Geotechnical Engineering Report

Bona Vista (Hot Springs) 3MG Water Tank
North Ogden, Utah
September 17, 2021
Terracon Project No. 61215154

Prepared for:
Bona Vista Water Improvement District
Ogden, UT

Prepared by:
Terracon Consultants, Inc.
Midvale, Utah

September 17, 2021

Bona Vista Water Improvement District
2020 West 1300 North
Ogden, UT 84404

Attn: Mr. Blake Carlin, General Manager
P: (801) 430-1080
E: blake@bonavistawater.com

Re: Geotechnical Engineering Report
Bona Vista (Hot Springs) 3MG Water Tank
Approximately 4300 North US-89
North Ogden, Utah
Terracon Project No. 61215154

Dear Mr. Carlin:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P61215154 dated July 30, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

REGISTERED PROFESSIONAL ENGINEER
No. 313118
RICK L. CHESNUT
9/17/2021
CIVIL
STATE OF UTAH

Kristopher Powell
Staff Geologist

Rick L. Chesnut, P.E., P.G.
Senior Principal

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Bona Vista (Hot Springs) 3MG Water Tank
Approximately 4300 North US-89
North Ogden, Utah

Terracon Project No. 61215154
September 17, 2021

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed water tank to be located at Approximately 4300 North US-89 in North Ogden, Utah. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Excavation considerations
- Lateral earth pressures
- Foundation design and construction
- Site preparation and earthwork
- Seismic site classification per IBC

The geotechnical engineering Scope of Services for this project included the advancement of 2 test borings to depths ranging from approximately 10 to 40 feet below existing site grade.

Maps showing the site and boring locations are provided in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at an existing gravel quarry near US-89 and approximately 4300 North in North Ogden, Utah. Site coordinates are approximately: Latitude 41.338917° N, Longitude 112.024623° W See **Site Location**
Existing Improvements	Existing sand and gravel quarry.

Item	Description
Current Ground Cover	Grading associated with sand and gravel operations.
Existing Topography	Uneven surface with earth mounds and excavations.
Geology	Subsurface soils are sands and gravels, underlain by shale bedrock.
Seismic Hazards	The site is located within 1000 feet of a mapped[1] Quaternary fault. It appears that the site is located outside of the special study area.

1. Gary E. Christenson, Lucas M. Shaw, 2008, Geographic Information System Database Showing Geologic-Hazard Special-Study Areas, Wasatch Front, Utah

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Project information via email from JUB, via email on 7/21/21.
Project Description	A new reinforced concrete 3MG water storage tank.
Proposed Structure	The project includes construction of one 148 foot diameter tank
Building Construction	Reinforced concrete tank on ring and isolated foundations.
Finished Floor Elevation	Approximately 10 to 20 feet below adjacent grade.
Grading/Slopes	Cut slopes around portions of the perimeter of the tank
Below-Grade Structures	Partially buried tank.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	**Silty sand**	Brown, dense
2	**Silty sand with gravel**	Brown, very dense
3	**Silty gravel with sand and cobbles**	Brown, very dense
4	**Bedrock**	Reddish-brown, laminated

GEOTECHNICAL OVERVIEW

In our opinion, the site appears suitable for the proposed construction from a geotechnical engineering perspective, provided the recommendations presented in this geotechnical report are followed.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include excavations and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations and floor slabs.

The proposed water storage tank may be supported on a shallow strip and spread footing foundation system bearing uniformly on one material, such as entirely on competent bedrock, entirely on a minimum of 24 inches of properly placed and compacted structural fill, or entirely on properly prepared native soil. Differentially settlement should be expected if foundations are placed on a combination of bedrock and fill or soil.

A sub-drainage system, consisting of a layer of free-draining gravel and perforated drain pipes, should be placed below the floor slab of the tank and a perimeter drainpipe should be placed around the tank at foundation grade to collect water along the sides and bottom of the tank and discharge the water to a suitable point away from the tank and fill slopes. Further details of the sub-drain system are provided in the **Lateral Earth Pressures** section below.

The use of heavy-duty excavation and possibly ripping and blasting may be required to remove very dense soil and rock material from below the tank and within utility excavations and cut areas. An experienced contractor, familiar with performing excavation in similar materials for the height and dimensions required for this project, should be retained to perform the work. A blast design

should be prepared by a qualified designer prior to construction for bedrock excavation, as necessary. Excavation and specialty contractors should review this report and the boring logs and provide appropriate equipment to completed excavations to design grades.

Site Preparation

Prior to construction all topsoil, fill, native soil and disturbed, loose, or fragmented rock material should be removed from below planned foundation and slab areas. Exposed subgrades should be observed by the geotechnical engineer to aid in assessing conditions and to provide additional recommendations as appropriate. Exposed soils should be scarified, moisture conditioned to near optimum moisture content, and compacted to the requirements of this report. In exposed bedrock areas bearing surfaces should be free of loose and fragmented rock and should consist of competent bedrock.

The site should be initially graded to create a relatively level surface for foundations. If fill is placed below the structure, the site should be graded to provide for a relatively uniform thickness of fill beneath the entire structure footprint.

If fill is placed in areas of the site where existing slopes are steeper than 5:1 (horizontal:vertical), the area should be benched to reduce the potential for slippage between existing slopes and fills. Benches should be wide enough to accommodate compaction and earthmoving equipment, and to allow placement of horizontal lifts of fill.

Excavations

It is anticipated that excavations in soil can generally be accomplished with conventional earthmoving equipment, however, specialty heavy-duty equipment may be required in the very dense soil with cobbles. Excavations penetrating the bedrock will require the use of specialized heavy-duty equipment, with possible drilling and blasting to facilitate rock break-up and removal.

For excavation into rock material that is not able to be ripped with machinery, a blast design should be prepared by a qualified designer. Blast plans should meet the requirements of the project specifications and should, at a minimum, include the following:

- Blast location.
- Drilling pattern, including diameters, spacing, depth, and orientation of drill holes.
- Types, strengths and quantities of explosives proposed for use in each hole, on each delay and for each blast.
- Distribution of the charge in the holes, priming of each hole and stemming of holes.
- Type, sequence and number of delays, delay pattern, diagram for blast, size and type of hookup lines and lead lines and type and capacity of blast initiation device.

The contractor should perform trial blasts and or adjust the blast parameters as required by the existing rock conditions, in order to comply with project specifications and the recommendations of this report.

Blasting mats may be required to prevent adverse impact from fly rock. Blasts should be designed to not exceed a maximum peak particle velocity (largest single component) of one inch per second measured 100 feet from the blast.

Rock excavation requiring blasting should comply with UOSH Constructions Standards Chapter U rules and regulations and NFPA 495 code for the use of explosive materials.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety, or the contractor's activities; such responsibility shall neither be implied nor inferred.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below, or within 10 feet of structures or constructed slopes. General fill is material used to achieve grade outside of these areas. Earthen materials used for structural and general fill should meet the following material property requirements:

Fill Type [1]	Application	Requirements		
		Gradation		Plasticity
		Size	Percent finer by weight	
Structural Fill[2]	Below foundations, concrete slabs or other structural areas	4 inch No. 4 Sieve No. 200 Sieve	100 30 - 80 < 35	Liquid Limit 20 max Plasticity Index 5 max
Site Grading Fill	Fill in non-structural areas and below pavements	4 inch No. 200 Sieve	100 < 50	Liquid Limit 35 max Plasticity Index 15 max

1. All fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Crushed angular rock with more than 50 percent with two fractured faces as per ASTM D 5821.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used	12 inches
Minimum Compaction Requirements [1, 2, 3]	95% of the material's maximum dry density	92% of max.
Water Content Range [1]	Granular: -2% to +2% of optimum	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. High plasticity cohesive fill should not be compacted to more than 100% of standard Proctor maximum dry density.
3. If the granular material is a coarse sand or gravel, or of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254).

Utility Trench Backfill

Utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the tank should be effectively sloped to reduce the potential for water accumulation below the tank.

Grading and Drainage

All grades must provide effective drainage away from the water tank area during and after construction and should be maintained throughout the life of the structure. Water retained next to the tank can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements.

Construction Observation and Testing

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. If unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing pressure [1, 2]	3,000 psf
Required Bearing Stratum [3]	Competent bedrock, minimum of 24 inches of compacted Structural Fill, or properly prepared native soil
Minimum Foundation Dimensions	Columns: 18 inches Continuous: 12 inches
Ultimate Coefficient of Sliding Friction [5]	0.4 (structural fill or native soil) 0.50 (bedrock)
Minimum Embedment below Finished Grade [6]	30 inches
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch
Estimated Differential Settlement [2, 7]	About 3/4 of total settlement

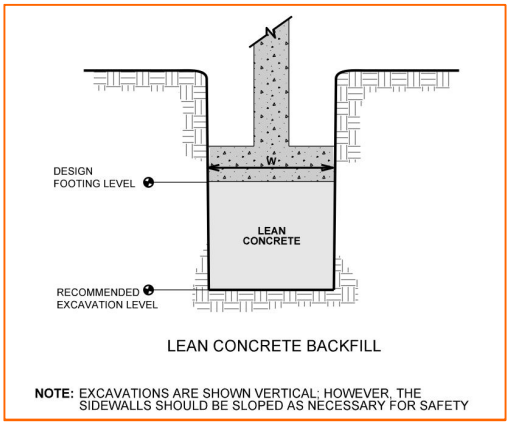
1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions.
6. Embedment necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
7. Differential settlements are as measured over a span of 50 feet.

Foundation Construction Considerations

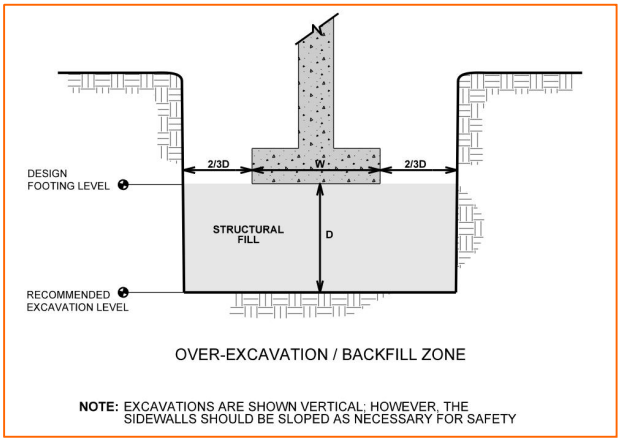
As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

If unsuitable bearing materials are encountered at the base of the planned footing excavation, the excavation should be extended deeper to suitable material, and the footings could bear directly

on these materials at the lower level or on lean concrete backfill placed in the excavations. This is illustrated on the sketch below. All foundations should bear on uniform bearing material.



Over-excavation for structural fill placement below footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with Structural Fill placed, as recommended in the **Earthwork** section.



SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil and bedrock properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is C**. Subsurface explorations at this site were extended to a maximum depth of 40 feet. The site

properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth. The site is located within 1000 feet of a mapped[1] Quaternary fault. It appears that the site is located outside of the special study area.

The National Seismic Hazard Map database was searched to identify the peak ground acceleration (PGA) and spectral accelerations for 0.2 second (Ss) and 1.0 second (S1) periods for a 2% probability of exceedance (PE) in 50 years at the project site for IBC Site Class C. These values should be adjusted for site effects using appropriate site class factors from the 2018 IBC.

Description	Value
2018 International Building Code Site Classification (IBC)	C
Risk Category of Structure(s) based on Table 1604.5	II
Site Latitude	N 41.338884 °
Site Longitude	W -112.024592 °
MCE_G PGA	0.69 g
S_s Spectral Acceleration for a Short Period	1.517 g
S_1 Spectral Acceleration for a 1-Second Period	0.552 g
F_a Site Coefficient for a Short Period	1.2
F_v Site Coefficient for a 1-Second Period	1.448
Seismic Design Category (based on S_{ds} and S_{d1}) [1]	D
F_{PGA} Site Coefficient for PGA [2]	1.2
PGA_M (MCE_G PGA adjusted for site class effects) [2]	0.828

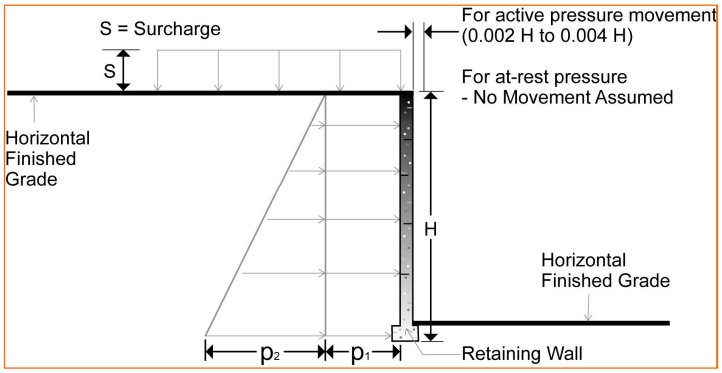
1. Based on ASCE 7-16, Section 11.6
2. Based on ASCE 7-16, Section 11.8.3

LATERAL EARTH PRESSURES

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown in the diagram below. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The “at-rest” condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls

restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



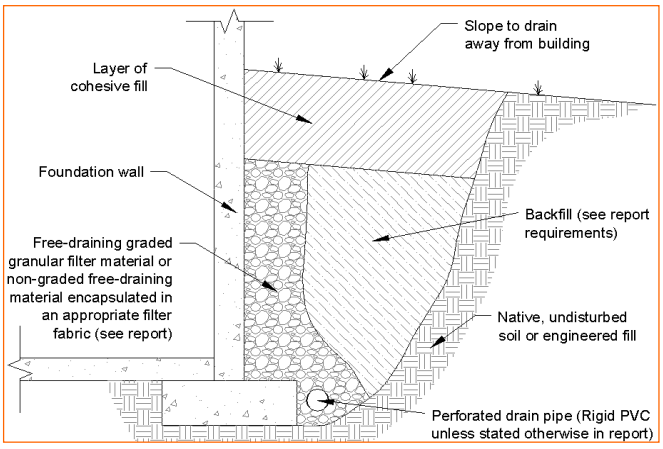
Lateral Earth Pressure Design Parameters [7]			
Earth Pressure Condition [1]	**Coefficient for Backfill Type** [2]	**Surcharge Pressure** [3, 4, 5] **p_1 (psf)**	**Effective Fluid Pressures (psf)** [2, 4, 5] **Unsaturated** [6]
Active (Ka)	Granular - 0.28	(0.28)S	(35)H
At-Rest (Ko)	Granular - 0.44	(0.44)S	(55)H
Passive (Kp)	Granular - 3.54	---	(442)H
Seismic Active (Ka)	Granular - 0.54	(0.54)S	(67.5)H
Seismic Passive (Kp)	Granular – 2.81	---	(351.8)H

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill, compacted to at least 95% of the ASTM D 1557 maximum dry density, rendering a maximum unit weight of 125 pcf.
3. Uniform surcharge, where S is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. To achieve “Unsaturated” conditions, follow guidelines in **Subsurface Drainage for Below-Grade Walls** below. “Submerged” conditions are recommended when drainage behind walls is not incorporated into the design.
7. Assume slope backfill angles are zero.

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

Subsurface Drainage for Below-Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade the tank area or exterior retaining wall should be placed near foundation bearing level. In addition, drain pipes should be placed below the floor slab of the tank. The drain pipes should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump or daylight away from fills and structures. The drain lines should be surrounded by clean, free-draining granular material having less than 5% passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill adjacent to the tank should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used for drainage on the sides of the tank. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

CORROSIVITY

The table below lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary						
Boring	**Sample Depth (feet)**	**Soil Description**	**Soluble Sulfate (%)**	**Soluble Chloride (%)**	**Electrical Resistivity (Ω-cm)**	**pH**
B-1	10	Silty sand with gravel	<5.09	<5.09	13,400	9.48

Results of water-soluble sulfate testing indicate that samples of the on-site soils have an exposure class of S0 when classified in accordance with Table 19.3.1.1 of the American Concrete Institute (ACI) Design Manual. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 19. To improve sulfate resistance of concrete in severe sulfate exposure when Type V cement is not available, the following should be considered:

- Use of Type I-II modified cement for sulfate resistance
- Cement should have a tricalcium aluminate content of not more than 8%.
- Concrete mixture should contain at least 20% Class F fly ash.
- Provide air-entrainment of 4% to 7% by volume.
- Lower the water to cement ratio to 0.4 to 0.45.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client.

Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

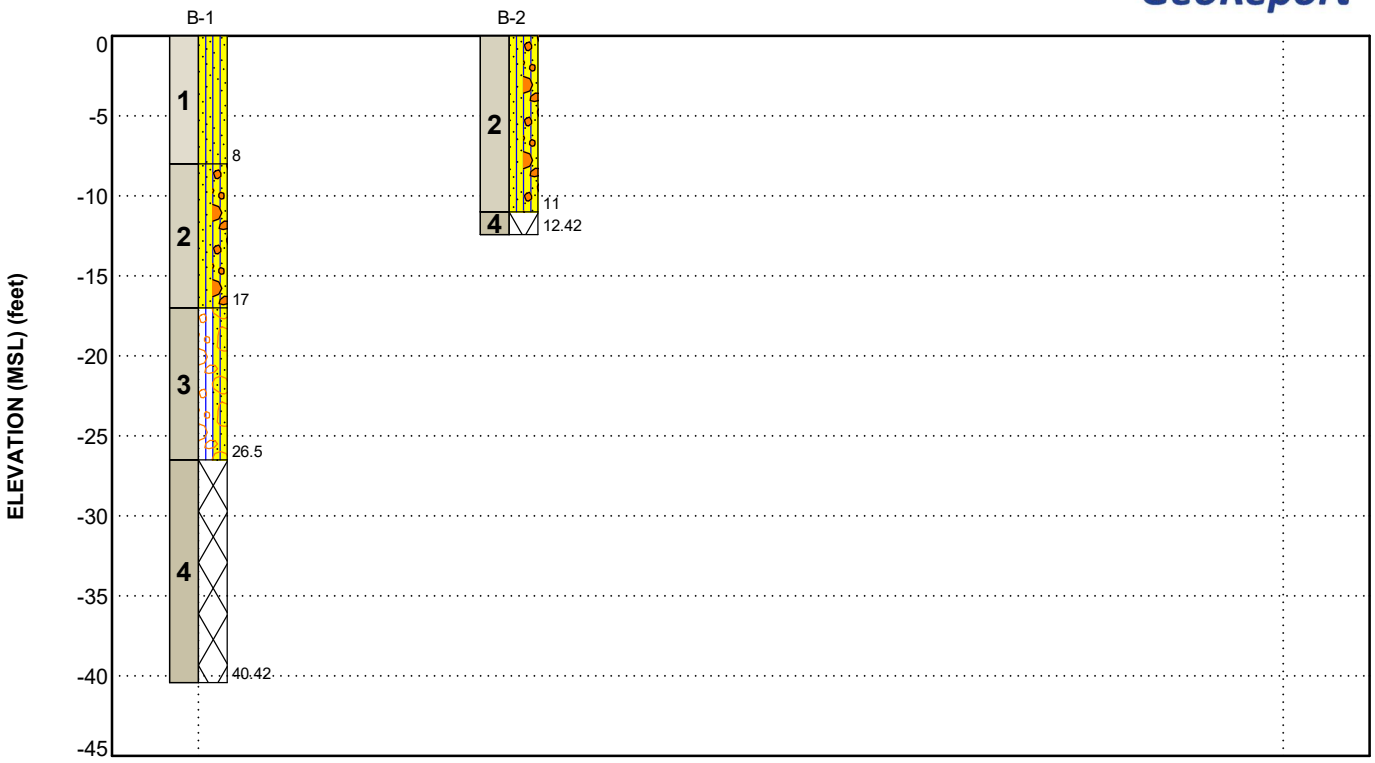
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

FIGURES

Contents:

GEOMODEL

Bona Vista 3MG Water Storage Tank ■ North Ogden, UT
Terracon Project No. 61215154



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	Silty sand	reddish brown, dense
2	Silty sand with gravel	reddish brown, very dense
3	Silty gravel with sand	reddish brown and purple, very dense
4	Bedrock	Weathered shale, reddish brown and purple

LEGEND

Silty Sand
Silty Sand with Gravel
Silty Gravel with Sand
Weathered Shale

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
1	40	Water tank
1	12	Water tank

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted, track-mounted, ATV-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem, as necessary, depending on soil conditions). Two samples were obtained in the upper 10 feet of each boring, at intervals of 2.5 feet from 10 feet to 30 feet bgs, and every 5 feet thereafter. . In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. Ring-lined, split-barrel sampling procedures are similar to standard split spoon sampling procedure; however, blow counts are typically recorded for 6-inch intervals for a total of 12 inches of penetration. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil and rock strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils

The laboratory testing program often included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Bona Vista (Hot Springs) 3MG Water Tank ■ North Ogden, Utah
September 17, 2021 ■ Terracon Project No. 61215154

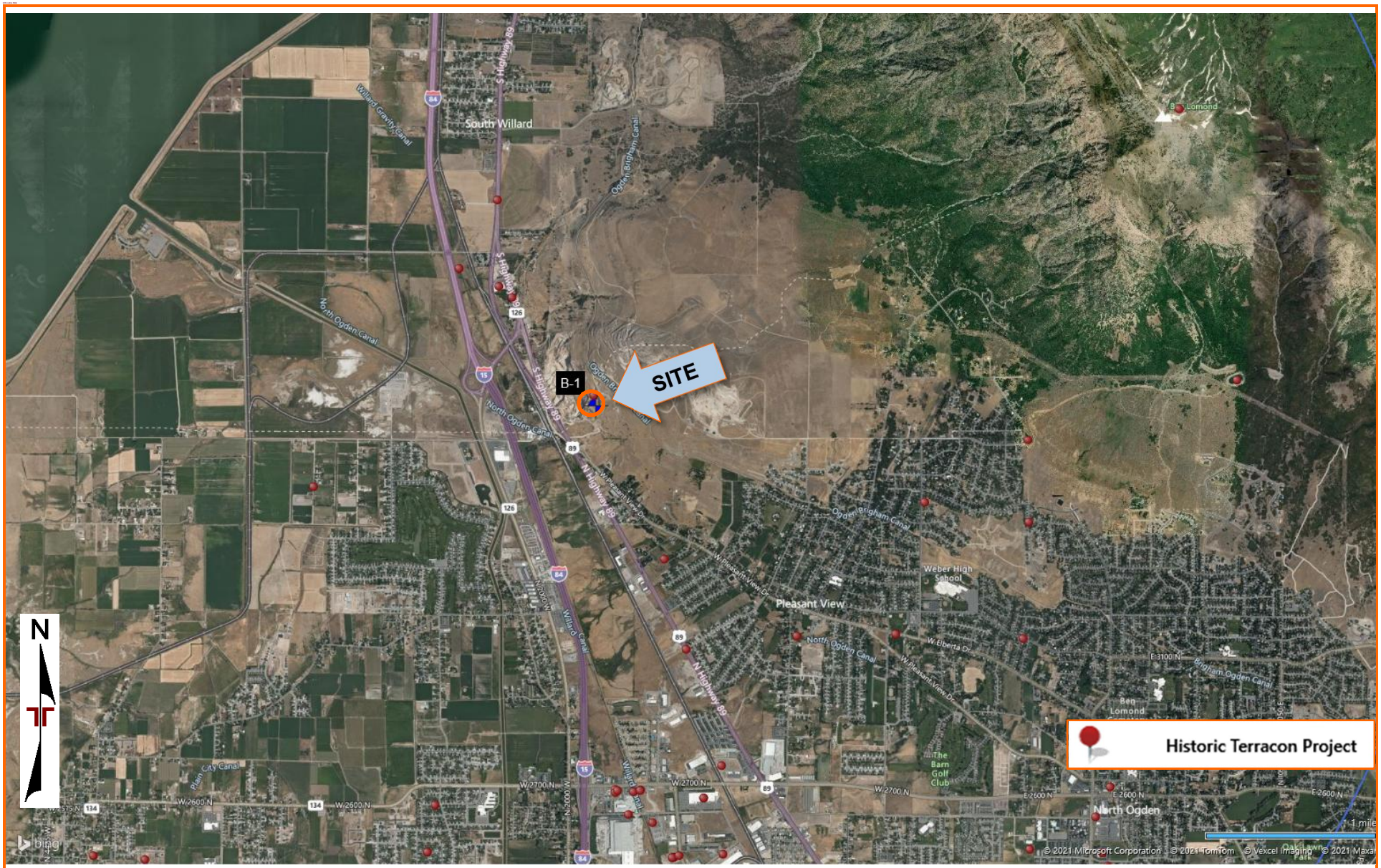
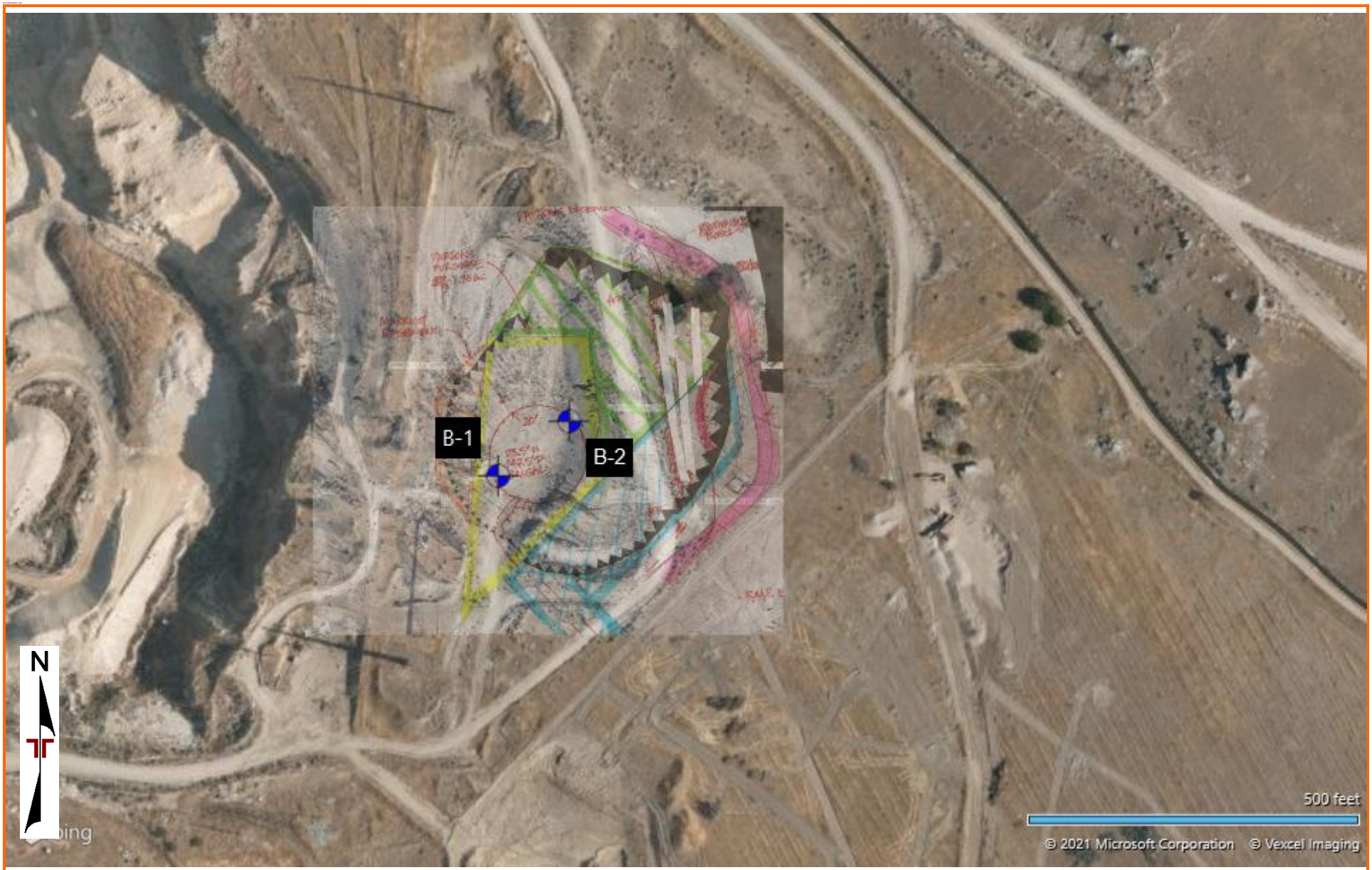


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS



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MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Bona Vista 3MG Water Storage Tank

CLIENT: Bona Vista Water Improvement District
Farr West, UT

SITE: US-89
North Ogden, UT

LOCATION See Exhibit A-2

Latitude: 41.3387° Longitude: -112.0247°

DEPTH	GRAPHIC LOG	DESCRIPTION	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
		SILTY SAND (SM), trace gravel, brown and red, dense						
5					13	12-13-17 N=30	4.6	19
8.0		**SILTY SAND WITH GRAVEL (SM)**, light gray, very dense						
10					6	45-50/4"	1.2	
		with cobbles, very dense, - color change to brown			3	75/3"		
15					5	75/5"	2.2	17
17.0		**SILTY GRAVEL WITH SAND (GP-GM)**, with cobbles, brown and purple, very dense, potential boulders			2	75/5"		
20		very dense, - oxidation stains			2	75/5"		
					3	75/5"		
25								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
6949 S High Tech Dr Ste 100
Midvale, UT

Boring Started: 08-25-2021 | Boring Completed: 08-25-2021

Drill Rig: CME 75 | Driller: Davis

Project No.: 61215154 | Exhibit: A-1

BORING LOG NO. B-1

PROJECT: Bona Vista 3MG Water Storage Tank

CLIENT: Bona Vista Water Improvement District
Farr West, UT

SITE: US-89
North Ogden, UT

LOCATION See Exhibit A-2

Latitude: 41.3387° Longitude: -112.0247°

DEPTH	GRAPHIC LOG	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
		SILTY GRAVEL WITH SAND (GP-GM), with cobbles, brown and purple, very dense, potential boulders *(continued)*				2	75/5"		
26.5		**WEATHERED SHALE**, reddish brown and purple				6	10-75/2"		
			30			2	75/4"		
		- laminated	35			7	41-75/3"		
40.4		- laminated, fissile	40			4	75/5"		
		Boring Terminated at 40.42 Feet							

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
6949 S High Tech Dr Ste 100
Midvale, UT

Boring Started: 08-25-2021 | Boring Completed: 08-25-2021

Drill Rig: CME 75 | Driller: Davis

Project No.: 61215154 | Exhibit: A-2

BORING LOG NO. B-2

PROJECT: Bona Vista 3MG Water Storage Tank

CLIENT: Bona Vista Water Improvement District
Farr West, UT

SITE: US-89
North Ogden, UT

LOCATION See Exhibit A-2

Latitude: 41.3389° Longitude: -112.0245°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY ()	FIELD TEST RESULTS	WATER CONTENT (%)	PERCENT FINES
	SILTY SAND WITH GRAVEL (SM), trace cobbles, reddish brown and purple							
		5			3	50/4"	5.2	
		10			0	75/5"		
	11.0 **WEATHERED SHALE**, purple							
	12.4 ***Refusal at 12.42 Feet***				2	75/5"		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
6949 S High Tech Dr Ste 100
Midvale, UT

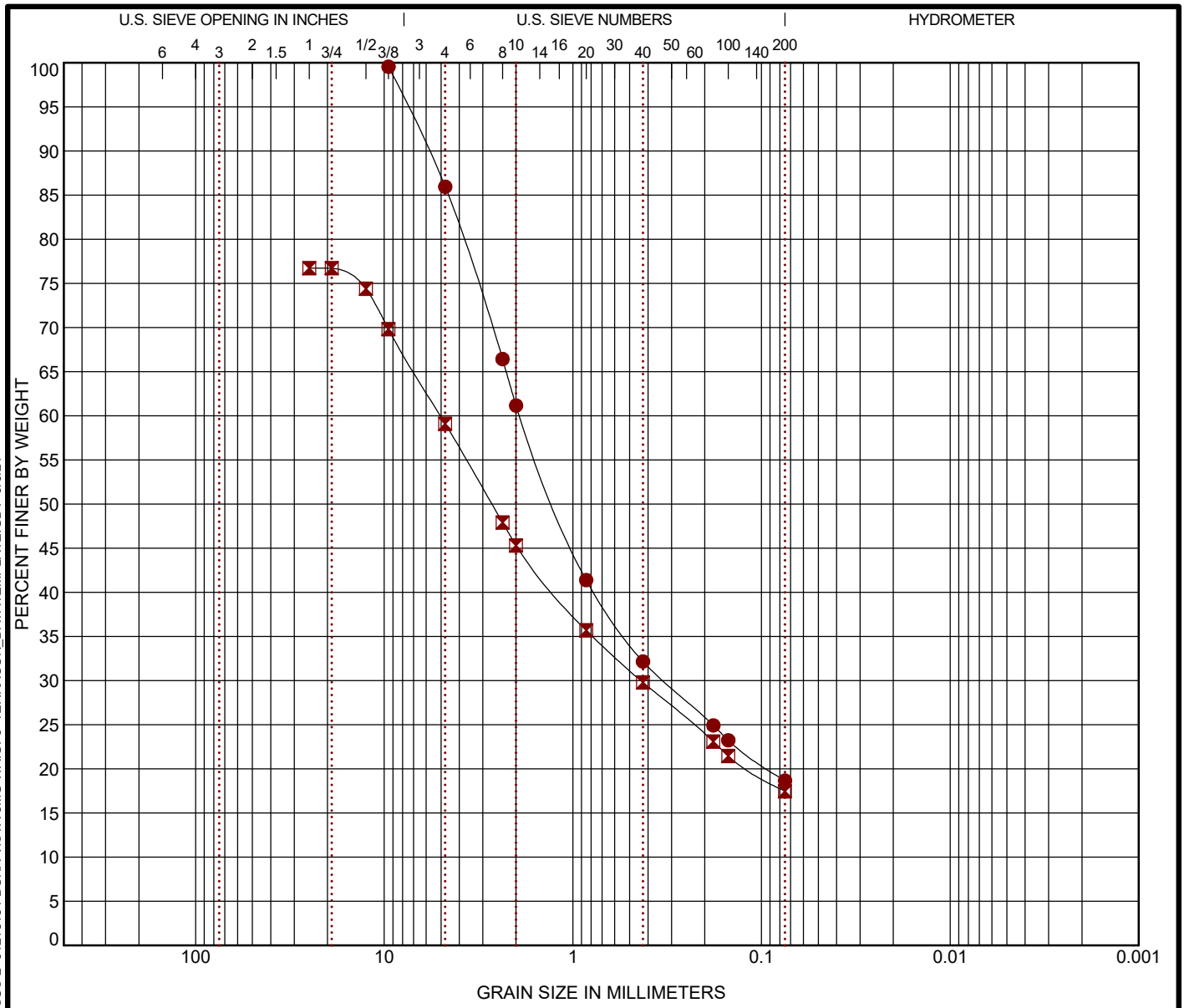
Boring Started: 08-25-2021 | Boring Completed: 08-25-2021

Drill Rig: CME 75 | Driller: Davis

Project No.: 61215154 | Exhibit: A-3

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
B-1	5 - 6.5	SILTY SAND (SM)	4.6	NP	NP	NP		
B-1	15 - 15.4	SILTY SAND with GRAVEL (SM)	2.2	NP	NP	NP		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
B-1	5 - 6.5	9.5	1.902	0.329			13.6	67.3		18.7	
B-1	15 - 15.4	25	5.036	0.436			17.6	41.6		17.5	

PROJECT: Bona Vista 3MG Water Storage Tank

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6949 S High Tech Dr Ste 100
Midvale, UT

PROJECT NUMBER: 61215154

CLIENT: Bona Vista Water Improvement District
Farr West, UT

EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 61215154 BONA VISTA 3MG WA.GPJ TERRACON_DATATEMPLATE.GDT 9/3/21

INORGANIC ANALYTICAL REPORT

Client: Terracon Consultants, Inc. **Contact:** Charles Molthen
Project: Bona Vista 3MG Water Storage Tank / 61215154
Lab Sample ID: 2108870-001
Client Sample ID: B-1 @ 10.0-10.8
Collection Date:
Received Date: 8/31/2021 1633h

Analytical Results

Compound	Units	Date Prepared	Date Analyzed	Method Used	Reporting Limit	Analytical Result	Qual
Chloride	mg/kg-dry		9/1/2021 850h	SW9251	5.09	< 5.09	&
pH @ 25° C	pH Units		8/31/2021 1702h	SW9045D	1.00	**9.48**	
Resistivity	ohm-cm		9/1/2021 544h	SM2510B	10.0	**13,400**	&
Sulfate	mg/kg-dry		9/1/2021 631h	SM4500-SO4-E	5.09	< 5.09	&

& - Analysis is performed on a 1:1 DI water extract for soils.
The date collected and expiration status of the sample is unknown as this information was not provided by the client.

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Salt Lake City, UT 84119

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Jennifer Osborn
Laboratory Director

Jose Rocha
QA Officer

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above “A”		CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above “A” line		CH	Fat clay [K, L, M]
			PI plots below “A” line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add “with sand” to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add “with organic fines” to group name.

[I] If soil contains ³ 15% gravel, add “with gravel” to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add “sandy” to group name.

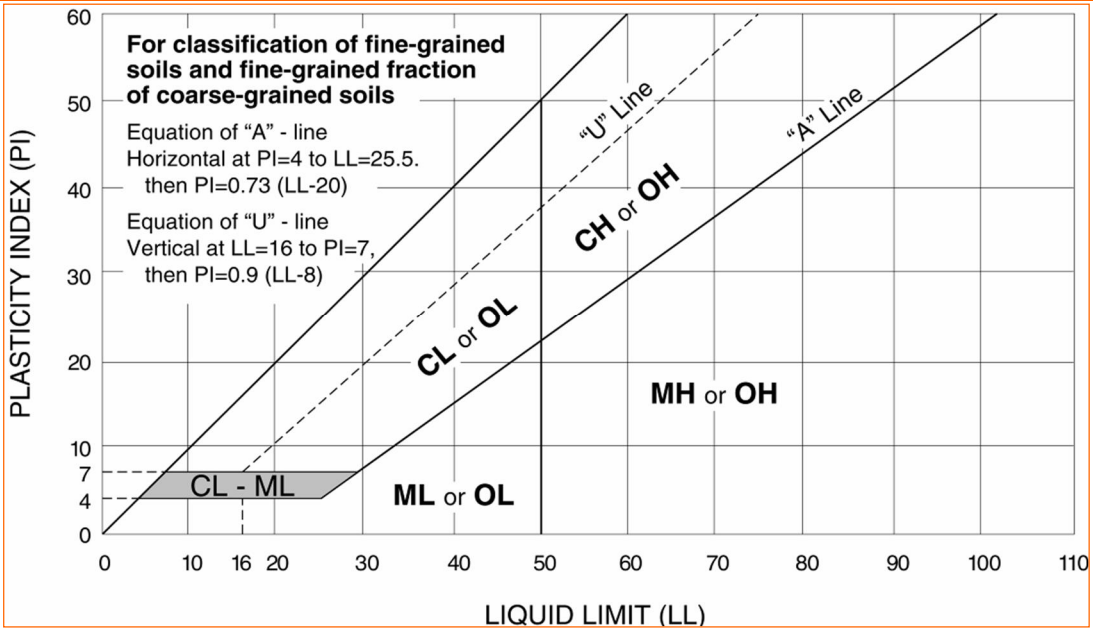
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI ³ 4 and plots on or above “A” line.

[O] PI < 4 or plots below “A” line.

[P] PI plots on or above “A” line.

[Q] PI plots below “A” line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a 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 decomposed 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.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009
Technical Manual for Design and Construction of Road Tunnels – Civil Elements