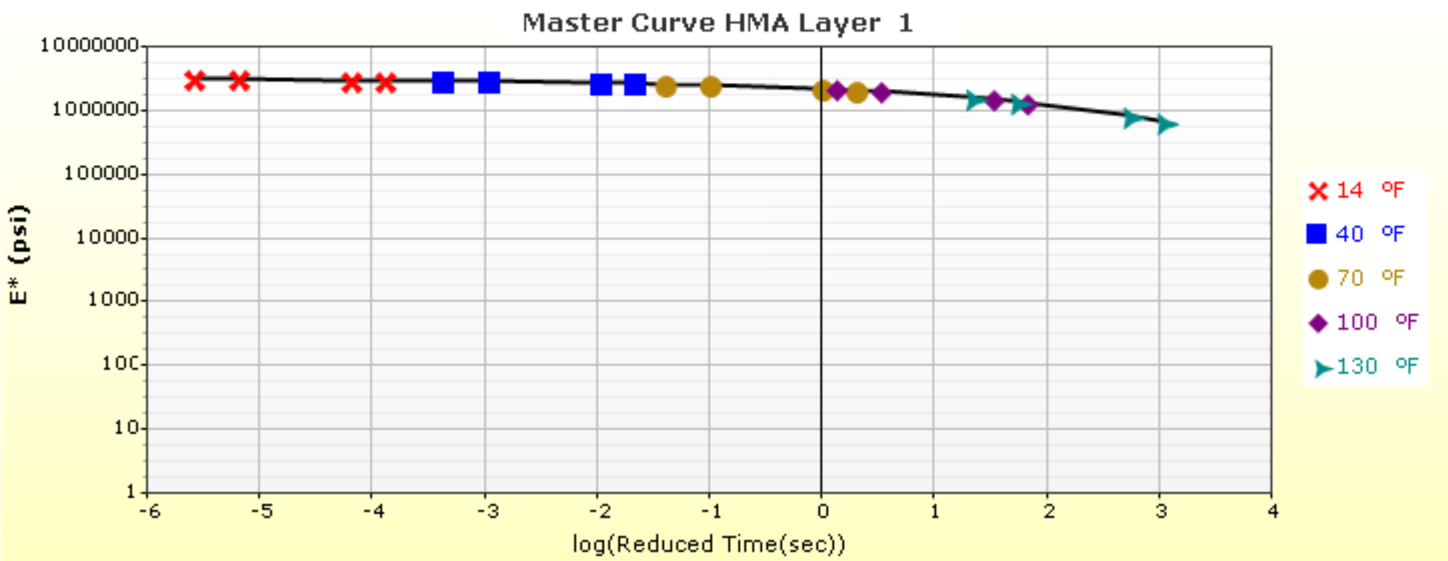
Indirect tensile strength at 14 ºF (psi)	451.00

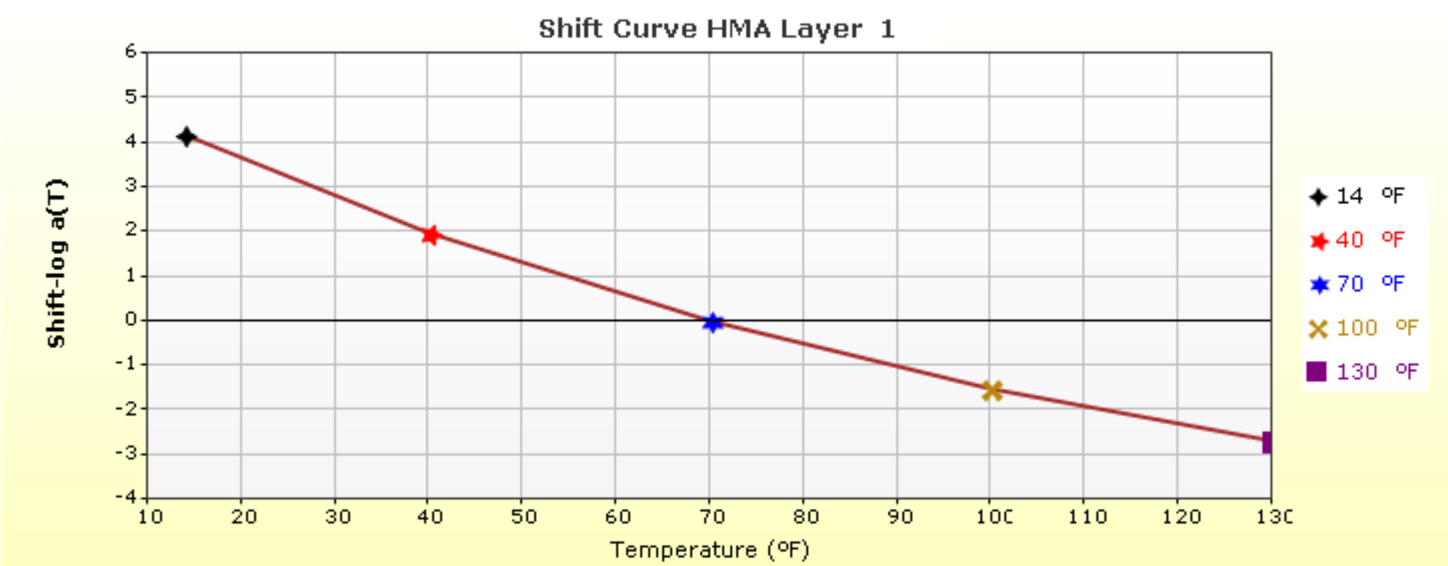
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	11.8

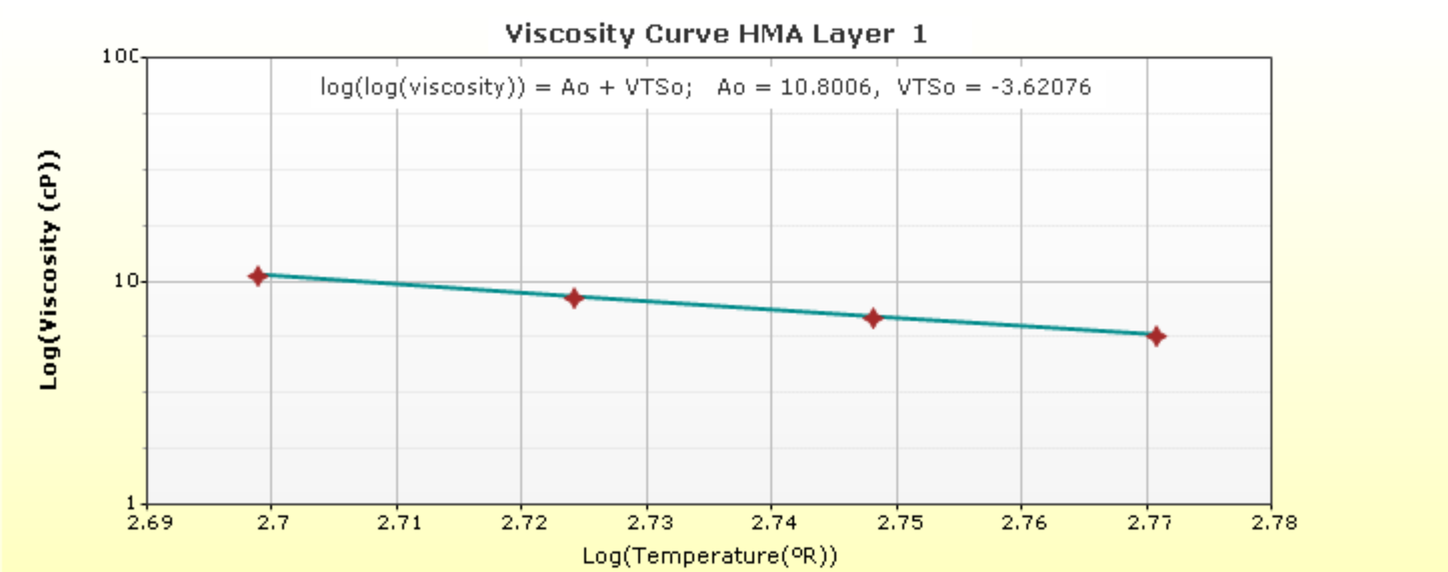
	Creep Compliance (1/psi)		
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	3.34e-007	4.19e-007	4.99e-007
2	3.53e-007	4.64e-007	6.19e-007
5	3.79e-007	5.15e-007	7.49e-007
10	4.05e-007	5.70e-007	9.08e-007
20	4.31e-007	6.26e-007	1.08e-006
50	4.87e-007	7.27e-007	1.43e-006
100	5.05e-007	8.41e-007	1.79e-006



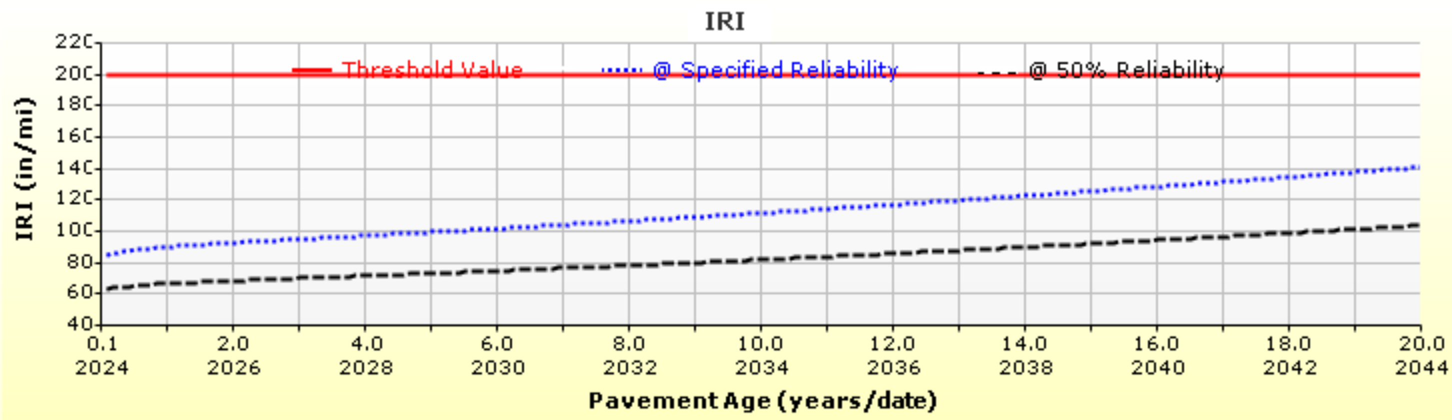
HMA Layer 1: Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

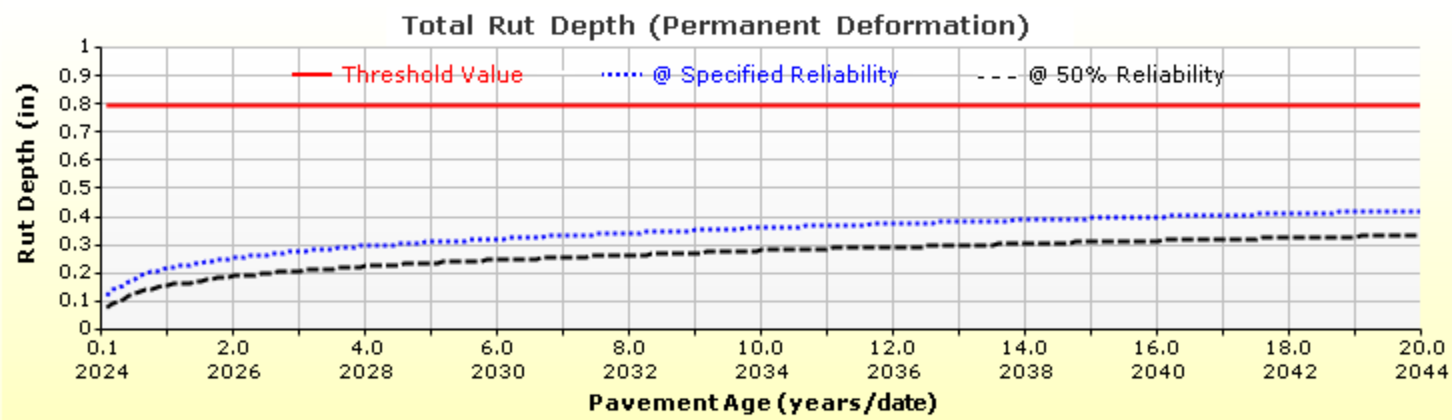


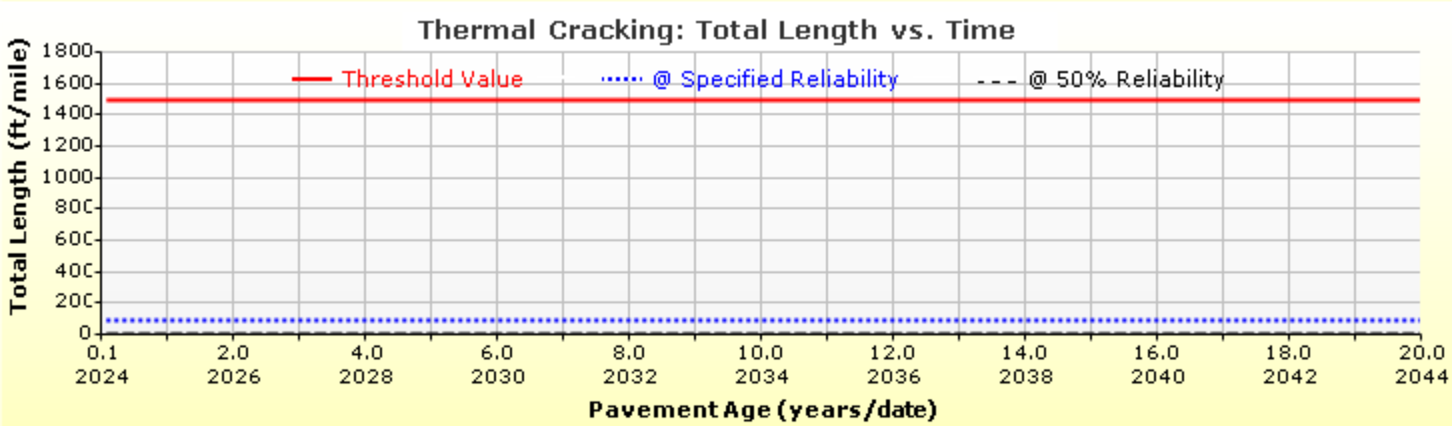


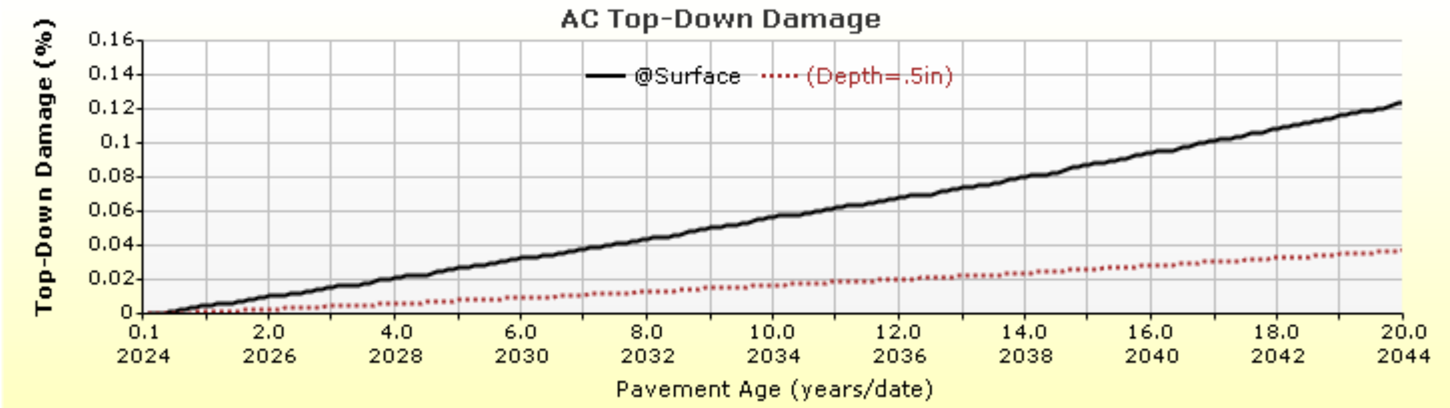


Analysis Output Charts

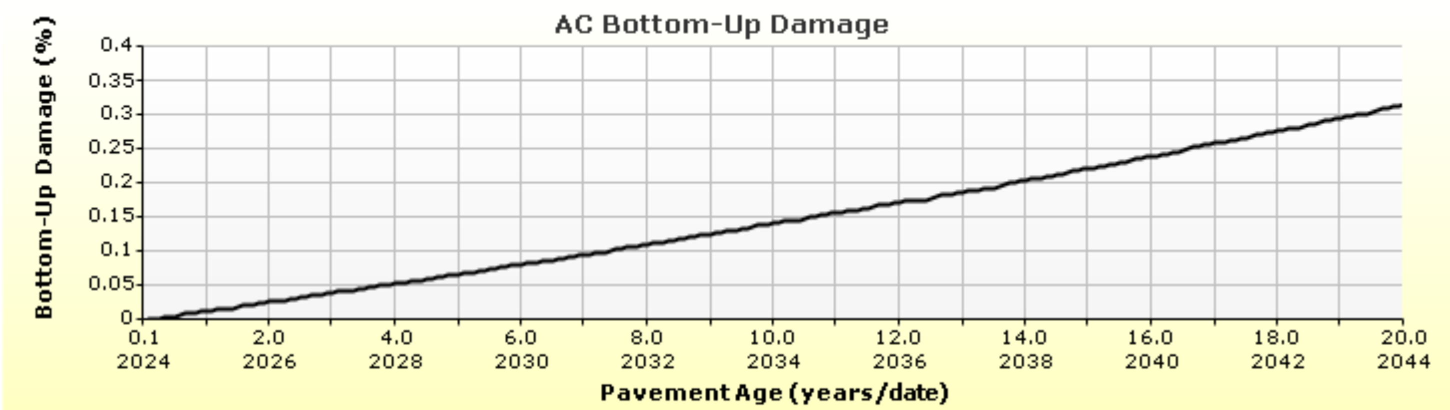




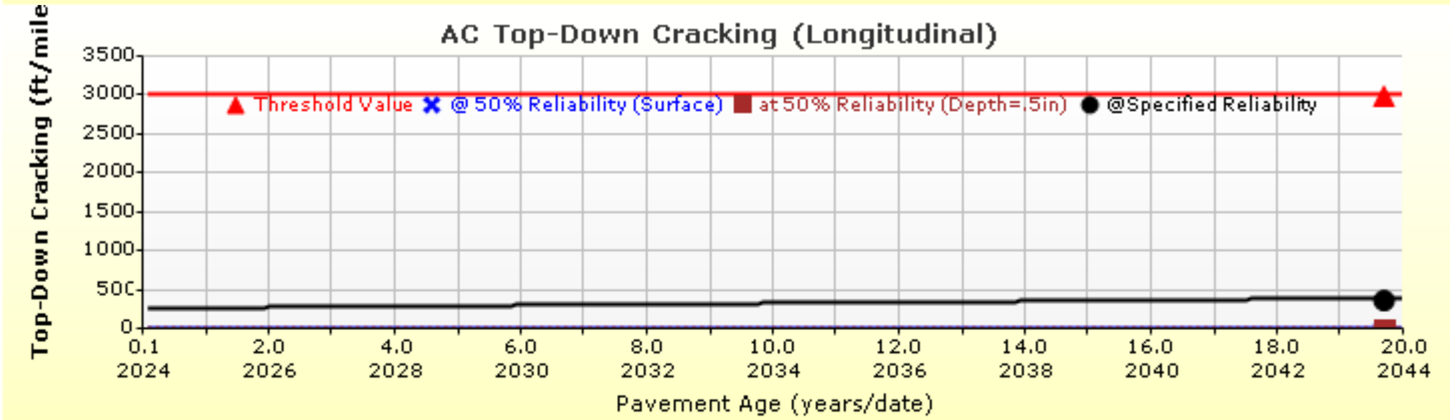




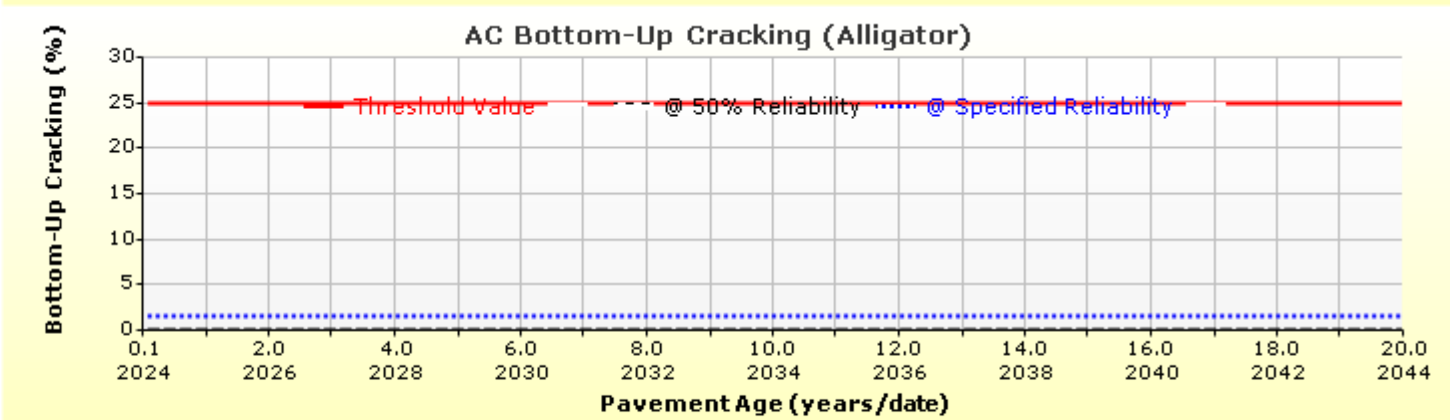
AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)



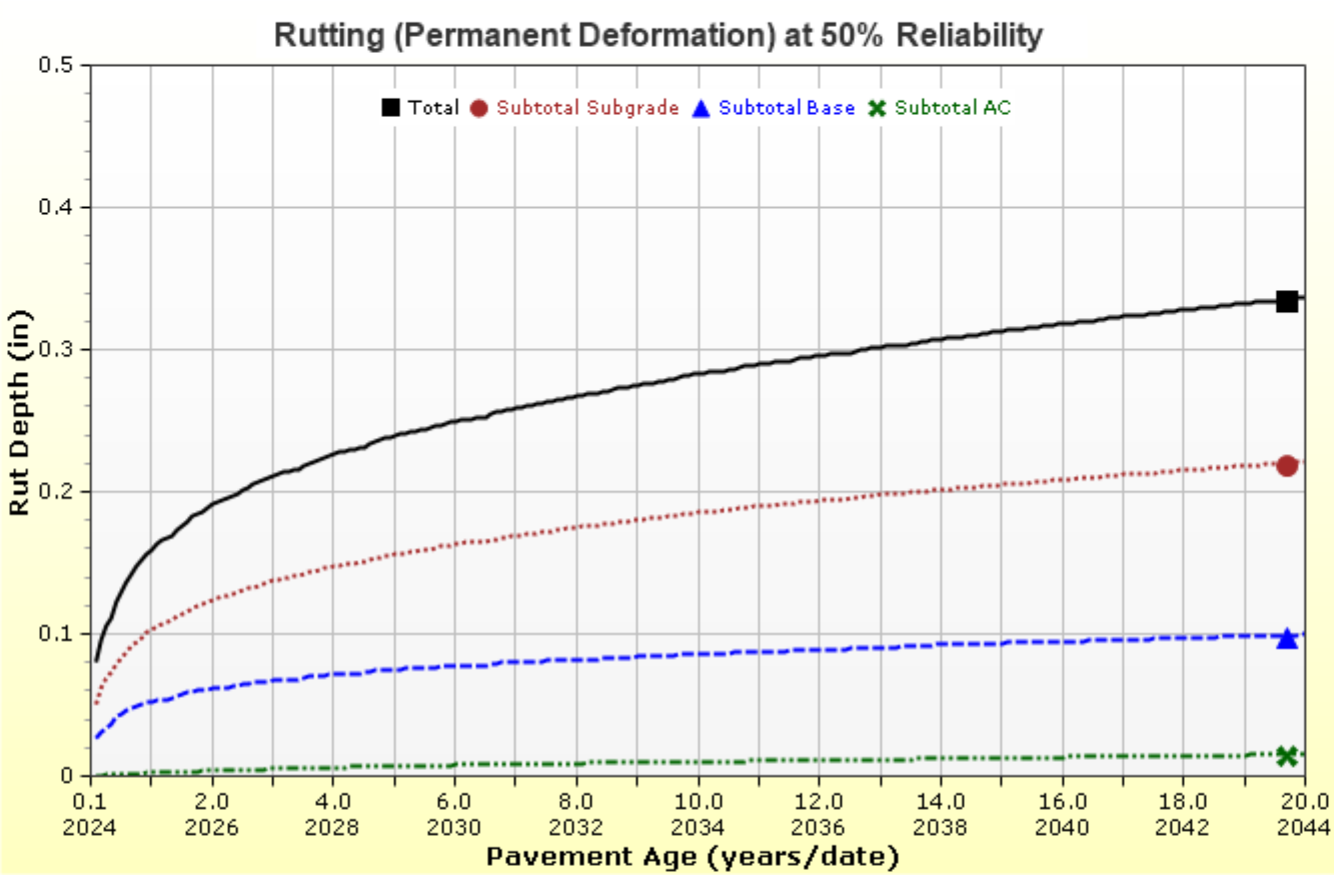
AC Bottom-Up Damage
Bottom-Up Damage (%)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)

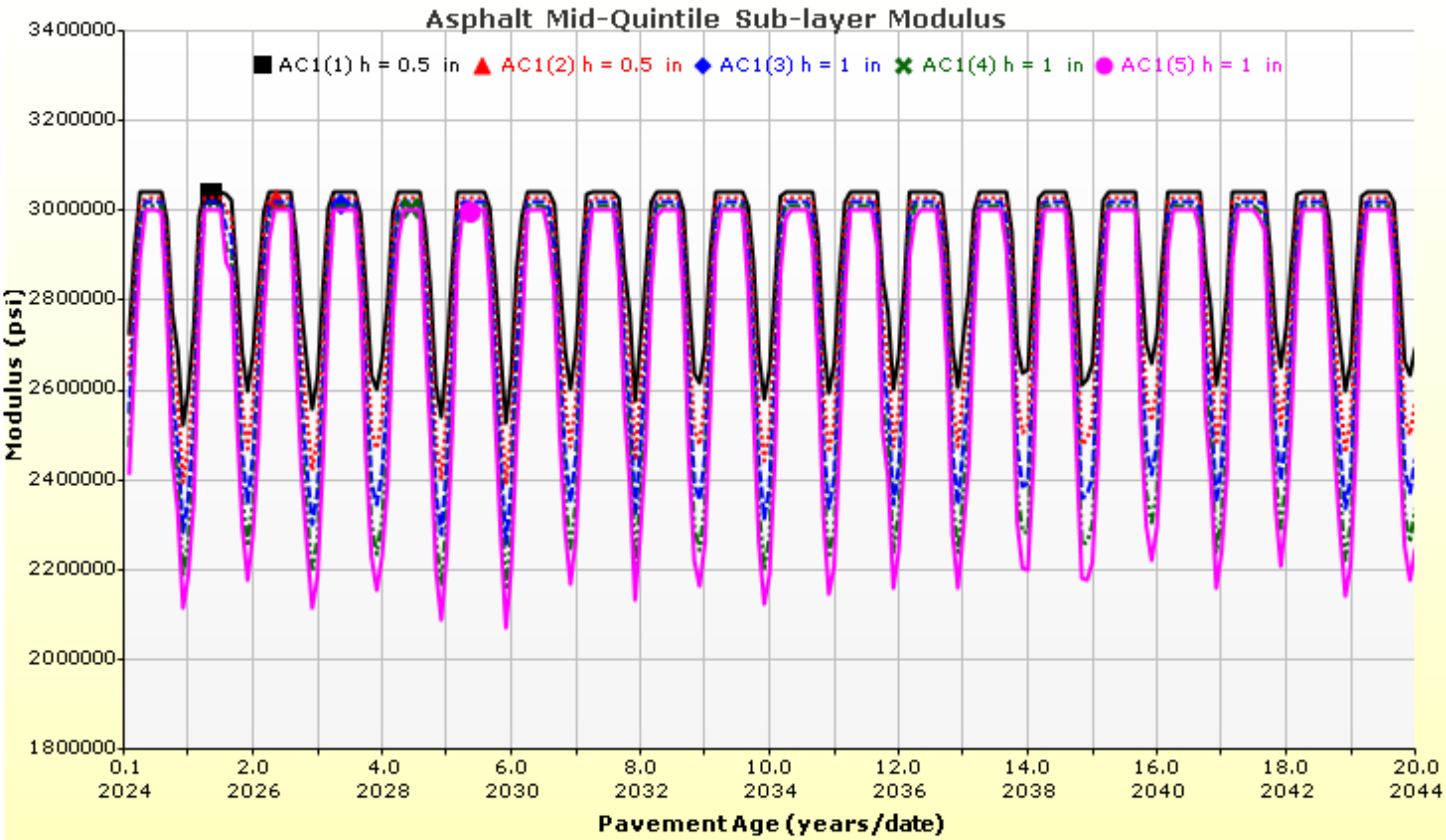


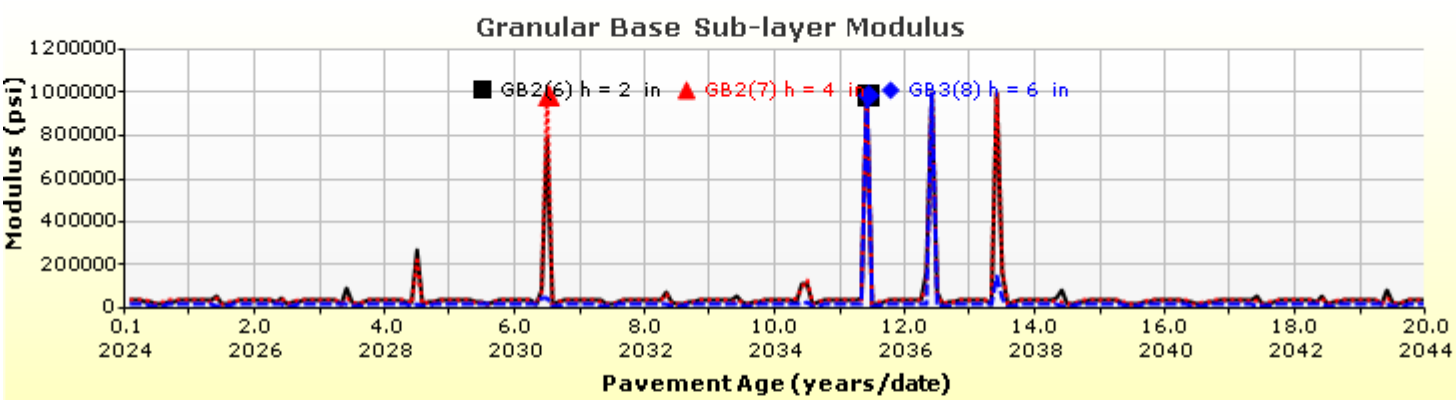
AC Top-Down Cracking (Longitudinal)
Threshold Value
@ 50% Reliability (Surface)
at 50% Reliability (Depth=.5in)
@Specified Reliability
Top-Down Cracking (ft/mile
3500
3000
2500
2000
1500
1000
500
0
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)

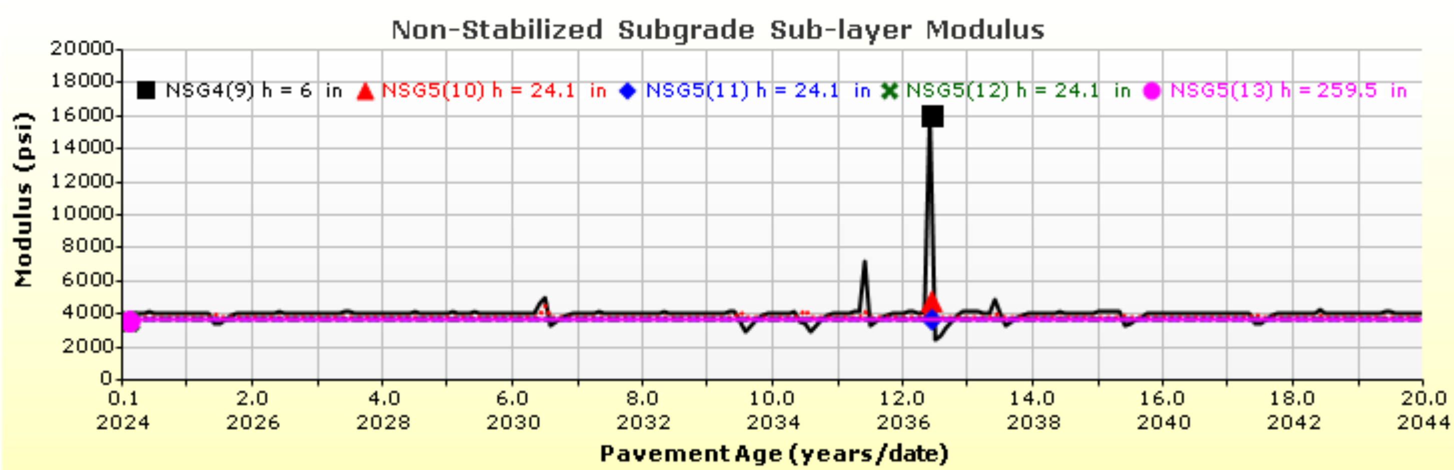


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
30
25
20
15
10
5
0
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044
Pavement Age (years/date)


Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal Base
Subtotal AC
Rut Depth (in)
Pavement Age (years/date)
0.5
0.4
0.3
0.2
0.1
0
0.1 2024
2.0 2026
4.0 2028
6.0 2030
8.0 2032
10.0 2034
12.0 2036
14.0 2038
16.0 2040
18.0 2042
20.0 2044


Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
Modulus (psi)
Pavement Age (years/date)


Granular Base Sub-layer Modulus
GB2(6) h = 2 in
GB2(7) h = 4 in
GB3(8) h = 6 in
Modulus (psi)
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
NSG4(9) h = 6 in
NSG5(10) h = 24.1 in
NSG5(11) h = 24.1 in
NSG5(12) h = 24.1 in
NSG5(13) h = 259.5 in
Modulus (psi)
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

Asphalt		
Thickness (in)	4.0	
Unit weight (pcf)	140.5	
Poisson's ratio	Is Calculated?	True
	Ratio	-
	Parameter A	-1.63
	Parameter B	3.84E-06

Asphalt Dynamic Modulus (Input Level: 1)

T (ºF)	0.5 Hz	1 Hz	10 Hz	25 Hz
14	2910500	2947100	3034800	3058600
40	2620500	2695700	2882400	2934800
70	2057300	2190500	2549800	2658300
100	1334300	1500400	2017600	2195500
130	697600	836500	1365200	1584000

Asphalt Binder

Temperature (ºF)	Binder Gstar (Pa)	Phase angle (deg)
168.8	451	85
147.2	1857	81.6
158	889	83.1

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.8
Air voids (%)	6.9
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23

Identifiers

Field	Value
Display name/identifier	R2 Level 1 SX(75) PG 64-22
Description of object	Mix ID # 19127A
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	SX
User defined field 2	
User defined field 3	
Revision Number	0

Layer 2 Non-stabilized Base : Crushed gravel

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)
25000.0

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

Identifiers

Field	Value
Display name/identifier	Crushed gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	42

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-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	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 3 Non-stabilized Base : River-run gravel

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)
11000.0

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

Identifiers

Field	Value
Display name/identifier	River-run gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-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	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : A-7-6

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)
6482.0

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

Identifiers

Field	Value
Display name/identifier	A-7-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	51.0
Plasticity Index	30.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	98.6
Saturated hydraulic conductivity (ft/hr)	False	8.849e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	22.2

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	136.4179
bf	0.5183
cf	0.0324
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	79.1
#100	
#80	84.9
#60	
#50	
#40	88.8
#30	
#20	
#16	
#10	93.0
#8	
#4	94.9
3/8-in.	96.9
1/2-in.	97.5
3/4-in.	98.3
1-in.	98.8
1 1/2-in.	99.3
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Layer 5 Subgrade : A-7-6

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)
6482.0

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

Identifiers

Field	Value
Display name/identifier	A-7-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	51.0
Plasticity Index	30.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	97.7
Saturated hydraulic conductivity (ft/hr)	False	8.946e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	22.2

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	136.4179
bf	0.5183
cf	0.0324
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	79.1
#100	
#80	84.9
#60	
#50	
#40	88.8
#30	
#20	
#16	
#10	93.0
#8	
#4	94.9
3/8-in.	96.9
1/2-in.	97.5
3/4-in.	98.3
1-in.	98.8
1 1/2-in.	99.3
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Calibration Coefficients

AC Fatigue

$$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$$

$$C = 10^M$$

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$$

k1: 0.007566
k2: 3.9492
k3: 1.281
Bf1: 1
Bf2: 1
Bf3: 1

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_a^2 + 2.4868 * H_a - 17.342$$

$$C_2 = 0.0172 * H_a^2 - 1.7331 * H_a + 27.428$$

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

AC Rutting Standard Deviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer	K1:-3.35412 K2:1.5606 K3:0.4791	Br1:1 Br2:1 Br3:1

Thermal Fracture

$$C_f = 400 * N\left(\frac{\log C / h_{ac}}{\sigma}\right)$$

$$\Delta C = (k * \beta t)^{n+1} * A * \Delta K^n$$

$$A = 10^{(4.389 - 2.52 * \log(E * \sigma_m * n))}$$

C_f = observed amount of thermal cracking(ft/500ft)
k = refression coefficient determined through field calibration
$N()$ = standard normal distribution evaluated at()
σ = standard deviation of the log of the depth of cracks in the pavments
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 = mixture stiffness
σ_M = Undamaged mixture tensile strength
β_t = Calibration parameter

Level 1 K: 1.5	Level 1 Standard Deviation: 0.1468 * THERMAL + 65.027
Level 2 K: 0.5	Level 2 Standard Deviation: 0.2841 * THERMAL + 55.462
Level 3 K: 1.5	Level 3 Standard Deviation: 0.3972 * THERMAL + 20.422

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: 1	k2: 1	Bc1: 0.75	Bc2:1.1

Subgrade 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 veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
ε_r = resilient strain(in/in)

Granular		Fine	
k1: 2.03	Bs1: 1	k1: 1.35	Bs1: 1
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

$$FC_{top} = \left(\frac{C_4}{1 + e^{\left(C_1 - C_2 * log_{10}(Damage)\right)}}\right) * 10.56$$

AC Bottom Up Cracking

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

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

AC Top Down Cracking				AC Bottom Up Cracking		
c1: 7	c2: 3.5	c3: 0	c4: 1000	c1: 1	c2: 1	c3: 6000
AC Cracking Top Standard Deviation				**AC Cracking Bottom Standard Deviation**		
200 + 2300/(1+exp(1.072-2.1654*LOG10 (TOP+0.0001)))				1.13 + 13/(1+exp(7.57-15.5*LOG10 (BOTTOM+0.0001)))		

CSM Cracking

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

C1: 0	C2: 75	C3: 5	C4: 3

CSM Standard Deviation

CTB*1

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

Design Inputs

Design Life: 30 years
Design Type: FLEXIBLE

Base construction: May, 2024
Pavement construction: July, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.134, -108.538

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R2 Level 1 SX(75) PG 64-22	4.0
NonStabilized	Crushed gravel	6.0
NonStabilized	River-run gravel	6.0
Subgrade	A-7-6	6.0
Subgrade	A-7-6	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	11.8
Air voids (%)	6.9

Traffic

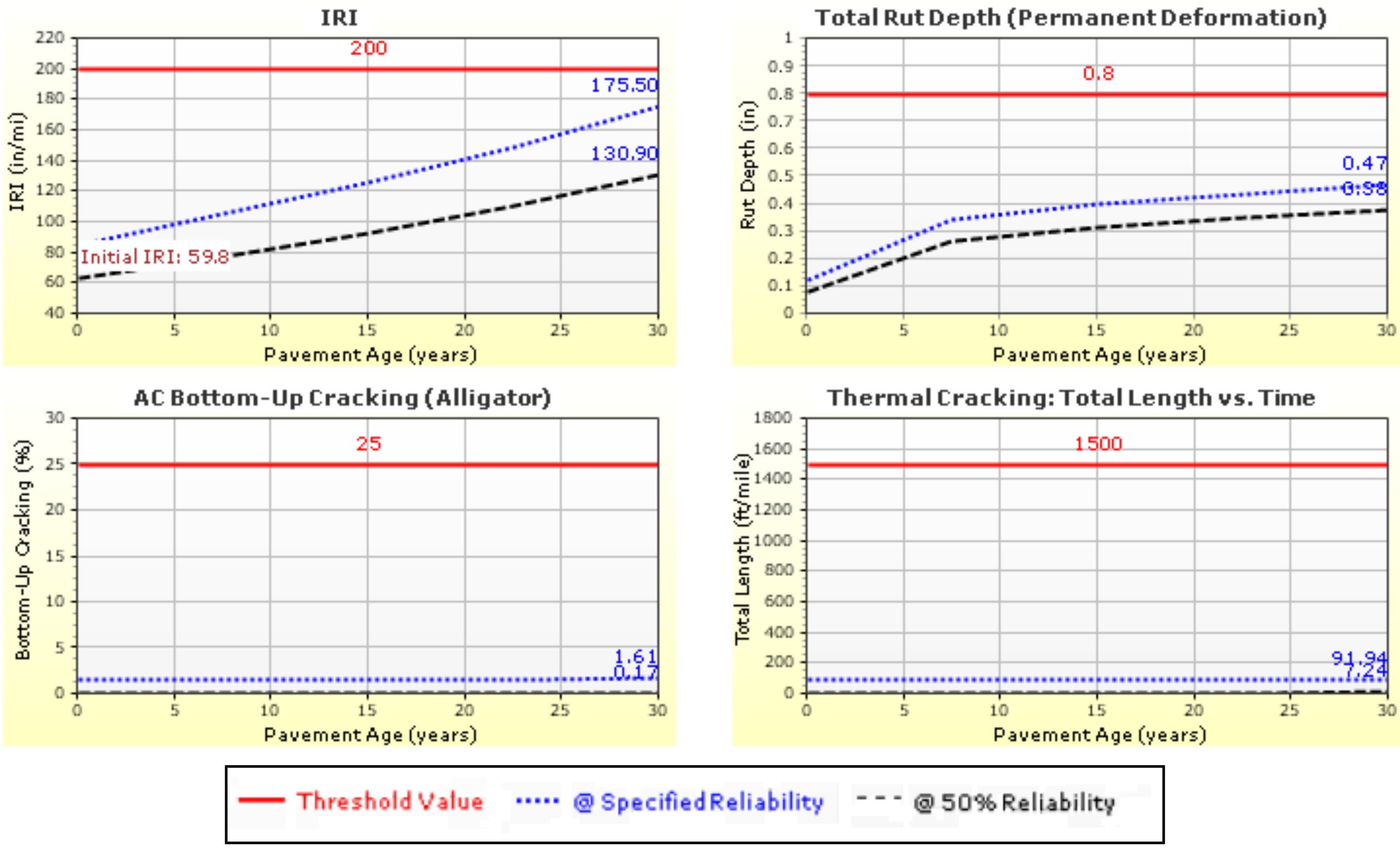
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	20
2039 (15 years)	128,170
2054 (30 years)	305,813

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	175.47	90.00	97.66	Pass
Permanent deformation - total pavement (in)	0.80	0.47	90.00	100.00	Pass
AC bottom-up fatigue cracking (% lane area)	25.00	1.61	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	91.94	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	3000.00	471.03	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.65	0.03	90.00	100.00	Pass

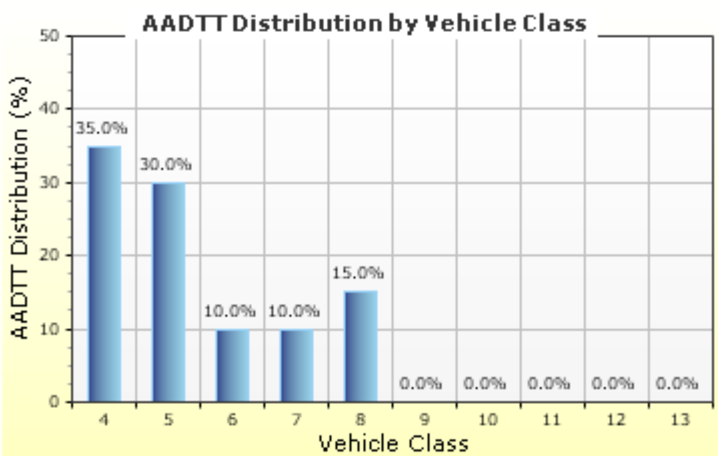
Distress Charts

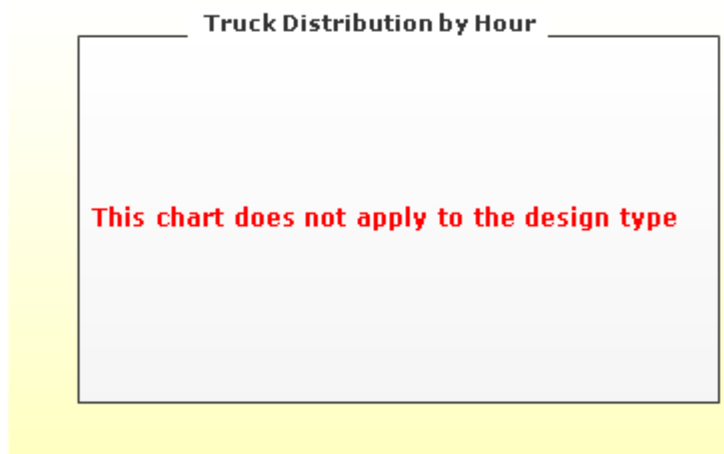


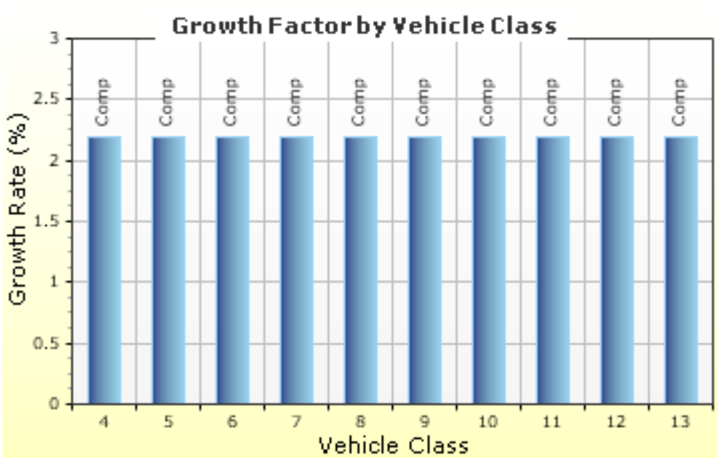
Traffic Inputs

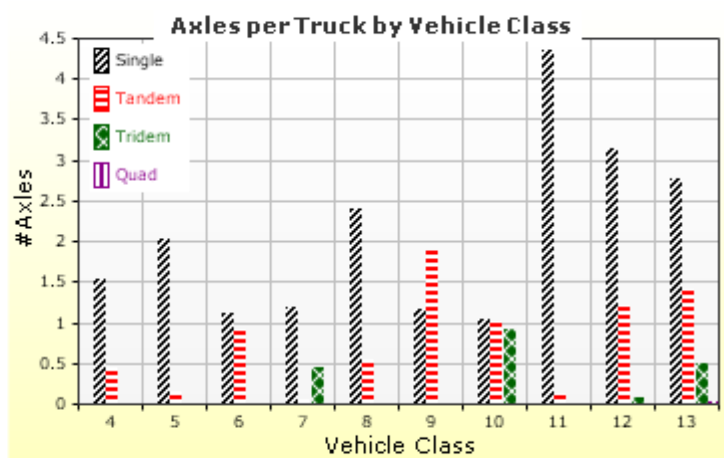
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	20	Percent of trucks in design direction (%):	100.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	25.0

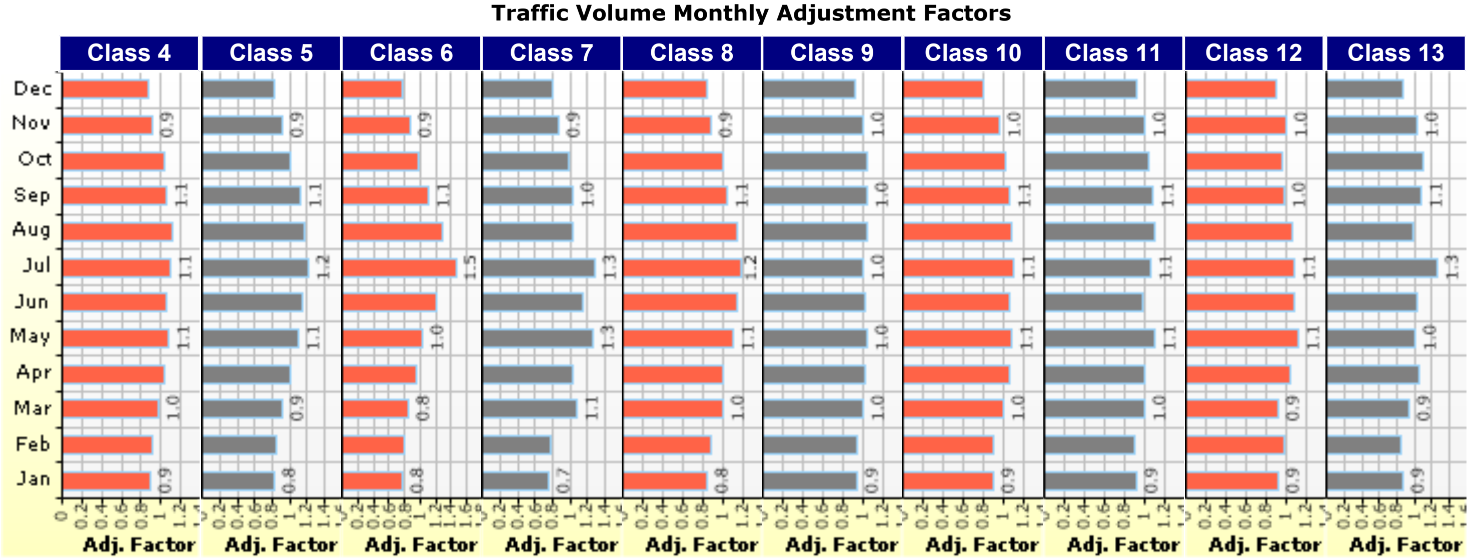








Traffic Volume Monthly Adjustment Factors



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	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	35%	2.2%	Compound
Class 5	30%	2.2%	Compound
Class 6	10%	2.2%	Compound
Class 7	10%	2.2%	Compound
Class 8	15%	2.2%	Compound
Class 9	0%	2.2%	Compound
Class 10	0%	2.2%	Compound
Class 11	0%	2.2%	Compound
Class 12	0%	2.2%	Compound
Class 13	0%	2.2%	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

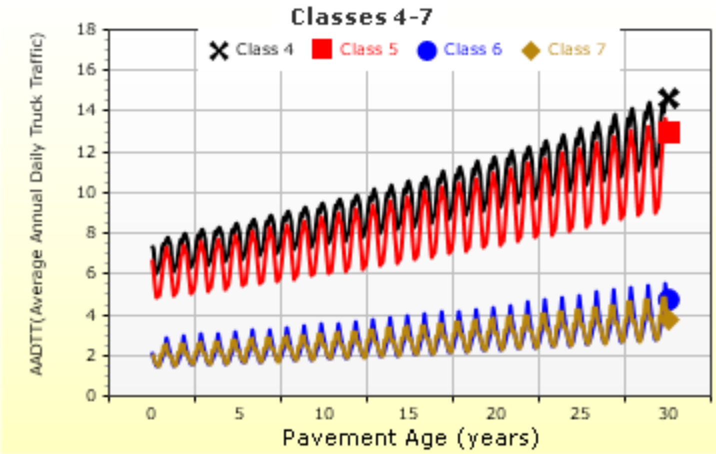
Wheelbase does not apply

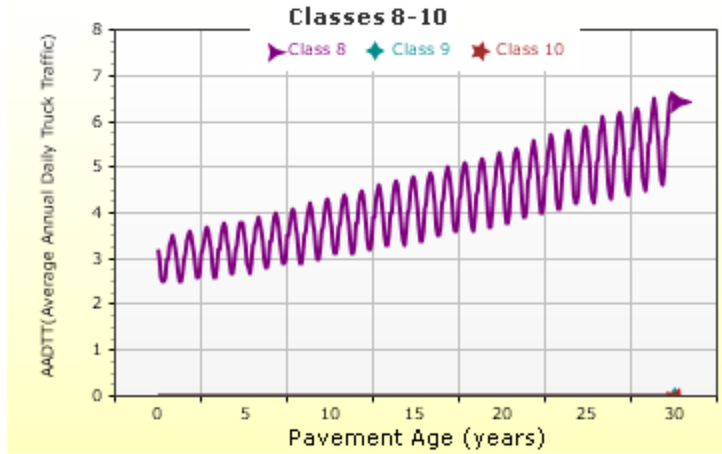
Number of Axles per Truck

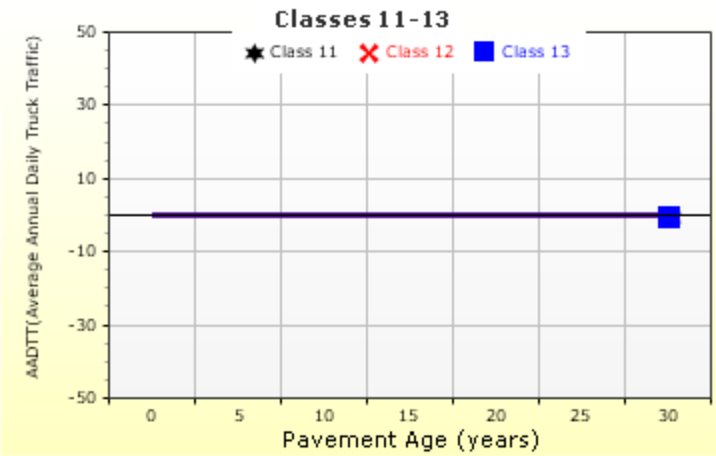
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

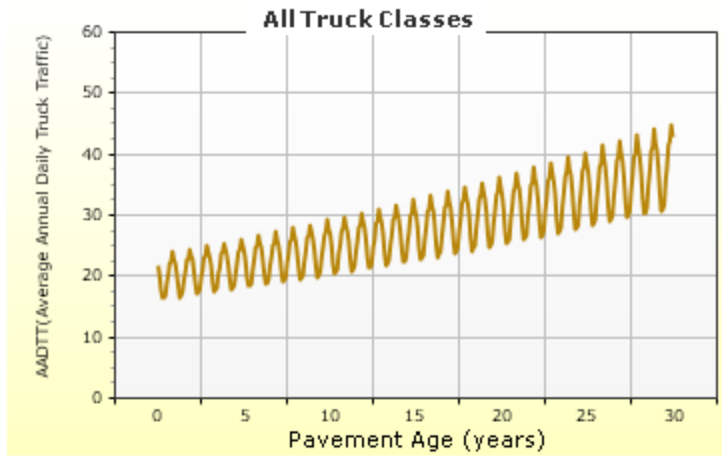
AADTT (Average Annual Daily Truck Traffic) Growth

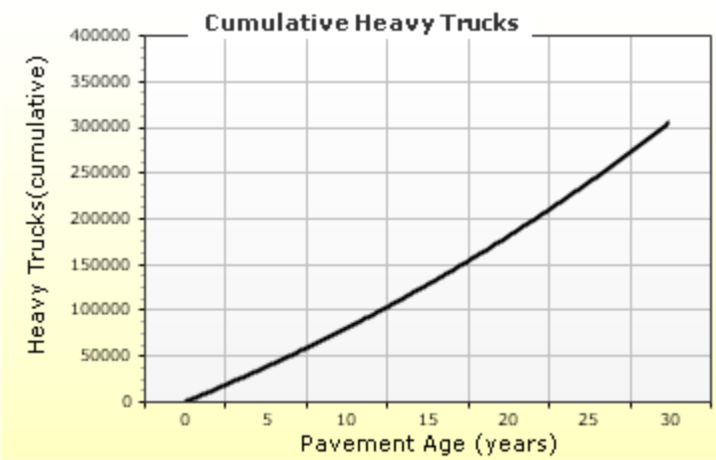
*** Traffic cap is not enforced**







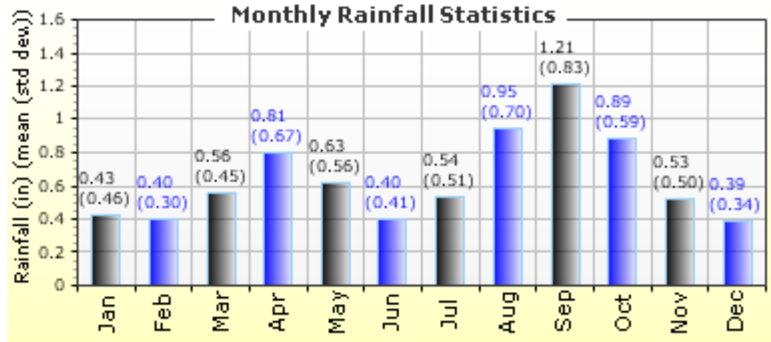




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
GRAND JUNCTION, CO	39.13400 -108.53800 4839

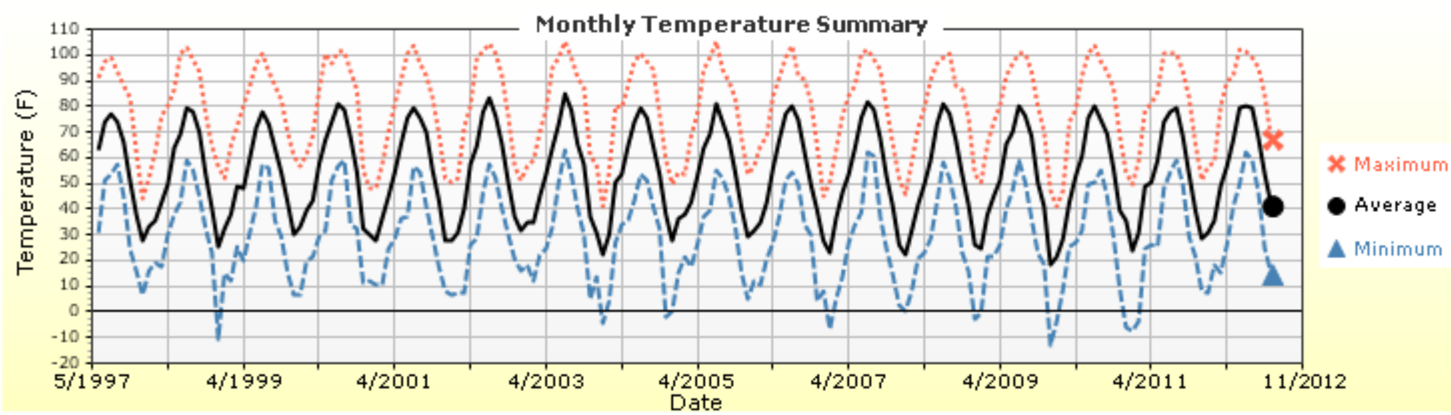


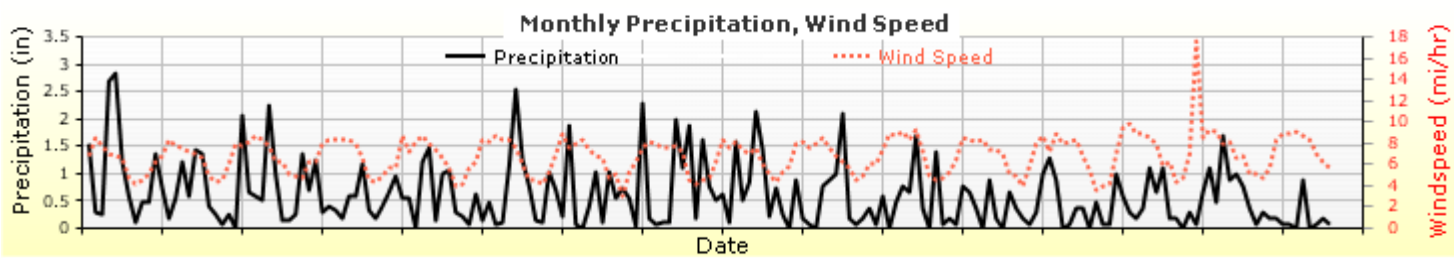
Annual Statistics:

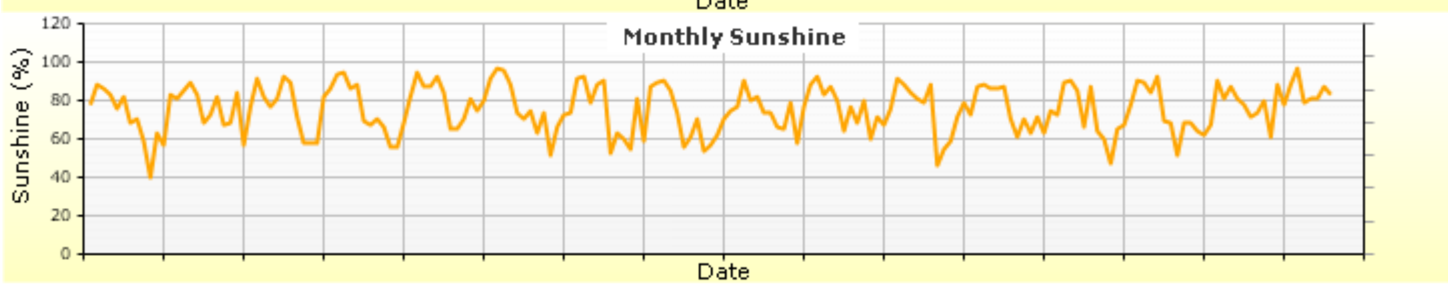
Mean annual air temperature (ºF)	53.55
Mean annual precipitation (in)	7.76
Freezing index (ºF - days)	398.73
Average annual number of freeze/thaw cycles:	111.77

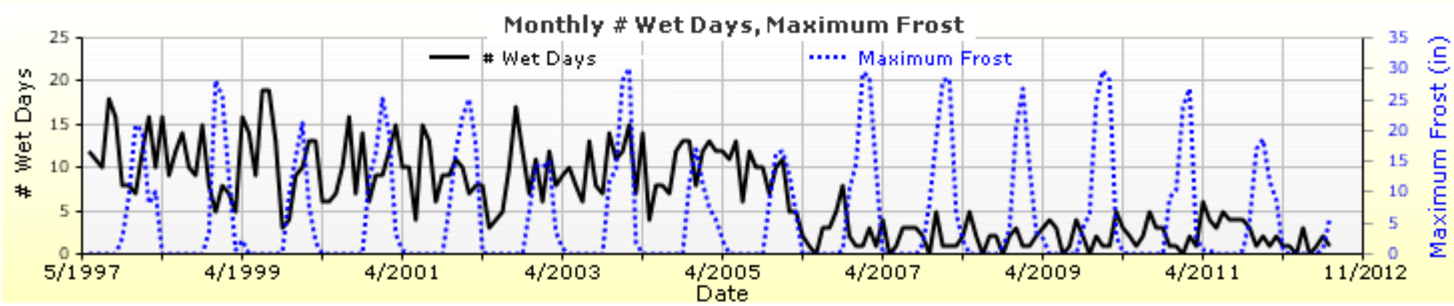
Water table depth (ft) 4.00

Monthly Climate Summary:

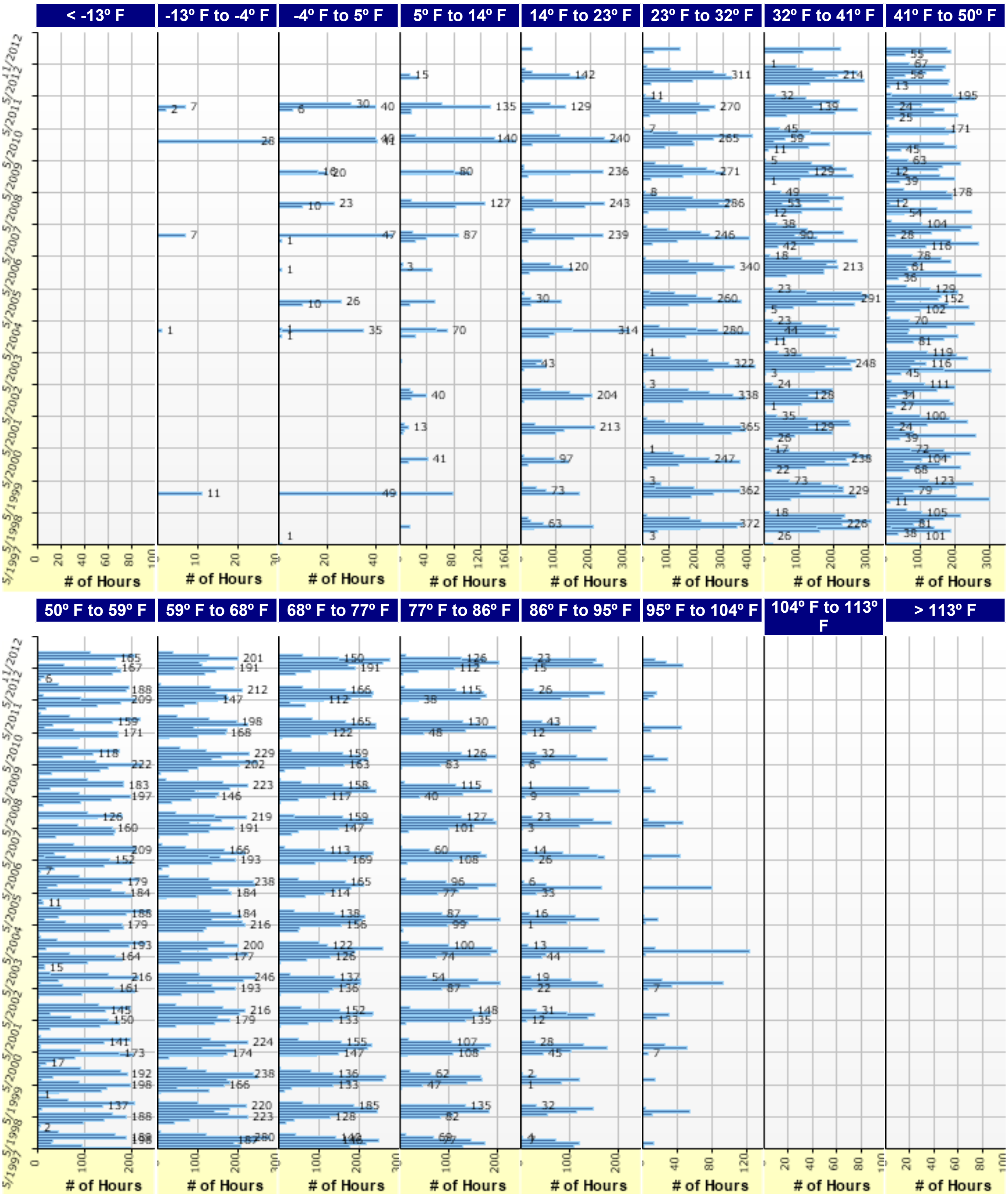








Hourly Air Temperature Distribution by Month:



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

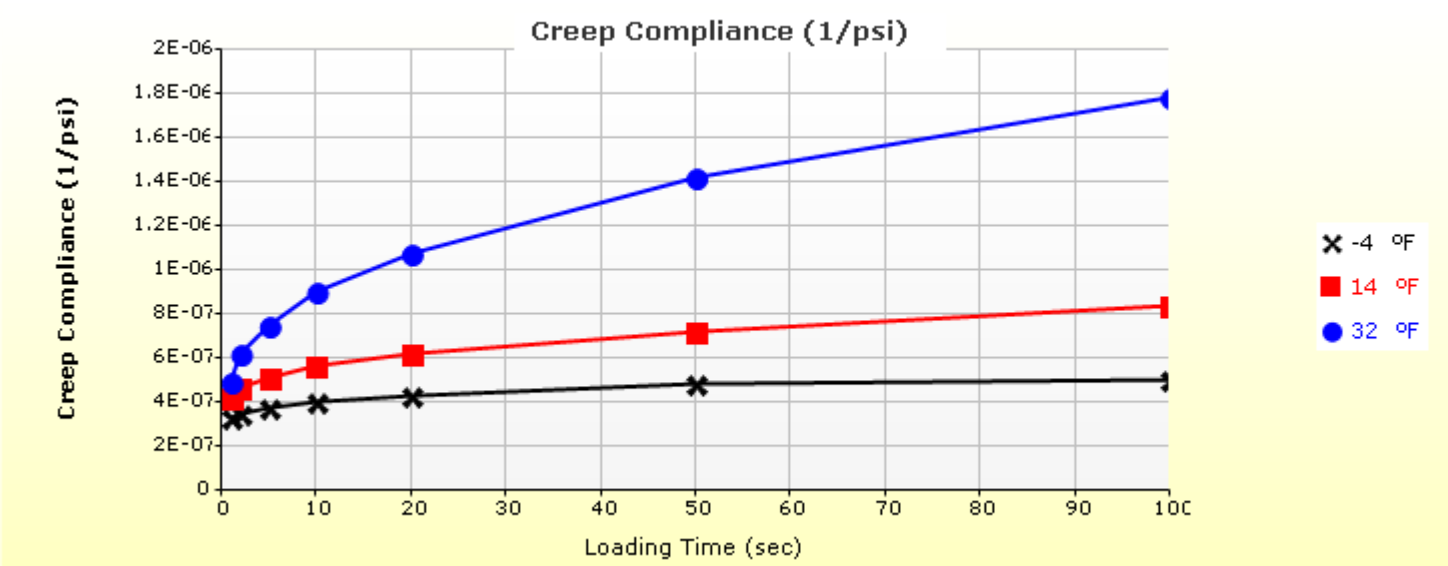
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : R2 Level 1 SX (75) PG 64-22	Flexible (1)	1.00
Layer 2 Non-stabilized Base : Crushed gravel	Non-stabilized Base (4)	1.00
Layer 3 Non-stabilized Base : River-run gravel	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : A-7-6	Subgrade (5)	1.00
Layer 5 Subgrade : A-7-6	Subgrade (5)	-

Thermal Cracking (Input Level: 1)

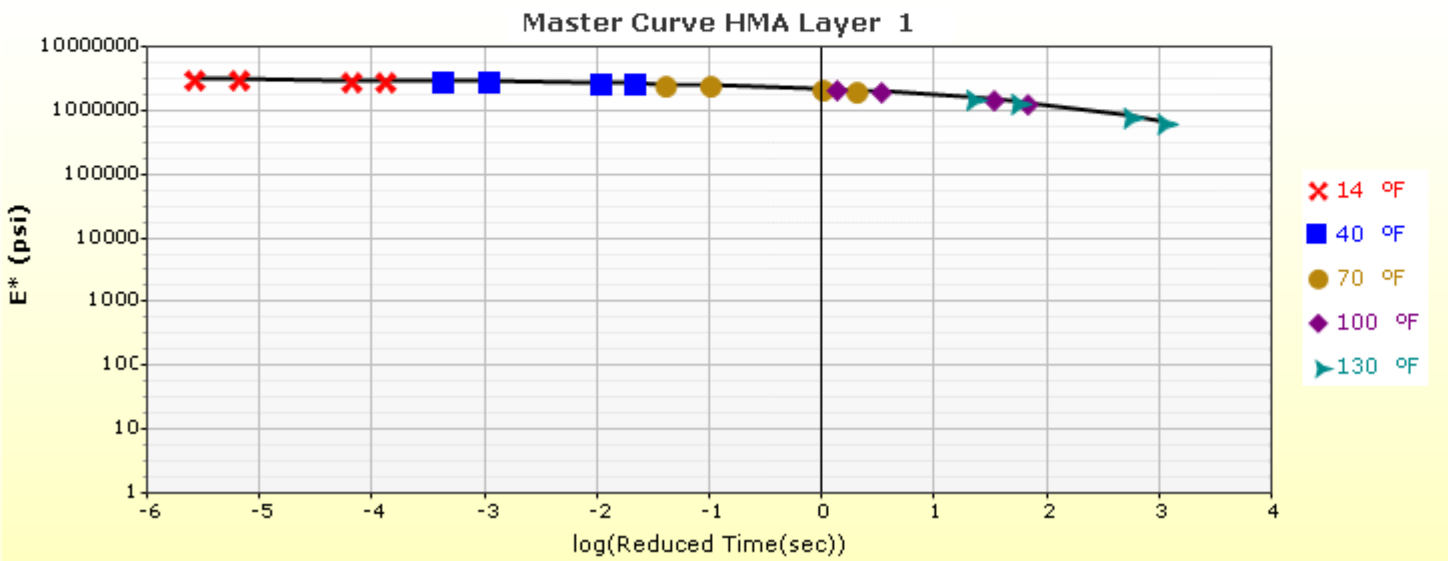
Indirect tensile strength at 14 ºF (psi)	451.00

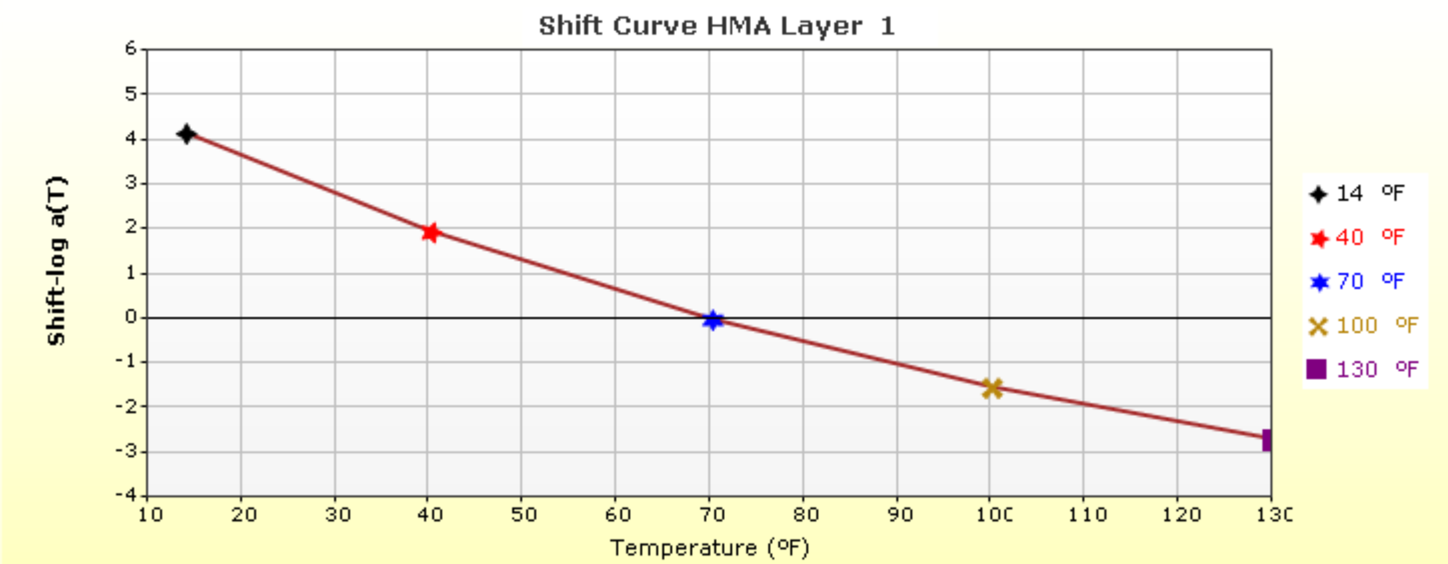
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	18.7

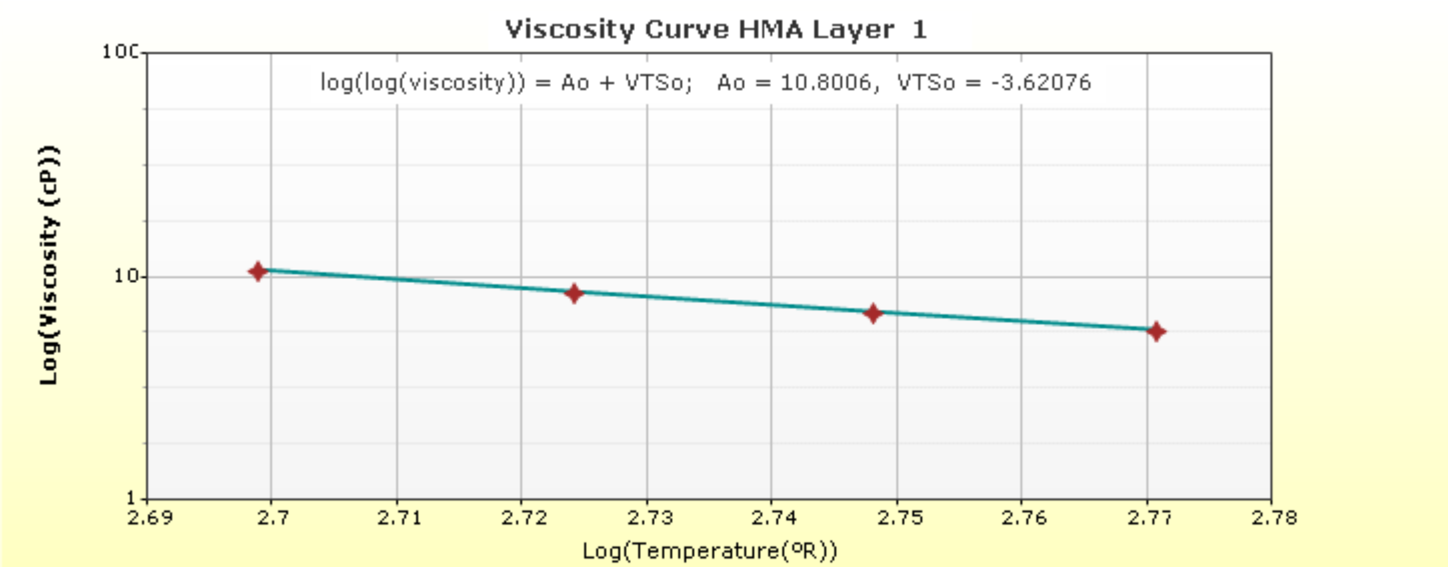
	Creep Compliance (1/psi)		
Loading time (sec)	-4 ºF	14 ºF	32 ºF
1	3.34e-007	4.19e-007	4.99e-007
2	3.53e-007	4.64e-007	6.19e-007
5	3.79e-007	5.15e-007	7.49e-007
10	4.05e-007	5.70e-007	9.08e-007
20	4.31e-007	6.26e-007	1.08e-006
50	4.87e-007	7.27e-007	1.43e-006
100	5.05e-007	8.41e-007	1.79e-006



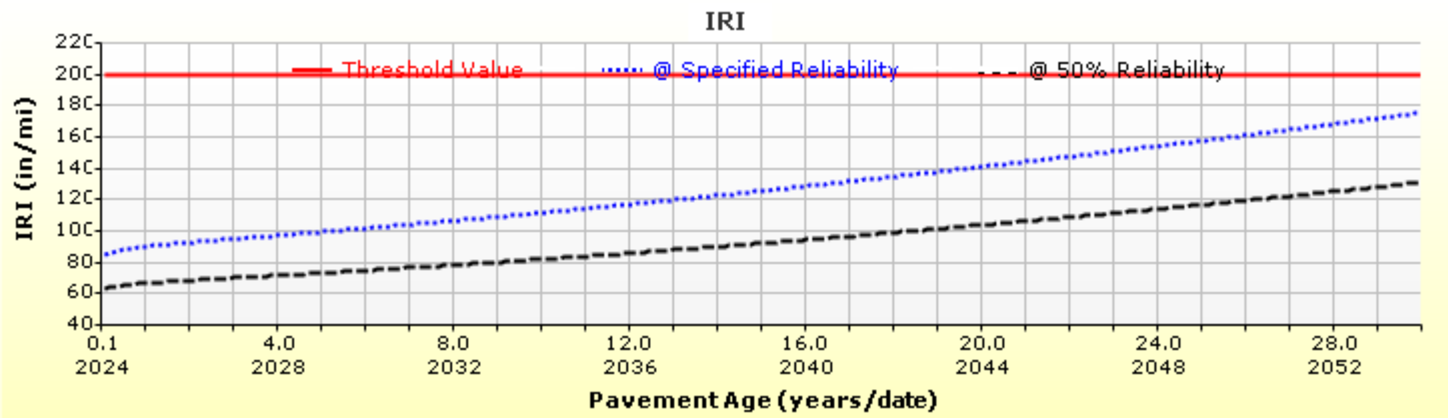
HMA Layer 1: Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

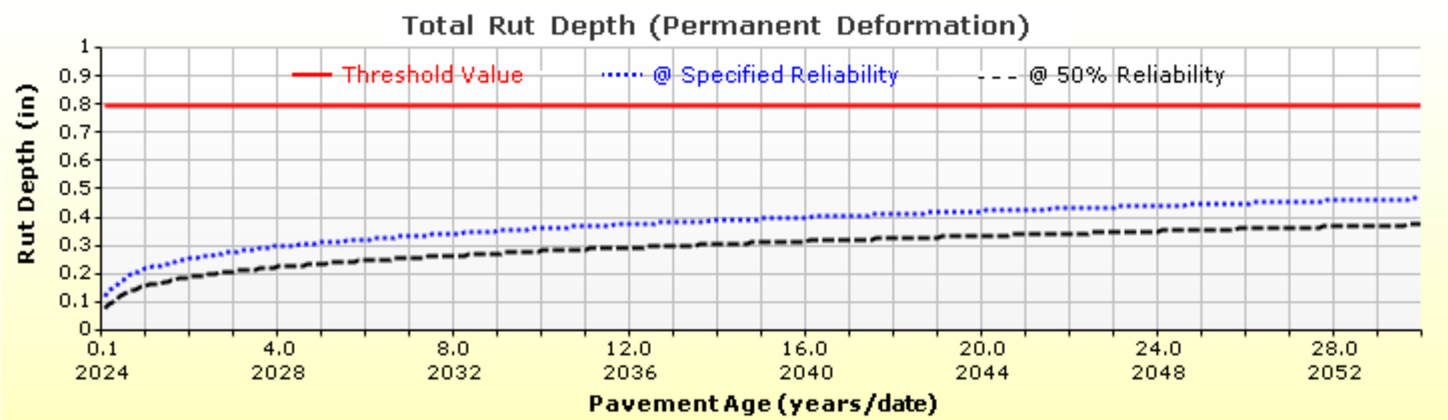


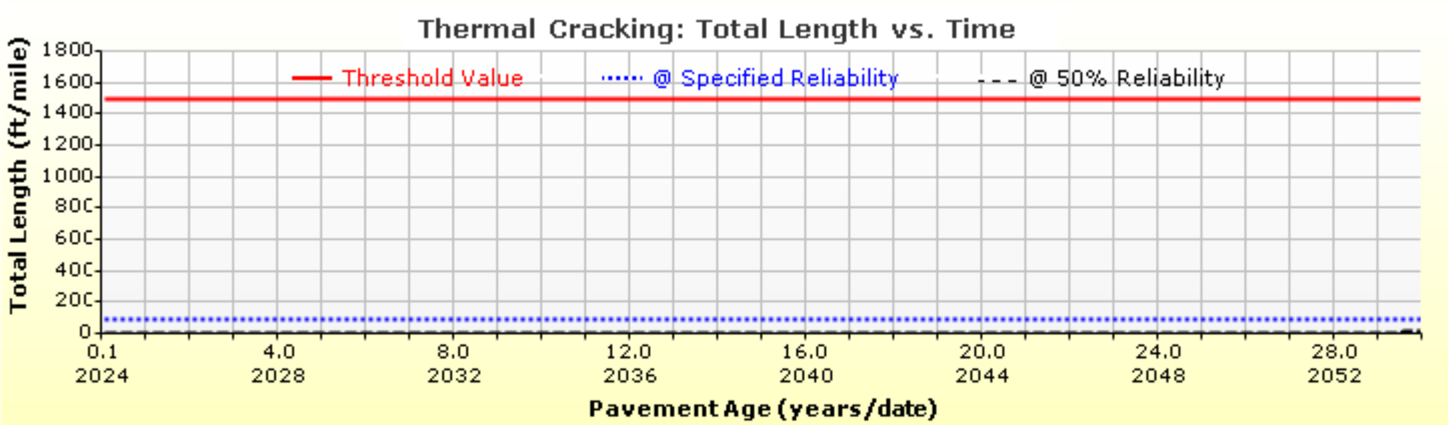


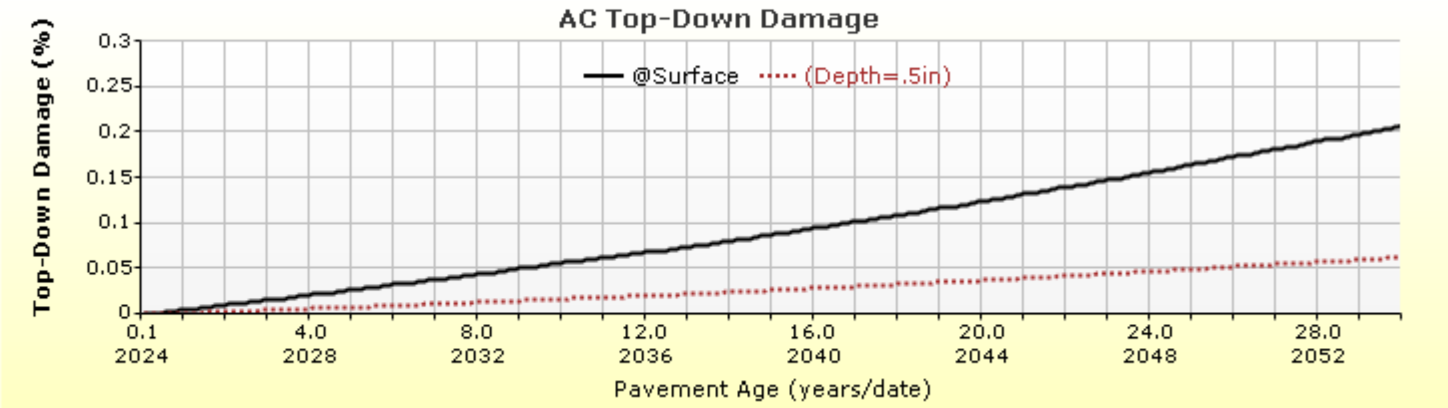


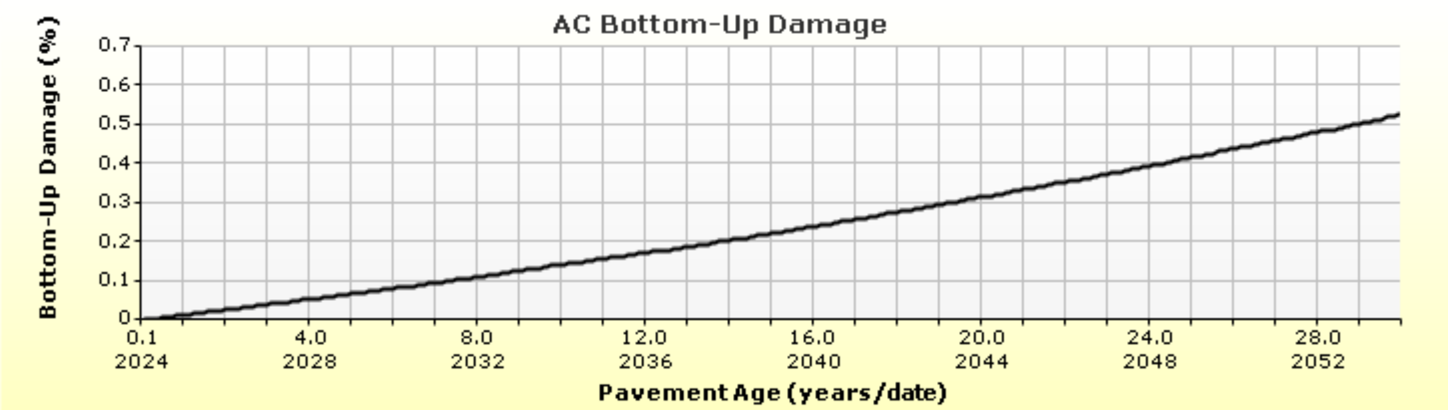
Analysis Output Charts

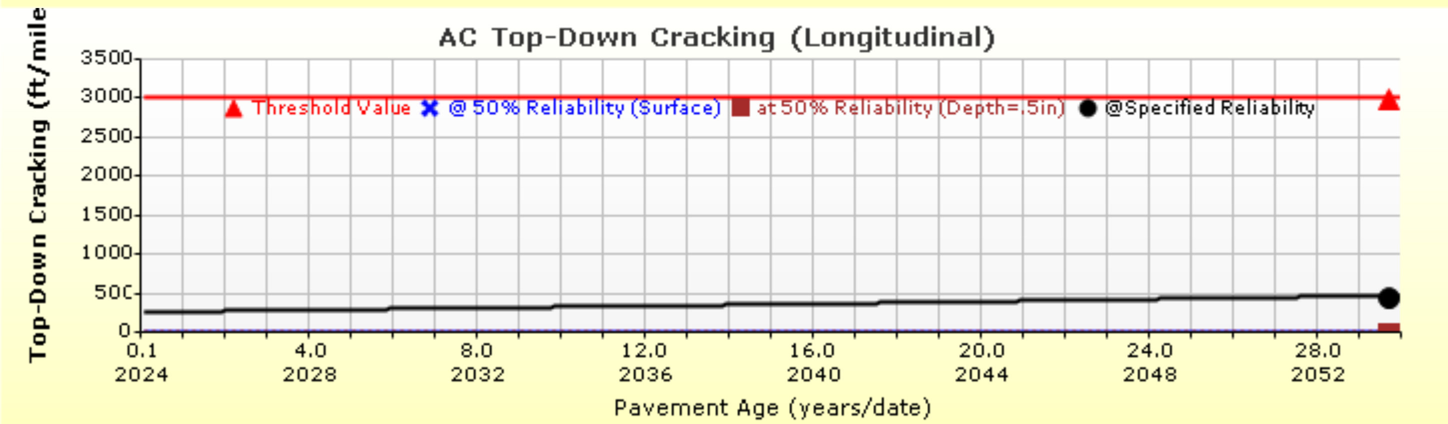


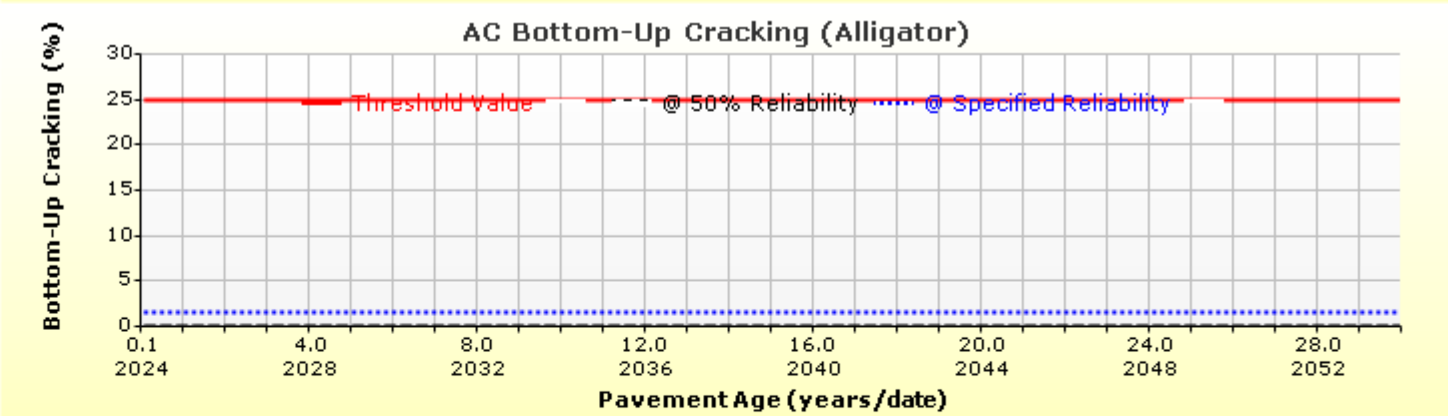


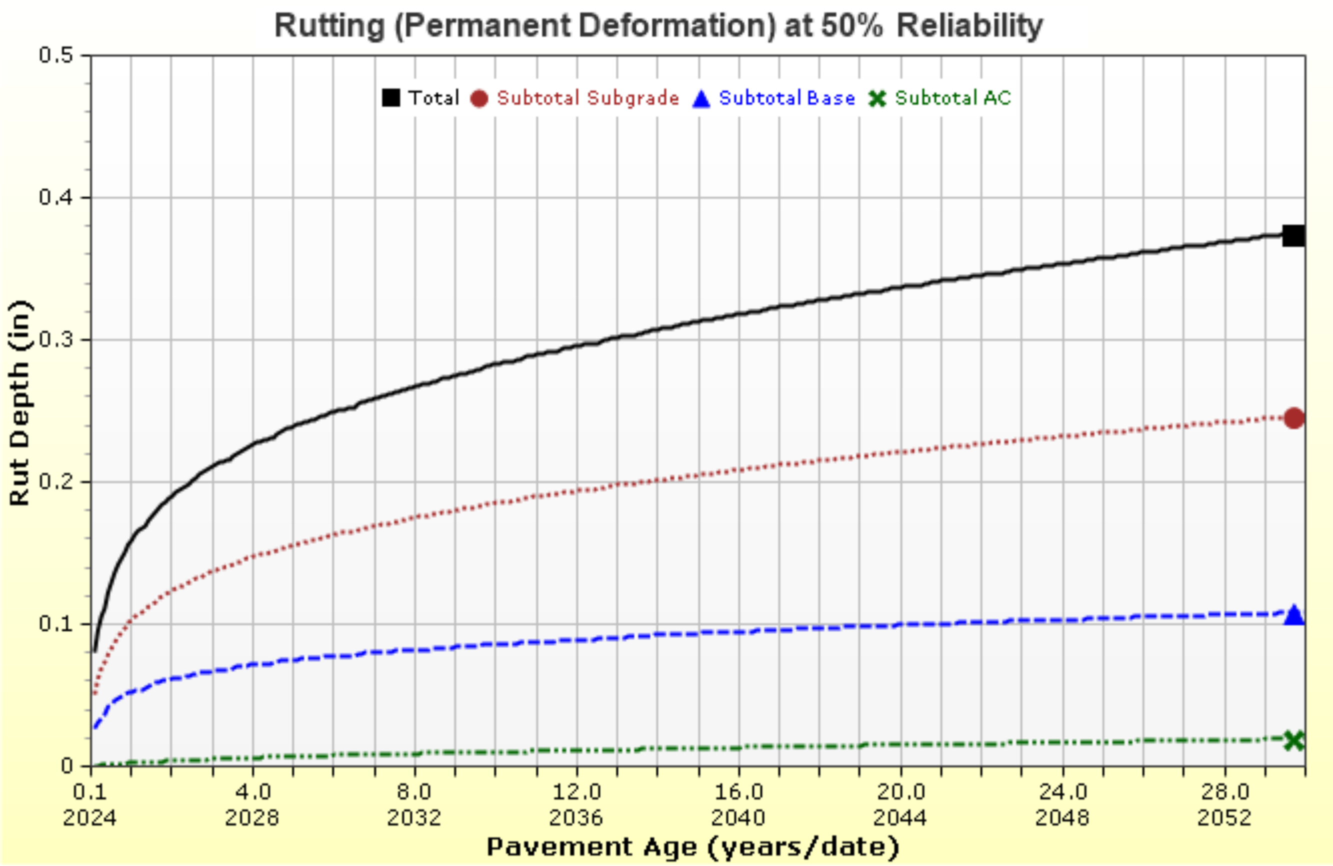



AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
Pavement Age (years/date)

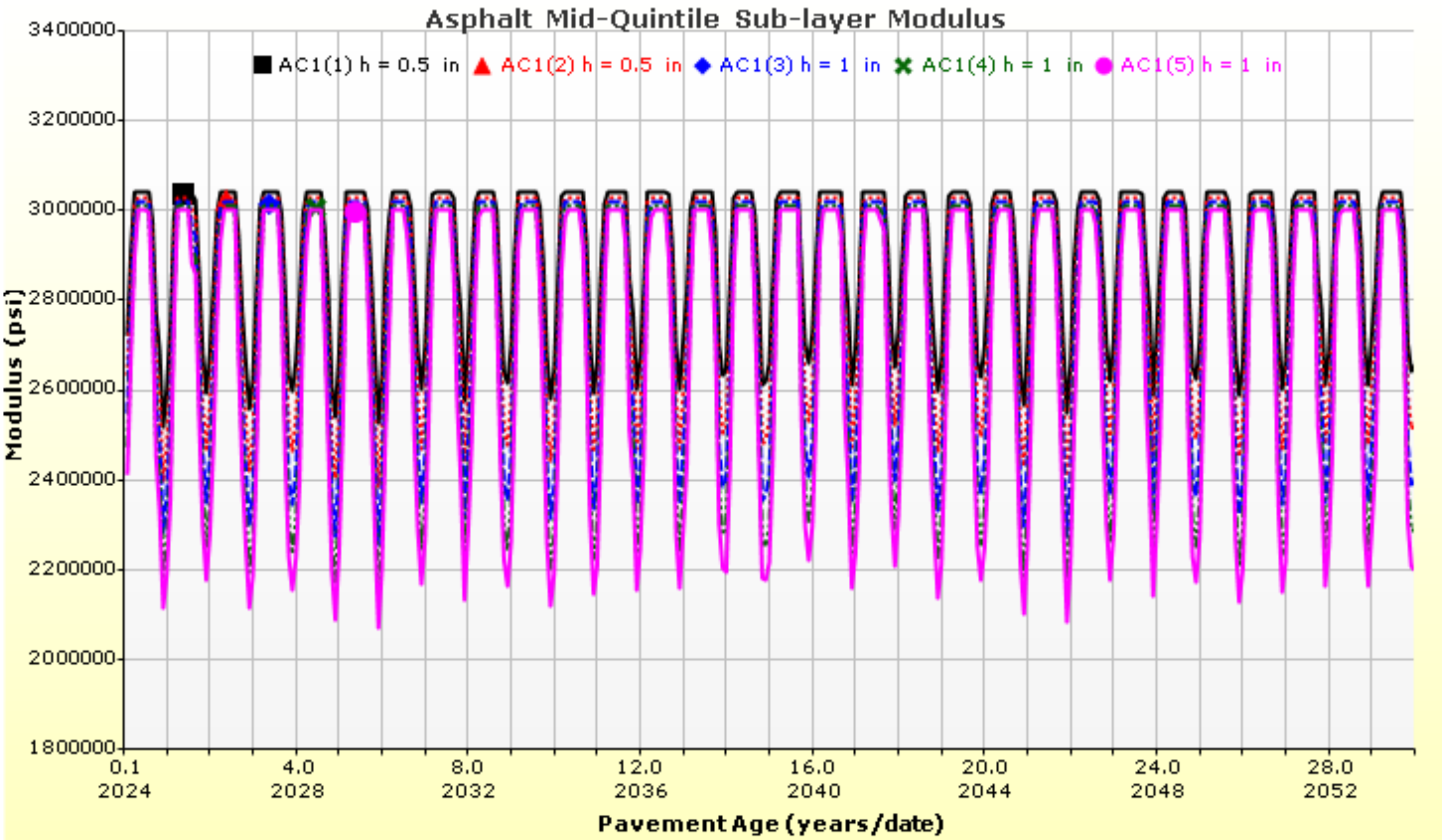

AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)

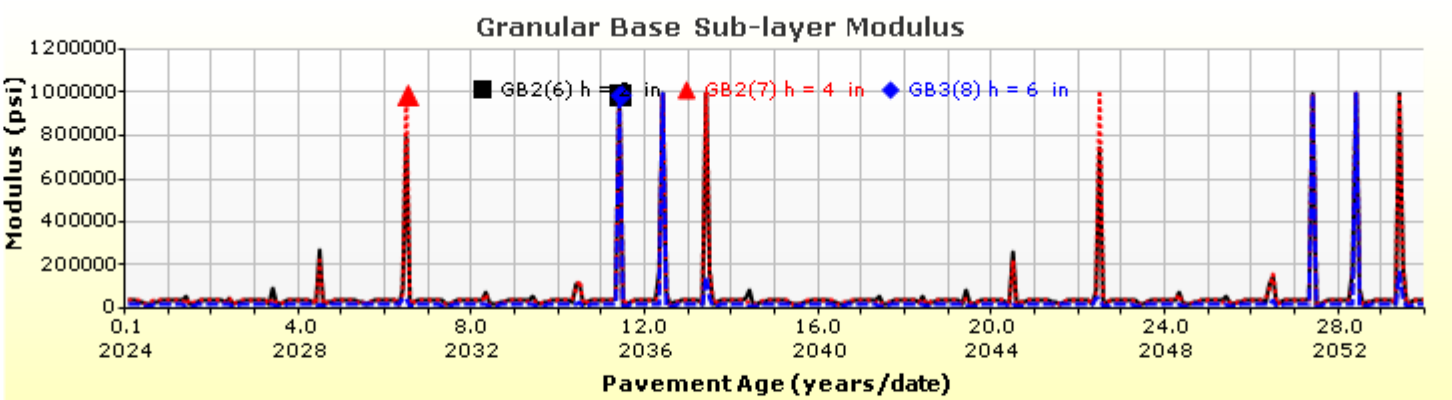

AC Top-Down Cracking (Longitudinal)
Threshold Value
@ 50% Reliability (Surface)
at 50% Reliability (Depth=.5in)
@Specified Reliability
Top-Down Cracking (ft/mile
Pavement Age (years/date)

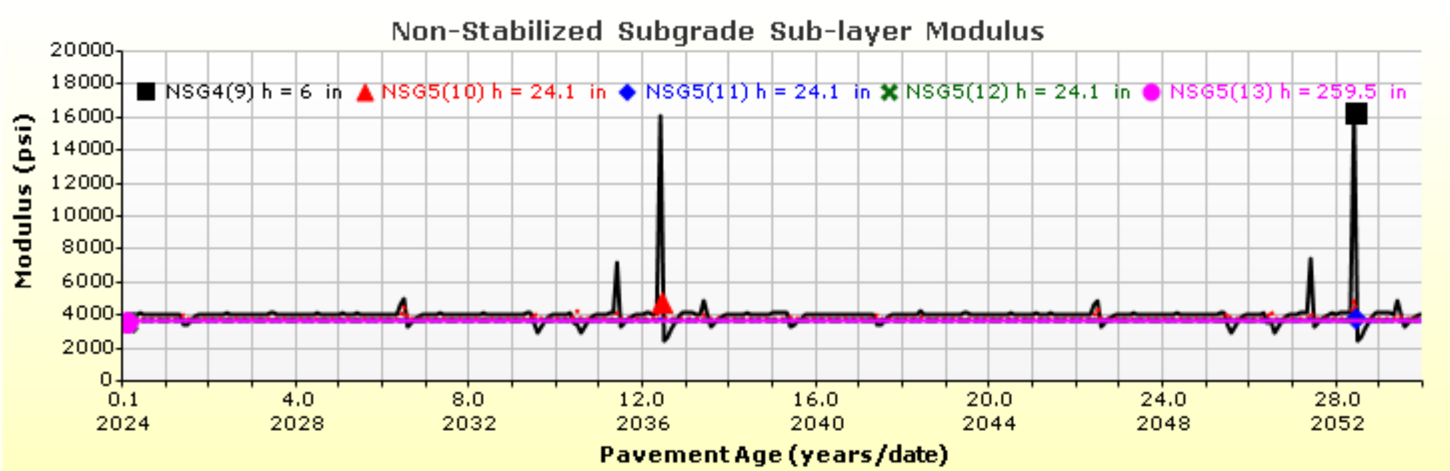

AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
Pavement Age (years/date)



Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal Subgrade
Subtotal Base
Subtotal AC
Rut Depth (in)
0.5
0.4
0.3
0.2
0.1
0
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)


Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC1(4) h = 1 in
AC1(5) h = 1 in
Modulus (psi)
3400000
3200000
3000000
2800000
2600000
2400000
2200000
2000000
1800000
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)


Granular Base Sub-layer Modulus
GB2(6) h = 2 in
GB2(7) h = 4 in
GB3(8) h = 6 in
Modulus (psi)
1200000
1000000
800000
600000
400000
200000
0
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)


Non-Stabilized Subgrade Sub-layer Modulus
NSG4(9) h = 6 in
NSG5(10) h = 24.1 in
NSG5(11) h = 24.1 in
NSG5(12) h = 24.1 in
NSG5(13) h = 259.5 in
Modulus (psi)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : R2 Level 1 SX(75) PG 64-22

Asphalt		
Thickness (in)	4.0	
Unit weight (pcf)	140.5	
Poisson's ratio	Is Calculated?	True
	Ratio	-
	Parameter A	-1.63
	Parameter B	3.84E-06

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	11.8
Air voids (%)	6.9
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23

Asphalt Dynamic Modulus (Input Level: 1)

T (ºF)	0.5 Hz	1 Hz	10 Hz	25 Hz
14	2910500	2947100	3034800	3058600
40	2620500	2695700	2882400	2934800
70	2057300	2190500	2549800	2658300
100	1334300	1500400	2017600	2195500
130	697600	836500	1365200	1584000

Identifiers

Field	Value
Display name/identifier	R2 Level 1 SX(75) PG 64-22
Description of object	Mix ID # 19127A
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	SX
User defined field 2	
User defined field 3	
Revision Number	0

Asphalt Binder

Temperature (ºF)	Binder Gstar (Pa)	Phase angle (deg)
168.8	451	85
147.2	1857	81.6
158	889	83.1

Layer 2 Non-stabilized Base : Crushed gravel

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)
25000.0

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

Identifiers

Field	Value
Display name/identifier	Crushed gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	42

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-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	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 3 Non-stabilized Base : River-run gravel

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)
11000.0

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

Identifiers

Field	Value
Display name/identifier	River-run gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-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	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 4 Subgrade : A-7-6

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)
6482.0

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

Identifiers

Field	Value
Display name/identifier	A-7-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	51.0
Plasticity Index	30.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	98.6
Saturated hydraulic conductivity (ft/hr)	False	8.849e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	22.2

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	136.4179
bf	0.5183
cf	0.0324
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	79.1
#100	
#80	84.9
#60	
#50	
#40	88.8
#30	
#20	
#16	
#10	93.0
#8	
#4	94.9
3/8-in.	96.9
1/2-in.	97.5
3/4-in.	98.3
1-in.	98.8
1 1/2-in.	99.3
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Layer 5 Subgrade : A-7-6

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)
6482.0

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

Identifiers

Field	Value
Display name/identifier	A-7-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	51.0
Plasticity Index	30.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	97.7
Saturated hydraulic conductivity (ft/hr)	False	8.946e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	22.2

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	136.4179
bf	0.5183
cf	0.0324
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	79.1
#100	
#80	84.9
#60	
#50	
#40	88.8
#30	
#20	
#16	
#10	93.0
#8	
#4	94.9
3/8-in.	96.9
1/2-in.	97.5
3/4-in.	98.3
1-in.	98.8
1 1/2-in.	99.3
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Calibration Coefficients

AC Fatigue

$N_f = 0.00432 * C * \beta_{f1} k_1 \left(\frac{1}{\varepsilon_1}\right)^{k_2 \beta_{f2}} \left(\frac{1}{E}\right)^{k_3 \beta_{f3}}$	k1: 0.007566
	k2: 3.9492
$C = 10^M$	k3: 1.281
	Bf1: 1
$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$	Bf2: 1
	Bf3: 1

AC Rutting

$$\frac{\varepsilon_p}{\varepsilon_r} = k_z \beta_{r1} 10^{k_1} T^{k_2 \beta_{r2}} N^{k_3 \beta_{r3}}$$

$$k_z = (C_1 + C_2 * depth) * 0.328196^{depth}$$

$$C_1 = -0.1039 * H_a^2 + 2.4868 * H_a - 17.342$$

$$C_2 = 0.0172 * H_a^2 - 1.7331 * H_a + 27.428$$

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

AC Rutting Standard Deviation	0.24 * Pow(RUT,0.8026) + 0.001	
AC Layer	K1:-3.35412 K2:1.5606 K3:0.4791	Br1:1 Br2:1 Br3:1

Thermal Fracture

$$C_f = 400 * N\left(\frac{\log C / h_{ac}}{\sigma}\right)$$

$$\Delta C = (k * \beta t)^{n+1} * A * \Delta K^n$$

$$A = 10^{(4.389 - 2.52 * \log(E * \sigma_m * n))}$$

C_f = observed amount of thermal cracking(ft/500ft)
k = refression coefficient determined through field calibration
$N()$ = standard normal distribution evaluated at( )
σ = standard deviation of the log of the depth of cracks in the pavments
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 = mixture stiffness
σ_M = Undamaged mixture tensile strength
β_t = Calibration parameter

Level 1 K: 1.5	Level 1 Standard Deviation: 0.1468 * THERMAL + 65.027
Level 2 K: 0.5	Level 2 Standard Deviation: 0.2841 * THERMAL + 55.462
Level 3 K: 1.5	Level 3 Standard Deviation: 0.3972 * THERMAL + 20.422

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: 1	k2: 1	Bc1: 0.75	Bc2:1.1

Subgrade 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 veritcal strain(in/in)
$\varepsilon_0, \beta, \rho$ = material properties
ε_r = resilient strain(in/in)

Granular		Fine	
k1: 2.03	Bs1: 1	k1: 1.35	Bs1: 1
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

$$FC_{top} = \left(\frac{C_4}{1 + e^{(C_1 - C_2 * log_{10}(Damage))}}\right) * 10.56$$

AC Bottom Up Cracking

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

$$C_2' = -2.40874 - 39.748 * (1 + h_{ac})^{-2.856}$$

$$C_1' = -2 * C_2'$$

AC Top Down Cracking				AC Bottom Up Cracking		
c1: 7	c2: 3.5	c3: 0	c4: 1000	c1: 1	c2: 1	c3: 6000

AC Cracking Top Standard Deviation	AC Cracking Bottom Standard Deviation
200 + 2300/(1+exp(1.072-2.1654*LOG10 (TOP+0.0001)))	1.13 + 13/(1+exp(7.57-15.5*LOG10 (BOTTOM+0.0001)))

CSM Cracking

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

C1: 0	C2: 75	C3: 5	C4: 3

CSM Standard Deviation

CTB*1

IRI Flexible Pavements

C1 - Rutting
C2 - Fatigue Crack
C3 - Transverse Crack
C4 - Site Factors

C1: 40	C2: 0.4	C3: 0.008	C4: 0.015

APPENDIX J

AASHTO 1993 FLEXIBLE PAVEMENT OUTPUT SHEETS

INITIAL VALUES

Initial Serviceability Index=	2.5
Final Serviceability Index=	2
Overall Standard Deviation, So=	0.44
Reliability, R (percent)=	90
Standard Normal Deviate (ZR)=	-1.282
Structural Coefficient of HMA=	0.44
Structural Coefficient of ABC=	0.12
Design Life ESALs=	130,000
R-Value=	**10**

INTERMEDIATE CALCULATIONS

Calculated Mr=	6482
Design Mr=	6482
Design Serviceability Loss (ΔPSI)=	2.5

FINAL CALCULATIONS

SN= **2.5254**

Such That:

Log_{10}ESAL	≤	**Thickness Equation**
5.1139	≤	5.1140

Full HMA:

Depth= **5.74** in

HMA over ABC:

Depth Class 6 and Class 2 or 3 ABC=	**12**	in	
Depth HMA=	**2.60**	in	Use 3.0 inches

THIS SHEET USES THE "NEW" CDOT R-VALUE TO RESILIENT MODULUS EQUATION

ESAL's = the number of Equivalent 18-kip axle loads for the appropriate design period
Mr = subgrade Resilient Modulus in pounds per square inch (psi)

R-Value = 10
If Mr is based on R-Value ===> Mr = 6,482 psi For Post-2015 CDOT Correlation

130,000 = Design Life ESALs

SN = 2.525 = Required SN when B equals (or slightly exceeds) A

$Log_{10}ESAL$ = A = 5.11394

Design Mr = 6,482 psi

=

Thickness Equation= B = 5.11404 with no drainage reduction

0.77310145	A
3.53	B
691.862257	C
1.9812396	D
-0.01687012	E
0.200000	F
3.53	G
5.12188513	H
-0.56408	I

When A = B, ESAL's and SN agree, then calculate thickness
Take Calculated Thickness and round appropriately for design thickness

Structural Coefficient of HMA = 0.44
Structural Coefficient of Class 6 ABC = 0.12
Structural Coefficient of Class 2 ABC = 0.11

Design Serviceability Loss (ΔPSI)= 2.5

Initial Serviceability Index= 4.5
Final Serviceability Index = 2.0

Calculated thickness, inches = 5.74
FULL DEPTH HMA

Overall Standard Deviation, So = 0.44
Reliability, R (percent) = 90
Standard Normal Deviate (ZR) = -1.282
(Use Table 1.4 from CDOT Pavement Design Manual)

Composite HMA over ABC
(using specified layer of ABC)
Inches of Class 6 ABC = 6.0
Inches of Class 2 or 3 ABC = 6.0
Calculated Inches of HMA = 2.60 Use 3.0 inches

Reliability, R (percent)	Standard Normal Deviate(Z_R)
50	0.000
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	-1.037
90	-1.282
91	-1.340
92	-1.405
93	-1.476
94	-1.555
95	-1.645
98	-2.054

INITIAL VALUES

Initial Serviceability Index=	2.5
Final Serviceability Index=	2
Overall Standard Deviation, So=	0.44
Reliability, R (percent)=	90
Standard Normal Deviate (ZR)=	-1.282
Structural Coefficient of HMA=	0.44
Structural Coefficient of ABC=	0.12
Design Life ESALs=	210,000
R-Value=	**10**

INTERMEDIATE CALCULATIONS

Calculated Mr=	6482
Design Mr=	6482
Design Serviceability Loss (ΔPSI)=	2.5

FINAL CALCULATIONS

SN= **2.7150**

Such That:

Log_{10}ESAL	≤	**Thickness Equation**
5.3222	≤	5.3230

Full HMA:

Depth=	**6.17**	in

HMA over ABC:

Depth Class 6 and Class 2 or 3 ABC=	**12**	in	
Depth HMA=	**3.03**	in	Use 3.5 inches

THIS SHEET USES THE "NEW" CDOT R-VALUE TO RESILIENT MODULUS EQUATION

ESAL's = the number of Equivalent 18-kip axle loads for the appropriate design period
Mr = subgrade Resilient Modulus in pounds per square inch (psi)

R-Value = 10
If Mr is based on R-Value ===> Mr = 6,482 psi For Post-2015 CDOT Correlation

210,000 = Design Life ESALs

SN = 2.715 = Required SN when B equals (or slightly exceeds) A

$Log_{10}ESAL$ = A = 5.32222

=

Thickness Equation= B = 5.32301 with no drainage reduction

Design Mr = 6,482 psi

0.77310145	A
3.72	B
908.000873	C
1.60484466	D
-0.02082679	E
0.200000	F
3.72	G
5.33481454	H
-0.56408	I

When A = B, ESAL's and SN agree, then calculate thickness
Take Calculated Thickness and round appropriately for design thickness

Structural Coefficient of HMA = 0.44
Structural Coefficient of Class 6 ABC = 0.12
Structural Coefficient of Class 2 ABC = 0.11

Design Serviceability Loss (ΔPSI)= 2.5

Initial Serviceability Index= 4.5
Final Serviceability Index = 2.0

Calculated thickness, inches = 6.17
FULL DEPTH HMA

Overall Standard Deviation, So = 0.44
Reliability, R (percent) = 90
Standard Normal Deviate (ZR) = -1.282
(Use Table 1.4 from CDOT Pavement Design Manual)

Composite HMA over ABC
(using specified layer of ABC)
Inches of Class 6 ABC = 6.0
Inches of Class 2 or 3 ABC = 6.0
Calculated Inches of HMA = 3.03 Use 3.5 inches

Reliability, R (percent)	Standard Normal Deviate(Z_R)
50	0.000
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	-1.037
90	-1.282
91	-1.340
92	-1.405
93	-1.476
94	-1.555
95	-1.645
98	-2.054

APPENDIX K

PAVEMENT M-E DESIGN RIGID PAVEMENT OUTPUT SHEET

Matchett Park New PCCP Design

File Name: C:\Users\goldbaum\Documents\My PMED Designs\My ME Design\Projects\Matchett Park\Matchett Park New PCCP Design.dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP

Existing construction: -
Pavement construction: May, 2024
Traffic opening: September, 2024

Climate Data Sources (Lat/Lon): 39.134, -108.538

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	7.0
NonStabilized	Crushed gravel	8.0
Subgrade	A-7-6	6.0
Subgrade	A-7-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	12.0
Dowel diameter (in)	-
Slab width (ft)	12.0

Traffic

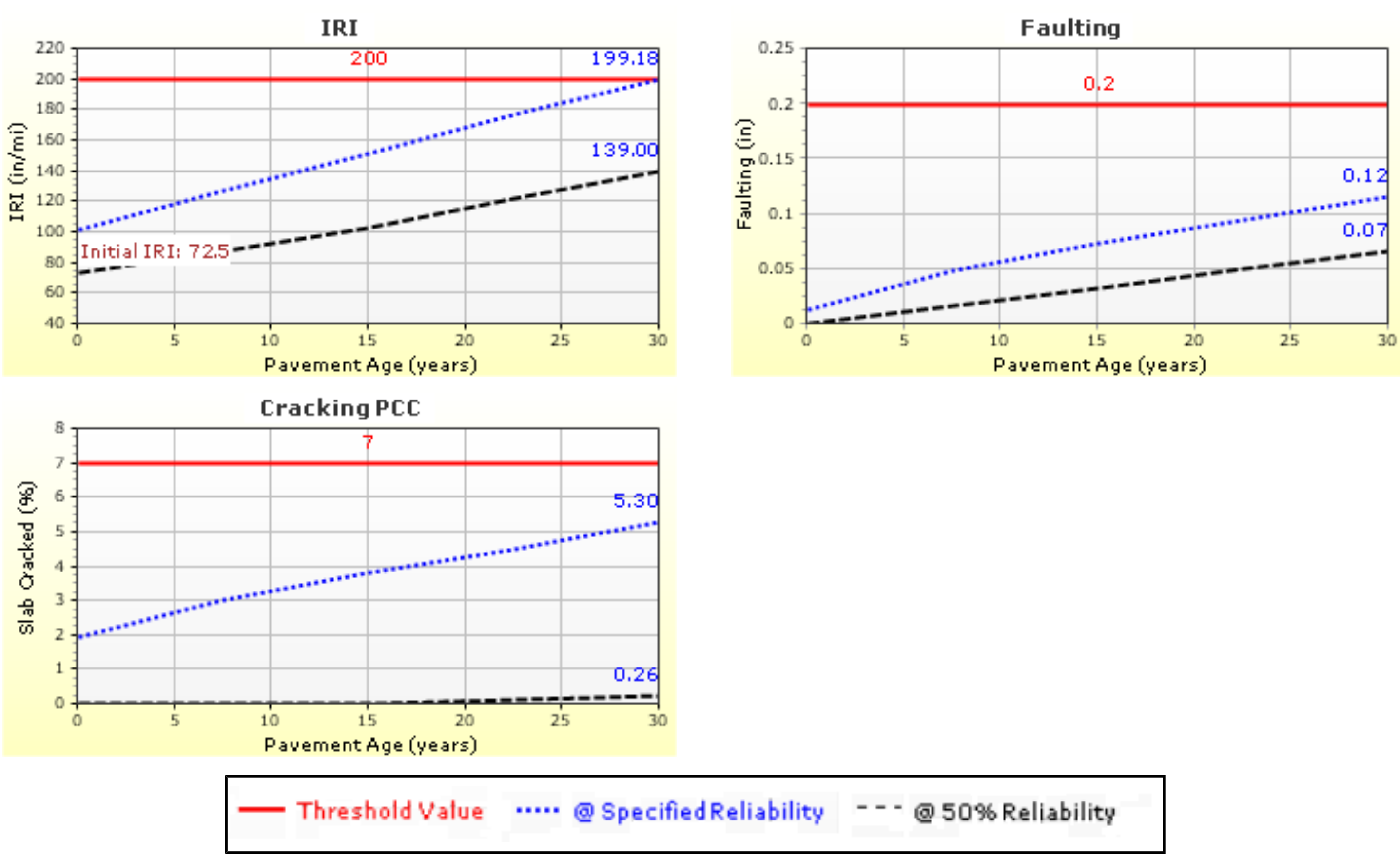
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	20
2039 (15 years)	128,170
2054 (30 years)	305,813

Design Outputs

Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	199.18	90.00	90.30	Pass
Mean joint faulting (in)	0.20	0.12	90.00	99.98	Pass
JPCP transverse cracking (percent slabs)	7.00	5.30	90.00	95.66	Pass

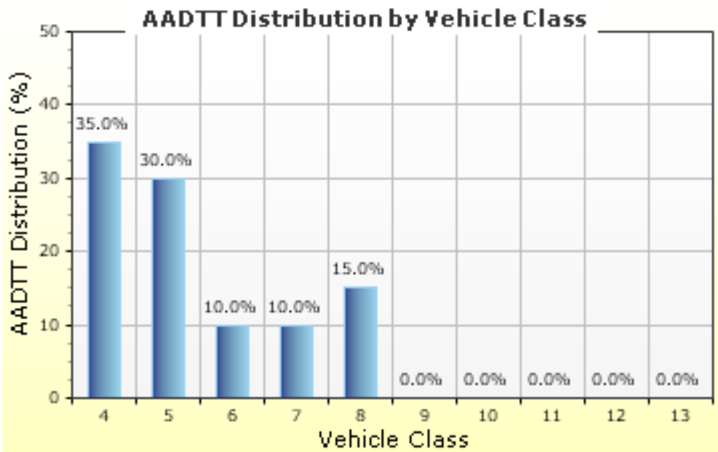
Distress Charts

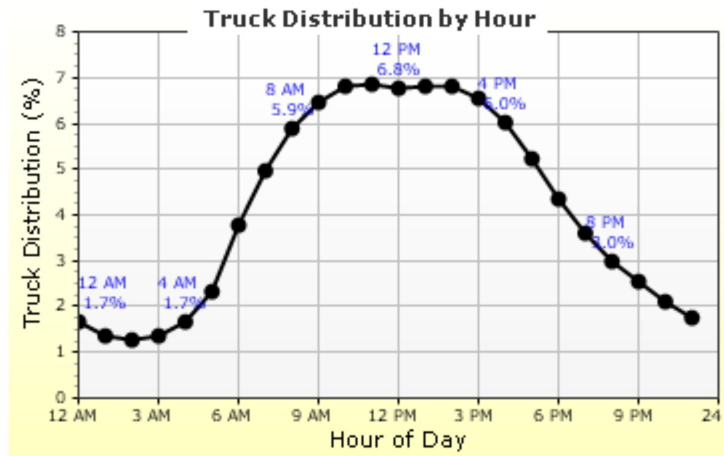


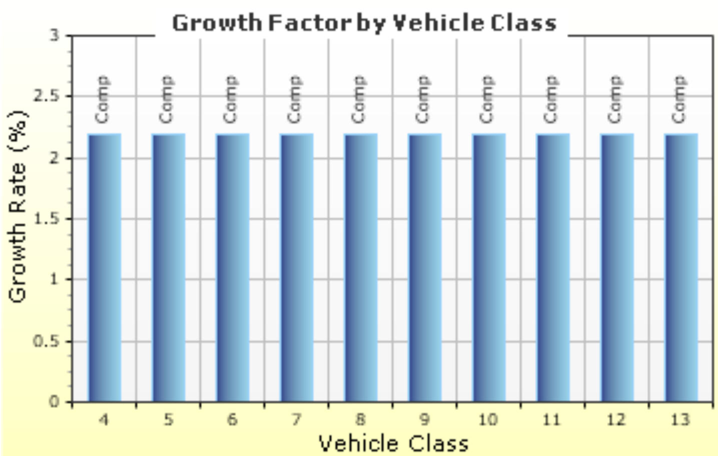
Traffic Inputs

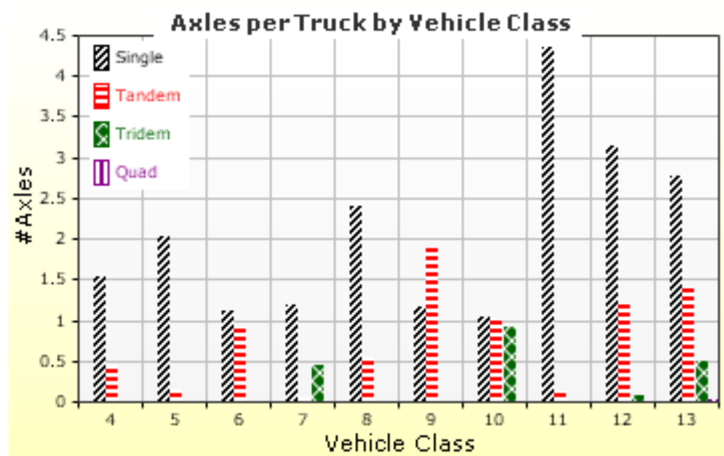
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	20	Percent of trucks in design direction (%):	100.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	25.0

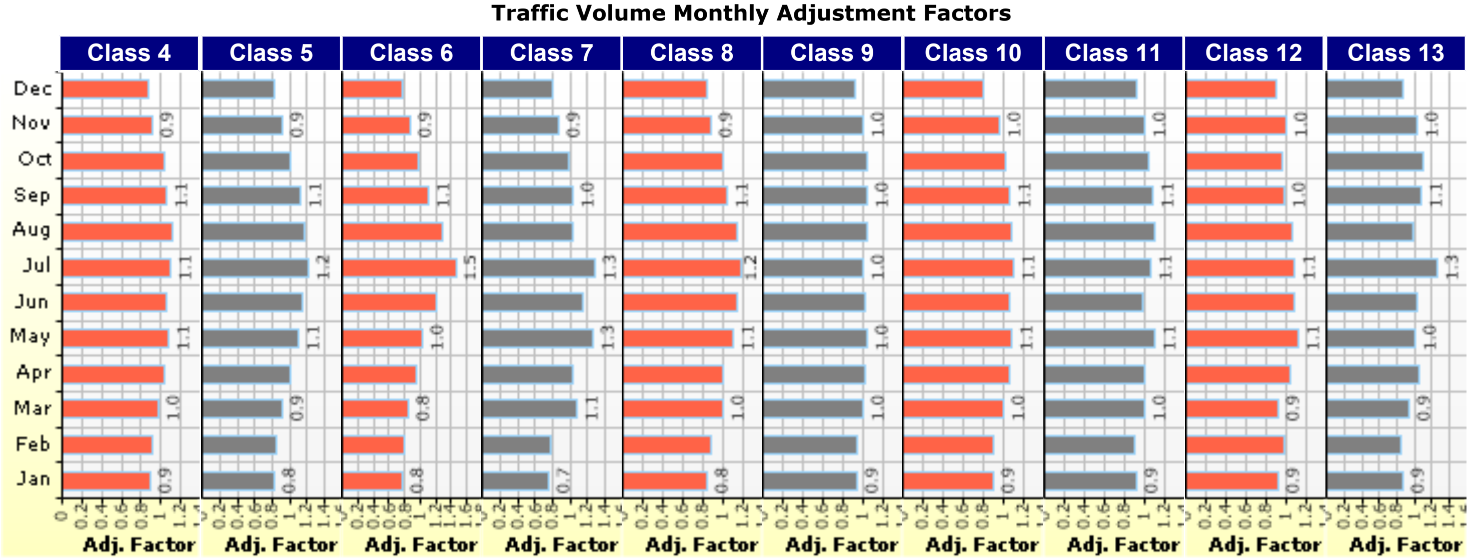








Traffic Volume Monthly Adjustment Factors



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	0.9	0.8	0.8	0.7	0.8	0.9	0.9	0.9	0.9	0.9
February	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	0.8
March	1.0	0.9	0.8	1.1	1.0	1.0	1.0	1.0	0.9	0.9
April	1.0	1.0	0.9	1.0	1.0	1.0	1.1	1.0	1.0	1.1
May	1.1	1.1	1.0	1.3	1.1	1.0	1.1	1.1	1.1	1.0
June	1.1	1.1	1.2	1.1	1.1	1.0	1.1	1.0	1.1	1.0
July	1.1	1.2	1.5	1.3	1.2	1.0	1.1	1.1	1.1	1.3
August	1.1	1.2	1.3	1.0	1.1	1.0	1.1	1.1	1.1	1.0
September	1.1	1.1	1.1	1.0	1.1	1.0	1.1	1.1	1.0	1.1
October	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.1
November	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0
December	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.9	0.9	0.9

Distributions by Vehicle Class

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	35%	2.2%	Compound
Class 5	30%	2.2%	Compound
Class 6	10%	2.2%	Compound
Class 7	10%	2.2%	Compound
Class 8	15%	2.2%	Compound
Class 9	0%	2.2%	Compound
Class 10	0%	2.2%	Compound
Class 11	0%	2.2%	Compound
Class 12	0%	2.2%	Compound
Class 13	0%	2.2%	Compound

Truck Distribution by Hour

Hour	Distribution (%)	Hour	Distribution (%)
12 AM	1.65%	12 PM	6.75%
1 AM	1.37%	1 PM	6.81%
2 AM	1.28%	2 PM	6.83%
3 AM	1.36%	3 PM	6.56%
4 AM	1.66%	4 PM	6.02%
5 AM	2.32%	5 PM	5.23%
6 AM	3.8%	6 PM	4.35%
7 AM	4.95%	7 PM	3.59%
8 AM	5.9%	8 PM	2.98%
9 AM	6.48%	9 PM	2.56%
10 AM	6.83%	10 PM	2.12%
11 AM	6.85%	11 PM	1.75%
		Total	100%

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

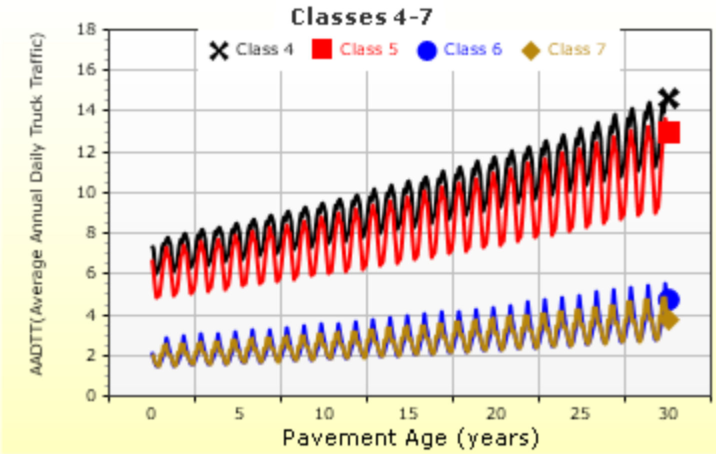
Wheelbase			
Value Type / Axle Type	Short	Medium	Long
Average spacing of axles (ft)	12.0	15.0	18.0
Percent of Trucks (%)	17.0	22.0	61.0

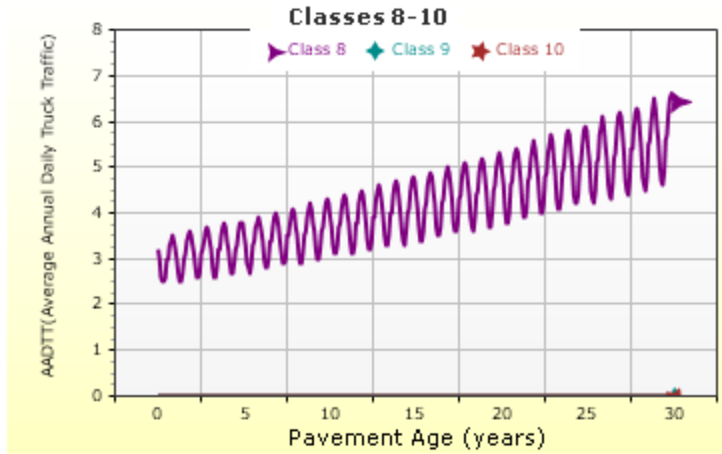
Number of Axles per Truck

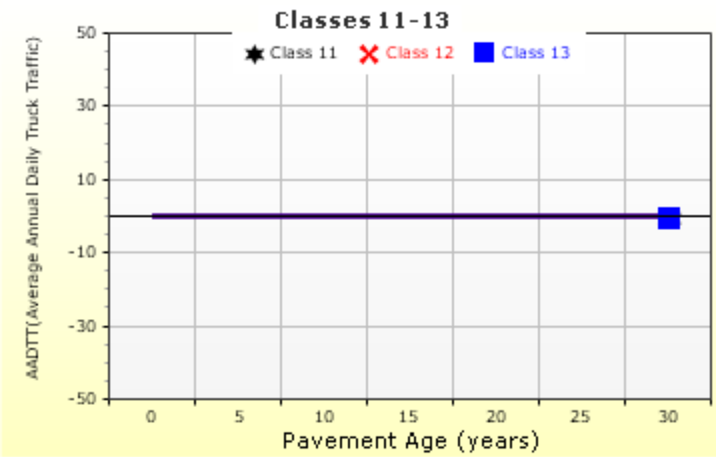
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4	0.51	0.04

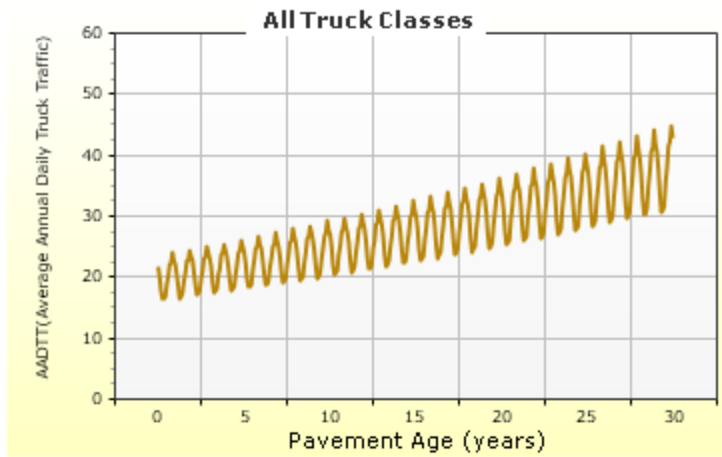
AADTT (Average Annual Daily Truck Traffic) Growth

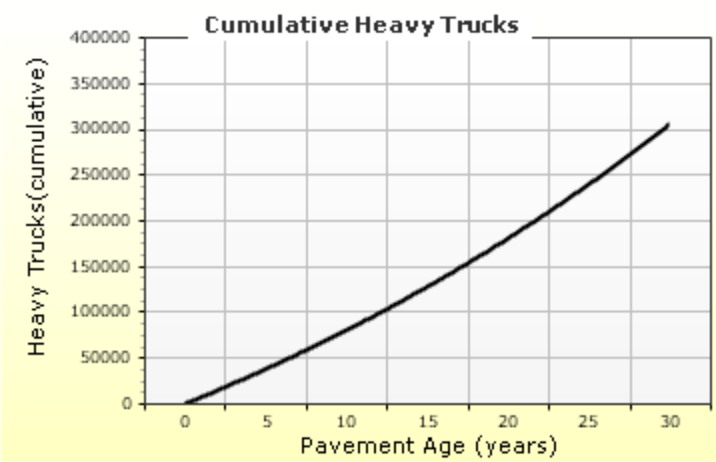
*** Traffic cap is not enforced**







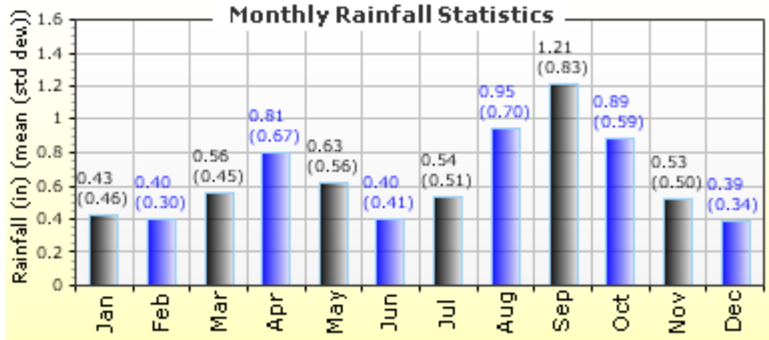




Climate Inputs

Climate Data Sources:

Climate Station Cities:	Location (lat lon elevation(ft))
GRAND JUNCTION, CO	39.13400 -108.53800 4839

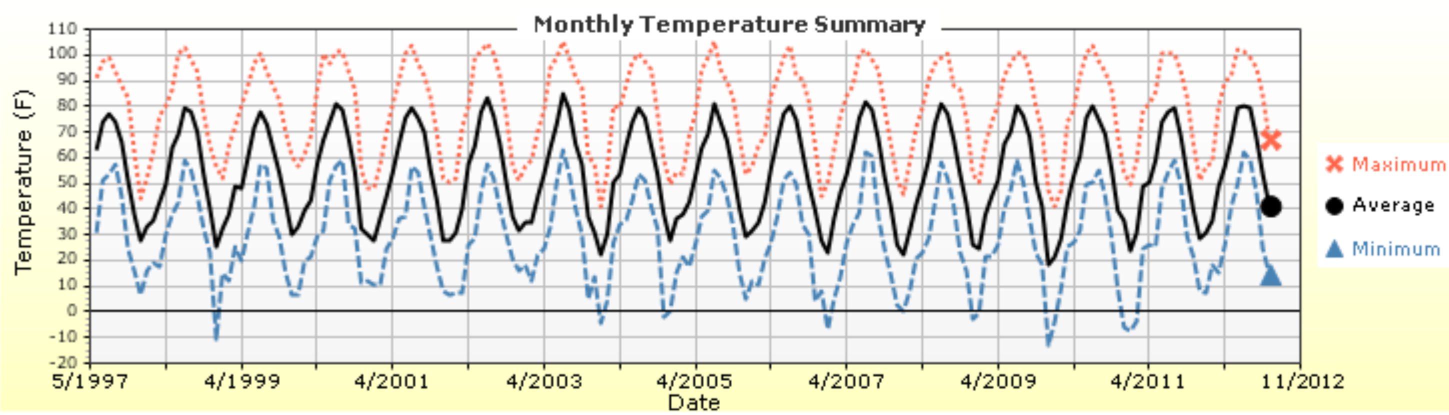


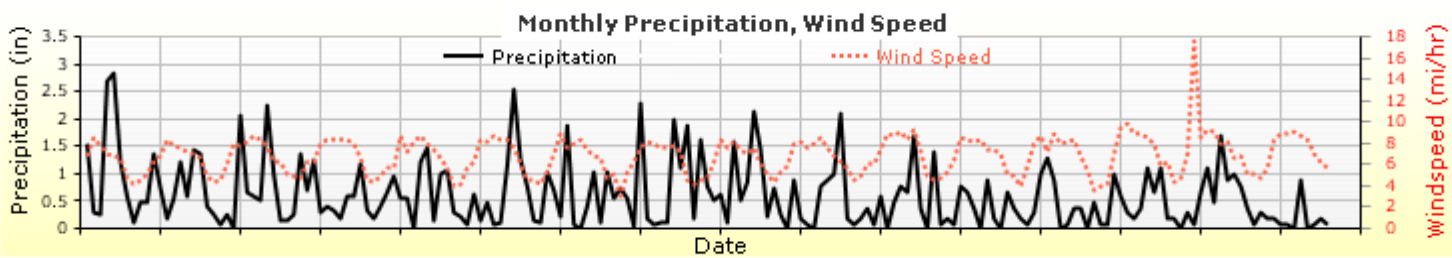
Annual Statistics:

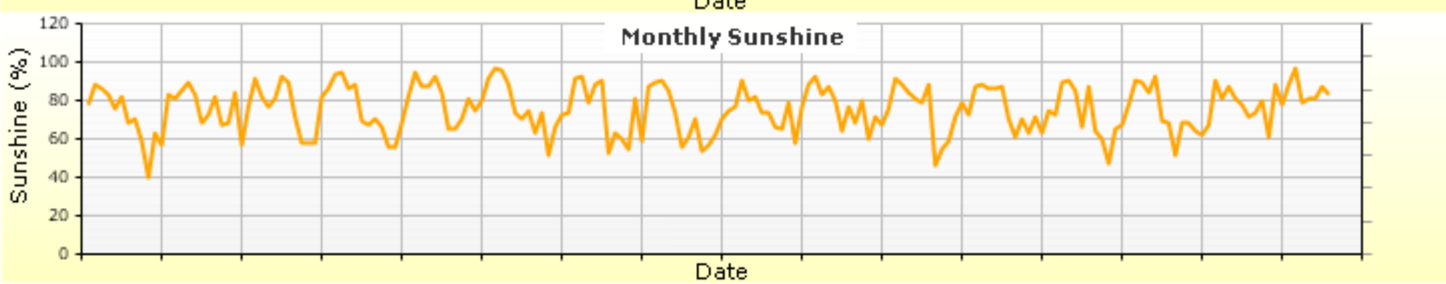
Mean annual air temperature (ºF)	53.55
Mean annual precipitation (in)	7.76
Freezing index (ºF - days)	398.73
Average annual number of freeze/thaw cycles:	111.77

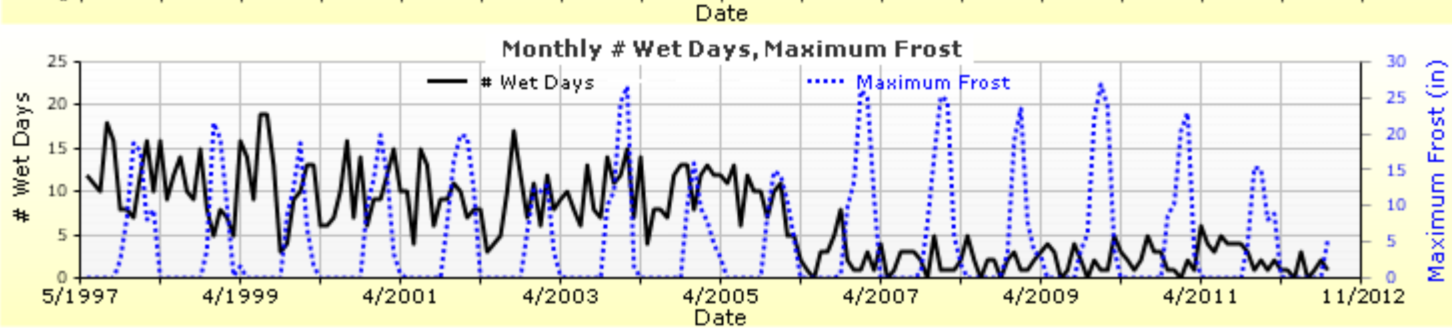
Water table depth (ft) 4.00

Monthly Climate Summary:

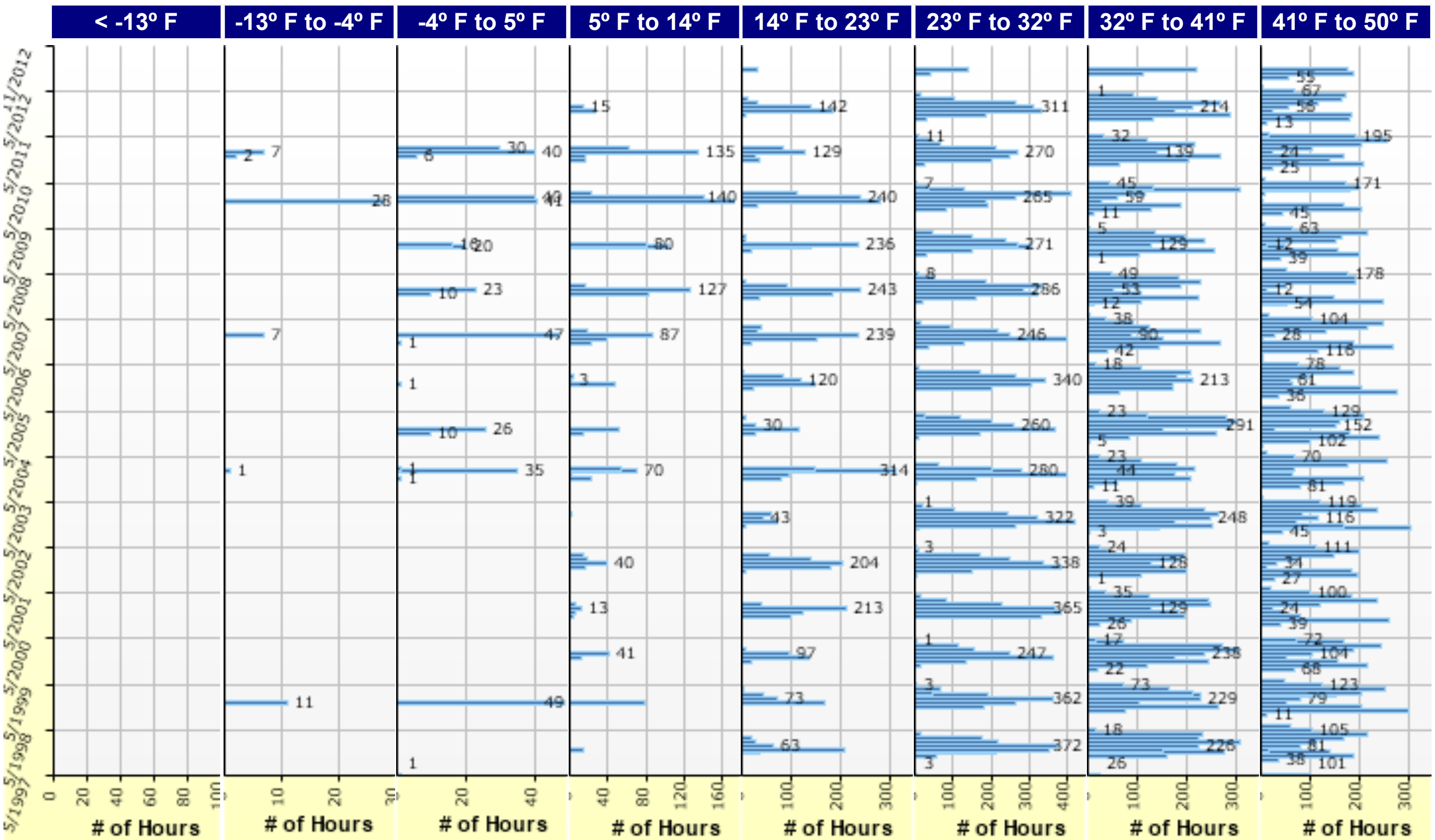


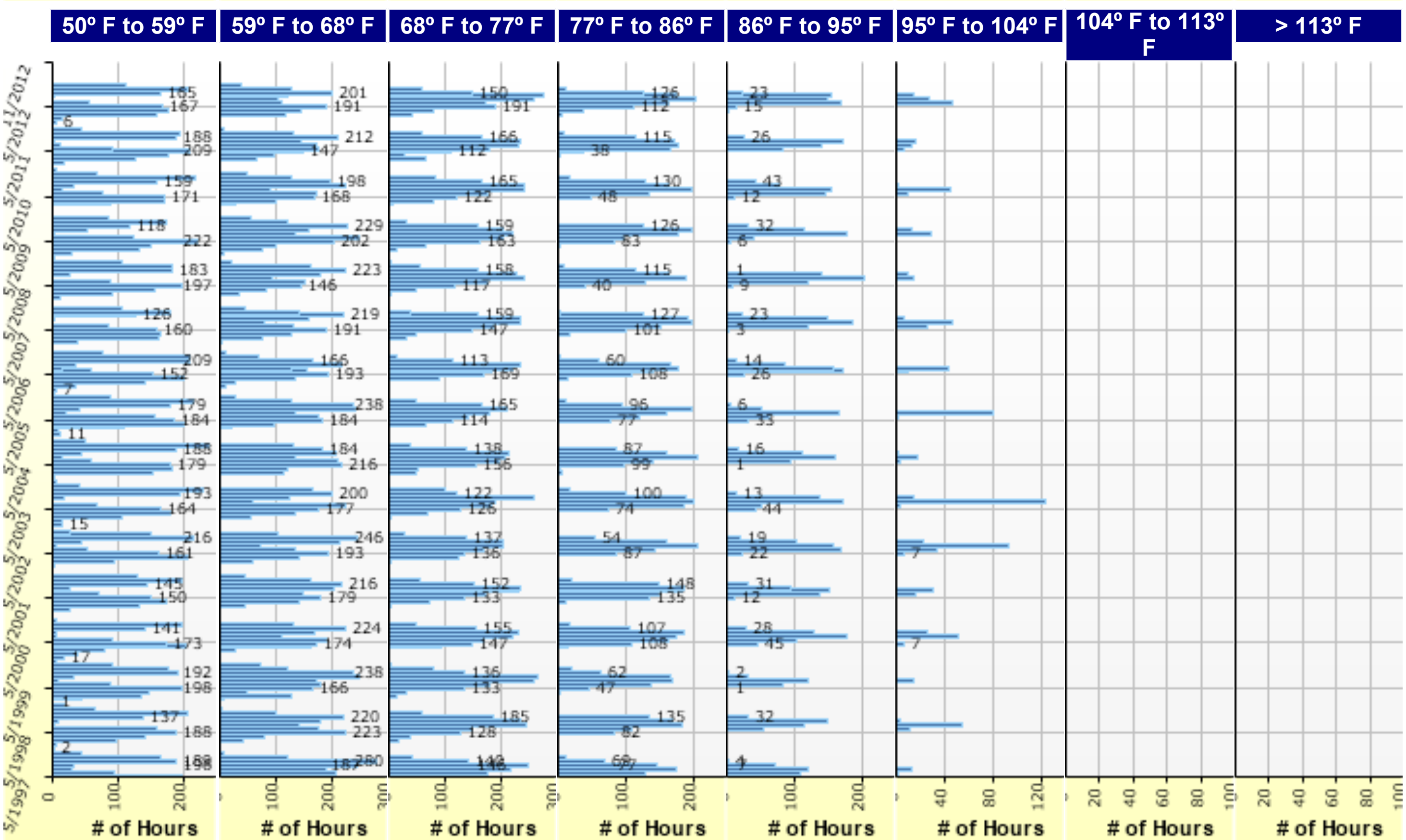






Hourly Air Temperature Distribution by Month:





Design Properties

JPCP Design Properties

Structure - ICM Properties	
PCC surface shortwave absorptivity	0.85

Doweled Joints	
Is joint doweled ?	False
Dowel diameter (in)	-
Dowel spacing (in)	-

Tied Shoulders	
Tied shoulders	True
Load transfer efficiency (%)	50.00

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

Widened Slab	
Is slab widened ?	False
Slab width (ft)	12.00

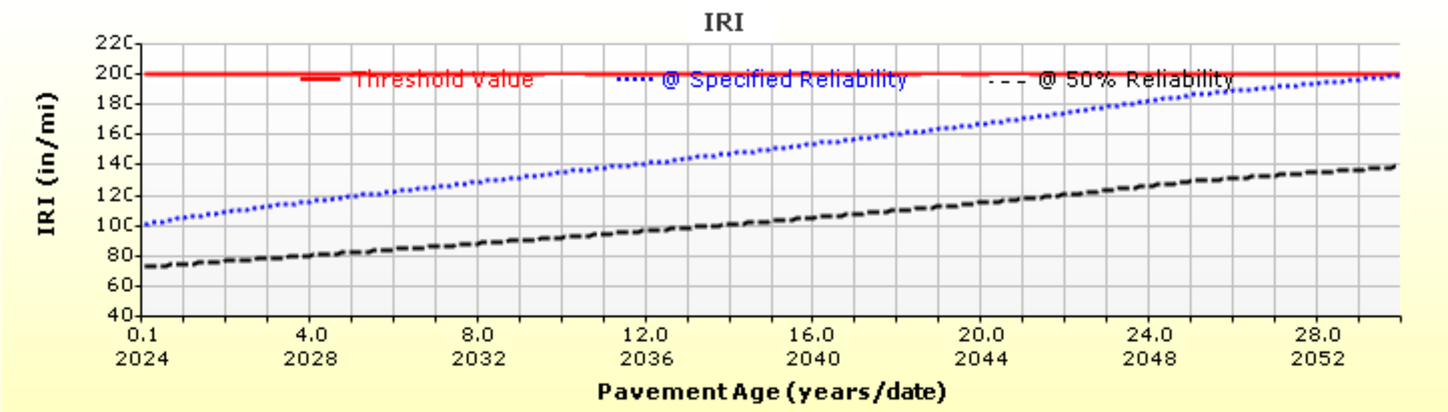
PCC-Base Contact Friction	
PCC-Base full friction contact	True
Months until friction loss	360.00

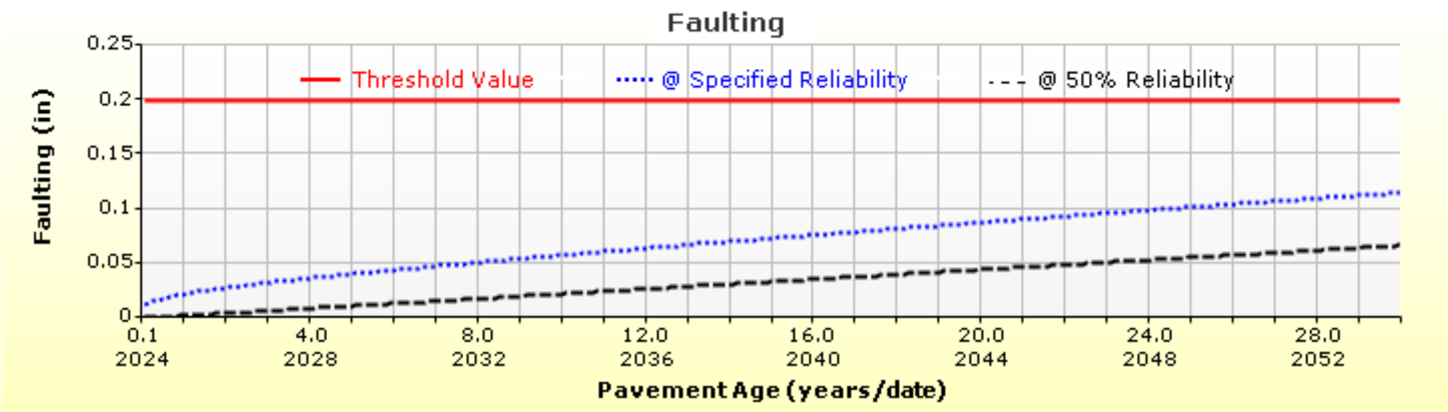
Sealant type	Other(Including No Sealant... Liquid... Silicone)

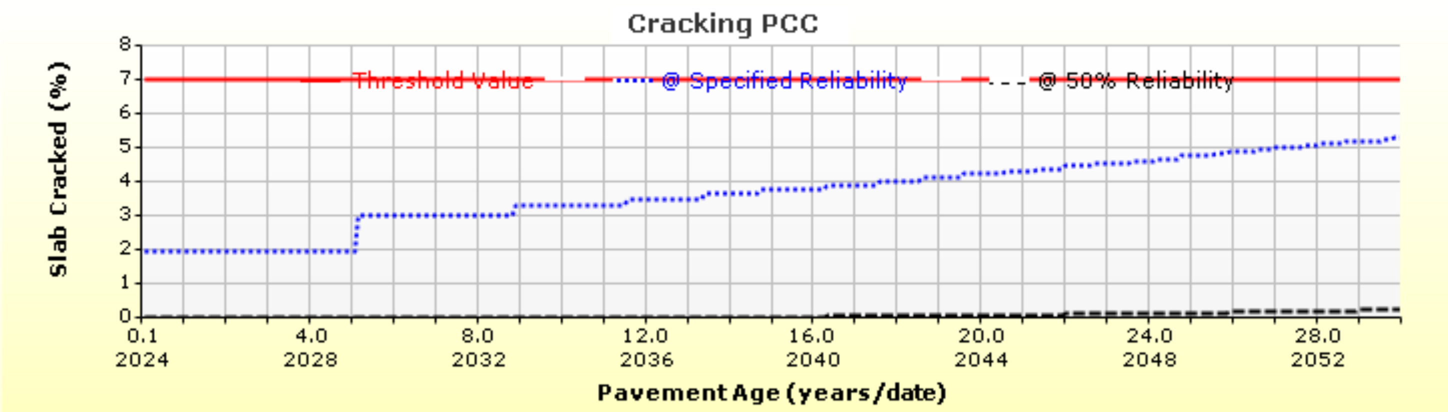
Erodibility index	4

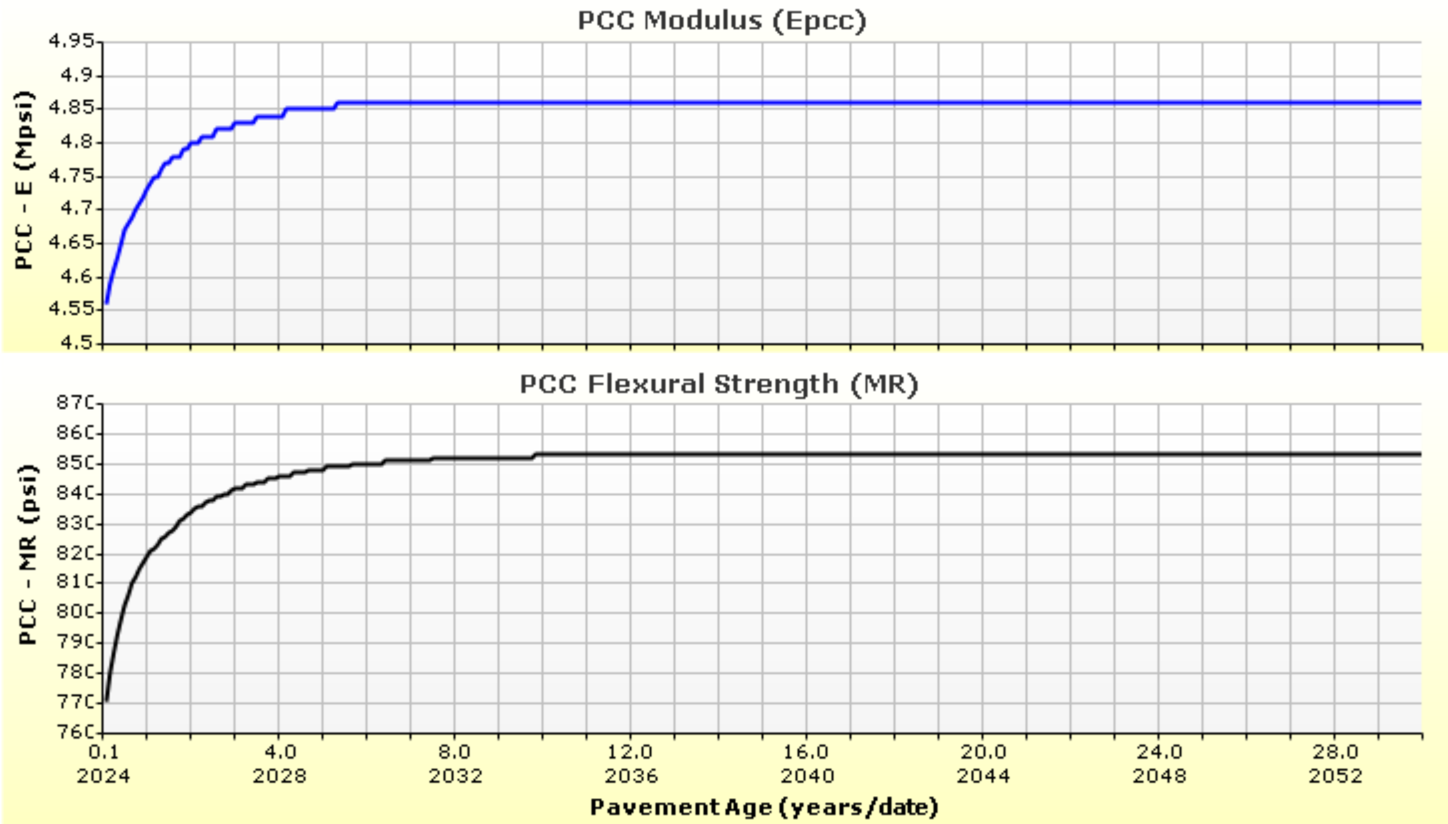
Permanent curl/warp effective temperature difference (ºF)	-10.00

Analysis Output Charts

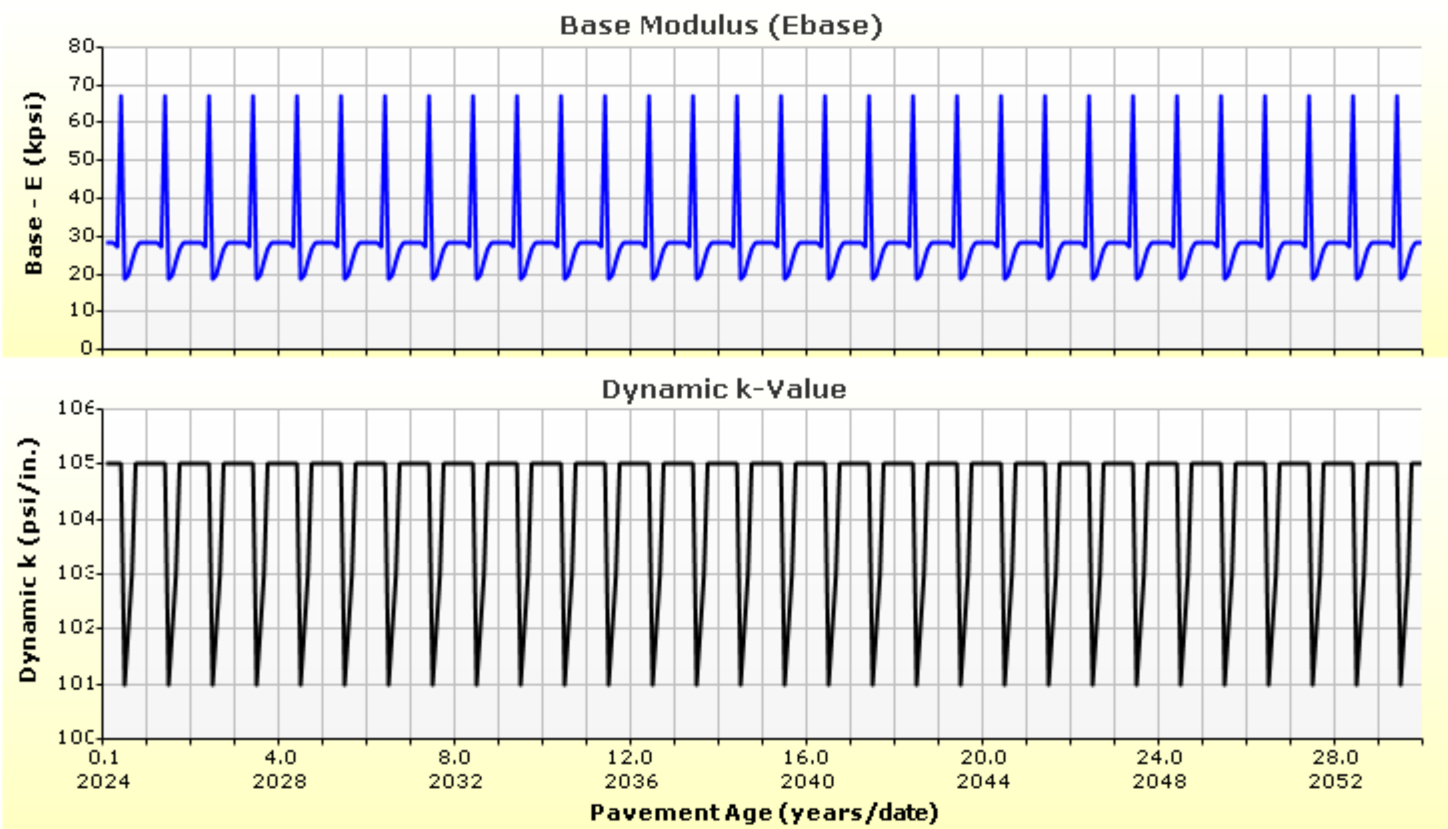




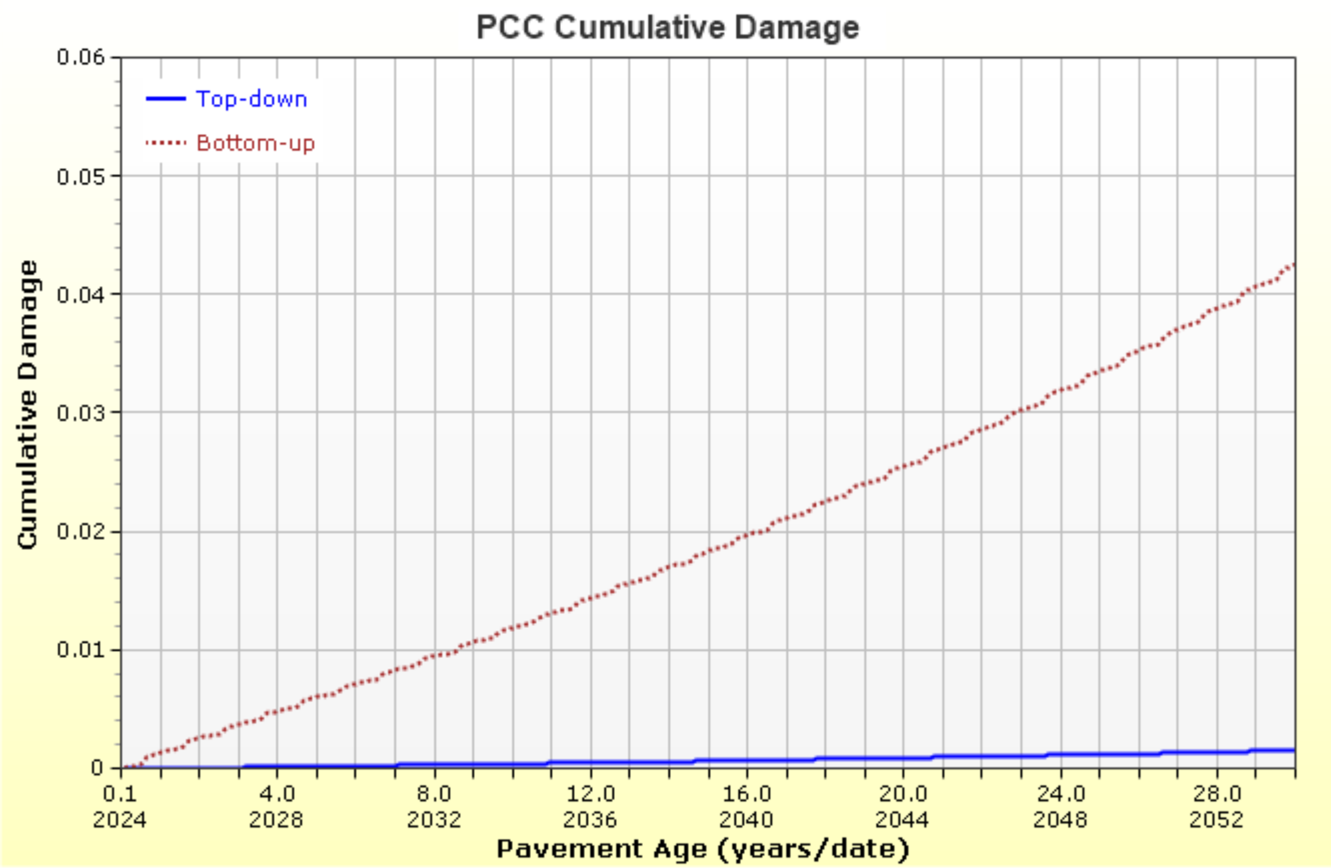


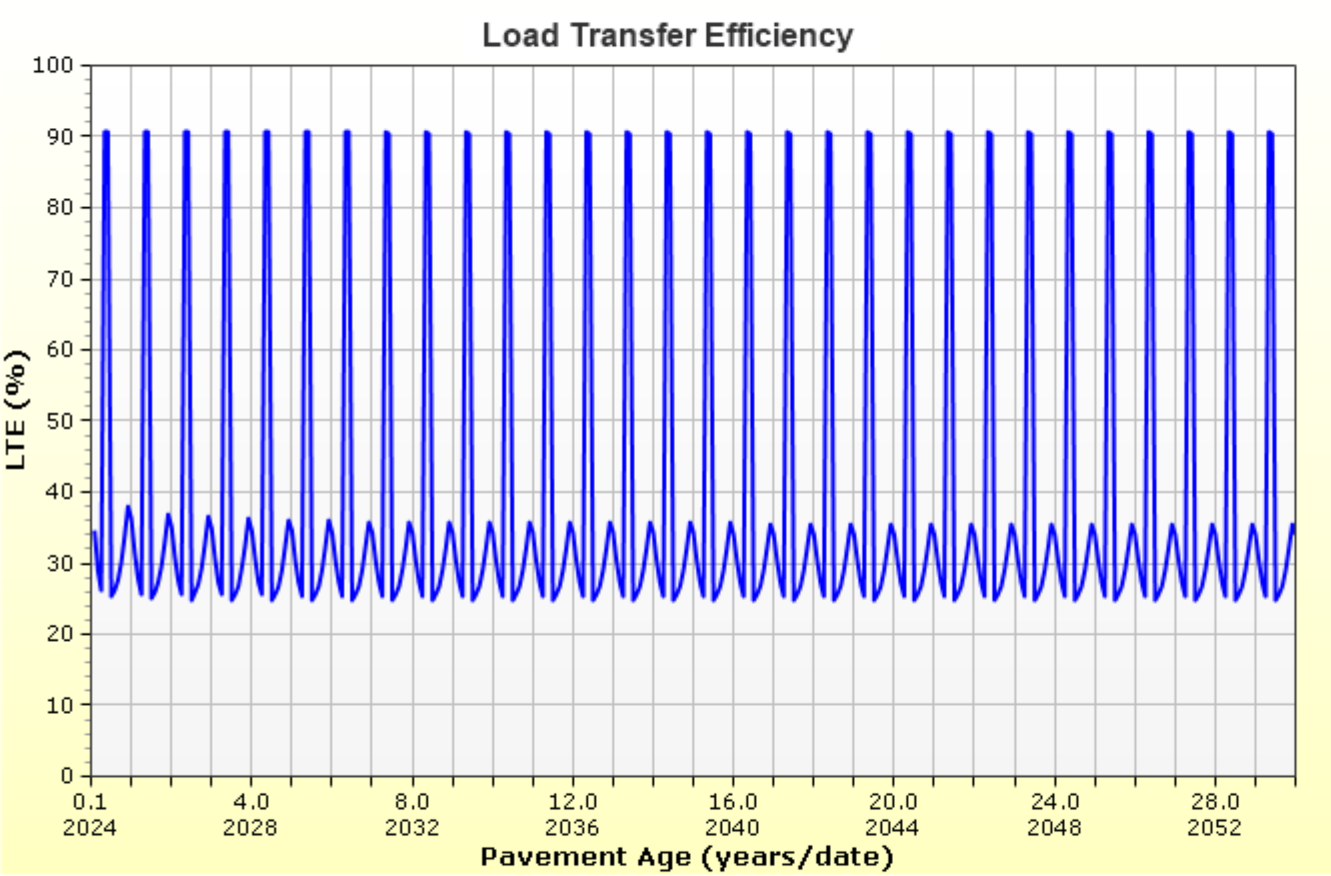


PCC Modulus (Epcc)
PCC - E (Mpsi)
4.95
4.9
4.85
4.8
4.75
4.7
4.65
4.6
4.55
4.5
PCC Flexural Strength (MR)
PCC - MR (psi)
870
860
850
840
830
820
810
800
790
780
770
760
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)



Base Modulus (Ebase)
Base - E (kpsi)
80
70
60
50
40
30
20
10
0
Dynamic k-Value
Dynamic k (psi/in.)
106
105
104
103
102
101
100
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)


PCC Cumulative Damage
Top-down
Bottom-up
Cumulative Damage
0.06
0.05
0.04
0.03
0.02
0.01
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)


Load Transfer Efficiency
LTE (%)
100
90
80
70
60
50
40
30
20
10
0
0.1
2024
4.0
2028
8.0
2032
12.0
2036
16.0
2040
20.0
2044
24.0
2048
28.0
2052
Pavement Age (years/date)

Layer Information

Layer 1 PCC : R4 Level 1 Lawson

PCC	
Thickness (in)	7.0
Unit weight (pcf)	140.6
Poisson's ratio	0.2

Thermal	
PCC coefficient of thermal expansion (in/in/ºF x 10^-6)	4.86
PCC thermal conductivity (BTU/hr-ft-ºF)	1.25
PCC heat capacity (BTU/lb-ºF)	0.28

Mix		
Cement type		Type I (1)
Cementitious material content (lb/yd^3)		563
Water to cement ratio		0.36
Aggregate type		Dolomite (2)
PCC zero-stress temperature (ºF)	Calculated Internally?	True
	User Value	-
	Calculated Value	90.7
Ultimate shrinkage (microstrain)	Calculated Internally?	True
	User Value	-
	Calculated Value	516.0
Reversible shrinkage (%)		50
Time to develop 50% of ultimate shrinkage (days)		35
Curing method		Curing Compound

Identifiers

Field	Value
Display name/identifier	R4 Level 1 Lawson
Description of object	Mix ID # 2009105
Author	CDOT
Date Created	4/3/2013 12:00:00 AM
Approver	CDOT
Date approved	4/3/2013 12:00:00 AM
State	Colorado
District	
County	
Highway	
Direction of Travel	
From station (miles)	
To station (miles)	
Province	
User defined field 1	Region 4/1/6
User defined field 2	
User defined field 3	
Revision Number	0

PCC strength and modulus (Input Level: 1)

Time	Modulus of rupture (psi)	Elastic modulus (psi)
7-day	560	3230000
14-day	620	3500000
28-day	710	4030000
90-day	730	4240000
20-year/28-day	1.2	1.2

Layer 2 Non-stabilized Base : Crushed gravel

Unbound	
Layer thickness (in)	8.0
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)
18000.0

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

Identifiers

Field	Value
Display name/identifier	Crushed gravel
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	42

Sieve

Liquid Limit	6.0
Plasticity Index	1.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.7
Saturated hydraulic conductivity (ft/hr)	False	5.054e-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	7.2555
bf	1.3328
cf	0.8242
hr	117.4000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	8.7
#100	
#80	12.9
#60	
#50	
#40	20.0
#30	
#20	
#16	
#10	33.8
#8	
#4	44.7
3/8-in.	57.2
1/2-in.	63.1
3/4-in.	72.7
1-in.	78.8
1 1/2-in.	85.8
2-in.	91.6
2 1/2-in.	
3-in.	
3 1/2-in.	97.6

Layer 3 Subgrade : A-7-6

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)
6482.0

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

Identifiers

Field	Value
Display name/identifier	A-7-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	51.0
Plasticity Index	30.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	98.6
Saturated hydraulic conductivity (ft/hr)	False	8.849e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	22.2

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	136.4179
bf	0.5183
cf	0.0324
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	79.1
#100	
#80	84.9
#60	
#50	
#40	88.8
#30	
#20	
#16	
#10	93.0
#8	
#4	94.9
3/8-in.	96.9
1/2-in.	97.5
3/4-in.	98.3
1-in.	98.8
1 1/2-in.	99.3
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

Layer 4 Subgrade : A-7-6

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)
6482.0

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

Identifiers

Field	Value
Display name/identifier	A-7-6
Description of object	Default material
Author	AASHTO
Date Created	1/1/2011 12:00:00 AM
Approver	
Date approved	1/1/2011 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	51.0
Plasticity Index	30.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	97.7
Saturated hydraulic conductivity (ft/hr)	False	8.946e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	22.2

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	136.4179
bf	0.5183
cf	0.0324
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	79.1
#100	
#80	84.9
#60	
#50	
#40	88.8
#30	
#20	
#16	
#10	93.0
#8	
#4	94.9
3/8-in.	96.9
1/2-in.	97.5
3/4-in.	98.3
1-in.	98.8
1 1/2-in.	99.3
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.9

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: 0.5104	C2: 0.00838	C3: 0.00147	C4: 0.008345
C5: 5999	C6: 0.8404	C7: 5.9293	C8: 400
PCC Reliability Faulting Standard Deviation			
0.0831*Pow(FAULT,0.3426) + 0.00521			

IRI-jpcp

C1 - Cracking	C1: 0.8203	C2: 0.4417
C2 - Spalling	C3: 1.4929	C4: 25.24
C3 - Faulting	**Reliability Standard Deviation**	
C4 - Site Factor	5.4	

PCC Cracking

$$\log(N) = C1 \cdot \left(\frac{MR}{\sigma}\right)^{C2}$$

$$CRK = \frac{100}{1 + C4\ FD^{C5}}$$

Fatigue Coefficients		Cracking Coefficients	
C1: 2	C2: 1.22	C4: 0.6	C5: -2.05
PCC Reliability Cracking Standard Deviation			
Pow(57.08*CRACK,0.33) + 1.5			

APPENDIX L

AASHTO 1998 RIGID PAVEMENT OUTPUT SHEET

Rigid Pavement Design - Based on AASHTO Supplemental Guide

Reference: *LTPP DATA ANALYSIS - Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*

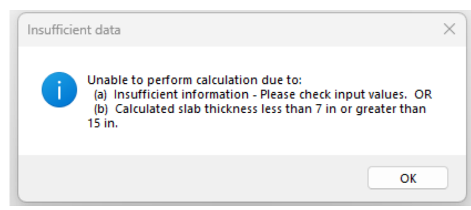
Results

Project # 599.84
Description: Matchett Park and Community Recreation Center

Location: Grand Junction, CO

Slab Thickness Design

Pavement Type	JPCP	
18-kip ESALs Over Initial Performance Period (million)	0.26	million
Initial Serviceability	4.5	
Terminal Serviceability	2	
28-day Mean PCC Modulus of Rupture	650	psi
Elastic Modulus of Slab	3,400,000	psi
Elastic Modulus of Base	18,000	psi
Base Thickness	8.0	in.
Mean Effective k-Value	125	psi/in
Reliability Level	90	%
Overall Standard Deviation	0.34	
Calculated Design Thickness		in



Temperature Differential

Mean Annual Wind Speed	8.8	mph
Mean Annual Air Temperature	50.3	°F
Mean Annual Precipitation	15.3	in
Maximum Positive Temperature Differential		°F

Modulus of Subgrade Reaction

Period	Description	Subgrade k-Value, psi

Seasonally Adjusted Modulus of Subgrade Reaction		psi/in
Modulus of Subgrade Reaction Adjusted for Rigid Layer and Fill Section		psi/in

Traffic

Performance Period		years
Two-Way ADT		
Number of Lanes in Design Direction		
Percent of All Trucks in Design Lane		
Percent Trucks in Design Direction		

Vehicle Class	Percent of ADT	Annual Growth	Initial Truck Factor	Annual Growth in Truck Factor	Accumulated 18-kip ESALs (millions)

Total Calculated Cumulative ESALs	0.23	million

Faulting

Doweled

Dowel Diameter	1.25	in
Drainage Coefficient	1.00	
Average Fault for Design Years with Design Inputs		in
Criteria Check		

Nondoweled

Drainage Coefficient	1	
Average Fault for Design Years with Design Inputs		in
Criteria Check		

APPENDIX D

TEST PIT PHOTOGRAPHS