Geologic Hazards and Geotechnical Investigation Report
Appleton Fire Station #7
City of Grand Junction, Colorado

RockSol Project No. 599.89
October 13, 2023

Prepared for:

City of Grand Junction Public Works
244 North 7th Street
Grand Junction, Colorado, 81501

Attention: Kirsten Armbruster, PE

Prepared by:

RockSol Consulting Group, Inc.
12076 Grant Street
Thornton, Colorado 80241
(303) 962-9300

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1.0 PROJECT PURPOSE AND DESCRIPTION

This report documents the geotechnical investigation performed by RockSol Consulting Group, Inc. (RockSol) to assist with design of a proposed Fire Station for the City of Grand Junction. It is under the assumption that this fire station will be a two-story structure with interior slab-supported parking for fire trucks, living quarters, and offices. The exterior of the building will also include asphalt and concrete supported parking with concrete vehicle aprons, sidewalks, and landscaped areas. The Appleton Fire Station #7 Concept layout is shown in Figure 1.

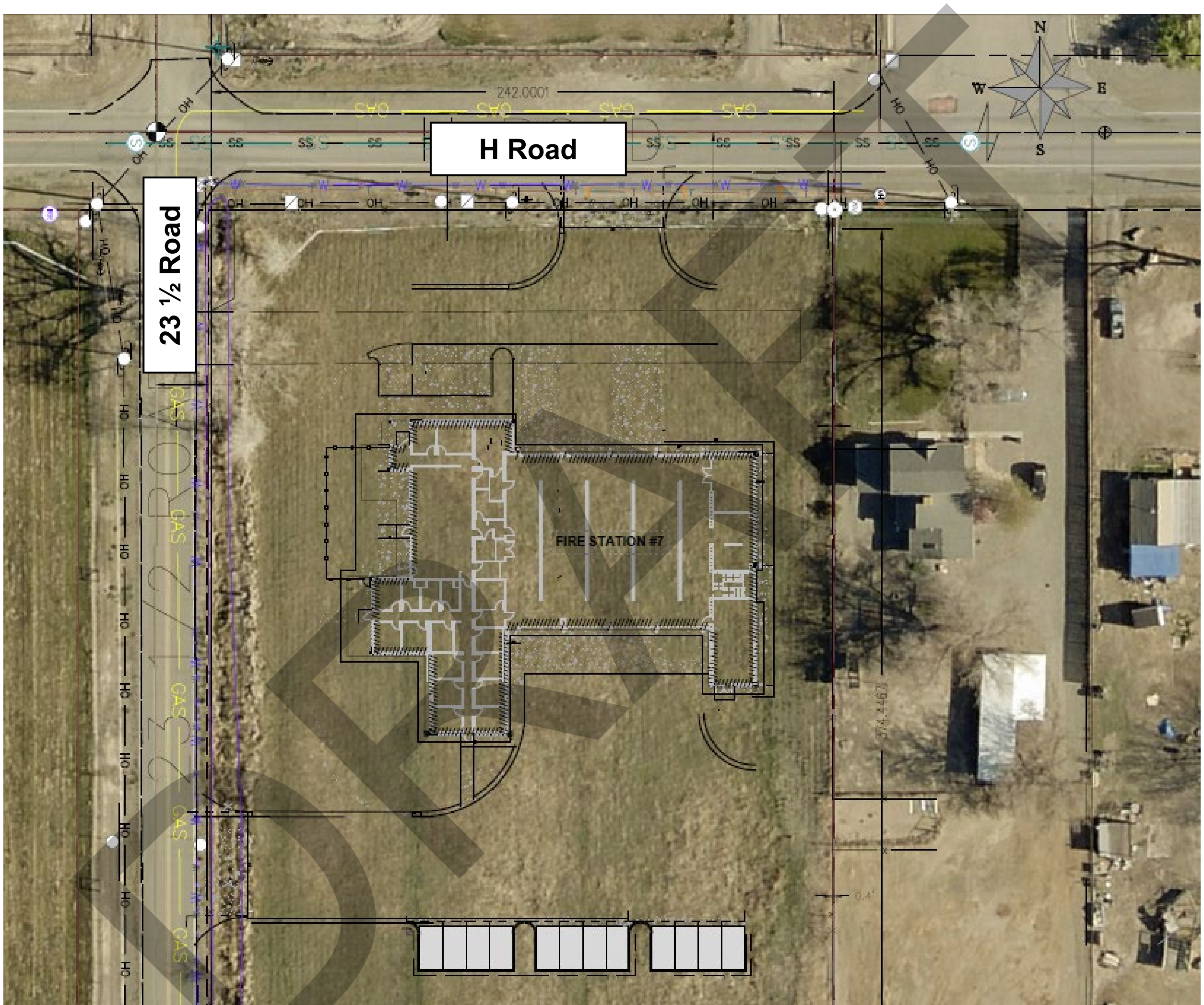


Figure 1 – Fire Station #7 Site Plan and Layout

The scope of work for this geotechnical investigation includes:

- Formulating a drilling pattern and performing the necessary geotechnical subsurface investigation, including collecting subsurface samples as required.
- Performing appropriate laboratory tests and analyzing the data to determine strength, allowable bearing capacity, and corrosiveness of foundation material.
- Providing foundation type and subgrade preparation recommendations including bearing capacity and lateral earth pressure recommendations.
- Providing recommendations for pavement sections (flexible and rigid pavement types).

- Providing drainage, grading, and general earthwork recommendations.
- Evaluation of potential geologic hazards at the site.
- Preparing a Geotechnical Investigation Report summarizing the subsurface conditions encountered, the laboratory test results, geological hazards, geotechnical parameters for foundation design, pavement design recommendations, and earthwork recommendations.

The pavement design recommendations will include both Flexible (asphalt) and Rigid (concrete) designs for the proposed Fire Station driveways and parking areas. Pavement Design recommendations will be completed in accordance with the City of Grand Junction Transportation Engineering Design Standards (TEDS).

2.0 PROJECT SITE CONDITIONS

The project site is located in Section 32, Township 1 North, Range 1, West of the Ute Principal Meridian in Grand Junction, Mesa County, Colorado. The project site is bounded to the north by H Road, to the west by 23 ½ Road (see Figures 1 and 2). To the south the site is bounded by the Appleton drainage ditch, and to the east by the residence at 2355 H Road. Developments near or adjacent to the site include agricultural fields and residential developments to the north, east, and west, and limited businesses. Appleton Elementary School is located directly northeast of the project site, at 2358 H Road. Topography at the generally consists of nearly flat slopes in all directions.

3.0 GEOLOGICAL SETTING

Based on information presented in the *Geologic Map of the Grand Junction Quadrangle, Mesa County, Colorado* by Robert B. Scott, Paul E. Carrara, William C. Hood, and Kyle E. Murray dated 2002 (Figure 2 – Site Geologic Map), the site is underlain by Alluvium and Colluvium, undivided (Holocene and late Pleistocene) (Qac) which contains a combination of alluvium, sheetwash, and debris flow deposits and typically consists of light-gray and light-olive-gray, fine sandy silt and clayey silt. Starting approximately 0.75 miles east of the project site alluvium deposits (Qa) distributed by tributary streams (Holocene and late Pleistocene) are mapped. Approximately 1 mile east of the project site Pediment deposits (Qpwf), and Mancos Shale bedrock (Km) are mapped on the north side of H Road and south of I-70.

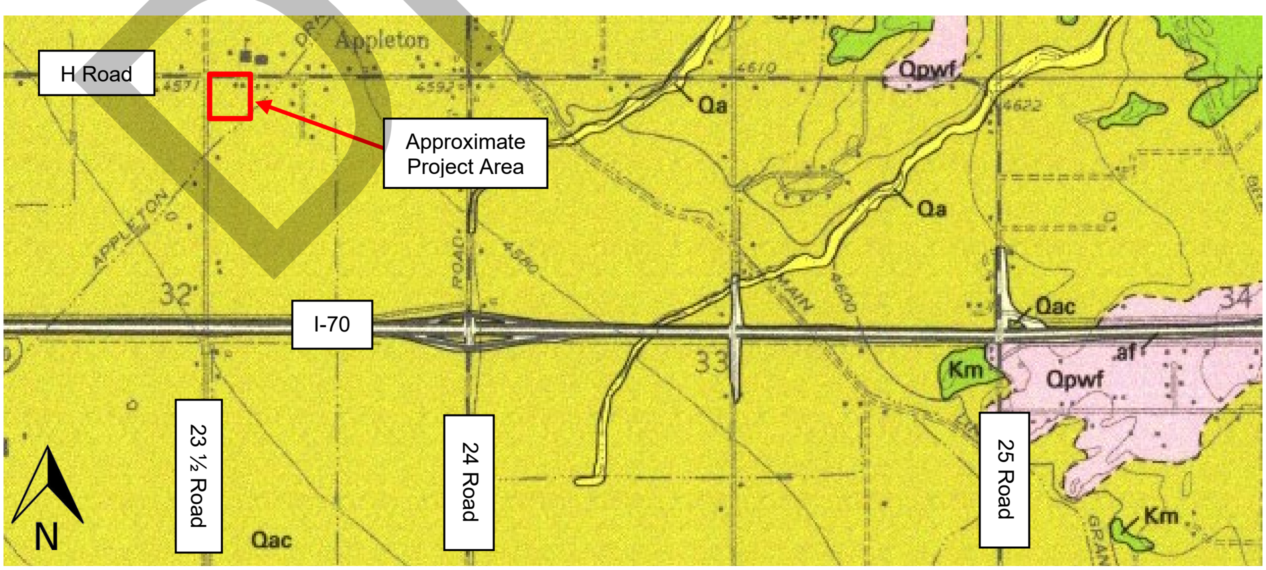


Figure 2 – Site Geologic Map (USGS)

Geological hazards present at this project site include soft to very soft subgrade soils extending to depths of approximately 30 to 40 feet below existing grades. A slight potential risk of flooding is presented from the Appleton Drainage Ditch located approximately 630 feet south of the proposed location of the Fire Station building. RockSol anticipates a very low risk of potential flooding from the Main Line Grand Valley Canal located 0.5 miles north and 0.6 miles east of the project site.

4.0 SUBSURFACE EXPLORATION

On August 9, 2023, RockSol completed four boreholes identified as BH-2, BH-3, P-1, and P-2 and one test pit identified as TP-1, to evaluate subsurface conditions at the project site. On August 24, 2023 a fifth borehole identified as BH-1 was completed at the project site. Boreholes BH-1 through BH-3 were drilled at the approximate location of the proposed Appleton Fire Station #7 building to assist with foundation and interior slab design. Boreholes P-1 and P-2 were drilled to assist with pavement design for access and parking pavements. The test pit, TP-1, was completed for the purpose of obtaining bulk material for proctor curve and R-Value testing. See Figure 3 below for approximate borehole and test pit locations.

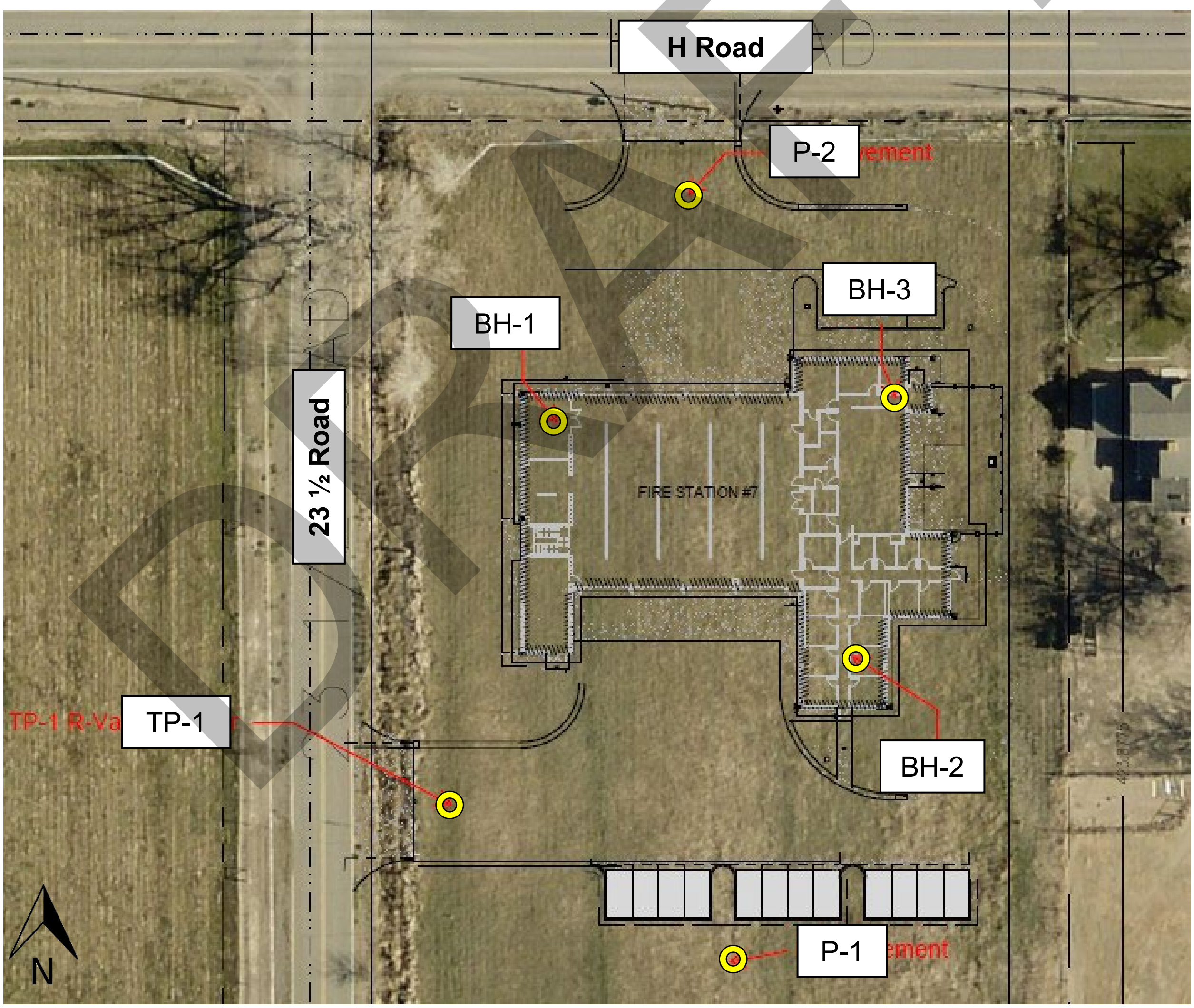


Figure 3 – Fire Station #7 Site Plan and Layout

A truck mounted CME-55 drill rig was used for drilling and sampling at all borehole locations. The test pit was excavated using a Bobcat 435. The boreholes were advanced using 7.5-inch outside diameter hollow stem augers to maximum depths ranging from approximately 6.5 feet to 61.5 feet below existing grades. The boreholes and test pit were logged in the field by a representative of RockSol with the depth to groundwater, if encountered, noted at the time of sampling. The boreholes were backfilled with sand and pea gravel material at the completion of sampling activities. The test pit was backfilled with the excavated material not collected for the bulk sample.

Subsurface materials were identified at each borehole and the test pit by a representative of RockSol using visual-manual methods as described in ASTM D2488. Samples were collected from the soil boreholes using modified California barrel and standard split spoon samplers. Penetration Tests were performed at each soil borehole using an automatic lift system and a hammer weighing 140 pounds falling 30 inches.

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. The standard split spoon sampling method is the Standard Penetration Test (SPT) described by ASTM Method D-1586. 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 per ASTM D3550. 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 soil borehole 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 Borehole Logs (See Appendix A).

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)
- Proctor (AASHTO T99 Method A)
- Resistance Value (AASHTO T-190)

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. Laboratory test results are presented in Appendix B and are summarized on the Borehole Logs presented in Appendix A.

6.0 SUBGRADE CHARACTERIZATION

Subsurface conditions generally consist of topsoil overlying fill and native soils. Bedrock material was not encountered in the boreholes to the depths sampled. Groundwater was encountered at approximate depths ranging from 4.8 feet to 7.2 feet below existing grades. See Table 1 for groundwater depths and elevations where encountered. Descriptions of the surface and subsurface conditions encountered in the boreholes and the test pit are provided below and are also summarized on the Borehole Logs and Test Pit Log presented in Appendix A.

6.1 Surface and Subsurface Materials

Surface Material

Approximately 3 to 12 inches of sandy and silty clay topsoil was encountered at the ground surface of all soil boreholes and the test pit at this project site.

Fill Material

Fill material was encountered at Borehole locations BH-3, P-1, and P-2 and generally consisted of 1.75 feet of sandy to slightly silty clay. Fill material was not encountered at the test pit location.

Native Soils

Native soils were encountered in all boreholes and the test pit sampled for this project and generally consisted of interbedded layers of non-plastic clay, silt, or silty sand to the maximum depths explored or overlying gravelly and cobbly sand.

Bedrock

Bedrock was not encountered to the depths explored in any of the soil boreholes or the test pit. Based on discussions with local (Grand Junction area) geotechnical drilling personnel and our experience, bedrock is estimated to be just below the maximum depth drilled of 61.5 feet below existing grades at the subject location, possibly on the order of 65 to 70 feet.

Groundwater

Groundwater was encountered in Boreholes BH-3, P-1, and P-2 at the time of drilling. Boreholes BH-1, BH-2, and BH-3 were left open for the purpose of subsequent water level readings. Groundwater was not encountered at the test pit location. At Borehole BH-1, a piezometer was installed to the maximum depth drilled of 60 feet below grade. A summary of the groundwater measurements obtained from each borehole is provided in Table 1. Groundwater at this site is likely influenced by the Appleton Drain located approximately 350 feet south of the project site. Approximately 0.6 miles east of the project site is the Main Line Grand Valley Canal. Groundwater levels at the site may be subject to seasonal change, local irrigation practices and long-term precipitation trends. See Figure 4 for a contour map of the approximate groundwater elevations taken at the last reading of each borehole location.

Table 1 - Groundwater Measurements

Sample Location	Ground Surface Elevation (ft)	Depth Explored (ft)	Piezometer Installed?	Measurement Date	Depth to WT (ft)	Elevation of WT (ft)
BH-1	4571.2	60	Yes	8/24/2023	NE	-
				8/25/2023	7.2	4564.0
BH-2	4570.9	60	No	8/9/2023	NE	-
				8/11/23	6.5	4564.4
				8/18/23	6.2	4564.7
				8/23/23	6.7	4564.2
				8/24/23	7.0	4563.9
				8/25/23	6.7	4564.2
BH-3	4571.7	30	No	8/9/2023	7.0	4564.7
				8/10/23	7.0	4564.7
				8/11/23	6.2	4565.5
				8/18/23	4.8	4566.9
				8/23/23	5.7	4566.0
				8/24/23	7.0	4564.7
				8/25/23	7.0	4564.7
P-1	4569.4	6.5	No	8/9/2023	6.0	4563.4
P-2	4572.4	6.5	No	8/9/2023	6.0	4566.4
TP-1	4570.0	6.0	No	8/9/2023	NE	-

WT = Water Table, NE = Not Encountered

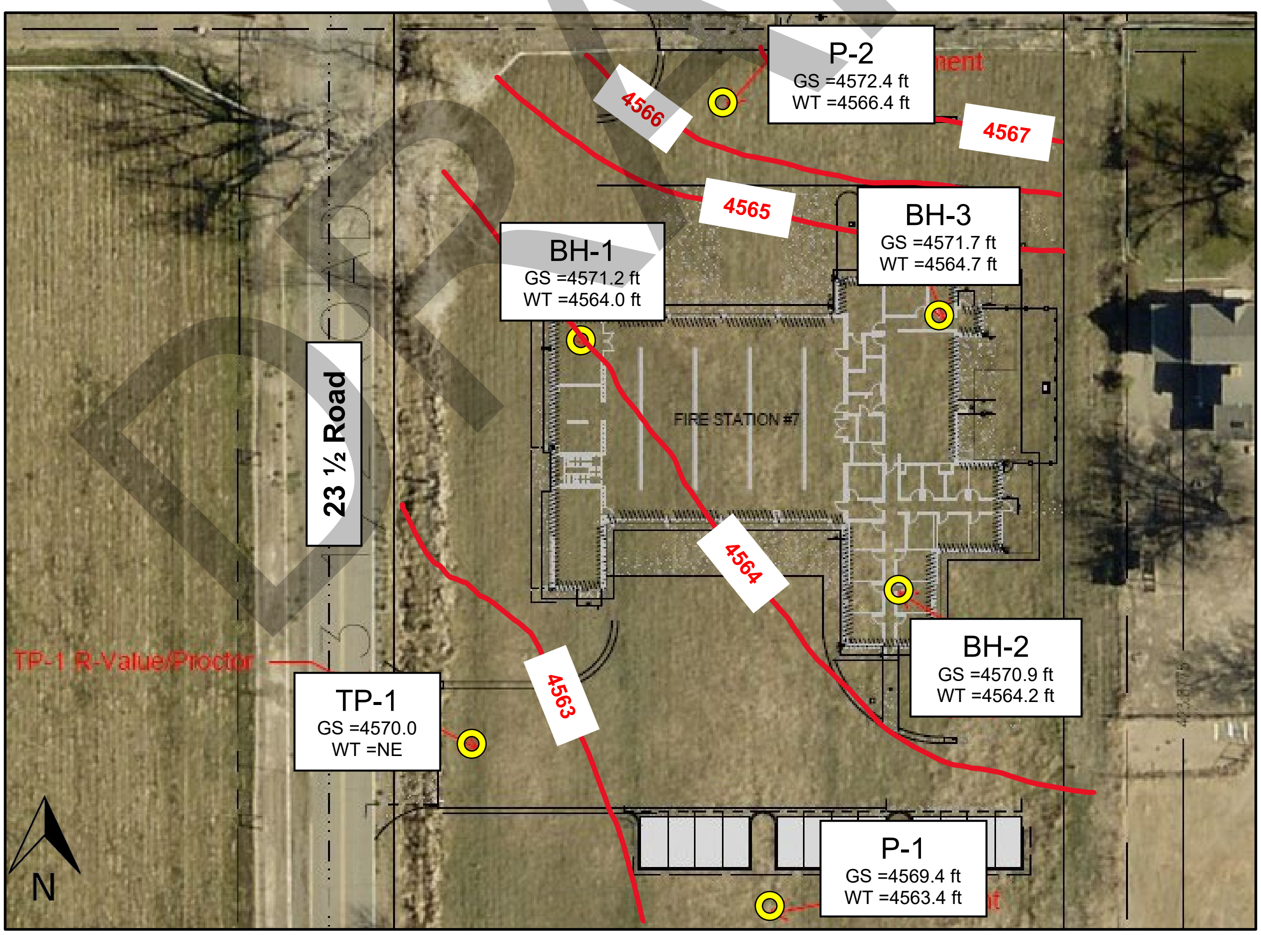


Figure 4 – Approximate Groundwater Elevation Contour Map

6.2 Swell Potential of Subgrade Soils

Two swell tests were performed on samples obtained from Boreholes BH-2 and BH-3 at approximately 1 foot below existing grades. Based on swell test results and plasticity index (PI) testing, the subgrade soils encountered within the upper 1 foot of the surface of the proposed Appleton Fire Station #7 exhibit low swell potential (0.3 to 1.8 percent swell under a 200 psf surcharge pressure). Soils encountered below depths of 2 feet were too moist to exhibit swell potential. No consolidation tests were assigned due to the very soft conditions. Output sheets of the swell test results can be found in Appendix B.

6.3 Cement Type/Sulfate Resistance Discussion

The City of Grand Junction uses the 2021 International Building Code (IBC 2021) for development of concrete resistance parameters. The IBC 2021 references the American Concrete Institute (ACI) for such parameters. Cementitious material requirements for concrete in contact with site soils or groundwater are based on the percentage of water-soluble sulfate in either soil or groundwater that will be in contact with concrete constructed for this project. Mix design requirements for concrete exposed to water-soluble sulfates in soils or water is considered by the ACI as shown in Table 2 and in the Building Code Requirements for Structural Concrete (ACI 318-08) (ACI Table 4.3.1).

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

Exposure Class	Water-soluble sulfate (SO_4), in dry soil, percent	Sulfate (SO_4), in water, ppm	Water Cementitious Ratio, maximum	Cementitious Material Requirements (ASTM C150)
S0	0.00 to <0.10	0 to <150	Not Applicable	No Restriction
S1	0.10 to < 0.20	151 to <1,500	0.50	Type II
S2	0.20 to 2.0	1,500 to 10,000	0.45	Type V
S3	2.01 or greater	10,001 or greater	0.45	Type V plus pozzolan

The concentration of water-soluble sulfates measured in soil samples obtained from RockSol's exploratory boreholes varied from 0.10 percent to 0.19 percent by weight. Based on the results of the water-soluble sulfate testing, Exposure Class S1 is recommended for concrete in contact with subgrade materials for the project. For Exposure Class S1, Type II cement is recommended.

6.4 Corrosion Resistance Discussion

Water-soluble sulfate and chloride content, pH, and electrical resistivity tests were performed on the bulk sample obtained from Borehole BH-2 and are summarized in Table 3. The electrical resistivity analysis was performed in the RockSol laboratory using the soil box method (ASTM G-187).

Table 3 – 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-2	5-10	0.0189	1,300 @ 15.3%	**0.16**	7.8	CR 2
BH-3	15	-	-	**0.11**	-	CR 2
BH-3	25	-	-	**0.10**	-	CR 1
P-2	2-5	-	-	**0.19**	-	CR 2

Based on 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 1 and CR 2 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 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 Appleton Fire Station #7 should be considered as a CR 2 category.

In addition, electrical resistivity analyses were performed in the RockSol laboratory using the soil box method (ASTM G-187). Comparison of the results of the electrical resistivity testing performed with *Table 2 – Minimum Pipe Thickness For Metal Pipes Based On The Resistivity And pH Of The Adjacent Soil* as presented in the *CDOT Pipe Materials Selection Guide,* effective April 30, 2015*,* suggests the minimum required gauge thickness for metal pipe material, if used for this project, is *0.052 inches (18 Gauge) Polymer Coated*. Additional testing at specific structure locations should be performed to provide structure specific recommendations.

In the Federal Highways document FHWA NHI-09-087 *Corrosion/Degradation of Soil Reinforcements For Mechanically Stabilized Earth Walls and Reinforced Soil Slope* Table 2-3 *Effect of Resistivity on Corrosion (NCHRP, 1978)* defines resistivities between 700 to 2,000 ohms-cm as corrosive. Due to our resistivity test resulting in a resistivity of 1,300 ohm-cm, special corrosion resistance should be considered for the foundation design recommendations included in this report.

7.0 SEISMICITY DISCUSSION

The City of Grand Junction uses the 2021 International Building Code (IBC-2021) 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 subject site meets criteria for Seismic Site Class D. Seismic design parameters for Site Class D are discussed below. Shear wave velocity testing was not performed by RockSol.

Based on Table 1604.5 *Risk Category of Buildings and Other Structures* in accordance with ASCE 7-16, buildings and structures identified as essential facilities including fire, rescue, ambulance, police stations, and emergency vehicle garages shall be classified with Risk Category IV.

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: U.S. Seismic Design Maps (seismicmaps.org). The proposed fire station or emergency structure qualifies as risk category IV per Table 1604.5 of the *IBC-2021*. 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 4.

Table 4 – Seismic Acceleration Coefficients (IBC 2021)

Proposed Appleton Fire Station #7 (Latitude°/Longitude°)	Peak Ground Acceleration (PGA)	Spectral Acceleration Coefficient - S_s (Period 0.2 sec)	Spectral Acceleration Coefficient - S_1 (Period 1.0 sec)
39.1203 N/ 108.6168 W	0.131	0.238	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 5.

Table 5 – Seismic Site Factor Values

Proposed Appleton Fire Station #7 (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)
39.1203 N/ 108.6168 W	1.538	1.6	2.4

Table 6 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. 16-39* of the IBC-2021 and the horizontal response spectral Acceleration Coefficient at 0.2 Seconds, S_{DS}, as determined by *Eq. 16-38.* Values for S_1 and F_v are presented in Tables 4 and 5, 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 6 – Seismic Performance Zone

Proposed Appleton Fire Station #7 (Latitude°/Longitude°)	Acceleration Coefficient at 1.0 seconds (S_{D1})	Acceleration Coefficient at 0.2 seconds (S_{DS})	Seismic Design Category (1)
39.1203 N/ 108.6168 W	0.105	0.254	C

8.0 GEOTECHNICAL ANALYSIS AND RECOMMENDATIONS

Based on the subsurface conditions encountered, recommended foundation types for the Appleton Fire Station #7 building include a shallow footing foundation system with ground improvement, helical piers, or driven piles. While drilled shafts are a feasible foundation alternative, they are not recommended due to the amount of soil that would be brought to the surface and required to be hauled off site. Discussion of the foundation recommendations is presented in Sections 8.1, 8.2, and 8.3.

8.1 Shallow Footing Foundation Recommendations

Due to the presence of shallow, very soft soils, a very low allowable bearing pressure for shallow foundations is recommended at this site to limit potential settlement. For the existing site soils, a maximum allowable bearing pressure of 500 pounds per square foot (psf) is recommended. RockSol anticipates this value will not be feasible for design of the Fire Station foundation system, but may be acceptable for pad supported exterior electrical equipment structures.

Ground improvement is recommended to achieve a service bearing resistance greater than 500 psf at this site. At a minimum, RockSol recommends ground improvement consisting of overexcavation of subgrade soils to a minimum depth of 3 feet below the bottom of shallow foundations (footings) and replacement with at least 3-feet of a material meeting CDOT Class 1 Structure Backfill requirements, or granular material that will provide equal, or better, structural support and is approved for use by the City. The Class 1 Structure Backfill material shall also extend a minimum of 2 feet horizontally beyond the limits of the foundation perimeter.

Placement of the backfill material should be in horizonal lifts with a maximum lift thickness of 6 inches. Compaction of each lift with vibratory methods using lightweight equipment is recommended.

With three feet (vertically) of Structural Backfill materials, RockSol considers an allowable bearing resistance of 1.0 ksf appropriate. If greater allowable bearing resistance is required, additional thickness of replaced subgrade soil is required. Due to potential fluctuations in the groundwater elevation at this site, groundwater may be encountered as shallow as 5 feet below the existing grades during the summer/early fall time of the year. **Replacement of subgrade soils must consider the potential to encounter shallow groundwater.**

Based on conditions encountered in the boreholes, bearing resistances are presented in Table 7 for shallow (footing) foundations for the proposed fire station structure. Values for AASHTO LRFD strength limit state, service limit state, and Allowable Bearing Resistance (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 7 –Bearing Resistances for Shallow Foundation After Ground Improvement

Over-excavation and Replacement Thickness	Ultimate (Nominal) Resistance (ksf)	Allowable Bearing Resistance (ASD) Service Bearing Resistance (LRFD) (ksf)
3 feet	4.6	1.0
4 feet	5.9	1.5

Allowable bearing resistance is estimated to correspond to a total settlement of less than 1-inch. RockSol assumes a minimum foundation width of 4 feet for all footings. The bottom of all footings shall be a minimum of 3 feet below finished grade for frost considerations unless a frost protected shallow foundation system is utilized and approved by the City.

The Fire Station building will include plumbing and related utility lines. As a result of the ground disturbance from excavation and backfill of utility trenches, a shallow foundation system for the Fire Station building carries an increased risk of settlement if utility trenches are not properly compacted.

A representative of the geotechnical engineer should observe all foundation excavations prior to placement of the structure backfill materials.

8.2 Helical Pier Foundation System Recommendations

Helical piers are an alternative to shallow foundations, especially if greater bearing resistance is required. The helical piers would need to bear into a dense sand/gravel/cobble layer. RockSol anticipates a **minimum length of 65 feet** required. The depth to the sand/gravel/cobbles may vary slightly across the site therefore some allowance for variations in the total length of the helical piers must be considered. RockSol anticipates that a single large diameter plate for each pier will be needed with a minimum plate diameter of 18-inches.

For helical pier capacity estimating, the bearing stratum of cobbles should be modeled as a cohesionless material with an effective friction angle of 34 degrees and with a total unit weight of 140 pcf and a submerged unit weight of 77 pcf. The overburden soils above the bearing layer should be modeled with a total unit weight of 125 pcf and a submerged unit weight of 62 pcf with groundwater modeled at a depth of 7 feet. If adequate torque is not achieved within the sand/gravel/cobble layer the helical pier will need to extend into the anticipated claystone/shale layer below the cobbles. Minimum pier lengths in that case would be 75 feet.

8.3 Driven Pile Foundation System Recommendations

Alternatively, the Appleton Fire Station #7 structure may be supported on driven steel H-piles (Grade 50 steel). RockSol recommends the piles be driven to practical refusal in bedrock. Estimated pile lengths on the order of 70 to 75 feet are anticipated. If significant penetration into bedrock (greater than 5 feet) is necessary for lateral resistance requirements, pre-drilling may be required.

For the LRFD method, a nominal (ultimate) geotechnical capacity of 30 ksi, based on the cross-section area of the pile, can be used for Grade 50 steel.

During construction, RockSol recommends pile driving be monitored per CDOT requirements per Section 502 of the "CDOT Standard Specifications for Road and Bridge Construction (SSRBC), 2023". Monitoring shall be conducted using a Pile Driving Analyzer (PDA) to determine the condition of the pile, the efficiency of the hammer and the static bearing capacity of the pile, and to establish the pile driving criteria. A resistance factor of 0.65 is recommended for LRFD strength limit state design for axial compression provided PDA testing is performed.

Additional design and construction considerations for driven piles are presented below.

(a) Steel piling, pile driving equipment, and installation of the driven steel H-piles is recommended to follow the guidelines specified in "CDOT Standard Specifications for Road and Bridge Construction (SSRBC), Section 502, 2023".

(b) Lateral load parameters presented in Table 8 may be used for lateral load analysis. Battered piles may be used to resist the lateral loads. The battered piles inclination should be within one (1) horizontal to four (4) vertical.

(c) RockSol anticipates that 3 to 5 feet of pile penetration into bedrock will be required to achieve capacity. The actual length of the piles should be determined during installation.

(d) Center to center pile spacing should not be less than 30 inches or 2.5 pile diameters. For evaluation of horizontal pile foundation movement, the effects of group interaction shall be evaluated in accordance with AASHTO LRFD Bridge Design Specifications, Section 10.7.2.4.

(e) Pile tips should be protected against damage using driving shoes during penetration into the cobbles and sedimentary bedrock.

(f) Potential damage to adjacent properties or structures during pile installation due to noise and vibrations should be considered and evaluated, if necessary.

8.4 Lateral Resistance Parameters (Helical Pier and Driven Pile Foundations)

Recommended lateral resistance parameters for driven piles constructed are presented in Table 8. The parameters listed are for use with LPILE® or equivalent software.

Table 8 – Helical Pier and Driven Pile 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)
CLAY, with sand above water table	Soft Clay	300	0	250	0.020	125 (Total)
CLAY, with sand Below water table	Soft clay w/ free water	150	0	100	0.025	63 (Submerged)
SAND, gravelly to GRAVEL, sandy, Below water table	Sand	0	34	60	--	63 (Submerged)
Claystone/Shale Bedrock	Stiff clay w/o free water	8,000	0	2,000	0.004	125 (Total)

Total unit weight indicated in the table above includes soil plus moisture content. Depths at which groundwater were encountered are indicated in Table 1 of this report and included on the attached borehole logs found in Appendix A.

Lateral Earth Pressure Parameters (Stem Walls)

To assist with design of stem walls, lateral earth pressure parameters are presented in Table 9 for the existing soils encountered. Also included are parameters for CDOT Class 1 Structure backfill material.

Table 9 – Lateral Earth Pressure Parameters

Soil Type	Total Unit Weight (γ) pcf	Effective Friction Angle, ϕ' (degrees)	Undrained Shear Strength (psf)	Lateral Earth Pressure Coefficients (Notes 1 and 2)		
				Active (k_a)	At-Rest (k_o)	Passive (k_p) (Note 3)
CDOT Class 1 Structure Backfill (CDOT Section 703.08)	125	34	0	0.28	0.44	3.54
CLAY, sandy	125	0	300	0.46	0.63	2.20

Note 1: Based on Coloumb Theory of earth pressure
Note 2: For horizontal backslope and foreslope.
Note 3: Full value, no reduction applied.

9.0 INTERIOR FLOOR SLAB AND SUBGRADE SUPPORT DISCUSSION

Based on penetration data obtained from our boreholes, special mitigation is recommended for design and construction of interior slab-on-grade flatwork, parking and drive lane pavements, and fire truck garage interior concrete pavement due to settlement potential and constructability. Mitigation may consist of over excavation and replacement with coarse, granular material with geosynthetic fabrics or geogrids to help stabilize subgrade soils.

To provide stable subgrade support within the interior limits of the building, remove and dispose the full extents of saturated or unstable existing subgrade soil (including topsoil material) down to stable subgrade or to a minimum depth of 24-inches below elevation of the bottom of final subgrade elevations. Place one layer of Mirafi RS 380i, Hanes TerraTex HPG HM28, or approved woven geotextile in accordance with the manufacturer's installation recommendations. Place and compact 6-inches of coarse, granular material on top of the geotextile. Proof roll the section and add additional geotextile with coarse, granular material layers (maximum of 6-inch lifts) as needed to pass proof rolling at finished subgrade elevations. If necessary, add Tensar triaxial geogrid, or approved equal.

As an alternative to the mitigation through sub-excavation and replacement with granular material and geotextile layers the interior floor system may be designed and constructed as a structurally supported floor system.

9.1 Compaction Specifications

All 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 10.

Table 10 – Compaction Specifications

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

A representative of the geotechnical engineer should observe and test fill placement operations.

9.2 Pavement and Landscape Area Subgrade Preparation

At a minimum, the ground surface underlying exterior slab-on-grade flatwork (sidewalks and drive lanes) should be carefully prepared by removing all organic matter (topsoil), scarification to a minimum depth of 6 inches and recompacting to the requirements for maximum dry density and moisture content listed in Table 10 of this report prior to concrete placement.

10.0 PAVEMENT SECTION DESIGN AND TRAFFIC ANALYSIS

Typically, existing pavement design procedures are used for roadways with a mix of vehicles, volumes, and speeds greater than 10 miles per hour. The pavement design for the Appleton Fire Station #7 is an atypical pavement design using the existing procedures outlined in the City of Grand Junction Transportation Engineering Design Standards. Therefore, RockSol explored the use of various design procedures to develop cost-effective pavement sections for this project.

For the Appleton Fire Station #7 project, two different pavement designs are required. The first pavement design is for access pavements at the driveway locations that will carry the fire trucks in and out of the fire station. The second design is for the parking area stalls that will be used primarily for employee parking and occasional delivery vehicles. See Sections 10.1 of this report for driveway pavement recommendations, and Section 10.2 of this report for parking area pavement recommendations.

10.1 Driveway Recommendations

For the design of the driveway pavements, the fire trucks used at this station will be classified as Class 6 vehicles when using the Federal Highway vehicle type classification system. The average annual daily truck traffic (AADTT) was based on an estimated number of emergencies this fire station would receive. RockSol estimated 40 as the AADTT for the pavement design of the driveway with a linear growth rate of 1 percent. RockSol developed a project specific vehicle class distribution as shown in Table 11.

Table 11 – Project Specific Vehicle Class Distribution and Growth Rate (From PMED Output Sheet)

Vehicle Class	AADTT Distribution (%) (Level 3)	Growth Factor	
		Rate (%)	Function
Class 4	0%	0%	None
Class 5	0%	0%	None
Class 6	95%	1%	Linear
Class 7	5%	1%	Linear
Class 8	0%	0%	None
Class 9	0%	0%	None
Class 10	0%	0%	None
Class 11	0%	0%	None
Class 12	0%	0%	None
Class 13	0%	0%	None

RockSol established the single and tandem axle load spectra from the vehicle specifications for a Smeal 105' Rear Mount Ladder Truck. It is estimated that tridem and quad axles will not be anticipated for the driveway or traffic lanes. The estimated 18,000-pound Equivalent Single Axle Loads (18K ESAL) over the 30-year design life is approximately 220,000 for flexible pavement and about 300,000 for rigid pavement.

10.1.1 Summary of Driveway Pavement Recommendations

A summary of the flexible and rigid pavement thickness recommendations for the driveway pavement is shown below.

Table 12 – Summary of Driveway Pavement Design Recommendations

Pavement Type	Design Procedure	Total Pavement Thickness (inches)	Class 6 ABC Thickness (inches)	Class 3 ABC Thickness (inches)	Appendix Location
Flexible	PMED	6.0 (Note 1)	6.0	24.0	D
	AASHTO 93	4.5	6.0	24.0	E
Rigid	PMED	8.0	6.0	-	F

Note 1: 6.0 total inches of asphalt including 2 different binder materials, see Section 10.1.2 for details.
ABC = Aggregate Base Course
PMED = Pavement Mechanistic-Empirical Design

10.1.2 Flexible Pavement Alternative

<u>ME-Pavement Design</u>

The first flexible pavement design procedure was performed using the 2021 Colorado Department of Transportation M-E Pavement Design Manual with the 2024 Addendum and the AASHTOWare Pavement M-E Design (PMED) software, Version 2.3.1. The output sheets can be found in Appendix D.

Under this design procedure, RockSol recommends **2.0 inches of SX (100) PG 64-28 over 4.0 inches of SX (75) PG 64-22, over 6.0 inches of Class 6 ABC, over 2 feet of Class 3 ABC.** This pavement section is based on achieving a stable subgrade upon which to construct the pavement. See Section 10.3 of this report for subgrade preparation details.

AASHTO 93

The second flexible pavement design procedure used a spreadsheet developed by RockSol since the AASHTOWare DARWin 3.1 Pavement Design and Analysis System recommended in subsection 29.32.040(a) of the City of Grand Junction Transportation Engineering Design Standards is no longer available. The output sheet for this design method can be found in Appendix E.

This design procedure produced a design consisting of **4.5 inches of SX (75) PG 64-22, over 6.0 inches of Class 6 ABC, over 2 feet of Class 3 ABC**. There is also a full-depth pavement option of **6.0 inches of SX (75) 64-22 over 2 feet of Class 3 ABC.** This pavement section is based on achieving a stable subgrade upon which to construct the pavement. See Section 10.3 of this report for subgrade preparation details.

10.1.3 Rigid Pavement Alternative

ME-Pavement Design

The Portland Cement Concrete Pavement (PCCP) design procedure was performed using the 2021 Colorado Department of Transportation M-E Pavement Design Manual with the 2024 Addendum and the AASHTOWare Pavement M-E Design (PMED) software, Version 2.3.1. The output sheets for this design method can be found in Appendix F.

Under this design procedure, RockSol recommends **8.0 inches of PCCP over 6.0 inches of Class 6 ABC over the existing subgrade.** This pavement section is based on achieving a stable subgrade upon which to construct the pavement. See Section 10.3 of this report for subgrade preparation details.

10.2 Parking Area Recommendations

For the design of the parking area pavement section, RockSol has presumed that fire trucks will not be driving or parking within the parking stall locations. Therefore, motorcycles, passenger cars, light duty trucks, and an occasional delivery truck classified as Classes 1, 2 ,3 and 5 respectively when using the Federal Highway vehicle type classification system were used for pavement design. The estimated 18K ESAL's over the 30-year design life for flexible pavement is 22,000 and the estimated 18K ESAL's over the 30-year rigid pavement is 30,000. Since the PMED software is not suitable for Class 1 through Class 3 vehicles and a small number of Class 5 vehicles, two pavement thickness design procedures were used for the 30-year design life of new flexible pavement and new rigid pavement.

10.2.1 Parking Area Pavement Recommendations

A summary of the recommended pavement thicknesses for the parking pavement is shown below.

Table 13 – Summary of Parking Area Pavement Design Recommendations

Pavement Type	Pavement Design Procedure	Pavement Thickness (inches)	Class 6 ABC Thickness (inches)	Class 3 ABC Thickness (inches)	Appendix
Flexible	PAVEXpress	4.0	6.0	12	G
Rigid	ACPA Designer	7.0	6.0	-	H

ABC = Aggregate Base Course

10.2.2 Flexible Pavement Alternative

PAVEXpress

The procedure utilized for flexible pavement used 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 and the output results for this design method can be found in Appendix G.

Under this design procedure, RockSol recommends **4.0 inches of SX(75) PG 64-22 over 6.0 inches of class 6 ABC, over 12 inches of class 3 ABC.** This pavement section is based on achieving a stable subgrade upon which to construct the pavement. See Section 10.3 of this report for subgrade preparation details.

10.2.3 Rigid Pavement Alternative

ACPA Pavement Designer

The procedure utilized for rigid pavement used the American Concrete Pavement Association's newest version of WinPAS called PavementDesigner for the design of concrete parking lot in accordance with subsection 29.32.040 (b) of the City of Grand Junction Transportation Engineering Design Standards as stated in the Scope of Work. The output results for this design method can be found in Appendix H.

Under this design procedure, RockSol recommends **7.0 inches of PCCP over 6.0 inches of class 6 ABC, over the existing subgrade.** This pavement section is based on achieving a stable subgrade upon which to construct the pavement. See Section 10.3 of this report for subgrade preparation details.

10.3 Pavement Subgrade Preparation

Based on penetration data obtained from our boreholes, special mitigation of subgrade soils may be required for parking and drive lane pavements to assist with constructability. Mitigation may consist of over excavation and replacement with coarse, granular material (Class 3 ABC) with geosynthetic fabrics or geogrids to help stabilize subgrade soils.

To provide stable subgrade support within pavement areas, remove and dispose the full extents of saturated or unstable existing subgrade soil (including topsoil material) down to stable subgrade or to a minimum depth of 24-inches below elevation of the bottom of final subgrade elevations. Place one layer of Mirafi RS 380i, Hanes TerraTex HPG HM28, or approved woven geotextile in accordance with the manufacturer's installation recommendations. Place and compact 6-inches of class 3 ABC on top of the geotextile. Proof roll the section and add additional geotextile with coarse, granular material layers (maximum of 6-inch lifts) as needed to pass proof rolling at finished subgrade elevations. If necessary, add Tensar triaxial geogrid, or an approved equivalent geogrid.

All 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 14.

Table 14 – Compaction Specifications

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

A representative of the geotechnical engineer should observe and test fill placement operations.

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 fire station. 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 and groundwater conditions at the proposed Appleton Fire Station #7 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

LEGEND
AND
INDIVIDUAL BOREHOLE LOGS
AND TEST PIT LOG

RockSol Consulting Group, Inc.

LEGEND

CLIENT City of Grand Junction

PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89

PROJECT LOCATION Grand Junction, Colorado

LITHOLOGY

- **Fill - CLAY, sandy**
- **TOPSOIL**
- **Native - SAND, silty**
- **Native - CLAY**
- **Native - CLAY, sandy**
- **Fill - CLAY**
- **Native - SAND**
- **Native - SAND, gravelly**
- **Native - CLAY, silty**
- **Native - GRAVEL/COBBLES**

SAMPLE TYPE

B BULK SAMPLE (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 AT TIME OF DRILLING

GROUND WATER LEVEL AT 2ND MEASUREMENT

GROUND WATER LEVEL AT 3RD MEASUREMENT

RockSol Consulting Group, Inc.

BORING : BH-1

CLIENT City of Grand Junction

PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89

PROJECT LOCATION Grand Junction, Colorado

DATE STARTED 8/24/23 **COMPLETED** 8/24/23

GROUND ELEVATION 4571.2 ft **STATION NO.**

DRILLING CONTRACTOR Western Colorado Drillers

NORTH 76487.5 **EAST** 55152.9

DRILLING METHOD Hollow Stem Auger **HOLE SIZE** 7.5"

BORING LOCATION:

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

GROUND WATER LEVELS: **1ST DEPTH** None Encountered on 8/24/23

NOTES

2ND DEPTH 7.2 ft on 8/25/23

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 (%)
4571.2	0	(Topsoil) CLAY, silty, approximately 1 foot thick										
		(Native) CLAY, silty, wet, brown, very soft										
			SS	0/12					25	20	5	95.1
			MC	0/12			83.4	25.6				
4561.2	10		MC	1/12			98.5	27.9				79.4
		(Native) SAND, silty, wet, tan to brown, very loose										
4551.2	20		MC	1/12			97.2	26.5				
		(Native) SAND, wet, tan, very loose										
4541.2	30		MC	3/12			102.2	20.6				
4531.2	40		MC	1/12			90.6	29.5	31	24	7	0.1
		(Native) CLAY, sandy, moist, stiff										
4521.2	50		MC	13/12			93.2	28.2				
		(Native) SAND, gravelly, with cobbles, wet, loose										
4511.2	60		SS	3/4/5								
		Bottom of hole at 61.5 feet.										

BORING : BH-2

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 8/9/23 **COMPLETED** 8/9/23
GROUND ELEVATION 4570.9 ft **STATION NO.**
DRILLING CONTRACTOR Western Colorado Drillers
NORTH 76390.5 **EAST** 55072.3
DRILLING METHOD Hollow Stem Auger **HOLE SIZE** 7.5"
BORING LOCATION:
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS: **1ST DEPTH** 6.5 ft on 8/11/23
NOTES CME 55
2ND DEPTH 6.2 ft on 8/18/23 **3RD DEPTH** 7.0 ft on 8/24/23

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 (%)
4570.9	0	(Topsoil) CLAY, sandy and silty, moist, brown, medium stiff	MC	7/12	0.3		95.2	16.3				
		(Native) CLAY, moist to very moist, brown, medium stiff	SS	1/1/1								
		(Native) CLAY, moist to very moist, brown, very soft **Approximate Bulk Depth 5-10** Liquid Limit= 30 Plastic Limit= 20 Plasticity Index= 10 Fines Content= 89.9 Sulfate= 0.16	BULK			0.16			30	20	10	89.9
4560.9	10		MC	0/12			99.6	26.8				78.5
4550.9	20	(Native) CLAY, lean, very moist, brown, very soft	SS	0/0/0					27	15	12	92.1
4540.9	30		MC	3/12								
		(Native) SAND, silty, brown, medium dense	SS	3/7/6					NP	NP	NP	23.5
4530.9	40	(Native) CLAY, lean, moist, tan, stiff to medium stiff	SS	4/5/7					29	21	8	100.0
			MC	8/12			91.4	25.3				
4520.9	50	(Native) SAND, moist, tan, dense	SS	4/8/9								
		(Native) GRAVEL/COBBLES, with sand, moist, tan, dense										
4510.9	60		SS	7/16/22					NP	NP	NP	11.5
		Bottom of hole at 61.5 feet.										

BORING : BH-3

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado

DATE STARTED 8/9/23 **COMPLETED** 8/9/23
GROUND ELEVATION 4571.7 ft **STATION NO.**
DRILLING CONTRACTOR Western Colorado Drillers
NORTH 76371.5 **EAST** 55165.4
DRILLING METHOD Hollow Stem Auger **HOLE SIZE** 7.5"
BORING LOCATION:
LOGGED BY R. Lepro **HAMMER TYPE** Automatic
GROUND WATER LEVELS: **1ST DEPTH** 7.0 ft on 8/9/23
NOTES CME 55
2ND DEPTH 4.8 ft on 8/18/23 **3RD DEPTH** 7.0 ft on 8/24/23

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	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
4571.7	0		(Topsoil) CLAY, sandy, slightly moist to moist, brown, approximately 3 inches thick										
			(Fill) CLAY, moist, brown, stiff	MC	10/12	1.8		99.4	14.3				
			(Native) CLAY, lean, very moist to wet, brown, very soft	B BULK									
4566.7	5			SS	0/0/1								
4561.7	10			SS	0/0/1								
4556.7	15			MC	1/12		0.11	98.8	26.3	23	15	8	97.7
4551.7	20			SS	1/1/4					22	15	7	71.5
			(Native) CLAY, silty, with sand, wet, brown, medium stiff, slightly calcareous										
4546.7	25		(Native) CLAY, lean, wet, brown, soft to medium stiff, slightly calcareous	MC	3/12		0.10	100.2	26.7				82.2
4541.7	30			SS	0/3/4					29	17	12	95.5
			Bottom of hole at 31.5 feet.										

BORING : P-1

RockSol Consulting Group, Inc.

CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 8/9/23 **COMPLETED** 8/9/23
GROUND ELEVATION 4569.4 ft **STATION NO.**
DRILLING CONTRACTOR Western Colorado Drillers
NORTH 76448.6 **EAST** 54948.1
DRILLING METHOD Hollow Stem Auger **HOLE SIZE** 7.5"
BORING LOCATION:
LOGGED BY RL/TW **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES CME 55
▼ **WATER DEPTH** 6.0 ft on 8/9/23

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 (%)
4569.4	0.0		(Topsoil) CLAY, sandy, slightly moist, brown, approximately 3 inches thick										
			(Fill) CLAY, sandy to slightly silty, moist, light brown to brown, soft	SS	3/3/1								
			(Native) CLAY, with sand, very moist to wet, brown, very soft										
4566.9	2.5		**Approximate Bulk Depth 2-5** Liquid Limit= 31 Plastic Limit= 20 Plasticity Index= 11 Fines Content= 74.8	B BULK						31	20	11	74.8
4564.4	5.0	▼		SS	0/0/1								
			Bottom of hole at 6.5 feet.										

RockSol Consulting Group, Inc.

BORING : P-2

CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 8/9/23 **COMPLETED** 8/9/23
GROUND ELEVATION 4572.4 ft **STATION NO.**
DRILLING CONTRACTOR Western Colorado Drillers
NORTH 76435.4 **EAST** 55236.4
DRILLING METHOD Hollow Stem Auger **HOLE SIZE** 7.5"
BORING LOCATION:
LOGGED BY T. Woolley **HAMMER TYPE** Automatic
GROUND WATER LEVELS:
NOTES CME 55
WATER DEPTH 6.0 ft on 8/9/23

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 (%)
4572.4	0.0		(Topsoil) CLAY, sandy, moist, brown, approximately 3 inches thick										
			(Fill) CLAY, sandy to slightly silty										
			(Native) CLAY, moist to very moist, brown, medium stiff										
4569.9	2.5			SS	2/2/3								
			Approximate Bulk Depth 2-5 Liquid Limit= 33 Plastic Limit= 19 Plasticity Index= 14 Fines Content= 93.6 Sulfate= 0.19	BULK			0.19			33	19	14	93.6
4567.4	5.0		(Native) CLAY, sandy, very moist to wet, brown, very soft	SS	0/0/0								
			Bottom of hole at 6.5 feet.										

RockSol Consulting Group, Inc.

TEST PIT : TP-1

CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado
DATE STARTED 8/9/23 **COMPLETED** 8/9/23
GROUND ELEVATION 4570.0 ft **STATION NO.**
EXCAVATION CONTRACTOR Western Colorado Drillers
NORTH 76324.4 **EAST** 55005.7
EXCAVATION METHOD Bobcat 435 **TEST PIT SIZE** N/A
TEST PIT LOCATION:
LOGGED BY T. Woolley
GROUND WATER LEVELS:
NOTES
WATER DEPTH None Encountered on 8/9/23

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 (%)
4570.0	0		(Topsoil) CLAY, silty, approximately 6 inches thick, agricultural field										
			(Native) CLAY, sandy, moist, brown										
4569.0	1												
4568.0	2		(Native) CLAY, moist, brown										
4567.0	3												
4566.0	4		(Native) CLAY, silty, with sand, very moist, brown, very soft										
4565.0	5		**Approximate Bulk Depth 4-6** Liquid Limit= 22 Plastic Limit= 18 Plasticity Index= 4 Fines Content= 83.0	B BULK						22	18	4	83.0
4564.0	6		Bottom of test pit at 6.0 feet.										

APPENDIX B

LABORATORY TEST RESULT SUMMARY SHEET
AND
TEST RESULT SHEETS

RockSol Consulting Group, Inc.

SUMMARY OF PHYSICAL & CHEMICAL TEST RESULTS

CLIENT City of Grand Junction

PROJECT NUMBER 599.89

PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

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	5	25	20	5		95	CL-ML	A-4 (4)										
BH-1	6.5								25.6	83.4								
BH-1	10					79			27.9	98.5								
BH-1	20								26.5	97.2								
BH-1	30								20.6	102.2								
BH-1	40	31	24	7		0		A-2-4 (0)	29.5	90.6								
BH-1	50								28.2	93.2								
BH-2	1				0.3				16.3	95.2								
BH-2	5-10	30	20	10		90	CL	A-4 (8)				0.16	1300 @ 15.3%	7.8	0.0189			
BH-2	9					79			26.8	99.6								
BH-2	19	27	15	12		92	CL	A-6 (9)										
BH-2	30	NP	NP	NP		24	SM	A-2-4 (0)										
BH-2	40	29	21	8		100	CL	A-4 (8)										
BH-2	45								25.3	91.4								
BH-2	60	NP	NP	NP		12		A-2-4 (0)										
BH-3	1				1.8				14.3	99.4								
BH-3	15	23	15	8		98	CL	A-4 (6)	26.3	98.8		0.11						
BH-3	20	22	15	7		71	CL-ML	A-4 (2)										
BH-3	25					82			26.7	100.2		0.10						
BH-3	30	29	17	12		95	CL	A-6 (10)										
P-1	2-5	31	20	11		75	CL	A-6 (7)										
P-2	2-5	33	19	14		94	CL	A-6 (13)				0.19						
TP-1	4-6	22	18	4		83	CL-ML	A-4 (1)								114.2	13.1	S

ATTERBERG LIMITS RESULTS
AASHTO T89 Method A/T90

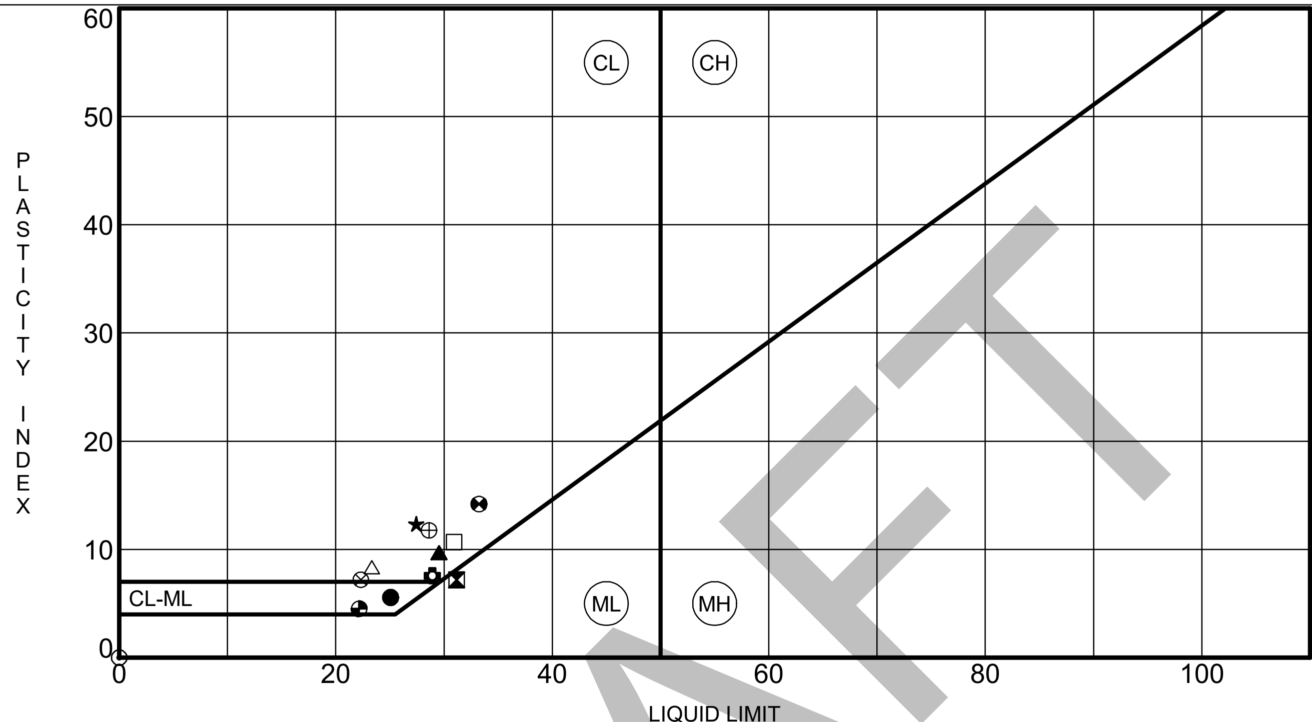
RockSol Consulting Group, Inc.

CLIENT City of Grand Junction

PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89

PROJECT LOCATION Grand Junction, Colorado



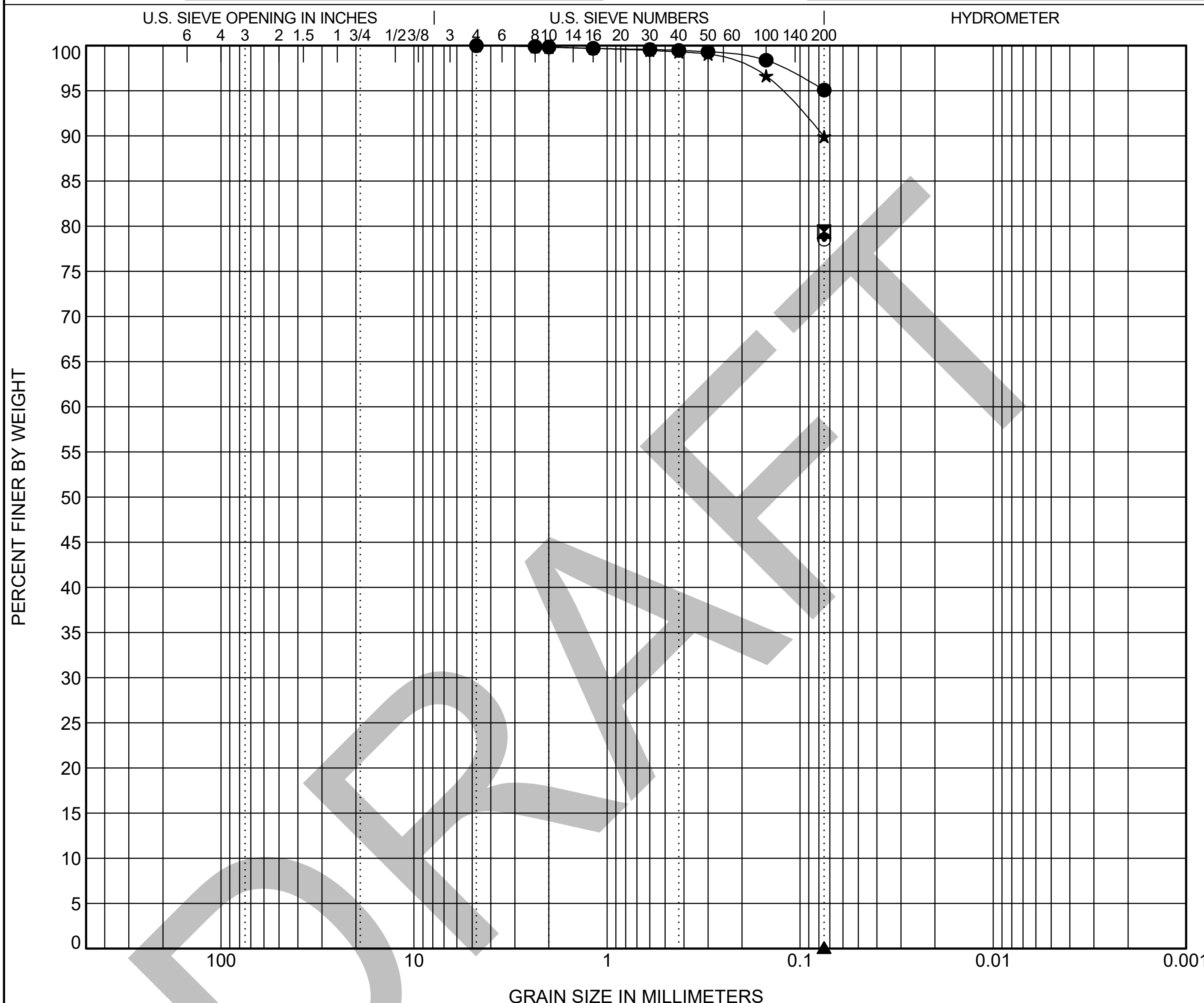
	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH-1**	**5.0**	**25**	**20**	**5**	**95.1**	**SILTY CLAY (CL-ML) (A-4)**
⧗	**BH-1**	**40.0**	**31**	**24**	**7**	**0.1**	**(Native) SAND (A-2-4)**
▲	**BH-2**	**5.0-10.0**	**30**	**20**	**10**	**89.9**	**LEAN CLAY (CL) (A-4)**
★	**BH-2**	**19.0**	**27**	**15**	**12**	**92.1**	**LEAN CLAY (CL) (A-6)**
⊙	**BH-2**	**30.0**	**NP**	**NP**	**NP**	**23.5**	**SILTY SAND (SM) (A-2-4)**
	BH-2	**40.0**	**29**	**21**	**8**	**100.0**	**LEAN CLAY (CL) (A-4)**
○	**BH-2**	**60.0**	**NP**	**NP**	**NP**	**11.5**	**(Native) GRAVEL, sandy (A-2-4)**
△	**BH-3**	**15.0**	**23**	**15**	**8**	**97.7**	**LEAN CLAY (CL) (A-4)**
⊗	**BH-3**	**20.0**	**22**	**15**	**7**	**71.5**	**SILTY CLAY with SAND (CL-ML) (A-4)**
⊕	**BH-3**	**30.0**	**29**	**17**	**12**	**95.5**	**LEAN CLAY (CL) (A-6)**
□	**P-1**	**2.0-5.0**	**31**	**20**	**11**	**74.8**	**LEAN CLAY with SAND (CL) (A-6)**
	P-2	**2.0-5.0**	**33**	**19**	**14**	**93.6**	**LEAN CLAY (CL) (A-6)**
	TP-1	**4.0-6.0**	**22**	**18**	**4**	**83.0**	**SILTY CLAY with SAND (CL-ML) (A-4)**

GRAIN SIZE DISTRIBUTION

RockSol Consulting Group, Inc. RockSol

CLIENT City of Grand Junction **PROJECT NAME** Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89 **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-1**	**5.0**	**SILTY CLAY (CL-ML) (A-4)**	**25**	**20**	**5**		
⧗	**BH-1**	**10.0**	**(Native) CLAY, silty**					
▲	**BH-1**	**40.0**	**(Native) SAND (A-2-4)**	**31**	**24**	**7**		
★	**BH-2**	**5.0-10.0**	**LEAN CLAY (CL) (A-4)**	**30**	**20**	**10**		
⊙	**BH-2**	**9.0**	**(Native) CLAY**					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt / %Clay
●	**BH-1**	**5.0**	**4.75**				**0.2**	**0.4**	**4.4**	**95.1**
⧗	**BH-1**	**10.0**	**0.075**							**79.4**
▲	**BH-1**	**40.0**	**0.075**							**0.1**
★	**BH-2**	**5.0-10.0**	**4.75**				**0.2**	**0.5**	**9.4**	**89.9**
⊙	**BH-2**	**9.0**	**0.075**							**78.5**

GRADATION - STANDARD 599.89_APPLETON FIRE STATION #7.GPJ ROCKSOL TEMPLATE.GDT 10/6/23

GRAIN SIZE DISTRIBUTION

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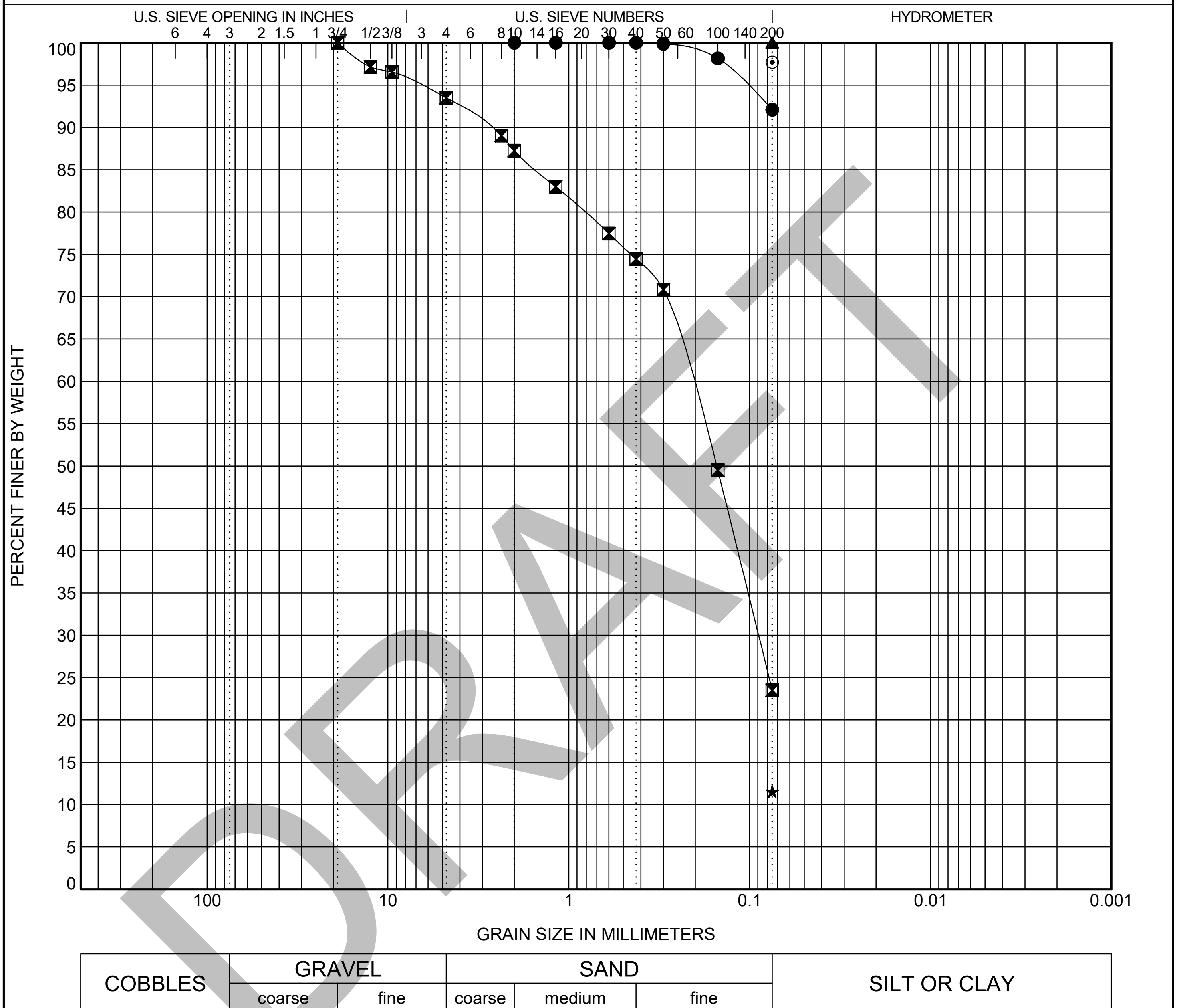
CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado



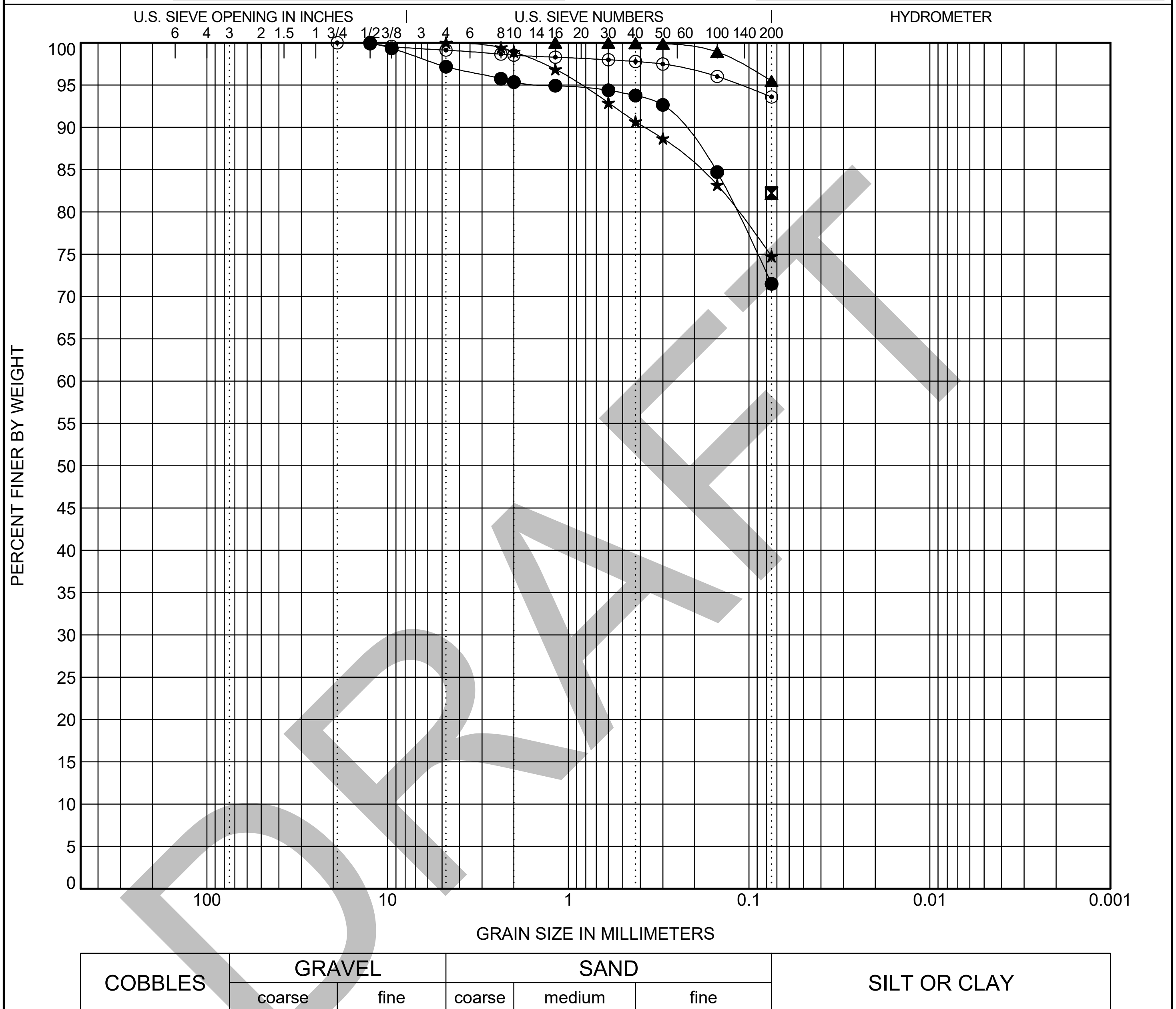
Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● BH-2	19.0	**LEAN CLAY (CL) (A-6)**	27	15	12		
⌧ BH-2	30.0	**SILTY SAND (SM) (A-2-4)**	NP	NP	NP		
▲ BH-2	40.0	**LEAN CLAY (CL) (A-4)**	29	21	8		
★ BH-2	60.0	**(Native) GRAVEL, sandy (A-2-4)**	NP	NP	NP		
⊙ BH-3	15.0	**LEAN CLAY (CL) (A-4)**	23	15	8		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
● BH-2	19.0	2				0.0	0.0	7.9	92.1	
⌧ BH-2	30.0	19	0.211	0.089		12.7	12.8	51.0	23.5	
▲ BH-2	40.0	0.075				0.0	0.0	0.0	100.0	
★ BH-2	60.0	0.075							11.5	
⊙ BH-3	15.0	0.075							97.7	

GRAIN SIZE DISTRIBUTION

RockSol

CLIENT City of Grand Junction
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation
PROJECT NUMBER 599.89
PROJECT LOCATION Grand Junction, Colorado



	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**BH-3**	**20.0**	**SILTY CLAY with SAND (CL-ML) (A-4)**	**22**	**15**	**7**		
⧗	**BH-3**	**25.0**	**(Native) CLAY, lean**					
▲	**BH-3**	**30.0**	**LEAN CLAY (CL) (A-6)**	**29**	**17**	**12**		
★	**P-1**	**2.0-5.0**	**LEAN CLAY with SAND (CL) (A-6)**	**31**	**20**	**11**		
⊙	**P-2**	**2.0-5.0**	**LEAN CLAY (CL) (A-6)**	**33**	**19**	**14**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**BH-3**	**20.0**	**12.5**				**4.7**	**1.6**	**22.3**	**71.5**	
⧗	**BH-3**	**25.0**	**0.075**							**82.2**	
▲	**BH-3**	**30.0**	**1.18**				**0.0**	**0.1**	**4.5**	**95.5**	
★	**P-1**	**2.0-5.0**	**4.75**				**1.1**	**8.3**	**15.9**	**74.8**	
⊙	**P-2**	**2.0-5.0**	**19**				**1.5**	**0.7**	**4.2**	**93.6**	

GRADATION - STANDARD 599.89_APPLETON FIRE STATION #7.GPJ ROCKSOL TEMPLATE.GDT 10/6/23

GRAIN SIZE DISTRIBUTION

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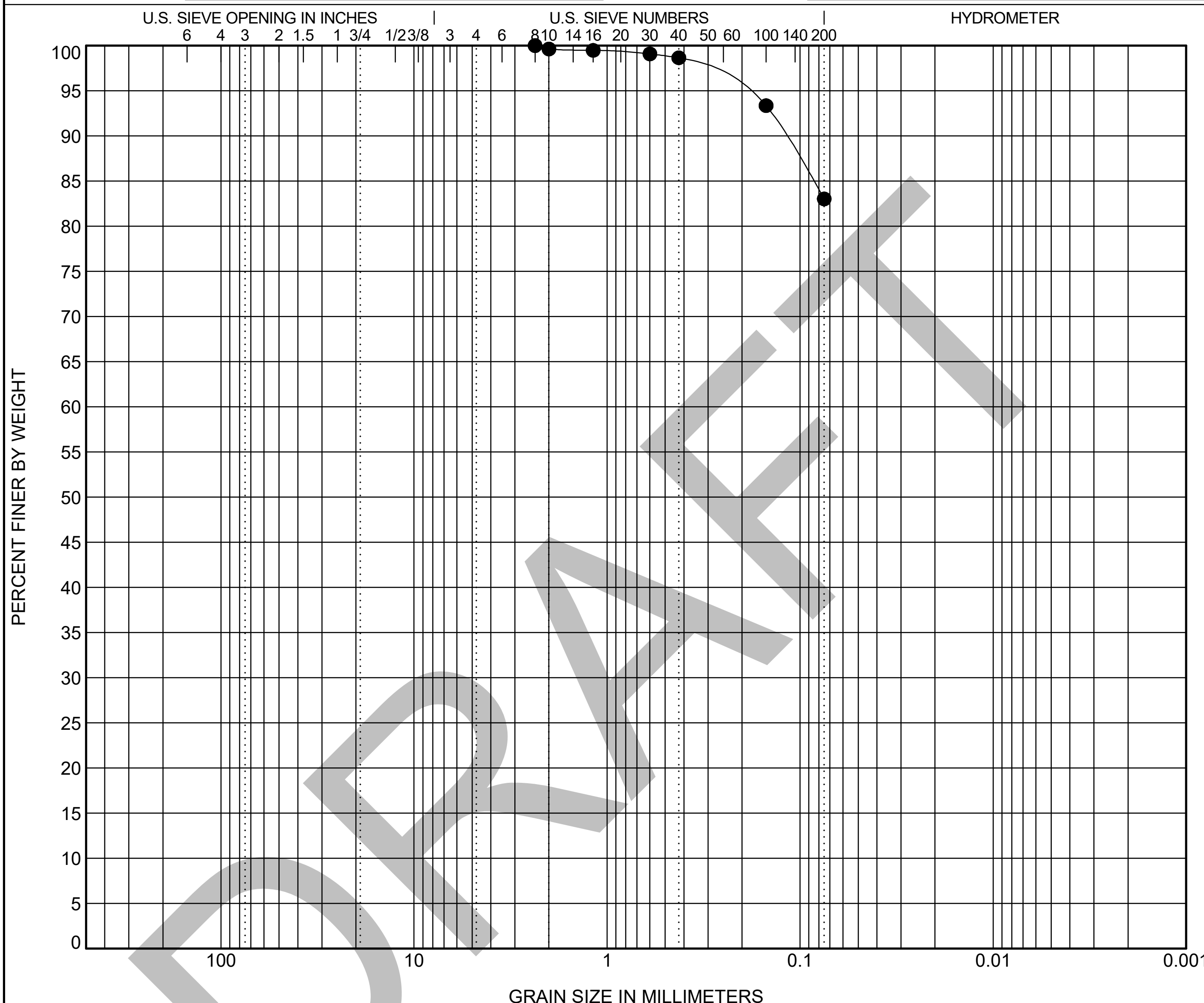
PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89

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**	**4.0-6.0**	**SILTY CLAY with SAND (CL-ML) (A-4)**	**22**	**18**	**4**		

Specimen Identification			D100	D60	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
●	**TP-1**	**4.0-6.0**	**2.36**				**0.4**	**1.0**	**15.6**	**83.0**	

SWELL - CONSOLIDATION TEST

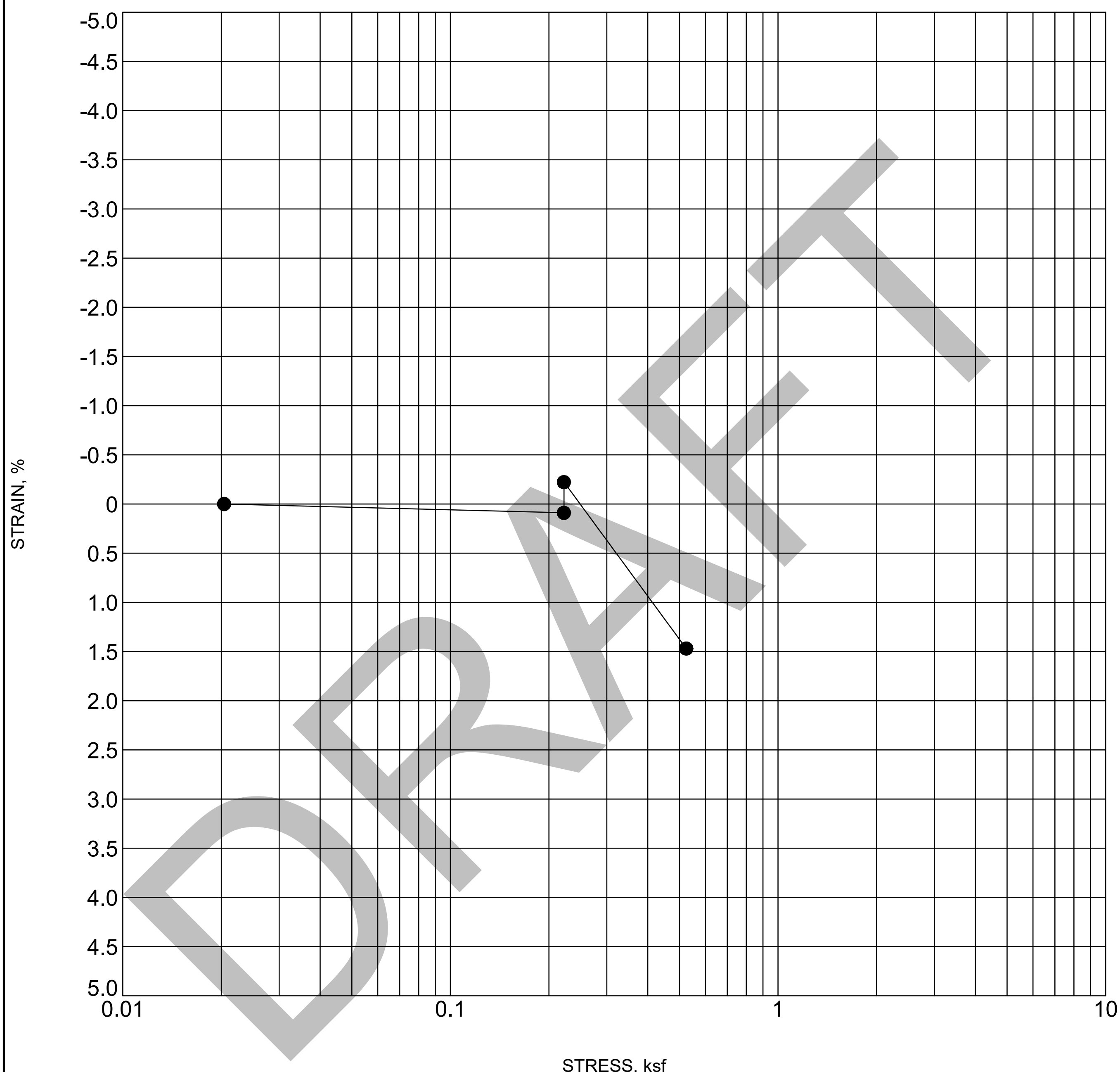
RockSol Consulting Group, Inc.

CLIENT City of Grand Junction

PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89

PROJECT LOCATION Grand Junction, Colorado



Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● BH-2	1	(Native) CLAY	0.3	95.2	16.3

SWELL - CONSOLIDATION TEST

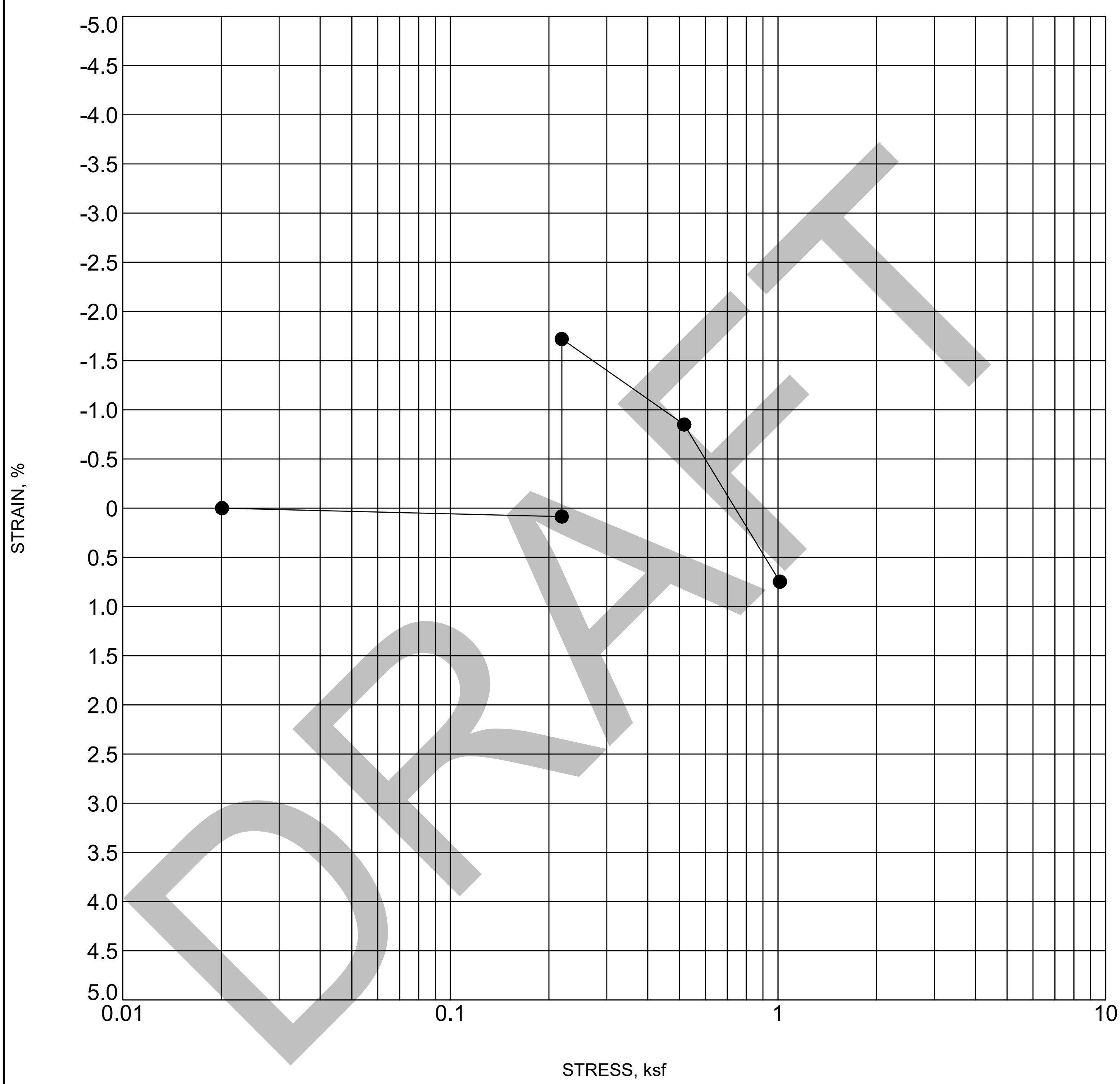
RocksSol Consulting Group, Inc.

CLIENT City of Grand Junction

PROJECT NAME Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89

PROJECT LOCATION Grand Junction, Colorado

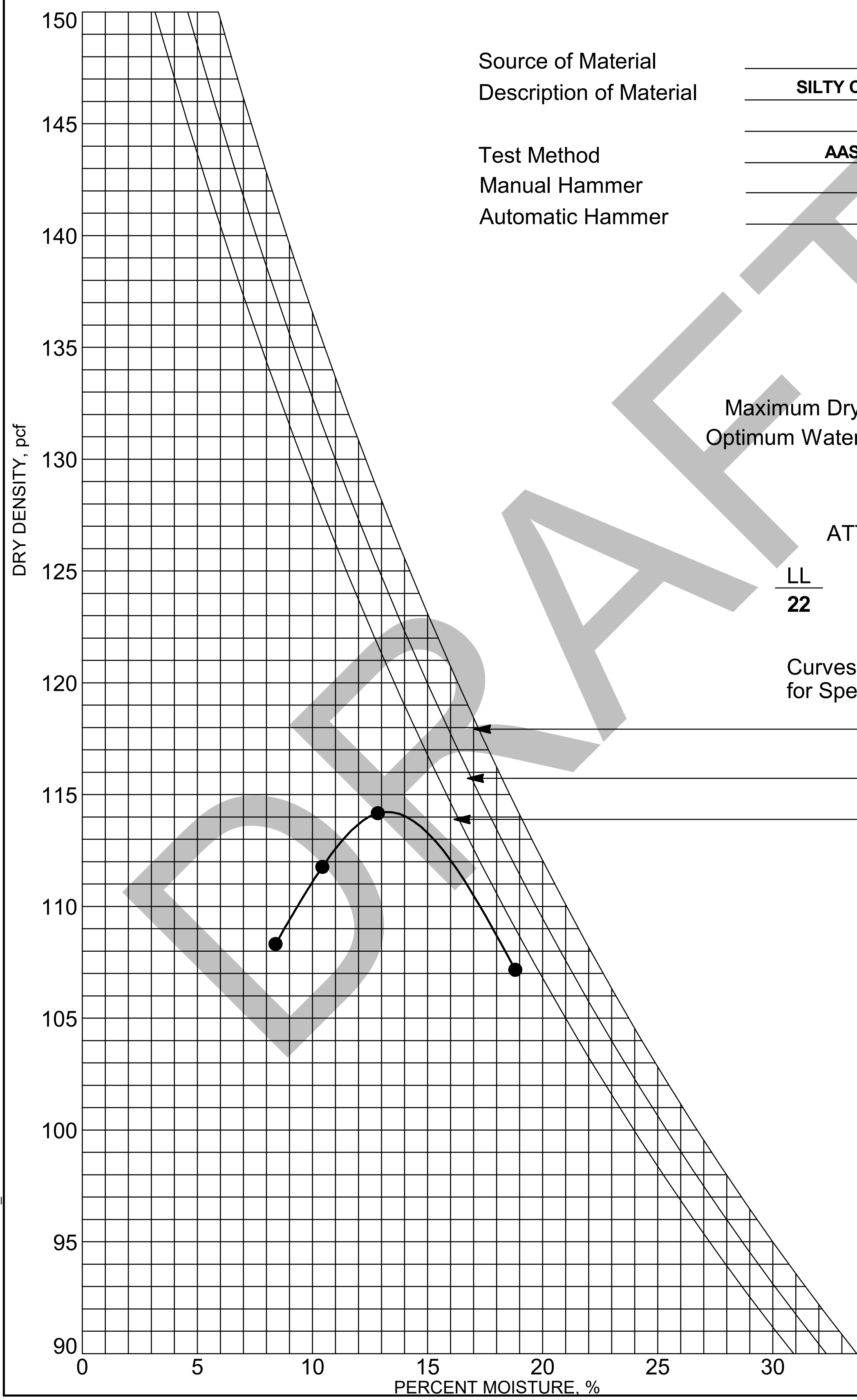


Specimen Identification		Classification	Swell/Consol. (%)	γ_d (pcf)	MC%
● **BH-3**	**1**	**(Fill) CLAY**	**1.8**	**99.4**	**14.3**

RockSol Consulting Group, Inc. RockSol

CLIENT City of Grand Junction **PROJECT NAME** Appleton Fire Station #7 Geotechnical Investigation

PROJECT NUMBER 599.89 **PROJECT LOCATION** Grand Junction, Colorado



Source of Material	**TP-1 4-6 ft**
Description of Material	**SILTY CLAY with SAND(CL-ML)**
	A-4 (1)
Test Method	**AASHTO T99 Method A**
Manual Hammer	X
Automatic Hammer	

TEST RESULTS

Maximum Dry Density **114.2 PCF**

Optimum Water Content **13.1 %**

ATTERBERG LIMITS

LL	PL	PI
22	**18**	**4**

Curves of 100% Saturation for Specific Gravity Equal to:

2.80

2.70

2.60

DRAFT

APPENDIX C

SEISMIC DESIGN PARAMETER OUTPUT SHEETS

USGS web services were down for some period of time and as a result this tool wasn't operational, resulting in *timeout* error.
USGS web services are now operational so this tool should work as expected.

OSHPD

Latitude, Longitude: 39.1212, -108.6167

Date	10/6/2023, 3:42:26 PM
Design Code Reference Document	ASCE7-16
Risk Category	IV
Site Class	D - Default (See Section 11.4.3)

Type	Value	Description
S_S	0.238	MCE_R ground motion. (for 0.2 second period)
S_1	0.066	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.381	Site-modified spectral acceleration value
S_{M1}	0.157	Site-modified spectral acceleration value
S_{DS}	0.254	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	C	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	0.131	MCE_G peak ground acceleration
F_{PGA}	1.538	Site amplification factor at PGA
PGA_M	0.202	Site modified peak ground acceleration
T_L	4	Long-period transition period in seconds
SsRT	0.238	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.252	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	0.07	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}	0.131	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

Type	Value	Description
C_{R1}	0.932	Mapped value of the risk coefficient at a period of 1 s
C_V	0.776	Vertical coefficient

DISCLAIMER

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APPENDIX D

DRIVEWAY
ME-PAVEMENT DESIGN OUTPUT SHEETS
FLEXIBLE DESIGN

Fire Station 7_AC(30yr)

File Name: C:\Users\RSGeoTech\Desktop\PMED Projects\599.89\Fire Station 7_AC(30yr).dgpx

Design Inputs

Design Life: 30 years
Design Type: FLEXIBLE

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

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

Design Structure

Layer type	Material Type	Thickness (in)
Flexible	R3 Level 1 SX(100) PG 64-28	2.0
Flexible	R2 Level 1 SX(75) PG 64-22	4.0
NonStabilized	Crushed stone	6.0
Subgrade	A-1-a	24.0
Subgrade	A-4	6.0
Subgrade	A-4	Semi-infinite

Volumetric at Construction:	
Effective binder content (%)	10.7
Air voids (%)	5.7

Traffic

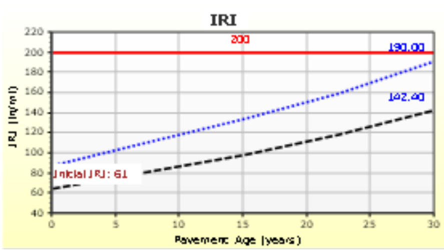
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	40
2039 (15 years)	117,245
2054 (30 years)	250,927

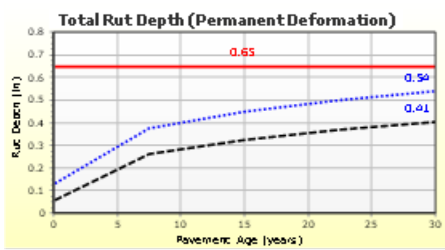
Design Outputs

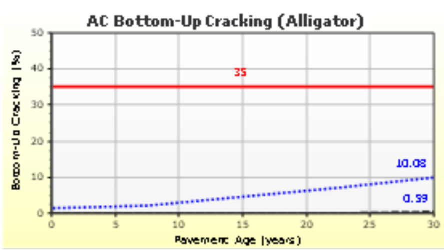
Distress Prediction Summary

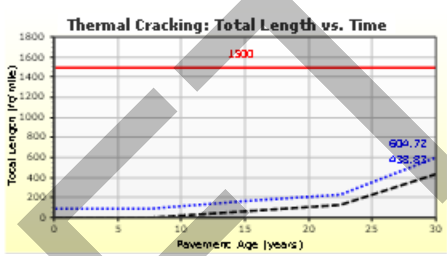
Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	189.97	90.00	93.96	Pass
Permanent deformation - total pavement (in)	0.65	0.54	90.00	99.02	Pass
AC bottom-up fatigue cracking (% lane area)	35.00	10.08	90.00	100.00	Pass
AC thermal cracking (ft/mile)	1500.00	604.72	90.00	100.00	Pass
AC top-down fatigue cracking (ft/mile)	3000.00	314.64	90.00	100.00	Pass
Permanent deformation - AC only (in)	0.65	0.37	90.00	100.00	Pass

Distress Charts





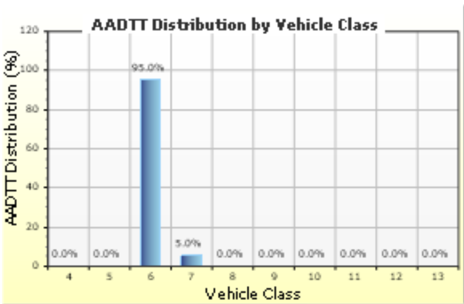


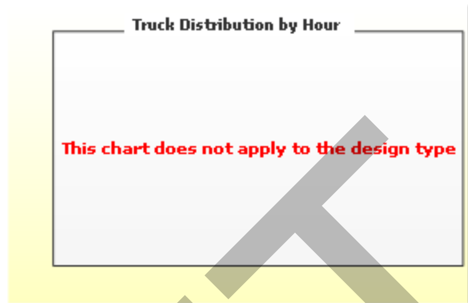


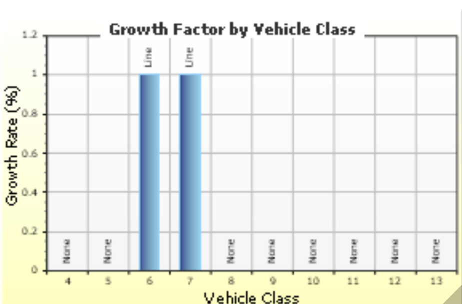
Traffic Inputs

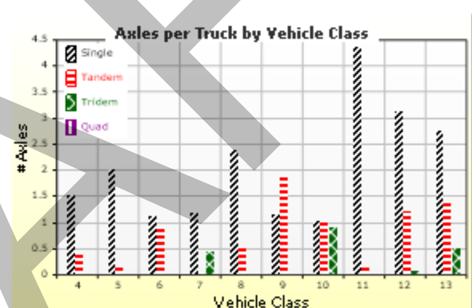
Graphical Representation of Traffic Inputs

Initial two-way AADTT:	40	Percent of trucks in design direction (%):	50.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	5.0

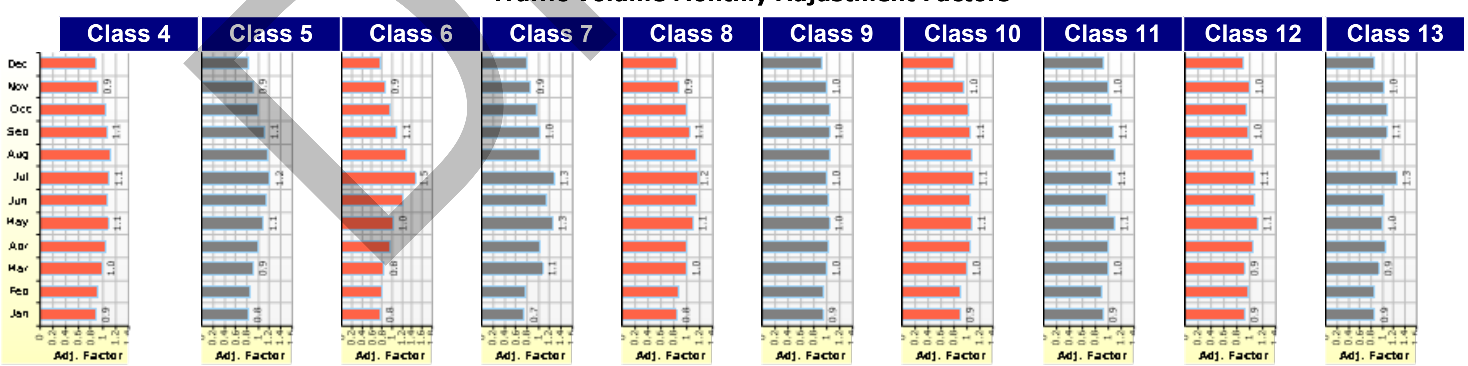








Traffic Volume Monthly Adjustment Factors



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	0%	0%	None
Class 5	0%	0%	None
Class 6	95%	1%	Linear
Class 7	5%	1%	Linear
Class 8	0%	0%	None
Class 9	0%	0%	None
Class 10	0%	0%	None
Class 11	0%	0%	None
Class 12	0%	0%	None
Class 13	0%	0%	None

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)	8.4
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	52.0
Tridem axle spacing (in)	0.0
Quad axle spacing (in)	0.0

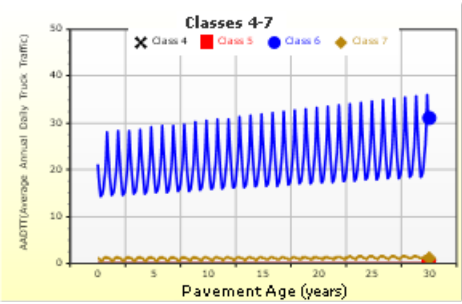
Wheelbase does not apply

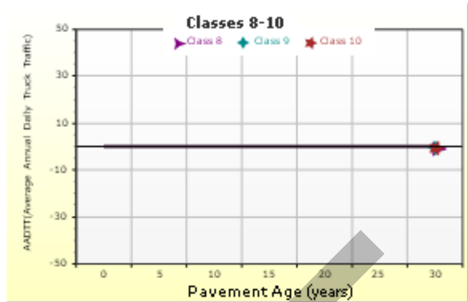
Number of Axles per Truck

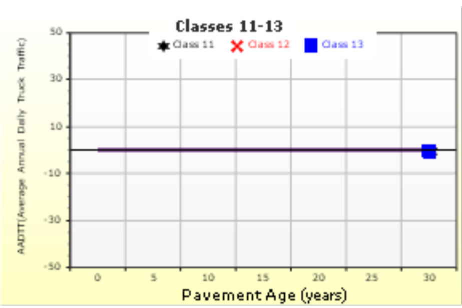
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4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

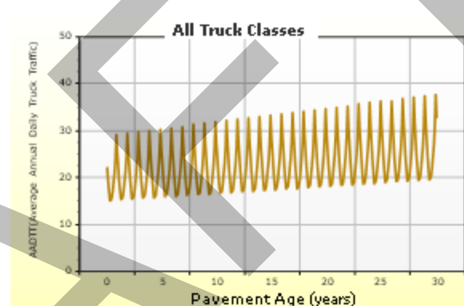
AADTT (Average Annual Daily Truck Traffic) Growth

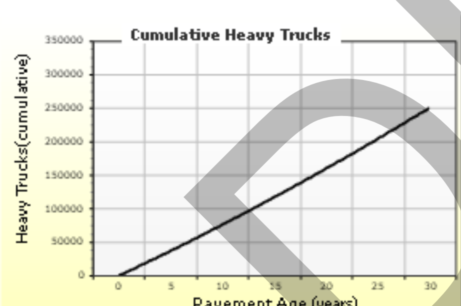
*** Traffic cap is not enforced**











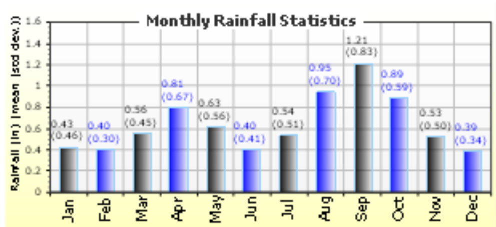
Fire Station 7_AC(30yr)

File Name: C:\Users\RSGeoTech\Desktop\PMED Projects\599.89\Fire Station 7_AC(30yr).dgpx

Climate Inputs

Climate Data Sources:

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

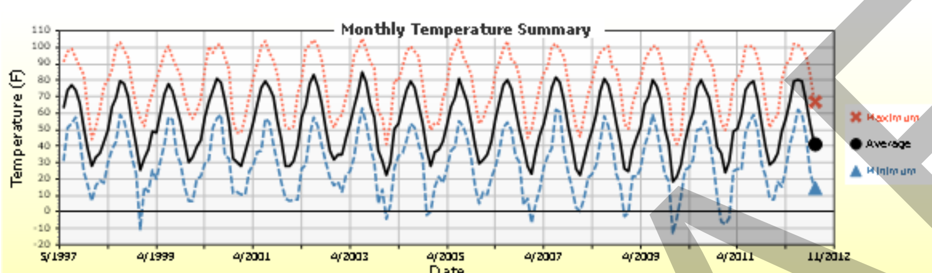


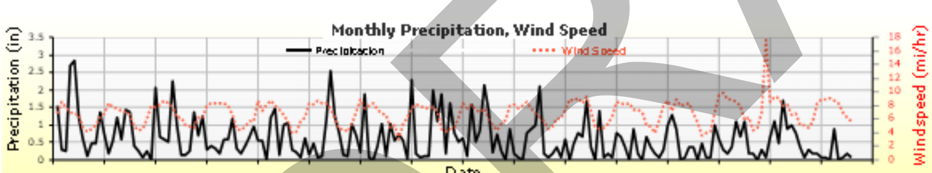
Annual Statistics:

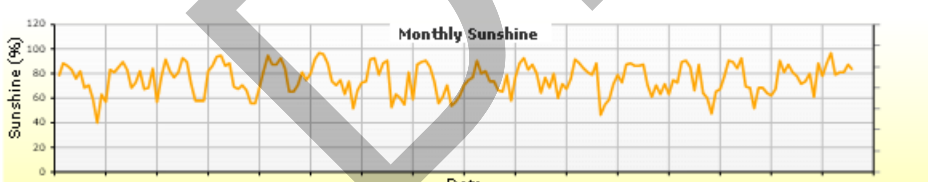
Mean annual air temperature (ºF)	53.55
Mean annual precipitation (in)	7.76
Freezing index (ºF - days)	398.73
Average annual number of freeze/thaw cycles:	111.77

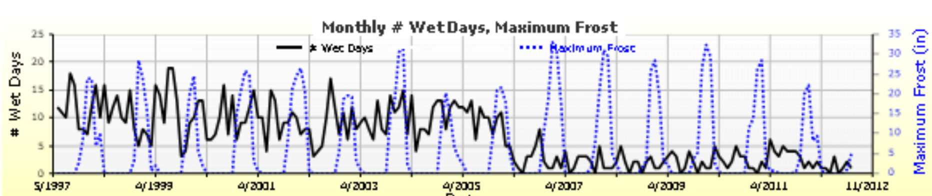
Water table depth (ft) 5.00

Monthly Climate Summary:

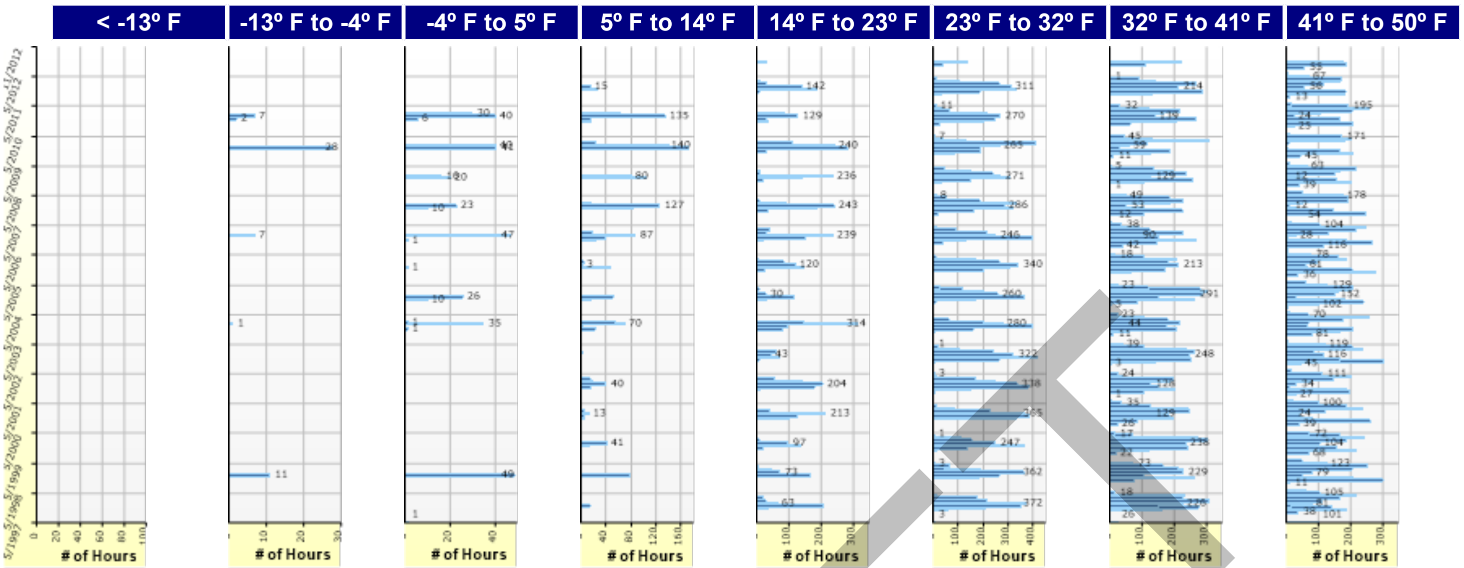


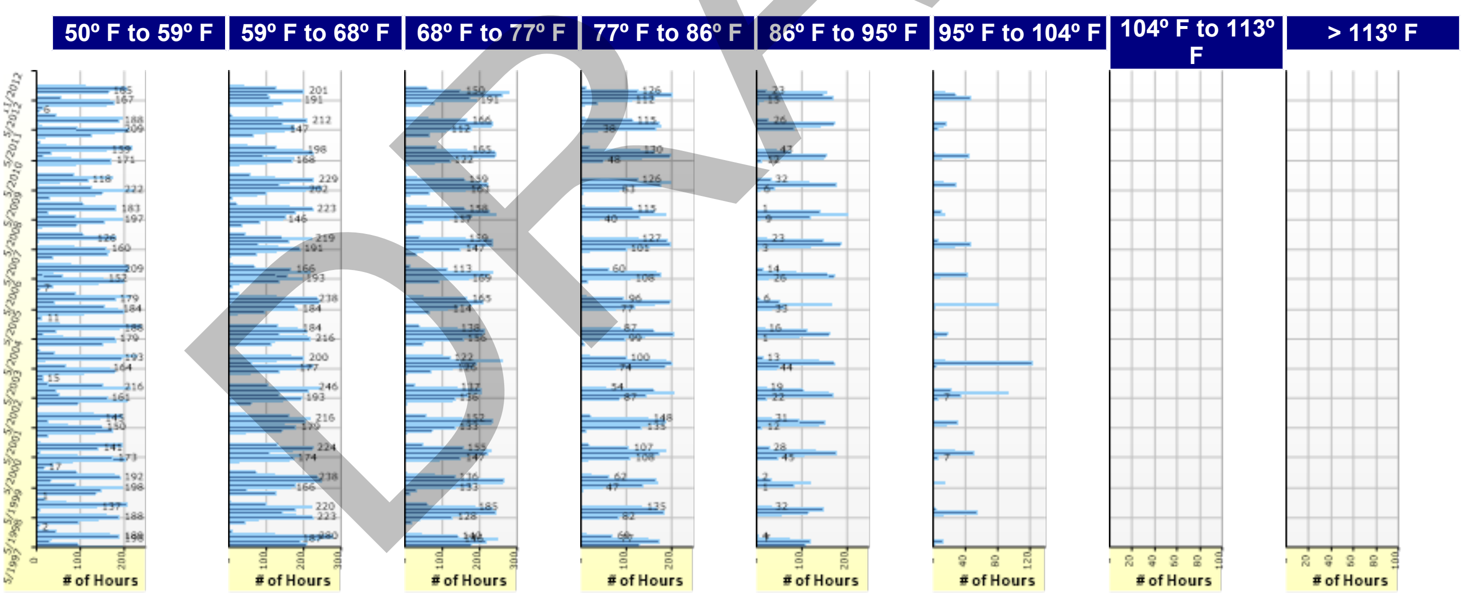






Hourly Air Temperature Distribution by Month:





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

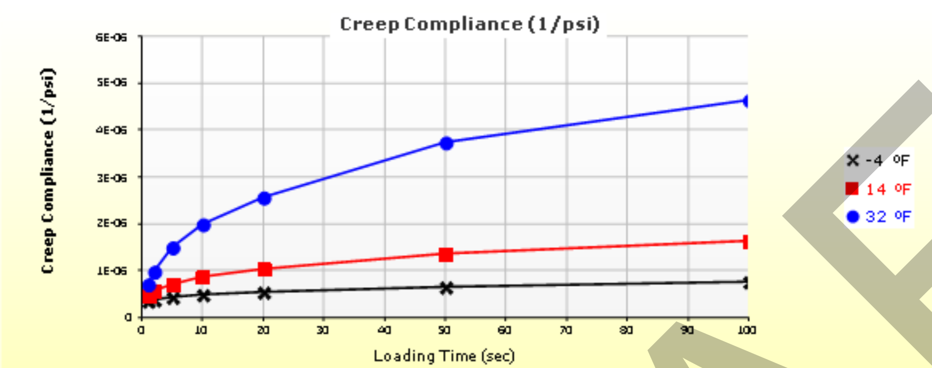
Layer Name	Layer Type	Interface Friction
Layer 1 Flexible : R3 Level 1 SX (100) PG 64-28	Flexible (1)	1.00
Layer 2 Flexible : R2 Level 1 SX (75) PG 64-22	Flexible (1)	1.00
Layer 3 Non-stabilized Base : Crushed stone	Non-stabilized Base (4)	1.00
Layer 4 Subgrade : A-1-a	Subgrade (5)	1.00
Layer 5 Subgrade : A-4	Subgrade (5)	1.00
Layer 6 Subgrade : A-4	Subgrade (5)	-

Thermal Cracking (Input Level: 1)

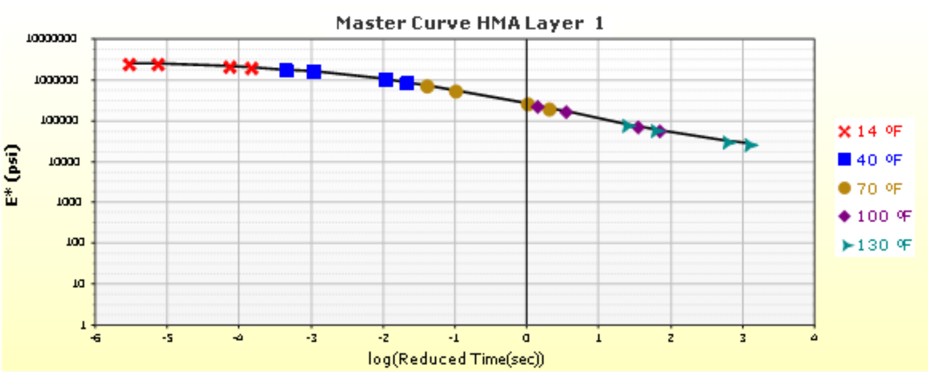
Indirect tensile strength at 14 ºF (psi)	519.00

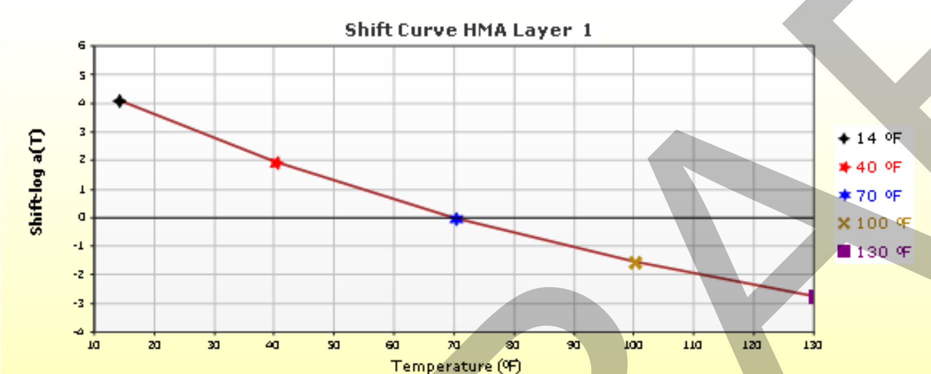
Thermal Contraction	
Is thermal contraction calculated?	True
Mix coefficient of thermal contraction (in/in/ºF)	-
Aggregate coefficient of thermal contraction (in/in/ºF)	5.0e-006
Voids in Mineral Aggregate (%)	16.4

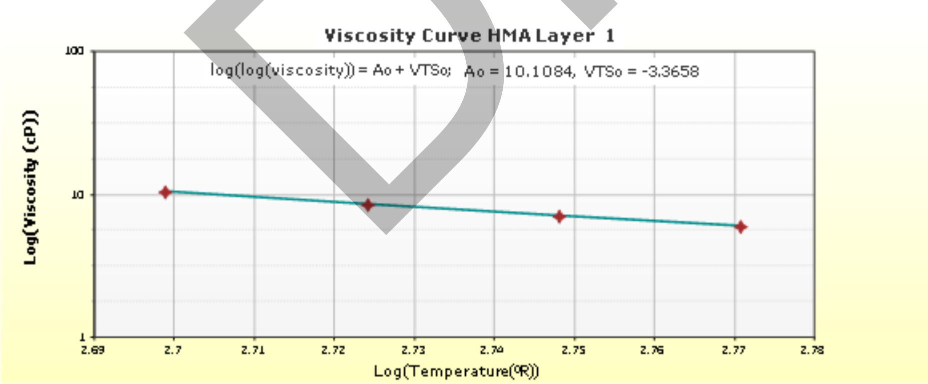
	Creep Compliance (1/psi)		
Loading time (sec)	**-4 ºF**	**14 ºF**	**32 ºF**
1	3.61e-007	4.73e-007	7.12e-007
2	4.04e-007	5.74e-007	9.97e-007
5	4.51e-007	7.35e-007	1.52e-006
10	5.11e-007	8.78e-007	1.99e-006
20	5.67e-007	1.04e-006	2.59e-006
50	6.57e-007	1.37e-006	3.75e-006
100	7.68e-007	1.66e-006	4.66e-006



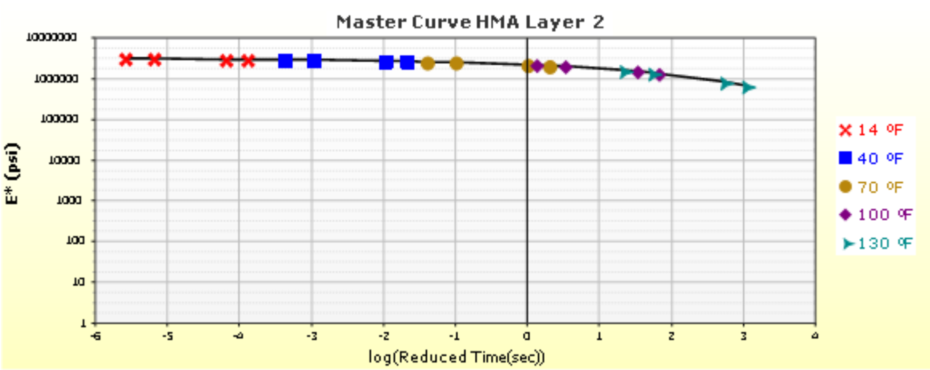
HMA Layer 1: Layer 1 Flexible : R3 Level 1 SX(100) PG 64-28

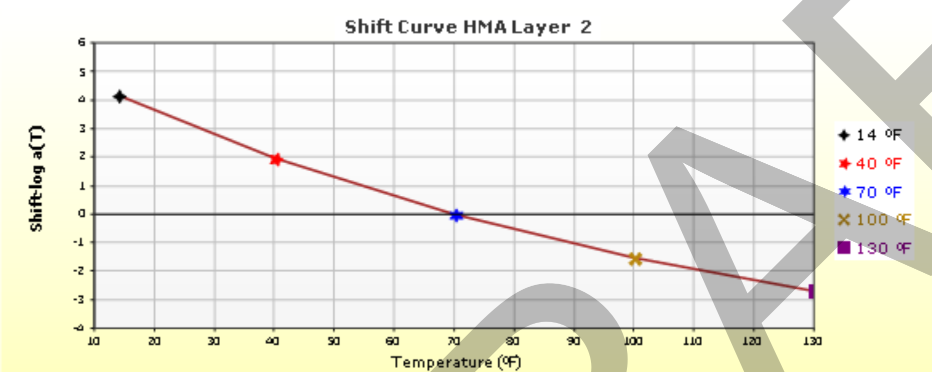


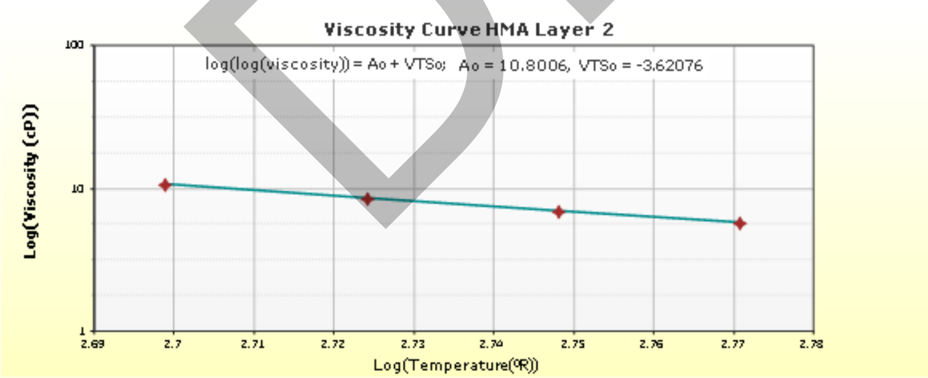




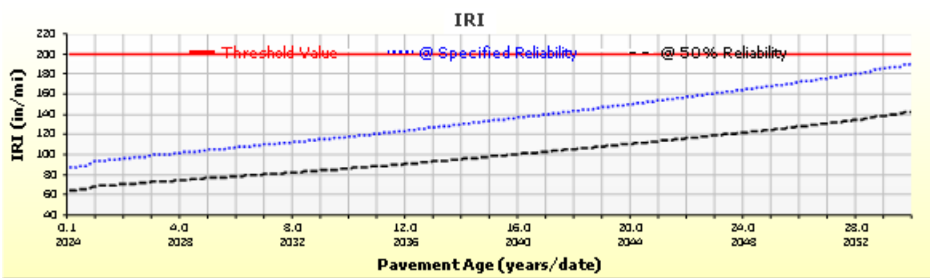
HMA Layer 2: Layer 2 Flexible : R2 Level 1 SX(75) PG 64-22

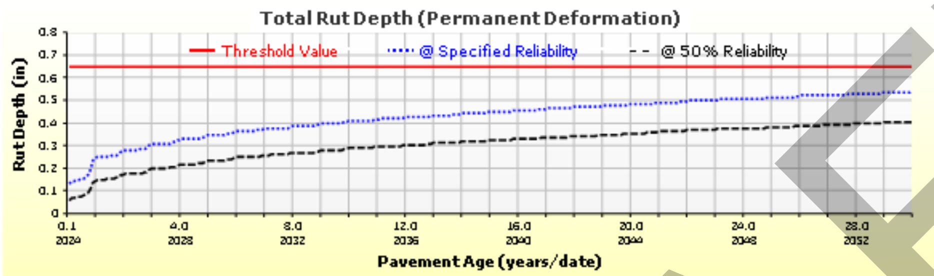


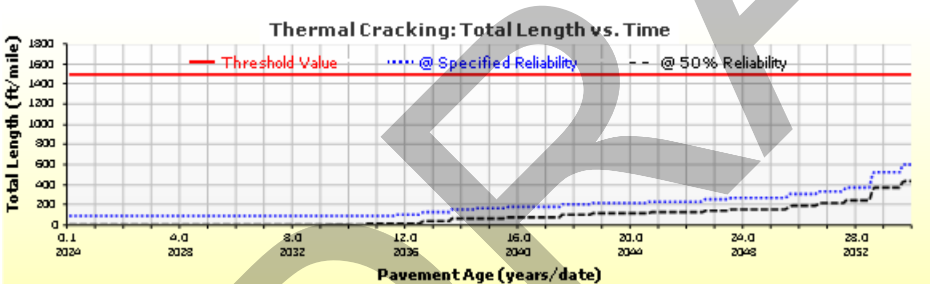


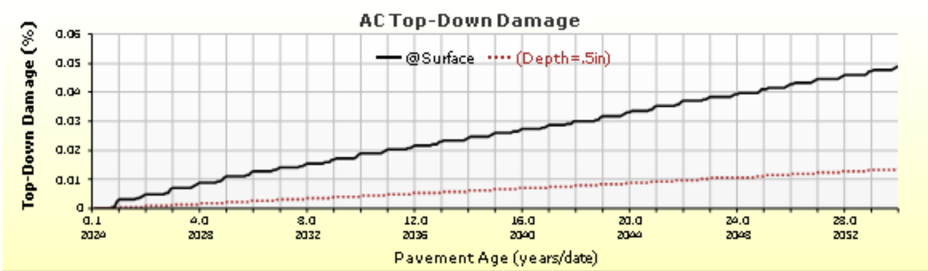


Analysis Output Charts

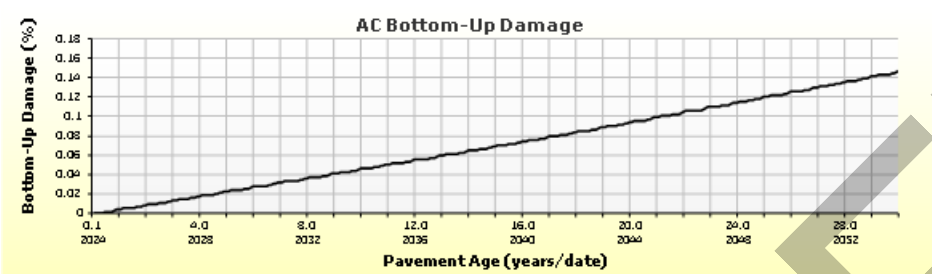




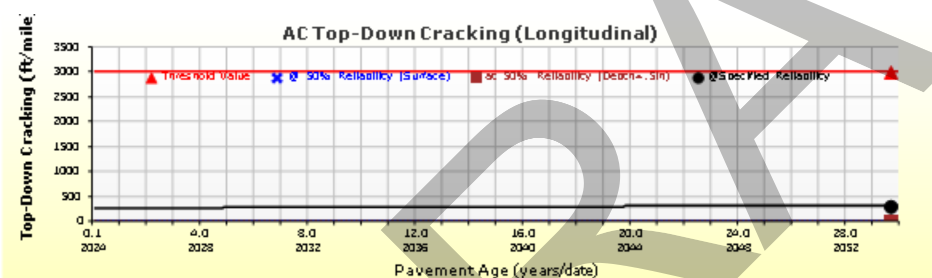




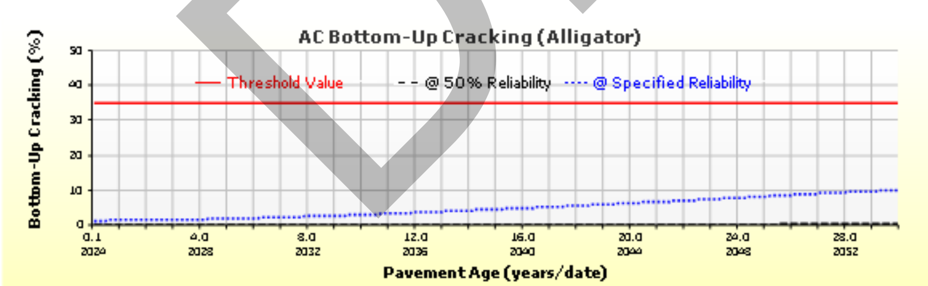
AC Top-Down Damage
@Surface
(Depth=.5in)
Top-Down Damage (%)
Pavement Age (years/date)



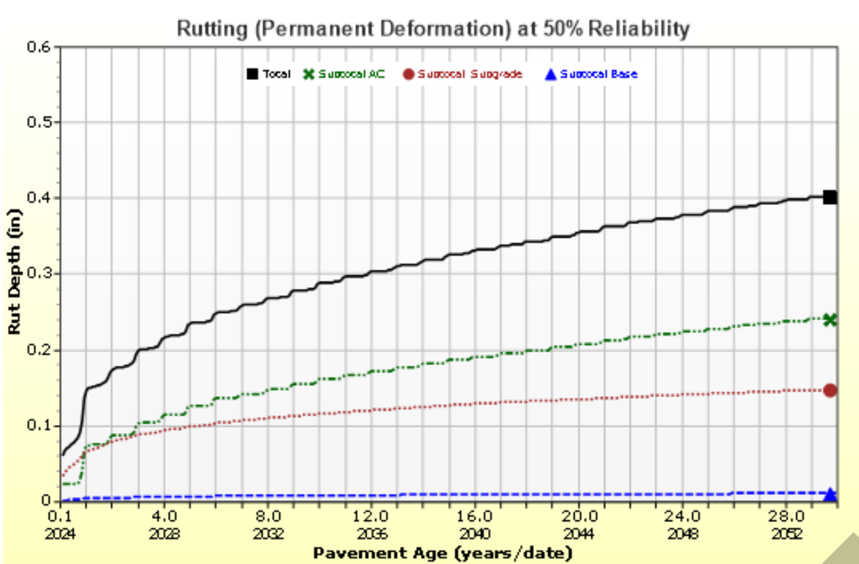
AC Bottom-Up Damage
Bottom-Up Damage (%)
Pavement Age (years/date)

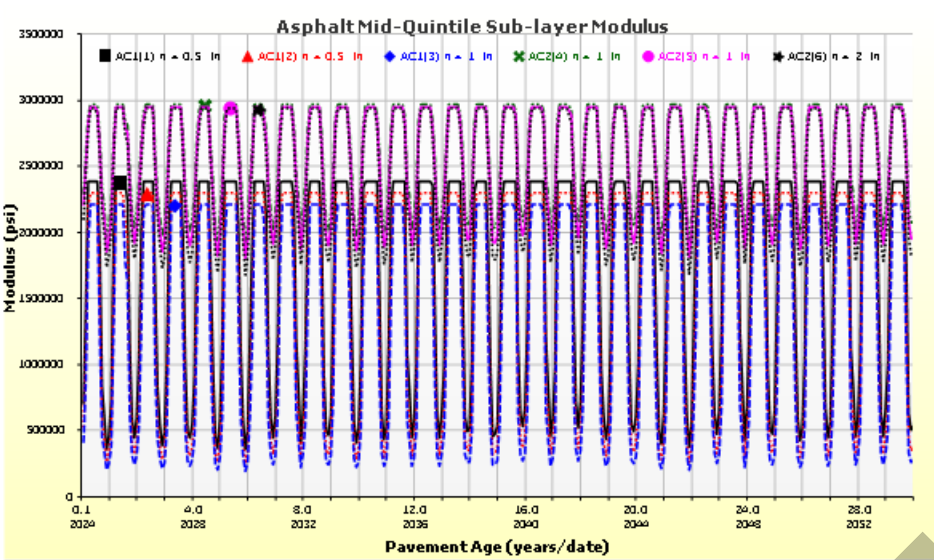


AC Top-Down Cracking (Longitudinal)
Threshold Value
@ 50% Reliability (Surface)
@ 50% Reliability (Depth=.5in)
@Specified Reliability
Top-Down Cracking (ft/mile)
Pavement Age (years/date)

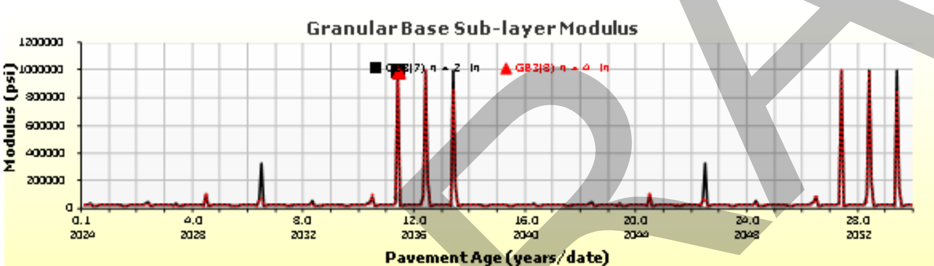


AC Bottom-Up Cracking (Alligator)
Threshold Value
@ 50% Reliability
@ Specified Reliability
Bottom-Up Cracking (%)
Pavement Age (years/date)

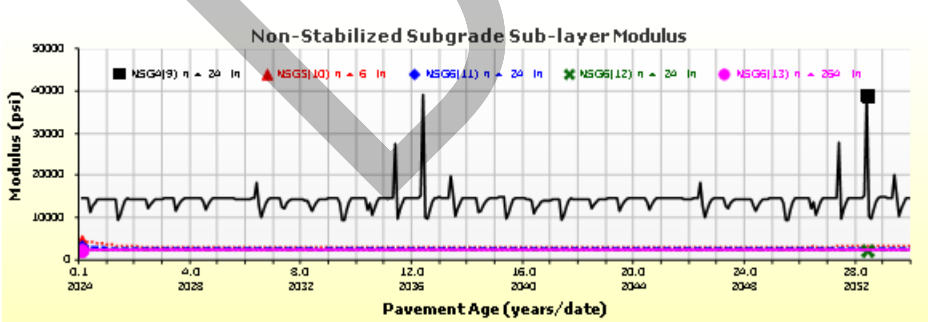

Rutting (Permanent Deformation) at 50% Reliability
Total
Subtotal AC
Subtotal Subgrade
Subtotal Base
Rut Depth (in)
Pavement Age (years/date)
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052



Asphalt Mid-Quintile Sub-layer Modulus
AC1(1) h = 0.5 in
AC1(2) h = 0.5 in
AC1(3) h = 1 in
AC2(4) h = 1 in
AC2(5) h = 1 in
AC2(6) h = 2 in
Modulus (psi)
Pavement Age (years/date)



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



Non-Stabilized Subgrade Sub-layer Modulus
NSG4(9) h = 24 in
NSG5(10) h = 6 in
NSG6(11) h = 24 in
NSG6(12) h = 24 in
NSG6(13) h = 264 in
Modulus (psi)
Pavement Age (years/date)

Layer Information

Layer 1 Flexible : R3 Level 1 SX(100) PG 64-28

Asphalt

Asphalt		
Thickness (in)	2.0	
Unit weight (pcf)	145.0	
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	1687360	2134249	2493389	2608869
40	697463	1127680	1612900	1802220
70	173403	334774	616373	765125
100	54259	93163	175106	227742
130	27890	38645	60413	74657

Asphalt Binder

Temperature (ºF)	Binder Gstar (Pa)	Phase angle (deg)
147.2	3051	81.6
158	1495	83.1
168.8	772	85

General Info

Name	Value
Reference temperature (ºF)	70
Effective binder content (%)	10.7
Air voids (%)	5.7
Thermal conductivity (BTU/hr-ft-ºF)	0.67
Heat capacity (BTU/lb-ºF)	0.23

Identifiers

Field	Value
Display name/identifier	R3 Level 1 SX(100) PG 64-28
Description of object	Mix ID # FS1959
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 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 3 Non-stabilized Base : Crushed stone

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)
20000.0

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

Identifiers

Field	Value
Display name/identifier	Crushed stone
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	20

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-1-a

Unbound	
Layer thickness (in)	24.0
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)
9494.0

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

Identifiers

Field	Value
Display name/identifier	A-1-a
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?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	127.2
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 5 Subgrade : A-4

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)
5355.0

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

Identifiers

Field	Value
Display name/identifier	A-4
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	21.0
Plasticity Index	5.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	119
Saturated hydraulic conductivity (ft/hr)	False	7.589e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Layer 6 Subgrade : A-4

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)
5355.0

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

Identifiers

Field	Value
Display name/identifier	A-4
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	21.0
Plasticity Index	5.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	118.4
Saturated hydraulic conductivity (ft/hr)	False	8.325e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

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: 130.3674
Bf2: 1
Bf3: 1.217799

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	0.1414 * Pow(RUT,0.25) + 0.001	
AC Layer	K1:-3.35412 K2:1.5606 K3:0.3791	Br1:4.3 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: 6.3	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: 6.3	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: 0.22	k1: 1.35	Bs1: 0.37
Standard Deviation (BASERUT) 0.0104 * Pow(BASERUT,0.67) + 0.001		Standard Deviation (BASERUT) 0.0663 * Pow(SUBRUT,0.5) + 0.001	

AC Cracking

AC Top Down Cracking

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

c1: 7	c2: 3.5	c3: 0	c4: 1000

AC Cracking Top Standard Deviation

200 + 2300/(1+exp(1.072-2.1654*LOG10 (TOP+0.0001)))

AC Bottom Up Cracking

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

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

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

c1: 0.021	c2: 2.35	c3: 6000

AC Cracking Bottom Standard Deviation

1 + 15/(1+exp(-3.1472-4.1349*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: 50	C2: 0.55	C3: 0.0111	C4: 0.02

APPENDIX E

DRIVEWAY
ME-PAVEMENT DESIGN OUTPUT SHEETS
RIGID DESIGN

Fire Station 7_PC

File Name: C:\Users\RSGeoTech\Desktop\PMED Projects\599.89\Fire Station 7_PC.dgpx

Design Inputs

Design Life: 30 years
Design Type: JPCP

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

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

Design Structure

Layer type	Material Type	Thickness (in)
PCC	R4 Level 1 Lawson	8.0
NonStabilized	Crushed stone	6.0
Subgrade	A-4	6.0
Subgrade	A-4	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.00
Slab width (ft)	12.0

Traffic

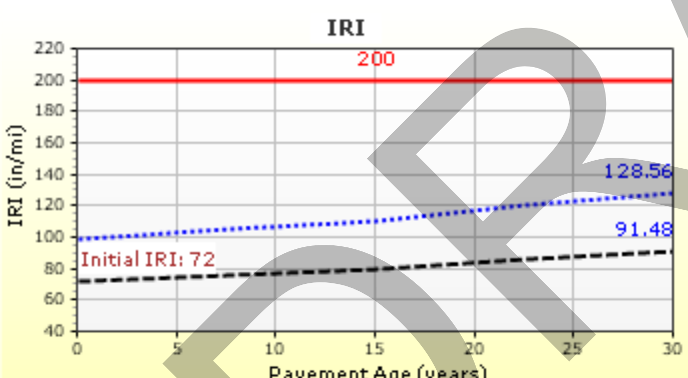
Age (year)	Heavy Trucks (cumulative)
2024 (initial)	40
2039 (15 years)	117,245
2054 (30 years)	250,927

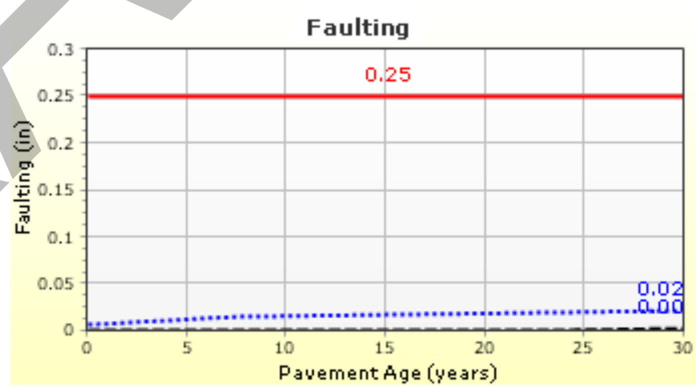
Design Outputs

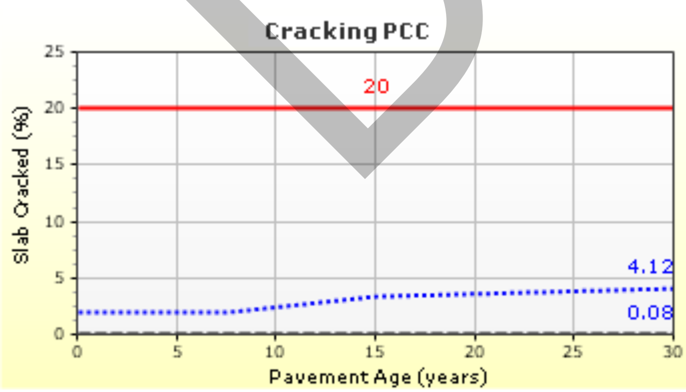
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	200.00	128.56	90.00	99.99	Pass
Mean joint faulting (in)	0.25	0.02	90.00	100.00	Pass
JPCP transverse cracking (percent slabs)	20.00	4.12	90.00	100.00	Pass

Distress Charts





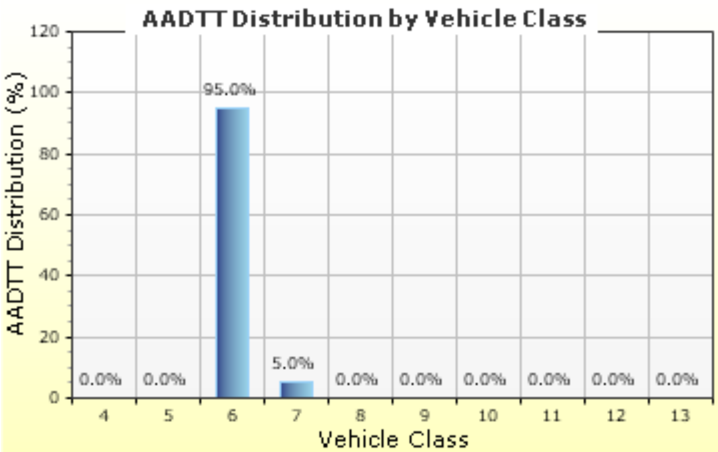


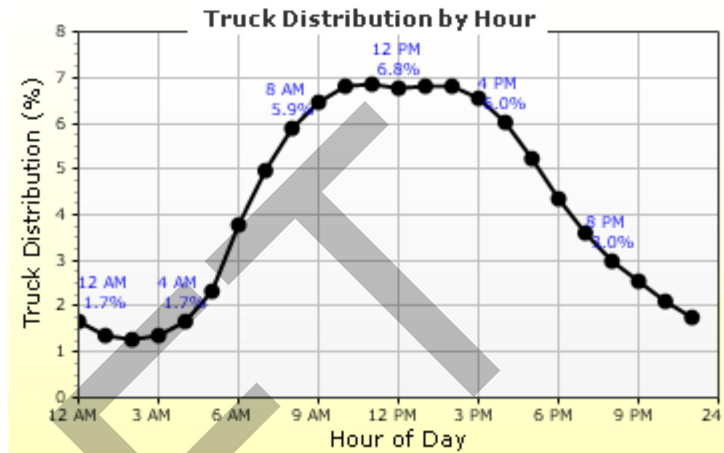
Threshold Value @ Specified Reliability @ 50% Reliability

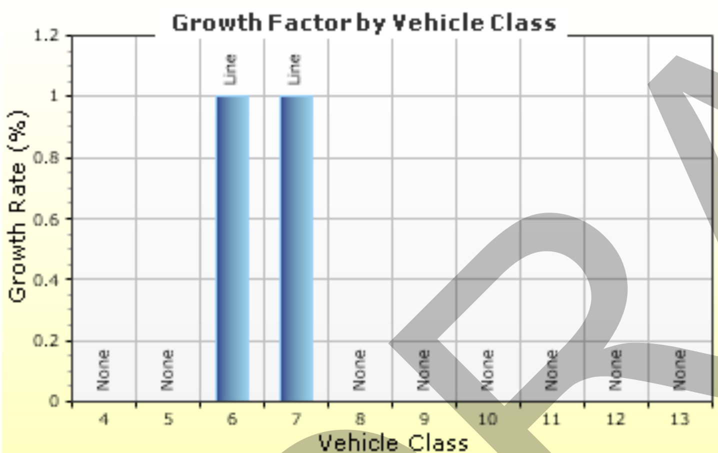
Traffic Inputs

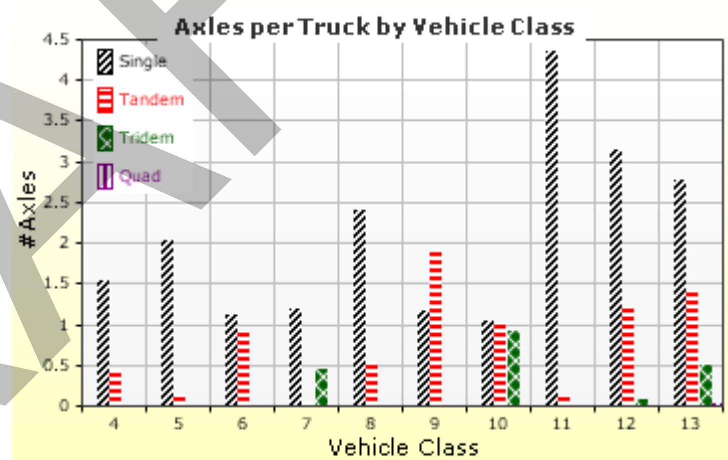
Graphical Representation of Traffic Inputs

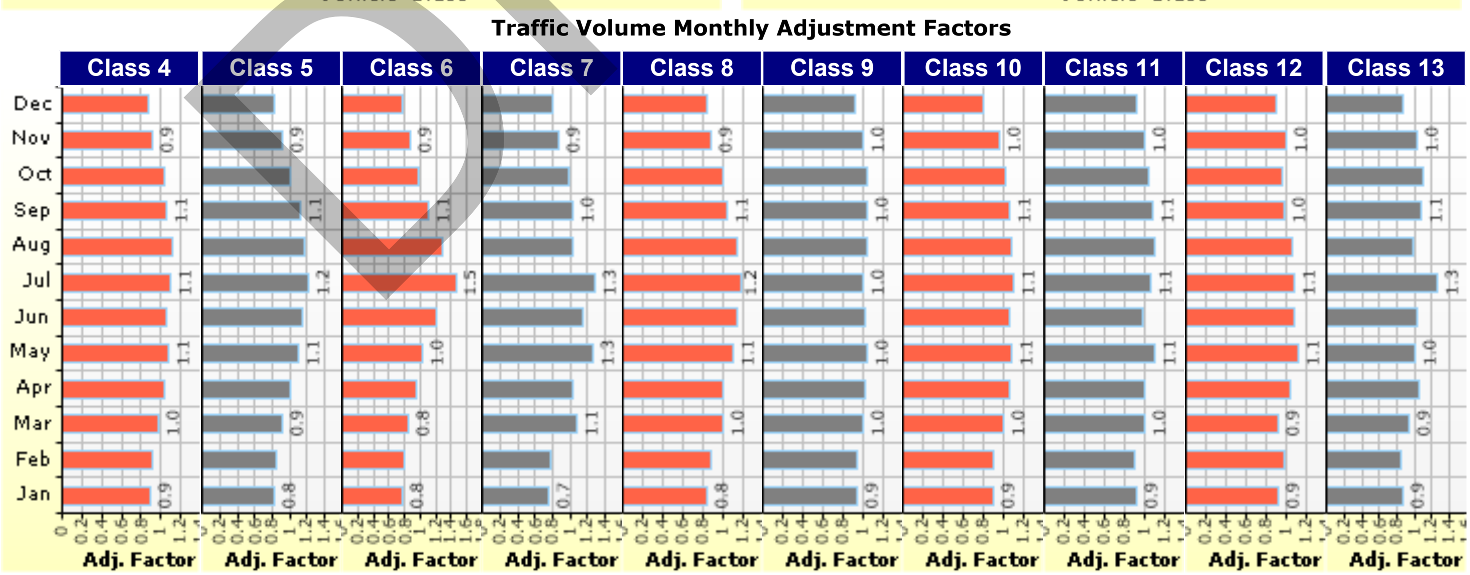
Initial two-way AADTT:	40	Percent of trucks in design direction (%):	50.0
Number of lanes in design direction:	1	Percent of trucks in design lane (%):	100.0
		Operational speed (mph)	5.0











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 (%)	Growth Factor Function
Class 4	0%	0%	None
Class 5	0%	0%	None
Class 6	95%	1%	Linear
Class 7	5%	1%	Linear
Class 8	0%	0%	None
Class 9	0%	0%	None
Class 10	0%	0%	None
Class 11	0%	0%	None
Class 12	0%	0%	None
Class 13	0%	0%	None

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)	8.4
Dual tire spacing (in)	12.0
Tire pressure (psi)	120.0

Average Axle Spacing	
Tandem axle spacing (in)	52.0
Tridem axle spacing (in)	0.0
Quad axle spacing (in)	0.0

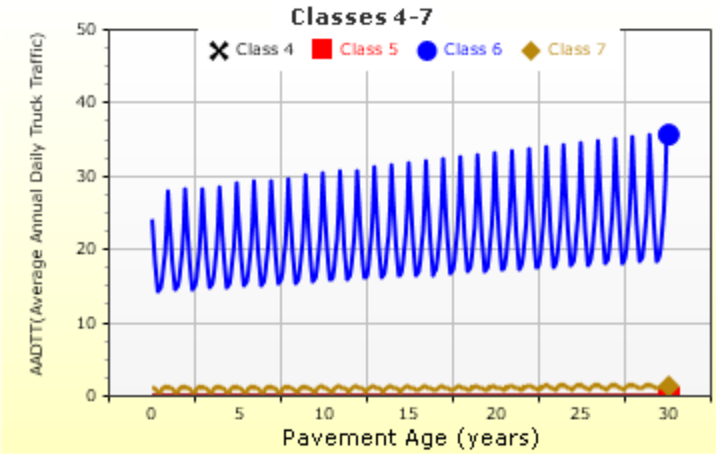
Wheelbase: Value Type / Axle Type	Short	Medium	Long
Average spacing of axles (ft)	12.0	15.0	18.0
Percent of Trucks (%)	17.0	22.0	61.0

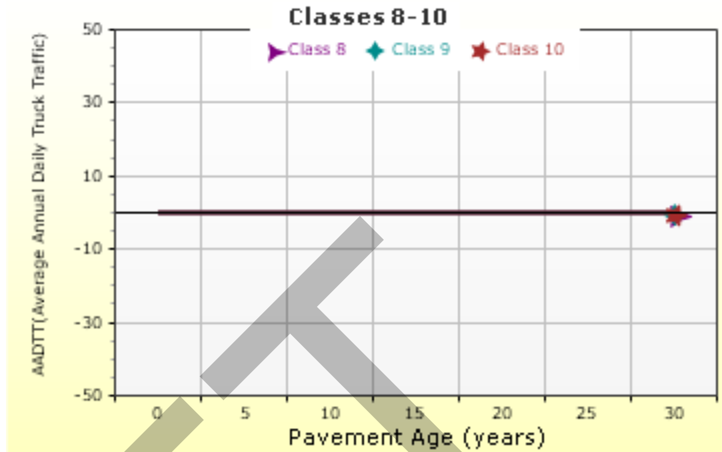
Number of Axles per Truck

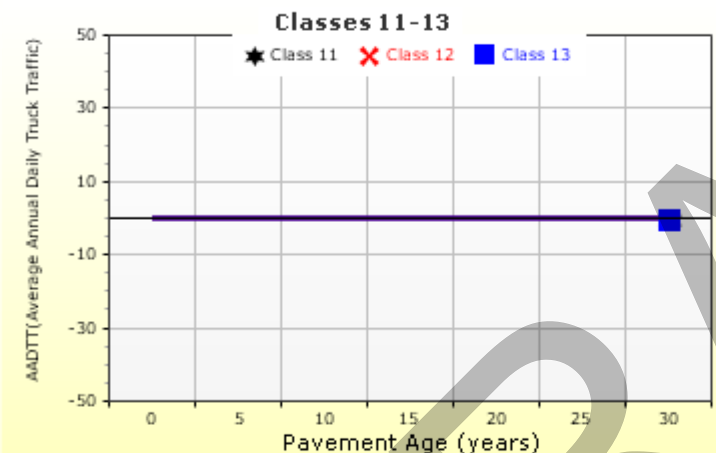
Vehicle Class	Single Axle	Tandem Axle	Tridem Axle	Quad Axle
Class 4	1.53	0.45	0	0
Class 5	2.02	0.16	0.02	0
Class 6	1.12	0.93	0	0
Class 7	1.19	0.07	0.45	0.02
Class 8	2.41	0.56	0.02	0
Class 9	1.16	1.88	0.01	0
Class 10	1.05	1.01	0.93	0.02
Class 11	4.35	0.13	0	0
Class 12	3.15	1.22	0.09	0
Class 13	2.77	1.4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

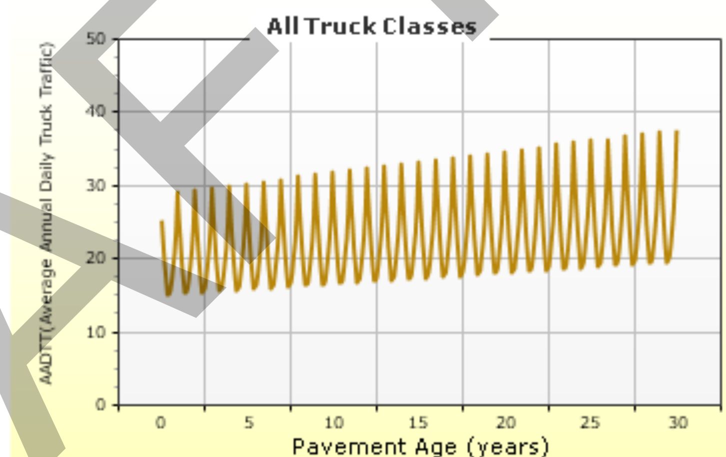
AADTT (Average Annual Daily Truck Traffic) Growth

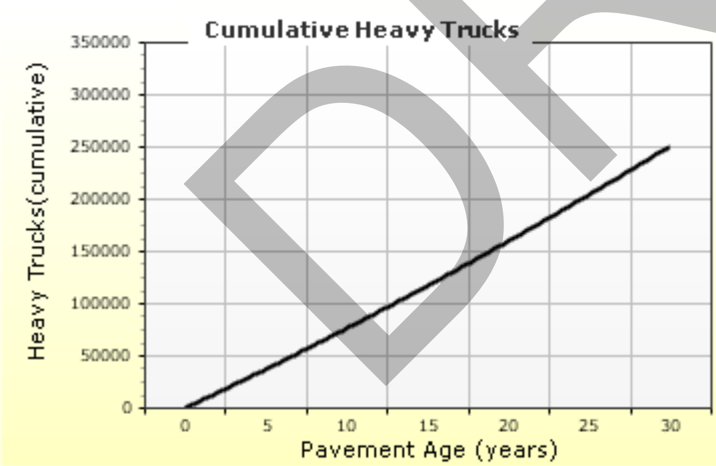
*** Traffic cap is not enforced**







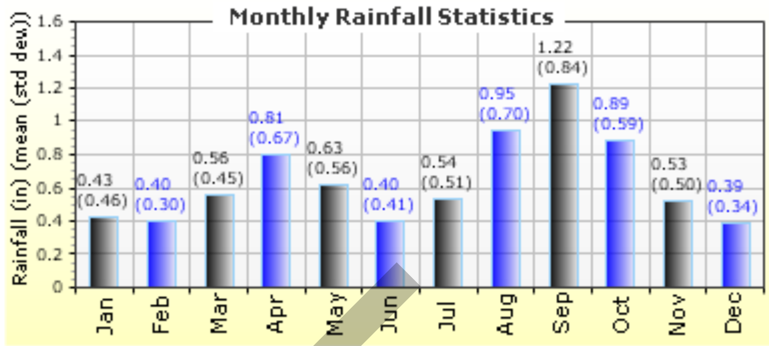




Climate Inputs

Climate Data Sources:

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

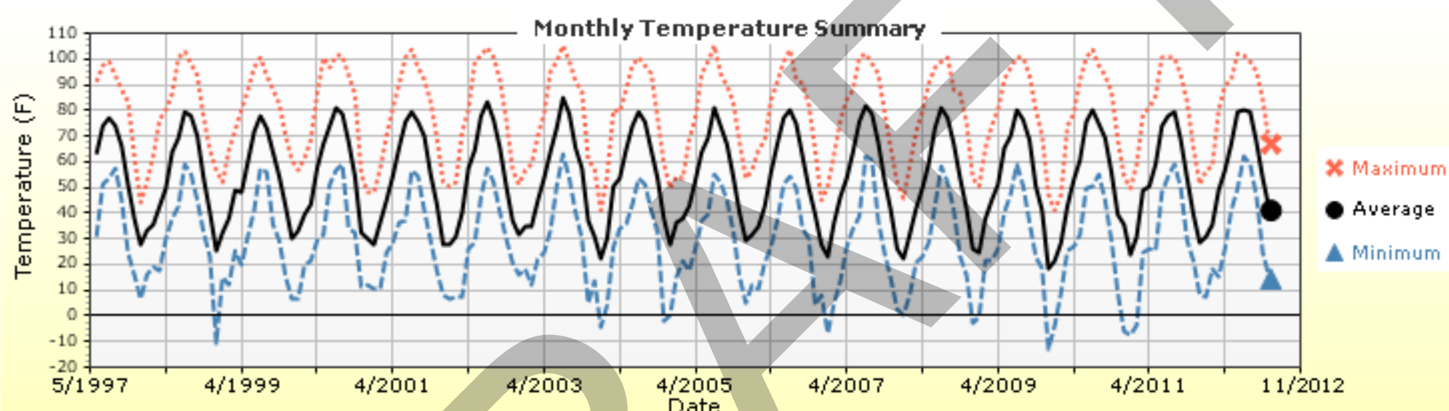


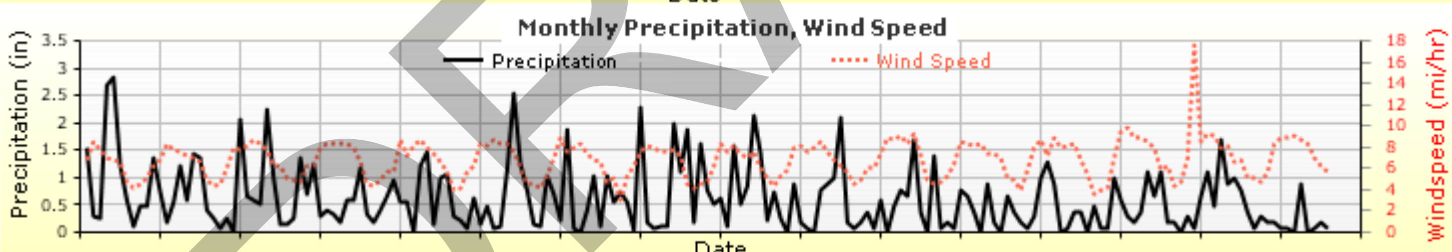
Annual Statistics:

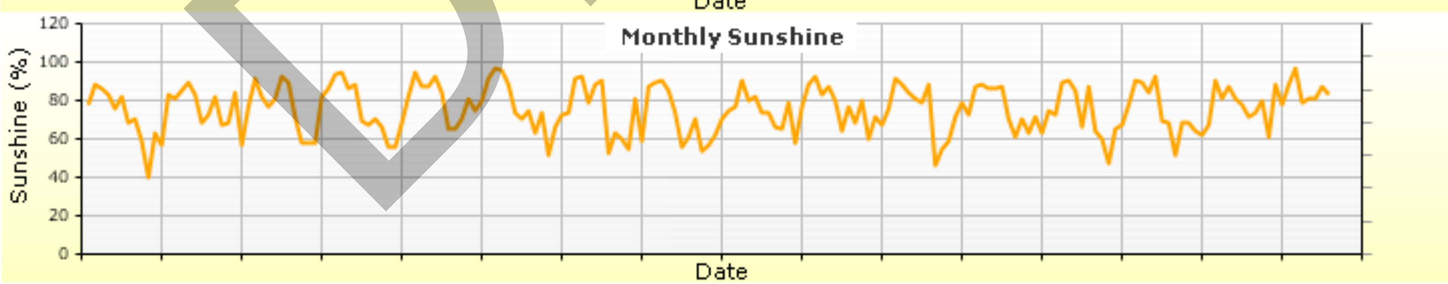
Mean annual air temperature (ºF)	53.51
Mean annual precipitation (in)	7.75
Freezing index (ºF - days)	399.81
Average annual number of freeze/thaw cycles:	111.77

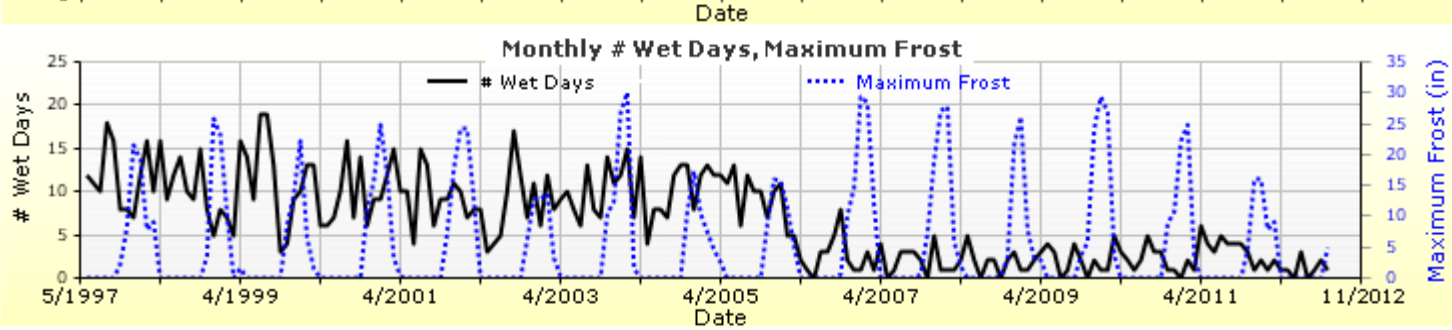
Water table depth (ft) 5.00

Monthly Climate Summary:

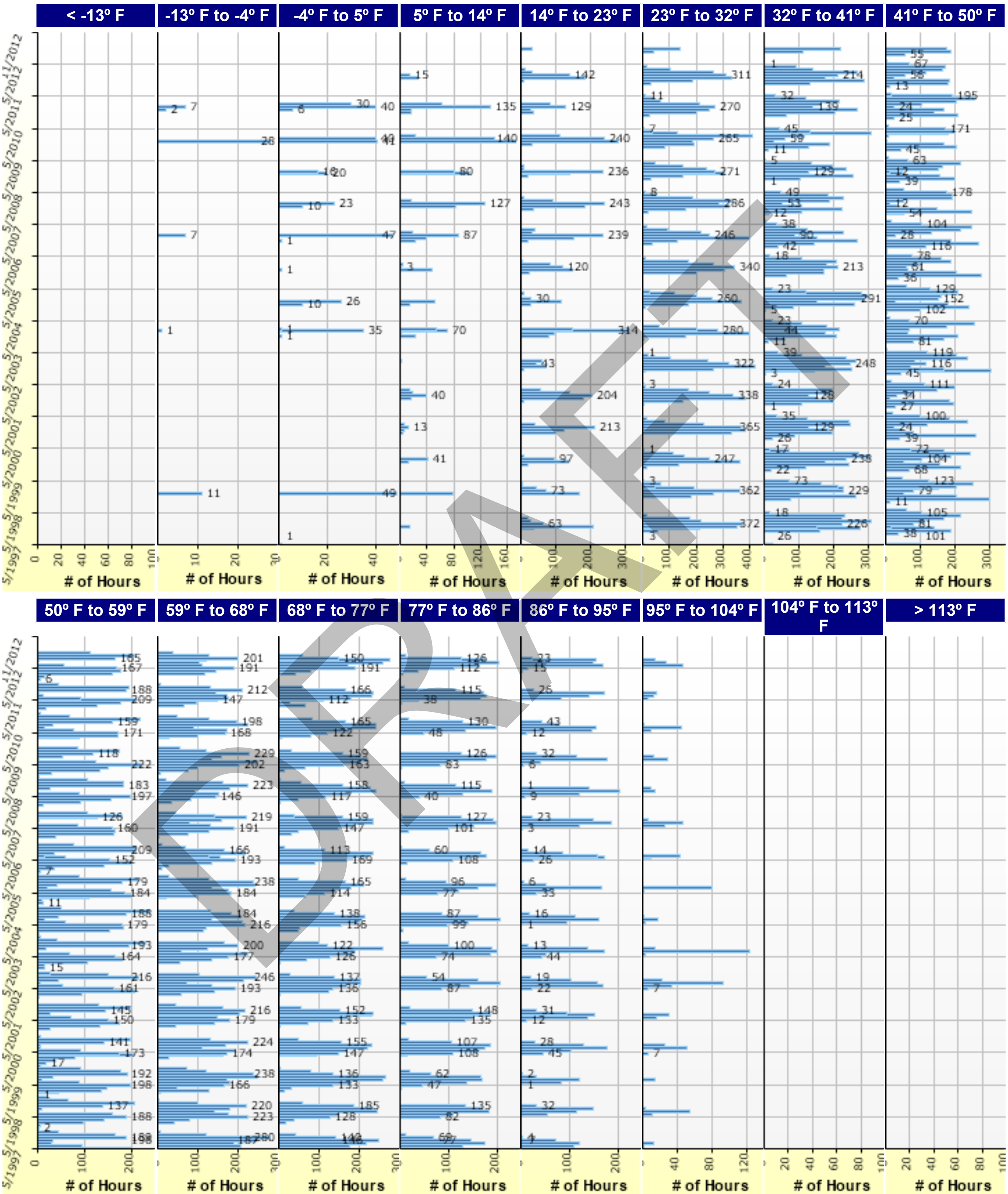








Hourly Air Temperature Distribution by Month:



Design Properties

JPCP Design Properties

Structure - ICM Properties	
PCC surface shortwave absorptivity	0.85

Doweled Joints	
Is joint doweled ?	True
Dowel diameter (in)	1.00
Dowel spacing (in)	12.00

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

PCC joint spacing (ft)	
Is joint spacing random ?	False
Joint spacing (ft)	15.00

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

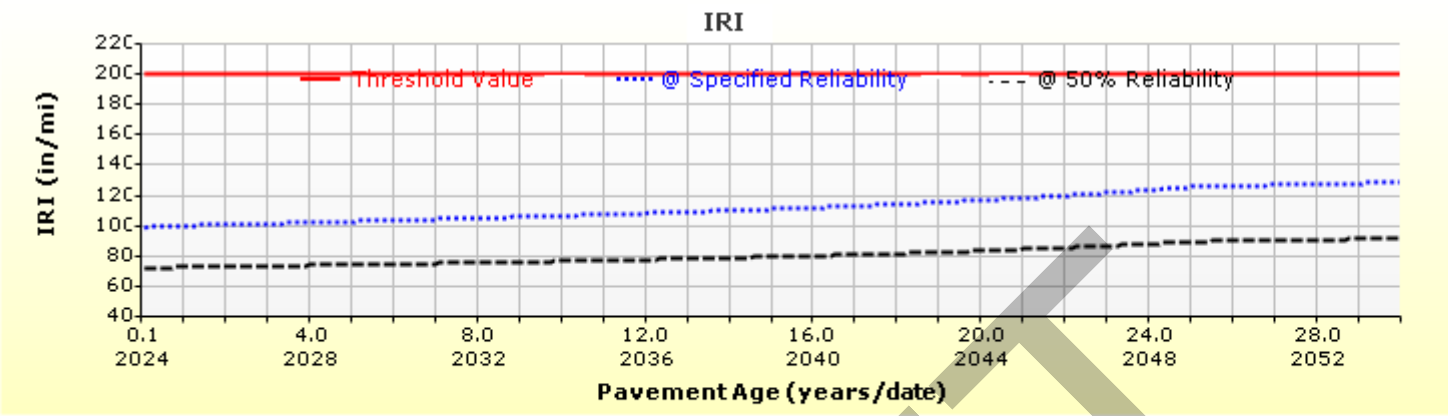
PCC-Base Contact Friction	
PCC-Base full friction contact	True
Months until friction loss	360.00

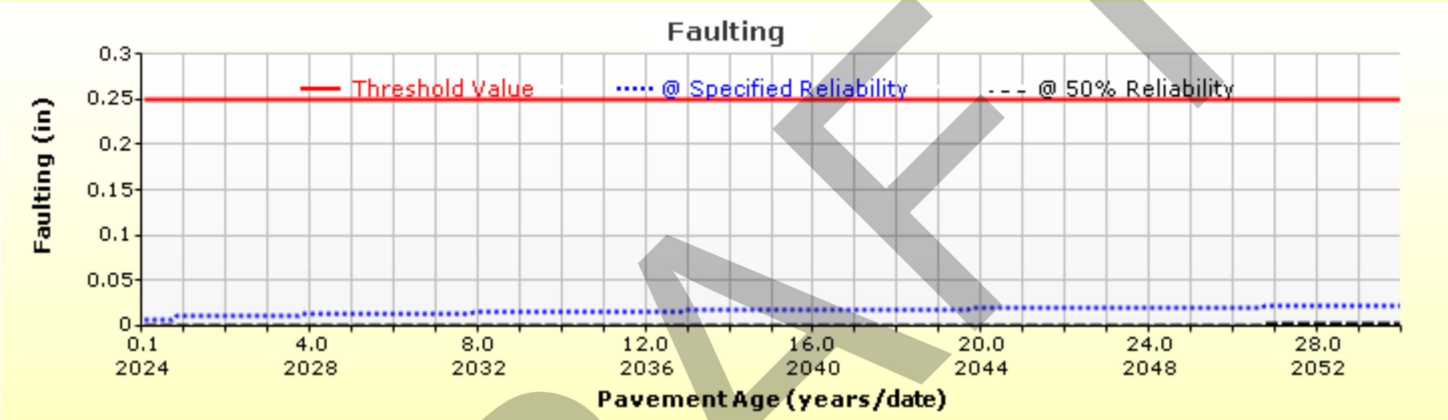
Sealant type	Other(Including No Sealant... Liquid... Silicone)

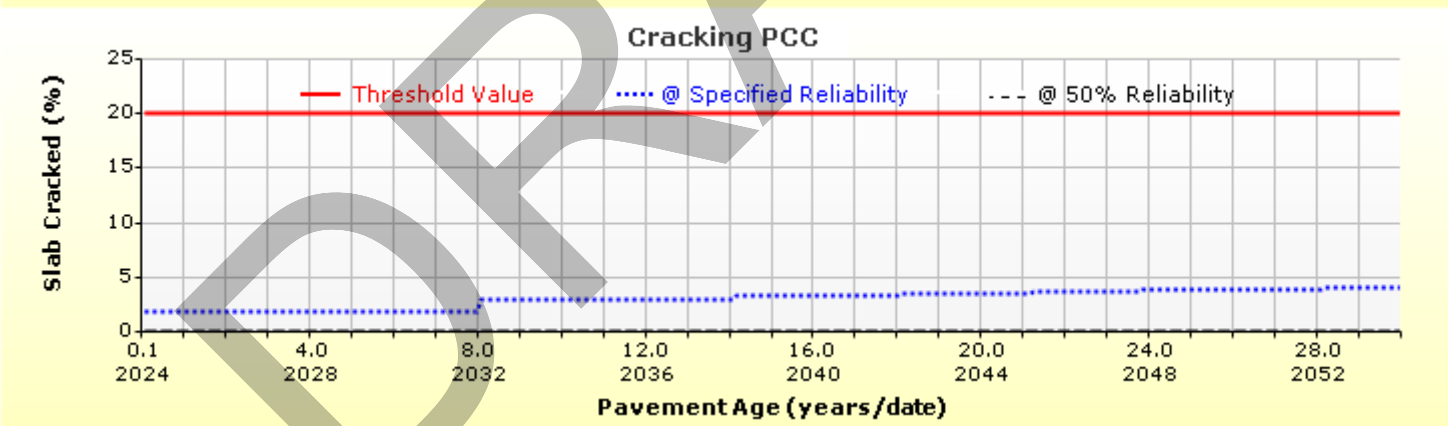
Erodibility index	3

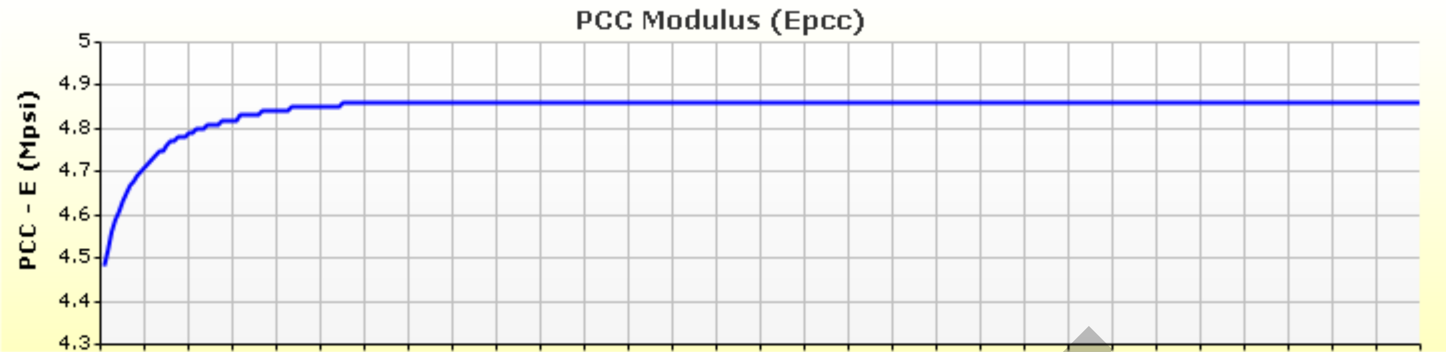
Permanent curl/warp effective temperature difference (ºF)	-10.00

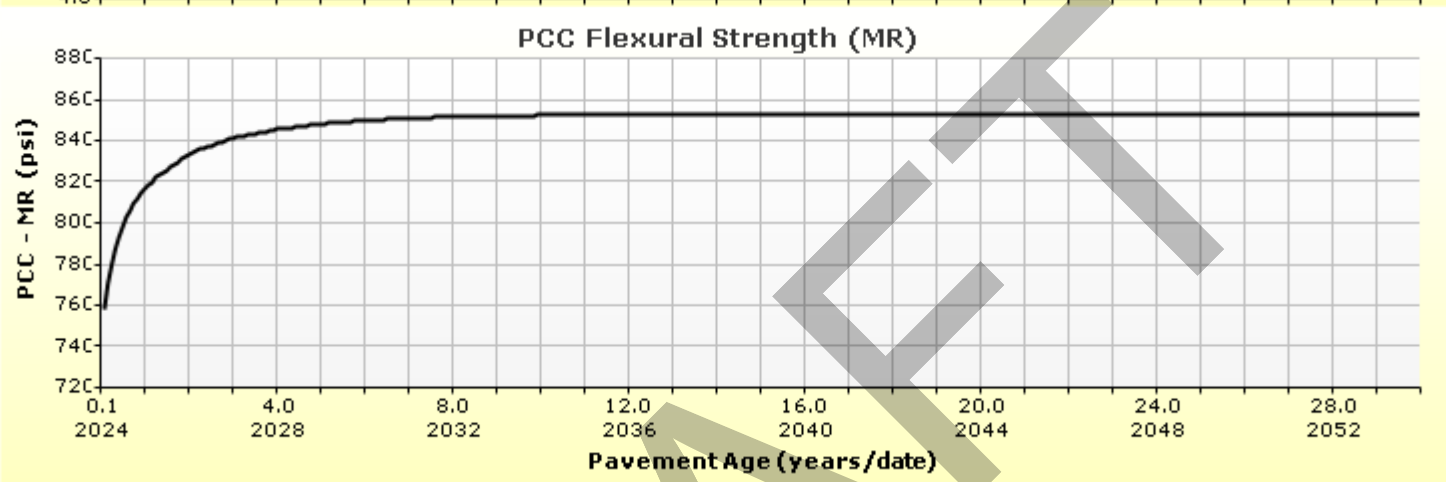
Analysis Output Charts

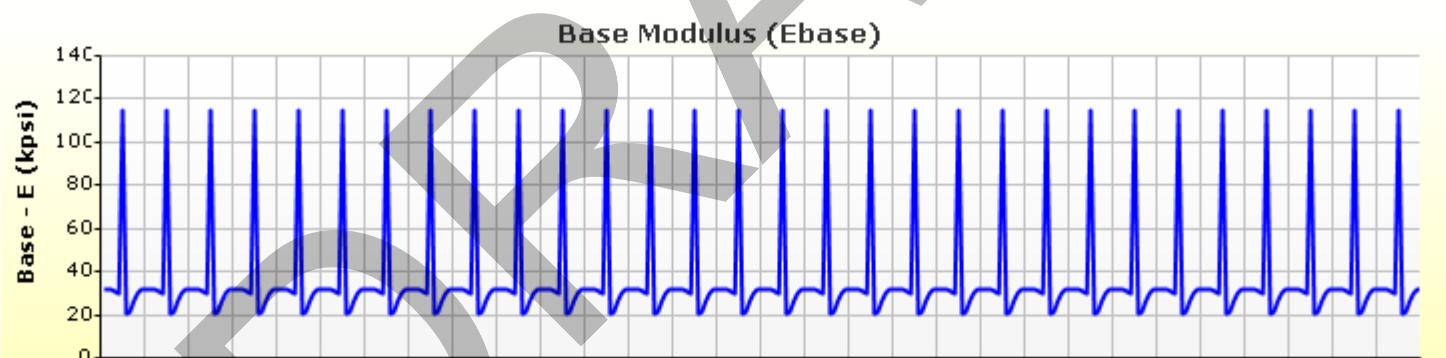


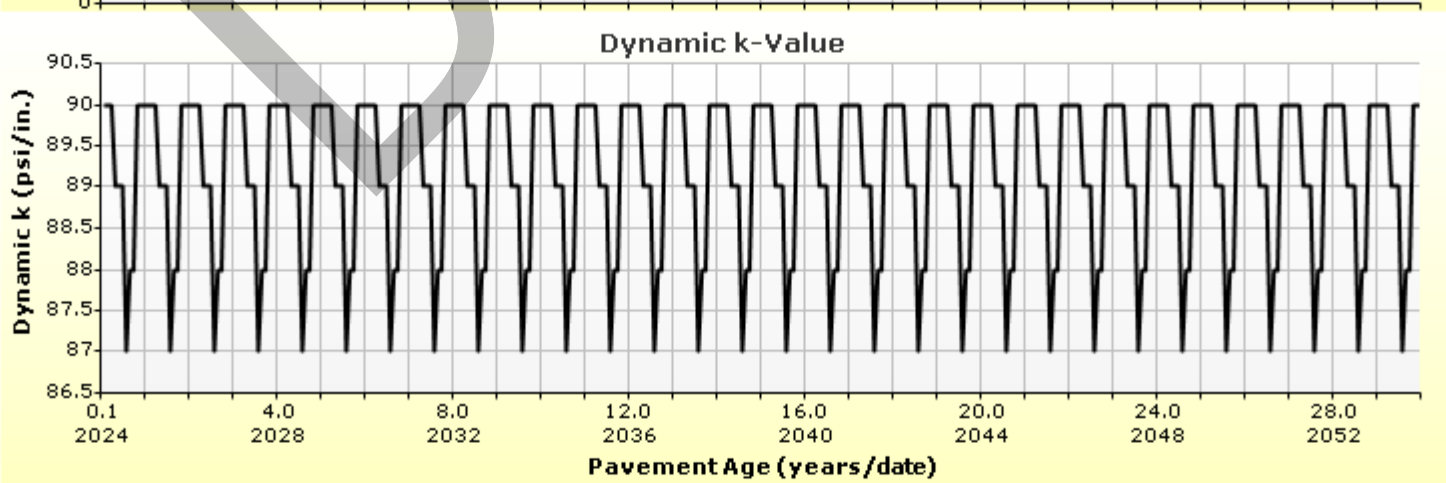


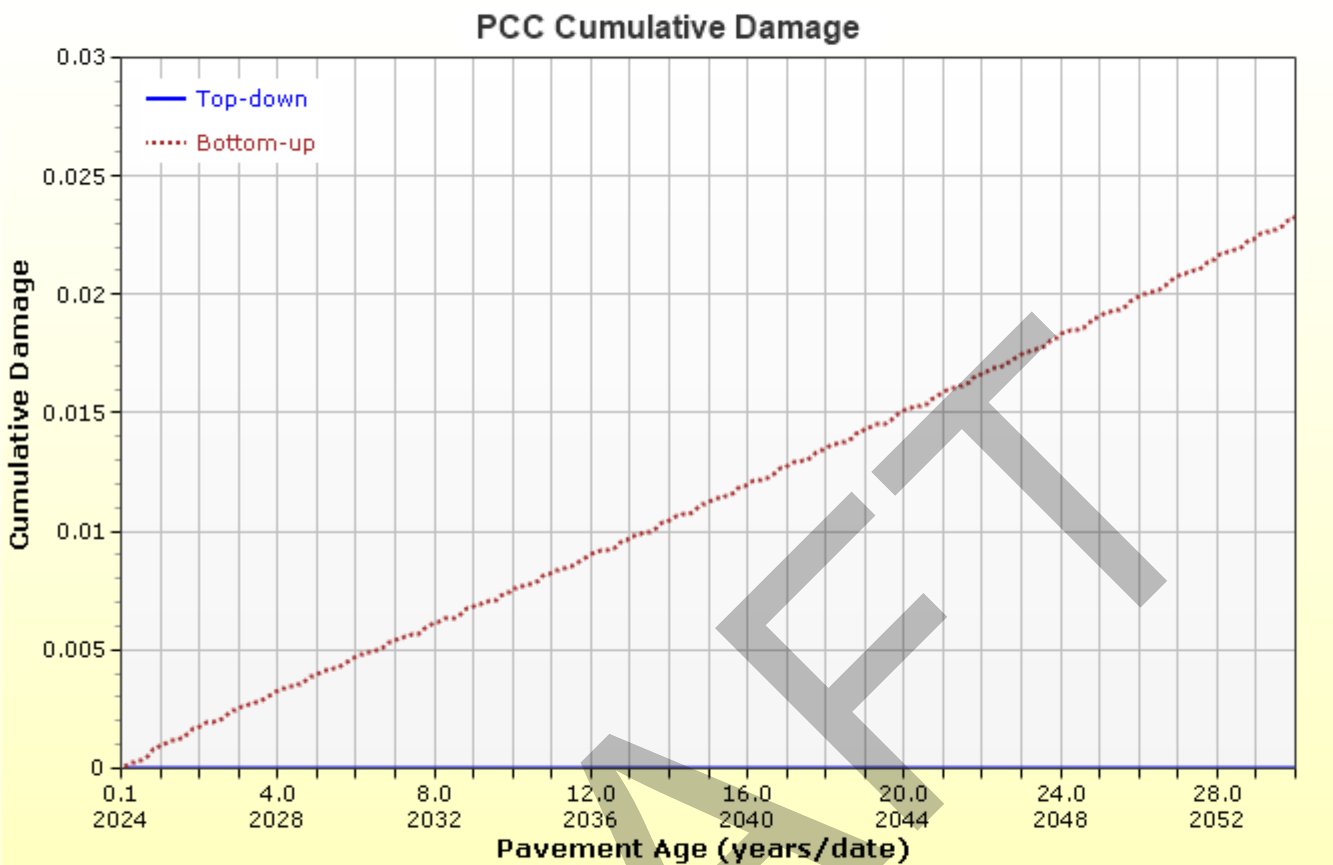



PCC Modulus (Epcc)
PCC - E (Mpsi)
5
4.9
4.8
4.7
4.6
4.5
4.4
4.3

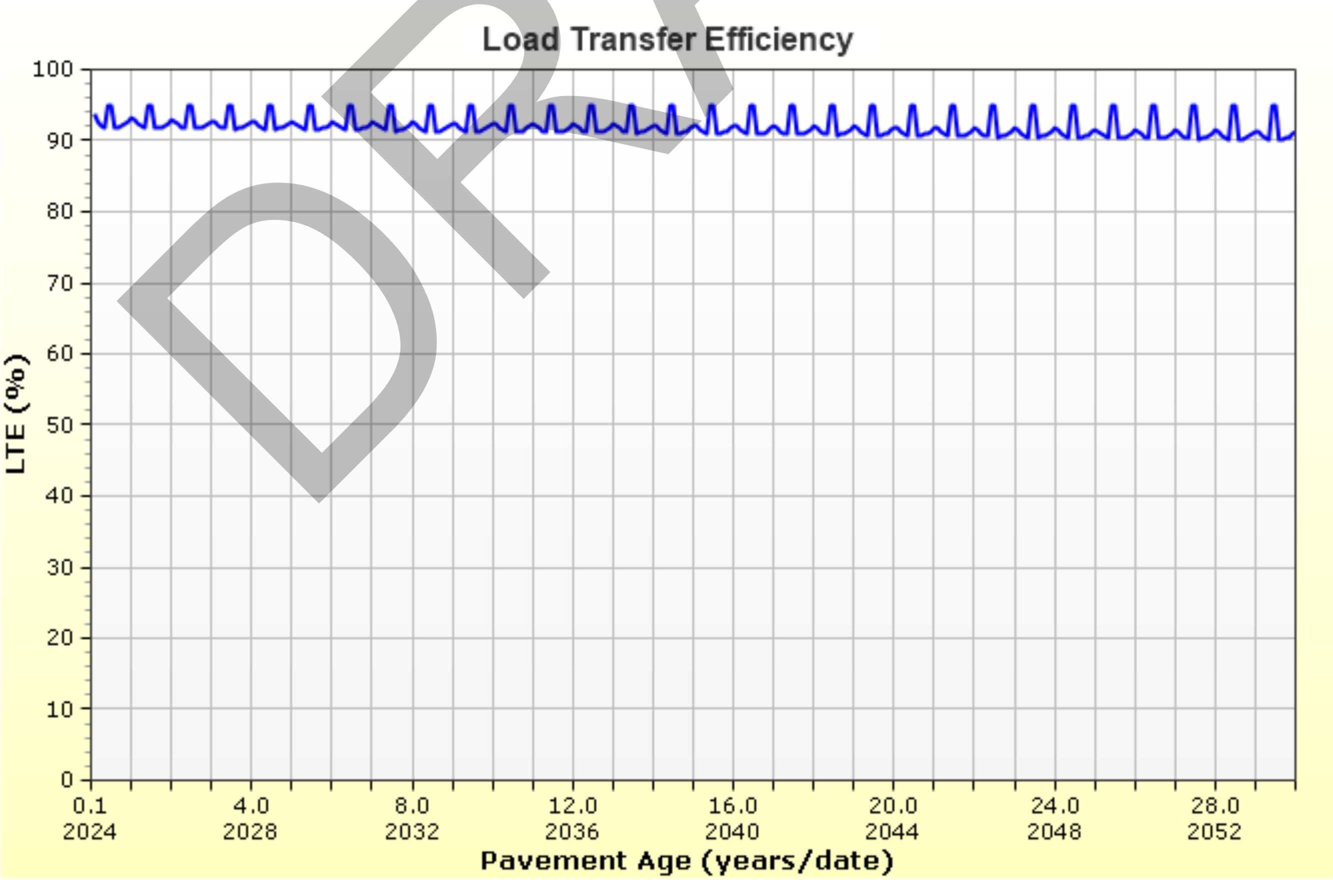

PCC Flexural Strength (MR)
PCC - MR (psi)
880
860
840
820
800
780
760
740
720
0.1 2024
4.0 2028
8.0 2032
12.0 2036
16.0 2040
20.0 2044
24.0 2048
28.0 2052
Pavement Age (years/date)


Base Modulus (Ebase)
Base - E (kpsi)
140
120
100
80
60
40
20
0


Dynamic k-Value
Dynamic k (psi/in.)
90.5
90
89.5
89
88.5
88
87.5
87
86.5
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
0.03
0.025
0.02
0.015
0.01
0.005
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)	8.0
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

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

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

Layer 2 Non-stabilized Base : Crushed stone

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)
20000.0

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

Identifiers

Field	Value
Display name/identifier	Crushed stone
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	20

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-4

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)
5875.4

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

Identifiers

Field	Value
Display name/identifier	A-4
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	21.0
Plasticity Index	5.0
Is layer compacted?	True

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	119
Saturated hydraulic conductivity (ft/hr)	False	7.589e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

Layer 4 Subgrade : A-4

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)
5875.4

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

Identifiers

Field	Value
Display name/identifier	A-4
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	21.0
Plasticity Index	5.0
Is layer compacted?	False

	Is User Defined?	Value
Maximum dry unit weight (pcf)	False	118.4
Saturated hydraulic conductivity (ft/hr)	False	8.325e-06
Specific gravity of solids	False	2.7
Water Content (%)	False	11.8

User-defined Soil Water Characteristic Curve (SWCC)	
Is User Defined?	False
af	68.8377
bf	0.9983
cf	0.4757
hr	500.0000

Sieve Size	% Passing
0.001mm	
0.002mm	
0.020mm	
#200	60.6
#100	
#80	73.9
#60	
#50	
#40	82.7
#30	
#20	
#16	
#10	89.9
#8	
#4	93.0
3/8-in.	95.6
1/2-in.	96.7
3/4-in.	98.0
1-in.	98.7
1 1/2-in.	99.4
2-in.	99.6
2 1/2-in.	
3-in.	
3 1/2-in.	99.8

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

DRIVEWAY
AASHTO 93 OUTPUT SHEETS
FLEXIBLE DESIGN

INITIAL VALUES

Initial Serviceability Index=	4.5
Final Serviceability Index=	2.5
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=	0.11
Design Life ESALs=	220,000
R-Value=	**20**

INTERMEDIATE CALCULATIONS

Calculated Mr=	7844
Design Mr=	7,844
Design Serviceability Loss (ΔPSI)=	2

FINAL CALCULATIONS

SN= **2.6056**

Such That:

Log_{10}ESAL	≤	**Thickness Equation**
5.3424	≤	5.3425

Full HMA:

Depth=	**5.92**	in	-->	use 6**.0 inches**

HMA over ABC:

Depth ABC=	**6.0**	in		
Depth HMA=	**4.42**	in	-->	use 4**.5 inches**

APPENDIX G

PARKING AREA
PAVEXPRESS OUTPUT SHEET
FLEXIBLE DESIGN

Project: Fire Station 7

New Asphalt Pavement Design

AASHTO '93/'98: Flexible Pavement Design

Pavement Diagram

Recommended Surface (4.0 in)
Aggregate subbase (6.0 in)

Required minimum design SN: 0.00

Layer Thicknesses (in)

Recommended Surface: 4.0 in
Aggregate subbase: 6.0 in

Total SN: 2.42

⚠ *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: New Asphalt Pavement Design

Created By: Madison Philips, philips@rocksol.edu

Last Modified: October 4, 2023 1:17:39 pm

Design Parameters

Design Period: 30 years

Reliability Level (R): 90%

Combined Standard Error (S_0): 0.5

Initial Servicability Index (p_i): 4.5

Terminal Servicability Index (p_t): 2

Delta Servicability Index (ΔPSI): 2.5

Total Design ESALs (W_{18}): 0.22

Layers

Recommended Surface - Asphalt

Thickness: 4 in

Aggregate subbase - Base

Thickness: 6 in

Structural Coefficient: 0.11

Drainage Coefficient: 1

APPENDIX H

PARKING AREA
ACPA DESIGNER OUTPUT SHEET
RIGID DESIGN

PavementDesigner.org

DESIGN SUMMARY REPORT FOR

CONCRETE PARKING LOT

DATE CREATED:

Wed Oct 04 2023 13:21:52 GMT-0600 (Mountain Daylight Time)

Project Description

Project Name:	Appleton Fire Station 7 Parking Lot	Owner: City of Grand Junction	Zip Code: Grand Junction, Colorado
Designer's Name:	M. Philips	**Route:**	

Project Description:

Design Summary

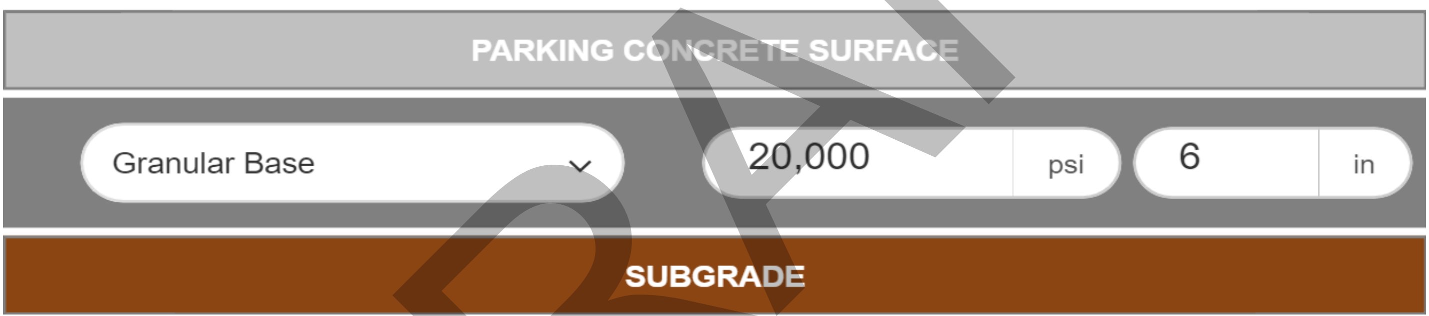
	Undoweled		Undoweled
Recommended Design Thickness:	7.00 in	Maximum Joint Spacing:	14 ft
Calculated Minimum Thickness:	6.95 in		

Pavement Structure

SUBBASE

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

Layer Type | **Resilient Modulus** | **Layer Thickness**



CONCRETE

28-Day Flex Strength:	650 psi	Edge Support:	YES
Modulus of Elasticity:	3400000 psi		

SUBGRADE

CBR Value:	4 %
Calculated MRSG Value:	5014 psi

Project Level

TRAFFIC

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

USER DEFINED TRAFFIC

Trucks Per Day:	1

GLOBAL

Reliability:	90 %
% Slabs Cracked at End of Design Life:	10 %

Design Method

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