Draft Geotechnical Investigation Report

Private Hangar Lots A1 and A2

Rifle-Garfield County Airport

Rifle, Colorado

Yeh Project No.: 222-084

March 18, 2022

Prepared for:

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Yeh and Associates, Inc.
Consulting Engineers & Scientists

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1. PURPOSE AND SCOPE OF STUDY

This report presents the results of our geotechnical engineering investigation for the proposed hangar on Lots A-1 and A-2 at the Rifle Garfield County Airport in Rifle, Colorado. The investigation was performed in accordance with Yeh and Associates Inc. (Yeh) Proposal No. 222-084, dated February 14, 2022. Our scope of services was authorized by Mr. Scott Moffat, a Preconstruction Manager with Crisak Inc., on February 16, 2022. The purpose of the work is to collect subsurface data from the site and prepare foundation, floor slab and general site grading recommendations for the proposed improvements. The project location is presented in Figure 1.

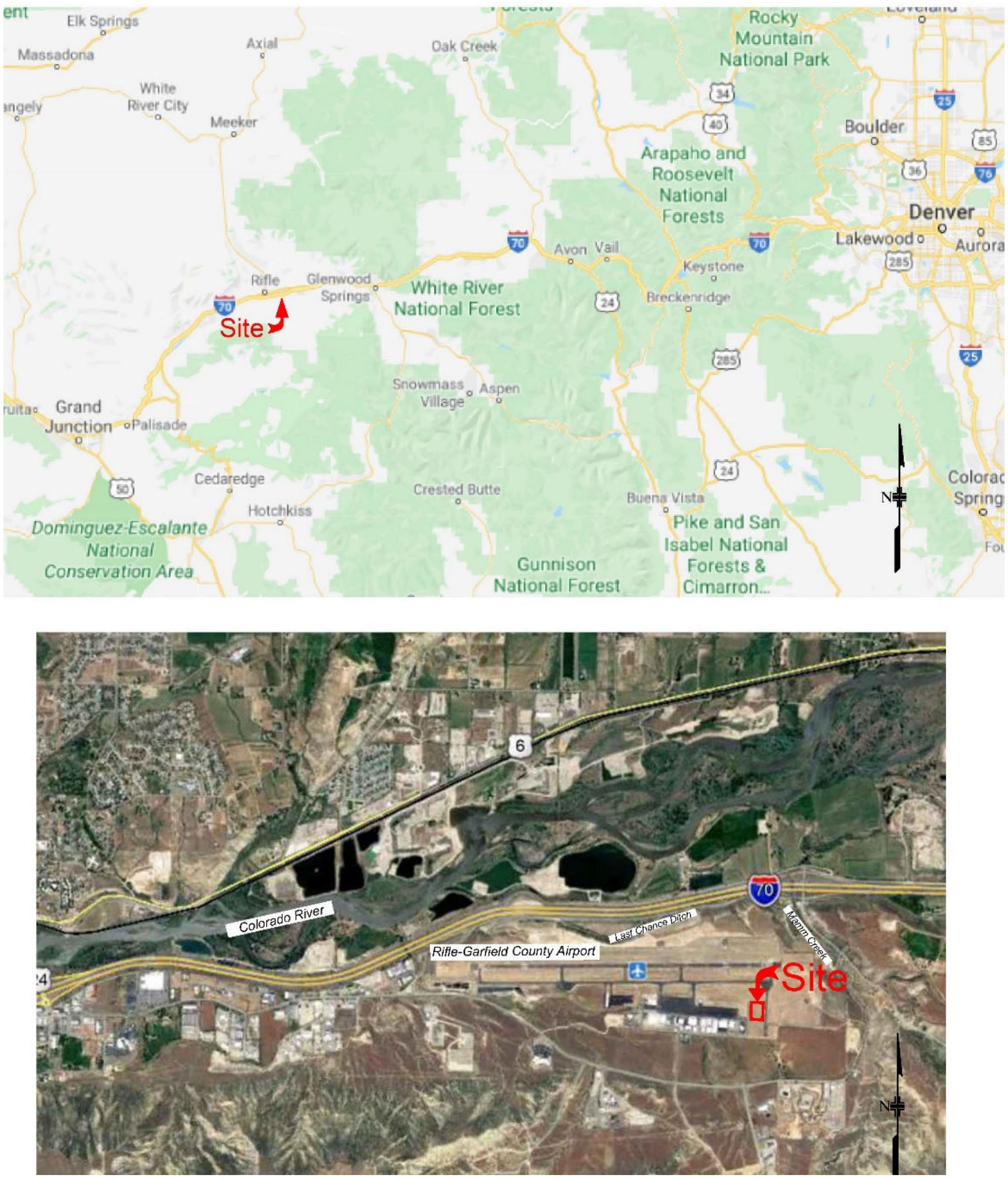


Figure 1 - Project Area Location

Our scope of services included the following:

- Drill a minimum of two (2) borings near proposed structure corners
- Collect soil samples and perform laboratory testing to include classification, R-value, swell/collapse potential, unconfined compressive strength and corrosivity
- Record standard penetration blow counts to be used in geotechnical analysis and design
- Prepare a report that:
    - Summarizes field and laboratory data
    - Presents the results of geotechnical engineering analyses
    - Provides structure foundation, concrete floor slab and general site grading recommendations

The geotechnical investigation consisted of geologic reconnaissance and drilling of exploratory borings to investigate subsurface conditions. Field investigation activities were overseen by a Yeh engineer. Samples obtained during the field exploration were examined by the project engineer and laboratory testing of representative samples was performed to evaluate the engineering characteristics of materials encountered.

Based on our investigation, Yeh completed a geotechnical engineering evaluation for the proposed improvements. This report summarizes our field investigation, the results of our analyses, and our conclusions and recommendations based on the proposed construction, site reconnaissance, subsurface investigation, and results of the laboratory testing. A detailed pavement evaluation was outside the scope of our services. Yeh should be contacted, as needed, to provide additional pavement design recommendations under a supplemental scope of services.

2. PROPOSED CONSTRUCTION

A preliminary site plan provided by the client shows the proposed construction site. . Based on preliminary plans and email communications with the client, proposed structures include a pre-engineered metal frame airport hangar with concrete floor slab located east of the terminal building on Lots A-1 and A-2 along Taxiway B4, the Group II Taxilane. The planned hangar dimensions are 176 feet by 133 feet and new pavement is expected to connect the hangar to the Taxilane. Boring locations were chosen based on the information as above.

3. SITE CONDITIONS AND GEOLOGIC SETTING

3.1 Site Conditions

The Rifle Garfield County Airport, identified by the FAA as RIL, is located at the north end of Runway Road, less than one mile from its intersection with County Road 352, south of Interstate 70, and southeast of Rifle, Garfield County, Colorado. The project area includes unimproved Lots A-1 and A-2 west of Taxiway B4, east of the existing terminal building and south of Runway 26 as shown on the Figure B-1 Approximate Test Boring Location Map in Appendix B.

Elevations were estimated from Google Earth and ranged between approximately 5,535 and 5,545 feet. The project site was nearly level with grades of less than 2 percent. The Last Chance Ditch is approximately 0.5 miles north and approximately 150 feet lower than the project area, with Mamm Creek located approximately 0.5 mile to the east and northeast, and the Colorado River is approximately 0.9 mile to the north. Vegetation at the site included native and cultured grasses and no trees or shrubs were observed at the site. The ground was snow-covered at the time of this investigation.

Public utilities in the area were located and marked after UNCC One Call locates. We were not notified of private infrastructure near the drill locations and private utility locates were outside of our scope of services for this investigation.

3.2 Geologic Setting

The project area is situated on a small mesa northeast of Grass Mesa in the southeast area of the Piceance Basin of western Colorado, a complex of numerous anticlines and synclines and a major gas production area. The Piceance Basin is located in the Colorado Plateau province and the topography of the basin is made up of high plateaus, ridges and deep valleys. The asymmetrical, arc-shaped basin is 100 miles long by 50 miles wide that is oriented northwest-southeast and is deepest on the east edge. It is bounded structurally on the north by the Uinta Mountains, on the northeast by the Axial Uplift, on the east by the Grand Hogback/White River Uplift and the Elk Mountains, on the south by the Uncompahgre Uplift and on the west by the Douglas Creek Arch/Rangely Dome. Underlying bedrock near the project site, generally dips, or tilts, at approximately 3 to 8 degrees to the west and northwest. Based on the U.S. Geological Survey Geologic Map of the Silt quadrangle (Shroba, 2001), bedrock underlying the site, and also exposed surrounding the site, is the varicolored claystone, mudstone, siltstone and weakly cemented sandstone of the Tertiary age Shire Member of the Wasatch Formation. The formation contains a weak calcite cement and may be prone to landslides.

Surficial deposits at the site include Quaternary age loess deposits of wind-blown, calcareous clay, silt and sand overlying sand, pebbles, and cobbles of terrace alluvium. The terrace alluvium in this area may be mantled by two loess sheets and may contain or be overlain by Quaternary age Lava Creek B volcanic ash (Shroba, 2001). The loess in the project area is estimated to be 3 to 24 feet (1 to 8 meters) thick. Artificial/manmade fill and disturbed areas may be present at the project site. Based on Shroba, 2001 mapping information and our experience in this area, the loess deposits and potential ash layers may be prone to sheet erosion, gullying, piping, and hydro-compaction. A Geology Map is presented in Appendix A.

4. SUBSURFACE INVESTIGATION AND CONDITIONS

4.1 Field Investigation

A total of three (3) borings were drilled in the project area. Boring B-1 was drilled in the northwest quadrant of Lot A-1, boring B-2 was drilled in the southeast quadrant of Lot A-2 and boring B-3 was drilled through the existing pavement at the west edge of Taxiway B4 along the east perimeter of the lots. The borings were completed on February 24, 2022 at locations selected by Yeh based on the estimated structure foundation layout as provided by the client. Survey of the borings was outside the scope of this investigation. The approximate locations of the borings are presented on Figure B-1, Approximate Test Boring Location Map, in Appendix B.

All borings were advanced using a Diedrich D-90 track-mounted drill rig with 4-inch solid, continuous flight auger. At selected intervals, a modified California sampler with a 2-inch interior diameter (ID) and 2.5 inch outside diameter (OD), or a standard split spoon sampler with a 1⅜-inch ID and 2-inch OD were used to record blow counts (SPT) and obtain samples. The sampler was seated at the bottom of the boring, then advanced by a 140-pound hydraulic automatic, or “auto,” hammer falling a distance of 30 inches. The number of blows required to drive the sampler two 6-inch intervals or a fraction thereof, constitutes the N-value. Bulk samples of drill cuttings were also obtained. Boring logs and legend are presented in Appendix C. See Figures 2 and 3 for boring activity photos.

Figure 2. - Drilling boring B-1 looking west

Figure 3 – Drilling boring B-3 at east edge Taxiway B4 looking north

4.2 Subsurface Conditions

Subsoils encountered in borings B-1 and B-2 at the surface consisted of approximately 6 inches of topsoil over stiff to hard sandy clay or clay with sand to depths explored of up to 30 feet. Boring B-1 encountered a dense sand and gravel lens at approximately 5 to 9 feet deep. Boring B-3 was drilled at the west edge of the Taxiway B-4 and had 4.5 inches of asphalt over 24 inches of base material of gravel and sand with clay over sandy clay. Groundwater was not encountered in any of the borings. Bedrock was not encountered and drilling to bedrock was not included in the scope of services. Boring logs and legend are presented in Appendix C and results of the laboratory testing are presented in Appendix D.

4.3 Laboratory Testing

Representative soil samples were selected for geotechnical and analytical laboratory testing. Laboratory testing was performed in general accordance with industry standards and local practice. Tests included the following:

- Natural moisture and dry density
- Particle-size analysis
- Atterberg limits
- Swell/collapse potential
- Water soluble sulfates
- R-value

Results of the laboratory testing are shown on the boring logs in Appendix C and presented in the Laboratory Summary in Appendix D. Unconfined compressive strength testing was attempted but samples crumbled upon extrusion from liners due to the percentage of sand and the low moisture content.

4.3.1 Clay

Laboratory testing was performed on 12 clay samples that had 53 to 80 percent fines (material passing the No. 200 sieve). Atterberg limit testing on 11 of these samples indicated liquid limits of 21 to 31 percent, and plasticity indices of 4 to 18 percent. Swell/collapse testing (ASTM D4546) on four of these samples taken at depths between 3 and 10 feet exhibited collapse of 1.7 to 3.1 percent upon wetting and an applied pressure of 1,000 pounds per square foot (psf). Hveem (R-value) testing performed on a bulk sample of clay taken between depths of 0.5 to 5 feet resulted in a value of 14 at exudation pressures of 300 pounds per square inch (psi).The clay samples classified as CL and CL-ML according to the Unified Soil Classification

System (USCS) and as A-4 (0), A-4 (2), and A-6 with group indices of 3, 5, 6, 9 and 10 based on the American Association of State Highway and Transportation Officials (AASHTO).

4.3.2 Sand

One sand sample tested had 36 percent fines, a liquid limit of 22 percent and a plasticity index of 8 percent. The sand sample tested classified as SC (USCS) and as A-4 (0) (AASHTO).

4.4 Groundwater

No groundwater was encountered in the borings during drilling. Variation in groundwater levels will be largely dependent upon the amount of spring snowmelt, duration and intensity of precipitation, site grading changes, and the surface and subsurface drainage characteristics of the surrounding area. Perched water tables may be present but were not encountered in the exploratory borings.

5. SEISMIC CONSIDERATIONS

Results of the field investigation and laboratory test results were used to evaluate the seismic site classification in accordance with IBC 2015 using Seismic Design Maps Web Services. Based upon the nature of the subsurface materials we recommend that Site Class D (stiff soil) be used in the design of the risk category II, III and IV structures for the proposed project (approximate site coordinates: 39.5237° N, -107.7168° W). The site class was based on the conditions encountered in our shallow exploratory soil borings and our knowledge of the subsurface conditions in the site vicinity. The soil characteristics extending beyond the depth of our borings were assumed for the purposes of providing this site classification. The site seismic design parameters are presented in Tables 1 and 2. These values are the same for risk categories II, III and IV.

Table 1 – Seismic Parameters for Reference Site Class B

PGA (0.0 sec)	S_S (0.2 sec)	S_1 (1.0 sec)
0.179 g	0.307 g	0.08 g

Table 2 – Seismic Design Parameters for Project Site

Site Class	F_a (0.2 sec)	F_v (1.0 sec)	S_{DS} (0.2 sec)	S_{D1} (1.0 sec)
D	1.554	2.4	0.318 g	0.128 g

6. FOUNDATION RECOMMENDATIONS

In general, the site appears suitable for the proposed construction based on geotechnical conditions encountered in the borings. The hangar can be supported on shallow foundations such as spread or strip footings bearing on native soils at the recommended depth. An email received from SGM, project structural engineer, on March 3, 2022 anticipates a maximum column location load of 150 kips for shallow foundations and pier loads of 250 kips or more for deep foundations. An increased bearing pressure may be used if shallow foundations are placed on a properly prepared layer of structural fill as described below. Deep foundations such as helical piles would also be an appropriate option in the existing soils.

Foundation design and construction should follow the Garfield County requirements and the 2015 International Building code (IBC). Recommendations presented herein should be confirmed by a representative of Yeh once excavations for foundations are completed and prior to placement of reinforcing steel and concrete.

6.1 Shallow Foundations

Based on the subsurface exploration and laboratory test results, shallow foundations placed on undisturbed native soil may be used to support the hangar. A higher bearing pressure can be achieved, as described below if a thickness of clay soil below the foundation elements is removed and replaced with imported structural fill in accordance with Section 10.5, Engineered and Structural Fill Requirements. On-site soil should not be used as structural fill placed beneath footings due to the high percentage of fine-grained material. Shallow foundations should be designed in accordance with the following recommendations:

1. Shallow foundations, including strip footings or spread footings, bearing on native soil can be designed for an allowable bearing pressure of 2,500 psf.

2. An allowable bearing pressure of 4,500 psf can be used if existing clay soils are removed to a minimum depth of 2 feet below shallow foundations and replaced with imported structural fill meeting the criteria in Table 3. The fill should extend 2 feet laterally beyond all footing edges.

3. The allowable design values are based on a factor of safety of 3.0. A one-third increase in the allowable bearing pressure may be used for temporary loading conditions including wind or seismic conditions.

4. For frost heave protection, footings should bear a minimum of 36 inches below lowest adjacent finished grade. Interior footings not subject to freezing should bear a minimum of 12 inches below finish floor elevation (FFE).

5. Resistance to sliding may be derived from passive resistance along the vertical face of the footings, and friction between the bottom of the footings and the bearing soil. An ultimate passive resistance using an equivalent fluid density of 350 pounds per cubic foot (pcf) may be used for the design. An ultimate coefficient of friction of 0.4 or 0.6 can be used for the sliding resistance between the bottom of the footings and native clay or structural fill, respectively. A factor of safety of 2.0 is recommended to calculate allowable values. We recommend the upper 2 feet of the soils to be neglected in the passive resistance unless the adjacent ground surface is paved.

6. Continuous (strip) footings should have a minimum width of 18 inches, and isolated spread footings should have a minimum width of 24 inches. Minimum edge to edge distance between adjacent foundations should not be less than the largest footing width.

7. We recommend that all old fill material, debris, organic material including topsoil, and loose or deleterious material be removed prior to establishing bearing grades.

Footings should be proportioned to reduce differential foundation movement. Proportioning on the basis of equal total movement is recommended; however, proportioning to relative constant dead load pressure will also reduce differential movement between adjacent footings. Total movement is estimated to be on the order of one (1) inch or less. Differential movement is anticipated to be on the order of ½ to ¾ of the estimated total movement. Footings and foundations should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

If unstable conditions are present at the time of foundation excavation it may be necessary to install a geotextile to reinforce the subgrade at the base of the excavation and facilitate structural fill placement. The geotextile should be selected in accordance with the intended application and should extend a minimum of two (2) feet laterally beyond all footing edges along with the structural fill.

Lab testing on soil samples resulted in a generally low to moderate collapse potential if soil becomes saturated. The performance of a shallow foundation system will be highly dependent upon proper drainage during and following construction. Ponding water, waterline leaks, and other sources of water near the structure foundation can result in an increase in the predicted movements including foundation distress and/or observed cracking.

Conversely, during construction the water content in the foundation soils must be maintained during dry weather to prevent excessive drying, which can also result in a greater amount of movement than predicted. Even with a properly designed and constructed foundation system, foundation movements can cause distress to the structure, such as cracks and misalignments of various components. Footings and foundations should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement.

Foundation excavations should be observed by Yeh. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

6.2 Deep Foundations

Deep foundations such as helical piles are an option for support of the hangar. The foundation elements are typically tied together in a rigid cap of reinforced concrete which may be the foundation footing or a grade beam. Typically, these systems are designed and installed by a specialty contractor working under a performance specification. Design and construction recommendations for helical piles are provided below.

6.2.1 Helical Pile Foundation

Some benefits of helical piles include relative ease of installation with no grouting and no cure time, reduced construction noise compared to drilling and no drill cuttings or wastewater that require management and disposal. Helical piles may be more cost effective and require less installation time compared to a deep foundation system requiring drilling and grout or concrete placement. Helical pile systems should be designed in accordance with the 2015 IBC and meet the acceptance criteria for helical pile systems and devices. General recommendations for design and construction of helical piles are presented below.

1. The structural engineer should determine helical pile locations and load requirements. This information should be provided to a specialty design/build contractor to develop drawings for the helical piles. Provided site grades are not raised by more than three (3) feet, we do not believe down drag would induce additional loading on the foundation. Foundation design need not account for downdrag loads when new fill heights are less than three (3) feet.

2. Since drilling refusal and a consistent, relatively thick cohesionless bearing stratum were not encountered within the borings, the anticipated depths of helical pile refusal are difficult to predict. Depending on the pile spacing, target depths for helical piles may range between 10 to 20 feet below existing grade based on information from borings B-1 and B-2. These pile lengths are estimates and actual lengths may exceed these values.

3. Onsite verification testing should be performed in accordance with specialty contractor recommendations. A representative of the geotechnical engineer, Yeh and Associates, should observe helical pile installation.

6.3 Floor Slab Design and Construction

Floor slabs for the structure should be supported on a minimum 6-inch layer of imported structural fill meeting the requirements of Table 3 or Colorado Department of Transportation (CDOT) Class 6 Aggregate Base Course (ABC) material. Some differential movement of a slab-on-grade floor system is possible should the subgrade soils become elevated in moisture content. To reduce potential slab movements, the subgrade soils should be prepared according to Section 10.1, Site and Subgrade Preparation. For structural design of concrete slabs-on-grade, a modulus of subgrade reaction of 150 pounds per cubic inch (pci) may be used for floors supported on 6 inches of non-expansive, gravel or imported structural fill compacted as described Section 10.6, Compaction Requirements.

Additional floor slab design and construction recommendations are as follows:

1. Positive separations and/or isolation joints should be provided between slabs and all foundations, columns or utility lines to allow independent movement.

2. Control joints should be provided in slabs to control the location and extent of cracking.

3. Interior trench backfill placed beneath slabs should be properly placed and compacted.

4. Floor slabs should not be constructed on frozen subgrade.

5. Other design and construction considerations, as outlined in Section 302.1 R-04 of the ACI Guide for Concrete Floor and Slab Construction are recommended.

7. PAVEMENT

Pavement design was outside our approved scope of services. The new pavement, at the entrance to the hangar, is anticipated to experience less loading than the existing taxiway which appears to be in good to excellent condition at the time of this report. We recommend the new pavement section match the existing Taxiway B4/Group II Taxilane section of 4.5 inches of asphalt concrete over 2 feet of aggregate base course.

8. CORROSIVITY

The concentrations of water-soluble sulfates measured in two samples obtained from the exploratory borings at depths of 2.0 to 4.5 feet and from 4.0 to 5.5 feet were 0.045 and 0.072 percent, respectively. Based on these laboratory test results, typical soils in the area present a Class 0 exposure rating based on a range of less than 0.10 percent as presented in the American Concrete Institute (ACI) Guide to Durable Concrete and corrosive soils are not anticipated at the project site. A qualified corrosion engineer should review this data to determine the appropriate level of corrosion protection.

9. RADON GAS

Radon gas can be found in nearly all rock and soil and can move into buildings or other enclosed spaces and create a health hazard if radioactive particles are inhaled. Evaluation of the radon gas potential was not within our authorized scope of service and should be addressed by others.

10. SITE GRADING AND CONSTRUCTION CONSIDERATIONS

Site preparation and earthwork operations should be performed in accordance with applicable codes, safety regulations, and other local, state, or federal guidelines. We recommend earthwork on the project be observed and evaluated by Yeh. The evaluation of earthwork should include observation and testing of engineered fills, subgrade preparation, foundation bearing materials and other geotechnical conditions exposed during the construction of the project. We also recommend that Yeh review the project grading plans to ensure they are in conformance with the recommendations presented herein.

10.1 Site and Subgrade Preparation

Preparation of the site should begin with stripping and removal of remaining topsoil, organic materials, and construction debris or unsuitable material. The stripped materials should be removed for offsite disposal in accordance with local laws and regulations or stockpiled. All exposed surfaces should be free of mounds and depressions, which could prevent uniform compaction.

Following the above, all exposed areas which will receive fill, support structures, or pavements, should be scarified to a minimum depth of 8 inches, moisture conditioned, and compacted according to Section 10.6, Compaction Requirements. Prior to placement of fill or structural elements, the condition of the exposed subgrade soil should be evaluated by observation of a proof roll. Proof rolling the subgrade aids in identifying soft or disturbed areas. Unsuitable areas identified by the proof rolling operation should be undercut and replaced with imported structural fill. Proof rolling may be accomplished through use of a fully loaded, pneumatic-tire dump truck or similar equipment providing an equivalent subgrade loading. Proof rolling should be performed under the observation of the geotechnical engineer using multiple passes in both directions to ensure complete coverage.

Following proof roll observations, suitable fill should be placed to the design grade as soon as practical to avoid moisture changes in the underlying soils. All structural fill soils should meet the requirements of Section 10.5, Engineered and Structural Fill Requirements, in this report and be placed and compacted in accordance with the criteria presented in Section 10.6, Compaction Requirements.

10.2 Undercutting and Subgrade Stabilization

Based on the subsurface conditions encountered in the borings, subgrade soils exposed during construction of the proposed structures will be moisture-sensitive and could become overly soft and unstable at higher moisture levels. If unstable conditions are encountered or develop during construction, stability may be improved by scarifying and drying/wetting the subgrade soils.

Clays may require 3 to 6 inches of crushed rock/gravel to provide a stable working surface. The amount of aggregate and type of stabilization required will be a function of the conditions encountered during construction. Over excavation of wet zones and replacement with structural fill or crushed rock may be necessary.

If areas are found to be unsuitable for re-work, additional stabilization will be required. If additional stabilization is required, Yeh should be contacted to evaluate the conditions in the field, and a suitable stabilization method can be provided. In addition, any soft and/or wet areas exposed during the excavation may need to be stabilized prior to the placement of new fill to create a stable, firm construction platform. A typical stabilization method may include utilizing crushed rock with the combination of geogrid (e.g., Tensar BX1200 or TX160) to create a stable base. Other stabilization methods may also be appropriate.

10.3 Excavation and Trench Construction

Excavations within the on-site geologic materials will encounter a variety of conditions, including sand, clay and organic material. Additionally, fill placed during previous grading operations may be encountered that was not present in our widely spaced borings. We anticipate these materials will be excavatable with conventional heavy-duty earth moving equipment. The excavation contractor is responsible for determining the means and method necessary to accomplish earthwork operations.

All excavations must comply with the applicable local, State, and Federal safety regulations, and with the excavation standards of the Occupational Safety and Health Administration (OSHA). Construction site safety, including excavation safety, is the sole responsibility of the Contractor as part of its overall responsibility for the means, methods, and sequencing of construction operations. Yeh's recommendations for excavation support is provided for the Client's sole use in planning the project, and in no way do they relieve the Contractor of its responsibility to construct, support, and maintain safe slopes. Under no circumstances should the following information be interpreted to mean that Yeh is assuming responsibility for either construction site safety or the Contractor's activities.

We believe the overburden soil encountered on this site will classify as a Type A material, using OSHA criteria. OSHA requires that unsupported cuts be no steeper than 0.75H:1V for Type A material for unbraced excavations up to 20 feet in height. Flattened slopes may be required if hazardous ground movement is observed, or the slopes will be exposed for an extended period of time. Please note that the Contractor's OSHA-qualified "competent person" must make the actual determination of soil type and allowable sloping in the field.

The soils encountered in the proposed excavations may vary significantly across the site. The preliminary classifications presented above are based solely on the materials encountered in widely spaced exploratory test borings. The contractor should verify that similar conditions exist throughout the proposed area of excavation. Note the above classifications presume a dry slope and that seepage encountered within temporary cut slopes will act to destabilize excavations.

As a safety measure, it is recommended that all vehicles and soil piles be kept to a lateral distance equal to at least the depth of the excavation from the crest of the slope. The exposed slope face should be protected against the elements and monitored by the contractor on at least a daily basis.

10.4 Dewatering/Shoring

Groundwater was not encountered in the borings at the time of drilling. If water is discovered at the time of construction, appropriate dewatering equipment/systems such as well points, sumps, and trenches, will be the responsibility of the contractor. In addition, trenching into unstable, saturated overburden soils will require temporary shoring, where construction of safe slopes is not feasible. OSHA requirements for excavation in unstable materials should be followed.

10.5 Engineered and Structural Fill Requirements

Based on our laboratory test results, the on-site soils should not be utilized as engineered fill placed directly beneath structural foundations due to the amount of fines present. On-site soils may be used as engineered fill to raise grade beneath floor slabs as necessary provided requirements of Section 6.3 are satisfied. Imported structural fill should consist of non-expansive, well-graded granular material meeting the criteria presented in Table 3. In addition, structural fill should be non-corrosive to concrete and metal.

Table 3 – Imported Structural Fill Criteria

Gradation Requirements	
Standard Sieve Size	**Percent Passing**
2-inch	100
No. 4	30 to 100
No. 50	10 to 60
No. 200	5 to 20
Plasticity Requirements (Atterberg Limits)	
Liquid Limit	35 maximum
Plasticity Index	6 maximum

We recommend that a qualified representative of Yeh visit the site during excavation and during placement of the structural fill to verify the soils exposed in the excavations are consistent with those encountered during our subsurface exploration and that proper foundation subgrade preparation and placement is performed.

All fill placed on this site should be compacted according to the recommendations in Section 10.6, Compaction Requirements, of this report. It is recommended that a sample of any imported fill material proposed for use on the project be submitted to our office for approval and testing at least three (3) days prior to stockpiling at the site.

10.6 Compaction Requirements

Fill materials should be placed in horizontal lift thicknesses that are suitable for the compaction equipment being used but in no case should exceed 8 inches by loose measure. Fill materials should be moisture conditioned and compacted in accordance with the criteria shown in Table 4.

Table 4 – Compaction Requirements

Fill Location	Material Type	Percent Compaction	Moisture Content
Subgrade	On-site clay, sand, silt	95 minimum (ASTM D698)	± 2 % of optimum
Foundation Areas, Paved Areas	Imported Structural Fill [1], Class 6 ABC	95 minimum (ASTM D1557)	± 2 % of optimum
Utility Trench Backfill (areas outside structural and paved areas)	Imported Structural Fill or on-site clay, sand, silt	90 minimum (ASTM D698)	± 2 % of optimum

[1]Material meeting the criteria in Section 10.5, Engineered and Structural Fill Requirements

10.7 Utility Trench Backfill

On-site soils may be utilized as backfill material in utility trenches provided the location is not beneath structures or pavement and the backfill is free of plant matter, organic soil, debris, trash, other deleterious matter, and rock particles larger than 3-inches. Backfill should be placed in loose lifts of 8-inches or less and compacted with appropriate trench compaction equipment.

Pipe bedding material should meet the requirements of the pipe manufacturer, project specifications and/or as recommended by the design civil engineer for the project. Imported granular fill, as described in Section 10.5, Engineered and Structural Fill Requirements could be considered for pipe bedding material. We suggest maximum aggregate size for drainage pipe bedding material should be limited to 1.5 inches for plastic pipe, with 2.0 inches acceptable for other types. Utility trench backfill should be compacted as recommended in Section 10.6, Compaction Requirements.

10.8 Cut and Fill Slopes

Permanent cut and fill slopes should be inclined no steeper than 2H:1V. Vegetation should be established on slopes as soon as possible to reduce the potential for erosion of the surface of cut/fill slopes.

10.9 Drainage Considerations

Positive drainage should be provided during construction and maintained throughout the life of the project. Proper design of drainage should include prevention of ponding water on or immediately adjacent to the hangar structure. We recommend the ground surface surrounding structures be sloped to drain away from the structures at a minimum and preferably covered with area paving to minimize water infiltration. Roof run-off should be directed away from building foundation systems. Surface features that could retain water in areas adjacent to the structures should be sealed or eliminated. Backfill against any kind of structure and in utility line trenches should be well compacted and free of construction debris to reduce the possibility of moisture infiltration and migration. Concentrated runoff should be avoided in areas susceptible to erosion and slope instability. Slopes and other stripped areas should be protected against erosion by re-vegetation or other methods.

10.10 Construction in Wet or Cold Weather

Engineered fill, structural fill, or other fill should not be placed on frosted or frozen ground, nor should frozen material be placed as fill. Frozen ground should be allowed to thaw or be completely removed prior to placement of fill. A good practice is to temporarily cover the compacted fill with a “blanket” of loose fill to help prevent the compacted fill from freezing.

Concrete structures should not be constructed on frozen soil. Frozen soil should be completely removed from beneath the concrete elements, or thawed, scarified and re-compacted. The amount of time passing between excavation or subgrade preparation and placing concrete should be minimized during freezing conditions to prevent the prepared soils from freezing. Blankets, soil cover, or heating as required may be utilized to prevent the subgrade from freezing.

11. LIMITATIONS

The findings and recommendations presented in this report are based upon data obtained from borings, field observations, laboratory testing, our understanding of proposed construction, and other sources of information referenced in this report. It is possible that subsurface conditions may vary between or beyond the locations explored. The nature and extent of such variations may not become evident until construction. If during construction conditions appear to be different from those described herein, Yeh should be advised and provided the opportunity to observe and evaluate those conditions and provide additional recommendations, as necessary. Yeh should also be contacted if the scope of construction changes from that generally described within this report. The conclusions and recommendations contained in this report shall not be considered valid unless Yeh reviews all proposed construction changes and either verifies or modifies the conclusions of this report in writing. Yeh should be contacted to perform general observations and materials testing services during construction. If another firm is contracted for these services, this firm will assume responsibility for following recommendations provided herein.

This report was prepared in a manner consistent with that level of care and skill ordinarily exercised by other members of our profession practicing in the same locality, under similar conditions and at the date the services are provided. Yeh makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

The scope of services for this project did not include, specifically or by implication, any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, or conditions or biological conditions. If the owner is concerned about the potential for such contamination, conditions or pollution, other studies should be undertaken and a professional in that field should be consulted.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than five (5) years from the date of the report.

12. REFERENCES

American Concrete Institute (ACI) 201.2R-08, 2008, Guide to Durable Concrete.

American Concrete Institute (ACI) 302.1R-04, 2004, Guide for Concrete Floor and Slab Construction.

Colorado Department of Transportation (CDOT), 2021, Standard Specifications for Road and Bridge Construction.

ICC Acceptance Criteria for Helical Pile Systems and Devices, Compliance date December 1, 2013.

International Code Council. International Building Code. Falls Church, Va. :International Code Council, 2015.

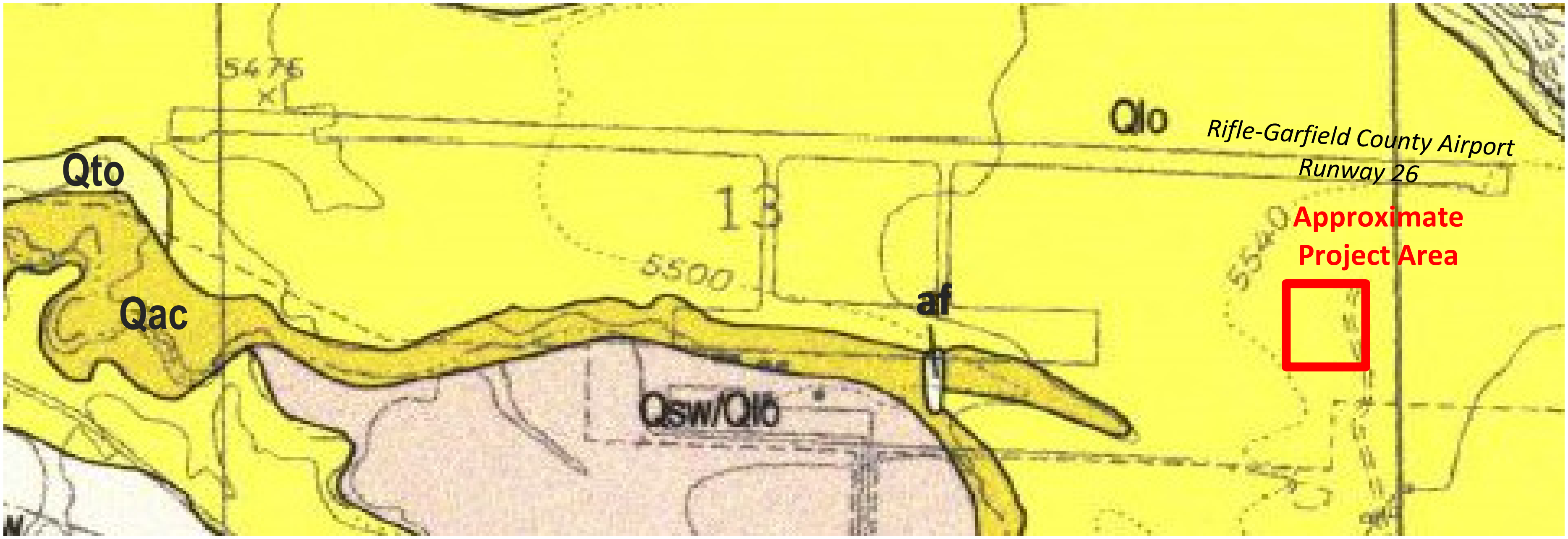
Shroba, R.R., and Scott, R.B., 2001, Geologic map of the Silt quadrangle, Garfield County, Colorado: U.S. Geological Survey, Miscellaneous Field Studies Map MF-2331, Version 1.0, scale 1:24,000.

Structural Engineers Association of California, US Seismic Design Maps Web Service, https://seismicmaps.org/, accessed on March 9, 2022.

APPENDICES

Appendix A

GEOLOGY MAP



Qac	Qlo	af	Qsw/Qlo	Qto
Alluviium and colluvium	Loess	Artificial fill	Sheetwash deposits over loess	Older terrace alluvium

North

Base map from Shroba, R. and Scott, R., 2001, Geologic map of the Silt quadrangle, Garfield County, Colorado

Date: 3/1/2022
File Name: Rifle-Garfield County Airport Hangar
Scale: Not to scale

Geologic Map - Approximate Project Location
Rifle Garfield County Airport Hangar Lot A-1
Rifle, Garfield County, Colorado

SHEET NUMBER: **A-1**

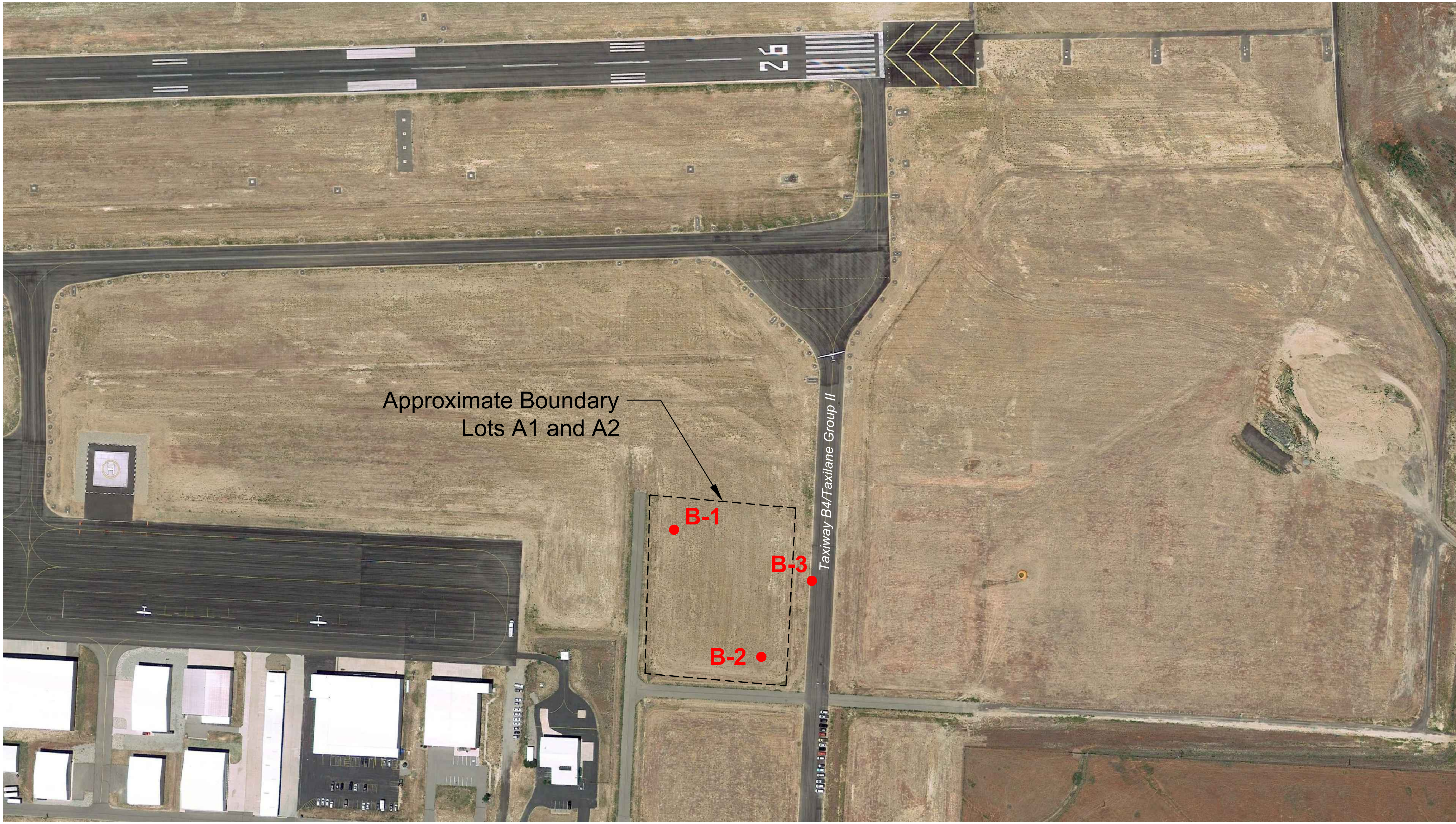
Yeh and Associates, Inc.
Geotechnical - Geological - Construction Services

Drawn by: SAW
Checked by: KD/SWR

Yeh and Associates
Project No. 222-084

Appendix B

BORING LOCATION MAP



LEGEND

B-1 ● Indicates approximate location of test borings

NOTES:
1. Base map from Google Earth.
2. Boring locations determined in field based on preliminary construction plan and accessibility
3. Approximate lot boundary based on preliminary information from client.

Yeh and Associates, Inc.
Geotechnical-Geological-Construction Services

DRAWN BY: SAW	DATE: 03/07/2022	PROJECT: Rifle-Garfield County Airport Hangar Lots A-1 and A-2 Garfield County, Colorado	FIGURE
CHECKED BY: KD/SWR	DATE: 03/07/2022		
DESIGNED FOR: Crisak Inc.		**Approximate Test Boring Location Map**	B-1
PROJECT NUMBER: 222-084			
SCALE: 1"=200'			

0 100' 200' 400'

Appendix C

BORING LOGS AND LEGEND

Legend for Symbols Used on Borehole Logs

Sample Types

- Modified California Sampler (2.5 inch OD, 2.0 inch ID)
- Standard Penetration Test (ASTM D1586)

Drilling Methods

- SOLID-STEM AUGER (4" OD)

Lithology Symbols

(see Boring Logs for complete descriptions)

- Asphalt
- FILL - Base material
- Topsoil
- CLAY (CL)
- CLAY, sandy (CL, CL-ML)
- SAND, clay (SC)

Lab Test Standards

Moisture Content	ASTM D2216
Dry Density	ASTM D7263
Sand/Fines Content	ASTM D421, ASTM C136, ASTM D1140
Atterberg Limits	ASTM D4318
AASHTO Class.	AASHTO M145, ASTM D3282
USCS Class.	ASTM D2487

(Fines = % Passing #200 Sieve
Sand = % Passing #4 Sieve, but not passing #200 Sieve)

Other Lab Test Abbreviations

pH	Soil pH (AASHTO T289-91)
S	Water-Soluble Sulfate Content (AASHTO T290-91, ASTM D4327)
Chl	Water-Soluble Chloride Content (AASHTO T291-91, ASTM D4327)
S/C	Swell/Collapse (ASTM D4546)
UCCS	Unconfined Compressive Strength (Soil - ASTM D2166, Rock - ASTM D7012)
R-Value	Resistance R-Value (ASTM D2844)
DS (C)	Direct Shear cohesion (ASTM D3080)
DS (phi)	Direct Shear friction angle (ASTM D3080)
Re	Electrical Resistivity (AASHTO T288-91)
PtL	Point Load Strength Index (ASTM D5731)

Notes

1. Visual classifications are in general accordance with ASTM D2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)".
2. "Penetration Resistance" on the Boring Logs refers to the uncorrected N value for SPT samples only, as per ASTM D1586. For samples obtained with a Modified California (MC) sampler, drive depth is 12 inches, and "Penetration Resistance" refers to the sum of all blows. Where blow counts were > 50 for the 3rd increment (SPT) or 2nd increment (MC), "Penetration Resistance" combines the last and 2nd-to-last blows and lengths; for other increments with > 50 blows, the blows for the last increment are reported.
3. The Modified California sampler used to obtain samples is a 2.5-inch OD, 2.0-inch ID (1.95-inch ID with liners), split-barrel sampler with internal liners, as per ASTM D3550. Sampler is driven with a 140-pound hammer, dropped 30 inches per blow.

Yeh and Associates, Inc.
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Project Name: Rifle-Garfield County Airport Hangar Lots A1 and A2

Project Number: 222-084 *Boring No.:* **B-1**

Boring Began: 2/24/2022
Boring Completed: 2/24/2022
Drilling Method(s): Solid-Stem Auger (4" OD)
Driller: HRL Compliance Solutions
Drill Rig: D-90
Hammer: Automatic (hydraulic), ER: %

Total Depth: 30.0 ft
Ground Elevation:
Coordinates:
Location: NW corner area of lot
Logged By: K. Dye
Final By: S. White

Weather Notes: Clear, 20F
Inclination from Horiz.: Vertical
Night Work: ☐

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Blows per 6 in	Penetration Resistance	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Liquid Limit	Plasticity Index	AASHTO & USCS Classifications	Field Notes and Other Lab Tests
	0.0			**0.0 - 0.5 ft.** (topsoil).									
	0.5			**0.5 - 5.0 ft. Sandy CLAY to Silty, sandy CLAY**, tan, low plasticity, dry to damp, stiff, calcareous, with organics.									
		5-6	11		4.9		3.0	39.0	58.0	24	8	A-4 (2) CL	S=0.045%
		7-9-1	10		4.9	88.0	3.0	44.0	53.0	21	4	A-4 (0) CL-ML	S/C=-3.1%
	5			**5.0 - 9.0 ft. Clayey SAND with gravel**, tan, low plasticity, dry to damp, dense.									**5.0 ft** - Noisier drilling between 5 and 6 feet.
		13-35	48		5.3		22.0	42.0	36.0	22	8	A-4 (0) SC	
		11-22-16	38										
	9	8-14	22	**9.0 - 10.0 ft. CLAY with sand**.	6.6	106.0	0.0	30.0	70.0				S/C=-1.7%
	10			**10.0 - 27.0 ft. Sandy CLAY**, tan, low plasticity, dry to damp, stiff to very stiff, calcareous, with organics, oxidized zones.									
	15	3-12-13	25		8.0		9.0	37.0	54.0	26	11	A-6 (3) CL	
	20	4-12	16										
	25	6-11-11	22										
	27			**27.0 - 30.0 ft. CLAY with sand**, red-brown, low plasticity, dry to damp, stiff.									
	30	6-8	14		11.9		0.0	20.0	80.0	24	10	A-4 (5) CL	

Bottom of Hole at 30.0 ft.

Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

Project Name: Rifle-Garfield County Airport Hangar Lots A1 and A2

Project Number: 222-084 *Boring No.:* **B-2**

Boring Began: 2/24/2022
Boring Completed: 2/24/2022
Drilling Method(s): Solid-Stem Auger (4" OD)

Total Depth: 25.5 ft
Ground Elevation:
Coordinates:
Location: SE corner area of lot

Weather Notes: Clear, 30F
Inclination from Horiz.: Vertical
Night Work: ☐

Driller: HRL Compliance Solutions
Drill Rig: D-90
Hammer: Automatic (hydraulic), ER: %

Logged By: K. Dye
Final By: S. White

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Soil Samples: Blows per 6 in	Soil Samples: Penetration Resistance	Material Description	Moisture Content (%)	Dry Density (pcf)	Gravel Content (%)	Sand Content (%)	Fines Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	AASHTO & USCS Classifications	Field Notes and Other Lab Tests
	0			**0.0 - 0.5 ft.** (topsoil).	*4.8*		*0.0*	*20.0*	80.0	*31*	*15*	*A-6 (10) CL*	R-Value=14
	1	11-19	30	**0.5 - 9.0 ft. Sandy CLAY**, tan, low to medium plasticity, dry to damp, very stiff, calcareous.	5.5	95.0	2.0	32.0	66.0	27	11	A-6 (5) CL	S/C=-2%
	5	7-7-9	16		4.9		3.0	30.0	67.0	27	12	A-6 (5) CL	S=0.072%
	10	5-14	19	**9.0 - 14.0 ft. CLAY with sand**, tan, medium plasticity, dry to damp, very stiff, calcareous.	6.3	106.0	0.0	24.0	76.0	28	16	A-6 (9) CL	S/C=-2%
	15	6-6-9	15	**14.0 - 23.0 ft. Sandy CLAY**, tan, medium plasticity, dry to damp, hard, calcareous, with oxidized zones.	7.4		1.0	42.0	57.0	29	15	A-6 (5) CL	
	20	14-17	31		4.9	112.0	2.0	30.0	68.0	30	18	A-6 (9) CL	
	25	1-3-10	13	**23.0 - 25.5 ft. CLAY with sand**, red-brown, low plasticity, dry to damp, stiff.	9.5		3.0	22.0	75.0	26	11	A-6 (6) CL	

Bottom of Hole at 25.5 ft.

Yeh and Associates, Inc. Geotechnical • Geological • Construction Services	*Project Name:* Rifle-Garfield County Airport Hangar Lots A1 and A2	*PAGE 1 of 1*
	Project Number: 222-084 *Boring No.:* **B-3**	

Boring Began: 2/24/2022
Boring Completed: 2/24/2022
Drilling Method(s): Solid-Stem Auger (4" OD)

Driller: HRL Compliance Solutions
Drill Rig: D-90
Hammer: Automatic (hydraulic), ER: %

Total Depth: 3.0 ft
Ground Elevation:
Coordinates:
Location: Pavement at east edge of lot

Logged By: K. Dye
Final By: S. White

Weather Notes:
Inclination from Horiz.: Vertical

Night Work: ☐

Groundwater Levels: Not Observed			
Symbol			
Depth	-	-	-
Date	-	-	-

Elevation (feet)	Depth (feet)	Sample Type/Depth	Drilling Method	Soil Samples: Blows per 6 in	Soil Samples: Penetration Resistance	Lithology	Material Description	Moisture Content (%)	Dry Density (pcf)	Fines Content (%)	Atterberg Limits: Liquid Limit	Atterberg Limits: Plasticity Index	AASHTO & USCS Classifi-cations	Field Notes and Other Lab Tests
							0.0 - 0.4 ft. 4.5 inches, (asphalt).							
						F F	**0.4 - 2.5 ft.** 24 inches, (Base).							
							2.5 - 3.0 ft. Sandy CLAY, tan, dry to damp.							
							Bottom of Hole at 3.0 ft.							

Appendix D

LABORATORY TEST RESULTS

YEH & ASSOCIATES, INC.

Summary of Laboratory Test Results

Project No: 222-084 Project Name: Rifle-Garfield County Airport Hangar Lots A1 and A2

Sample Location			Moisture Content (%)	Dry Density (pcf)	Gradation			Atterberg			Water Soluble Sulfate (%)	Swell (+)-Consolidation (-)		R-Value	AASHTO	USCS	Material Description
Test Boring	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI		%	psf				
B-1	2.0 to 4.5	Bulk-mixed samples	4.9		3	39	58	24	16	8	0.045				A-4 (2)	CL	CLAY, sandy
	3.0	MC	4.9	88	3	44	53	21	17	4		-3.1	1,000		A-4 (0)	CL-ML	CLAY, sandy, silty
	6.0 to 8.0	Bulk-mixed samples	5.3		22	42	36	22	14	8					A-4 (0)	SC	SAND, clayey with gravel
	9.0	MC	6.6	106	0	30	70					-1.7	1,000				CLAY, with sand
	14.0	SPT	8.0		9	37	54	26	15	11					A-6 (3)	CL	CLAY, sandy
	29.0	MC	11.9		0	20	80	24	14	10					A-4 (5)	CL	CLAY with sand

MC-Indicates Modified California sampler
SPT-Indicates standard split spoon sampler
Bulk-Indicates auger cuttings or mixed MC and SPT samples

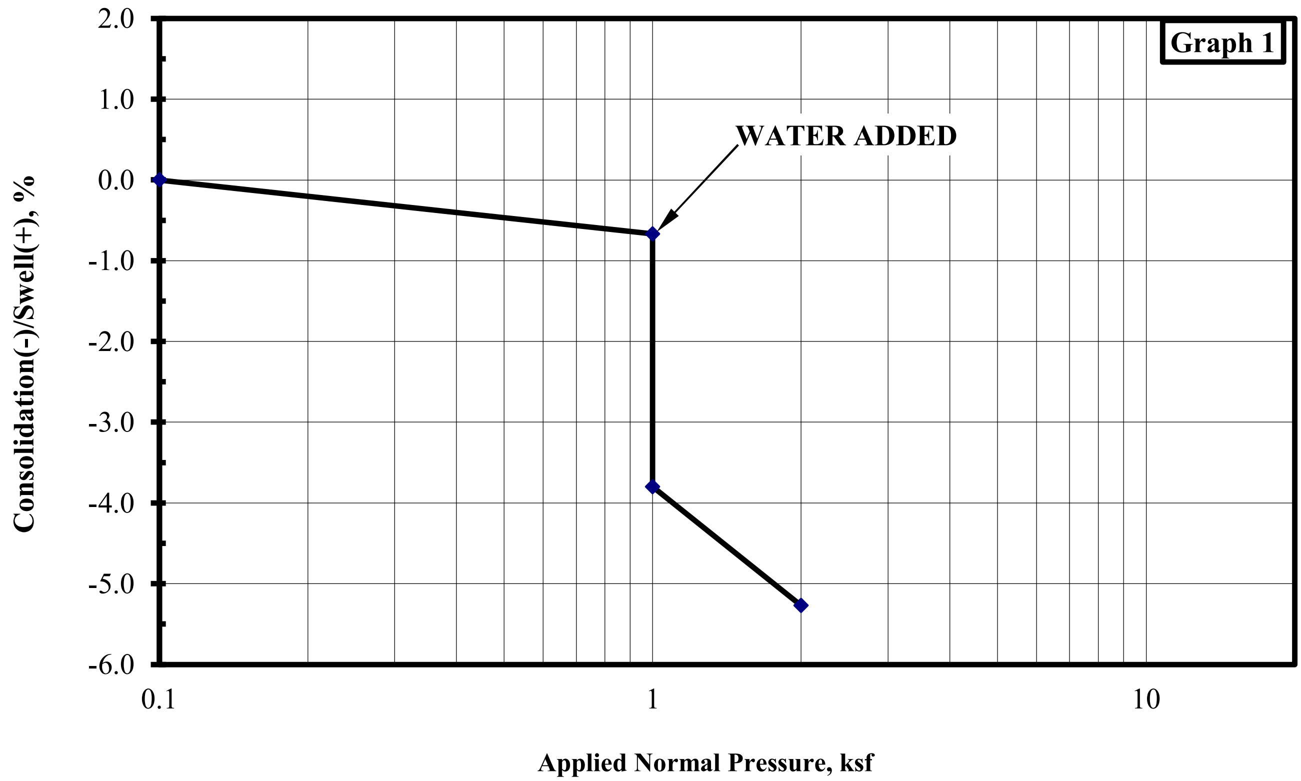
YEH & ASSOCIATES, INC.

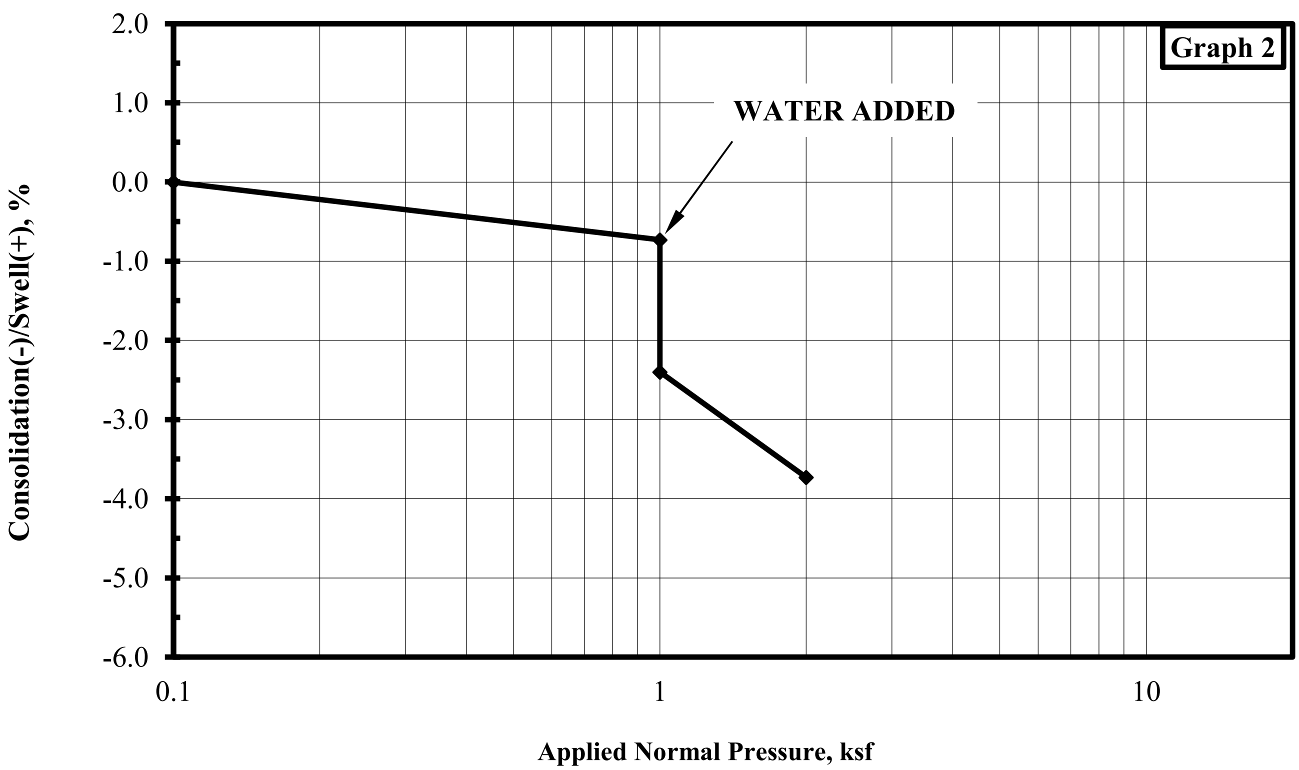
Summary of Laboratory Test Results

Project No: 222-084 Project Name: Rifle-Garfield County Airport Hangar Lots A1 and A2

Sample Location			Moisture Content (%)	Dry Density (pcf)	Gradation			Atterberg			Water Soluble Sulfate (%)	Swell (+)- Consolidation (-)		R-Value	AASHTO	USCS	Material Description
Test Boring	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PL	PI		%	psf				
B-2	0.5 to 5	Bulk	4.8		0	20	80	31	16	15				14	A-6 (10)	CL	CLAY with sand
	1.0	MC	5.2	95	2	32	66	27	16	11		-2.0	1,000		A-6 (5)	CL	CLAY, sandy
	4.0	SPT	4.9		3	30	67	27	15	12	0.072				A-6 (5)	CL	CLAY, sandy
	9.0	MC	6.3	106	0	24	76	28	12	16		-2.0	1,000		A-6 (9)	CL	CLAY with sand
	14.0	SPT	7.4		1	42	57	29	14	15					A-6 (5)	CL	CLAY, sandy
	19.0	MC	4.9	112	2	30	68	30	12	18					A-6 (9)	CL	CLAY, sandy
	24.0	SPT	9.5		3	22	75	26	15	11					A-6 (6)	CL	CLAY with sand

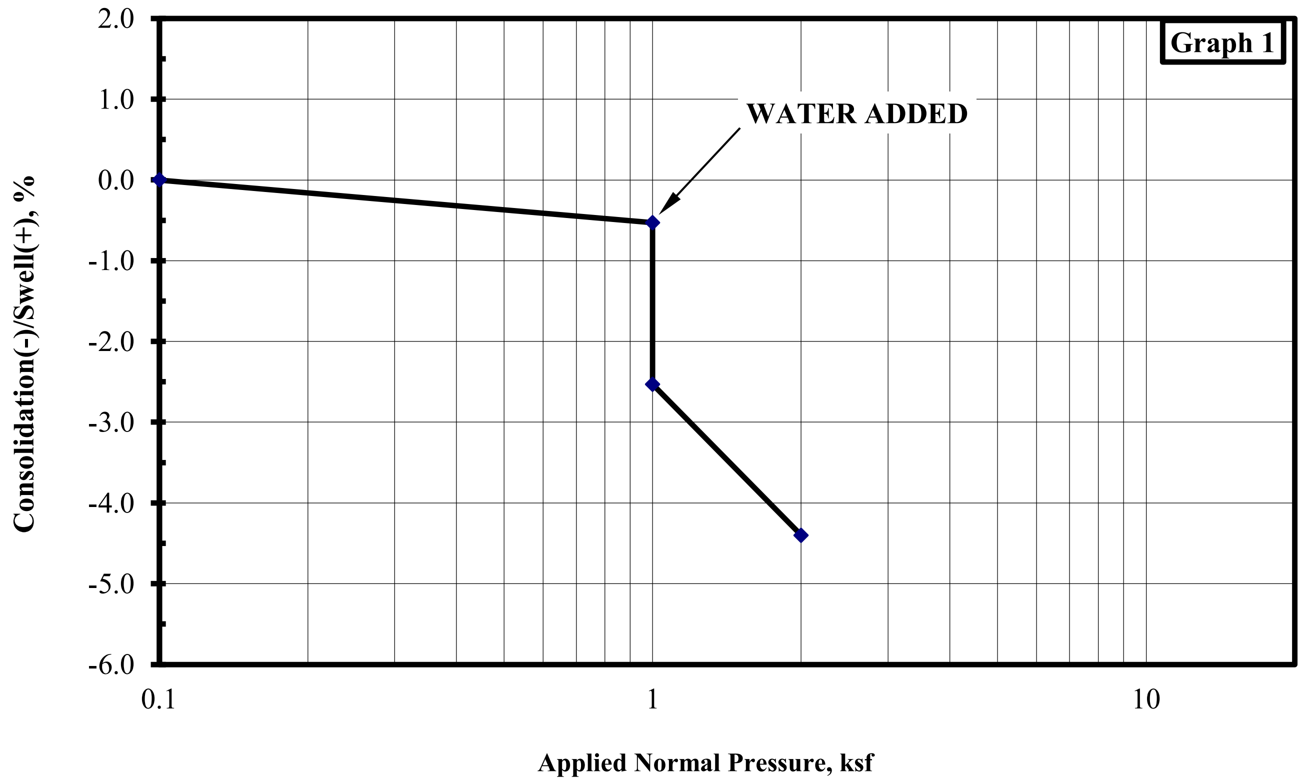
MC-Indicates Modified California sampler
SPT-Indicates standard split spoon sampler
Bulk-Indicates auger cuttings or mixed MC and SPT samples

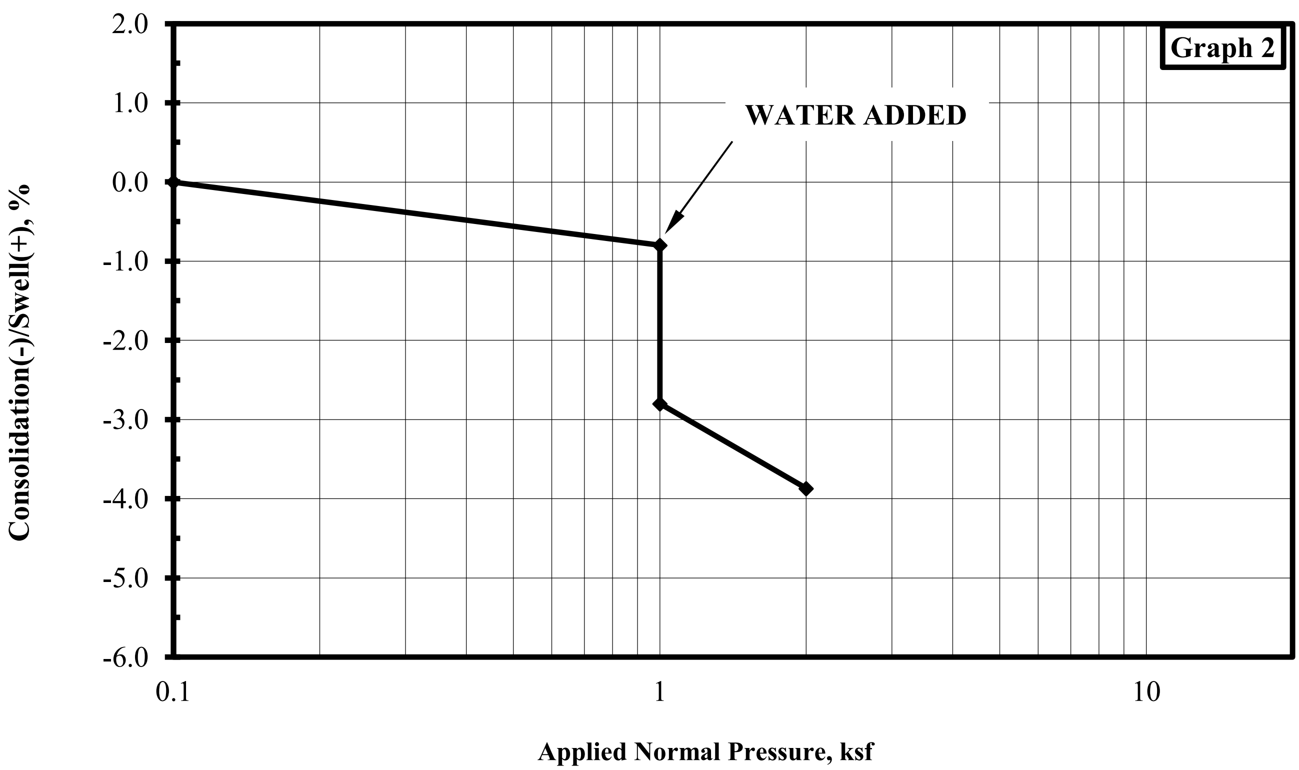




Graph Number	Boring Number	Depth (ft)	Natural Dry Density (pcf)	Moisture Content (%)	Swell(+) / Consolidation(-) (%)	Soil Description	SWELL / CONSOLIDATION GRAPH	
1	B-1	3.0	88	4.9	-3.1	CLAY, sandy, silty (CL-ML)	Drawn By:	LVK
2	B-1	9.0	106	6.6	-1.7	CLAY, with sand	Checked By:	SW/KD
Job No:	222-084	**Project Name:**	Rifle-Garfield County Airport Hangar Lots A1 and A2				Figure No. D-1	

YEH & ASSOCIATES, INC.



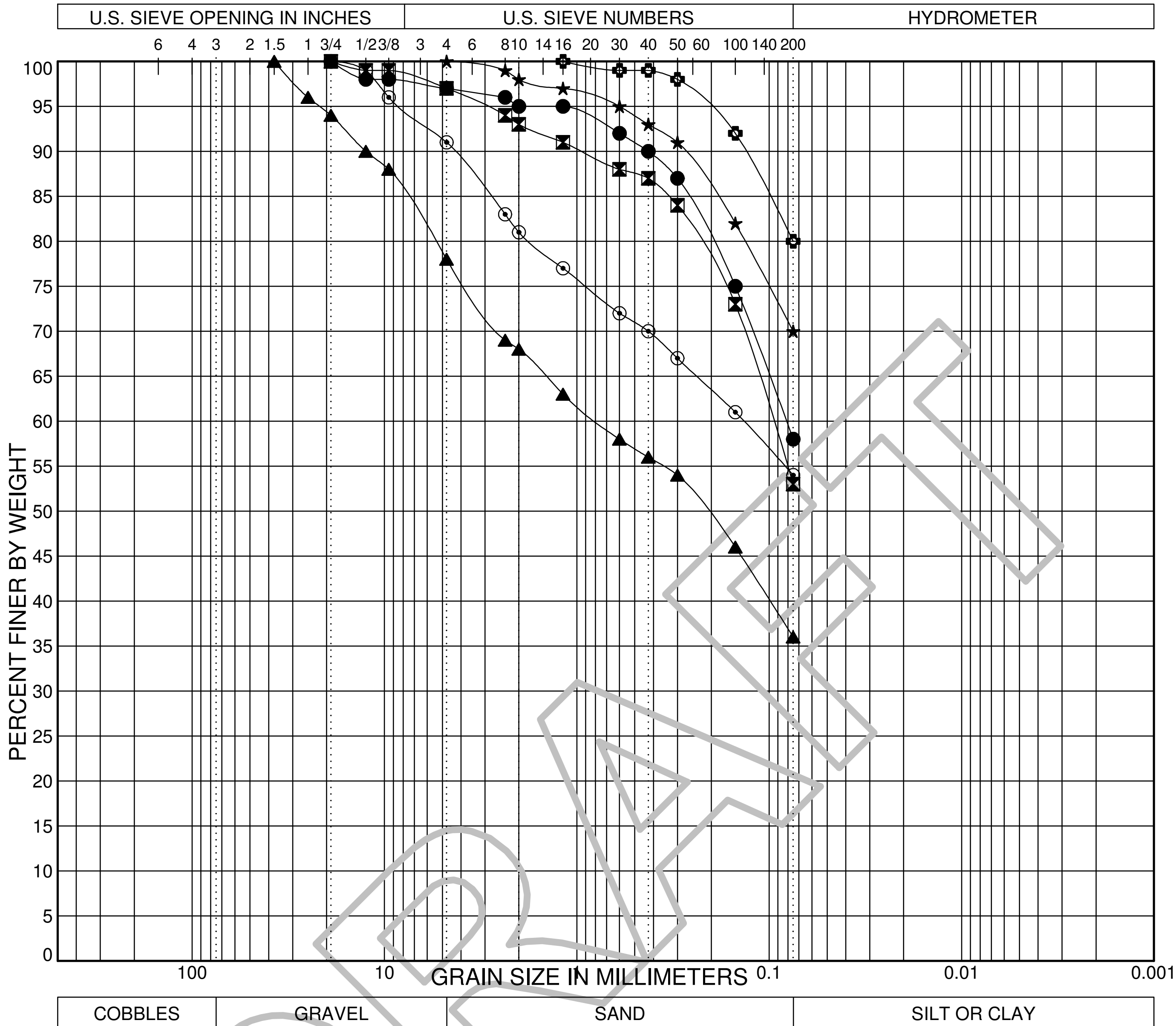


Graph Number	Boring Number	Depth (ft)	Natural Dry Density (pcf)	Moisture Content (%)	Swell(+) / Consolidation(-) (%)	Soil Description	SWELL / CONSOLIDATION GRAPH
1	B-2	1.0	97	5.2	-2.0	CLAY, sandy (CL)	Drawn By: LVK
2	B-2	9.0	106	6.3	-2.0	CLAY with sand (CL)	Checked By: SW/KD

Job No:	222-084	**Project Name:**	Rifle-Garfield County Airport Hangar Lots A1 and A2

Figure No. D-2

YEH & ASSOCIATES, INC.



	BOREHOLE	DEPTH (ft)	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines	
										%Silt	%Clay
●	B-1	2.0	A-4 (2)	CL	24	16	8	3.0	39.0	58.0	
⧗	B-1	3.0	A-4 (0)	CL-ML	21	17	4	3.0	44.0	53.0	
▲	B-1	6.0	A-4 (0)	SC	22	14	8	22.0	42.0	36.0	
★	B-1	9.0						0.0	30.0	70.0	
⊙	B-1	14.0	A-6 (3)	CL	26	15	11	9.0	37.0	54.0	
✪	B-1	29.0	A-4 (5)	CL	24	14	10	0.0	20.0	80.0	

Yeh and Associates, Inc.
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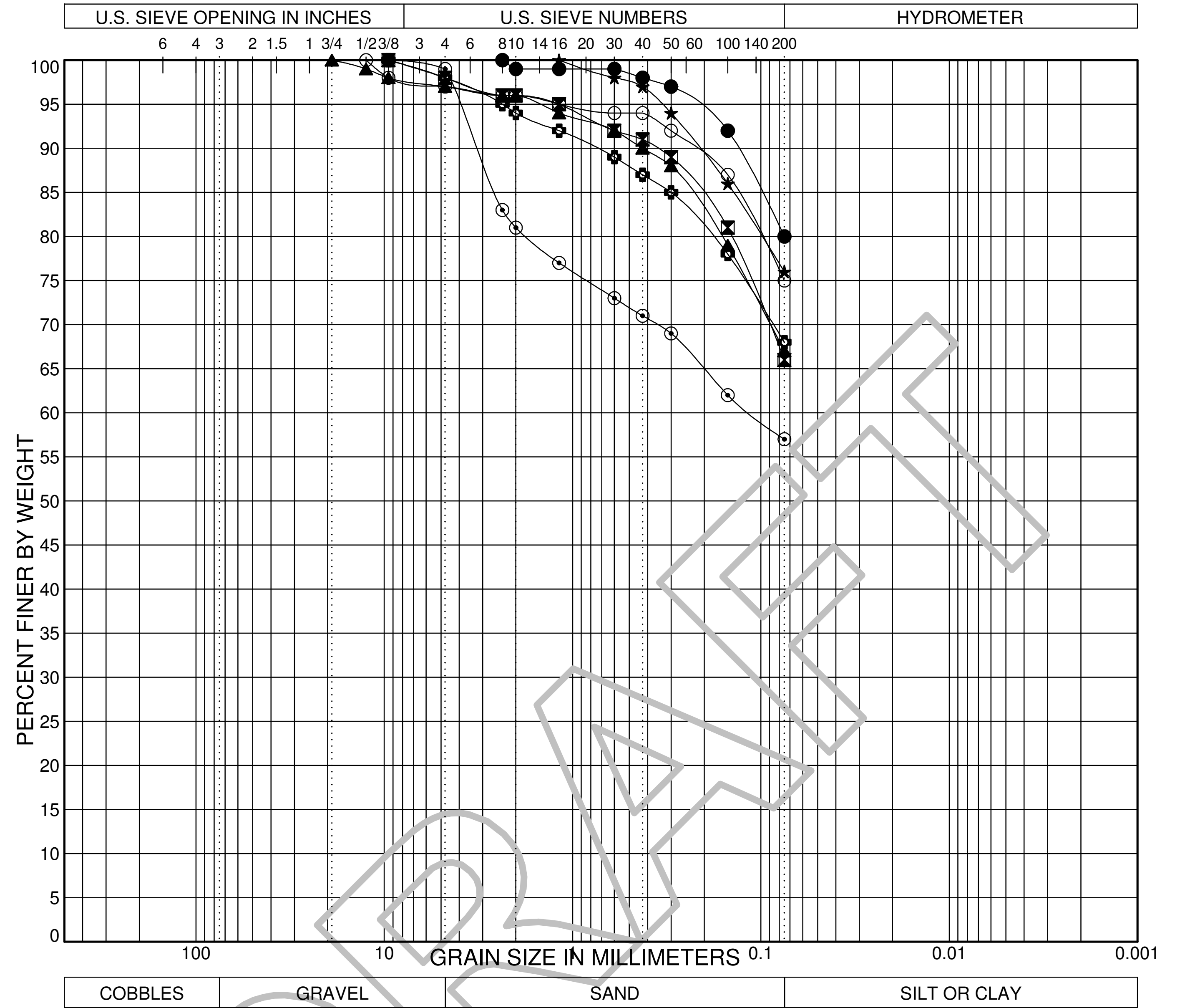
SIEVE ANALYSIS

Project No. 222-084 Date: 03-09-2022
Report By: Yeh Lab:
Checked By:

Rifle-Garfield County Airport Hangar
Lots A1 and A2

Figure
D-3

04 GRAIN SIZE YEH 10 SAMPLES 222-084 RIFLE AIRPORT HANGAR.GPJ 2021 YEH COLORADO TEMPLATE.GDT 2021 YEH COLORADO LIBRARY.GLB 3/9/22



	BOREHOLE	DEPTH (ft)	AASHTO Classification	USCS Classification	LL	PL	PI	%Gravel	%Sand	%Fines (%Silt / %Clay)
●	B-2	0.5	A-6 (10)	CL	31	16	15	0.0	20.0	80.0
⧗	B-2	1.0	A-6 (5)	CL	27	16	11	2.0	32.0	66.0
▲	B-2	4.0	A-6 (5)	CL	27	15	12	3.0	30.0	67.0
★	B-2	9.0	A-6 (9)	CL	28	12	16	0.0	24.0	76.0
⊙	B-2	14.0	A-6 (5)	CL	29	14	15	1.0	42.0	57.0
✿	B-2	19.0	A-6 (9)	CL	30	12	18	2.0	30.0	68.0
○	B-2	24.0	A-6 (6)	CL	26	15	11	3.0	22.0	75.0

Yeh and Associates, Inc.
Geotechnical • Geological • Construction Services

SIEVE ANALYSIS

Project No. 222-084 Date: 03-09-2022
Report By: Yeh Lab:
Checked By:

Rifle-Garfield County Airport Hangar
Lots A1 and A2

Figure
D-4