VIVID Engineering Group, Inc.

1053 Elkton Drive, Colorado Springs, CO 80907

June 4, 2024

Steven Jones, PE
Dewberry
990 South Broadway, Suite 400
Denver, Colorado 80209-4275
sjones@Dewberry.com

Subject: Geologic Hazards Evaluation
Project: Proposed Colorado Springs Utilities Skyway Pump Station Site
Location: Parcel #6506300005, Southwest Corner of Star Ranch Road and Broadmoor Valley Road, Colorado Springs, Colorado
Project No: D24-2-754

Dear Mr. Jones:

Vivid Engineering Group, Inc. (VIVID) has completed a geologic hazards evaluation in general accordance with the City of Colorado Springs Engineering Criteria Manual for the proposed Colorado Springs Utilities Water Pump Station site located at the southwest corner of Star Ranch Road and Broadmoor Valley Road in Colorado Springs, Colorado.

1.0 GENERAL PROJECT INFORMATION

We understand the proposed project consists of the construction of a new single-story water pump station building on a vacant 14,255-square-foot parcel (parcel I.D. #6506300005) at the southwest corner of Star Ranch Road and Broadmoor Valley Road in Colorado Springs, Colorado. Figure 1 (Vicinity Map) illustrates the site location in relation to the existing features.

The proposed water pump station building is planned to house pumps and electrical equipment and is planned to be founded on a shallow reinforced concrete mat foundation or shallow spread footings. No below-grade construction (other than adjacent pipe and flexible connections) is anticipated to be included as part of this project. A small retaining wall with a planned height of approximately 2 feet is planned on the west side of the site.

Final grading plans were still being prepared when this report was completed; however, we estimate general site grading will be limited to providing proper drainage away from the site improvements and preparing the foundation subgrade for the pump station. No structural loads were provided at the time this report was written.

The project site is currently zoned as R-5 HS (multi-family high) and is located within the hillside overlay zone as described in the Colorado Springs Hillside Overlay Zone Map. We anticipate that the zoning of this parcel will change to accommodate the proposed pump station structure. Colorado Springs Utilities has existing waterlines and large vault on the project site.

1.1 QUALIFICATIONS OF PREPARERS

This report has been prepared by William J. Barreire, who is a licensed Professional Engineer in the State of Colorado, and Brysen T. Mustain, who is a Professional Geologist as defined by Colorado Revised Statutes section 34-1-201(3).

2.0 STUDY OVERVIEW

The purpose of this evaluation was to research the general and site-specific geologic conditions of the subject site as well as observe the conditions at the site. The information gathered was used to analyze, evaluate, and identify geologic hazards at the site and assess the possible effect the hazards may have on the proposed development of the site. This investigation has been performed in general accordance with the Geological Hazard Study and Mitigation guidelines (Section 3.0) of the City of Colorado Springs Engineering Criteria Manual, dated July 1, 2010, and in general accordance with Section 7.4.5 of the City of Colorado Springs Code.

VIVID's evaluation of the subject site included a site visit, review of available documents, historic aerial photographs, and performing exploratory geotechnical borings as part of the Geotechnical Evaluation performed for this site, dated May 6, 2024. The geotechnical evaluation was focused on the planned location of the pump station building within the subject parcel.

The following geotechnical and geologic reports and maps were reviewed during this evaluation and the findings, conclusions and recommendations contained in these reports and maps were considered during this evaluation:

- *Geotechnical Evaluation Report, Proposed Skyway Pump Station & Holly Valve, Vicinity of Star Ranch Road and Broadmoor Valley Road, Vicinity of Holly Avenue and 1st Street, Colorado Springs, Colorado, VIVID Project No. D23-2-702, dated 5/6/2024.*
- *Regency Drive Landslide, White, J.L., Noe, D.C., Colorado Geological Survey, dated 4/4/2000.*
- *Geologic Map of the Colorado Springs Quadrangle, El Paso County, Colorado (Carroll, C.J., and Crawford, T.A.), Colorado Geological Survey Open-File Report OF-00-3, scale 1:24,000.*
- *Map of Areas Susceptible to Differential Heave in Expansive, Steeply Dipping Bedrock, City of Colorado Springs, Colorado, Himmelreich, Jr. J.W. and Noe, David C., 1999.*
- *Flood Insurance Rate Map, El Paso County, Colorado and Unincorporated Areas, Community Panel No. 08041C0739G, Federal Emergency Management Agency (FEMA), December 7, 2018.*

The proposed pump station site is planned to be located on the southwest corner of the intersection of Star Ranch Road and Broadmoor Valley Road. Oher than existing waterlines and an existing vault owned by Colorado Springs Utilities, the site was vacant but surrounded by existing residential development. The ground surface slopes gently down toward the north and northeast and is covered in arid grasses/weeds, cactus, and occasional trees/bushes. The approximate difference in elevation across the site was estimated at about 10 feet or less based on published topographic mapping.

The site is located on the Cheyenne Mountain Front which has various mapped dormant and inactive landslide deposits and is located approximately 1.5-miles east of the Ute Pass Fault zone. According to the Colorado Geological Survey (CGS), the faults within this zone are not considered to be active.

The project site also lies within an area that contains expansive soil and bedrock. No exposures of bedrock, groundwater seeps/areas of seepage, or areas of standing surficial water were observed on the site. Recent landslide movement has occurred southwest of the site on adjacent parcels, with a visible head scarp present within the hillside east of Regency Drive. The toe of this recent slide is visible approximately 500 feet west of the site.

3.0 SITE EVALUATION TECHNIQUES

Surface and subsurface conditions at the project site were evaluated using the following techniques:

Review of Geologic Maps

The primary geologic map used to review the site was the Geologic Map of the Colorado Springs Quadrangle, El Paso County, Colorado (Carroll, C.J., and Crawford, T.A.: Colorado Geological Survey Open-File Report OF-00-3, scale 1:24,000), a portion of which is presented on Figure 2.2. According to the mapping, Quaternary-aged colluvium (Qc) and landslide deposits (Qls) comprised of sand, gravel, and clay, underlain by sedimentary bedrock of the Cretaceous-aged Pierre Shale Formation (Kp) is present at the site. The mapping is generally consistent with the subsurface conditions encountered in the geotechnical borings performed by VIVID on this site. More recent landslide deposits (Qlsr) and associated geomorphic features related to the 1995 Regency Drive landslide event were observed immediately west and southwest of the parcel.

Review of Historic Aerial Photographs

The aerial photographs used to review the past and present conditions of the subject site included aerial photos dating from 1999, and 2011 through 2023. The aerial photographs were used to evaluate the presence of previously demolished structures (if any), the condition of the project site and adjacent parcels, and the existence of any man-made fill. Aerial photos indicate that little to no change in site conditions has occurred since 1999.

Topographic Information

The topographic map used to review the site was the USGS US Topo 7.5-minute map for Colorado Springs, Colorado, 2023, scale 1:24,000. Mapping at this scale indicates that the subject parcel slopes gently downward to the north and northeast.

Geotechnical Exploration and Engineering Analysis

A site-specific Geotechnical Evaluation was performed for the subject site by VIVID under project number D23-2-702, dated May 6, 2024, and is provided under separate cover.

The geotechnical evaluation included a total of four exploratory borings. On January 4, 2024, three borings were advanced within the planned footprint of the pump station building with a CME-45 truck-mounted drill rig to a maximum depth of about 29.5 feet below the ground surface. Drive samples were generally taken at approximate 2.5- to 5-foot intervals, or at changes in soil type. A 140-pound hammer falling 30 inches was used to record blow counts, or the relative density of the soil encountered.

In order to regularly monitor for slope movements within the subject parcel, on December 7, 2023, an inclinometer was installed with a CME-750 buggy-mounted drill rig on the western edge of the parcel to a depth of approximately 80 feet below the ground surface. Continuous dry-core sampling was conducted between the ground surface and approximately 30 feet below the ground surface, followed by HQ wireline rock coring until the inclinometer borehole termination depth of approximately 80 feet below the ground surface. VIVID is currently performing monthly monitoring of this inclinometer for a duration of 12 months after installation. It should be noted that inclinometer monitoring can take several months to a year to verify if there is existing movement, depending on the rate of slope movement, if any. To date, no discernable movement has been detected in the inclinometer.

The approximate locations of these exploratory borings and inclinometer are shown on Figures 2.1 and 2.2 of this report. The logs of the exploratory borings and inclinometer readings obtained to date are included in Attachment A of this study.

Select soil and bedrock samples collected were tested for their relevant engineering characteristics, as related to the proposed site development.

- Description and Identification of Soils (Visual-Manual Procedure)
- Classification of Soils for Engineering Purposes
- Moisture Content and Unit Weight
- Sieve Analysis
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- Swell-Settlement Testing
- Unconfined Compressive Strength Testing

Results of the geotechnical laboratory tests are presented in Attachment B of this report. Selected test results are also shown on the boring logs in Attachment A.

4.0 GEOLOGIC DESCRIPTION

Bedrock

Based on geologic mapping and VIVID's Geotechnical Evaluation report, the bedrock underlying the project site consists of Cretaceous-aged, weathered claystone, claystone and shale of the Pierre Shale Formation. The Pierre Shale Formation in this location typically consists of a silty to sandy claystone and shale. Thin beds of bentonite are not uncommon in this unit and were encountered in the inclinometer boring at the locations and approximate depths indicated on the boring log in Attachment A. It is our experience that claystone and shale bedrock of the Pierre Shale Formation can exhibit low to very high expansion potential when subjected to water and can also be subject to slope instability under certain conditions. Weathered claystone was encountered in borings B-2, B-3, and INC-1 at approximate depths of 12, 15 and 19.5 feet below the ground surface, respectively, and extended to depths between approximately 19.5 and 29 feet below the ground surface. Relatively unweathered claystone was encountered at depths between approximately 19 and 28 feet below the existing ground surface. The top of the formational shale bedrock was located at depths between approximately 24.5 and 29 feet below the existing ground surface and extended to the maximum depth explored in each boring. The shale bedrock encountered was hard to very hard, slightly moist, and gray to dark gray in color.

Regionally, the Pierre Shale Formation has been known to fail, in regard to slope stability, where present on steep to moderate slopes, and it has been documented that failures within the Pierre Shale have occurred where present on slopes of less than 10 degrees. Overlying coarse soils can allow groundwater to pass through to the underlying Pierre Shale Formation, destabilizing it through means of increased pore-water pressure, increased weight, decreased shear strength, and lubricated slip planes. The Pierre Shale Formation has exhibited rotational and translational landslides and earthflows. Translational slides have been known to slip along thin shear zones.

It is important to note that the influence of such shear zones on stability is primarily controlled by topography and bedding dip and direction. Based on geologic mapping of the site, the Pierre Shale has exhibited a dip of 13 degrees down towards the northeast. Since this site is located on the Cheyenne Mountain Front that has various mapped dormant and active landslide deposits (including those deposits mapped on (dormant) and adjacent (active) to this subject parcel) and due to existing site and surrounding topography, unstable slopes associated with the Pierre Shale are a concern on this site.

Surficial Deposits

Quaternary-aged colluvium and landslide deposit materials were encountered at the ground surface of each boring location and consisted of a thin layer of silty sand with occasional gravel and cobbles at the ground surface, extending to depths of between 2.5 and 3 feet below the existing ground surface. The sand was medium brown in color and slightly moist to moist. Lean to fat clay with variable amounts of sand was encountered below the sand soils described above. The clay soils were light to medium brown, reddish-brown, olive-brown, and gray in color, moist, and very stiff to hard based on field penetration testing. Swell testing was performed on three samples of the clay which exhibited measured swells of between 1.5 and 5.7 percent when wetted under 500 or 1,000 pounds per square foot (psf) surcharge pressure. This indicates that a low to high risk of damage to foundations and floor slabs exists without some type of mitigation.

Geomorphic Features

No geomorphic features of note were observed, specifically on the subject parcel. There are no current obvious surface features that indicate landslide movement is or has "recently" occurred on this particular project site. Such observations would generally include surface shears, cracks, scarps in the soil or in the immediate adjacent roads. However, distinct landslide-related geomorphic features related to the 1995 Regency Drive landslide event were observed immediately west and northwest of the subject parcel. Features observed included an obvious headscarp above Regency Drive, uneven/hummocky terrain extending downhill to the north/northeast towards Broadmoor Valley Road, and an obvious landslide toe feature directly above Broadmoor Valley Road.

Structural Features

No structural features of note were observed on this site.

Surface Drainage

The ground surface generally comprises arid grasses/weeds, cactus, and occasional trees/bushes. Surface topography and overall drainage follows a slight slope downward towards the northeast. Storm sewer inlets are present adjacent the site within Broadmoor Valley Road and Star Ranch Road. It also appeared that surface water drainage features have been graded into the vacant parcel located to the west of the subject parcel, presumably sometime prior to 1999. According to published FEMA floodplain mapping, the site does not lie within any potential flood areas.

Groundwater

Groundwater was not encountered in any of the geotechnical evaluation borings at the time of drilling or when measured one day after the completion of drilling. Soil moisture levels and groundwater levels commonly vary over time and space depending on seasonal precipitation, irrigation practices, land use, and runoff conditions. These conditions and the variations that they create often are not apparent at the time of field investigation. Accordingly, the soil moisture and groundwater data in this report pertain only to the locations and times at which exploration was performed. They can be extrapolated to other locations and times only with caution. It should also be noted that VIVID has not performed a hydrologic study to verify the seasonal high-water level.

5.0 GEOLOGIC INTERPRETATION

In general accordance with the City of Colorado Springs Geologic Hazard Evaluation Specification and City Code 7.4.5, we have evaluated the following potential geologic hazards and engineering constraints for the subject site:

1) Landslide Areas or Potential Landslide Areas
2) Unstable or Potentially Unstable Slopes

3) Expansive Soils and Expansive Bedrock
4) Steeply Dipping Bedrock
5) Erosive Soils
6) Settlement-Prone Soils
7) Corrosive Soils
8) Radioactivity
9) Seismicity

These potential geologic hazards and engineering constraints are discussed in more detail below.

Landslide Areas or Potential Landslide Areas

As mentioned above, the subject parcel is located entirely within a large, mapped landslide deposit that encompasses a much larger area (hundreds of acres) than this subject parcel. According to geologic mapping, the landslide deposit is considered a slowly creeping landslide to long-inactive landslide. However, smaller localized recent landslide deposits with fresh morphological features are both mapped and apparent directly adjacent the subject site. This more recent (1995) active landslide activity occurred west (uphill) of this site (i.e., Regency Drive Landslide). This slide is located between 500 to 1,000 feet away from this project site. It does not appear that the more recent 1995 landslide impacted the subject parcel.

Unstable or Potentially Unstable Slopes

No unstable or potentially unstable slopes were observed on the subject site. Construction plans for the pump station building and infrastructure should include considerations for the foundation over-excavation and final grading that do not impact slope stability of soils and bedrock on the site. Surface drainage should be designed so that surface water will flow away from the pump station and other improvements as rapidly as possible and not be allowed to stand or pond.

Expansive Soils and Expansive Bedrock

The near-surface clay soils encountered on this site were found to have low to high expansion potential. In addition, our experience indicates that the claystone of the Pierre Shale Formation has a low to high shrink-swell potential and heaving bedrock problems due to the presence of smectitic claystone and bentonite beds. Mitigation for this potential hazard on the subject site includes over-excavation of at least 6 feet of clay soils from below foundations, and replacement with a combination of moisture treated clay and imported granular structural fill. This mitigation method is addressed in more detail in the site-specific Geotechnical Evaluation Report for the project.

Steeply-Dipping Bedrock

The site is located outside of the mapped Steeply-Dipping Bedrock area.

Erosive Soils

Soils with a sandy matrix, such as the surficial silty sands with gravel encountered at the ground surface on the site, are susceptible to erosion in deep or steep excavations. Erosion concerns are normally addressed in an erosion control plan provided by others. Since we understand the majority of the site will have either a building constructed on it or will be paved and/or landscaped, the potential for erosion will be mitigated by these improvements. This is addressed in more detail in VIVID's site-specific Geotechnical Evaluation Report for the project and will be part of the construction plans and specifications for the project.

Settlement-Prone Soils

The site soils are not considered settlement-prone. However, the overburden clay soils will likely undergo some settlement if heavily loaded and or wetted. Mitigation for this potential hazard includes over-excavation of at least 6 feet of clay soils from below foundations and replacement with a combination of moisture treated clay and imported granular structural fill. This mitigation method is addressed in more detail in the site-specific Geotechnical Evaluation Report for the project.

Corrosive Soils

The site is underlain by clay soils and claystone bedrock that contain corrosive minerals. Corrosive minerals can have detrimental effects on concrete and buried metals if not identified prior to design and properly mitigated. Laboratory testing was completed to provide data regarding corrosivity of onsite soils. Our scope of services does not include corrosion engineering and, therefore, a detailed analysis of the corrosion test results is not included. A qualified corrosion engineer should be retained to review the test results and design protective systems that may be required. The potential for corrosive minerals affecting metals and concrete is addressed in the site-specific Geotechnical Evaluation Report.

Elevated Radioactivity/Radon

Results of an EPA supported radon study in Colorado found that soils similar to those that underlie this site are generally below the EPA guideline level of 4 pCi/l. However, radon levels often vary significantly within the same geologic formation. It should be mentioned that all of El Paso County is considered to be in Zone 1 of the EPA's Map of Radon Zones, which is a county considered to have a predicted average indoor radon screening level greater than 4 pCi/L. This is a more significant issue for inhabited below grade construction and structures that are more air tight such as residential structures. Therefore, we do not anticipate specific mitigation will be required for this project.

Seismicity

Seismicity is not anticipated to be a significant design factor for this site and is addressed in the site-specific Geotechnical Evaluation Report.

6.0 THE BEARING OF GEOLOGIC FACTORS UPON THE INTENDED LAND USE AND CONCLUSIONS & RECOMMENDATIONS

We understand there is a significant need for a water pump station to be located on this site to serve customers of Colorado Springs Utilities. While avoidance of the construction as planned is the only way to eliminate the risk of movement and damage due to potential landslide reactivation, based on conversations with Colorado Springs Utilities we understand that is not currently a viable option. Therefore, moving forward with the planned type and location of construction with mitigation measures is desired.

Based on our evaluation, soil explorations, observations, and desktop review, we believe the site in its current condition can be used for construction of the pump station as planned with the understanding there is inherent risk of slide re-activation and facility damage on this site. There are no current surface observations, nor inclinometer results that show obvious indication of recent movement/distress typical for an active landslide. However, mitigation will be required for potential landslide movement and expansive soils at the foundation and floor slab elevations.

Mitigation for the expansive soils will require excavation of at least 6 feet of clay from below the foundations and floor slabs and replacement with a combination of moisture treated clay and imported granular structural fill. Stability of the over-excavation cut and sidewalls will depend largely on the contractor's methods and performing the over-excavation in a timely manner. Inclinometer readings and

monitoring of the excavation sidewalls should be performed continuously during construction. Earthwork and excavation recommendations are addressed in the site-specific Geotechnical Evaluation Report.

While future movement of the overall, larger landslide complex as well as smaller localized slides/slumps in this area cannot be eliminated, mitigation recommendations for this potential hazard on the subject site includes the following:

- Continue to monitor the inclinometer that has been installed uphill of the site for landslide-related movement, including monitoring during construction and foundation excavations.
- Construction excavations on site (unknown length and depth at this time) may require considerations to minimize risk of inducing shallow slide movement.
- Constructing the pump station on a shallow reinforced mat foundation that has the ability to move with the overall landslide deposit should movement occur, rather than on a deep foundation system founded in underlying bedrock that can be catastrophically damaged should a landslide occur.
- Construction of the pump station should consider overall "flexibility" of the connections/piping as much as feasible.
- A general understanding of a plan and estimated cost should be understood/prepared for rapid implementation of a landslide mitigation. Mitigation can include a landslide movement warning system, water system shut-off, and potentially earth retention systems such as tiebacks and caisson walls. It should be noted that the location, size and depth of landslide movement is impossible to predict therefore structural mitigation plans (i.e. tiebacks/caisson walls) would have to be based more on recent nearby slide activity.

The site does also have expansive soil that will require mitigation for vertical movement (heave) due to swell. These types of mitigations are relatively standard in this area. Recommendations regarding mitigation of the expansive soils include over-excavation of at least 6 feet of clay soils from below foundations, and replacement with a combination of moisture treated clay and imported granular structural fill. These recommendations are addressed in the site-specific Geotechnical Evaluation Report and within this evaluation under the section titled **Expansive Soils and Expansive Bedrock**, and through the use of current building design codes.

We feel the project site exhibits no other geologic hazards that pose a significant risk to the proposed project or adjacent properties that cannot be mitigated through proper land usage planning, foundation design, engineering design, and/or construction practice. Based upon the results of our geologic hazard evaluation, the recommendations and comments contained in this report as well as the site-specific Geotechnical Evaluation Report should be incorporated into the plans, designs, specifications and construction planning for this project.

LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of VIVID's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions and opinions are based on a limited number of observations and data. Data or conclusions presented herein apply to the specific test pit and percolation test locations only. It is likely that subsurface conditions will vary somewhat beyond the locations investigated. VIVID makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

CLOSING

We appreciate this opportunity to serve you, and we look forward to working with you again. Should you have any questions concerning this report, please contact the undersigned at 719.896.4356.

Sincerely,

6/4/2024

Brysen T. Mustain, PG
Engineering Geologist

William J. Barreire, PE
Senior Geotechnical Engineer

Attachments:

Application Form for Geologic Hazard Report
Figure 1 – Vicinity Map
Figure 2.1 – Field Exploration Plan
Figure 2.2 – Geologic Map
Figure 2.3 – Landslide Boundary Overlay

A – Geotechnical Evaluation Boring Logs and Inclinometer Graphs
B – Summary of Geotechnical Evaluation Laboratory Test Results

LAND USE REVIEW DIVISION
COMMUNITY DEVELOPMENT DEPARTMENT

CITY OF COLORADO SPRINGS

APPLICATION FORM FOR GEOLOGIC HAZARD REPORT

Applicant: _____ Telephone _____ Fax _____

Address: _____ Zip Code _____ e-mail _____

Premises Involved: Development Plan/Subdivision Plat Name: _____

Tax Schedule No(s). __ __ __ __ __ - __ __ - __ __ __, __ __ __ __ __ - __ __ - __ __ __
(This can be obtained from the El Paso County Tax Assessor located at 27 E. Vermijo Avenue on the 2nd Floor; phone: 520-6600 or at their web site http://www.land.elpasoco.com)

GEOLOGIC HAZARD REPORT REQUIRED: (FIVE (5) PRELIMINARY COPIES)

An application review fee will be required to accompany these applications (make checks payable to City of Colorado Springs). The fee schedule is as follows:

Review of Geologic Hazard Reports	City Planning Fee: $300 plus any Colorado Geological Survey Review Cost Over $300
	City Engineering Fee: $284

The following documents have been included and considered as part of this report (checked off by individual(s) preparing the geologic report):

Development Plan: _____

Landscape Plan (if applicable): _____

Grading Plan: _____

Drainage Report (necessary if debris and/or mud flow hazard is present): _____

ENGINEERS STATEMENT

I hereby attest that I am qualified to prepare a Geologic Hazard Study in accordance with the provisions of Section 504 of the Geologic Hazards Ordinance of Colorado Springs. I am qualified as:

_____X_____ Professional Geologist as defined by CRS 34-1-201(3); or,

_____ Professional Engineer as defined by Board Policy Statement 50.2 - "Engineering in Natural Hazard Areas" of the Colorado State Board of Registration for Professional Engineers and Professional Land Surveyors. Board authority as defined by CRS 12-25-107(1).

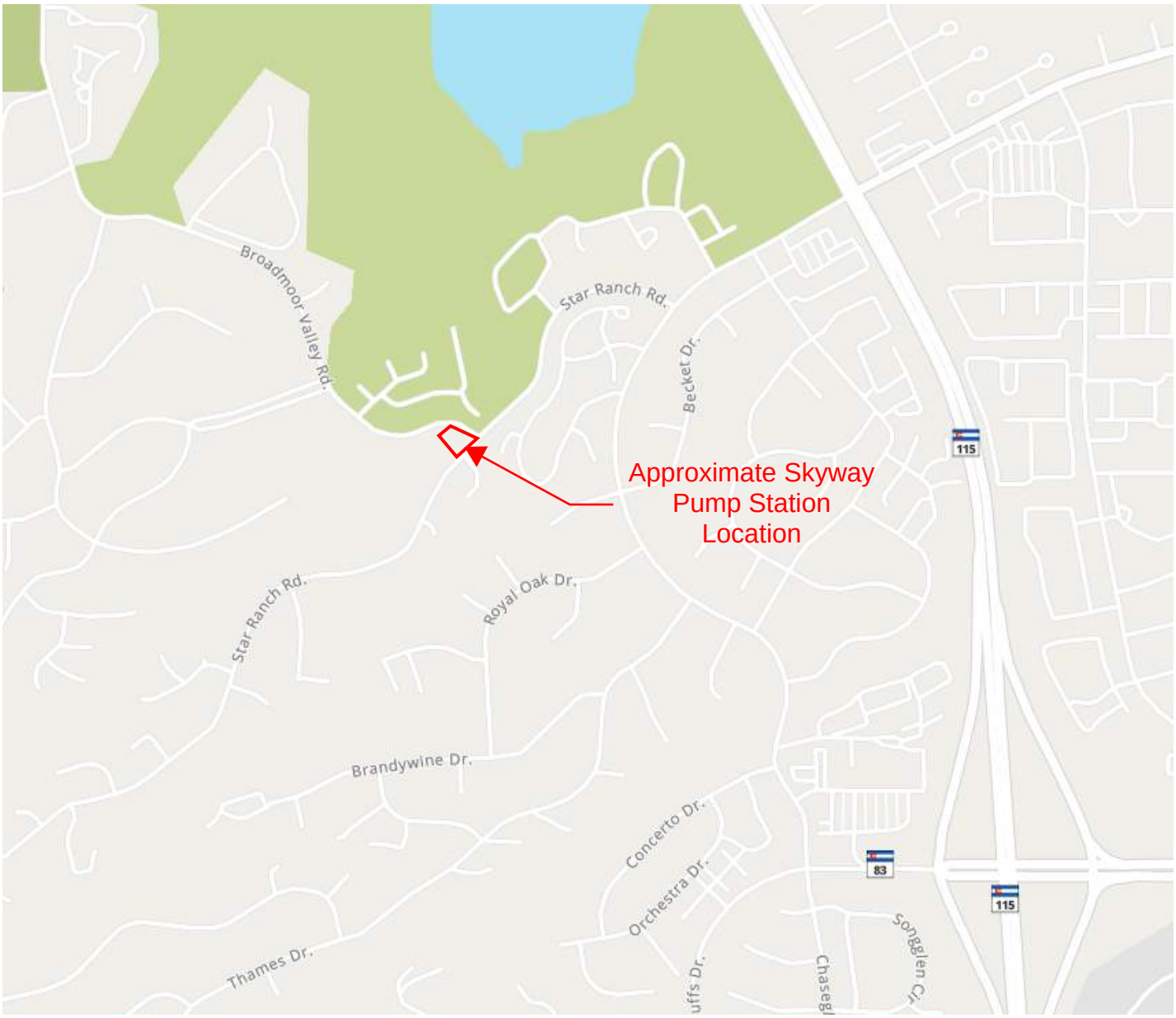
Submitted by: _____ Date: 6/4/2024

This Geologic Hazard Study is filed in accord with the Zoning Code of the Code of the City of Colorado Springs, 2001, as amended.

_____ _____

City Engineer Date City Planning Director Date

Figures



REFERENCE:

Base image obtained from Mapquest, 6/3/2024

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, CO 80907
719-896-4356

Project No. D24-2-754

Date: 6/3/2024

Drawn by: BTM

Reviewed by: WJB

VICINITY MAP

Proposed Skyway Pump Station
Vicinity of Star Ranch Rd. and Broadmoor Valley Rd.
Colorado Springs, Colorado

FIGURE

1

Note: Not to Scale.

REFERENCE
Base Image obtained from Google Earth Pro, 2024.

LEGEND
- B-1 — Approximate Boring Location
- INC-1 — Approximate Inclinometer Location

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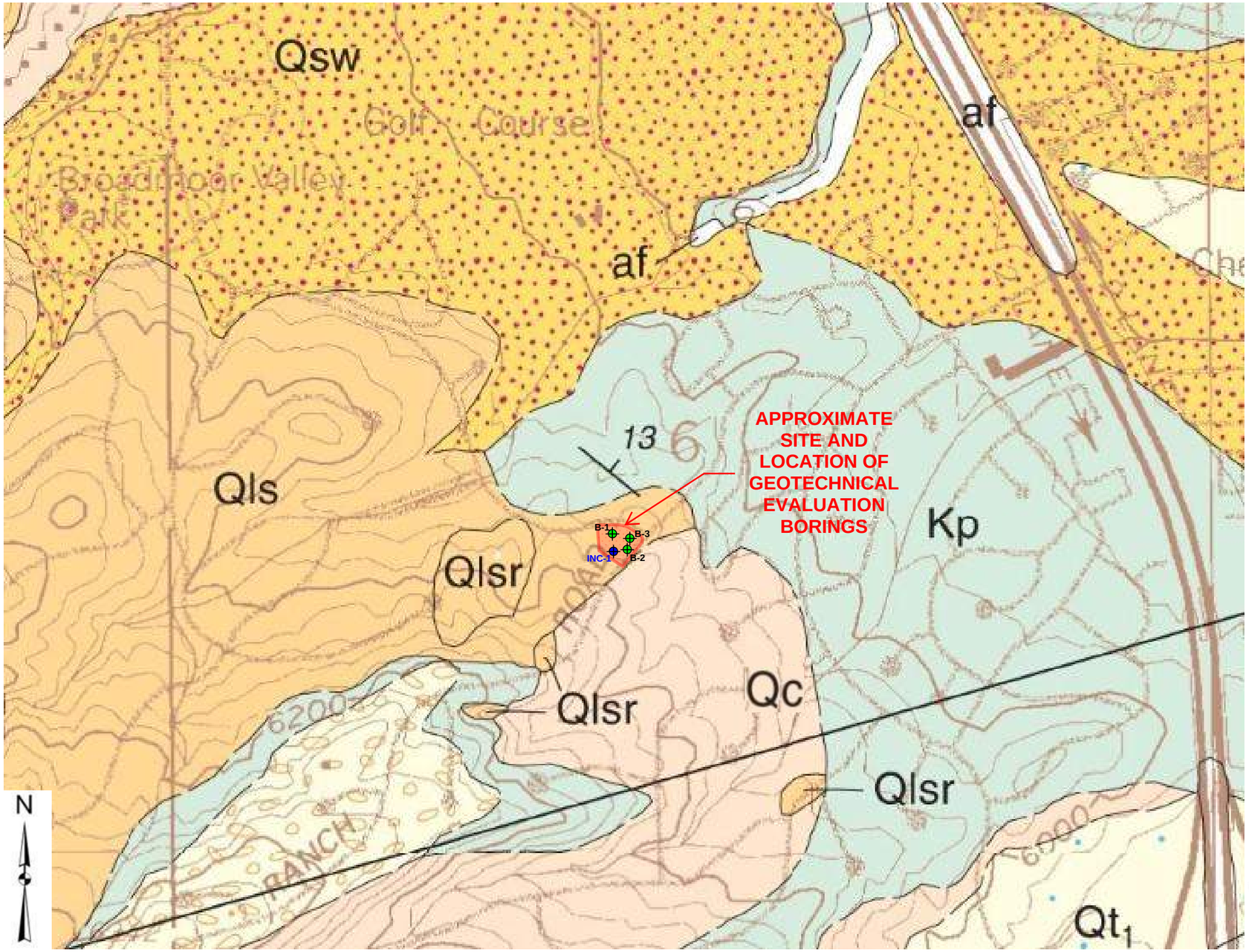
FIELD EXPLORATION PLAN
(AERIAL)

Proposed Skyway Pump Station
Vicinity of Star Ranch Rd. and Broadmoor Valley Rd.
Colorado Springs, Colorado

FIGURE
2.1



ALLUVIAL DEPOSITS—Sediments deposited in stream channels, on flood plains, on pediment surfaces, and as sheetwash

Qt_1 **Terrace alluvium one (Holocene)**—Poorly to moderately sorted, unconsolidated, matrix-supported cobble gravel in a sandy, silty, or clayey matrix. Includes stream-channel deposits, flood-plain deposits, and low-terrace deposits up to 10 ft above Fountain and Monument Creeks

Qsw **Sheetwash deposits (Holocene and late Pleistocene)**—Silty sand, clayey silt, and clay deposited in valleys of intermittent and ephemeral streams, on gentle hillslopes below terraces, landslides and alluvial fans, or in basinal areas locally derived from Pierre Shale

COLLUVIAL DEPOSITS—Sediments deposited on valley sides, valley floors, and hillslopes that were mobilized, transported, and deposited primarily by gravity

Qlsr **Recent landslide deposits (Late Holocene)**—Includes recently active landslide material with fresh morphological features such as lateral shear zones, hummocky terrain, headscarps and slip-plane toes that have opened or moved within the last 20 years. A heterogeneous unit of unsorted material consisting of clay, silt, sand, and rock frag-ments. Most large recent landslides involve Pierre Shale. Several recent landslides (Qlsr) occurred or were reactivated after large precipitation events in April and August, 1999

Qc **Colluvium (Holocene and late Pleistocene)**—Unit is mostly matrix-supported, gravelly sand, silty clay, and clayey silt. Deposits are usually coarser grained in upper reaches and finer grained in lower reaches where Pierre Shale parent material is present. Consists of very coarse-grained debris along steep slopes of Cheyenne Mountain and medium- to fine-grained sand over clayey material in slopes below terraces underlain by pediment deposit two (Qg_2). Unit may also include landslide deposits (Qls), or sheetwash deposits (Qsw)

Qls **Landslide deposits (Holocene and Pleistocene)**—Similar in texture to recent landslide deposits (Qlsr) with more weathered hummocky terrain and lacks fresh morphological features. Ranges from slowly creeping landslides to long-inactive, landslides that post-date deposition of the pediment deposit two (Qg_2)

Kp **Pierre Shale (Upper Cretaceous)**—Gray shale. Includes numerous bentonite beds that are typically 1-3 in. thick and occasionally up to 8 in. thick). Typically weathers to brown and olive-green clay, with curvilinear fractures filled with sulfate salts. Formation is mostly covered by Quaternary deposits and is particularly susceptible to slope instability in steep areas

MAP SYMBOLS

Formation or unit contact—Dashed where approximately located, queried where very uncertain

25 **Strike and dip of inclined beds**—Angle of dip shown in degrees

Note: Not to Scale.

REFERENCE
Base Image obtained CGS Geologic Map of the Colorado Springs quadrangle, Carroll & Crawford, 2000

BORING LEGEND

B-1 Approximate Boring Location

INC-1 Approximate Inclinometer Location

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Colorado Springs, CO 80907
719-896-4356

Project No. D24-2-754

Date: 6/3/2024

Drawn by: BTM

Reviewed by: WJB

GEOLOGIC MAP

Proposed Skyway Pump Station
Vicinity of Star Ranch Rd. and Broadmoor Valley Rd.
Colorado Springs, Colorado

FIGURE
2.2

NOTES:
LANDSLIDE BOUNDARIES ARE APPROXIMATE AND ESTIMATED FROM GEOLOGIC MAP OF COLORADO SPRINGS QUADRANGLE PRESENTED ON FIGURE 2.2

N

Note: Not to Scale.

REFERENCE
Base Image obtained from Google Earth Pro, dated 10/19/2018.

LEGEND

Qlsr — Approximate Recent Landslide (Qlsr) Boundary

Qls — Approximate Older Landslide (Qls) Boundary

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LANDSLIDE BOUNDARY OVERLAY

Proposed Skyway Pump Station
Vicinity of Star Ranch Rd. and Broadmoor Valley Rd.
Colorado Springs, Colorado

FIGURE
2.3

ATTACHMENT A

GEOTECHNICAL EVALUATION BORING LOGS AND INCLINOMETER GRAPHS

Vivid Engineering Group, Inc.
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Telephone: 719-896-4356
Fax: 719-896-4357

KEY TO SYMBOLS

CLIENT Dewberry

PROJECT NAME Proposed Skyway Pump Station

PROJECT NUMBER D23-2-702

PROJECT LOCATION Colorado Springs, Colorado

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)


ASPHALT


CH: USCS High Plasticity Clay


CL: USCS Low Plasticity Clay


CLAYSTONE


GP: USCS Poorly-graded Gravel


SC: USCS Clayey Sand


SHALE


SM: USCS Silty Sand


SW-SM: USCS Well-graded Sand with Silt


WEATHERED CLAYSTONE

SAMPLER SYMBOLS


Grab Sample


2" I.D. Modified California Sampler (MC)


Rock Core


Standard Penetration Test (SPT)

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
MC - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
FINES- PERCENT PASSING NO. 200 SIEVE


Water Level at Time Drilling, or as Shown

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BORING NUMBER B-1

CLIENT Dewberry
PROJECT NAME Proposed Skyway Pump Station
PROJECT NUMBER D23-2-702
PROJECT LOCATION Colorado Springs, Colorado
DATE STARTED 1/4/24 **COMPLETED** 1/4/24
GROUND ELEVATION _____ **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-45)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY D. Crozier **CHECKED BY** W. Barreire
AT END OF DRILLING ---
NOTES Skyway Pump Station
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0					Silty SAND with gravel, medium brown, moist
					2.5
	SPT	9-11-11 (22)	MC = 13.3% LL = 49 PL = 19 Fines = 86.0%		Lean CLAY, medium to light brown, slightly moist, very stiff
5					5.0
	MC	15-25			Sandy CLAY, light brown, moist, hard
	MC	15-29	MC = 15.3% DD = 116.8 pcf UCS = 15,444 psf		
10					10.0
	MC	15-12	MC = 25.3% DD = 99.7 pcf Swell = 5.1% when wetted under a 1,000 psf load		CLAY, reddish-brown and olive-brown with iron oxide staining, moist to slightly moist, hard, calcareous deposits
15	MC	16-18	MC = 22.4% DD = 105.0 pcf Swell = 2.3% when wetted under a 1,000 psf load		
					19.0
20	MC	16-31			**Pierre Shale Formation** CLAYSTONE, dark gray to gray, olive-brown, slightly moist, medium hard, calcareous deposits
					24.5
25	MC	30-50/4"			**Pierre Shale Formation** SHALE, dark gray, slightly moist, very hard
	MC	50/3"			29.3
					Bottom of borehole at 29.3 feet.

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BORING NUMBER B-2

CLIENT Dewberry
PROJECT NAME Proposed Skyway Pump Station
PROJECT NUMBER D23-2-702
PROJECT LOCATION Colorado Springs, Colorado
DATE STARTED 1/4/24 **COMPLETED** 1/4/24
GROUND ELEVATION **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-45)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY D. Crozier **CHECKED BY** W. Barreire
AT END OF DRILLING ---
NOTES Skyway Pump Station
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0					Silty SAND, medium brown, moist
					2.5
	SPT	10-12-15 (27)	MC = 12.7% LL = 48 PL = 20 Fines = 87.0%		Lean CLAY, medium brown and reddish-brown with iron oxide staining, moist, very stiff
5	MC	10-21	MC = 16.1% DD = 113.0 pcf Swell = 5.7% when wetted under a 500 psf load		
	MC	9-18			
10	MC	12-22			
					12.0
					Pierre Shale Formation Weathered CLAYSTONE, medium brown to olive-brown with iron oxide staining, slightly moist, hard, calcareous deposits
15	MC	18-26	MC = 17.1% DD = 115.8 pcf Fines = 97.0% UCS = 12,704 psf		
					19.5
20	MC	18-31			**Pierre Shale Formation** CLAYSTONE, dark brown, dark gray, slightly moist, hard, calcareous deposits
25	MC	38-35			
					28.0
					Pierre Shale Formation SHALE, dark gray, slightly moist, very hard
	MC	50/4"			29.3
					Bottom of borehole at 29.3 feet.

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BORING NUMBER B-3

CLIENT Dewberry
PROJECT NAME Proposed Skyway Pump Station
PROJECT NUMBER D23-2-702
PROJECT LOCATION Colorado Springs, Colorado
DATE STARTED 1/4/24 **COMPLETED** 1/4/24
GROUND ELEVATION **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-45)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY D. Crozier **CHECKED BY** W. Barreire
AT END OF DRILLING ---
NOTES Skyway Pump Station
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0					Silty SAND with gravel, medium brown, moist
					1.5
					GRAVEL and COBBLES
					2.0
					2.5
					Silty SAND with gravel, medium brown, moist
	SPT	35-44-24 (68)	MC = 12.5% LL = 51 PL = 19 Fines = 69.0%		Sandy Fat CLAY, medium brown to light brown, moist, very stiff
5	MC	14-15			
	MC	10-12	MC = 19.9% DD = 105.7 pcf Swell = 1.5% when wetted under a 1,000 psf load		
10	MC	10-12			
			MC = 21.3% DD = 106.1 pcf Fines = 97.0% UCS = 7,179 psf		
15	MC	6-10			15.0
					Pierre Shale Formation Weathered CLAYSTONE, medium brown to gray, moist to slightly moist, medium hard
					19.5
20	MC	16-32			**Pierre Shale Formation** CLAYSTONE, gray, slightly moist, very hard
25	MC	23-50/5"			
					28.0
					Pierre Shale Formation SHALE, gray to dark gray, slightly moist, hard to very hard, calcareous deposits
	MC	50/5"			29.4
					Bottom of borehole at 29.4 feet.

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BORING NUMBER INC-1

CLIENT Dewberry
PROJECT NAME Proposed Skyway Pump Station
PROJECT NUMBER D23-2-702
PROJECT LOCATION Colorado Springs, Colorado
DATE STARTED 12/7/23 **COMPLETED** 12/8/23
GROUND ELEVATION _____ **HOLE SIZE** 8 inches
DRILLING CONTRACTOR VINE (CME-750)
GROUND WATER LEVELS:
DRILLING METHOD 8" Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY D. Crozier **CHECKED BY** W. Barreire
AT END OF DRILLING ---
NOTES Skyway Pump Station
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION
0	DC 1	80		Silty SAND, medium brown, slightly moist
3.0				Lean CLAY with sand, dark brown, gray, slightly moist
5	DC 2	87		
7.5				RESIDUAL CLAY/CLAYSTONE, gray, slightly moist, calcareous deposits
10	DC 3	100		
15	DC 4	100		
19.5				**Pierre Shale Formation** Weathered CLAYSTONE, gray, slightly moist
20	DC 5	100		
25	DC 6	100		
29.0				**Pierre Shale Formation** SHALE, dark gray with iron oxide staining, slightly moist
30	RC 1	100 (98)		
35	RC 2	100 (100)		
40				

(Continued Next Page)

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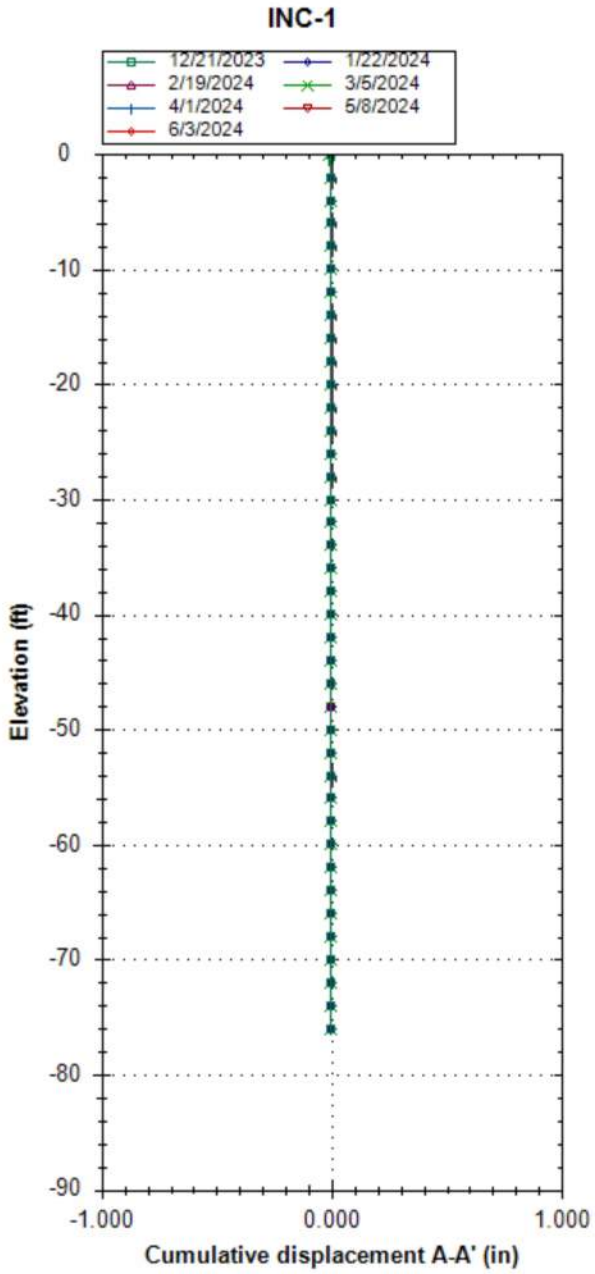
BORING NUMBER INC-1

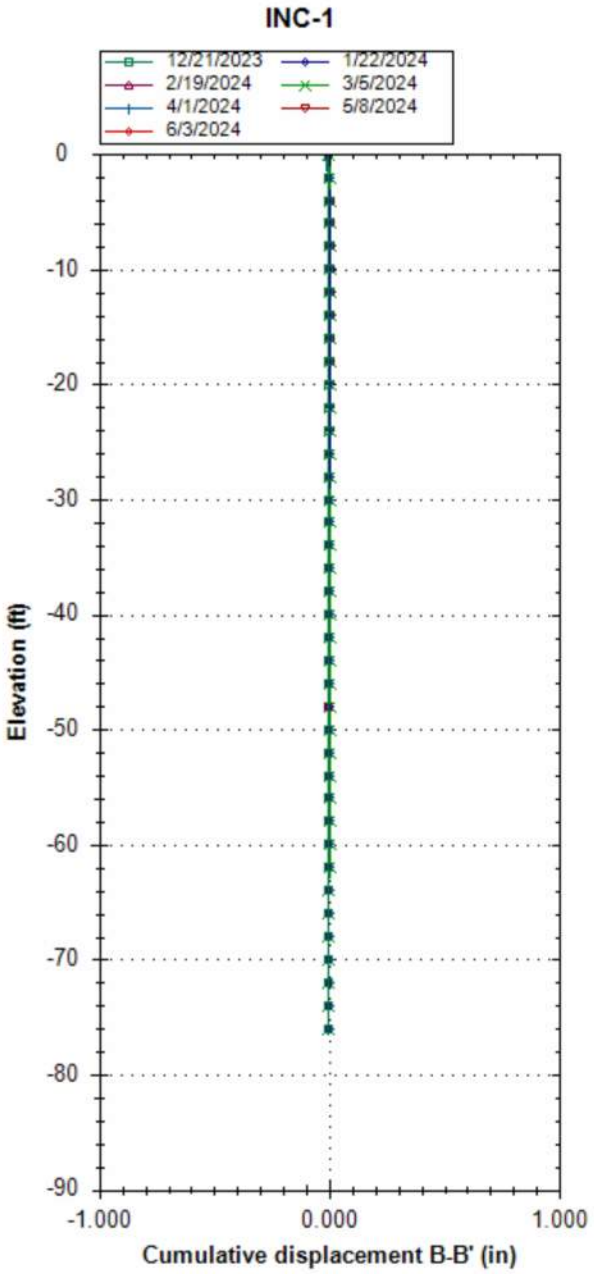
CLIENT Dewberry **PROJECT NAME** Proposed Skyway Pump Station

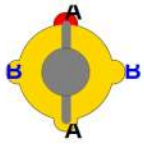
PROJECT NUMBER D23-2-702 **PROJECT LOCATION** Colorado Springs, Colorado

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	GRAPHIC LOG	MATERIAL DESCRIPTION
40				**Pierre Shale Formation** SHALE, dark gray with iron oxide staining, slightly moist *(continued)*
45	RC 3	100 (100)		
50	RC 4	100 (88)		- bentonite layer at approximately 47 feet 3 inches below the ground surface
55	RC 5	100 (93)		
60	RC 6	100 (98)		
65	RC 7	100 (100)		
70	RC 8	100 (100)		
75	RC 9	80 (80)		- bentonite layer at approximately 73 feet 8 inches below the ground surface
80	RC 10	100 (100)		80.0

Bottom of borehole at 80.0 feet.







Inst. date:
Top elevation: 0
Bottom elevation: -76
Alpha (deg): 0
Last reading: 6/3/2024 9:52:00 AM
Cumulative A+: 0, A-: 0
Cumulative B+: 0, B-: -0.01

ATTACHMENT B

SUMMARY OF GEOTECHNICAL EVALUATION LABORATORY TEST RESULTS

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SUMMARY OF LABORATORY RESULTS

CLIENT Dewberry

PROJECT NAME Proposed Skyway Pump Station

PROJECT NUMBER D23-2-702

PROJECT LOCATION Colorado Springs, Colorado

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)		
B-1	2.5	49	19	30	4.75	86	CL	13.3			
B-1	7.5							15.3	116.8		
B-1	10.0							25.3	99.7		
B-1	14.0							22.4	105.0		
B-2	2.5	48	20	28	4.75	87	CL	12.7			
B-2	5.0							16.1	113.0		
B-2	14.0				4.75	97		17.1	115.8		
B-3	2.5	51	19	32	19	69	CH	12.5			
B-3	7.5							19.9	105.7		
B-3	10.0				0.85	97		21.3	106.1		

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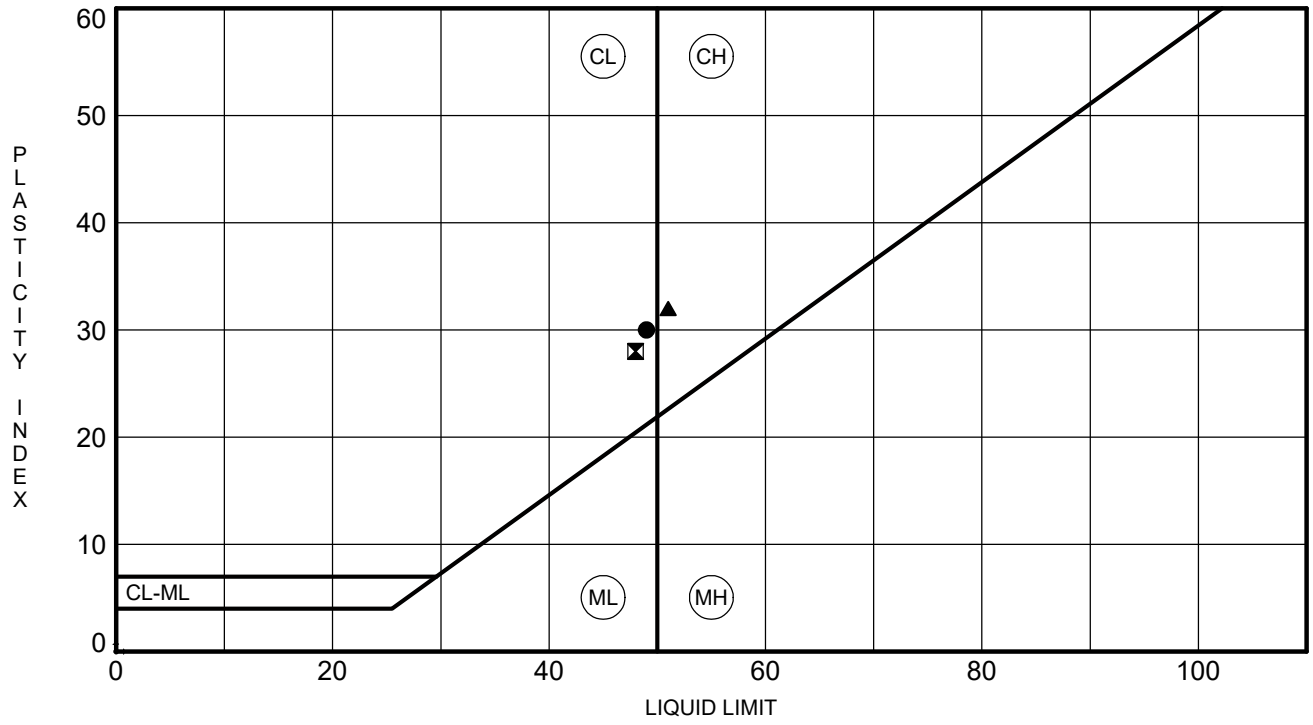
ATTERBERG LIMITS' RESULTS

CLIENT Dewberry **PROJECT NAME** Proposed Skyway Pump Station

PROJECT NUMBER D23-2-702 **PROJECT LOCATION** Colorado Springs, Colorado



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**2.5**	**49**	**19**	**30**	**86**	**LEAN CLAY(CL)**
⧓	**B-2**	**2.5**	**48**	**20**	**28**	**87**	**LEAN CLAY(CL)**
▲	**B-3**	**2.5**	**51**	**19**	**32**	**69**	**SANDY FAT CLAY(CH)**

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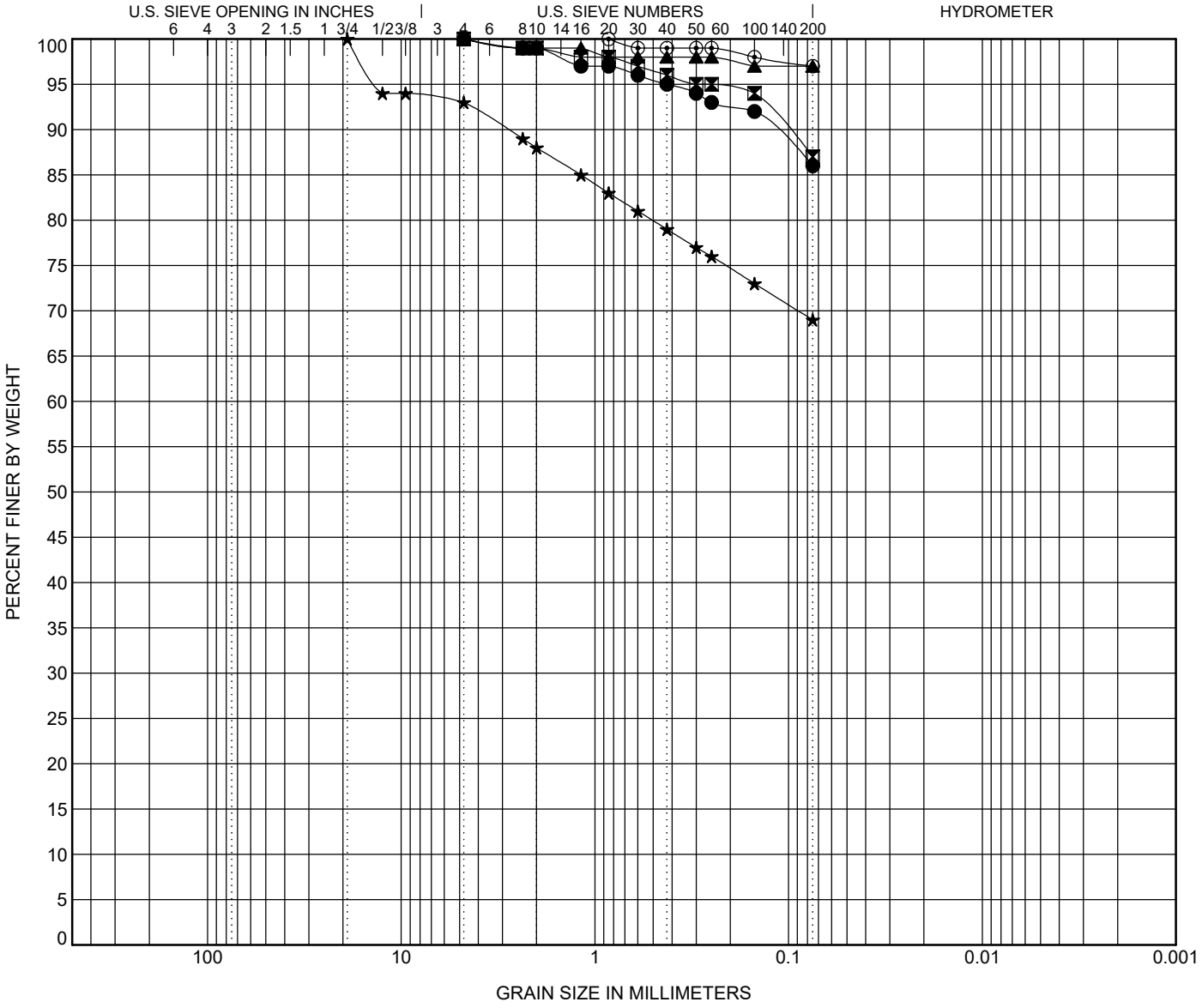
GRAIN SIZE DISTRIBUTION

CLIENT Dewberry

PROJECT NAME Proposed Skyway Pump Station

PROJECT NUMBER D23-2-702

PROJECT LOCATION Colorado Springs, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-1	2.5	LEAN CLAY(CL)	49	19	30		
⊠	B-2	2.5	LEAN CLAY(CL)	48	20	28		
▲	B-2	14.0						
★	B-3	2.5	SANDY FAT CLAY(CH)	51	19	32		
⊙	B-3	10.0						

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	2.5	4.75				0.0	14.0	86.0	
⊠	B-2	2.5	4.75				0.0	13.0	87.0	
▲	B-2	14.0	4.75				0.0	3.0	97.0	
★	B-3	2.5	19				7.0	24.0	69.0	
⊙	B-3	10.0	0.85				0.0	3.0	97.0	

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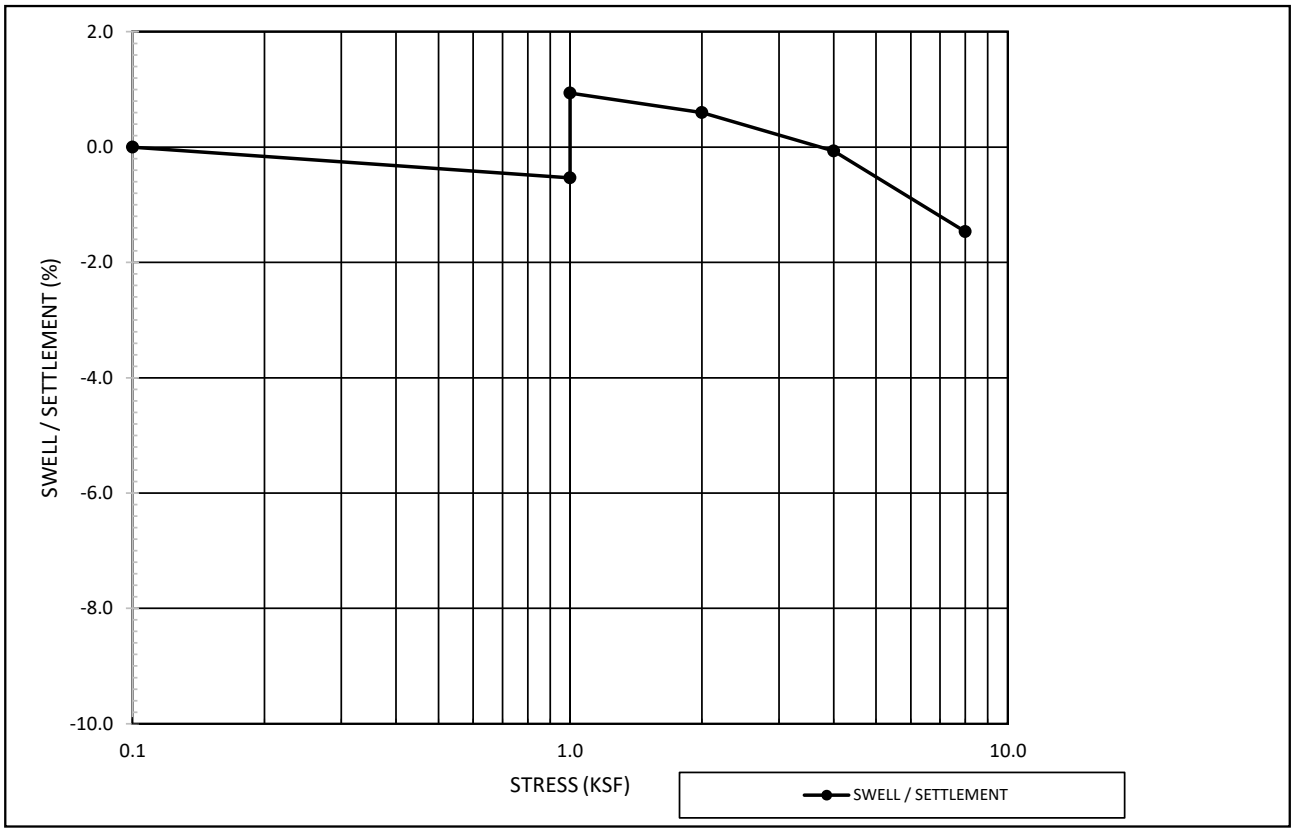
Project Name:	Proposed Skyway Pump Station	**Date**	1/16/2024
Project No.:	D23-2-702		
Boring ID.:	B-3	**Sample Depth (ft)**	7.5
Sample Description:	Sandy Fat CLAY, medium brown, moist		

	%
Swell @ Wetting Weight:	**1.5**

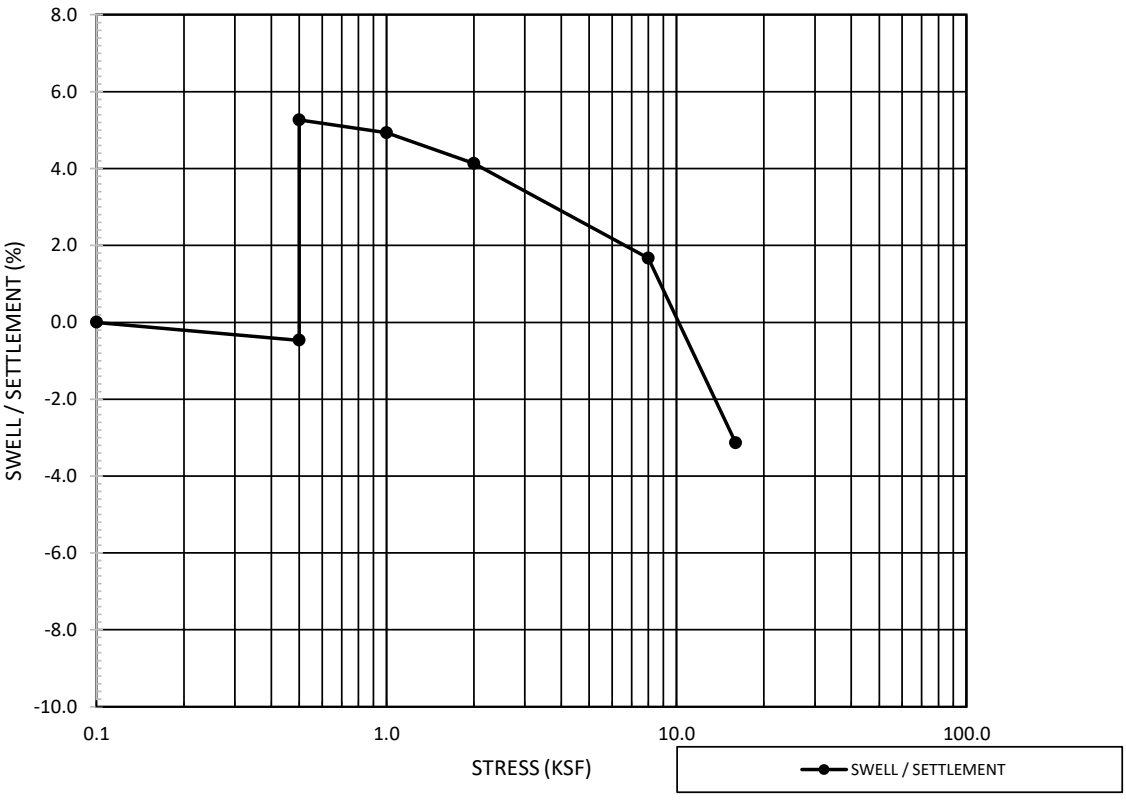


Initial Condition	
Moisture Content %	**19.9**
Dry Density (pcf)	**105.7**
Post-Swell Condition	
Moisture Content %	**24.8**

VIVID Engineering Group, Inc.

Project Name:	Proposed Skyway Pump Station	**Date**	1/16/2024
Project No.:	D23-2-702		
Boring ID.:	B-2	**Sample Depth (ft)**	5
Sample Description:	Lean CLAY, brown, moist		

	%
Swell @ Wetting Weight:	**5.7**

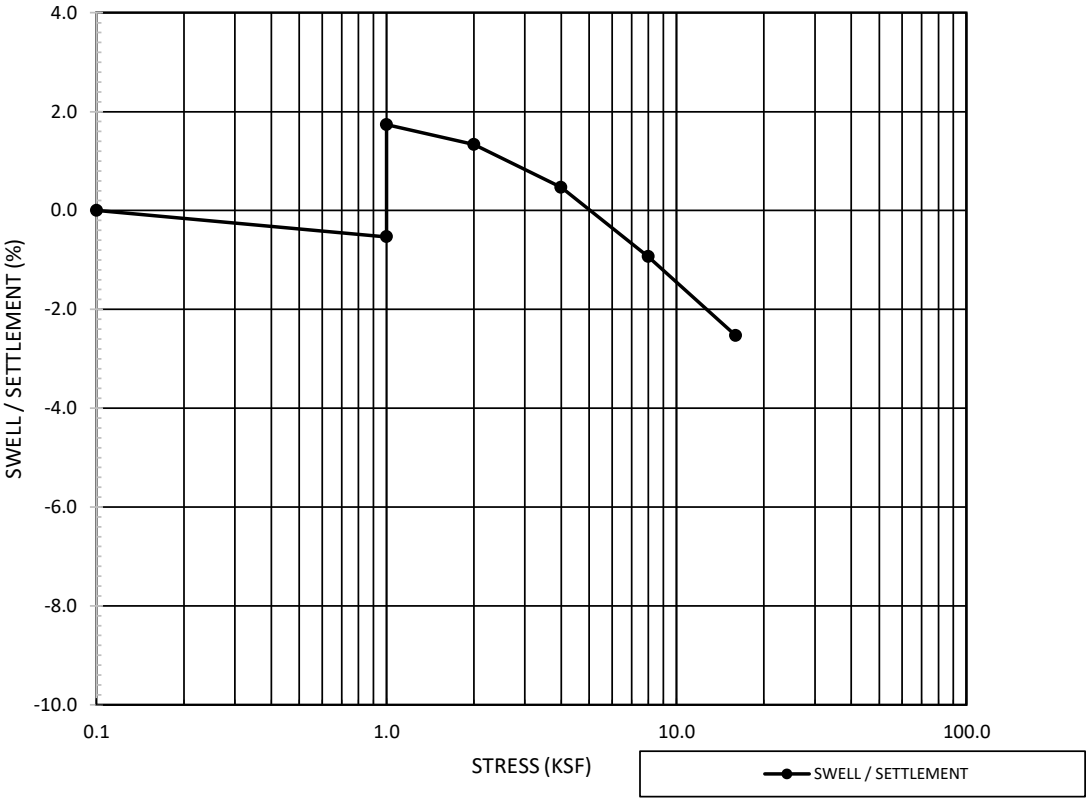


Initial Condition	
Moisture Content %	**16.1**
Dry Density (pcf)	**113.0**
Post-Swell Condition	
Moisture Content %	**19.9**

VIVID Engineering Group, Inc.

Project Name:	Proposed Skyway Pump Station	**Date**	1/16/2024
Project No.:	D23-2-702		
Boring ID.:	B-1	**Sample Depth (ft)**	14
Sample Description:	CLAY, reddish-brown, olive brown, iron oxide staining, moist		

	%
Swell @ Wetting Weight:	**2.3**

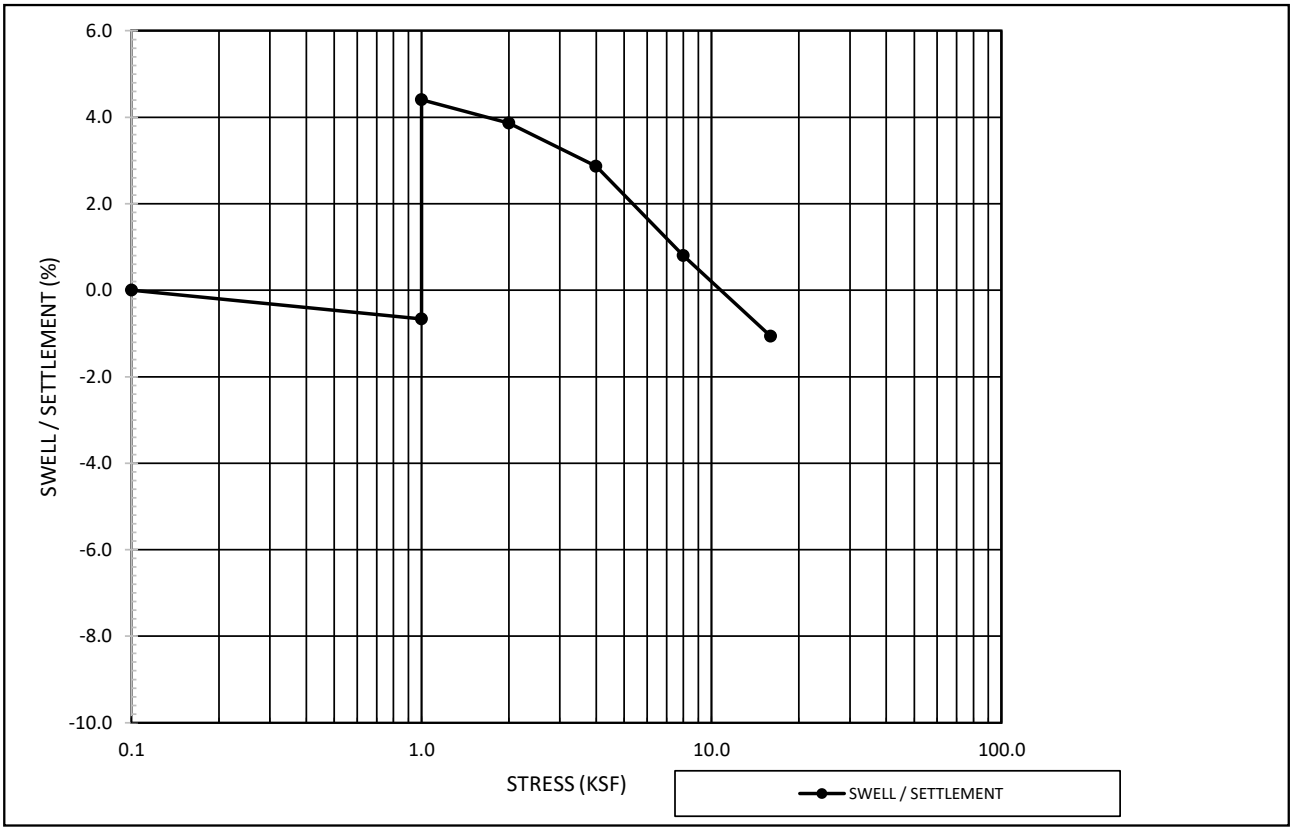


Initial Condition	
Moisture Content %	**22.4**
Dry Density (pcf)	**105.0**
Post-Swell Condition	
Moisture Content %	**23.2**

VIVID Engineering Group, Inc.

Project Name:	Proposed Skyway Pump Station	**Date**	1/16/2024
Project No.:	D23-2-702		
Boring ID.:	B-1	**Sample Depth (ft)**	10
Sample Description:	CLAY, reddish-brown, olive brown, iron oxide staining, moist		

	%
Swell @ Wetting Weight:	**5.1**



Initial Condition	
Moisture Content %	**25.3**
Dry Density (pcf)	**99.7**
Post-Swell Condition	
Moisture Content %	**27.7**

UNCONFINED COMPRESSION TEST
ASTM D 2166

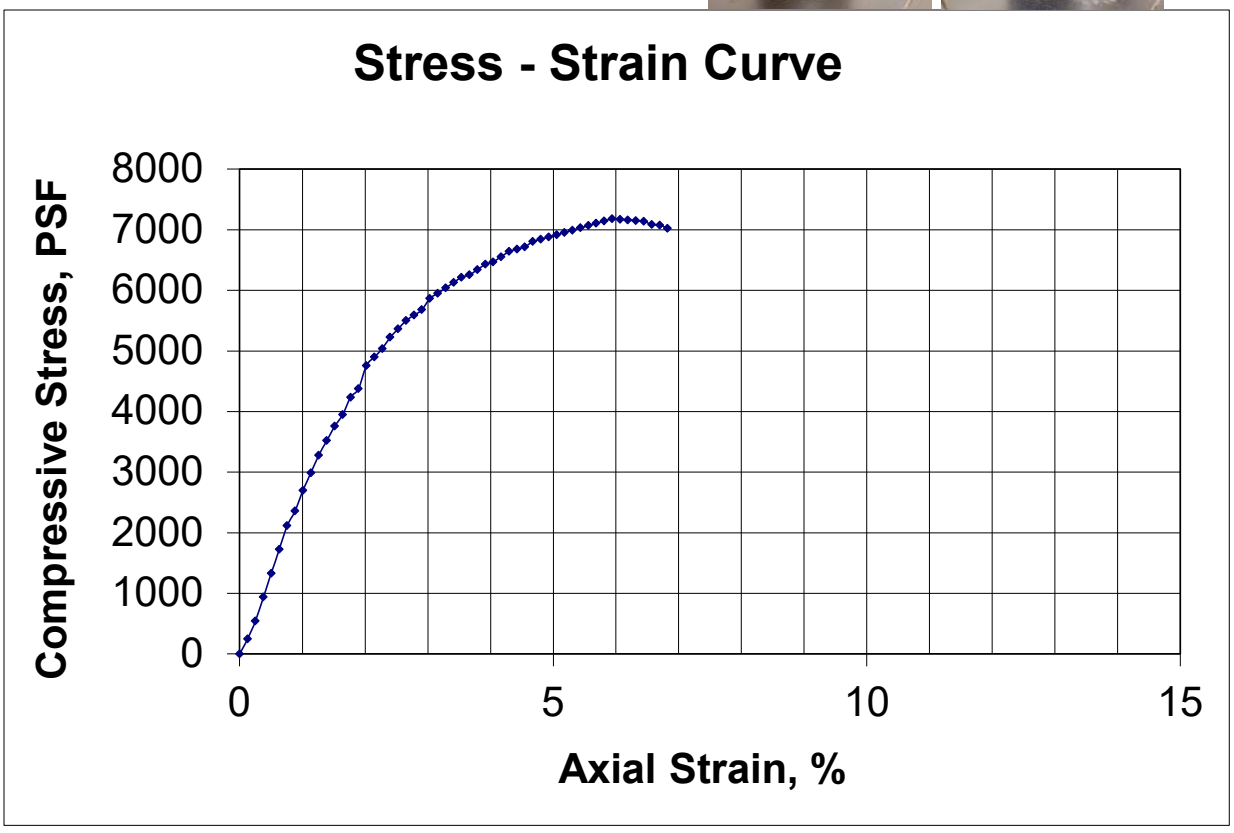
PROJECT NAME:	Proposed Skyway Pump Station	PROJECT ENG.:	MBR
PROJECT NO. :	D23-2-702	DATE RECEIVED:	1/5/2024
CLIENT NAME:	Dewberry	DATE TESTED:	1/16/2024
		TESTED BY:	TK
BORING NO. :	B-3	DATA ENTRY:	TK
SAMPLE NO.:	N/A		
DEPTH, FT. :	10ft	DESCRIPTION:	Sandy Fat CLAY, brown, moist
TEST SPECIMEN NO.:	N/A		

INITIAL DATA

Avg. Height, In.:	3.957
Avg. Diameter, In.:	1.923
L/D Ratio:	2.1
Moisture Content, %: (Sample, After test)	21.3
Dry Density, pcf:	106.1
Assumed Specific Gravity:	2.7
Saturation, %:	97.9
Void Ratio:	0.588
Rate of Strain, %/Minute:	1.0

Photo:

	PSF	PSI
Compressive Strength @ Failure:	7179	50
Shear Strength @ Failure:	3590	25
Axial Strain @ Failure,%:	5.9	5.9



UNCONFINED COMPRESSION TEST
ASTM D 2166

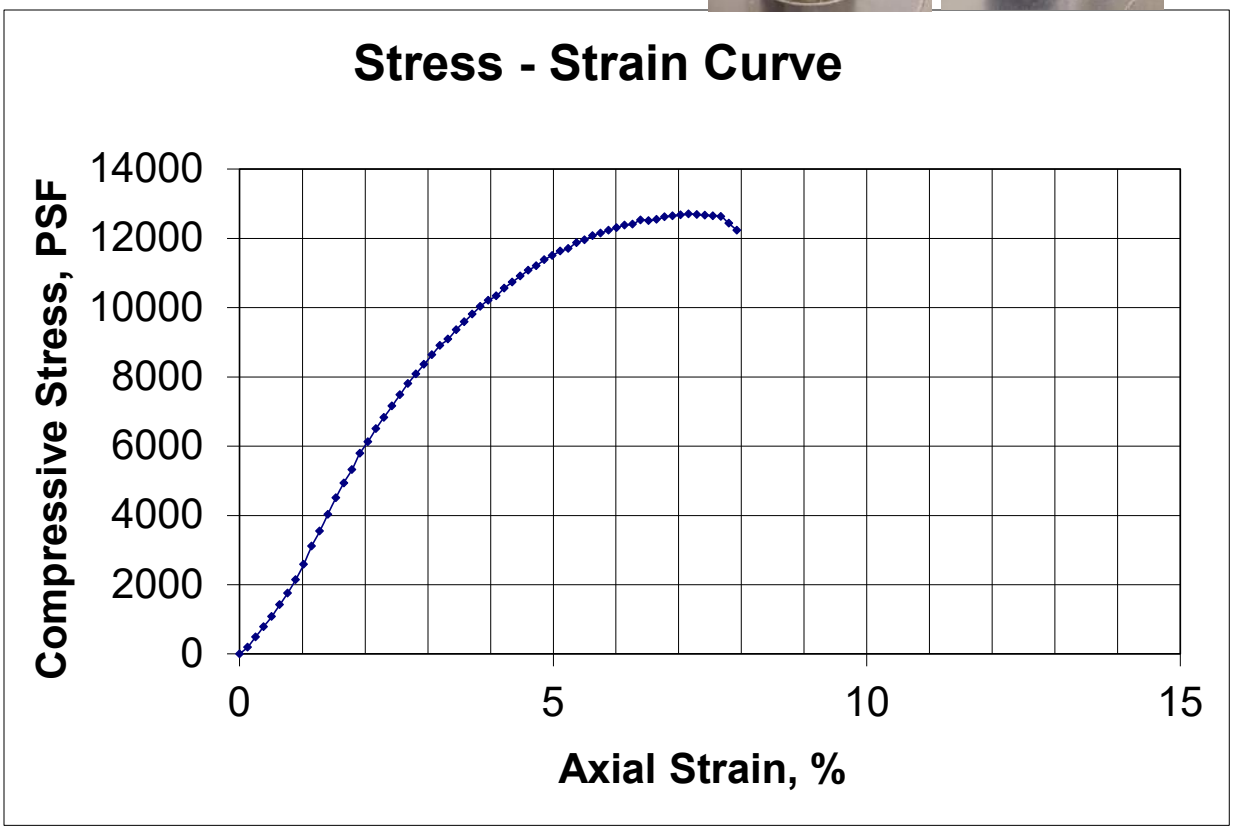
PROJECT NAME:	Proposed Skyway Pump Station	PROJECT ENG.:	MBR
PROJECT NO. :	D23-2-702	DATE RECEIVED:	1/5/2024
CLIENT NAME:	Dewberry	DATE TESTED:	1/16/2024
		TESTED BY:	TK
BORING NO. :	B-2	DATA ENTRY:	TK
SAMPLE NO.:	N/A		
DEPTH, FT. :	14ft	DESCRIPTION:	Weathered CLAYSTONE, brown
TEST SPECIMEN NO.:	N/A		moist

INITIAL DATA

Avg. Height, In.:	3.910
Avg. Diameter, In.:	1.930
L/D Ratio:	2.0
Moisture Content, %: (Sample, After test)	17.1
Dry Density, pcf:	115.8
Assumed Specific Gravity:	2.7
Saturation, %:	101.3
Void Ratio:	0.454
Rate of Strain, %/Minute:	1.0

Photo:

	PSF	PSI
Compressive Strength @ Failure:	12704	88
Shear Strength @ Failure:	6352	44
Axial Strain @ Failure,%:	7.2	7.2



VIVID Engineering Group

UNCONFINED COMPRESSION TEST
ASTM D 2166

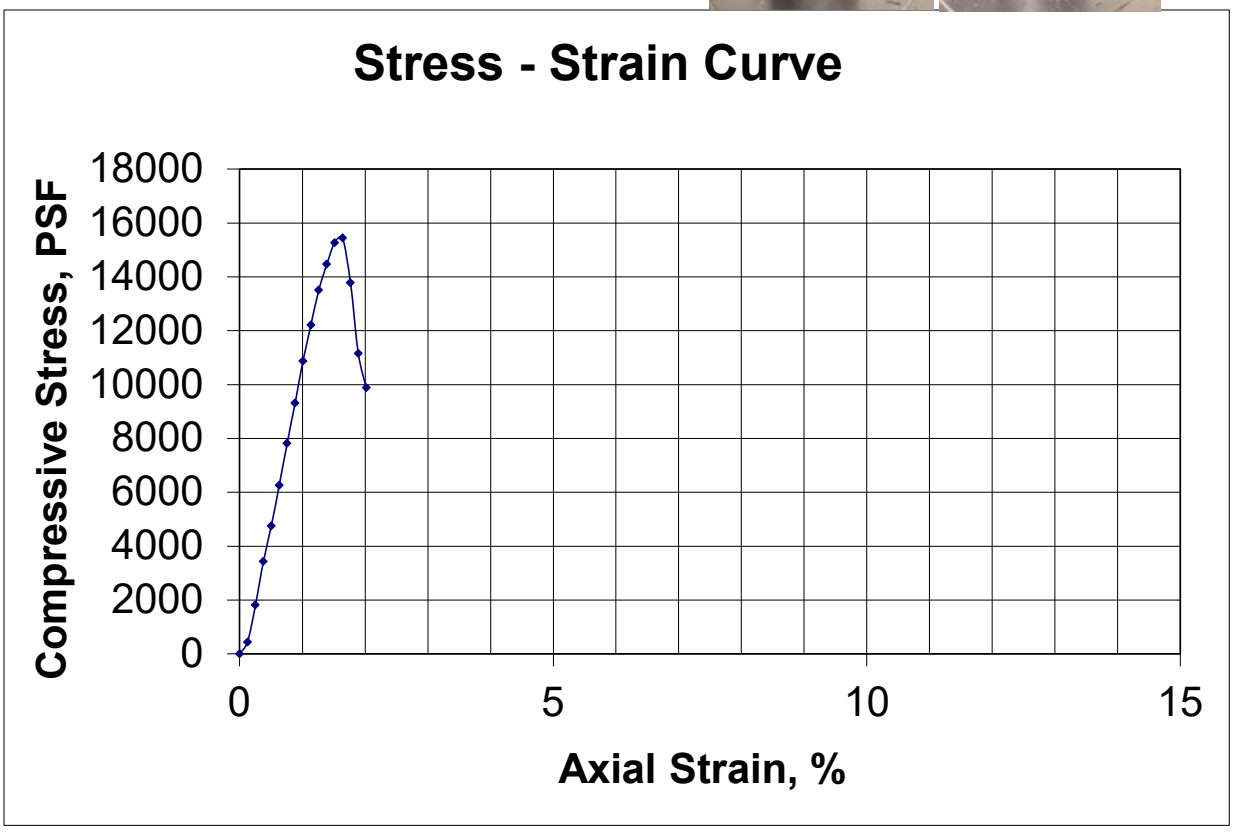
PROJECT NAME:	Proposed Skyway Pump Station	PROJECT ENG.:	MBR
PROJECT NO. :	D23-2-702	DATE RECEIVED:	1/5/2024
CLIENT NAME:	Dewberry	DATE TESTED:	1/16/2024
		TESTED BY:	TK
BORING NO. :	B-1	DATA ENTRY:	TK
SAMPLE NO.:	N/A		
DEPTH, FT. :	7.5ft	DESCRIPTION:	Sandy Fat CLAY, light brown, moist
TEST SPECIMEN NO.:	N/A		

INITIAL DATA

Avg. Height, In.:	3.960
Avg. Diameter, In.:	1.930
L/D Ratio:	2.1
Moisture Content, %: (Sample, After test)	15.3
Dry Density, pcf:	116.8
Assumed Specific Gravity:	2.7
Saturation, %:	93.3
Void Ratio:	0.442
Rate of Strain, %/Minute:	1.0

	PSF	PSI
Compressive Strength @ Failure:	15444	107
Shear Strength @ Failure:	7722	54
Axial Strain @ Failure,%:	1.6	1.6

Photo:



Corrosion Test Results

Project Name:	Proposed Skyway Pump Station	Tested By:	AL
Project No.	D23-2-702	Date Sampled:	1/4/2024
		Date Tested:	1/16/2024

Sample ID: **B-2 @ 0-4'** Matrix: Soil

Test	Results		Method
Chloride - Water Soluble	0.005	%	AASHTO T291-91/ASTM D4327
pH	7.8	units	AASHTO T289-91
Redox Potential	150.6	mv	ASTM D1498
Electrical Resistivity	510	ohm-cm	AASHTO T288-91
Sulfate - Water Soluble	0.550	%	CDOT CP-L 2103/ASTM D4327
Sulfide	Trace	-	AWWA C105

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