Geotechnical Engineering Report

City of Willcox WWTP Reconstruction

868 East Maley Street

Willcox, Arizona

July 26, 2013

Terracon Project No. 63135020

Prepared for:

Wilson Engineers
Phoenix, Arizona

Prepared by:

Terracon Consultants, Inc.
Tucson, Arizona

Offices Nationwide
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July 26, 2013

Wilson Engineers
9633 S. 48th Street, Suite 290
Phoenix, Arizona 85044

Attn: Mr. Dave Highfield, P.E.

Re: Geotechnical Engineering Report
City of Willcox WWTP Reconstruction
868 East Maley Street
Willcox, Arizona
Terracon Project No. 63135020

Dear Mr. Highfield:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our proposal number P63110027 dated January 31, 2011. This geotechnical engineering report presents the results of the subsurface exploration and provides geotechnical recommendations concerning earthwork, and the design and construction of foundations for the proposed structures.

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 (Civil)
CERTIFICATE NO.
47791
JESSE R.
HUSTON
Date Signed 7/26/13
ARIZONA, U.S.A.
Expires 6-30-2014

Jesse R. Huston, P.E.
Senior Project Manager

Donald R. Clark, P.E.
Senior Principal

Copies to: Addressee (1 via email)

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EXECUTIVE SUMMARY

A geotechnical engineering exploration has been performed for the proposed City of Willcox Wastewater Treatment Plant (WWTP) Reconstruction project located at 868 East Maley Street in Willcox, Arizona. Terracon's geotechnical scope of work included advancement of three test borings to depths ranging from approximately 51½ to 61½ feet below the existing site grades adjacent to Pond #1, one test pit to a depth of seven feet below existing grade within Pond #1, laboratory testing on representative samples of the subsurface materials, engineering analyses, and development of engineering recommendations for design and construction of foundations for the proposed improvements.

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the borings and test pit, and provided our recommendations contained in this report are properly implemented in the design and construction. Based on the information obtained from our engineering analyses of the field and laboratory data, the following geotechnical considerations were identified:

- Due to access restrictions for the truck mounted drill rig into the pond area, borings B-1 and B-2 were advanced from atop the earth berm surrounding the existing aeration basin, and boring B-3 was advanced east of the berm along the east perimeter of the basin. As part of our environmental services performed for this project, one test pit was advanced within the pond area. In borings B-1 and B-2 located atop the surrounding berm, the upper 10 to 12 feet consisted of silty sand and poorly graded sand with silt fill soils. The relative density of the fill soils was loose to medium dense. Below the upper fill soils, the native site soils consisted of interbedded layers of sand with varying amounts of clay, and lean clay with varying amounts of sand. The relative density of the native sand soils generally varied from loose to medium dense, and the consistency of the clay soils generally varied from soft to very stiff. Laboratory test results indicate the clay/clayey soils exhibit low to medium plasticity characteristics, and the silty sand soils are nonplastic.

- Test pit TP-1 encountered approximately three feet of organic rich soil at the surface of the pond bottom. These soils are not considered suitable for support of structures or placement as engineered fill, and should be removed from structural areas. Excluding the organic rich surface soils within the existing pond, the onsite soils are generally considered suitable for use as engineered fill for the project.

- Groundwater was encountered in all three borings advanced onsite at depths varying from 30 to 39 feet below the existing ground surface at the boring locations. Based on a bottom of pond elevation of 4,156 feet MSL, these depths correspond to depths varying from 26 to 31 feet below the existing bottom of pond elevation, and elevations varying from approximately 4,128 feet to 4,132 feet MSL.

- We recommend additional borings be performed in the footprint of the proposed structures once the pond area is accessible to truck mounted drilling equipment, and structure loads, locations and final grades have been determined. The additional borings are recommended to confirm and/or modify the engineering recommendations contained in this report.

- We understand the large tank structures (i.e., diameter or minimum width of 35 feet) will have bearing pressures ranging up to 2,000 psf. Due to the potential for excessive settlement (i.e., up to 5 inches) below the large tank structures supported near existing grade (i.e., elevation 4,156 feet MSL) within the pond area, the upper 15 to 20 feet below these structures will require ground improvement. We recommend a system of Rammed Aggregate Pier (RAP) elements by Geopier®, or an equivalent system, be used to support shallow spread or mat type foundations for the tank structures. Alternatively, the structures may be supported on drilled shaft foundations.

- We understand some of the structures will have bearing elevations greater than 10 feet below existing site grade. Dependent upon the actual design pressure of each structure and the embedment depth below the existing site grade, these structures may be fully compensated, meaning there will be a zero net increase in effective stress below these structures. For these structures where this condition exists, ground improvement is likely not necessary and the structures can be supported on undisturbed native soils. For preliminary planning, this condition exists when the design bearing pressure is less or equal to the product of the proposed bearing depth below existing grade multiplied by 120 pcf, and is valid for structures supported above the groundwater elevation. We recommend additional analysis be performed once actual structure loads and layout have been determined.

- The lightly loaded administration and laboratory type buildings with slab bearing pressures of 500 psf or less can be supported on shallow spread footings bearing on a minimum of 36 inches of engineered fill.

- The native soils within the existing pond area have elevated moisture contents and may be unstable in their current state. If unstable conditions exist or develop, workability may be improved by scarifying and drying, or by utilizing other stabilization techniques as described in the report.

- According to the Table 1613.5.2 of the 2006 International Building Code (IBC), the IBC seismic site classification for this site is Class D.

- Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during construction.

This executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
WILLCOX WWTP RECONSTRUCTION
868 EAST MALEY STREET
WILLCOX, ARIZONA

Terracon Project No. 63135020
July 26, 2013

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed Willcox Wastewater Treatment Plant (WWTP) Reconstruction project located at 868 East Maley Street in Willcox, Arizona. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- earthwork
- seismic considerations
- lateral earth pressures
- groundwater conditions
- foundation design and construction
- floor slab design and construction

Our geotechnical engineering scope of work for this project included drilling three test borings to depths ranging from 51½ to 61½ feet and one test pit to a depth of seven feet for subsurface exploration, laboratory testing, geotechnical engineering analysis, and preparation of this report.

A Site Plan and Boring Locations diagram (Exhibit A-1) and logs of the borings and test pit are included in Appendix A of this report. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included in Appendix B of this report. Descriptions of the field exploration and laboratory testing are included in their respective appendices.

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site Layout	See Exhibit A-1 in Appendix A.
Description	The project will include constructing new wastewater treatment structures within an area previously used as an aeration pond for the existing WWTP.
Structures	New structures will include the following equipment: an influent lift station, flow control structures, oxidation ditches, clarifiers, a chloride contact basin, an effluent lift station, a blower building and a sludge holding tank.
Structure construction	The structures will generally consist of reinforced concrete walls supported on reinforced concrete spread footing and/or mat foundations. The various structures contain the wastewater as it travels through the treatment process, and will also support mechanical equipment used during the treatment process.
Bearing elevations	We understand that the approximate bearing elevations of the new structures are as shown on the provided hydraulic profile.
Structure loads	Tank Structures: Wall Load – 3 to 4 kips per linear foot (assumed) Slab Load – up to 2,000 psf (provided) Buildings: Wall Load – up to 2 kips per linear foot (assumed) Slab Load - up to 500 psf (provided)
Grading	Based on the provided hydraulic profile, most structures will be founded at elevations below the existing grade of approximately 4,156 feet within the pond. However, the flow control and oxidation ditch structures mat may require up to two feet of fill to reach the planned grade.

2.2 Site Description

ITEM	DESCRIPTION
Location	Within the existing WWTP at 868 E. Maley Street in Willcox, AZ.
Previous use	The planned locations of the new structures are within an existing 5± acre area surrounded by an earth berm, creating an area which was previously used as the aeration pond for the existing plant.

ITEM	DESCRIPTION
Existing topography	Survey data of the pond bottom was not available at the time of this report. However, based on an estimated berm height of eight feet and an approximate top of berm elevation of 4,164 feet MSL, we estimate the surface elevation in the bottom of the pond to be approximately 4,156 feet MSL.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The project area is located in the Basin and Range physiographic province ([1]Cooley, 1967) of the North American Cordillera ([2]Stern, et al, 1979) of the southwestern United States. The southern portion of the Basin and Range province is situated along the southwestern flank of the Colorado Plateau and is bounded by the Sierra Nevada Mountains to the west. Formed during middle and late Tertiary time (100 to 15 million years ago), the Basin and Range province is dominated by fault controlled topography. The topography consists of mountain ranges and relatively flat alluviated valleys. These mountain ranges and valleys have evolved from generally complex movements and associated erosional and depositional processes.

Structurally, the site lies within the Willcox Playa area of the North Sulphur Springs Valley physiographic area. Surficial geologic conditions mapped at the site ([3]Richard, et al, 2000) consist of Holocene surficial deposits. These unconsolidated deposits are associated with modern fluvial systems. This unit consists primarily of fine-grained, poorly graded sediment on alluvial plains, but also includes gravelly channel, terrace, and alluvial fan deposits on middle and upper piedmonts.

3.2 Subsurface Soil Conditions

Specific conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for each boring can be found on the boring logs included in Appendix A of this report.

Based on conditions encountered in the borings, subsurface conditions on the project site can be generalized as follows:

[1] Cooley, M.E., 1967, **Arizona Highway Geologic Map**, Arizona Geological Society.
[2] Stern, C.W., et al, 1979, **Geological Evolution of North America**, John Wiley & Sons, Santa Barbara, California.
[3] Richard, S. M., Reynolds, S.J., Spencer, J. E., and Pearthree, P. A., 2000, ***Geologic Map of Arizona***: Arizona Geological Survey Map 35, 1 sheet, scale 1:1,000,000.

Description	Approximate Elevation at Bottom of Stratum (feet MSL)	Material Encountered	Consistency / Relative Density
Stratum 1	4,151 to 4,154	Silty Sand (Fill), Poorly Graded Sand with Silt, Silty Sand	Loose to Medium Dense
Stratum 2	4,139 to 4,143	Clayey Sand, Poorly Graded Sand with Clay	Loose to Medium Dense
Stratum 3	4,124 to 4,129	Sandy Lean Clay, Lean Clay with Sand	Stiff to Very Stiff
Stratum 4[1]	4,123 to 4,124	Poorly Graded Sand with Clay	Medium Dense
Stratum 5	4,113 to 4,119	Sandy Lean Clay with Gravel	Stiff to Very Stiff
Stratum 6	4,102 to 4,106 (maximum depths explored)	Clayey Sand, Poorly Graded Sand with Clay	Loose to Dense

[1] Stratum 4 soils were not observed in Boring B-2.

Laboratory tests were conducted on selected soil samples and the test results are presented in Appendix B. Laboratory test results indicate the clay/clayey soils exhibit low to medium plasticity characteristics, and the silty sand soils are nonplastic. Consolidation test results indicate the onsite soils exhibit variable compressibility at existing moisture contents and anticipated structural loads.

3.3 Groundwater Conditions

Groundwater was encountered in all three borings advanced onsite at depths varying from 30 to 39 feet below the existing ground surface at the boring locations. These depths correspond to groundwater elevations varying from approximately 4,128 feet to 4,132 feet. These observations represent groundwater conditions at the time of the field exploration and may not be indicative of other times, or at other locations. Groundwater conditions can change with varying seasonal and weather conditions, and other factors.

Based on information obtained from the Arizona Department of Water Resources – Groundwater Data website (https://gisweb.azwater.gov/waterresourcedata/GWSI.aspx), the depth to groundwater was measured in November of 2012 to be approximately 35 feet below the ground surface (approximate elevation of 4,135 feet above mean sea level) at an Arizona Department of Water Resources (ADWR) monitored well site located approximately three miles southwest of the site.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the borings and test pit, and provided our recommendations contained in this report are properly implemented in the design and construction. However, we recommend additional borings be performed in the footprints of the proposed structures once the pond area is accessible to truck mounted drilling equipment, and structure loads, locations and final grades have been determined. The additional exploration is recommended to confirm and/or modify the engineering recommendations contained in this report.

Groundwater was encountered in all three borings advanced onsite at depths varying from 30 to 39 feet below the existing ground surface at the boring locations. Based on a bottom of pond elevation of 4,156 feet MSL, these depths correspond to depths varying from 26 to 31 feet below the existing bottom of pond elevation, and elevations varying from approximately 4,128 feet to 4,132 feet MSL.

We understand the large tank structures (i.e., diameter or minimum width of 35 feet) will have bearing pressures up to 2,000 psf. Due to the potential for excessive settlement (i.e., up to 5 inches) below the large tank structures supported near existing grade (i.e., 4,156 feet) within the pond area, the upper 15 to 20 feet of existing grade below these structures will require ground improvement. We recommend a system of Rammed Aggregate Pier elements by Geopier®, or an equivalent system, be used to support shallow spread or mat type foundations for the tank structures. Alternatively, the structures may be supported on drilled shafts.

We understand some of the structures will have bearing elevations greater than 10 feet below existing site grade. Dependent upon the actual design pressure of each structure and the embedment depth below the existing site grade, these structures may be fully compensated, which corresponds to a zero net increase in effective stress below these structures. For these structures where this condition exists, ground improvement would not be necessary and the structures can be supported on undisturbed native soils. For preliminary planning, this condition exists when the design bearing pressure is less than the product of the proposed bearing depth below existing grade multiplied by 120 pcf, and is valid for structures supported above the groundwater elevation. We recommend additional analysis be performed once actual structure loads, layout and final grades have been determined.

The lightly loaded administration and laboratory type buildings with slab bearing pressures of 500 psf or less can be supported on shallow spread footings bearing on a minimum of 36 inches of engineered fill.

Test pit TP-1 encountered approximately three feet of organic rich soil at the surface of the pond. These soils are not suitable for support of structures or placement as engineered fill, and should be removed from structural areas. Excluding the organic rich surface soils within the existing pond, the onsite soils are generally suitable for use as engineered fill for the project.

The native soils within the existing pond area have elevated moisture contents and may be unstable in their current state. If unstable conditions exist or develop, workability may be improved by scarifying and drying, or by utilizing other stabilization techniques as described in this report.

Geotechnical engineering recommendations for foundation systems and other earth connected phases of the project are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing (which are presented in Appendices A and B), engineering analyses, and our current understanding of the proposed project.

4.2 Earthwork

The following sections present recommendations for site preparation, excavation, subgrade preparation and placement of engineered fills on the project. The recommendations presented for design and construction of foundations and slabs are contingent upon following the recommendations outlined in this section. Where engineered fill is necessary, grading for each structure should incorporate the limits of the proposed structure plus a minimum pad extension of five feet beyond proposed perimeter walls.

Earthwork on the project should be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

4.2.1 Site Preparation

Prior to placing any fill, all vegetation, organic soils, existing fill soils, remnants of any former equipment, and any otherwise unsuitable material should be removed from the proposed structure areas. At a minimum, the upper 36 inches of existing soil in the structure areas will require removal and disposal from structural areas of the site.

Stripped materials consisting of vegetation and organic materials should be wasted from the site, or used to vegetate landscaped areas or exposed slopes after completion of grading operations. If it is necessary to dispose of organic materials onsite, they should be placed in non-structural areas, and in fill sections not exceeding five feet in height. After grubbing and stripping, the exposed subgrade should be prepared per Section 4.2.3.

4.2.2 Excavation

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment. Based upon the subsurface conditions determined from the geotechnical exploration, the subgrade soils exposed during construction are expected to have elevated moisture contents and may be unstable. The stability of the subgrade may be further affected by precipitation, repetitive construction traffic or other factors.

If unstable conditions exist or develop, workability may be improved by scarifying and drying. Over-excavation of wet zones and replacement with granular materials may be necessary. Use of lime, fly ash, cement, geotextiles or geogrid could also be considered as a stabilization technique. Laboratory evaluation is recommended to determine the effect of chemical stabilization on subgrade soils prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottoms. Excavations should be sloped or shored in the interest of safety following local and federal regulations, including current OSHA excavation and trench safety standards. Instability in the form of caving, sloughing, and raveling should be expected in deeper excavations which extend into the granular soil deposits, but could also occur in other soils.

4.2.3 Subgrade Preparation

Exposed areas which will receive fill, once properly cleared and benched where necessary, should be scarified to a minimum depth of ten inches, moisture conditioned, and compacted. Exposed surfaces should be free of mounds and depressions which could prevent uniform compaction.

For the lightly loaded administration and laboratory buildings, engineered fill should extend below proposed footings within the geometric configurations and depths indicated in the following table. We recommend the entire building envelope be over-excavated to provide the recommended depth of engineered fill beneath the shallow footings, and the engineered fill should extend laterally a minimum distance of five (5) feet beyond the outside edge of perimeter footings, or 2/3 the depth of engineered fill below the footings, whichever distance is greater.

Building	Depth of Fill Below Footings
Lightly loaded administration and laboratory buildings	A minimum of 36 inches below foundation level or 36 inches below existing grade, whichever is deeper

After existing soil removal within the building areas, the exposed subgrade soils should be proof-rolled under engineering observation by Terracon to evaluate if there are soft zones which will require any additional removal. This proof-rolling effort will also assist in the densification and increased shear strength of the in-place soils.

At the time of our exploration, some of the existing site soils had moisture contents in excess of their optimum moisture contents. Scarification will not be required for subgrade soils exposed at a depth greater than three feet below existing site grades if compacting in-place will meet compaction and moisture content requirements outlined is Section 4.2.5. Proof-rolling can be performed with loaded scrapers or other heavy construction equipment.

Subgrade soils and fill materials beneath exterior slabs should be scarified, moisture conditioned and compacted to a minimum depth of ten inches. The moisture content and compaction of subgrade soils should be maintained until slab or pavement construction.

4.2.4 Fill Materials and Placement

All fill materials should be inorganic soils free of vegetation, debris, and fragments larger than four inches in size. Pea gravel or other similar non-cementitious, poorly-graded materials should not be used as fill or backfill without the prior approval of the geotechnical engineer.

Test pit TP-1 encountered approximately three feet of organic rich soil at the surface of the pond. These soils are not suitable for support of structures or placement as engineered fill, and should be removed from structural areas. Excluding the organic rich surface soils within the existing pond, the onsite soils are generally suitable for use as engineered fill for the project.

Imported soils (if required) for use as fill on the site should conform to the following specifications for low volume change materials:

Gradation	Percent Finer by Weight (ASTM C 136)
4"	100
No. 4 Sieve	50-100
No. 200 Sieve	45 (max)
■ Liquid Limit	25 (max)
■ Plasticity Index	10 (max)
■ Maximum expansive potential (%)*	1.5

*Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at about 2 percent below optimum water content. The sample is confined under a 100 psf surcharge and submerged/inundated.

Proposed import soils should be sampled, tested and approved by Terracon prior to being hauled to the site. Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture contents and densities throughout the lift. Fill lifts should not exceed ten inches loose thickness.

4.2.5 Compaction Requirements

Recommended compaction and moisture content criteria for engineered fill materials are as follows:

Material Type and Location	Per the Standard Proctor Test (ASTM D 698)		
	Minimum Compaction Requirement (%)	Range of Moisture Contents for Compaction (referenced from optimum moisture content)	
		Minimum	Maximum
Onsite or imported soils:			
All areas within 5 feet of finished grade:	95	-2%	+2%
All areas below 5 feet of finished grade:	98	-2%	+2%
Aggregate base (beneath foundations)	95	-3%	+3%
Miscellaneous backfill	95	-2%	+2%

4.2.6 Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the development. Infiltration of water into utility trenches or foundation excavations should be prevented during construction. In areas where sidewalks do not immediately adjoin the structures, we recommend that protective slopes be provided with a minimum grade of approximately five percent for at least 10 feet from perimeter walls. Backfill against footings, exterior walls, and in utility line trenches should be compacted to the densities specified in Section 4.2.5 and be free of all construction debris to reduce the possibility of moisture infiltration.

All grades must provide effective drainage away from the structures during and after construction. Water permitted to pond next to the structures can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential movements, cracked slabs and walls, and roof leaks. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

4.3 Foundation Recommendations - Lightly Loaded Buildings

The lightly loaded administration and laboratory buildings with column loads less than 32 kips, wall loads less than 2 kips per foot, and floor slab bearing pressures less than 500 psf can be supported by a shallow spread footing foundation system bearing on engineered fill. Design recommendations for foundations for these structures and related structural elements are presented as follows.

DESIGN ITEM	DESCRIPTION/RECOMMENDATION
Foundation Type	Conventional Shallow Spread Footings
Bearing Material	A minimum of 36 inches of engineered fill placed as outlined in Section 4.2.3 of this report
Allowable Bearing Pressure	2,500 psf
Minimum Embedment Depth Below Finished Grade	18 inches (exterior perimeter footings) 12 inches (interior footings beneath slabs)
Minimum Footing Dimensions	Isolated Column Footings: 24 inches Continuous Wall Footings: 16 inches
Total Estimated Settlement	1 inch or less
Estimated Differential Settlement	½ of the total settlement

Finished grade is defined as the lowest adjacent grade within five feet of the foundation for perimeter (or exterior) footings and finished floor level for interior footings. The allowable foundation bearing pressure applies to dead loads plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions. The weight of the foundation concrete below grade may be neglected in dead load computations.

Footings, foundations, and masonry walls should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement. The use of joints at openings or other discontinuities in masonry walls is recommended.

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

4.4 Foundation Recommendations – Tanks

We recommend the proposed tank structures be supported on shallow spread footings and/or mat foundations bearing on existing soil reinforced and improved by Rammed Aggregate Pier (RAP) elements, or a similar and equivalent type of ground improvement system. Ground improvement will be necessary to reduce the settlement and defferential movement of the tanks to within tolerable limits.

The piers are constructed by either augering a cavity or by using displacement methods, depending on soil conditions and project requirements. The aggregate is compacted in thin lifts using crowd pressure and a high energy vibratory hammer with a specialized tamper to densify the aggregate vertically and increase lateral stress in the soil matrix. The construction process results in a reinforced soil profile with less compressibility than the existing soil and increased bearing capacity. Constructed RAP elements typically range from 20- to 30-inches in diameter

and extend to depths of up to 25 feet for augered techniques and up to 40 feet for displacement techniques.

We have consulted with Geopier Foundation Company, Inc. (GFC), regarding the suitability of installing Geopiers (i.e., rammed aggregate piers) at the project site as a ground improvement technique. Based on the subsurface conditions, GFC preliminarily recommends 24-inch diameter RAP elements to a depth of 15 to 20 feet, placed on a 7 to 8 foot center-to-center grid to reduce settlements to less than 1½ inches beneath the planned tank structures. Additional borings within the footprint of the proposed tank structures will be necessary to finalize the design.

The RAP elements are constructed by drilling a shaft and backfilling with compacted #57 stone using a shielded rammer and 2-foot lifts. Subsequent to installation, the surface below the tank structures would be finished with a minimum 12-inch thickness of compacted aggregate base. With the subgrade improved with RAP elements, spread footings could be design for allowable bearing pressures up to 7,000 psf, and mat/slab bearing pressures up to 3,000 psf. Design of RAP elements are typically performed as a design-build process by GFC or other design-build contractors. The representative for Geopier at this project location is Mr. Ken Hoevelkamp, P.E. He may be reached at (949) 218-7032 for further discussion and evaluation of this potential ground improvement system.

4.4.1 Shallow Spread Footings

ITEM	DESCRIPTION/RECOMMENDATION
Foundation Type	Conventional Shallow Spread Footings
Bearing Material	Ground-improved existing soils using Rammed Aggregate Piers
Allowable Bearing Pressure	7,000 psf
Minimum Embedment Depth Below Finished Grade	18 inches (exterior) 24 inches (interior)
Minimum Dimensions	Columns: 24 inches Walls: 16 inches
Total Estimated Settlement	1½ inch
Estimated Differential Settlement	½ of the total settlement

4.4.2 Mat Foundations

DESIGN ITEM	DESCRIPTION/RECOMMENDATION
Foundation Type	Mat Foundations
Bearing Material	Ground-improved existing soils using Rammed Aggregate Piers
Design Modulus of Subgrade Reaction, k	300 pci
Modulus Correction Factor*	$k_c=k((b+1)/2b)^2$
Design Contact Stress	Any practical value up to 3,000 psf
Minimum Embedment Depth	12 inches
Total Estimated Settlement	1½ inches or less
Minimum Embedment for Frost Penetration	N/A

*It is common to reduce the k-value to account for dimensional effects of large loaded areas. Where k_c is the corrected or design modulus value and b is the mat width or tributary loaded area.

4.4.3 Additional Foundation Design Considerations

Finished grade is defined as the lowest adjacent grade within five feet of the foundation for perimeter (or exterior) footings and finished floor level for interior footings. The allowable foundation bearing pressures apply to dead loads plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions. The weight of the foundation concrete below grade may be neglected in dead load computations. Footings, foundations, and masonry walls should be reinforced as necessary to reduce the potential for distress caused by differential foundation movement. The use of joints at openings or other discontinuities in masonry walls is recommended.

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

4.4.4 Foundation Construction Considerations

Based on our experience with RAP elements, we anticipate the working elevation for installation of aggregate piers to be approximately 6 inches above the bottom of planned footing elevation. After installation of the impact piers, the area is cut to the bearing grade of the shallow foundation elements. Temporary formwork will be required to construct the shallow spread footings if construction proceeds as described above. Alternatively, the working elevations for installation of the impact piers could be approximately 6 inches above the top of footing elevation, and the footings could be constructed within the footing excavation. The construction sequence and working elevation for installation of the RAP elements will be dependent upon the top of footing elevation relative to bottom of slab elevation, foundation depths relative to existing grade, and other considerations. These details should be discussed with the ground improvement contractor during construction cost estimating.

4.5 Drilled Shaft Foundation Recommendations

4.5.1 Drilled Shaft Design Criteria

Drilled shaft foundations drilled a minimum of 15 feet or greater into natural soils are considered suitable for an alternative means of support for the proposed structures. Allowable vertical axial load capacities of drilled shaft foundations for various diameters are shown on Exhibit C-1 in Appendix C. Uplift loads on drilled shafts can be resisted through the side shear developed between the walls of the shaft and the surrounding soils and the weight of the drilled shaft. Allowable shaft uplift load capacities for various diameters are shown on Exhibit C-2 in Appendix C. The uplift capacity chart does not include the shaft weight.

If drilled shafts are constructed in groups, the capacity of individual shafts must be reduced when considering the effects of group action. Capacity reduction is a function of shaft spacing and the number of shafts within a group. If group action analyses are necessary, capacity reduction factors can be provided for the analyses upon request. Drilled shafts should be considered to work in group action if the horizontal spacing is less than six shaft diameters. A minimum practical horizontal spacing between shafts of at least three diameters should be maintained, and adjacent shafts should bear at the same elevation.

All shafts should be reinforced full-depth for the applied axial, lateral and uplift stresses imposed. Minimum reinforcement of at least one percent of the cross-sectional area of each shaft should is recommended. For this project, a minimum shaft diameter of 12 inches is recommended.

4.5.2 Lateral Loading Design Criteria

Recommended geotechnical parameters for lateral load analysis of drilled shaft foundations have been developed for use in the computer program L-PILE, which utilizes P-y curve analyses, and they are presented in the following table:

Soil Type	Approximate Elevation at Bottom of Stratum (feet)	Soil Type (P-y) Curve Model	Total Unit Weight (pcf)	Undrained Shear Strength (psf)	Friction Angle Φ'	Soil Modulus (pci)	Strain at ½ Max Principal Stress ε_{50}
Stratum 1	4,151 to 4,154	Sand (Reese)	115	---	30	25	---
Stratum 2	4,139 to 4,143	Sand (Reese)	120	---	32	25	---
Stratum 3	4,124 to 4,129	Stiff Clay w/ Water	125	1,000	---	500	0.007
Stratum 4	4,123 to 4,124	Sand (Reese)	125	---	34	90	---

Soil Type	Approximate Elevation at Bottom of Stratum (feet)	Soil Type (P-y) Curve Model	Total Unit Weight (pcf)	Undrained Shear Strength (psf)	Friction Angle Φ'	Soil Modulus (pci)	Strain at ½ Max Principal Stress ε_{50}
Stratum 5	4,113 to 4,119	Stiff Clay w/ Water	125	2000	---	1,000	0.005
Stratum 6	4,102 to 4,106	Sand (Reese)	125	---	36	---	---

Lateral load design parameters are valid for maximum soil strain of five percent acting over a distance of one shaft diameter. The soil modulus is an ultimate value in the above table. Appropriate factors of safety should be applied in the lateral load analyses of the drilled shafts.

4.5.3 Drilled Shaft Construction Considerations

Drilling of foundations to design depths of up to 40 feet should be possible with conventional drilling equipment. Due to the presence of sandy soils, groundwater, and the potential presence of loose zones, caving of the excavated shaft should be anticipated and may require the use of temporary casing during construction. We recommend the drilled shaft contractor evaluate the boring logs and be prepared with equipment and procedures to allow for successful construction. Drilled shaft concrete should be placed soon after completion of drilling and cleaning. No more than two inches of water should be present in the bottom of the drilled shaft excavation prior to concrete placement. Due to potential sloughing and raveling, foundation concrete quantities may exceed calculated geometric volumes.

If casing is used for drilled shaft construction, it should be withdrawn in a slow continuous manner maintaining a sufficient head of concrete above the bottom of the casing to help reduce the creation of voids in pier concrete. Drilled shaft concrete should have a relatively high fluidity when placed in cased pier holes or through a tremie. Concrete used for drilled shafts should have a slump of 6 inches or higher.

Free-fall concrete placement in drilled shaft excavations will only be acceptable if provisions are taken to avoid striking the concrete on the sides of the hole or reinforcing steel. The use of a bottom-dump hopper, or an elephant's trunk discharging near the bottom of the hole where concrete segregation will be minimized, is recommended.

Shaft bearing surfaces should be cleaned prior to concrete placement. A representative of the geotechnical engineer should inspect the bearing surface and shaft configuration. If the soil conditions encountered differ significantly from those presented in this report, supplemental recommendations will be required.

4.6 Seismic Considerations

The following table provides the seismic design criteria in accordance with the 2006 International Building Code at the approximate center of the site, obtained from the USGS Earthquake Hazards website (http://earthquake.usgs.gov/hazards/designmaps/javacalc.php):

Location	Site Class[1]	Site Latitude (ºNorth)	Site Longitude (ºEast)	S_s - Spectral Acceleration for a Short Period	S_1 - Spectral Acceleration for a 1-Second Period	F_a - Site Coefficient for a Short Period	F_v - Site Coefficient for a 1-Second Period
Center of Site	D	32.24491	-109.82121	0.260g	0.078g	1.6	2.4

[1] Note: In general accordance with the *2006 International Building Code,* Table 1615.5.2, which relies on a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include a 100 foot soil profile determination. Borings extended to a maximum depth of 61½ feet. Additional exploration to deeper depths would be necessary to modify the above site class.

4.7 Lateral Earth Pressures

The lateral earth pressure recommendations herein are applicable to the design of footings and rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls.

DESIGN PARAMETER	VALUE[1]
Active Case	40
Passive Case	360
At-Rest Case	60 psf/ft
Coefficient of Base Friction	0.45[2]

[1]Note: The values are based on the onsite soils used as backfill.

[2]Note: The coefficient of base friction should be reduced to 0.30 when used in conjunction with passive pressure.

The lateral earth pressures herein do not include any factor of safety, they assume drained conditions, horizontal backfill, and they are not applicable for submerged soils/hydrostatic loading. Surcharge loads should be considered where they are located within a horizontal distance behind the wall equal to 1.5 times the height of the wall. Additional recommendations may be necessary if such conditions are to be included in the design.

Fill against foundations and retaining walls should be compacted to densities specified in the Earthwork section of this report. Compaction of each lift adjacent to walls should be accomplished with hand-operated tampers or other lightweight compactors.

4.8 Corrosion Considerations

Results of soluble sulfate testing indicate that ASTM Type I/II Portland cement is suitable for all concrete on and below grade. Foundation concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4 for low sulfate exposure.

Laboratory test results indicate that onsite soils have a pH value of approximately 9.6 and a soluble chlorides content of approximately 130 parts per million. These values should be used to determine potential corrosive characteristics of the onsite soils with respect to contact with the various underground materials which will be used for project construction.

Refer to Summary of Laboratory Results contained in Appendix B for the complete results of the various corrosivity testing conducted on the site soils in conjunction with this geotechnical exploration.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, 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. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

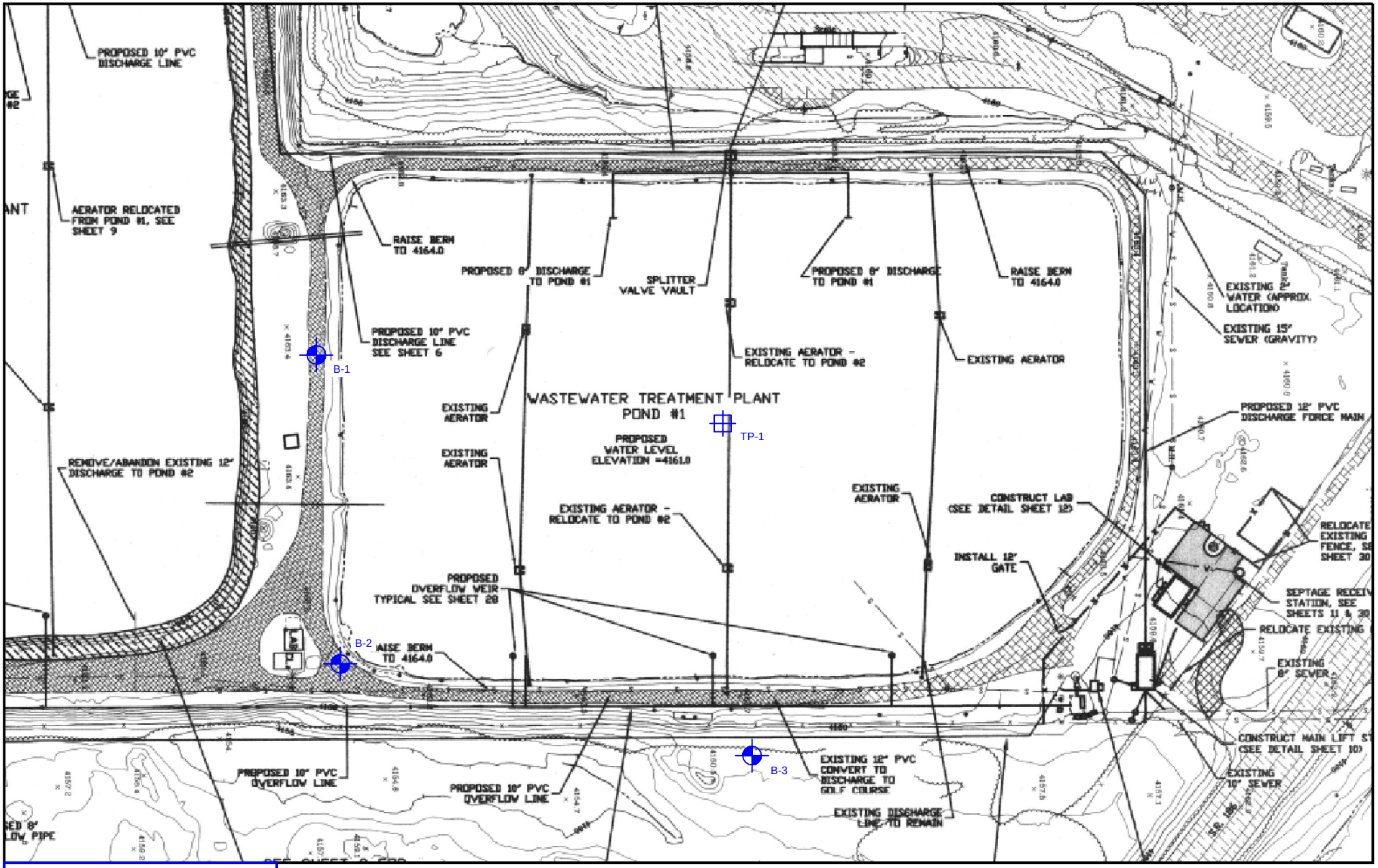
As previously outlined in this report, additional exploration is recommended in the footprint of strucutres once the pond area is accessible to truck mounted drilling equipment, and structure loads, locations and final grades have been determined. These additional borings are recommended to confirm and/or modify the engineering recommendations contained in this report.

The scope of services for this project 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.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION



N

TEST BORING LOCATION

TEST PIT LOCATION

Project Mngr:	BMB
Drawn By:	LDB
Checked By:	BMB
Approved By:	BMB

Project No.	63135020
Scale:	N/A
File No.	63135020.DWG
Date:	05/2013

Terracon
Consulting Engineers and Scientists
355 S EUCLID, SUITE 107 TUCSON, AZ 85719
PH. (520) 770-1789 FAX. (520) 792-3549

SITE PLAN & BORING LOCATIONS DIAGRAM

WILSON ENGINEERS
WILLCOX WWTP RECONSTRUCTION
868 EAST MALEY STREET

WILLCOX ARIZONA

EXHIBIT

A-1

Field Exploration Description

A total of three borings and one test pit were completed at the site on April 15, 2013 and April 16, 2013. The test borings were drilled to depths ranging from approximately 51½ to 61½ feet below the existing ground surface at the boring locations adjacent to the existing pond area. The test pit was excavated to a depth of approximately seven feet within the existing pond area. The approximate boring and test pit locations are shown on the attached Site Plan and Boring Locations diagram, Exhibit A-1.

Groundwater conditions were evaluated in the borings at the completion of drilling. The borings were immediately backfilled with cement-bentonite grout upon completion.

The borings were advanced with a truck-mounted drill rig utilizing 8-inch diameter hollow-stem augers, and the test pit was excavated with a backhoe. The borings and test pit were located in the field utilizing a preliminary site plan provided by Wilson Engineering.

A continuous lithologic log of each boring and test pit was recorded by the field engineer or geologist during the field operations. At selected intervals in the borings, samples of the subsurface materials were taken by driving split-spoon (SPT) or ring-lined barrel samplers in general accordance with ASTM Standards. Penetration resistance measurements were obtained by driving the split-spoon and ring-lined barrel samplers into the subsurface materials with a 140-pound automatic hammer falling 30 inches. The penetration resistance value is a useful index in estimating the consistency or relative density of materials encountered. Bulk samples of subsurface materials were also obtained from the auger cuttings of the test borings.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Bulk	Shelby Tube	Split Spoon
Rock Core	Macro Core	Modified California Ring Sampler
Grab Sample	No Recovery	Modified Dames & Moore Ring Sampler

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
N	N value
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

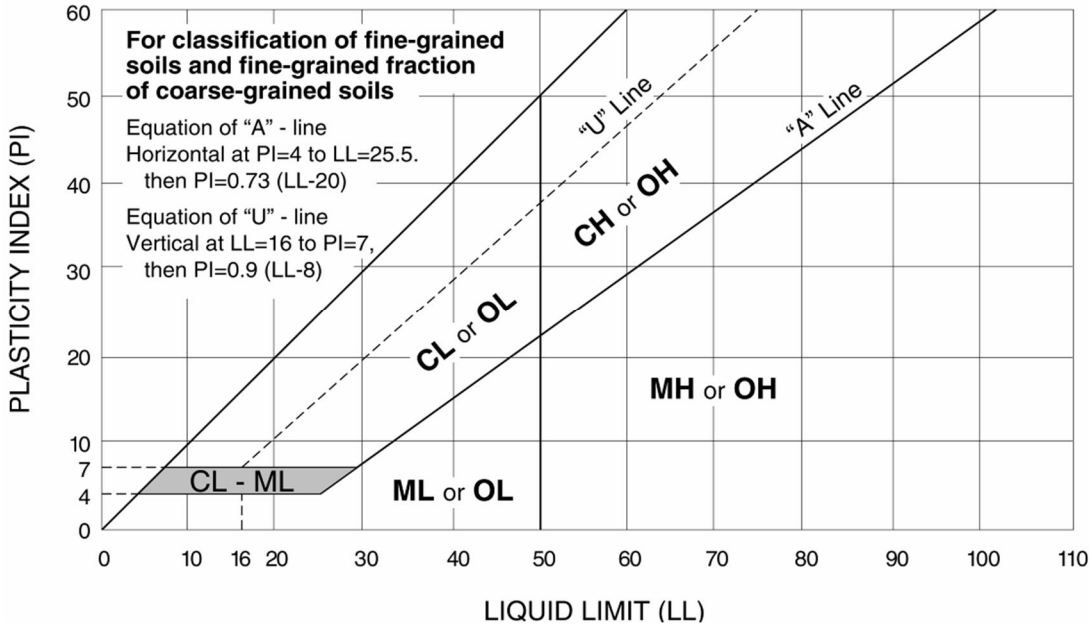
UNIFIED SOIL CLASSIFICATION SYSTEM

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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3$ [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" line [J]		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 ≥ 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 ≥ 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 ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 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.



Terracon

Exhibit A-4

BORING LOG NO. B-1

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4164 (Ft.)

DEPTH	ELEVATION (ft)	Description
		FILL - POORLY GRADED SAND WITH SILT (SP-SM), trace gravel, brown, loose, berm fill
12.0	4152	**POORLY GRADED SAND WITH CLAY (SP-SC)**, low to medium plasticity, brown, medium dense, weak to moderate cementation
25.0	4139	**SANDY LEAN CLAY (CL)**, low to medium plasticity, grayish-brown, stiff to very stiff, weak to moderate cementation
35.0	4129	**POORLY GRADED SAND WITH CLAY (SP-SC)**, low to medium plasticity, brown, medium dense, moderate cementation
40.0	4124	

DEPTH (Ft.)	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
5		5-6			NP	11
		7-6	11	107		
10		3-5	13	100		
15		9-19	21	101		
20		8-12	18	106		
25		6-12-14 N=26				
30		4-4-5 N=9				
35		10-13-14 N=27				
40						

WATER LEVEL OBSERVATIONS: ▽ 32' During Drilling

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
32' During Drilling

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Boring Started: 4/15/2013 | Boring Completed: 4/15/2013
Drill Rig: CME-75 | Driller: HAMI
Project No.: 63135020 | Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

BORING LOG NO. B-1

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4164 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (ft)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY LEAN CLAY WITH GRAVEL (CL), medium plasticity, brown, very stiff, weak to moderate cementation					5-9-11 N=20				
	45.0	4119	45							
	CLAYEY SAND (SC), trace gravel, low to medium plasticity, brown, loose to medium dense, weak to moderate cementation					1-2-3 N=5				
			50			6-8-12 N=20				
			55			9-13-30 N=43				
	61.5	4102.5	60			2-3-3 N=6				
	Boring Terminated at 61.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

32' During Drilling

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Boring Started: 4/15/2013
Boring Completed: 4/15/2013
Drill Rig: CME-75
Driller: HAMI
Project No.: 63135020
Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

BORING LOG NO. B-2

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4164 (Ft.)

DEPTH	ELEVATION (ft)	Description
		FILL - SILTY SAND (SM), brown, medium dense, berm fill
10.0	4154	
		CLAYEY SAND (SC), trace gravel, medium plasticity, brown, loose to medium dense, moderate cementation
25.0	4139	
		LEAN CLAY WITH SAND (CL), trace gravel, low to medium plasticity, grayish-brown, medium stiff to stiff, weak to moderate cementation
40.0	4124	

DEPTH (Ft.)	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
5		11-13				
10		7-10	22	102		
		7-11	18	109		
15		9-13	18	105		
20		6-9	27	94		
25		9-12	19	108		
30		6-4-5 N=9			32-20-12	77
35		3-3-4 N=7				
40						

WATER LEVEL OBSERVATIONS: ▽ 39' During Drilling

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
39' During Drilling

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Boring Started: 4/16/2013
Boring Completed: 4/16/2013
Drill Rig: CME-75
Driller: HAMI
Project No.: 63135020
Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

BORING LOG NO. B-2

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4164 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (ft)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY LEAN CLAY WITH GRAVEL (CL), medium plasticity, brown, stiff, weak to moderate cementation					5-4-7 N=11				
	45.0	4119	45							
	CLAYEY SAND (SC), trace gravel, low to medium plasticity, gray, medium dense to dense, weak to moderate cementation		50			8-15-18 N=33				
			55							
	61.5	4102.5	60			8-7-15 N=22				
	Boring Terminated at 61.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

39' During Drilling

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Boring Started: 4/16/2013 | Boring Completed: 4/16/2013
Drill Rig: CME-75 | Driller: HAMI
Project No.: 63135020 | Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

BORING LOG NO. B-3

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4158 (Ft.)

DEPTH	ELEVATION (ft)	DESCRIPTION
		SILTY SAND (SM), trace gravel, brown, loose to medium dense
7.0	4151	
		POORLY GRADED SAND WITH CLAY (SP-SC), trace gravel, low to medium plasticity, light brown, medium dense, weak cementation
15.0	4143	
		SANDY LEAN CLAY (CL), low to medium plasticity, dark brown to grayish-brown, soft, moderate cementation
		stiff
30.0	4128	
		POORLY GRADED SAND WITH CLAY (SP-SC), trace gravel, low to medium plasticity, brown, medium dense, weak to moderate cementation
35.0	4123	
		SANDY LEAN CLAY WITH GRAVEL (CL), low to medium plasticity, brown, very stiff, moderate to strong cementation

DEPTH (Ft.)	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		25-20	11	107		
5		6-9	14	102		
		15-27	13	117		
10		16-19	14	103		
15		2-2-2 N=4			34-22-12	50
20		2-3-10 N=13				
25		6-5-8 N=13				
30		15-17-12 N=29				
35		7-9-13 N=22				
40						

WATER LEVEL OBSERVATIONS: 30' During Drilling

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
30' During Drilling

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Boring Started: 4/16/2013
Boring Completed: 4/16/2013
Drill Rig: CME-75
Driller: HAMI
Project No.: 63135020
Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

BORING LOG NO. B-3

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4158 (Ft.)

DEPTH	ELEVATION (ft)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
SANDY LEAN CLAY WITH GRAVEL (CL), low to medium plasticity, brown, very stiff, moderate to strong cementation *(continued stratum from previous page)*					9-11-10 N=21				
45.0	4113	45							
POORLY GRADED SAND WITH CLAY (SP-SC), trace gravel, low to medium plasticity, brown, medium dense, weak to moderate cementation					13-12-15 N=27				
		50							
51.5	4106.5				12-10-14 N=24				
Boring Terminated at 51.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with cement-bentonite grout upon completion.

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

30' During Drilling

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Boring Started: 4/16/2013 | Boring Completed: 4/16/2013
Drill Rig: CME-75 | Driller: HAMI
Project No.: 63135020 | Exhibit: A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

TEST PIT LOG NO. TP-1

PROJECT: Willcox WWTP Reconstruction

CLIENT: Wilson Engineers
Phoenix, Arizona

SITE: 868 East Maley Street
Willcox, Arizona

LOCATION See Exhibit A-1

Surface Elev.: 4156 (Ft.)

GRAPHIC LOG	DEPTH	ELEVATION (ft)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	CLAYEY SAND (SC), medium plasticity, dark greenish brown, organics present due to leaching									
	3.0	4153								
	CLAYEY SAND (SC), medium plasticity, dark brown		5							
	7.0	4149								
	Test Pit Terminated at 7 Feet									

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

Advancement Method:

Abandonment Method:

See Exhibit A-2 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix A for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

Test Pit Started: 4/16/2013

Excavator: Backhoe

Operator:

Project No.: 63135020

Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 63135020.GPJ TERRACON2012.GDT 7/26/13

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix A. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

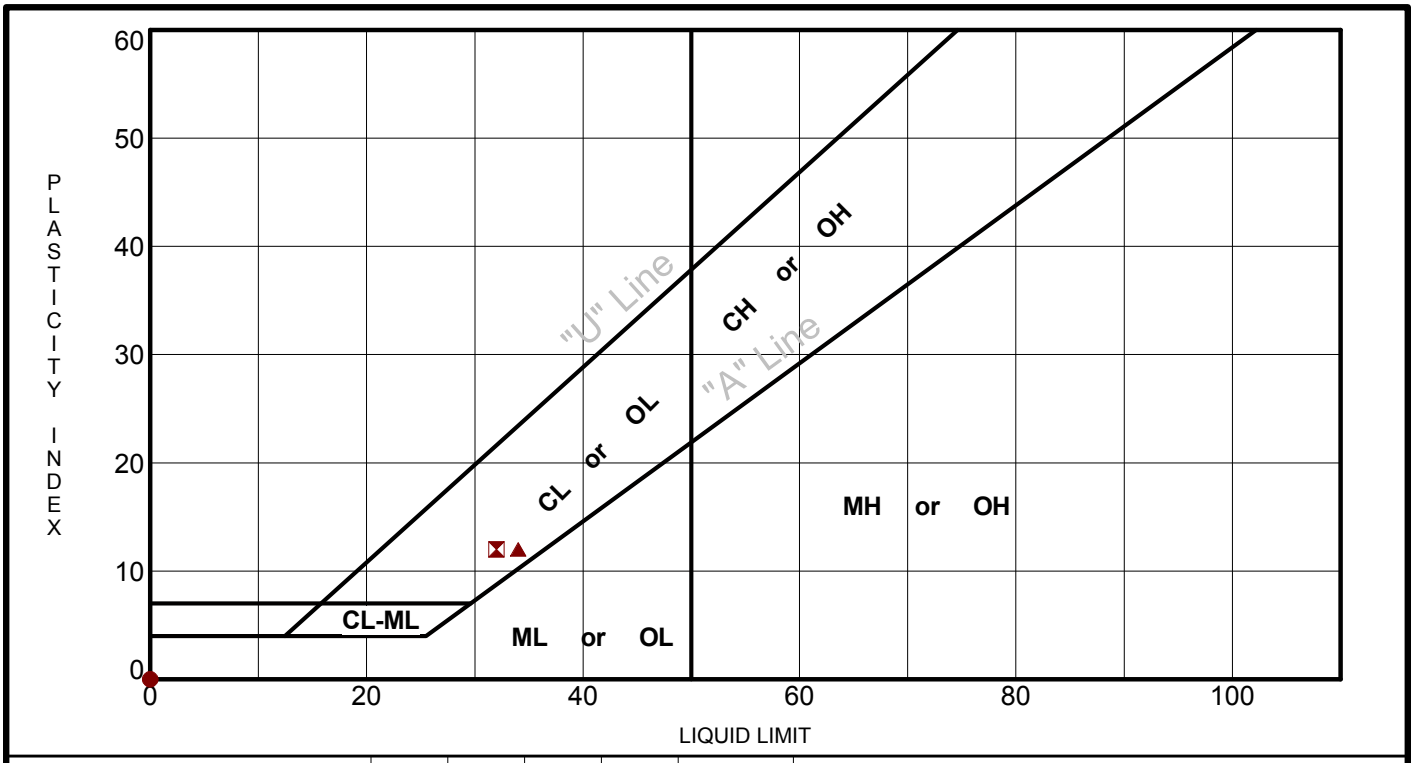
Laboratory tests were conducted on selected soil samples and the test results are presented in this appendix. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation, slab and pavement recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Atterberg Limits
- Moisture Content
- Consolidation
- Soluble Chlorides
- Sieve Analysis
- Dry Density
- pH
- Soluble Sulfates

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
●	B-1	5.0	NP	NP	NP	11	SP-SM	POORLY GRADED SAND with SILT
⊠	B-2	30.0	32	20	12	77	CL	LEAN CLAY with SAND
▲	B-3	15.0	34	22	12	50	CL	SANDY LEAN CLAY

PROJECT: Willcox WWTP Reconstruction

SITE: 868 East Maley Street
Willcox, Arizona

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

PROJECT NUMBER: 63135020

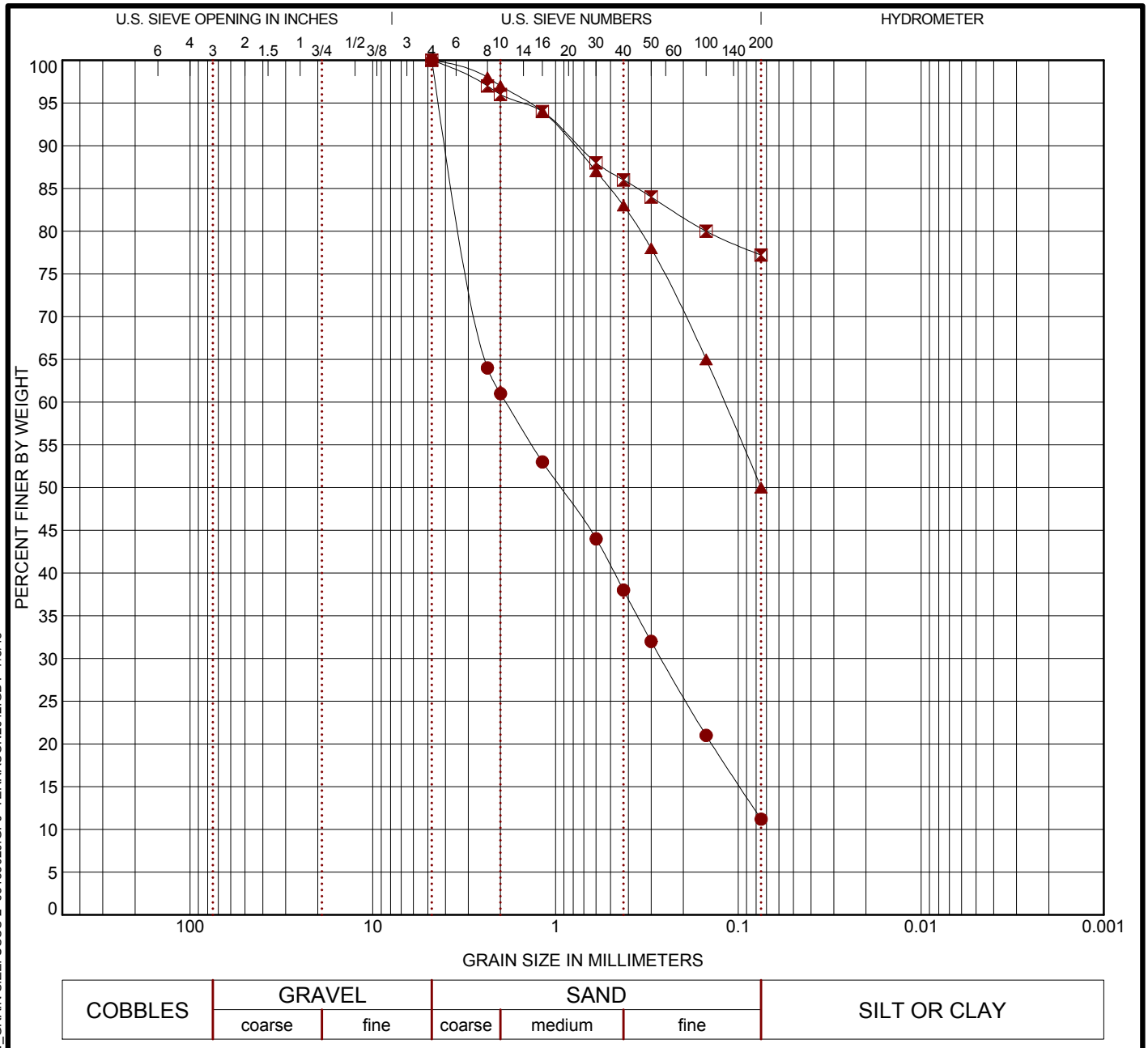
CLIENT: Wilson Engineers
Phoenix, Arizona

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 63135020.GPJ TERRACON2012.GDT 7/8/13

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	B-1	5.0	POORLY GRADED SAND with SILT(SP-SM)	NP	NP	NP	0.54	27.18
⊠	B-2	30.0	LEAN CLAY with SAND(CL)	32	20	12		
▲	B-3	15.0	SANDY LEAN CLAY(CL)	34	22	12		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	B-1	5.0	4.75	1.872	0.264		0.0	88.8	11.2	
⊠	B-2	30.0	4.75				0.0	22.8	77.2	
▲	B-3	15.0	4.75	0.119			0.0	50.0	50.0	

PROJECT: Willcox WWTP Reconstruction

SITE: 868 East Maley Street
Willcox, Arizona

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona

PROJECT NUMBER: 63135020

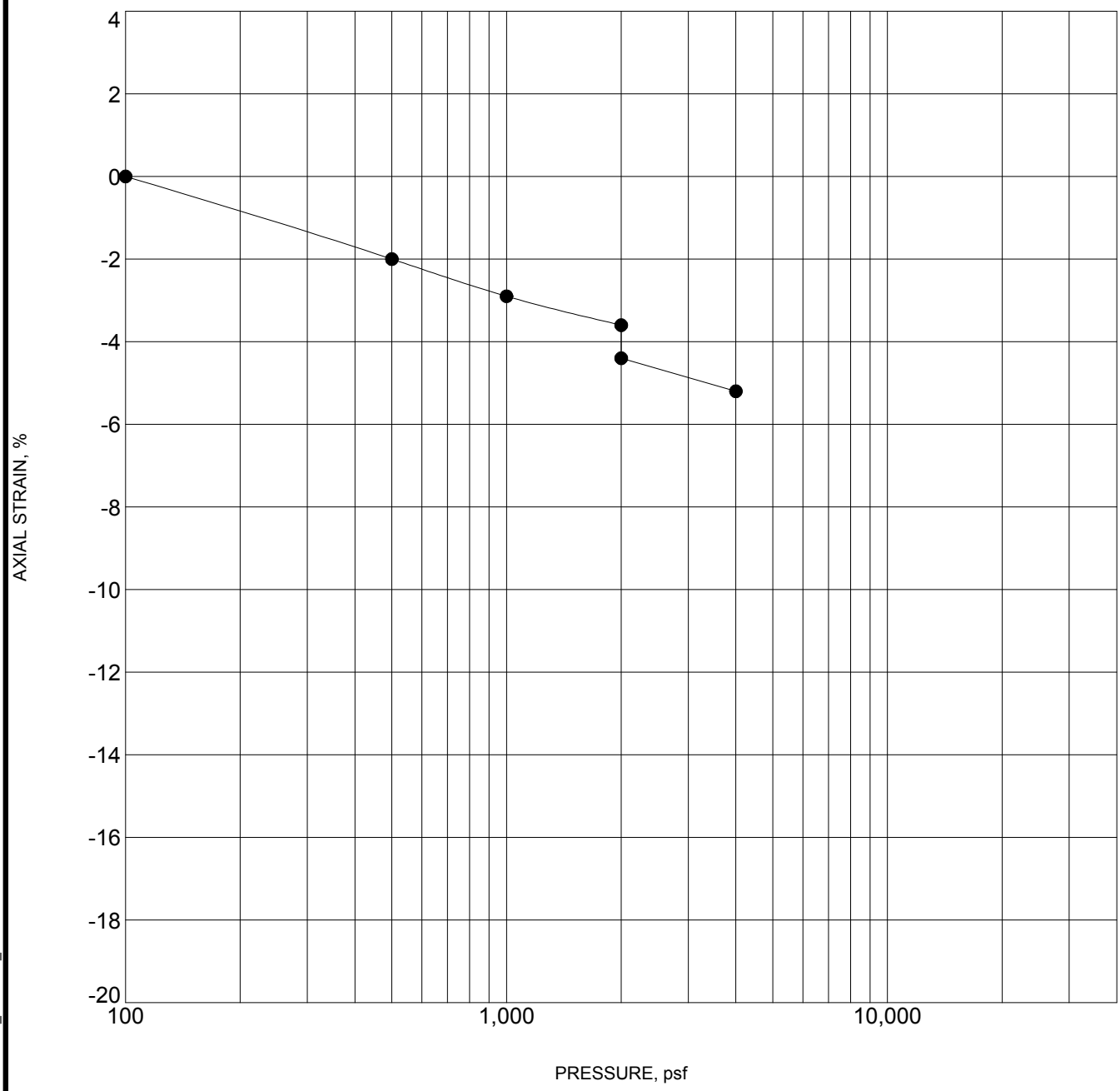
CLIENT: Wilson Engineers
Phoenix, Arizona

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SW_GRAIN SIZE: USCS-2 63135020.GPJ TERRACON2012.GDT 7/8/13

SWELL CONSOLIDATION TEST

ASTM D2435



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-1	10.0 ft	FILL: Poorly Graded Sand with Silt (SP-SM)	100	13

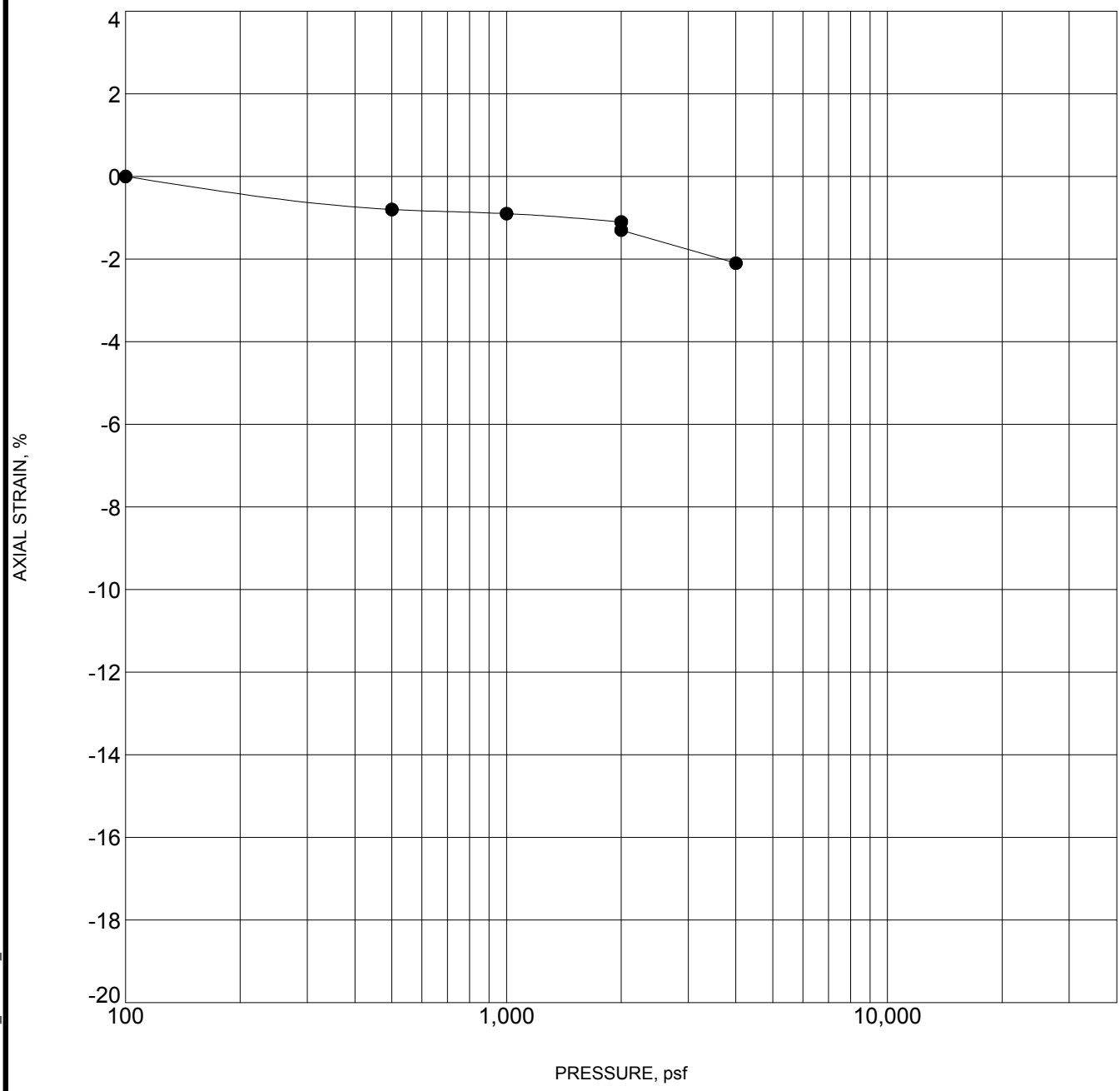
NOTES: Water added at 2,000 psf

PROJECT: Willcox WWTP Reconstruction	Terracon 355 S. Euclid, Suite 107 Tucson, Arizona	PROJECT NUMBER: 63135020
SITE: 868 East Maley Street Willcox, Arizona		CLIENT: Wilson Engineers Phoenix, Arizona
		EXHIBIT: B-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SW_CONSOL_STRAIN-USCS 63135020.GPJ TERRACON2012.GDT 7/26/13

SWELL CONSOLIDATION TEST

ASTM D2435



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-1	20.0 ft	Poorly Graded Sand with Clay (SP-SC)	106	18

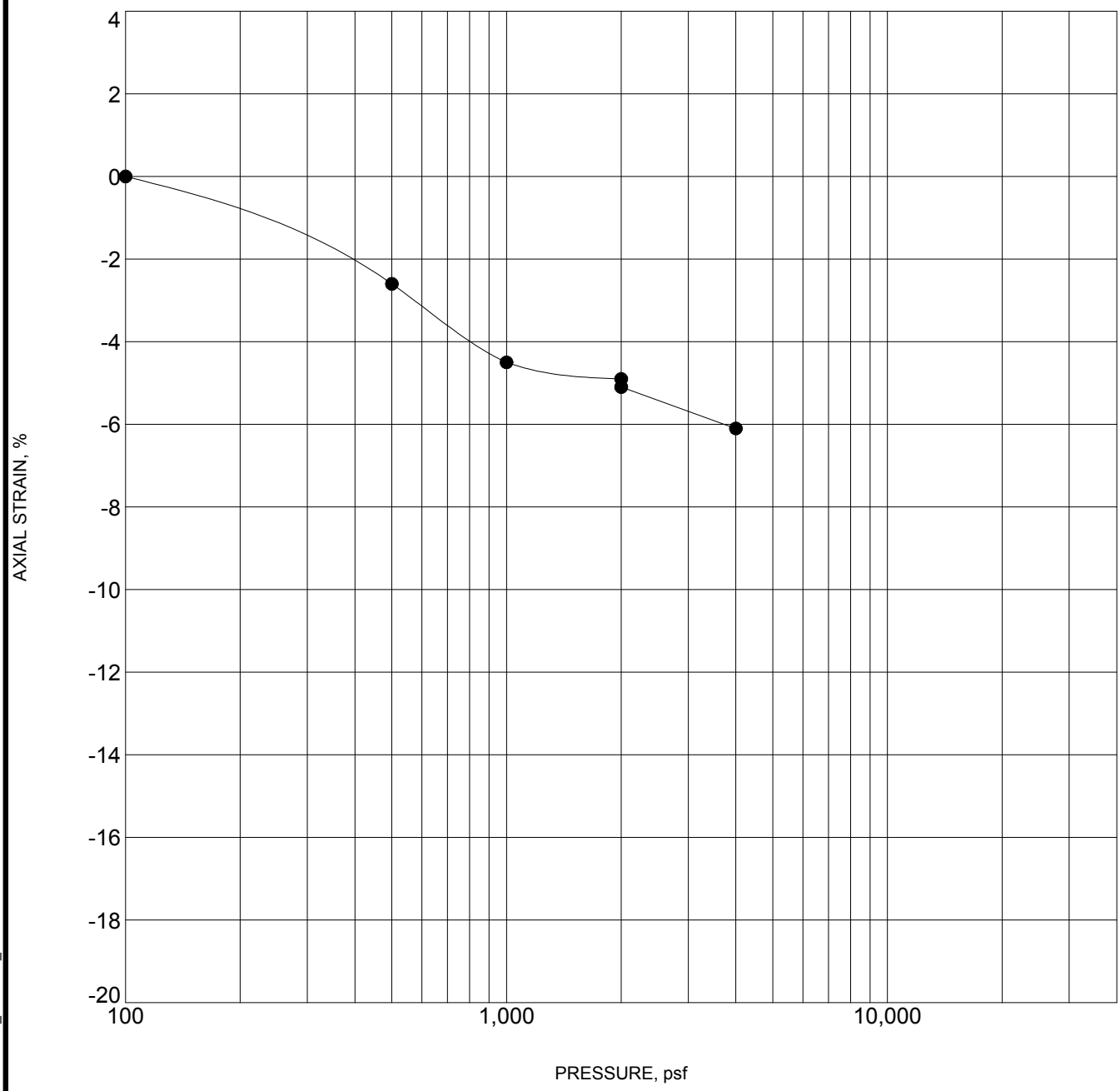
NOTES: Water added at 2,000 psf

PROJECT: Willcox WWTP Reconstruction	Terracon 355 S. Euclid, Suite 107 Tucson, Arizona	PROJECT NUMBER: 63135020
SITE: 868 East Maley Street Willcox, Arizona		CLIENT: Wilson Engineers Phoenix, Arizona
		EXHIBIT: B-5

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SW_CONSOL_STRAIN-USCS 63135020.GPJ TERRACON2012.GDT 7/26/13

SWELL CONSOLIDATION TEST

ASTM D2435



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-2	20.0 ft	Clayey Sand (SC)	94	27

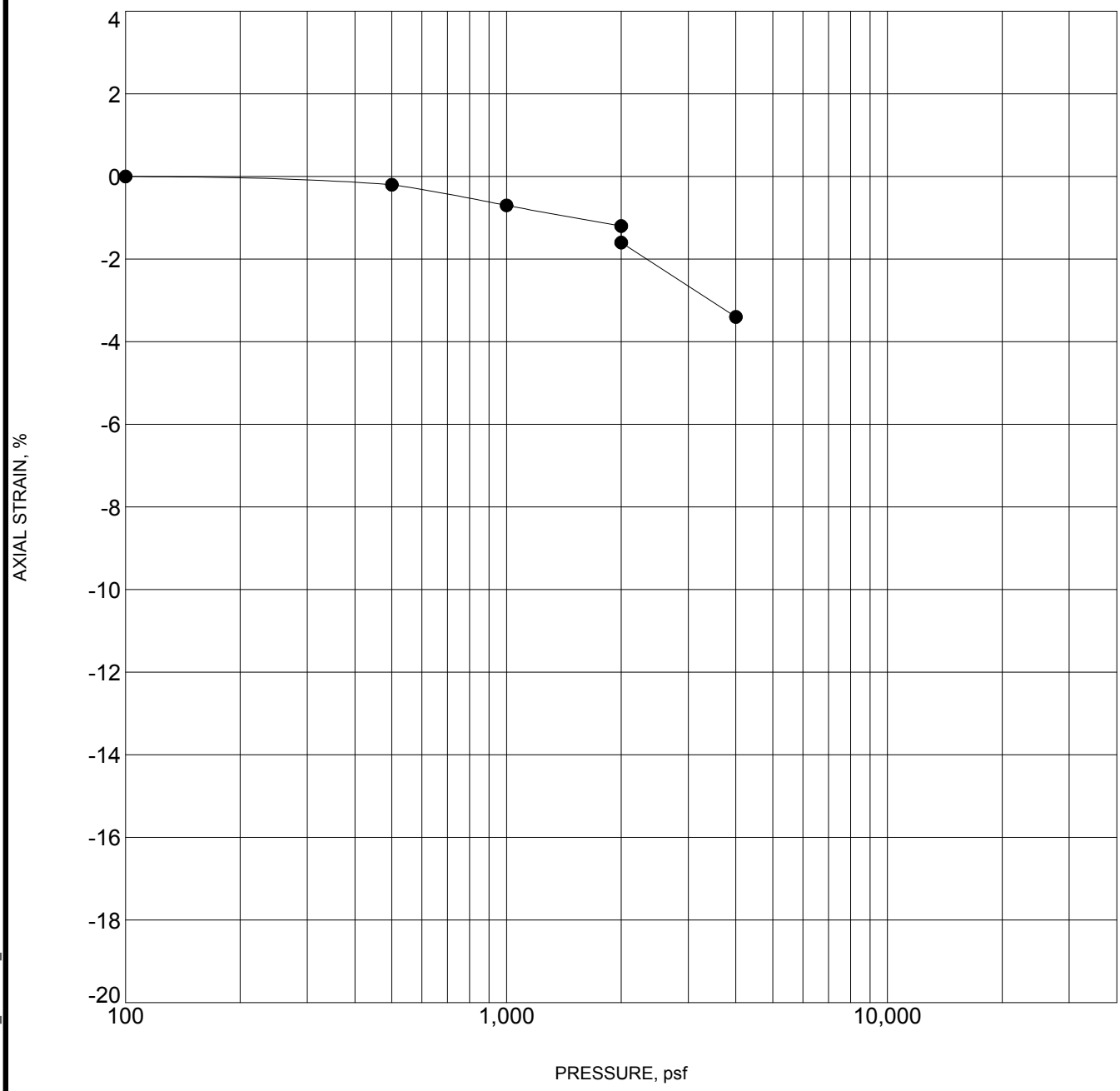
NOTES: Water added at 2,000 psf

PROJECT: Willcox WWTP Reconstruction	Terracon 355 S. Euclid, Suite 107 Tucson, Arizona	PROJECT NUMBER: 63135020
SITE: 868 East Maley Street Willcox, Arizona		CLIENT: Wilson Engineers Phoenix, Arizona
		EXHIBIT: B-6

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SW_CONSOL_STRAIN-USCS 63135020.GPJ TERRACON2012.GDT 7/26/13

SWELL CONSOLIDATION TEST

ASTM D2435



Specimen Identification			Classification	γ_d, pcf	WC, %
●	B-3	5.0 ft	Silty Sand (SM)	102	14

NOTES: Water added at 2,000 psf

PROJECT: Willcox WWTP Reconstruction	Terracon 355 S. Euclid, Suite 107 Tucson, Arizona	PROJECT NUMBER: 63135020
SITE: 868 East Maley Street Willcox, Arizona		CLIENT: Wilson Engineers Phoenix, Arizona
		EXHIBIT: B-7

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SW_CONSOL_STRAIN-USCS 63135020.GPJ TERRACON2012.GDT 7/26/13

SUMMARY OF LABORATORY RESULTS

Borehole No.	Depth (ft.)	USCS Soil Class.	In-Situ Properties		Classification				Expansion Testing					Corrosivity				Remarks
			Dry Density (pcf)	Water Content (%)	Passing #200 Sieve (%)	Atterberg Limits			Dry Density (pcf)	Water Content (%)	Surcharge (psf)	Expansion (%)	Expansion Index EI_{50}	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)	
						LL	PL	PI										
B-1	5	SP-SM			11	NP	NP	NP										
B-1	7	SP-SM	107	11														1, 2
B-1	10	SP-SM	100	13														
B-1	15		101	21														1, 2
B-1	20	SP-SC	106	18														
B-2	10	SC	102	22														1, 2
B-2	12	SC	109	18														1, 2
B-2	15	SC	105	18														1, 2
B-2	20	SC	94	27														
B-2	25	CL	108	19														1, 2
B-2	30	CL			77	32	20	12										
B-3	0	SM												9.6		130	140	2
B-3	2	SM	107	11														1, 2
B-3	5	SM	102	14														
B-3	7	SP-SC	117	13														1, 2
B-3	10	SP-SC	103	14														1, 2
B-3	15	CL			50	34	22	12										

REMARKS

1. Dry Density and/or moisture determined from one or more rings of a multi-ring sample.
2. Visual Classification.
3. Submerged to approximate saturation.
4. Expansion Index in accordance with ASTM D4829-95.
5. Air-Dried Sample

PROJECT: Willcox WWTP Reconstruction

SITE: 868 East Maley Street
Willcox, Arizona

Terracon
355 S. Euclid, Suite 107
Tucson, Arizona
PH. 520-770-1789 FAX. 520-792-2539

PROJECT NUMBER: 63135020

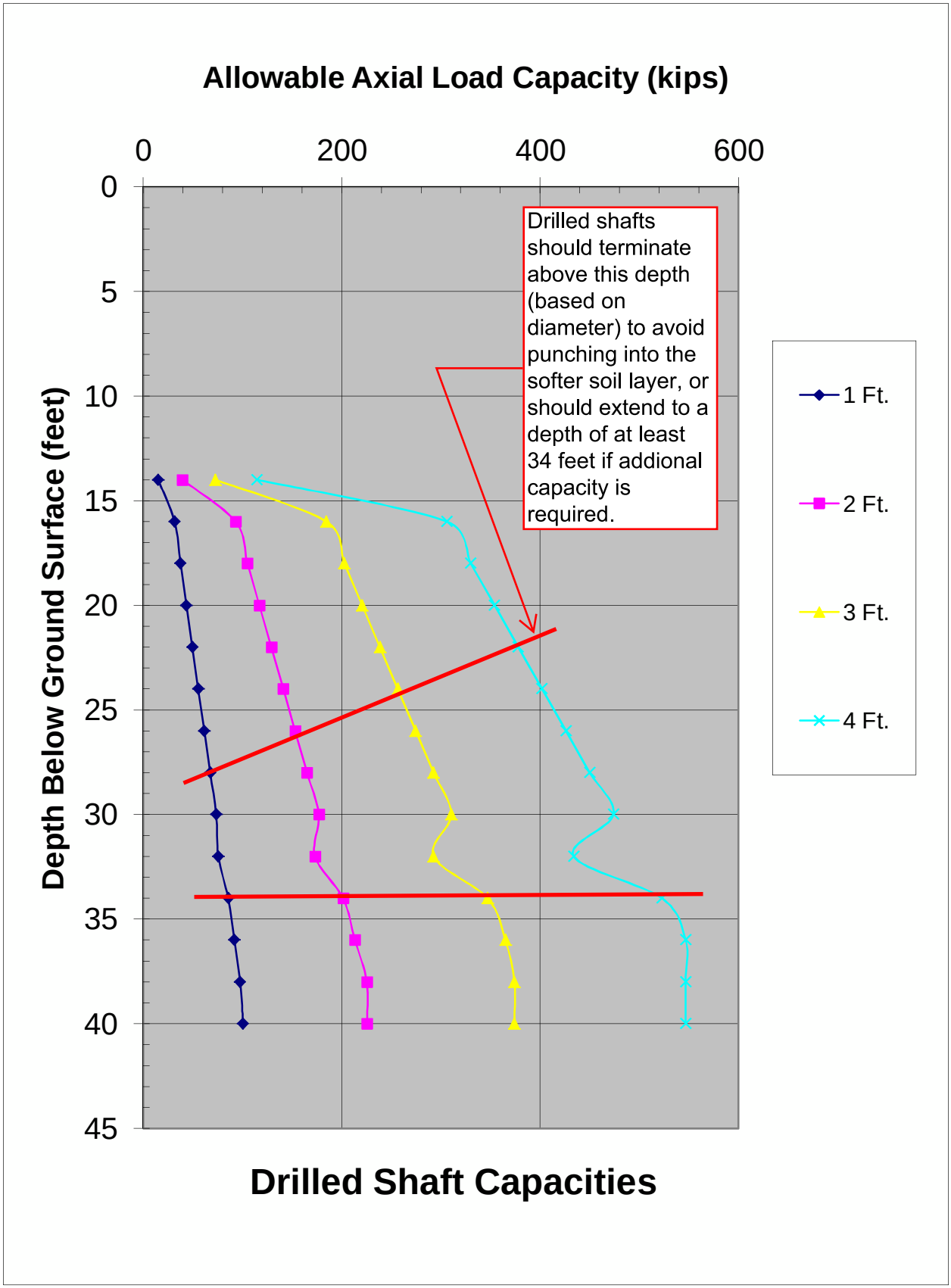
CLIENT: Wilson Engineers
Phoenix, Arizona

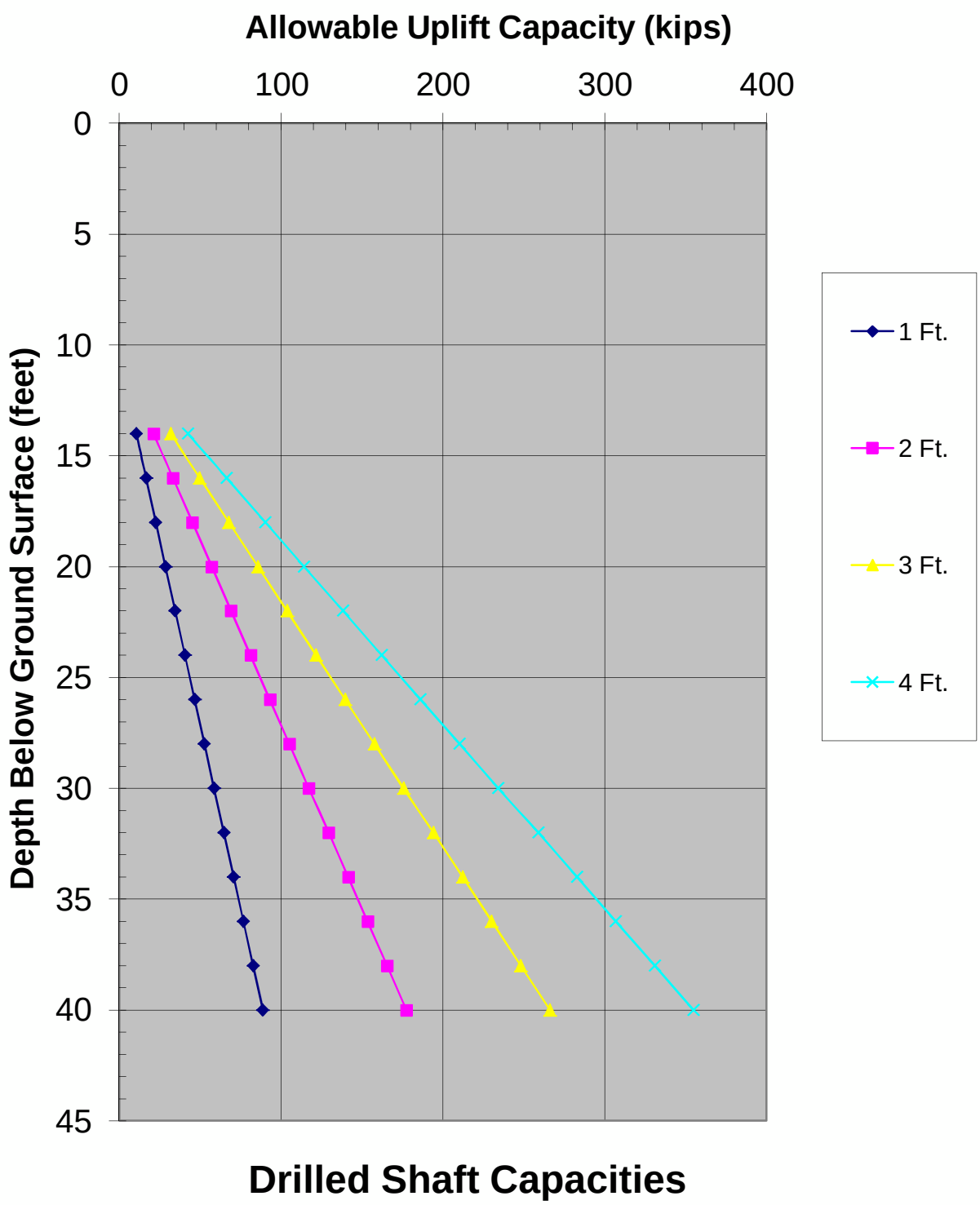
EXHIBIT: B-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. SOIL PROPERTIES 2 63135020.GPJ TERRACON2012.GDT 7/26/13

APPENDIX C

DRILLED SHAFT CAPACITY CURVES


Allowable Axial Load Capacity (kips)
0
200
400
600
0
5
10
15
20
25
30
35
40
45
Depth Below Ground Surface (feet)
Drilled shafts should terminate above this depth (based on diameter) to avoid punching into the softer soil layer, or should extend to a depth of at least 34 feet if addional capacity is required.
1 Ft.
2 Ft.
3 Ft.
4 Ft.
Drilled Shaft Capacities


Allowable Uplift Capacity (kips)
0
100
200
300
400
0
5
10
15
20
25
30
35
40
45
Depth Below Ground Surface (feet)
1 Ft.
2 Ft.
3 Ft.
4 Ft.
Drilled Shaft Capacities