LITHOS ENGINEERING

# GEOTECHNICAL INVESTIGATION REPORT

## COOLEY PRV AND METER VAULT STRUCTURES, THORNTON WATER PROJECT

## THORNTON, COLORADO

**SEPTEMBER 2022**

Engineering from the ground down

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September 8, 2022
Project No. 21207

Carollo Engineers
390 Interlocken Crescent, Ste 800
Broomfield, Colorado 80021

Attention: Mr. Bart Giles, PE
Senior Infrastructure Engineer

Regarding: Geotechnical Investigation Report
Cooley PRV and Meter Vault Structures, Thornton Water Project
Thornton, Colorado

Mr. Giles,

The following Geotechnical Investigation Report presents geotechnical findings and recommendations for the Cooley PRV and Meter Vault of the Thornton Water Project (TWP). This study was conducted in general accordance with the Task Order between Lithos Engineering and Carollo Engineers dated July 22, 2022. Contained herein are geotechnical recommendations for the design and construction of the various improvements.

If you have any questions regarding the contents of this report, please contact the undersigned.

Sincerely,
**Lithos Engineering**


9/8/22

Steve Kuehr, PE
Senior Consultant

Derek Magnuson, PG, CEG
Project Geologist

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# 1 INTRODUCTION

Carollo Engineers (Carollo) retained Lithos Engineering (Lithos) to provide geotechnical engineering services for the Cooley Pressure Reducing Vault (PRV) and Meter Vault of the Thornton Water Project (Project). The City of Thornton (City) will construct the two vaults and adjacent manholes on the southern side of E 100th Avenue, northwest of West Sprat Platte Lake. The vaults and manholes will be constructed along the alignment of an existing 36-in RCP pipeline. The purpose of this report is to provide geotechnical recommendations for design and construction of the proposed project.

## 1.1 Project Description

Based on our correspondence and review of concept drawings prepared by Carollo, we understand the Project will include the following facilities at locations noted on Figure 1:

- A meter vault with a footprint of approximately 10 feet by 13 feet. We understand the meter vault will be up to approximately 15 feet deep.
- Two circular manholes located on the east and west sides of the proposed meter vault with diameters of approximately 10 feet. We understand the manholes will be approximately 10 to 15 feet deep.
- A pressure reducing vault (sleeve valve vault) with a footprint of approximately 25 feet by 17 feet. We understand the PRV will be approximately 13 to 14 feet deep.

## 1.2 Site Description

The project site for the vaults is located along the southern side of E 100th Avenue and approximately one-quarter mile west of McKay Road, northwest of West Sprat Platte Lake in Thornton, Colorado. The vaults and manholes will be constructed in a relatively flat field portion of the West Sprat Platte Lake park with an elevation of approximately 5,070 feet. Based on our review of historical aerial imagery available on Google Earth, the site has existed similar to its present state since 1993.

# 2 GEOTECHNICAL INVESTIGATION

Lithos conducted a subsurface investigation at the project site (Boring LE-101) on June 27, 2022. Lithos previously performed a subsurface investigation for Thornton Water Project Segment A Pipeline under a separate contract for the City, and advanced boring TB-3700 on September 24, 2021. The geotechnical investigation included geotechnical drilling and a subsequent geotechnical laboratory testing program. Subsurface conditions encountered during the investigation are discussed in Section 3.

## 2.1 Subsurface Investigation

Lithos completed two geotechnical borings to investigate the general subsurface conditions in the site vicinity (Figure 1). The geotechnical borings include LE-101 and TB-3700, which were advanced to depths of 31.5 and 55 feet below existing ground surface (bgs), respectively.

Lithos subcontracted Vine Laboratories, Inc. from Commerce City, Colorado to drill LE-101 and Drilling Engineers from Fort Collins, Colorado to drill TB-3700. Each drilling company utilized a CME 55 truck mounted drilling rig. Drilling and sampling procedures were conducted in general accordance with ASTM D1586 – *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*, ASTM D3550 – *Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils*. Continuous-flight, hollow-stem augers and solid-stem augers were used to advance borings below the existing ground

surface to the maximum depth of exploration. During advance of the augers, Modified California or Split Spoon samples (2.0-inch, 1.4-inch inner diameter) were obtained at 2.5- to 5-foot intervals. The number of blows by a 140-pound hammer falling 30-inches required for 12 inches of sampler penetration (recorded in 6-inch increments) are presented on the boring logs (Appendix A).

## 2.2 Geotechnical Laboratory Testing

A geotechnical laboratory testing program was developed by Lithos. Martinez Associates performed laboratory testing on representative samples collected during the subsurface investigation for LE-101, and Kumar & Associates performed the laboratory testing on samples collected during the subsurface investigation for TB-3700. The geotechnical laboratory testing results are presented in Appendix B. Geotechnical laboratory tests were conducted in general accordance with local practice. If field characterized soil and bedrock descriptions differed from results indicated by laboratory classification testing, the boring logs presented in Appendix A were amended to reflect laboratory testing results.

# 3 SUBSURFACE CONDITIONS

Subsurface conditions were assessed based on the findings of the geotechnical investigation described in the previous section. Soil and rock descriptions noted on the boring logs and below are in general accordance with ASTM D2487 – *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)* and D2488 – *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. Boring logs and a supplementary boring log key explaining boring log details are provided in Appendix A.

## 3.1 Regional Geology

Geologic mapping of the greater Denver area by Trimble and Machette (1979) indicates the Project area is underlain by Holocene Post-Piney Creek and Piney Creek alluvium and Paleocene and Upper Cretaceous Denver Formation. The alluvium is described as gravel, sand, silt, and clay of modern stream flood plains and older terraces. The Denver Formation is described as claystone, siltstone, sandstone, and conglomerate composed of altered andesitic debris.

## 3.2 Subsurface Conditions

Primary materials encountered in borings LE-101 and TB-3700 include fill, coarse alluvium, fine alluvium, and Denver Formation bedrock.

### 3.2.1 Fill

Fill was encountered in boring LE-101 at the ground surface and extended to a depth of 4 feet bgs. Based on our understanding of the historical site development, we assume the fill at the site is related to aggregate mining associated with West Sprat Platte Lake and/or nearby slurry wall construction activities. Records of fill placement observation and associated materials testing have not been provided for our review and as such, the fill should be considered uncontrolled. Encountered fill was classified as brown sandy lean clay with gravel in accordance with USCS:

### 3.2.2 Coarse Alluvium

Coarse alluvium was encountered below the fill in boring LE-101 and at the ground surface in TB-3700. The coarse alluvium extended to a depth of 38 feet bgs in boring TB-3700 and to the depth explored of

31.5 feet in boring LE-101. Encountered coarse alluvium was classified as the following in accordance with USCS:

- Silty Sand (SM)
- Poorly Graded Sand (SP) with varying gravel content
- Poorly Graded Sand with Silt (SP-SM) and varying gravel content

Coarse alluvium was comprised of fine to coarse sand with varying amounts of silt and gravel. Blow counts in the coarse alluvium ranged from 10 blows per foot (bpf) to 88 blows per 9 inches, indicating a relative density of loose to very dense. The collected coarse alluvium samples were further described as pale olive to brown and dry to wet.

### 3.2.3 Fine Alluvium

Fine alluvium was encountered below approximately 13 to 14 feet in each boring and extended to depths of 29 to 34 feet bgs in borings LE-101 and TB-3700, respectively. Encountered fine alluvium was classified as the following in accordance with USCS:

- Lean Clay (CL) with varying sand content
- Fat Clay (CH) with varying sand content

Fine alluvium was comprised of clay with varying amounts of sand. Blow counts in the fine alluvium ranged from 5 to 14 blows per foot of sampler penetration indicating a relative consistency of medium stiff to stiff. The fine alluvium was further described as pale olive, gray, and moist.

### 3.2.4 Bedrock

Siltstone and claystone bedrock of the Denver Formation was encountered in boring TB-3700 below the coarse alluvium and extended to the depths of exploration of 55 feet. The bedrock was generally very soft to soft, slightly weathered to fresh, and olive yellow to bluish gray. Blow counts in the bedrock ranged from 48 blows per foot (bpf) to 50 blows per 3 inches,

### 3.2.5 Groundwater

A temporary monitoring well was installed in TB-3700. Groundwater levels in TB-3700 collected approximately 1 week after drilling and approximately monthly thereafter through April 23, 2022 indicated groundwater level fluctuations between depths of approximately 14.8 and 18.0 feet bgs, corresponding to an elevation of approximately 5,055 feet to 5,052 feet.

Groundwater was encountered in LE-101 during drilling at a depth of approximately 11.4 feet bgs, corresponding to an elevation of approximately 5,061 feet.

Fluctuations in groundwater levels may occur due to variations in the water level of nearby bodies of water, precipitation, seasonal moisture variations, temperature, future site development and other factors not evident at the time that these measurements were made.

# 4 GEOTECHNICAL DESIGN RECOMMENDATIONS

The following sections are included primarily for the engineer performing design. If additional geotechnical design recommendations are necessary, Lithos should be contacted to provide the required information.

## 4.1 Vault Foundations

Based on our understanding of the proposed PRV, meter vault, and manhole structure elevations and the results of our subsurface investigation, we anticipate both structures will bear at least 10 feet deep within loose coarse alluvium or medium stiff fine alluvium. We recommend the vaults are supported on a minimum 1-foot thick zone of moisture conditioned and compacted granular Select Fill extending to native soil. For vault and manholes foundations bearing on Select Fill, Lithos recommends the following design criteria for mat foundations:

- The foundation should be designed using a maximum allowable bearing pressure of 1,800 psf. This value includes appropriate allowable-stress-design (ASD) safety factors.
- The foundation should be designed to withstand a total vertical movement of 1 inch and differential movements of 0.5 inches.
- It is acceptable to increase the net allowable bearing capacity by one-third if the load combination utilized considers infrequent loads such as wind or earthquake. Snow loading is not considered an infrequent load condition.
- Sliding friction between anticipated subgrade and foundation materials should be evaluated using a coefficient of 0.4.
- The coefficient of subgrade reaction (k) is typically used for flexible foundation analysis and describes the load intensity per unit of displacement. For granular select fill, a k value of 100 psi/in is recommended.

## 4.2 Lateral Earth Pressures

Lateral earth pressures presented below should be considered during the structural design process for vault walls and foundation elements extending below grade. Lateral earth pressure values are a function of the properties and the geometry of the retained fill, soil, and/or bedrock and anticipated magnitude of lateral deflection. In addition, the presence of groundwater and saturated materials will increase the total horizontal stress, resulting in higher lateral earth pressures in comparison to retained materials above a groundwater table.

| Static Lateral Earth Pressures | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Backfill Material Type** | **Static Earth Pressure Coefficients** | | | **Static Equivalent Fluid Pressure (pcf)** | | | | | |
| | | | | **Active** | | **At-Rest** | | **Passive** | |
| | **Active** | **At-Rest** | **Passive** | **Above GWT[1]** | **Below GWT[1]** | **Above GWT[1]** | **Below GWT[1]** | **Above GWT[1]** | **Below GWT[1]** |
| Select Fill | 0.33 | 0.50 | 3.00 | 42 | 83 | 63 | 94 | 375 | 250 |

[1] GWT stands for Groundwater Table

In order for the lateral earth pressures presented above to remain applicable, backfill material placement adjacent to below-grade walls should be in accordance with procedures outlined in Section 4. In addition, backfilled material must be placed within a 1 horizontal to 1 vertical (1H:1V) backfill geometry, up and away from the base of the structure. We recommend a design ground water elevation of 5,063 feet for the vaults and manholes (approximate 100-year flood elevation on the adjacent segment of the South Platte River).

Consideration has not been given to vertical loads applied to the backfill surfaces during or after construction as a result of traffic and/or other surcharge loads or sloping backfill.

## 4.3 Frost Protection

In colder climates, certain soils can freeze and can cause heave resulting in larger than expected differential movement. Shallow foundations in non-heated areas should have a minimum cover of 36 inches for frost protection in accordance with the Adams County Building Code.

## 4.4 Geotechnical Parameters for Counteracting Buoyancy

Structures which extend below the highwater elevation should be evaluated for buoyancy. We recommend a design ground water elevations as noted in Section 4.2 corresponding to nearby 100-year flood elevations. Where the structure loads are not sufficient to counteract buoyancy, additional resistance to uplift can be achieved by extending the mat or footing foundations outside the vertical walls and engaging the weight of an additional wedge of soil. For design purposes, the wedge of soil providing resistance on the extended foundation can be defined by including the soil within a 12-degree slope (measured from vertical) up and away from the bottom exterior edge of the extended footing to the ground surface. A saturated unit weight of 120 pcf may be used for the soil wedge if the buoyant force on the structure includes the weight of water displaced by the soil wedge. If the buoyant force on the structure does not include the weight of water displaced by the soil wedge, i.e. only the volume of water that is displaced by the structure itself, then a soil unit weight of 55 pcf should be used.

## 4.5 Seismic Site Classification

Based on the International Building Code and the American Society of Civil Engineers Minimum Design Loads for Buildings and other Structures, our subsurface investigation, and our experience and knowledge of seismic conditions in the area, a Site Classification C is recommended for seismic design.

## 4.6 Water Soluble Sulfate

Water soluble sulfate testing was conducted on one sample of fine alluvium. The test result was 0.05%, which would characterize the concrete risk as “Not Applicable” as shown in the table below. These results should be considered when developing the concrete mix design specifications.

| American Concrete Institute Code 318-08 Water Soluble Sulfates | | |
|---|---|---|
| **Class** | **Water-Soluble Sulfate in Soil $SO_4$, Percent by Weight** | **Risk** |
| S0 | $SO_4$ <0.10 | Not Applicable |
| S1 | 0.10< $SO_4$ <0.20 | Moderate |
| S2 | 0.20< $SO_4$ <2.00 | Severe |
| S3 | $SO_4$ >2.00 | Very Severe |

# 5 CONSTRUCTION CONSIDERATIONS

The following sections are intended for the Engineer producing specifications and the contractor constructing the proposed project. Construction considerations include temporary excavations, preparation of excavated surfaces for foundations, backfill materials, fill placement and compaction, bedrock or oversize material excavation, drilled shaft construction, and construction dewatering.

## 5.1 Temporary Excavations

General site safety including temporary excavations are the sole responsibility of the contractor performing construction. Lithos is providing temporary excavation information strictly as an informational benefit to the project team, specifically the general contractor. An Occupational Safety and Health Administration (OSHA) defined competent person should be identified by the contractor to be in charge of temporary excavations. In general, the contractor's competent person should have experience or training in determining soil types, benching and shoring, and have the ability to detect potential temporary slope stability and protective system issues.

OHSA defines an excavation as a man-made cut, trench, or depression formed by the removal of earth. A trench is a specific type of narrow excavation with a geometry including a greater depth than width and a width of 15 feet or less. Trenches 5 feet deep or greater should be sloped, retained with shoring, or shielded appropriately. Shielding most commonly includes trench boxes. In general, shoring can include inclined, horizontal, or vertical systems depending on the excavation geometry and availability of retention alternatives. Sloping and benching should be in accordance with OSHA recommendations. Benching should include a maximum 4-foot vertical face for each bench and the overall excavation geometry less than or equal to the OSHA defined slope.

A registered professional engineer should approve the contractor's approach for trenches greater than or equal to 20 feet in depth. In addition, shoring for trench excavations greater than or equal to 20 feet should be designed by a professional engineer or be based on tabulated data prepared or approved by a registered professional engineer in accordance with OSHA 1926.652(b) and (c).

Lithos has evaluated observed soil conditions likely to be penetrated by the proposed vault and manhole construction. Based on the OSHA determined soil types, the following table presents maximum recommended temporary excavation slopes to be utilized during construction.

| OSHA Temporary Excavation Slopes | | |
|---|---|---|
| **Backfill Material Type** | **OSHA Classification** | **Maximum Recommended Slope (H:V) [1,2]** |
| Fill, Coarse Alluvium, Fine Alluvium | Type C | 1½:1 |

[1] H:V is an abbreviation for Horizontal:Vertical

[2] Valid for trench excavations less than 20 feet in depth

During construction, heavy equipment or excavated material stockpiles should be kept away from excavation edges to the extent possible. Underground utilities should be fully understood and documented prior to initiating excavations. Finally, the contractor's competent person should inspect trenches and excavations routinely for signs of instability including sliding, toppling, subsidence and bulging, heaving or squeezing, boiling, and/or other visual concerns.

### 5.1.1 Existing Slurry Wall Considerations

Vault siting and associated excavations for the project should consider proximity to the existing slurry wall at the site. From a slope stability standpoint, we recommend any open cut excavations at the site remain outside of a 1.5(H):1(V) slope extending from a point that is offset 10 feet from outermost edge of the existing slurry walls at the site. Open excavations that extend into the zone described above present a risk of damaging the existing slurry wall. If site excavations must extend into the zone described above, the excavation should be adequately supported with tight shoring; trench boxes or open cuts should not be allowed.

## 5.2 Site Grading and Earthwork

Appropriate site preparation, material placement and compaction, and backfill selection can reduce the risk of post-construction vertical movement and potential issues related to lateral earth pressures. General site grading and earthwork considerations are presented in the following sections.

### 5.2.1 Site Preparation

Areas supporting backfill should be properly prepared. Once the rough grade has been established in excavated areas, and prior to placement of backfill, the exposed subgrade should be carefully inspected via probing and testing, as determined necessary by the geotechnical engineer on site. Frozen, wet, soft, or loose soil, as well as any other undesirable material should be removed. Once suitable soil conditions are achieved, the subgrade should be scarified and compacted prior to fill placement. The suitable exposed soil materials should be scarified and moistened or dried, as necessary, to a minimum depth of 8 inches below the proposed construction. Scarified material should be compacted to the minimum specifications defined in the following sections.

### 5.2.2 Structure Backfill Material

Backfill is anticipated below and around the vaults and manholes. The backfill should consist of Select Fill material containing less than 40 percent fines, a plasticity index less than 15, and a liquid limit less than 40. The sandy onsite fill and coarse alluvium are suitable for use as Select Fill if properly processed as discussed below. The onsite fine alluvium will need to blended with onsite granular soil to meet the requirements of Select Fill. Excavated bedrock should not be used as backfill, but may be appropriate for use as general site fill on a case-by-case basis as approved by the geotechnical engineer.

Processing on-site material shall include removing expansive materials, frozen chunks, wood, trash, organic material, and cobbles and boulders larger than 3 inches in diameter. If another material is preferred for any of the presented applications, Lithos should be contacted to review submitted particle size distribution, Atterberg Limits testing results, and swell testing results.

### 5.2.3 Fill Placement and Compaction

We recommend fill placement occurs in maximum 8-inch loose lifts for fill under and backfill adjacent to structures. Minimum recommended compaction specifications are outlined in the following table.

| Soil Compaction Recommendations | | |
|---|---|---|
| **Backfill Material Type** | **Moisture and Compaction Specifications** | |
| | **Moisture Content[1]** | **Dry Density[2]** |
| Granular Soils | -2% to +2% | ≥ 95% |
| Cohesive Soils | -2% to +2% | ≥ 95% |

[1] Moisture content relative to the optimum moisture content as determined by ASTM D698

[2] Dry density relative to the maximum dry density as determined by ASTM D698

Mechanical compaction is required for all materials placed as backfill during construction. Compaction of cohesive materials is best accomplished with equipment such as a jumping jack or padfoot roller. Non-cohesive (granular) soils are best compacted with a vibratory plate or vibratory smooth-drum roller. Compaction utilizing any flooding type technique is not recommended. Care should be taken when compacting fill adjacent to structures. Generally, we recommend operating only light-weight compaction equipment such as jumping jacks and vibratory plates immediately adjacent to structures.

### 5.2.4 Bedrock or Oversized Material Excavation

Based on the subsurface investigation, bedrock below the proposed vaults and manholes at the site was classified as claystone and siltstone. Bedrock excavation is not anticipated during proposed construction activities.

## 5.3 Construction Dewatering

Groundwater was encountered during the subsurface investigation. Temporary construction dewatering should be anticipated for the proposed construction at locations where excavations extend below potential groundwater, including the vaults and manholes. Lithos is available to assist with dewatering design if required. Construction dewatering must adhere to the Colorado Department of Public Health and Environment (CDPHE) regulations and discharge permit requirements. Deep wells and/or well points will likely be required to lower the groundwater table beneath the excavation limits, and significant volumes of water could be generated. Dewatering should be carefully evaluated and accounted for in the construction estimate to avoid construction cost and time increases.

# 6 CONSTRUCTION OBSERVATION AND QUALITY ASSURANCE

Lithos anticipates the primary geotechnical components of construction will include excavations and backfill below the proposed foundation elements. Quality assurance of backfill material and backfill placement will be necessary to reduce potential for long term differential settlements. Inspection of subgrade materials prior to placing or forming and casting structural elements is also critical to project success. Lithos recommends a qualified testing agency is retained to provide quality assurance services during the backfill process. Lithos anticipates remaining involved in the project and providing geotechnical-related guidance throughout the design and construction of the project.

# 7 LIMITATIONS

This study was conducted in accordance with generally accepted geotechnical engineering and engineering geologic practices and principals; no warranty, express or implied is made. The subsurface conditions described in this report were based on data obtained from widely spaced exploratory borings, geotechnical laboratory testing, information provided by the client, engineering judgement, and our experience with similar subsurface conditions and projects. The boring logs presented in this report only depict the subsurface conditions at the actual boring locations. Subsurface conditions are typically variable, both laterally and vertically, and the nature and extent of the subsurface variations across the site may not become evident until construction. The boundaries between different soil types and bedrock presented in this report are approximate and, in some cases, may be more abrupt or gradational than described herein. Groundwater levels may vary with time, adjacent surface water levels, precipitation, and changes to the hydrogeological conditions at or surrounding the project site.

This report has been prepared exclusively for our client for design purposes for the subject project. Lithos Engineering is not responsible for technical interpretations by others of the data presented in this report or use of this report by others for the subject project or other projects. If differing site conditions are encountered during further evaluation of the subsurface conditions by others or during construction, Lithos Engineering should be notified immediately to determine if any changes to our recommendations presented in this report are warranted.

The recommendations presented in this report are only intended for the proposed design and construction as understood by Lithos Engineering at the time of issuing this report. If the proposed design and construction changes, Lithos Engineering should be notified immediately and given the opportunity to review the proposed changes and if necessary, modify our recommendations presented herein.

An environmental assessment was not included in Lithos Engineering scope of work for this project. Any statements regarding the absence or presence of hazardous and/or toxic substances presented herein are only intended for informational purposes. If the client is concerned about the environmental conditions at the site, Lithos Engineering recommends the client and/or owner retain a qualified environmental firm to conduct an environmental site assessment.

## REFERENCES


- ASTM Standards, ASTM International, West Conshohocken, PA (2012).
- Colorado Association of Geotechnical Engineers (CAGE), 1996, Guideline for slab performance risk evaluation and residential basement floor system recommendations, Guideline 1.
- Trimble, D.E. and M.N. Machette, 1979, Geologic Map of the greater Denver area, front range urban corridor, Colorado, US Geological Miscellaneous Investigations Series Map I-856-H, scale 1:100,000.

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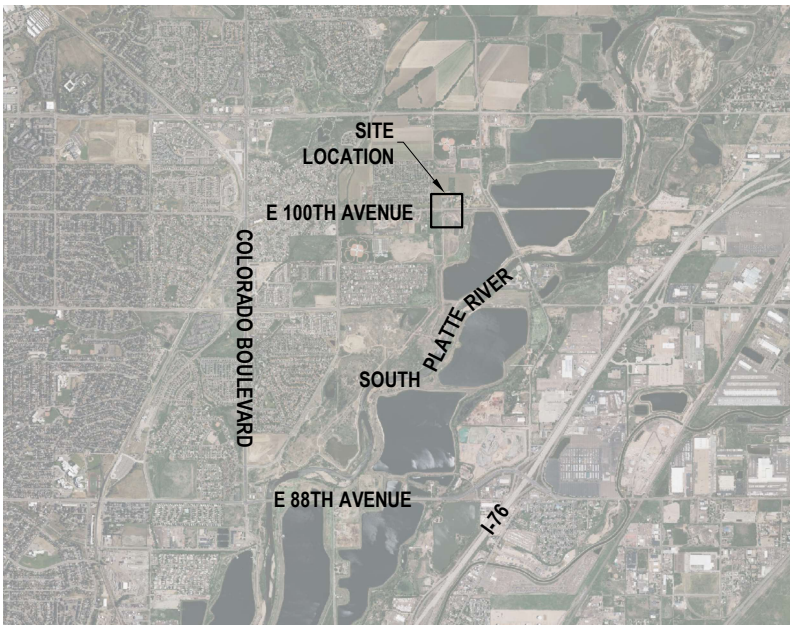
# FIGURES

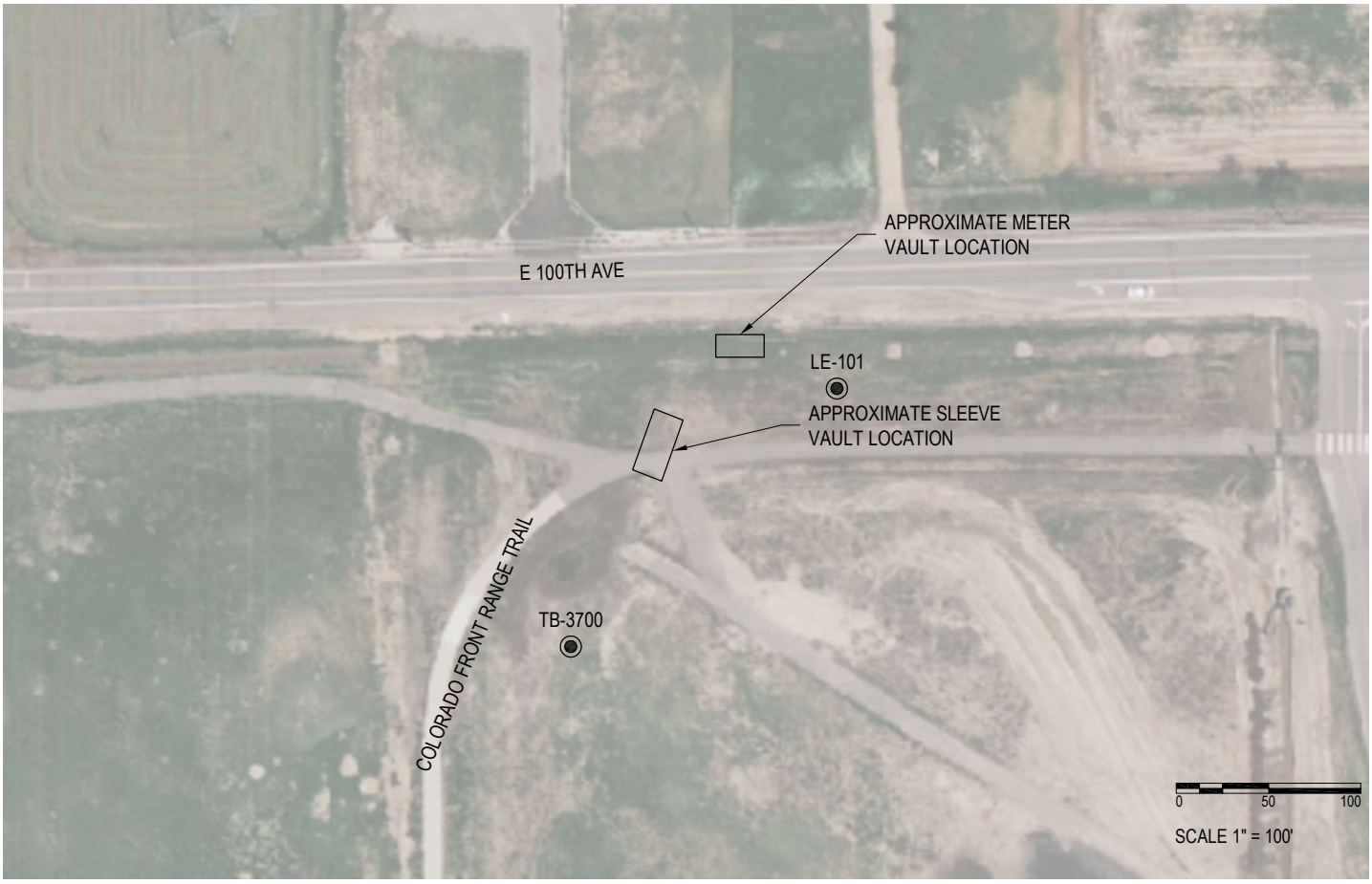



SITE VICINITY MAP

LEGEND:

LE-101 APPROXIMATE VAULT BORING LOCATION

TB-3700 TWP THORNTON REACH, PH. 2 BORING LOCATION




BORING LOCATIONS

LITHOS ENGINEERING
2750 S WADSWORTH BLVD, SUITE D-200
DENVER, COLORADO 80227
303.625.9502

PROJECT TITLE: COOLEY PRV & METER VAULT STRUCTURES, THORNTON WATER PROJECT

DRAWING TITLE: SITE VICINITY AND BORING LOCATIONS

OWNER: City of Thornton

CLIENT: carollo

| | | | |
|---|---|---|---|
| PROJECT NO.: | 21207 | DRAWN BY: | AR |
| LOCATION: | THORNTON, CO | DESIGNED BY: | AR |
| DATE: | 09/02/2022 | CHECKED BY: | DM |

FIGURE NUMBER: 1

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# APPENDIX – A

## Standard Geotechnical Drilling Keys and Boring Logs

# BORING LOG KEY

## *STANDARD GEOTECHNICAL DRILLING*

## Soil Classifications:

| Clear Square Sieve Openings | | | | U.S. Standard Series Sieve Sizes | | | |
|---|---|---|---|---|---|---|---|
| 12" | 3" | 3/4" | 4 | 10 | 40 | 200 | |
| Boulders | Cobbles | Gravel | | Sand | | | Silts and Clays |
| | | Coarse | Fine | Coarse | Medium | Fine | |
| 300mm | 75mm | 19mm | 4.75mm | 2.0mm | 0.42mm | 0.075mm | |

| Gradation Estimates by Field Observation | |
|---|---|
| **Description** | **Quantity (%)** |
| Trace | <5 |
| Few | 5 to 10 |
| Little | 15 to 25 |
| Some | 30 to 45 |
| Mostly | > 50 |

| Relative Density or Consistency of Non-cohesive and Cohesive Soils | | | |
|---|---|---|---|
| **Non-cohesive Soils** | | **Cohesive Soils** | |
| **Classification** | **Blows per 12 in** | **Classification** | **Blows per 12 in** |
| Very Loose | 0 to 4 | Very Soft | 0 to 2 |
| Loose | 5 to 10 | Soft | 3 to 4 |
| Medium Dense | 11-30 | Medium Stiff | 5 to 8 |
| | | Stiff | 9 to 15 |
| Dense | 31 to 50 | Very Stiff | 16 to 30 |
| Very Dense | >50 | Hard | >30 |

**Color:** Sample colors are in general accordance with basic brown, red, yellow, and gray combinations

| Description of Moisture | |
|---|---|
| **Description** | **Criteria** |
| Dry | Absence of moisture, dusty, dry to the touch |
| Moist | Damp but no visible water |
| Wet | Visible free water, usually soil below the groundwater table |

| Plasticity | |
|---|---|
| **Description** | **Criteria** |
| Nonplastic | A $\frac{1}{8}$" diameter thread cannot be rolled |
| Low | A $\frac{1}{8}$" in diameter thread can be rolled with difficulty; a lump cannot be formed at a moisture lower than the plastic limit |
| Medium | A $\frac{1}{8}$" in diameter thread can be rolled easily; a crumbly lump can be formed at a moisture lower than the plastic limit |
| High | A $\frac{1}{8}$" in diameter thread can be rolled very easily; a lump can be formed at a moisture lower than the plastic limit |

| Description of Odor | |
|---|---|
| **Description** | **Criteria** |
| No Organic Odor | Organic odor is not present |
| Trace Organic Odor | Mild organic odor; mixture of soil and organics |
| Strong Organic Odor | Prominent organic odor; sample is primarily organic |

| Cementation | |
|---|---|
| **Description** | Criteria |
| Weak | Crumbles with light finger pressure |
| Moderate | Crumbles with considerable finger pressure |
| Strong | Will not crumble with finger pressure |

## Rock Descriptions:

| Weathering | |
|---|---|
| **Description** | **Criteria** |
| Fresh | No visible sign of rock material weathering: perhaps slight discoloration on major discontinuity surfaces. |
| Slightly Weathered | Discoloration of rock material on discontinuity surfaces. |
| Moderately Weathered | Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as corestones. |
| Highly Weathered | More than half of the rock material is decompsed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones |
| Completely Weathered | All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact. |

| Texture | |
|---|---|
| **Description** | **Criteria** |
| Very Fine Grained | Grains not individually visible to the unaided eye |
| Fine Grained | Grains barely visible to the unaided eye, up to $\frac{1}{16}$" diameter |
| Medium Grained | Grain diameter between $\frac{1}{16}$" and $\frac{3}{16}$" |
| Coarse Grained | Grains diameter between $\frac{3}{16}$" and $\frac{1}{4}$" |
| Very Coarse Grained | Grains larger than $\frac{1}{4}$" in diameter |

| Field Hardness | |
|---|---|
| **Description** | **Criteria** |
| Very Hard | Cannot be scratched with a knife or sharp pick. |
| Hard | Can be scratched with a knife or pick only with difficulty |
| Medium | Can be gouged $\frac{1}{16}$" deep by firm pressure on knife or pick point |
| Soft | Can be grooved or gouged readily with knife or pick point |
| Very Soft | Can be carved with knife and scratched readily by fingernail |

## Geologic Interpretation:

A ***Geologic Interpretation*** of encountered soil and bedrock units is provided for each specific ***Visual Material Description***. Examples of geologic interpretations for soil that may be presented include: FILL, ALLUVIUM, AEOLIAN, AND GLACIAL TILL, AND RESIDUUM. Rock geologic interpretations are referenced based on a combination of field classifications and applicable geologic maps.

## Sample Graphics and Descriptions:

California Barrel Sampler: Barrel sampler loaded with sample liners and driven to collect a relatively representative and intact specimen of soil or weak rock.

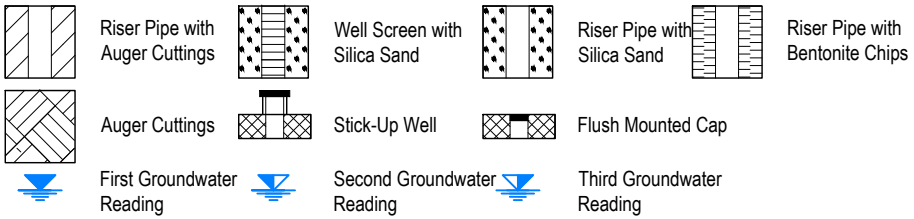
Split-Spoon Sampler: Split-barrel sampler driven in accordance with ASTM D1586 used to provide visual material descriptions and collect a disturbed specimen.

Shelby Tube Sampler: Thin wall tube hydraulically pushed into the subsurface to collect a representative and intact specimen of soil.

Bulk Sample: Bulk or bagged sample taken from auger cuttings.

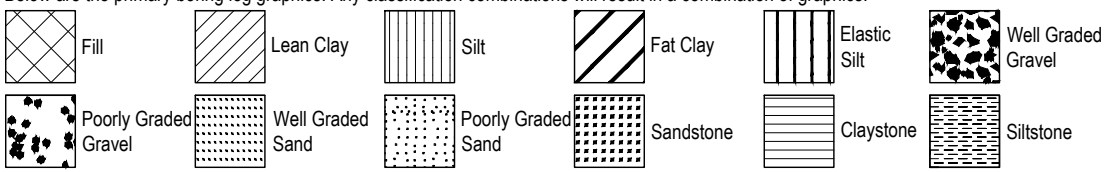
Continuous Sampler: A 5-foot long sampler barrel that is driven to collect a continuous 5-foot run of cohesive and non-cohesive soil.

## Groundwater Monitoring Well Graphics:




## Boring Graphics:

Below are the primary boring log graphics. Any classification combinations will result in a combination of graphics.




LITHOS ENGINEERING

# BORING: LE-101

**Project Name:** TWP Cooley PRV and Meter
**Project Number:** 21207
**Client's Name:** Carollo
**Owner's Name:** City of Thornton
**Drilling Subcontractor:** Vine Laboratories
**Lithos Representative:** A. Ristuccia
**Date(s) of Drilling:** 7/27/22

## Drilling and Sampling Methods

**Drill Make and Model:** CME 55 Truck Mount
**Drilling Method:** SSA
**Bit Type:** Cutting Head
**Casing Description:** N/A
**Hammer Weight (lbs)/Fall (in):** 140 lb / 30 in
**Sampler Type(s):** Mod. Cal, Split Spoon
**Sampler Diameter(s):** 2.0 in, 1.4 in

LITHOS ENGINEERING

**Boring Location:** 39.8778, -104.9208
**Boring Elevation:** 5,070 +/-
**Notes:** Location from Google Earth, Elevation from TWP Seg A Phase 2 Topo

| Depth (ft) | Elevation (ft) | Sample Identification | Blow Count/6 in | Recovery (in) / RQD (%) | Drilling Rate (min./ft.) | Geologic Graphic | Visual Material Description | Groundwater Depth / Monitoring Well Configuration | Moisture Content (%) | Dry Unit Weight (pcf) | Water Soluble Sulfates (%) | Gravel Content (%) | Sand Content (%) | Fines Content (%) | Liquid Limit (%) | Plasticity Index (%) | UCS (psf) | Swell Pressure (psf) | Swell Percent (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5070 | | | | | | **FILL**<br>Sandy LEAN CLAY with Gravel (CL), little fine to coarse sand, little fine gravel, brown, dry | | | | | | | | | | | | |
| | | | | | | | 4.0 ft. | | | | | | | | | | | | |
| 5 | 5065 | | 11<br>16<br>22 | 14 | | | **COARSE ALLUVIUM**<br>Silty SAND with Gravel (SM), mostly fine to coarse sand, few to little gravel up to 1 in, little silt, dense, brown, dry | | | | | | | | | | | | |
| 10 | 5060 | | 13<br>20<br>26 | 15 | | | As above, little gravel up to 1 in | (11.4 ft.) | | | | 22.6 | 59.3 | 18.1 | | | | | |
| | | | | | | | 13.0 ft. | | | | | | | | | | | | |
| 15 | 5055 | | 5<br>7 | NR | | | **FINE ALLUVIUM**<br>LEAN CLAY with sand (CL), little to some sand, stiff, gray, moist, sample retrieved with split spoon following no recovery with Mod Cal sampler | | 22.9 | | 0.05 | | | 73 | 38 | 15 | | | |
| 20 | 5050 | | 5<br>7 | 8 | | | As above except few sand. | | 25.4 | 94.5 | | | | 90.7 | 45 | 24 | | 0 | -0.1 |
| 25 | 5045 | | 6<br>8 | 6 | | | As above | | | | | | | | | | | | |
| | | | | | | | 29.0 ft. | | | | | | | | | | | | |
| 30 | 5040 | | 5<br>8<br>9<br>11<br>16 | 6<br>8 | | | **COARSE ALLUVIUM**<br>Poorly Graded SAND with Gravel, mostly fine to coarse sand, some fine to coarse gravel up to 2 in, medium dense, wet, red-brown | | | | | | | | | | | | |
| | | | | | | | 31.5 ft. | | | | | | | | | | | | |

**General Notes:**
1) Soil classificaitons are in general accordance with ASTM D2487
2) The maximum particle size identified in the material description is dependent on sampler dimensions.
3) Additional information is provided on the Boring Log Key.
4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

**Groundwater Data:**

| Date: | Elapsed Time: | Depth to Groundwater: |
|---|---|---|
| 7/27/22 | 0 hr | 11.4 ft |
| | | |
| | | |

# BORING: LE-101

**Project Name:** TWP Cooley PRV and Meter
**Project Number:** 21207
**Client's Name:** Carollo
**Owner's Name:** City of Thornton
**Drilling Subcontractor:** Vine Laboratories
**Lithos Representative:** A. Ristuccia
**Date(s) of Drilling:** 7/27/22

## Drilling and Sampling Methods

**Drill Make and Model:** CME 55 Truck Mount
**Drilling Method:** SSA
**Bit Type:** Cutting Head
**Casing Description:** N/A
**Hammer Weight (lbs)/Fall (in):** 140 lb / 30 in
**Sampler Type(s):** Mod. Cal, Split Spoon
**Sampler Diameter(s):** 2.0 in, 1.4 in

LITHOS ENGINEERING

**Boring Location:** 39.8778, -104.9208
**Boring Elevation:** 5,070 +/-
**Notes:** Location from Google Earth, Elevation from TWP Seg A Phase 2 Topo

| Sampling Data | | | | | | | Visual Material Description | Groundwater Depth / Monitoring Well Configuration | Laboratory Testing Results | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | In-Situ States | | | INDEX DATA | | | | | Strength & Compressibility | | |
| Depth (ft) | Elevation (ft) | Sample Identification | Blow Count/6 in | Recovery (in) / RQD (%) | Drilling Rate (min./ft.) | Geologic Graphic | | | Moisture Content (%) | Dry Unit Weight (pcf) | Water Soluble Sulfates (%) | Gravel Content (%) | Sand Content (%) | Fines Content (%) | Liquid Limit (%) | Plasticity Index (%) | UCS (psf) | Swell Pressure (psf) | Swell Percent (%) |
| | | | | | | | **Soil:**<br>**-GEOLOGIC INTERPRETATION-**<br>USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions<br><br>**Rock:**<br>**-GEOLOGIC INTERPRETATION-**<br>Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions | | | | | | | | | | | |
| | | | | | | | **END OF EXPLORATION** | | | | | | | | | | | | | |
| 35 | 5035 | | | | | | | | | | | | | | | | | | | |
| 40 | 5030 | | | | | | | | | | | | | | | | | | | |
| 45 | 5025 | | | | | | | | | | | | | | | | | | | |
| 50 | 5020 | | | | | | | | | | | | | | | | | | | |
| 55 | 5015 | | | | | | | | | | | | | | | | | | | |
| 60 | 5010 | | | | | | | | | | | | | | | | | | | |

**General Notes:**

1) Soil classificaitons are in general accordance with ASTM D2487
2) The maximum particle size identified in the material description is dependent on sampler dimensions.
3) Additional information is provided on the Boring Log Key.
4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

**Groundwater Data:**

| Date: | Elapsed Time: | Depth to Groundwater: |
|---|---|---|
| 7/27/22 | 0 hr | 11.4 ft |
| | | |
| | | |

# BORING: TB-3700

**Project Name:** TWP, Thornton Reach, Ph. 2
**Project Number:** 19049
**Client's Name:** AECOM
**Owner's Name:** City of Thornton
**Drilling Subcontractor:** Drilling Engineers
**Lithos Representative:** J. Halverson
**Date(s) of Drilling:** 09/24/21

## Drilling and Sampling Methods

**Drill Make and Model:** CME 55
**Drilling Method:** Hollow Stem Auger
**Bit Type:** Cutting Head
**Casing Description:** Hollow Stem Auger
**Hammer Weight (lbs)/Fall (in):** 140/30
**Sampler Type(s):** Mod. Cal., SPT
**Sampler Diameter(s):** 2.0 inches, 1.4 inches

LITHOS ENGINEERING

**Boring Location:** 800' W of West Sprat Platte
**Boring Elevation:** 5069.73 feet
**Notes:** Boring elevation from AECOM plan and profile drawings.

## Visual Material Description

**Soil:**
**-GEOLOGIC INTERPRETATION-**
USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions

**Rock:**
**-GEOLOGIC INTERPRETATION-**
Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions

| Depth (ft) | Elevation (ft) | Sample Identification | Blow Count/6 in | Recovery (in) / RQD (%) | Drilling Rate (min./ft.) | Geologic Graphic | Visual Material Description | Groundwater Depth / Monitoring Well Configuration | Moisture Content (%) | Dry Unit Weight (pcf) | Water Soluble Sulfates (%) | Gravel Content (%) | Sand Content (%) | Fines Content (%) | Liquid Limit (%) | Plasticity Index (%) | UCS (psf) | Swell Pressure (psf) | Swell Percent (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | **COARSE ALLUVIUM** Poorly Graded SAND with silt and gravel, mostly fine to coare sand, little fine gravel (SP-SM), few silt, pale olive, dry, description based on auger cuttings and borehole wall. | | | | | | | | | | | | |
| 5 | 5065 | | 3 7 | 7 | | | Poorly graded SAND with gravel (SP), mostly medium to coarse sand, little fine to coarse gravel, maximum particle size 1.25", loose, pale olive, moist. | | | | | | | | | | | | |
| 10 | 5060 | | 5 9 | 10 | | | As above except mostly fine to coarse sand, medium dense. | | | | | | | | | | | | |
| | | | 5 8 | 10 | | | Poorly graded SAND (SP), mostly fine to coarse sand, few to little fine gravel, trace silt, medium dense, pale olive, moist. | | 2 | 115 | | 14 | 83 | 3 | | | | | |
| | | | | | | | 14.0 ft. | 14.8 ft. | | | | | | | | | | | |
| 15 | 5055 | | 2 3 | 6 | | | **FINE ALLUVIUM** FAT CLAY with sand (CH), little fine sand, medium stiff, pale olive, moist. | | | | | | | | | | | | |
| | | | 3 5 | 6 | | | As above except greenish gray. | 18.0 ft. | 24 | 102 | | 0 | 20 | 80 | 58 | 40 | | | |
| 20 | 5050 | | 2 3 | 10 | | | As above. | | | | | | | | | | | | |
| | | | 5 6 | 10 | | | As above except stiff. | | | | | | | | | | | | |
| 25 | 5045 | | 2 5 | 4 | | | As above except medium stiff. | | | | | | | | | | | | |
| | | | 4 8 | 7 | | | As above except trace sand, stiff, pale olive. | | 28 | 96 | | | | 98 | 76 | 22 | | | |
| 30 | 5040 | | 4 8 | 7 | | | As above. | | | | | | | | | | | | |

**General Notes:**
1) Soil classificaitons are in general accordance with ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
2) The maximum particle size identified in the material description is dependent on sampler dimensions.
3) Additional information is provided on the Boring Log Key.
4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

**Groundwater Data:**

| Date: | Elapsed Time: | Depth to Groundwater: |
|---|---|---|
| 09/29/21 | 5 Days | 14.8 feet |
| 12/29/21 | 96 days | 18.0 feet |

# BORING: TB-3700

**Project Name:** TWP, Thornton Reach, Ph. 2
**Project Number:** 19049
**Client's Name:** AECOM
**Owner's Name:** City of Thornton
**Drilling Subcontractor:** Drilling Engineers
**Lithos Representative:** J. Halverson
**Date(s) of Drilling:** 09/24/21

## Drilling and Sampling Methods

**Drill Make and Model:** CME 55
**Drilling Method:** Hollow Stem Auger
**Bit Type:** Cutting Head
**Casing Description:** Hollow Stem Auger
**Hammer Weight (lbs)/Fall (in):** 140/30
**Sampler Type(s):** Mod. Cal., SPT
**Sampler Diameter(s):** 2.0 inches, 1.4 inches

LITHOS ENGINEERING

**Boring Location:** 800' W of West Sprat Platte
**Boring Elevation:** 5069.73 feet
**Notes:** Boring elevation from AECOM plan and profile drawings.

| Depth (ft) | Elevation (ft) | Sample Identification | Blow Count/6 in | Recovery (in) / RQD (%) | Drilling Rate (min./ft.) | Geologic Graphic | Visual Material Description | Groundwater Depth / Monitoring Well Configuration |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Soil:** **-GEOLOGIC INTERPRETATION-** USCS Classification (group symbol), particle sizes, density or consistency, color, moisture, odor, other descriptions. **Rock:** **-GEOLOGIC INTERPRETATION-** Bedrock Classification, hardness, weather, color, texture, joint size, other descriptions | |
| 35 | 5035 | | 38<br>50/3" | 16 | | | 34.0 ft.<br>**COARSE ALLUVIUM**<br>Poorly graded SAND with gravel (SP), mostly fine to coarse sand, little fine to coarse gravel, maximum particle size 1", very dense, pale olive, wet. | |
| 40 | 5030 | | 7<br>31 | 12 | | | 38.0 ft.<br>**DENVER FORMATION**<br>Siltstone, very soft, slightly weathered to fresh, olive yellow, wet. | |
| 45 | 5025 | | 44<br>50/3" | 7 | | | Claystone, soft, fresh, dark bluish gray. | |
| 50 | 5020 | | 50/4" | 4 | | | Siltstone, soft, fresh, bluish gray, mica grains present. | |
| 55 | 5015 | | 50/3" | 3 | | | Interbedded Claystone and Siltstone, soft, fresh, dark bluish gray to bluish gray.<br>55.0 ft.<br>**END OF EXPLORATION** | |
| 60 | 5010 | | | | | | | |

**Laboratory Testing Results**

| In-Situ States | | | INDEX DATA | | | | | Strength & Compressibility | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Moisture Content (%) | Dry Unit Weight (pcf) | Water Soluble Sulfates (%) | Gravel Content (%) | Sand Content (%) | Fines Content (%) | Liquid Limit (%) | Plasticity Index (%) | UCS (psf) | Swell Pressure (psf) | Swell Percent (%) |
| | | | | | | | | | | |

**General Notes:**

1) Soil classificaitons are in general accordance with ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
2) The maximum particle size identified in the material description is dependent on sampler dimensions.
3) Additional information is provided on the Boring Log Key.
4) Groundwater measurements for monitoring wells present water levels at the time of drilling, highest level, and lowest level. Refer to the respective report for a complete history of groundwater values.

**Groundwater Data:**

| Date: | Elapsed Time: | Depth to Groundwater: |
|---|---|---|
| 09/29/21 | 5 Days | 14.8 feet |
| 12/29/21 | 96 days | 18.0 feet |

LITHOS ENGINEERING

# APPENDIX – B

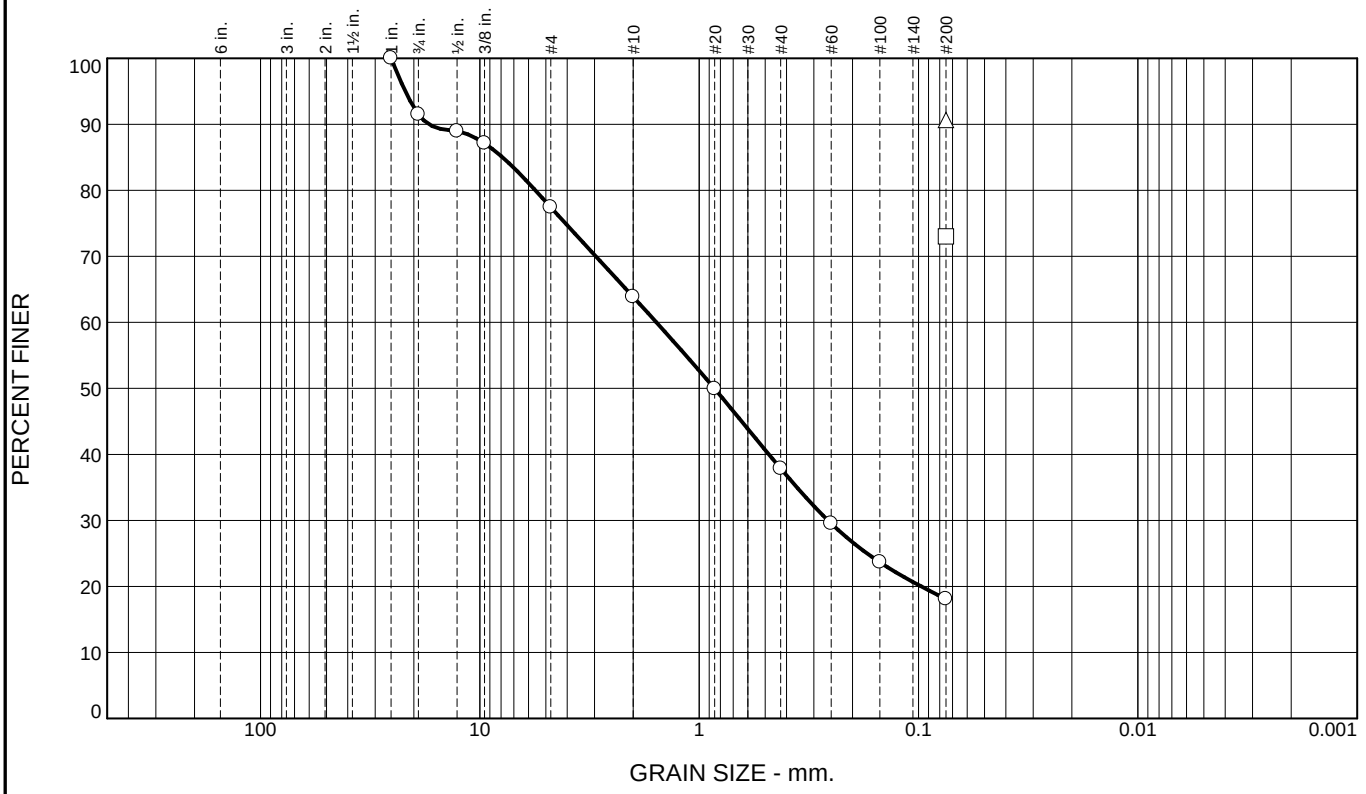
## Geotechnical Laboratory Testing Results

| Geotechnical Laboratory Testing Results | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Identification | | In-Place States | | Material Classification and Index Testing | | | | | Stress Strain Behavior | | Corrosion Properties | USCS Classification [1,2] | Description |
| | | | | Particle Size Distribution | | | Atterberg Limits (%) | | One-Dimensional Swell/Consolidation | | | | |
| Boring | Sample Depth (ft) | Moisture Content (%) | Dry Density (pcf) | Gravel (%) | Sand (%) | Fines (%) | Liquid Limit | Plasticity Index | Swell (%) | Swell Pressure (psf) | Water Soluble Sulfates (%) | | |
| LE-101 | 9.0-10.5 | | | 22.6 | 59.3 | 18.1 | | | | | | SM | Silty Sand with Gravel |
| LE-101 | 14.0-15.0 | 22.9 | | | | 73.0 | 38 | 15 | | | 0.05 | CL | Lean Clay with Sand |
| LE-101 | 19.0-20.0 | 25.4 | 94.5 | | | 90.7 | 45 | 24 | -0.1 | 0 | | CL | Lean Clay |
| TB-3700 | 12.0-13.0 | 2.0 | 114.6 | 14 | 83 | 3 | | | | | | SP | Poorly Graded Sand |
| TB-3700 | 16.5-17.5 | 24.1 | 101.8 | 0 | 20 | 80 | 58 | 40 | | | | CH | Fat Clay with Sand |
| TB-3700 | 26.5-27.5 | 27.6 | 95.9 | | | 98 | 76 | 54 | | | | CH | Fat Clay |

[1] Where Atterberg Limits and fines content testing were not performed, USCS classifications were visually determined in the field during the subsurface investigation

[2] "BR" is used in place of USCS classifications for bedrock

# Particle Size Distribution Report




| | +3" | % GRAVEL | % SAND | % SILT | % CLAY | USCS | LL | PL | PI |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 0.0 | 22.6 | 59.3 | 18.1 | | | | | |
| □ | | | | | | | 38 | 23 | 15 |
| △ | | | | | | | 45 | 21 | 24 |

| SIEVE inches size | PERCENT FINER ○ | □ | △ |
|---|---|---|---|
| 1" | 100.0 | | |
| 3/4" | 91.5 | | |
| 1/2" | 89.0 | | |
| 3/8" | 87.1 | | |
| GRAIN SIZE | | | |
| $D_{60}$ | 1.5665 | | |
| $D_{30}$ | 0.2587 | | |
| $D_{10}$ | | | |
| COEFFICIENTS | | | |
| $C_c$ | | | |
| $C_u$ | | | |

| SIEVE number size | PERCENT FINER ○ | □ | △ |
|---|---|---|---|
| #4 | 77.4 | | |
| #10 | 63.9 | | |
| #20 | 49.9 | | |
| #40 | 37.9 | | |
| #60 | 29.5 | | |
| #100 | 23.7 | | |
| #200 | 18.1 | 73.0 | 90.7 |

Material Description

○

□

△

REMARKS:

○

□

△

○ Location: LE-101 Depth: 9-10.5' Sample Number: 11244
□ Location: LE-101 Depth: 14-15' Sample Number: 11245
△ Location: LE-101 Depth: 19-20' Sample Number: 11246

Martinez Associates

Client: Lithos Engineering

Project: Thornton Water Project Cooley PRV & Meter Vault
LE Project # 21207

Project No.: 21-0198

Figure

**Martinez Associates**
14828 West 6th Avenue, Unit 9-B
Golden, Colorado 80401
Phone: (303) 459-2216
Fax: (303) 482-2230

Martinez Associates

## One Dimensional Swell/Consolidation (ASTM D 4546)

**(Denver Area Swell/Consolidation Test)**

Client Project No.: 21207 Proj. Name: Thornton Water Project Task 3.5 Cooley PRV & Meter Vault Sampled By: LE
Martinez Job No.: 21-0198 Lab Tech: T. Reid Test Date: 8/4/22 Sample Date: NP
Sample ID: 11246 Reviewed By: K. Runner
Sample Location: LE-101 at 19-20'
Soil Description:
USCS:

**Sample Data:**

| | | | |
|---|---|---|---|
| Ring No: | E | Dish No: | 32 |
| Ring Mass (g): | 237.8 | Dish Mass (g): | 8.1 |
| Sample Height (in): | 0.75 | Swell Machine #: | 5 |

| Pre-test Sample | | Post-test Sample | |
|---|---|---|---|
| Ring + Sample (g): | 306.5 | Ring + Sample (g): | 307.6 |
| Dish wt: | 8.1 | Dish wt: | 8.3 |
| Wet wt (g): | 312.3 | Wet wt (g): | 77.9 |
| Dry wt (g): | 250.7 | Dry wt (g): | 63.1 |

**Results:**

| Pre-test Sample | | Post-test Sample | |
|---|---|---|---|
| Moisture Content: | 25.4% | Moisture Content: | 27.0% |
| Wet Density (pcf): | 118.5 | Wet Density (pcf): | 123.8 |
| Dry Density (pcf): | 94.5 | Dry Density (pcf): | 97.5 |

**Swell/Consolidation**

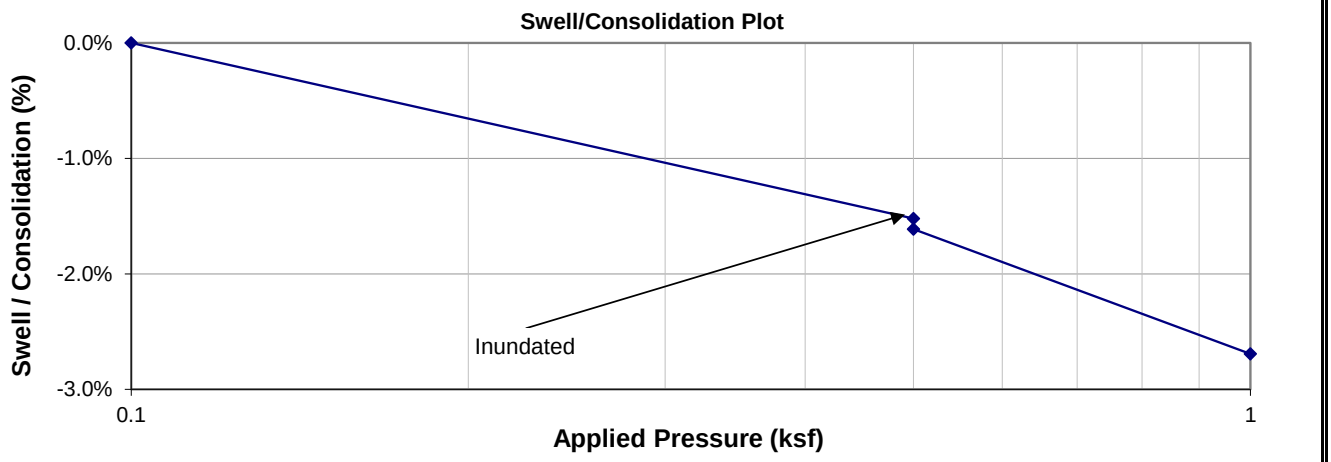
| Load (ksf): | 0.1 | 0.5 | Add Water | 0.5 | 1 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Correction (x 10-4): | 0 | 14 | | 14 | 32 | | | | |
| Dial Reading (x 10-4): | 2957 | 2829 | | 2822 | 2723 | | | | |
| Swell/Consolidation %: | **0.0%** | **-1.5%** | | **-1.6%** | **-2.7%** | | | | |

**Results:**

Settlement Upon Wetting @ 500 psf: **-0.1%**

Swell Pressure (psf): **NA**

Tested By: T. Reid
Checked By K. Runner



Martinez Associates

# Water Soluble Sulfates/Colorado Procedure- Laboratory 2103 (Method B)

| | | | |
|---|---|---|---|
| **Project:** | Thornton Water Project Task 3.5 Cooley PRV & Meter Vault | **Date:** | 8/10/2022 |
| **Sample Location:** | LE-101 at 14-15' | **Client Job No.:** | 21207 |
| **Lab ID Number:** | 11245 | **Martinez Job No.:** | 21-0198 |
| **Soil Description:** | | **Lab Technician:** | T. Reid |
| | | **Reviewed by:** | K. Runner |

| | |
|---|---|
| Sample Flask ID: | E |
| Date Test Set Up: | 8/5/2022 |
| Date in Solution: | 8/5/2022 |
| Date of Test: | 8/8/2022 |

| | | | |
|---|---|---|---|
| A | Number of Dilutions | 2 | |
| B | Final Dilution | 100 | :1 |
| C | Reading | 4 | mg/L |
| C.1 | Corrected Reading | 5 | mg/L |
| D | Sulfate Concentration ; D=(BxC.1) | 500 | ppm |
| E | Percent Sulfate Concentration E=D/10,000 | 0.05 | % |

## Moisture Content

| | |
|---|---|
| **Dish ID:** | UP |
| **Dish Mass (g):** | 165 |
| **Mass of Wet Soil+Dish (g):** | 631.3 |
| **Mass of DrySoil+Dish (g):** | 544.5 |
| **Moisture Content:** | 22.9% |