FINAL GEOTECHNICAL REPORT
La Cholla Boulevard – Ruthrauff Road to River Road

Pima County Project # 4LCITR

Submitted by:

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Submitted to:

ONE COMPANY
Many Solutions℠

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September 15, 2008

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July 14, 2009

Mr. Ted W. Buell, PE
HDR Engineering, Inc.
5210 East Williams Circle, Suite 530
Tucson, AZ 85711

RE: La Cholla Boulevard – Ruthrauff Road to River Road
Final Geotechnical Report: Addendum No. 1

Dear Mr. Buell:

At your request, we have developed this addendum to provide you with revised drilled shaft capacity charts necessitated due to change in scour depths. Table 1 provides a summary of the scour depths provided by you in your e-mail dated July 13, 2009.

Table 1: Summary of Scour Depths

Location	Scour Depth	
	100-yr	500-yr
Abutment	9-ft	23-ft
Pier	18-ft	29-ft
Note: Thalweg elevation = 2,247-ft		

Based on the scour depths in Table 1, four figures labeled 5.2a, 5.3a, 5.4a and 5.5a showing the revised drilled shaft capacity charts are included in this addendum. These figures replace Figures 5.2, 5.3, 5.4 and 5.5, respectively, in NCS' Final Geotechnical Report (FGR) dated September 15, 2008. The revised drilled shaft capacity charts should be used in accordance with the procedures in Section 5.0 of the FGR. Unless otherwise modified in writing, all other recommendations and qualifications of the FGR remain valid and applicable.

If you have any questions or comments on this addendum or require further information, please contact the undersigned at 520-544-2786.

Sincerely,
NCS Consultants, LLC,

Registered Professional Engineer (Civil)
CERTIFICATE NO.
32901
N. C.
SAMTANI
Date Signed 7-14-09
ARIZONA U.S.A.

EXPIRES 09/30/2010

Naresh C. Samtani, PE, PhD
President

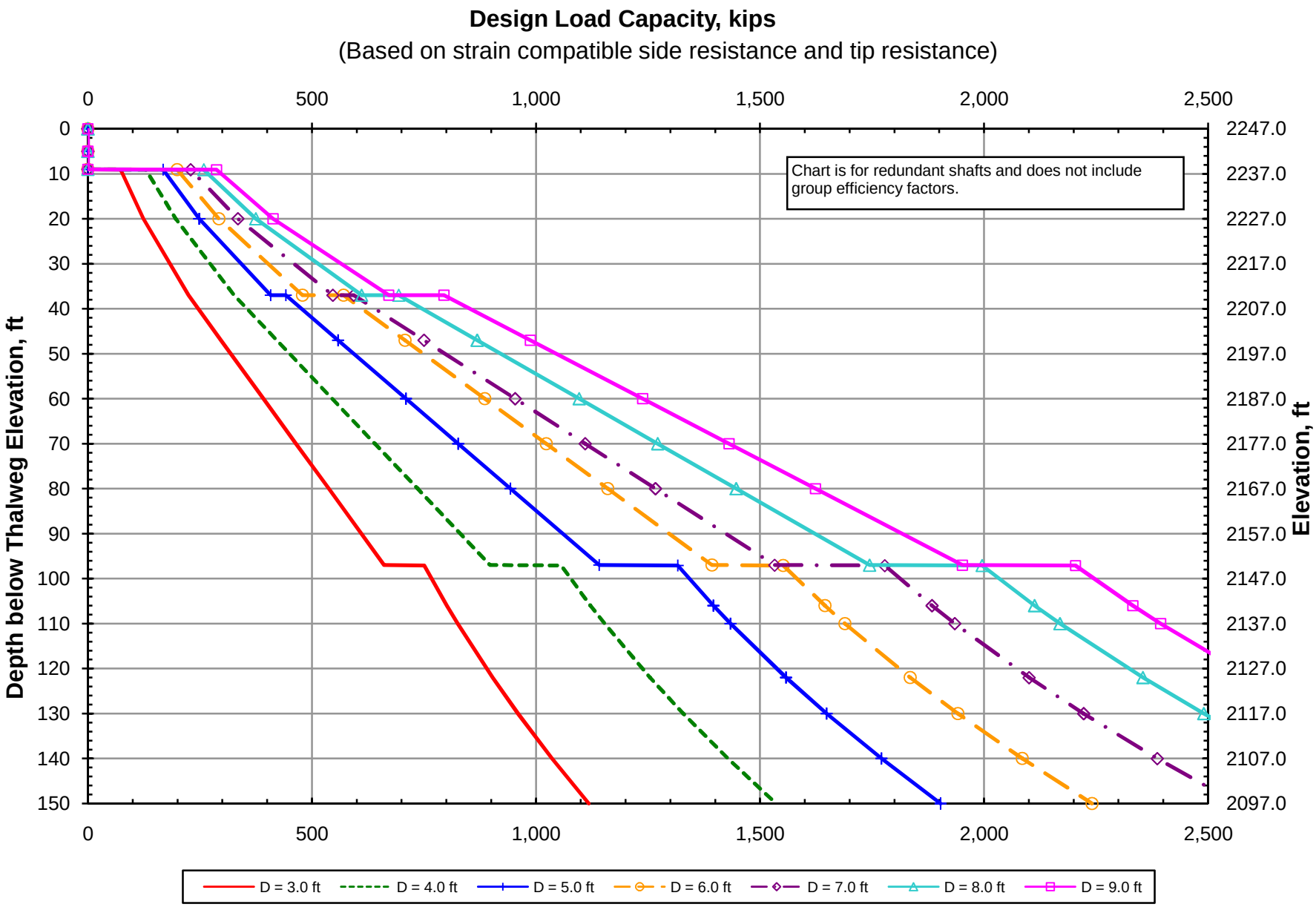

Figure 5.2a: Drilled Shaft Capacity Chart - Rillito River Bridge, Abutments - 100-yr flood

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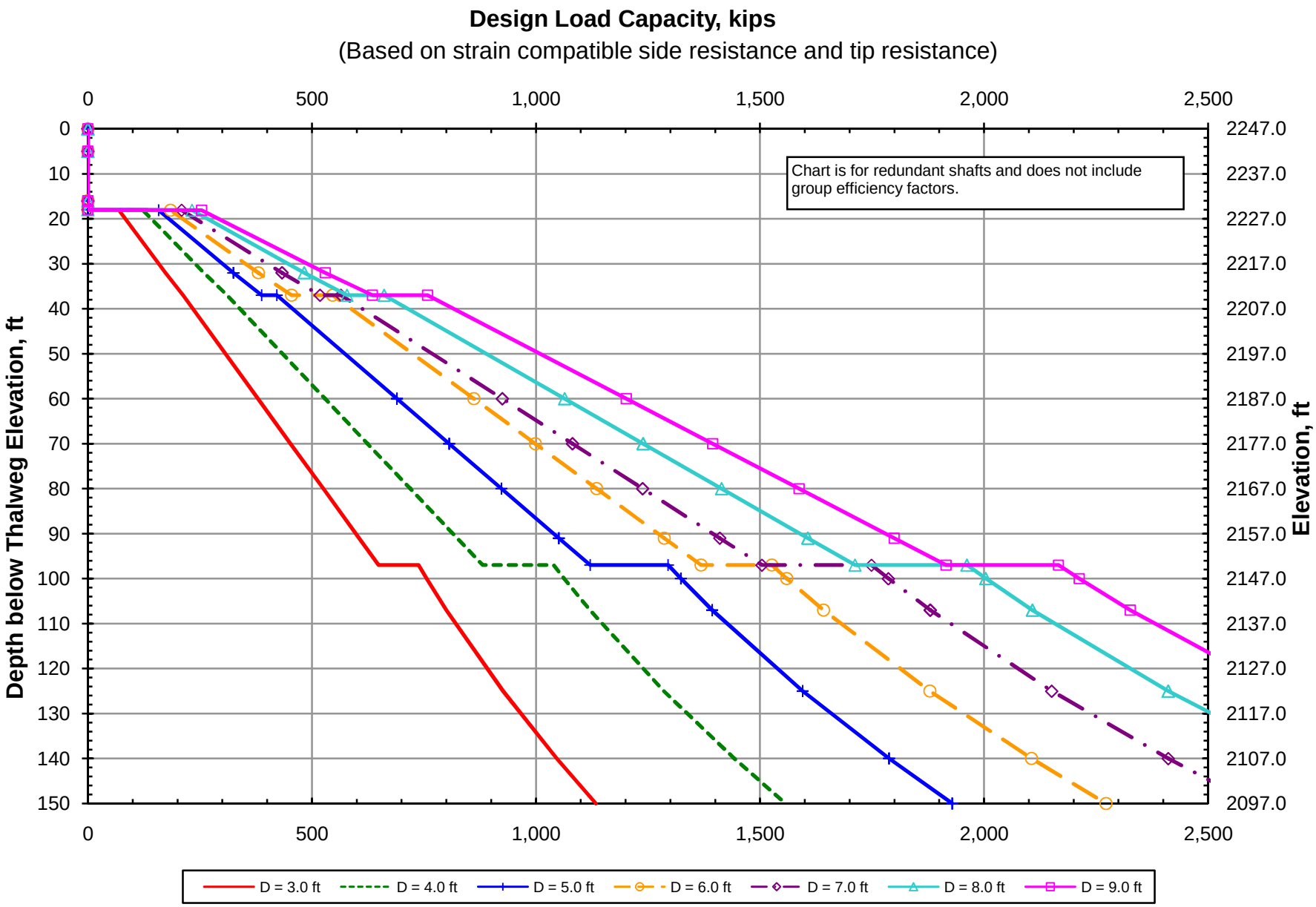

Figure 5.3a: Drilled Shaft Capacity Chart - Rillito River Bridge, Piers - 100-yr flood

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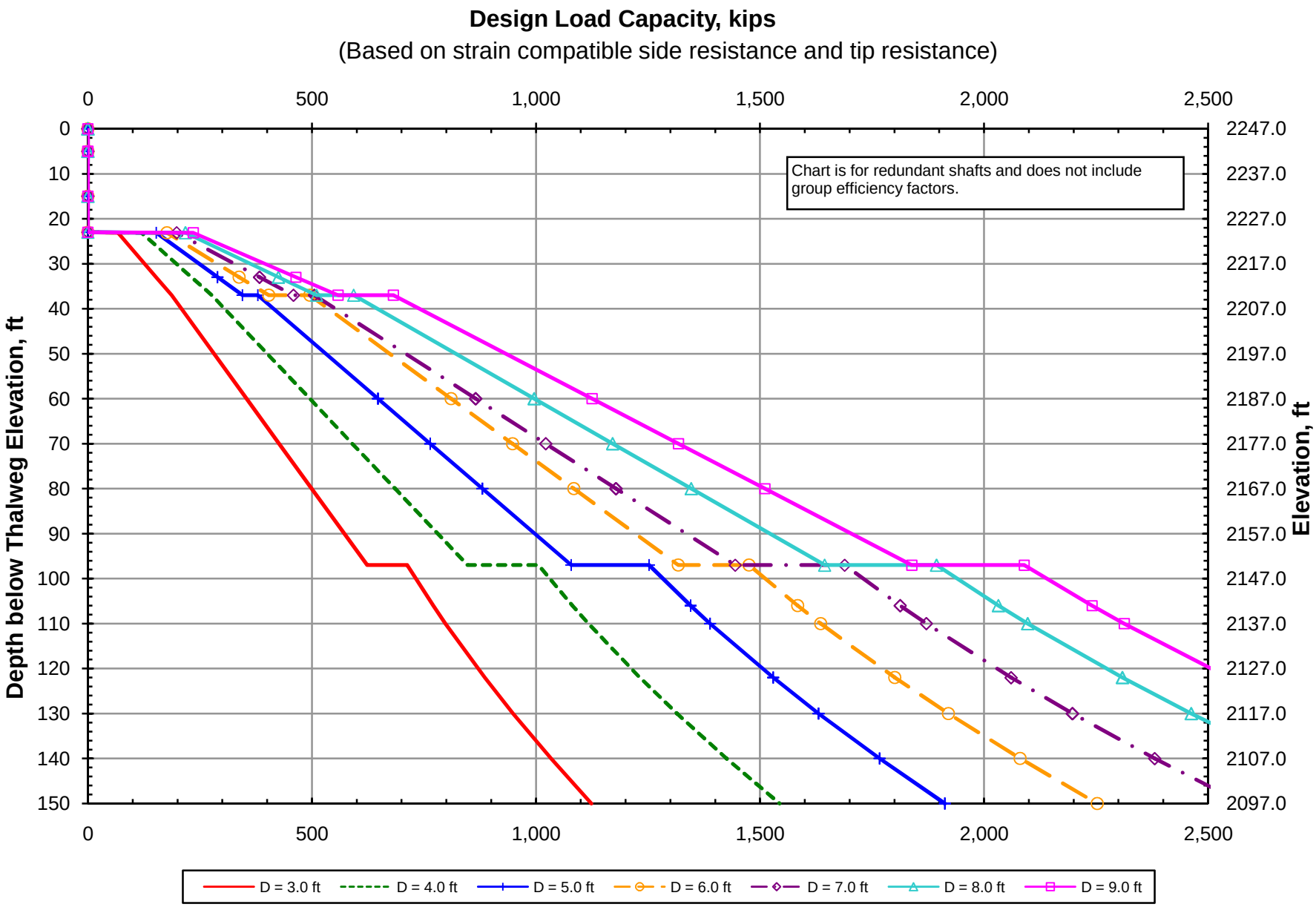

Figure 5.4a: Drilled Shaft Capacity Chart - Rillito River Bridge, Abutments - 500-yr flood

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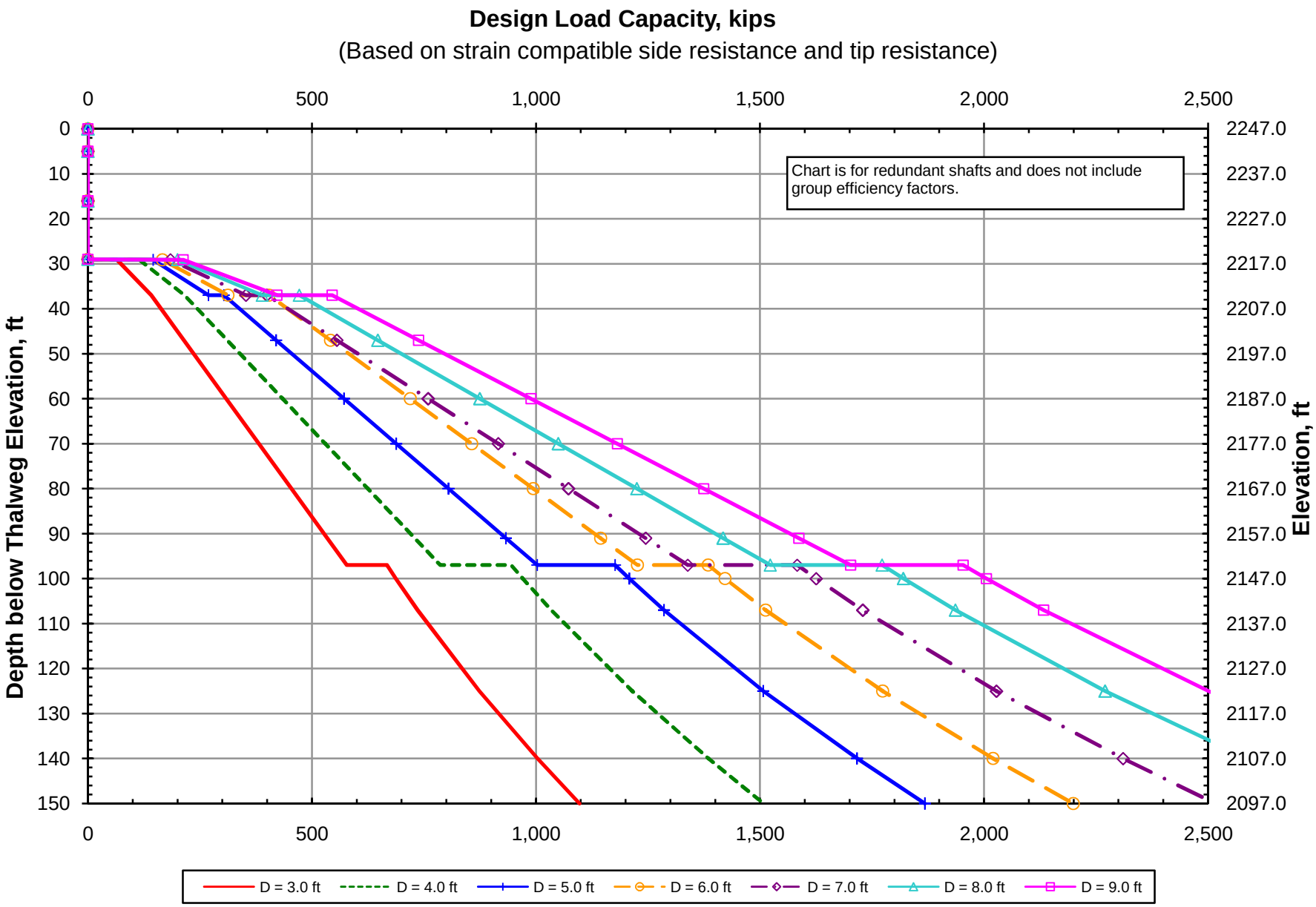

Figure 5.5a: Drilled Shaft Capacity Chart - Rillito River Bridge, Piers - 500-yr flood

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EXPIRES 03/31/2009

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation conducted by NCS Consultants, LLC (NCS) in support of the widening of La Cholla Boulevard between Ruthrauff Road and River Road in Pima County, Arizona. The purpose of this report is to present the preliminary geotechnical recommendations for the various new and existing structures associated with this project, including drainage structures, and the bridges over the Rillito River.

1.1 Project Overview and Site Description

The project site is located northwest of the City of Tucson (COT) in Pima County, Arizona. The project begins approximately 975 feet south of Ruthrauff Road and extends north approximately 4,000 feet to River Road. A project location map is shown in Figure 1.1.

Currently, La Cholla Boulevard within most of the project limits is an undivided two lane roadway without a center turn lane. La Cholla Boulevard provides access to several residential neighborhoods on either side of the road as well as access to businesses. The section of the La Cholla Boulevard corridor to be widened traverses mostly flat terrain with minimal desert vegetation such as scattered brush, trees and cacti. The existing alignment crosses the Rillito River, which is a tributary of the Santa Cruz River. The Rillito River is an ephemeral stream that can have significant peak flows and large scour depths. The proposed roadway improvements will include the complete reconstruction of the corridor to a six-lane arterial roadway with a raised median. Furthermore, the existing Rillito River bridge, which was constructed in 1980, will be demolished and replaced with two adjacent bridge structures; one for northbound and one for southbound traffic.

1.2 Scope of Work

NCS has provided the following services as part of the development of this report:

- A field investigation program that included 14 borings to provide information for the design of the foundations of the bridge structures and pavements. The field investigation program is described in Section 3. Boring logs and a key to symbols and terms are included in Appendix A.
- Laboratory testing of representative soil samples obtained during the geotechnical field investigation program to determine material classification and material geotechnical properties. Results of the laboratory testing program are discussed in Section 3. Laboratory test data are included in Appendix B.
- Engineering analyses and recommendations for the foundations of the bridges over the Rillito River.
- Soil evaluation for roadway subgrade with respect to collapse and swell potential.
- Preparation of this final geotechnical report.

- Internal Quality Assurance/Quality Control (QA/QC) reviews.

Pavement analysis and design including the preparation of a Pavement Design Report will be completed by HDR. The basic data for pavement design such as grain size distribution, Atterberg Limits and measured R-values are included in this report.

1.3 Project Coordination

NCS's work was coordinated with the following individuals:

- Ted Buell, P.E., HDR, Inc. (HDR) Project Manager, Elizabeth McGehee, E.I.T., and other members of the HDR team.
- Dean Papajohn, P.E. – Project Manager, Pima County,
- Clyde Pretti, P.E. – ConformaTech, Inc. (Conformatech) – Laboratory Testing
- John Purcell – Geomechanics Southwest, Inc. (GSI) – Drilling.

2.0 GEOLOGY

The project site is located in the Tucson basin. This basin is a broad 1,000 square mile area in the upper Santa Cruz River drainage basin. The following geologic description is taken from Davidson (1973) and Anderson (1987), who provided a comprehensive discussion of the Tucson basin based on geohydrologic and geophysical studies.

The Tucson basin is a structural depression filled with sediments. It is bounded by the Sierrita, Santa Rita, and Empire Mountains to the south; the Rincon Mountains to the east; the Santa Catalina Mountains to the northeast; the Tortolita Mountains to the northwest; and the Tucson Mountains to the west. The basin is 15 to 20 miles wide (east-west) in the southern and central parts and narrows to 4 miles at the northwest outlet; it is approximately 50 miles long (north-south). The project is located in the northwestern part of the basin.

The primary formations of interest for this project are the Tinaja beds and the Fort Lowell Formation. The Tinaja beds were deposited during the Miocene and Pliocene age. They are overlain by the Fort Lowell Formation that is of Pleistocene age. The Tinaja beds consist of three subunits, and are mainly composed of gravel and sand. The Fort Lowell Formation is composed of silty gravel at the edge of the basin, and silty or clayey sands toward the center. Throughout most of the basin, the Fort Lowell Formation is overlain by a thin veneer of younger sediments consisting of sand, silt and gravel or gravelly sand of fluvial origin. From a geotechnical engineering perspective, the younger sediments overlying the Fort Lowell Formation are the most important.

The younger sediments were formed by complex depositional and erosional processes that result in variable surficial stratigraphy throughout the Tucson Basin. At the project site, which is virtually bisected by the Rillito River, these sediments range from clays to silty and clayey sands and sandy gravels. However, due to the proximity of the Rillito

River, cobbles or boulders may also be present. The subsurface investigation program described in the next section confirmed the site geology described above.

3.0 GEOTECHNICAL INVESTIGATION PROGRAM

3.1 Geotechnical Borings

A field investigation program was conducted by NCS between April 14 and April 23, 2008. The elevations and depths of all the borings are summarized in Table 3.1. The locations of the borings are shown in Figure 3.1. Boring logs and a key to symbols and terms are included in Appendix A. NCS's field investigation program consisted of 14 borings. A breakdown of NCS's field investigation program follows:

- Four (4) 150-foot deep borings were advanced at the locations of the proposed bridge structures over the Rillito River. These are referred to as the "B" series borings and are shown on Sheet 4 of 4 in Figure 3.1.

- Eight (8) borings were advanced to 5 feet to provide subsurface information in support of the pavement design. These are referred to as the "P" series borings and are shown on Sheet 1 of 4 through Sheet 4 of 4 in Figure 3.1. Two borings, P01 and P03, could not be drilled at the locations shown in Figure 3 due to conflicts with underground utilities.

Table 3.1
Summary of Boring Characteristics

Boring #	Depth (ft)	Northing (ft)	Easting (ft)	Ground Elevation (ft)
B-01	150	475,305	979,550	2,266
B-02	150	475,132	979,582	2,247
B-03	150	475,014	979,581	2,247
B-04	150	474,813	979,687	2,265
P-02	5	474,551	979,568	2,264
P-04	5	474,244	979,569	2,260
P-05	5	473,896	979,655	2,264
P-06	5	473,562	979,575	2,264
P-07	5	473,244	979,666	2,266
P-08	5	472,913	979,595	2,267
P-09	5	472,645	979,682	2,268
P-10	5	472,183	979,596	2,268

3.1.1 Permits and Blue Stake Clearances

All borings were drilled in Pima County right-of-way (ROW). The Pima County ROW permit for drilling was approved on December 10, 2007 by Ms. Melissa Marks of Pima County Development Services Department. Blue Stake clearances were obtained by GSI.

3.1.2 Drilling, Sampling and Testing Methods

The borings were performed by GSI under supervision of geotechnical personnel from NCS. GSI used a truck-mounted CME 75 drill rig with a hollow stem auger having an outside diameter (O.D.) of 7.625 inches and an inside diameter (I.D.) of 4.25 inches to advance the borings.

Standard Penetration Tests (SPT) were performed in all borings deeper than 5 feet at increments of 5 feet from the surface to the depth of exploration. A 2-inch O.D., 18-inch long split spoon sampler was used in general accordance with ASTM D-1586 (ASTM, 2005). The split spoon sampler was driven in increments of 6 inches with a 140-pound automatic hammer freely falling from a height of 30 inches. The number of blows required for each 6 inches of penetration was recorded. The number of blows required to advance the sampler the last 12 inches is defined as the penetration resistance, or SPT N-value. The SPT N-value can be used to provide a qualitative description of the relative density of cohesionless soils or the consistency of cohesive soils. Additionally, 2.5-inch diameter ring samples were taken at specific locations for laboratory testing to obtain values of in-situ moisture content and density. A log is included in Appendix A for each boring.

Refusal SPT N-values were encountered at various locations throughout the project site. A refusal SPT N-value or sampler refusal is noted when the sampler cannot be driven the full 18-inch length of the sampler or when the blows of any 6-inch increment equal or exceed 50. Refusal N-values may also be indicative of the presence of cobbles or boulders whose size cannot be determined by the exploratory techniques used on this project. ***Therefore, cobbles or boulders should be anticipated in excavations.***

All samples were placed and sealed in plastic bags and transported to Conformatech for geotechnical laboratory testing.

Geotechnical personnel from NCS were present throughout the field investigation program to observe the drilling operations, to assist in sampling, and to prepare descriptive logs of each boring. Soils were identified and described in the field in general accordance with ASTM D-2488, "Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)."

3.1.3 Groundwater and Bedrock Conditions

Bedrock was not encountered in any of the borings at the time of the field investigations.

Groundwater was encountered in all borings at depths ranging from 36 feet to 55 feet. The measured soil moisture contents at the time of the field investigation were found to range from 5.7% to 34.9%. Degrees of saturation were calculated to be between 33% and 100%; the higher values are generally associated with higher plasticity soils.

3.2 Laboratory Testing

Representative samples were retrieved from the borings and tested for classification and material properties. The results of these tests were used to evaluate the subsurface conditions and to aid in the engineering design of the proposed structures. Conformatech performed all the laboratory tests. The laboratory testing program included grain-size analyses, Atterberg limits tests, moisture content tests, and dry unit weight (density) determinations. Selected samples were tested for pH, resistivity, sulfate and chloride contents and R-values. Tests on soil samples were performed in accordance with the standard test procedures listed in Table 3.2. Results of all laboratory tests are included in Appendix B. Laboratory classifications of the tested soil samples were determined according to the Unified Soil Classification System (USCS) and checked against the visual field classifications, which were then revised where appropriate in accordance with ASTM D-2487.

Table 3.2
Geotechnical Test Methods Applied to Representative Soil Samples
(ADOT, 2008; ARIZ, 1996; ASTM, 2005)

Geotechnical Test	Test Procedure
In-situ Moisture Content	ASTM D 2216
Sieve (Grain Size) Analysis	ARIZ 201, ASTM C-136
Atterberg Limits (Soil Plasticity)	ASTM D 4318
R-value	ASTM D 2844
pH	ASTM D 4972
Resistivity	ADOT 236
Sulfate and Chloride Content	ASTM D 4542

4.0 INTERPRETED SUBSURFACE CONDITIONS

4.1 General Description of Soils within the Limits of the Project Corridor

The overall geology at the project site was described in Section 2.0. Based on visual observation of the soil samples obtained from the borings and on the results of field and laboratory testing, this section of the report presents a general description of the soils, identification of hydro-collapsible soils, and the properties of the soils for engineering analysis of foundations.

Several distinct soil layers were encountered during the field investigations. The soils above approximate EL. 2,210 consist predominantly of sandy soils with varying amounts of fines and gravels (Layer 1). Within the sand fraction, coarse, medium and fine particle sizes are generally equally present. The "percent fines", i.e., silts and clays with particle sizes smaller than the No. 200 sieve or 0.075 mm, ranges from 5% to approximately 80%. The fines have varying degrees of plasticity. The silts are generally nonplastic (ML), while the clays exhibit mostly low to medium plasticity (CL). The coarse grained materials in the top layer are predominantly medium dense to very dense. Loose to medium dense sands that are prone to raveling during excavation were encountered at various depths during field investigations in the Rillito River bed.

The cohesionless top layer is underlain by a thick clayey stratum with interbedded layers of sandy materials (Layer 2). The cohesive components consist mainly of low to medium plastic clays (CL). The consistency based on SPT N-values of the clayey soils ranges from medium to hard, while the density of the cohesionless soils ranges from loose to very dense. Perched groundwater was encountered in all four borings immediately above Layer 2. The moisture contents of the clayey soils were between 17.1% and 34.9%, which represent degrees of saturation between 87% and 100%.

Below approximate EL. 2,150 down to the depth of the borings, the soils encountered consist predominantly of interbedded layers of sands with varying amounts of silts, clays, and gravels and of clayey soils with varying amounts of sand and gravel having USCS designations of SC, SW-SC, SM, CL, SW and SP (Layer 3). The density of the coarse grained soils ranges from dense to very dense, while the consistency of the fine grained soils ranges from very stiff to hard as reflected by their high SPT N-values.

Effect of Cementation: Some soils exhibited varying degrees of induration and/or calcium carbonate ($CaCO_3$) or lime cementation. In the field, cementation is simplistically identified based on the observed reaction ("no", "weak" or "strong") between a soil sample and HCl acid of 10% concentration (ASTM D 2488). The terms used to express the reaction to HCl are explained on Sheet 2 of 4 of "Key to Soil Symbols and Terms" in Appendix A. Reaction to HCl acid does not necessarily correlate to the degree of carbonate cementation. This is particularly true within the limits of this project where reaction to HCl acid was observed quite often as indicated in the boring logs in Appendix A. For example, some samples have low SPT N-values but exhibit a "strong" reaction to HCl. This behavior may indicate that the soil particles are coated with $CaCO_3$ or lime but the voids are mostly clear, i.e., the particles are not significantly cemented to each other; therefore, the density is loose. In other cases, soil samples may exhibit "no" to "weak" reaction to HCl but have relatively high SPT N-values. This behavior may be due to the effects of induration. Given the variability of the cementation at the project site, it is not possible to quantify it reliably for design. Therefore the effect of cementation was disregarded in assigning the values of the soil properties listed in Section 4.3.

In contrast to design, the variability of cementation or induration can have a significant influence on construction activities such as excavations. For example, soils having strong

cementation often necessitate the use of rock excavation tools. Therefore, the contractors are advised to review the boring logs carefully with respect to the qualitative description of a sample's reaction with HCl acid and qualitative description of degree of cementation (if noted) in conjunction with its SPT N-value to evaluate the effect of cementation and/or induration on construction activities.

4.2 Identification of Potentially Hydro-Collapsible Soils

Some dry soils in the desert southwest, including the Tucson area, are known to undergo rapid volume change (collapse) under moisture ingress and/or stress. In our experience, the presence of ephemeral watercourses, such as the Rillito River, suggests that collapse-susceptible (metastable) soils may be encountered in the river bed and/or the approaches to the bridge. Therefore, an evaluation of the site soils was performed based on data from the borings in the river bed and observation of the existing pavement conditions on the approaches to the bridge. These evaluations are discussed below.

Bridge Location: The following general criteria developed by Beckwith (1979) were used to assess the collapse potential for the soils in the river bed:

Plasticity Index, PI	< 10
In-Situ Dry Density, γ_d	< 95 pcf
In-Situ Moisture Content, w_i	< 8%
SPT N-value	<15

Based on the project-specific data, it is generally observed that the SPT N-values below a depth of 15 feet to 20 feet are greater than 15 blows/ft at the location of the proposed bridge structures. While SPT N-values of select samples shallower than 15 feet are less than 15 blows/ft, their in situ moisture content, Plasticity Index or in-situ dry density generally exceeds the threshold value for collapse potential. This suggests that these soils may not be susceptible to collapse. Furthermore, due to scour conditions, drilled shafts will be utilized for bridge foundations that will effectively bypass any potentially collapsible soils.

Approach Roadways: The current approach roadways north and south of the proposed bridge exhibit various levels of distress in the pavement as evidenced by numerous cracks. At the north abutment, the approach embankment has settled. In our opinion, these conditions of the pavement and approach embankment are not due to collapsible soils but can be largely attributed to the adverse drainage patterns that have resulted in damage to the subgrade. In the case of the approach embankment, the observed settlement pattern is also likely due to inadequate compaction during the original construction. Ponding is routinely observed on the approach roadways after rainstorms. Continued soaking of the pavement subgrade and/or approach embankments from vertical infiltration through the cracks and/or lateral infiltration due to adverse grades, has caused significant water damage that has resulted in loose or soft subgrade conditions. Such loose or soft subgrade soils need to be removed entirely or improved by

overexcavation and compaction to prevent damage to the proposed new roadways. The following measures are recommended:

1. Design the vertical and horizontal grades so that water is drained away from the pavements.

2. Overexcavate and recompact the native soils within 3 feet of the pavement finished grade. If fills are to be placed, then the overexcavation and recompaction depth should be limited to the difference between the height of the fills and 3 feet. For example, if the pavement is to be constructed on 2-foot high fills, then only 1-foot depth of the native soils needs to be overexcavated and recompacted. The recompaction effort should be such that the soils are compacted to 100% of the maximum dry density in accordance with the ASTM D 698 (Standard Proctor).

3. During the construction of the new bridges ensure that the compaction of the approach embankments, particularly in the abutment areas is done in accordance with the County standards.

4.3 Identification of Potentially Expansive Soils

For a soil to exhibit swell (expansion), a necessary precursor is the presence of clay minerals that are expansive, e.g., montmorillonite. The type of clay mineral can be identified based on the values of the Atterberg Limits and where they plot with respect to the A- and U-lines on the Plasticity Chart. Such plots are shown in Appendix B immediately following Table B.1. These plots clearly show that expansive clay minerals, such as montmorillonite, are not likely to be present in the site soils. Therefore, expansion (swell) potential of the site soils does not appear to be an issue on this project.

4.4 Recommended Soil Properties for Geotechnical Analysis

The soil properties of interest for the geotechnical analyses and design are the total (moist) unit weight, γ, and the shear strength parameters defined by the angle of effective (drained) internal friction, ϕ', and the effective (drained) cohesion, c'.

The values of the soil properties used here for analysis and design were derived from published correlations between those soil properties and SPT N-values and measured index properties such as grain size data and Atterberg Limits (AASHTO, 2002; Samtani and Nowatzki, 2006). Table 4.1 summarizes the design soil properties derived from such correlations for various soils encountered in the borings. The variations of moisture content, grain size, plasticity and density within a given layer were considered in the derivation of the design value for each parameter. For purposes of analysis an N-value of 75 was assigned in cases where sampler refusal was encountered. However, if N-values greater than 75 were actually measured, then the reported N-values were used for derivation of soil properties. The latter case applies where the sum of N-values in the last two consecutive 6-inch intervals is greater than 75, but the individual blow counts in each 6-inch segment are less than 50 (e.g., 42+38=80).

Table 4.1
Soil Properties Recommended for Geotechnical Design

Layer	Elevations, Top-Bottom	Range (Average; Std Dev) N-values	Design N-value	Design Total Unit Weight	Design Friction Angle	Design Cohesion	Adhesion Factor for axial resistance	Strain for max. shear strength for lateral resistance	Lateral Soil Modulus (Soil Type)
		N	N	γ	ϕ	c	α	ε_{50}	k
	(ft)	(blows/ft)	(blows/ft)	(pcf)	(degrees)	(psf)	(-)	(-)	(pci)
1	Surface-2,210	11 – 75 (31; 16.6)	30	120	34				40 ("Sand")
2	2,210-2,150	7 – 84 (35; 22.4)	30	120		4,000	0.51	0.005	500 ("Stiff Clay with Free Water")
3	2,150-2,100	21 – 94 (64; 20)	64	125	38				150 ("Sand")

LEGEND:

α : Multiplication Factor for cohesion to obtain adhesion for axial load analysis of drilled shafts (From Table 4.6.5.1.1A in AASHTO (2002))

ε_{50} : Strain corresponding to one-half of Max Principal Stress Difference (From LPILE manual for static loading; for cyclic loading use 50% of the value)

k : Lateral soil modulus (From LPILE Manual for static loading; for cyclic loading use 50% of listed value). The k value applies to the indicated "soil" type as per the LPILE^{PLUS} Version 4.0 or later.

Note: **The k value, soil type, and ε_{50} value assume that the structural engineer will use LPILE^{PLUS} Version 4.0 or later for lateral load analysis.**

The layers noted in the above table are idealized soil layers developed for the sole purpose of geotechnical analyses and design. They represent a significant simplification of the complex stratigraphy at the site as evidenced in the borings. Indeed, layers noted may vary from boring to boring by ± 10 ft. Soils different from the above idealizations may be encountered during construction. Intermixing of soil types within a given unit is frequent and random. Thus, the idealized subsurface conditions may not be suitable for contracting or bidding purposes.

5.0 RECOMMENDATIONS FOR BRIDGE FOUNDATIONS

5.1 Introduction

Two separate bridge structures crossing the Rillito River are proposed as part of the La Cholla Boulevard widening. Both bridges will be three-span AASHTO Type V Modified girder structures. Four 150-foot deep borings were advanced in the vicinity of the proposed abutment and pier locations.

5.2 Feasible Foundation Types Based on General Subsurface Conditions

As indicated in the boring logs, the soils generally present at shallow depths in the vicinity of the Rillito River bed are predominately medium dense to dense. In addition,

according to HDR, 23 feet of pier scour and 19 feet of abutment scour are anticipated during the 100-year design flood event and 26 feet of pier scour and 23 feet of abutment scour are expected during the 500-year flood event. Therefore, shallow spread-type foundations are unsuitable for this application. At depths below 50 feet, dense to very dense cohesionless or hard cohesive soils were encountered during the field investigations. In order to account for increased loads and deeper depths of scour compared with the design loads and scour depths assumed for the design of the existing scour-critical bridge, it is anticipated that a deep foundation system (driven piles or drilled shafts) will have to extend through these materials. In addition, driven piles, as were used as the foundation system for the existing Rillito River bridge, are not considered a viable alternative due to the difficulty associated with advancement of driven piles through these dense granular and hard cohesive materials without incurring substantial pile damage during driving. To avoid pile damage, pre-drilling through these dense and hard materials will likely be required and this activity will result in increased cost of the driven pile foundation system.

Using high-torque drill rigs, drilled shafts can be excavated through the dense and hard materials. Therefore drilled shafts appear to be the most economically feasible foundation alternative at this project site given the deep scour depths and relatively large lateral and axial loads. Drilled shafts will develop their capacities predominantly in side shear resistance with additional resistance provided by end-bearing where competent soils are present at depth. Therefore, only recommendations for drilled, cast-in-place reinforced concrete shafts have been developed in detail in this report. Design procedures and recommendations for the drilled shaft foundation system are provided in Section 5.3.

5.3 Design Procedure for Drilled Shafts

The design of drilled shafts involves evaluation of the axial and lateral capacities for a given set of loading and soil conditions. Recommendations and procedures for design of drilled shafts in accordance with AASHTO (2002) procedures are presented below.

5.3.1 Axial Load Analysis

The ultimate axial capacity (Q_{ult}) of a drilled shaft can be expressed as follows according to Section 4.6.5.1 of AASHTO (2002):

$$Q_{ult} = Q_s + Q_t - W \qquad \text{(AASHTO Eq. 4.6.5.1-1)}$$

where:

Q_{ult}	=	ultimate compressive shaft capacity in kips
Q_s	=	ultimate shaft side-resistance in kips (computed in accordance with Sections 4.6.5.1.1 and 4.6.5.1.2 of AASHTO, 2002)
Q_t	=	ultimate shaft tip resistance in kips (computed in accordance with Sections 4.6.5.1.3 and 4.6.5.1.4 of AASHTO, 2002)
W	=	weight of shaft in kips

Axial capacity charts for the design of drilled shafts for this project based on the above formulation are provided in this report. Since scour is a major factor for this project, the axial capacity charts show the relationship between depth of shaft below thalweg elevation of the Rillito River (EL. 2,247) and design load capacity for a range of shaft diameters and for site–specific subsurface conditions. The axial capacity charts include the mobilized tip resistance (Q_t) that is consistent with the displacement required to mobilize skin resistance.

The axial capacity charts are based on design loads. Therefore, the design axial capacity is obtained by dividing the ultimate capacity by an acceptable factor of safety. A factor of safety equal to 2.5 is recommended to obtain ultimate loads from service (design or allowable) loads as per Section 4.6.5.4 of AASHTO (2002). Accordingly, ***a factor of safety of 2.5 is included in the charts presented in this report.***

The design capacity in the axial capacity charts is applicable to a single shaft or a group of shafts with a center-to-center (CTC) spacing of 8 diameters or more as per AASHTO (2002). For shaft groups with a smaller CTC spacing, the design capacity should be reduced to account for the detrimental effects of stress overlap between adjacent shafts. AASHTO (2002) recommends use of a Group Reduction Factor (GRF) based on the CTC spacing. The GRF for axial capacity (GRF_{axial}) can be estimated from the following equations based on AASHTO recommendations (Section 4.6.5.2.4.2 AASHTO, 2002):

$$GRF_{axial} = 0.472 + 0.066(X/D) \quad \text{for } 3D < X < 8D; \quad GRF_{axial} = 1.0 \quad \text{for } X \geq 8D$$

where X is the center-to-center spacing of the shafts in a group and D is the shaft diameter. A center-to-center spacing less than 3 times the shaft diameter (X<3D) is not recommended without careful construction sequencing of shafts. The geotechnical engineer should be consulted to verify construction sequencing prior to installation of shafts in this case.

A step-by-step process for the use of a drilled shaft axial capacity chart is described below.

Sample Problem: Consider a single drilled shaft that is part of a 2-shaft pier foundation system for a viaduct (land crossing) having a total pier service load of 600 kips. Assuming the total load is equally distributed between the two shafts, each shaft will carry 300 kips. The problem is to find the depth of embedment below finished grade if the shafts are either 3-foot diameter or 4-foot diameter and are spaced 14 feet apart (CTC). Since this example illustrates the use of drilled shaft capacity charts by means of a land crossing, the depth below finished grade is used, while for water crossings, the thalweg elevation of the river or channel should be used with the depth of the scour hole accounted for in the chart. The following step-by-step process can be used to determine the length of the shaft:

Step 1:

Use a group reduction factor (GRF) to adjust the service load (P_{as}) for a single shaft to account for group interaction effects. In this example, the GRF for the 3- and 4-foot diameter shafts spaced at 14 feet on center will be as follows:

Diameter	X/D	GRF
3-ft	4.67	0.78
4-ft	3.50	0.70

Evaluate the prorated service load, P_{asp}, for each shaft as follows:

Diameter	GRF	$P_{asp} = P_{as}/GRF$
3-ft	0.78	300 kips / 0.78 = 385 kips
4-ft	0.70	300 kips / 0.70 = 429 kips

Step 2:

The axial capacity chart shown in Figure 5.1 will be used for this example. Note that the ordinate of the chart in Figure 5.1 is "Depth below finished grade" rather than "Depth below thalweg elevation" as is the case for the project-specific axial capacity charts presented in Section 5.4. This is because the example problem pertains to a situation where scour is not a factor. In general, the chart is used as follows: draw a vertical line corresponding to the prorated service load from finished grade to the depth below finished grade where this prorated service load line first intersects the capacity curve for an assumed shaft diameter (OP for 3-foot shaft; O'P' for 4-foot shaft). The depth at this intersection represents the required length for shafts with that diameter and group spacing. From the example chart provided in Figure 5.1, the lengths of the 3-foot and 4-foot diameter shafts will be as follows:

Diameter	P_{asp}	Shaft Length
3-ft	385 kips	45-ft
4-ft	429 kips	36-ft

Step 3:

Check the shaft capacity within a depth of 3 diameters below the bottom of the shaft to evaluate the potential for the shaft to punch into a softer deposit below the tip of the shaft. If the capacity is equal to or greater than that of the prorated service load then the length of the shaft determined in Step 2 is adequate. If the capacity is less, as may be the case where there is a weaker soil underlying the shaft tip elevation, then the shaft length should be increased until a capacity equal to or greater than the prorated service load is obtained within 3 diameters below the tip of the shaft. In this example, the depth below the tip within which the capacity should be checked is as follows:

Diameter	Shaft Length	Depth below Shaft Tip	Depth below Shaft Top
3-ft	45-ft	3 (3) = 9-ft	45+9 = 54-ft
4-ft	36-ft	3 (4) = 12-ft	36+12 = 48-ft

As shown in Figure 5.1, the shaft capacity reduces between depths of 50 to 55 feet. Since the top of the softer deposit at 50 feet is below 48 feet, the length of the 4-foot diameter shaft is adequate. However, for the 3-foot diameter shaft the softer deposit is within 3 diameters below the shaft tip determined from Step 3. Therefore, the shaft should be extended through the softer layer between the depths of 50 to 55 feet. Based on this logic, the recommended length of the shaft would be approximately 56 feet. The procedure should be repeated for the 3-foot diameter shaft founded at a depth of 56 feet to assure that no weaker zone exists within 9 feet of the tip elevation.

By using the above step-by-step process, the structural engineer can determine the optimal length of the shafts by increasing the diameter of the shafts and/or adjusting the spacing such that the reduction in capacity due to group effects is minimized.

5.3.2 Lateral Load Analysis

Once a shaft is sized based on axial capacity considerations, a lateral load analysis should be performed. Use of the LPILE^{PLUS} Version 4.0 (Reese et al., 2000) or a similar program is recommended for this purpose. The LPILE^{PLUS} program is based on the "p-y" concept and includes the effect of soil-structure interaction along the full depth of the shaft or pile. However, lateral load analysis of drilled shafts is an iterative process that starts by assuming that the drilled shafts are cantilevered with fixity occurring at a certain depth below the top of the shaft. For 4- to 6-foot diameter drilled shafts, this depth to fixity can be assumed to be approximately 4D for the site-specific conditions, where D is the diameter of the shaft (McBride and Mahoney, 1986). The analysis is then performed until the deformations from the cantilever model and the LPILE^{PLUS} model are in reasonable conformance, i.e. convergence is achieved. Once convergence is achieved, the distribution of shears and moments from the LPILE^{PLUS} model should be used for the design of the reinforcement of the shaft.

For lateral loads, as a general guide, the center-to-center spacing of adjacent shafts in a group, X, should be greater than 2.5D in the direction normal to loading, and X > 8D in the direction parallel to loading for the shafts to act individually (i.e., not being affected by the presence of nearby shafts/piles). For shaft layouts not conforming to this criterion, the effect of shaft interaction should be included in design. Table 5.1 presents the AASHTO (2002) recommendations for reduction of lateral capacity for such cases. Linear interpolation may be used for CTC spacings not included in Table 5.1. The group reduction factors shown in Table 5.1 should be applied to the lateral subgrade modulus, k, noted in Table 4.1.

Table 5.1
Group Reduction Factors for Lateral Load Analysis (AASHTO, 2002)

Center to Center Spacing in terms of Diameter for In-line Loading	Ratio of Lateral Resistance of Shaft in Groups to Single Shaft Resistance
≥ 8D	1.00
6D	0.70
4D	0.40
3D	0.25

The GROUP program (Reese and Wang, 2000) is recommended for lateral load analysis of shafts in a group. The program automatically calculates the group reduction factor based on Table 5.1.

Note that the final length for a given shaft will be the larger of the lengths required from axial and lateral load analysis.

5.4 Site-Specific Axial Capacity Charts

Project specific axial capacity charts are presented in Figures 5.2 through 5.5. The charts in Figures 5.2 and 5.3 apply to abutments and piers, respectively, for the 100-year flood event. The charts in Figures 5.4 and 5.5 apply to abutments and piers, respectively, for the 500-year flood event. The upper portions of the charts that show zero axial capacity represent the scour zones. The depths and elevations of scour zones shown in Figures 5.2 to 5.5 were based on information provided by HDR and are measured from the thalweg elevation of the Rillito River (El. 2,247). All axial capacity charts show the depth below EL 2,247 vs. design axial load capacity for a variety of shaft diameters.

The axial capacities in all charts in Figures 5.2 to 5.5 include a factor of safety, FS = 2.5. While a FS = 2.5 is applicable to the 100-year flood event, it may be conservative for a 500-year flood event. Agencies generally use a lower FS for a 500-year event since it is often considered to be an "extreme event." Some agencies use a FS = 1.0 for such events. It is recommended that HDR identify an appropriate FS for the 500-year flood event based on discussions with Pima County. Assume that this FS is denoted by FS_{500}. Then, the capacity read from the charts in Figures 5.4 and 5.5 should be multiplied by a factor of $2.5/FS_{500}$ to obtain the axial capacity consistent with a factor of safety equal to FS_{500}. For example, if $FS_{500} = 1.5$, then the axial capacity obtained from Figures 5.4 and 5.5 should be multiplied by a factor of 2.5/1.5 = 1.7.

Except for the adjustment for the FS for the 500-yr event, the charts in Figure 5.2 to 5.5 should be used in accordance with the procedures described in Section 5.3.1.

5.5 Estimated Settlements

Settlements of individual drilled shafts will depend on the final design service load, the depth of the drilled shaft, and the quality of the shaft construction. Estimates of shaft settlements expected for the bridge structures were obtained by using procedures

described in Section 4.6.5.5 of AASHTO (2002). Based on AASHTO procedures and location-specific soil conditions, the estimated total settlement of shafts extending into Layer 3, including short-term and long-term settlements, are expected to be approximately 2% of the shaft diameters ranging from 5 to 7 feet with 6 feet as an average shaft diameter. Approximately 25% of the total settlement will occur by the end of construction, while approximately 75% will happen over the design life of the structure For example, if a 6-foot diameter shaft is used, then the total estimated settlement is 6-ftx0.02x12-in/ft = 1.44-in, of which 25% or 0.36 inches will occur approximately at the end of construction. The remaining 75% or 1.08 inches will occur over the design life of the structure. The implication of the long-term settlement is that the connections of the bridge and its appurtenant structures to the piers and abutments will need to be designed for continued settlements over the design life of the structure.

5.6 Construction Considerations for Drilled Shaft Foundations

Drilled shafts should be constructed in general accordance with the latest version of Section 609 of the City of Tucson/Pima County Standard Specifications for Public Improvements (COTPC, 2003). During the field investigation program it was found that some of the less cohesive, more granular soil layers, especially near the thalweg elevation of the Rillito River, will be prone to caving during excavation. Additionally, localized caving conditions may be encountered at greater depths also. Therefore, localized caving should be anticipated during drilling operations. Additionally, cemented layers of soil as well as cobbles were encountered throughout the project area at various depths. The drilled shaft contractor should mobilize appropriate equipment for excavating those types of soils.

Local groundwater conditions should be checked at the time of construction to evaluate seasonal groundwater fluctuations at the project site. Groundwater was encountered in borings B-01 through B-04 at depths between 36 feet and 55 feet, which corresponds to EL. 2,210 to 2,217. ***Hence, it is anticipated that groundwater will be encountered during construction of the drilled shafts. Side-support in the form of casing and/or drilling slurry will be required.***

Once the foundation configurations such as the number of shafts, shaft diameters and shaft lengths are selected, it is recommended that project-specific special provisions for drilled shafts be developed by the project team. These special provisions should also address integrity testing (cross-hole sonic logging and gamma-gamma logging) and shaft acceptance criteria, which can be developed only after the shaft configurations are established by HDR and Pima County.

5.6.1 Test Shaft

When caving soils and/or ground water conditions are anticipated to be encountered, agencies often consider a test shaft to evaluate the constructability of production shafts. A test shaft is a sacrificial drilled shaft that is excavated before the production shafts. This is in contrast to a confirmation shaft that is commonly the first production drilled

shaft foundation. The test shaft is excavated at a representative location within the bridge location with care being taken to locate it outside the footprint of production shafts or other future constructed facilities. The constructability evaluation includes the selection of an appropriate drilling technique that involves the use of casing and/or slurry to support the drilled hole against collapse.

Given the soil conditions encountered in the drilled borings in the river bed, it is anticipated that surface casing extending to a depth of 20 to 25 feet may be necessary to control caving soils. Slurry will likely be used at greater depths to counteract the caving soils as well as groundwater pressures. Many types of slurries are available. However, the choice of the slurry is a function of the site-specific soil conditions and drilling tools used by the contractor. A test shaft can help evaluate the proper slurry type and drilling technique to minimize anomalies in production shafts. A test shaft will also help evaluate the effect of cementation as well as larger size particles, such as cobbles and boulders on drilled shaft construction. Finally, since the goal of the test shaft is to evaluate constructability, a reinforcement cage is not necessary; furthermore, the test shaft can be backfilled with lean concrete. Load testing to evaluate shaft capacity is not performed on a test shaft.

If a test shaft program is implemented, the test shaft should be constructed to the same depth and diameter as the production shafts in the Rillito River bed. A test shaft report should be prepared documenting the drilling equipment and methods used including any specialized stabilization techniques, drilling rates, etc. A detailed log of the materials encountered during excavation should be prepared by a qualified and experienced representative of the geotechnical engineer.

6.0 RECOMMENDATIONS FOR RETAINING WALLS

6.1 Introduction

The project corridor traverses several developed residential and commercial areas. In order to protect existing properties, noise walls are proposed in various locations along the project corridor. Additionally, it is anticipated that retaining walls will be associated with wingwalls and the reconstructed pedestrian path under the bridges in order to meet existing grades.

6.2 Lateral Loads Acting on Retaining Walls

We understand that all walls will have level backfill and will correspond to the Case II configuration listed on the ADOT Standard Drawings. An angle of internal friction of 33 degrees and a unit weight of 120 pcf were assumed for the structural backfill. The lateral loads listed below are based on a horizontal backfill adjacent to the wall and do not include hydrostatic pressures.

- Unrestrained, drained walls that are free to displace a distance of at least 0.1 percent of the wall height should be designed for an **active** lateral earth pressure condition equivalent to a hydrostatic pressure distribution of 35 pcf.

- Rigid and restrained walls at locations for which the deflection required to develop active earth pressure is not tolerable should be designed for an "**at-rest**" lateral earth pressure condition equivalent to a hydrostatic pressure distribution of 55 pcf.

Drainage systems consisting of porous backfill material as outlined in ADOT Standard Drawing B-19.10 (ADOT, 1992a) are recommended. Additionally, adequately designed and spaced weep holes should be used in all walls.

6.3 Design Factor of Safety Criteria for External Stability of Wall Footings

The stability of wall footings should be evaluated by considering the following potential failure modes: 1) sliding, 2) overturning, 3) bearing capacity, and 4) overall stability. The factor of safety criteria for these failure modes presented in Table 6.1 must be satisfied as per Sections 4.4.7.1.2, 5.2.2.3 and 5.5.5 of AASHTO (2002).

Table 6.1
Minimum Required Factors of Safety for Walls (AASHTO, 2002)

Design Criterion	Minimum Required Factor of Safety
Bearing Capacity	3.0
Sliding	1.5
Overturning	2.0
Overall Stability	1.5

6.4 Structural Design for Sliding and Overturning of Walls

The structural design of the walls should incorporate the following recommendations with respect to sliding and overturning:

- A coefficient of base friction, μ, equal to 0.4 should be used to evaluate sliding stability. If a base shear key is used, there are two methods for incorporating its effect into the sliding and overturning analyses:

  1. The following equation may be used to estimate an equivalent coefficient of base friction, μ_e:

     $$\mu_e = 0.4 + \{60D_k(2D+D_k)\,K_p\}/v$$

     where D_k is the height of the shear key (= 1.25 feet for ADOT standard walls), D is the depth of embedment measured from the finished grade in front of the wall to the base of the footing, v is the total vertical (unfactored) load on the wall

footing per linear foot of wall length in lbs/ft, and K_p is the passive earth pressure coefficient, which is expressed as follows:

$$K_p = \tan^2(45^o + \phi/2)$$

For ϕ=30-degrees, the value of K_p is 3.0. For K_p = 3.0 and D_k = 1.25 feet, the equivalent coefficient of friction, μ_e, may be expressed as follows:

$$\mu_e = 0.4 + \{75(2D+1.25)(3)\}/v$$
$$\mu_e = 0.4 + (450D + 281.25)/v$$

For ADOT standard CIP walls, the equivalent coefficient of friction, μ_e, may be expected to range from 0.45 to 0.50 depending on the wall height and backfill slope configurations.

2. Since the shear key is located under the stem, the passive resistance in front of the shear key can be calculated. This passive resistance should be estimated using a hydrostatic pressure distribution of 360 psf/ft. It is recommended that only the portion of the passive pressure distribution extending below the bottom of the base slab should be considered in design. Note that a footing must translate as much as 0.02 times the embedded depth of the base shear key to develop full passive resistance in compacted soils. For movements between 0 and 0.02 times the embedded depth, the developed passive resistance can be estimated by linear interpolation between 0 and 360 psf/ft; e.g., if a movement of 0.01 times the embedded depth of the base shear key can be tolerated then the passive resistance will be 180 psf/ft.

   For footings without shear key under the stem of the footing, the passive resistance should be neglected unless it can be ensured that during the entire design life of the structure there will be no disturbance of the soils in front of the footing element that are assumed to contribute to the passive resistance.

- The stability criterion for overturning is generally satisfied when the location of the bearing pressure resultant on the base of the foundation is within the middle third of the width of the footing.

6.5 Preparation of Subgrade for Wall Footings

For CIP walls that are to be constructed on native ground (not including abutment walls supported on drilled shaft foundations), it is recommended that the subgrade soils within a prism of depth of 3 feet below the footing and at least 2 feet around the perimeter of the wall footing footprint should be overexcavated and recompacted. These soils should be recompacted to achieve a maximum dry density corresponding to 100% of the Standard Proctor effort according to Arizona Test Method 225 (ARIZ, 1996) with compaction moisture content within ±2% of the optimum moisture content. The subgrade should be moistened and proof-rolled with a 10-ton heavy vibratory or impact roller before the

construction of the footings. Any soft areas found after proof-rolling shall be remediated by overexcavation and replacement with structural backfill as per the Section 203 of COTPC (2003) or ADOT (2008).

6.6 Bearing Capacity for Wall Footings

Assuming that the subgrade for wall footings will be prepared in accordance with the recommendations in Section 6.5 and a minimum embedment depth of 2 feet below finished grade, the allowable bearing capacity of 2.5 ksf can be assumed for footing widths ranging from 2 to 8 feet. For this allowable bearing capacity a total settlement of approximately 1 inch and a differential settlement of ½ inch to ¾ inch may be anticipated. The bearing capacity can be increased by one-third for seismic events. This increase is not applicable to other transient loads such as those from wind or vehicular impact.

7.0 TRENCH BACKFILL

Trench backfill in the form of bedding and shading material for pipes and similar drainage structures will be required on the project. This section discusses the chemical properties for such backfills and suitability of the on-site soils from a chemical as well as mechanical (gradation and plasticity) considerations.

7.1 Chemical Properties of Soils

The chemical properties for bedding and shading material for pipe or drainage structures as required by Section 501 of the City of Tucson and Pima County Standard Specifications (COTPC, 2003) are shown in Table 7.1.

A limited chemical testing program was performed to evaluate the suitability of site soils as bedding and backfill materials around drainage structures. The chemical tests consisted of pH, resistivity, chloride and sulfate contents. The tests were conducted on bulk samples retrieved within 5 feet below existing grades. The results of the chemical tests are summarized in Table 7.2.

By comparing the chemical properties listed in Table 7.2 with the COTPC requirements shown in Table 7.1, it can be seen that the soils in boring P09 do not meet the resistivity requirements for bedding and shading materials when metal structures are used. The comparison also indicates that the requirements for both bedding and shading are fulfilled in case concrete structures are used.

Table 7.1
COTPC (2003) Requirements for Chemical Properties of Bedding/Shading Soils

Property	Bedding Material		Shading Material	
	Metal Structure	Concrete Structure	Metal Structure	Concrete Structure
pH	6.0 to 10.0*	6.0 to 12.0	6.0 to 9.0	6.0 to 12.0
Resistivity	> 2,000 ohm-cm	--	> 2,000 ohm-cm	--
* For aluminum the limiting range of pH for bedding material is 6.0 to 9.0				

Table 7.2
Summary of Chemical Properties of Soils

Boring	Sample Depth (ft)	Chemical Properties of the Soil Samples			
		pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)
P02	0-5	6.5	4,485	0	14
P09	0-5	7.3	1,154	95	54

7.2 Suitability of On-Site Soils for Potential Backfill Applications

Table 7.3 provides a summary of the overall suitability of on-site soils for various potential backfill applications. The evaluation presented in Table 7.3 was based on a comparison of the data in Appendix B with the criterion for each potential application as specified in FHWA (2001) and COTPC (2003). In addition to the values of % fines (X) and PI, grain size distribution curves were compared to the gradation requirements for each potential application. The evaluation regarding suitability as presented in Table 7.3 should be interpreted as follows:

- If the suitability of on-site soils for a potential application is indicated to be "Maybe," it means that, although there are some local zones that may contain suitable materials it is equally likely that only unsuitable material may be encountered during construction. Additionally, it is strongly recommended that other application-specific discriminating parameters such as resistivity or pH be evaluated before those soils are used for that particular application.

- If the suitability of on-site soils for a potential application is indicated to be "Likely No," it means that, although there are some local zones that may contain suitable materials, it would not be possible to identify those zones with sufficient accuracy and regularity. Therefore, it is recommended that off-site borrow be considered for such potential applications in order to be conservative with respect to project cost. If additional geotechnical investigations are performed once potential on-site borrow sources are identified, then the use of on-site soils for such potential applications may be reevaluated.

Table 7.3
Evaluation of Suitability of On-Site Soils for Potential Applications in Terms of Selected Main Parameters (FHWA, 2001 and COTPC, 2003)

Potential Application	Main Parameter Requirement			Are on-site soils suitable?
	% Fines, X [1]	PI	X + PI	
MSE "select" backfill [2]	≤15%	<6	-	Maybe
Structure backfill	-	-	≤25	Maybe
Bedding material	≤8%	≤8	-	Likely No
Shading material	-	-	≤25	Maybe

1. % fines or X is the percent of material passing the No. 200 sieve, which has a sieve opening size of 0.075 mm.
2. For geosynthetic reinforcement according to FHWA (2001)

Unlike the specific requirements for bedding and shading materials, Subsection 501-2.06 of the COTPC Standard Specifications does not have any specific requirements for percent fines or PI for trench backfill materials for drainage pipes, unless the drainage structure is under a roadway prism. Subsection 501-2.06 of COTPC (2003) states that the trench material *"...shall not contain organic material, rubbish, debris and other deleterious material and shall not contain solid material which exceed 8-in. in greatest dimension and shall be soil selected from excavation or from a source selected by the contractor."* Furthermore, Subsection 501-3.04 of COTPC (2003) requires that *"The trench backfill shall conform to the requirements of Subsection 501-2.06 with the exception that, within the roadway prism, trench backfill material shall conform to the requirements of the shading material as specified in Subsection 501-2.05. However, when shading material is used as trench backfill, 100% of the material shall pass the 6-in. sieve."*

Based on these requirements, the on-site soils may be used as trench backfill material for drainage pipes within and outside of the roadway prism.

8.0 BORROW REQUIREMENTS FOR ROADWAY EMBANKMENTS

Borrow materials will likely be required during construction of roadway embankments for this project. All work performed shall be in accordance with the City of Tucson and Pima County Standard Specifications (COTPC, 2003) Section 203 with the following exception:

Plasticity Index (PI):	≤ 8
% passing #200 sieve (%fines):	≤ 35%

The compaction requirements shall conform to Section 203-9.03 of COTPC (2003). It should be noted that the above requirements are specific to roadway embankment materials only. The trench backfill requirements should be as discussed in Section 7.0.

The above PI and %fines correspond to an approximate correlated R-value of 45 as per ADOT PE&D manual (ADOT, 1989). HDR should evaluate the suitability of this R-value for pavement structures and, as needed, modify it to determine a cost-effective pavement structure. In the event that lower values of PI and %fines are adopted from a cost-effective pavement structure viewpoint, then consideration may be given to adopting those values for roadway embankment purposes as well to simplify procurement of borrow materials and to avoid multiple borrow sources and associated additional quality control requirements.

9.0 TEMPORARY EXCAVATIONS

Temporary cut and fill slopes will be required. In general, temporary slopes should be excavated in accordance with OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, Subpart P (OSHA, 1995). In accordance with Subpart P, Appendix A, the near-surface site soils (within the upper 5 to 15 feet) at the time of our field investigation are considered to be predominantly "Type C" soils. For excavations of less than 20 feet in such soils, Subpart P, Appendix B recommends a maximum allowable unshored slope of 1.5H:1V (H=horizontal, V=Vertical). This recommendation is based on the soil moisture contents being maintained at or near optimum moisture content for fill slopes and at or near in-situ moisture contents for cut slopes. Significant moisture increases in the soils within the slope could weaken the slopes due to a reduction in shear strength. The soils within a cut slope should be carefully observed and evaluated since soft soils were encountered at shallow depths in borings at various locations across the site. Such soils may cause local slope stability problems. Therefore excavations in such soils will require trench shields or shoring.

Should slopes steeper than 1.5H:1V be required due to the proximity of a cut to existing structures or for purposes of construction economy, the stability of such slopes should be verified through analysis by a registered Professional Engineer in the State of Arizona with demonstrated geotechnical engineering knowledge and experience.

Moderate to severe raveling and erosion of excavation faces may occur due to water infiltration and/or surface runoff. Therefore, the perimeter of all excavations should be protected against water infiltration from surface runoff or other reasons.

Heavy equipment or traffic should not be allowed within 10 feet from the edge of any excavation.

10.0 LIMITATIONS OF THE REPORT

NCS Consultants, LLC (NCS) represents that our services are performed within the limits prescribed by the Client, HDR, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No

other representation to the Client, expressed or implied, and no warranty or guarantee are included or intended.

The recommendations contained in this report are based on our understanding of the proposed corridor configuration and on field and laboratory investigations performed by NCS. It is anticipated that there will be variations in the soils between the boring locations. The nature and extent of the variations may not be evident until construction occurs. Thus, if any conditions are encountered that are significantly different from those described in this report, NCS should be notified immediately so that any necessary revisions to the recommendations contained in this report can be made.

11.0 REFERENCES

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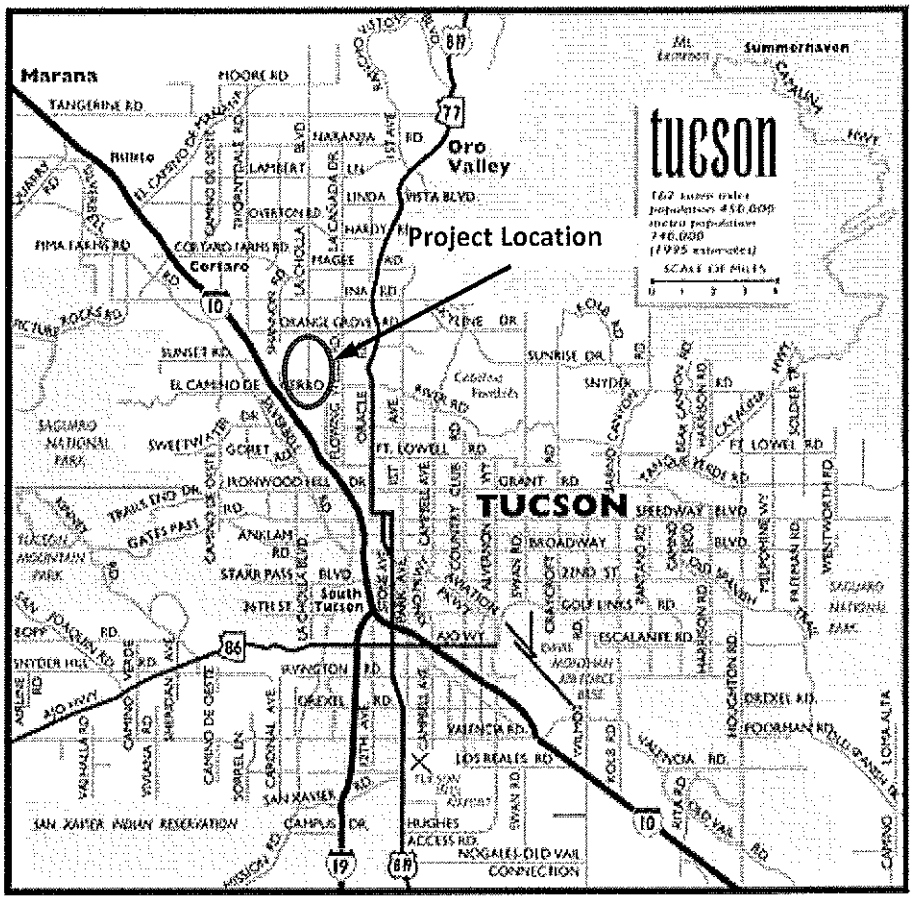
FIGURES



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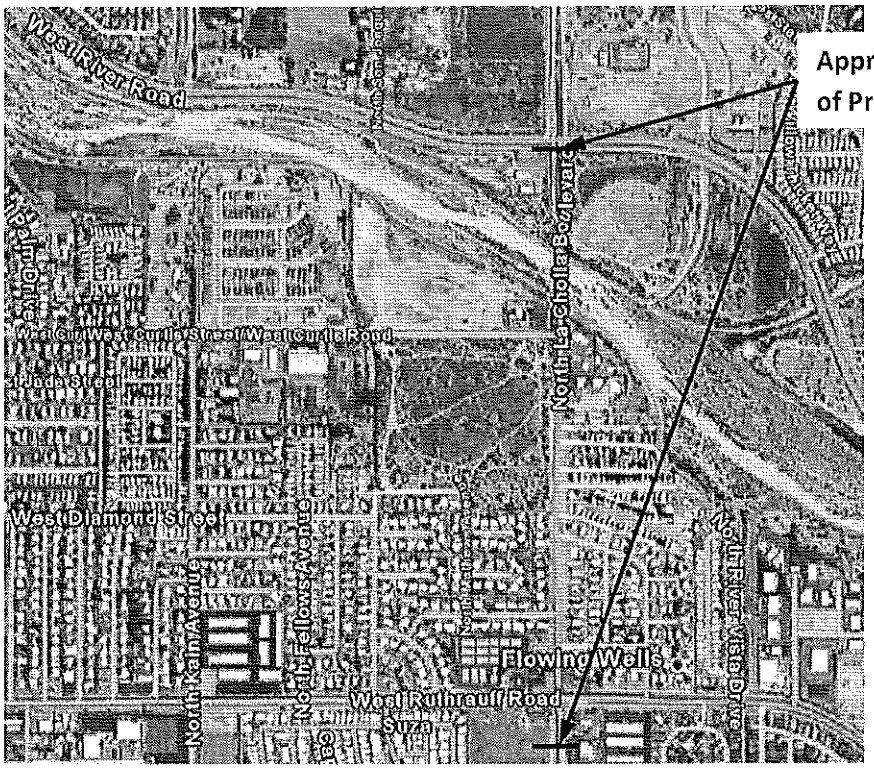
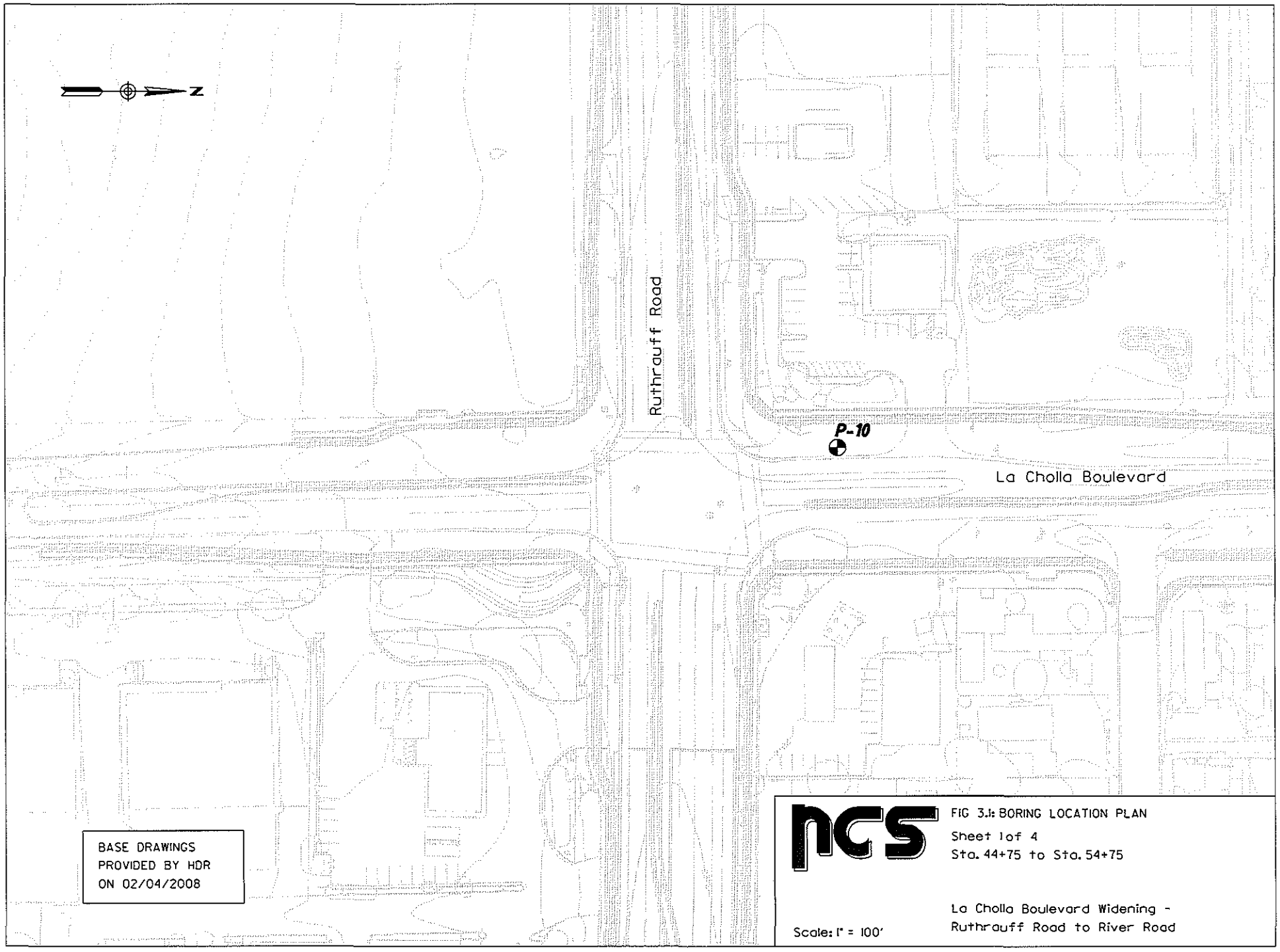
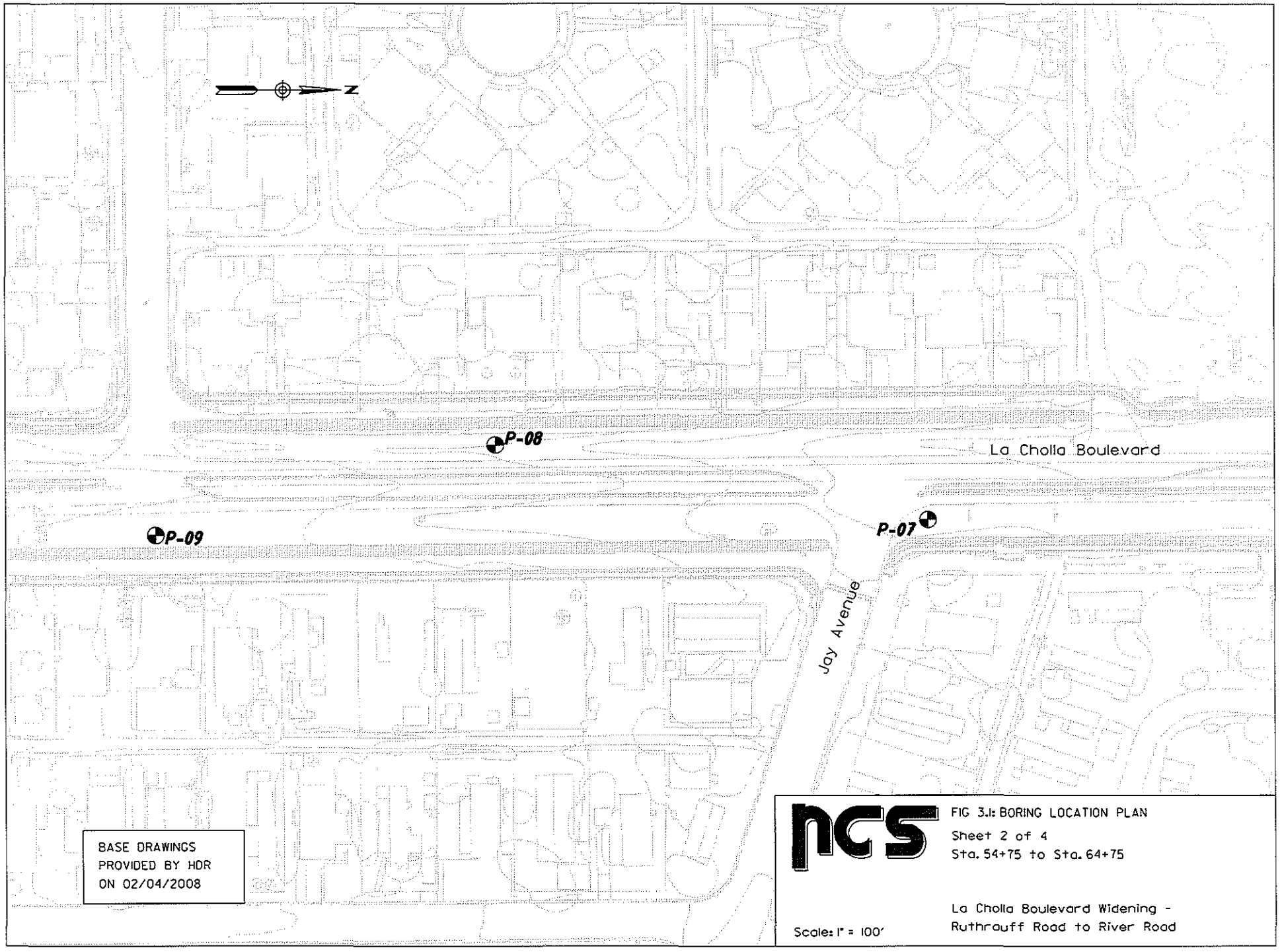
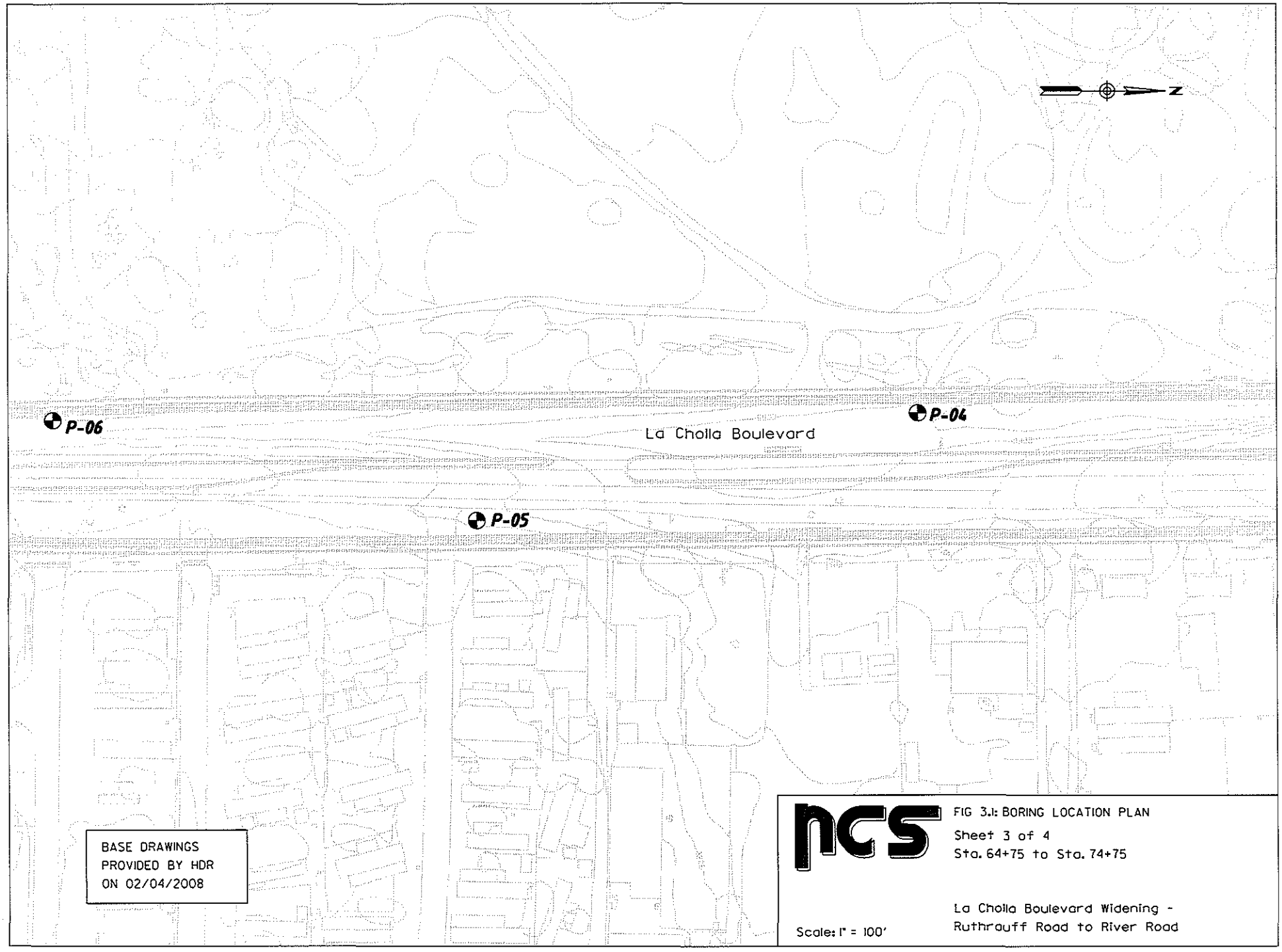


Figure 1.1: Project Vicinity and Location (Source: Google Earth)


N
Ruthrauff Road
P-10
La Cholla Boulevard
BASE DRAWINGS
PROVIDED BY HDR
ON 02/04/2008
ncs
FIG 3.1: BORING LOCATION PLAN
Sheet 1 of 4
Sta. 44+75 to Sta. 54+75
La Cholla Boulevard Widening -
Ruthrauff Road to River Road
Scale: 1" = 100'


N
P-08
La Cholla Boulevard
P-09
P-07
Jay Avenue
BASE DRAWINGS
PROVIDED BY HDR
ON 02/04/2008
ncs
FIG 3.1: BORING LOCATION PLAN
Sheet 2 of 4
Sta. 54+75 to Sta. 64+75
La Cholla Boulevard Widening -
Ruthrauff Road to River Road
Scale: 1" = 100'



ncs

FIG 3.1: BORING LOCATION PLAN

Sheet 3 of 4

Sta. 64+75 to Sta. 74+75

La Cholla Boulevard Widening -
Ruthrauff Road to River Road

Scale: 1" = 100'

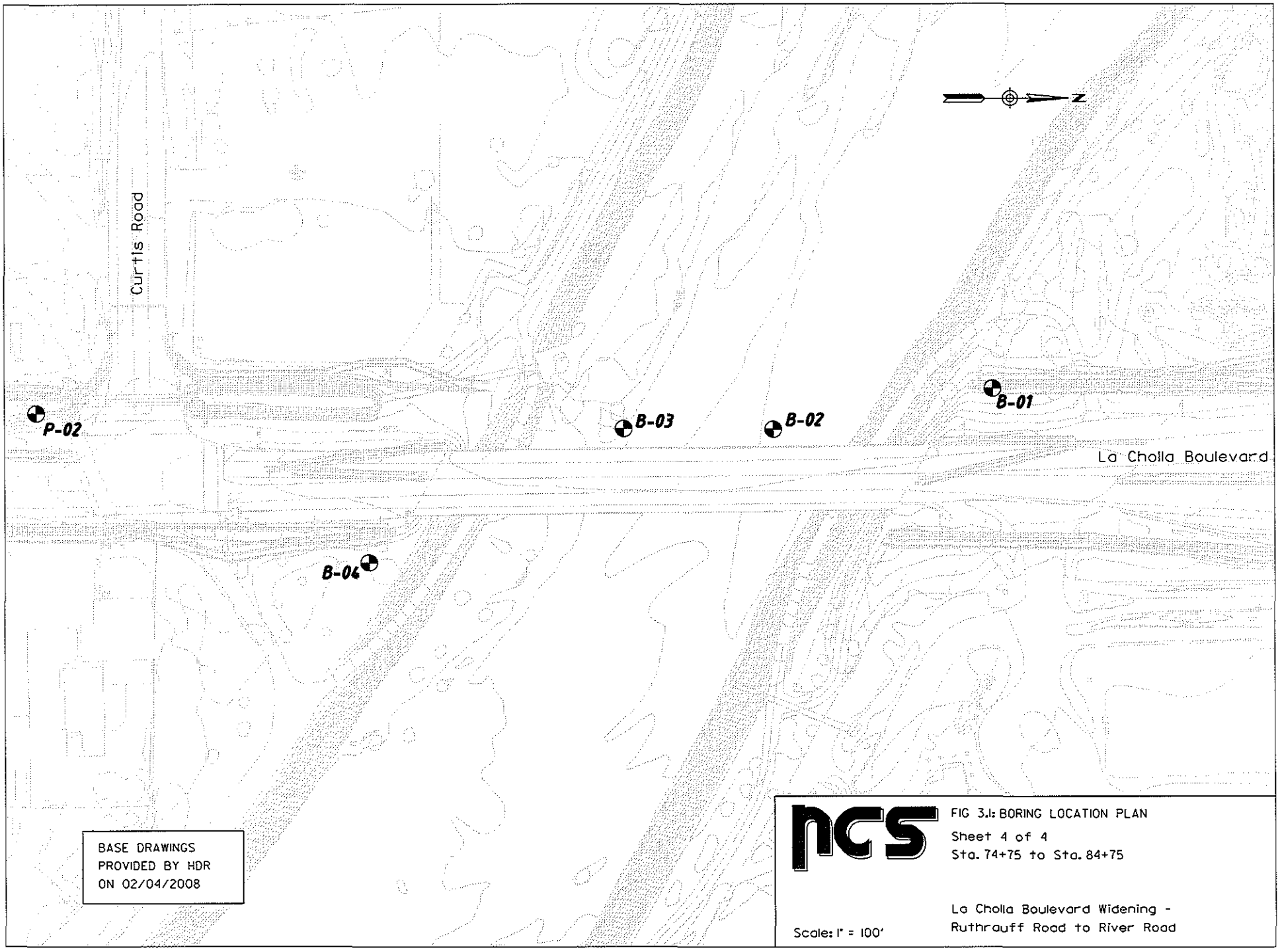


FIG 3.1: BORING LOCATION PLAN

Sheet 4 of 4

Sta. 74+75 to Sta. 84+75

La Cholla Boulevard Widening -
Ruthrauff Road to River Road

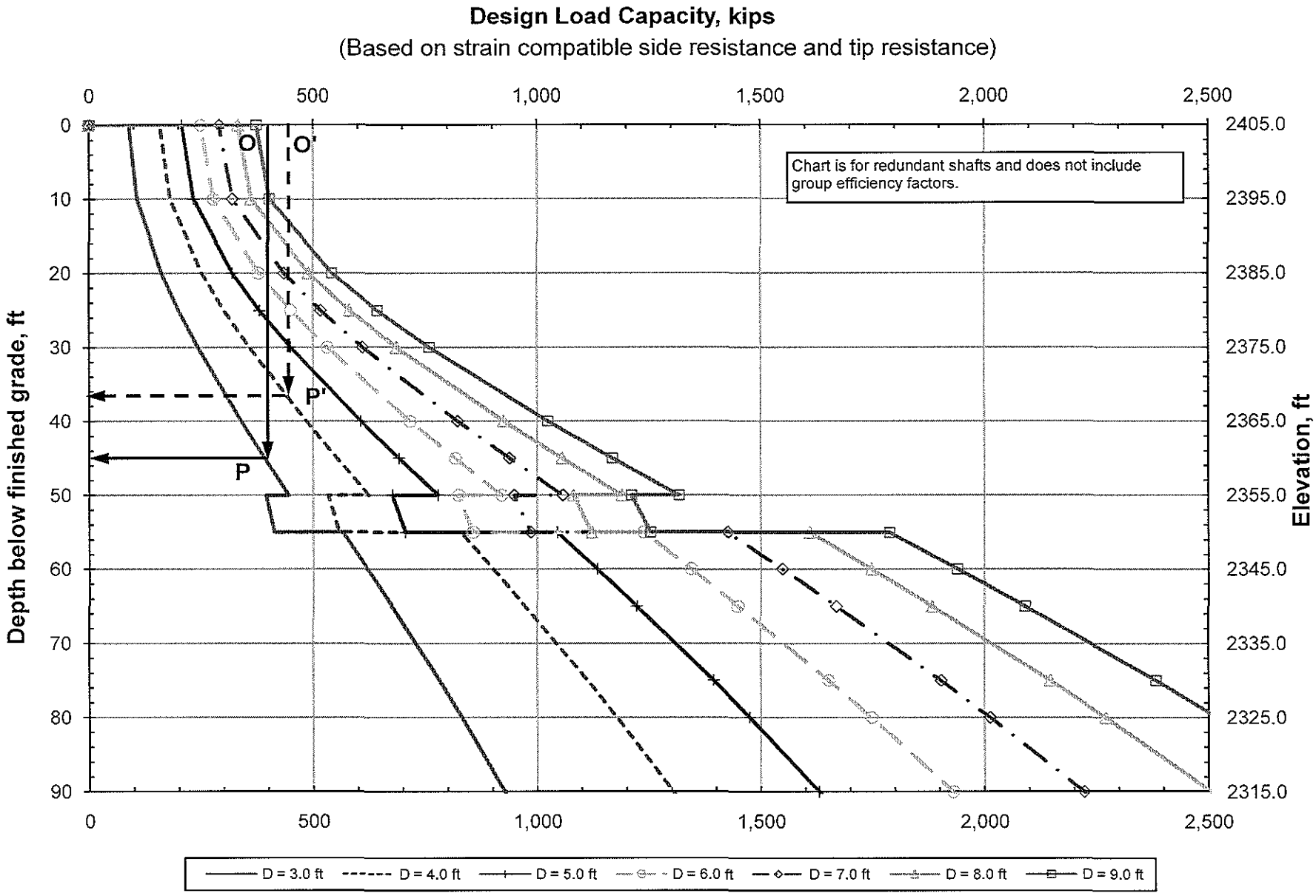


Figure 5.1: Drilled Shaft Capacity Chart - Sample Chart

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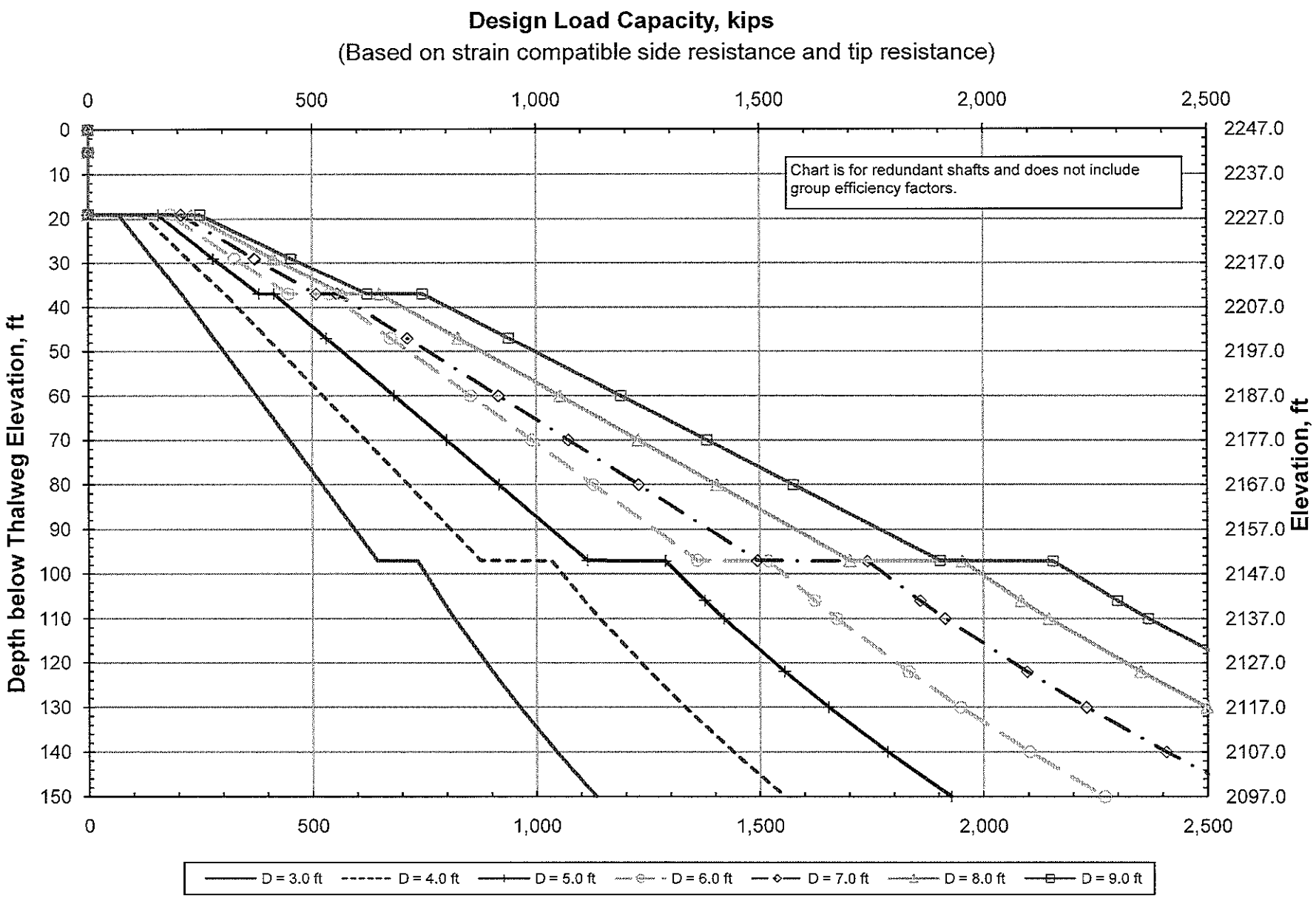

Figure 5.2: Drilled Shaft Capacity Chart - Rillito River Bridge, Abutments - 100-yr flood

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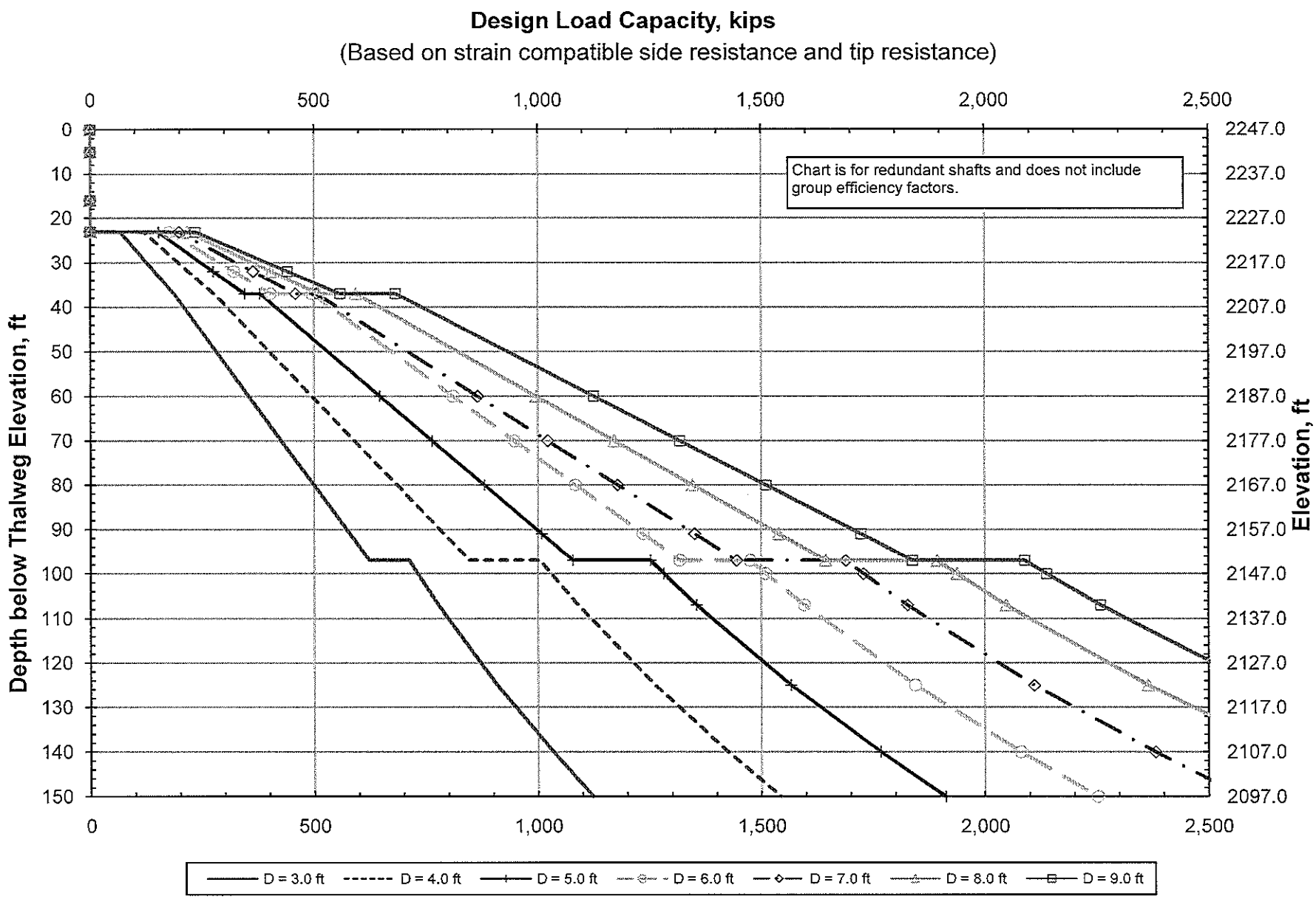

Figure 5.3: Drilled Shaft Capacity Chart - Rillito River Bridge, Piers - 100-yr flood

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ncs

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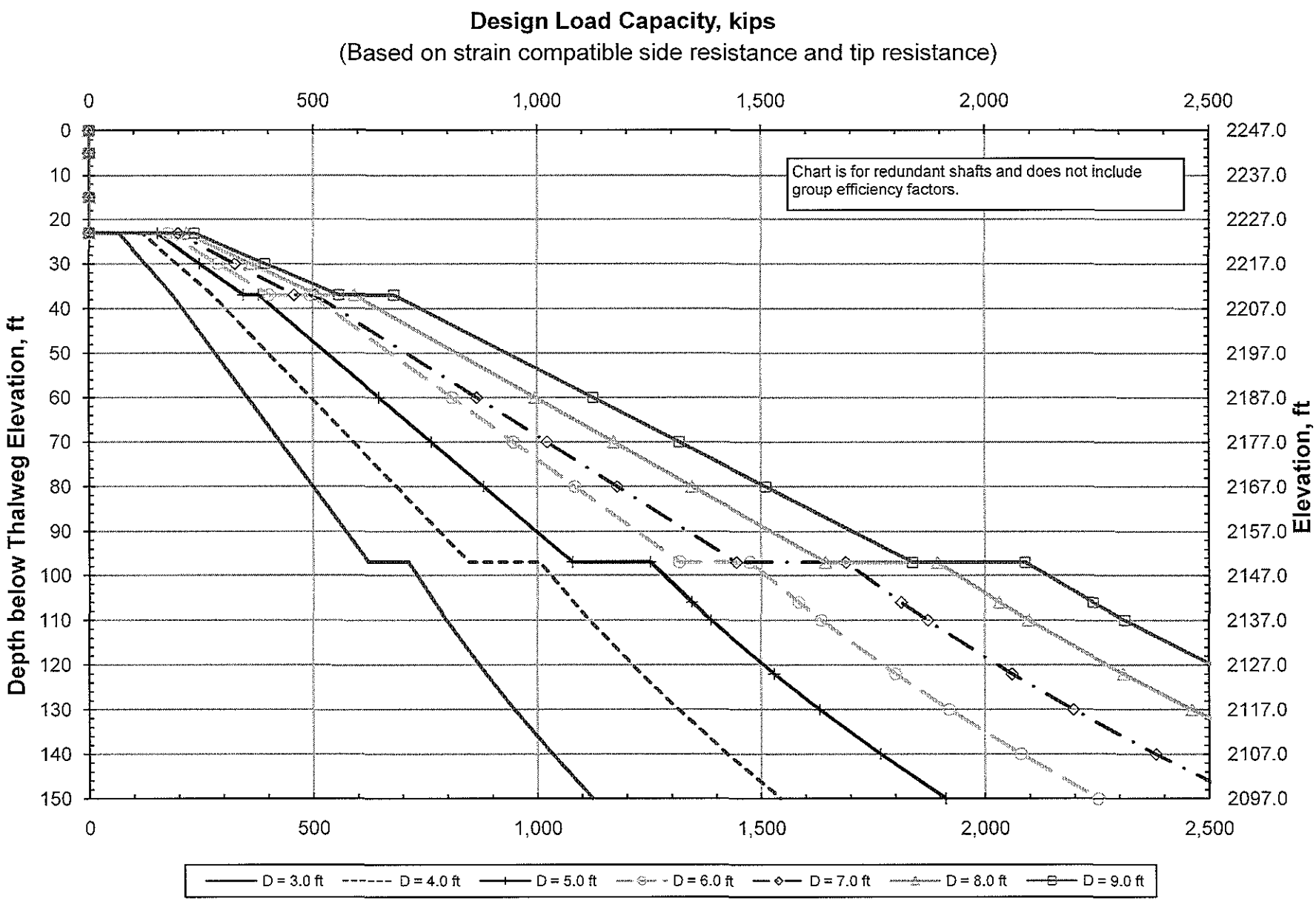

Figure 5.4: Drilled Shaft Capacity Chart - Rillito River Bridge, Abutments - 500-yr flood

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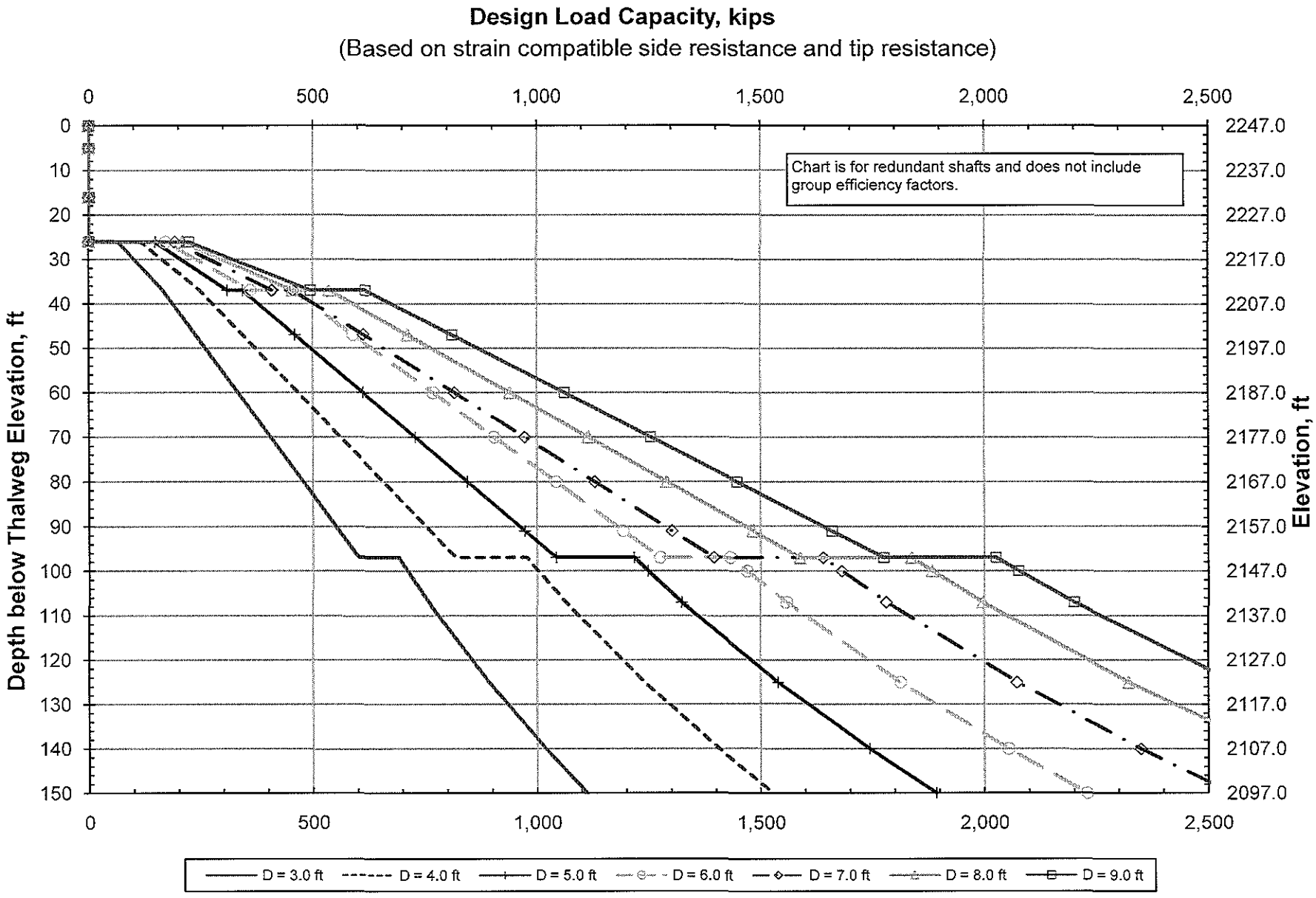

Figure 5.5: Drilled Shaft Capacity Chart - Rillito River Bridge, Piers - 500-yr flood

SS Version 9.0

ncs

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APPENDIX A
BORING LOGS

NCS Consultants, LLC

KEY TO SOIL SYMBOLS AND TERMS

PROJECT: La Cholla Blvd. - Ruthrauff to River
PROJECT #: J2007-09
LOCATION: Tucson, AZ
CLIENT: HDR (for Pima County)

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	SOIL SAMPLE						BLOWS			N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
		GRAPHIC	TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	0-6 INCH	6-12 INCH	12-18 INCH						
1	2	3	4	5	6	7	8	9	9	9	10	11	12	13	14	15
15	2600		S	1	X	16	17.5	10	21	26	47	14	SILTY SAND, dense, dry to moist, dark brown, medium to fine SAND, little non plastic fines, trace gravel, weak reaction to HCl. (SM)			X
20	2595															

1	Depth:	Distance (in feet) below ground surface.
2	Elevation	Elevation (in feet) above Mean Sea Level
3	Graphic:	Symbol associated with USCS classification (see Sheet 2).
4	Type:	Sampler type (See Sampler Codes below).
5	Number:	Identifies the number of the sample collected with indicated sample type.
6	Symbol:	Symbol associated with sampler type.
7	Depth From:	Beginning depth of sample run (ft.).
8	Depth To:	Ending depth of sample run (ft.).
9	Blows/6" (0/6):	The number of blows of a 140-lb hammer falling 30" used to drive the sampler 6".
10	N-Value:	Sum of blows for last 12-inches. Only reported for standard 2" O.D. sampler. "R" value indicates sampler refusal.
11	Rec (in.):	The amount of sample recovered (in inches) from the sampler. "--" indicates data not recorded.
12	Visual Soil Identification/Description and Remarks	Description of the soil and the USCS designation is based on visual identification (ASTM D 2488, Visual-Manual Procedure). Where laboratory tests were performed, the description and USCS designation represents classification of soil according to ASTM D 2487. Refer to laboratory test data to identify samples that were tested to obtain the soil classification.
13	Moisture, %:	Moisture content, (%) of sample collected. A blank field indicates the moisture content was not measured.
14	Dry Density (pcf):	Dry Density of sample collected. A blank field indicated the dry density was not measured.
15	Samples Sent to Lab:	An "X" indicates the sample was sent to a laboratory for testing.

SAMPLER CODES:

HSA = hollow stem auger
S = standard split-spoon
U = shelby tube
P = piston
R = ring
C = core barrel

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NCS Consultants, LLC

PROJECT: La Cholla Blvd. - Ruthrauff to River
PROJECT #: J2007-09
LOCATION: Tucson, AZ
CLIENT: HDR (for Pima County)

KEY TO SOIL SYMBOLS AND TERMS

CORRELATION OF STANDARD PENETRATION RESISTANCE WITH RELATIVE DENSITY AND CONSISTENCY

Relative Density of Cohesionless Soils:
(FHWA HI-97-021)

Penetration Resistance, N (blows/ft)	Relative Density
0-4	Very loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
>50	Very Dense

Consistency of Cohesive Soils:
(FHWA HI-97-021)

Penetration Resistance, N (blows/ft)	Consistency
<2	Very soft
2-4	Soft
4-8	Medium
8-15	Stiff
15-30	Very stiff
>30	Hard

PARTICLE SIZE DEFINITION FOR GRAVELS AND SANDS

(FHWA HI-97-021)

Soil Component	Grain Size
Boulders*	12 inches +
Cobbles*	12 inches to 3 inches
Gravel	
Coarse	3 inches to 3/4 inches
Fine	3/4 inches to #4 sieve
Sand	
Coarse	#4 to #10 sieve
Medium	#10 to #40 sieve
Fine	#40 to #200 sieve

* Boulders and cobbles are not considered soil or part of the soil's classification or description, except under miscellaneous description; i.e., with cobbles at about 5 percent (volume)

OTHER TERMINOLOGY (Modified from ASTM D 2488)

Quantity:

Trace	<5%
Few	5-10%
Little	15-25%
Some	30-45%
Mostly	50-100%

Reaction to HCl:

No reaction	No visible reaction
Weak reaction	Some reaction, with bubbles forming slowly
Strong reaction	Violent reaction, with bubbles forming immediately

Cementation:

Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Note: Reaction to dilute HCl (as per ASTM D 2488) does not necessarily correlate to the degree of carbonate cementation. Reaction to HCl, degree of carbonate cementation, SPT-N values and other relevant factors should all be evaluated together to determine the significance of cementation and/or presence of carbonate.

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.

2. Surface elevations are based on topographic maps and estimated locations.

3. Descriptions on these boring logs apply only at the specified locations and at the time the borings were made. They are not warranted to be representative of subsurface conditions at other locations and times.

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NCS Consultants, LLC

PROJECT: La Cholla Blvd. - Ruthrauff to River
PROJECT #: J2007-09
LOCATION: Tucson, AZ
CLIENT: HDR (for Pima County)

KEY TO SOIL SYMBOLS AND TERMS

USCS CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

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NCS Consultants, LLC

PROJECT: La Cholla Blvd. - Ruthrauff to River
PROJECT #: J2007-09
LOCATION: Tucson, AZ
CLIENT: HDR (for Pima County)

KEY TO SOIL SYMBOLS AND TERMS

PLASTICITY OF FINES (MATERIAL PASSING #200 SIEVE)
Based on Field Procedures (FHWA HI-97-021)

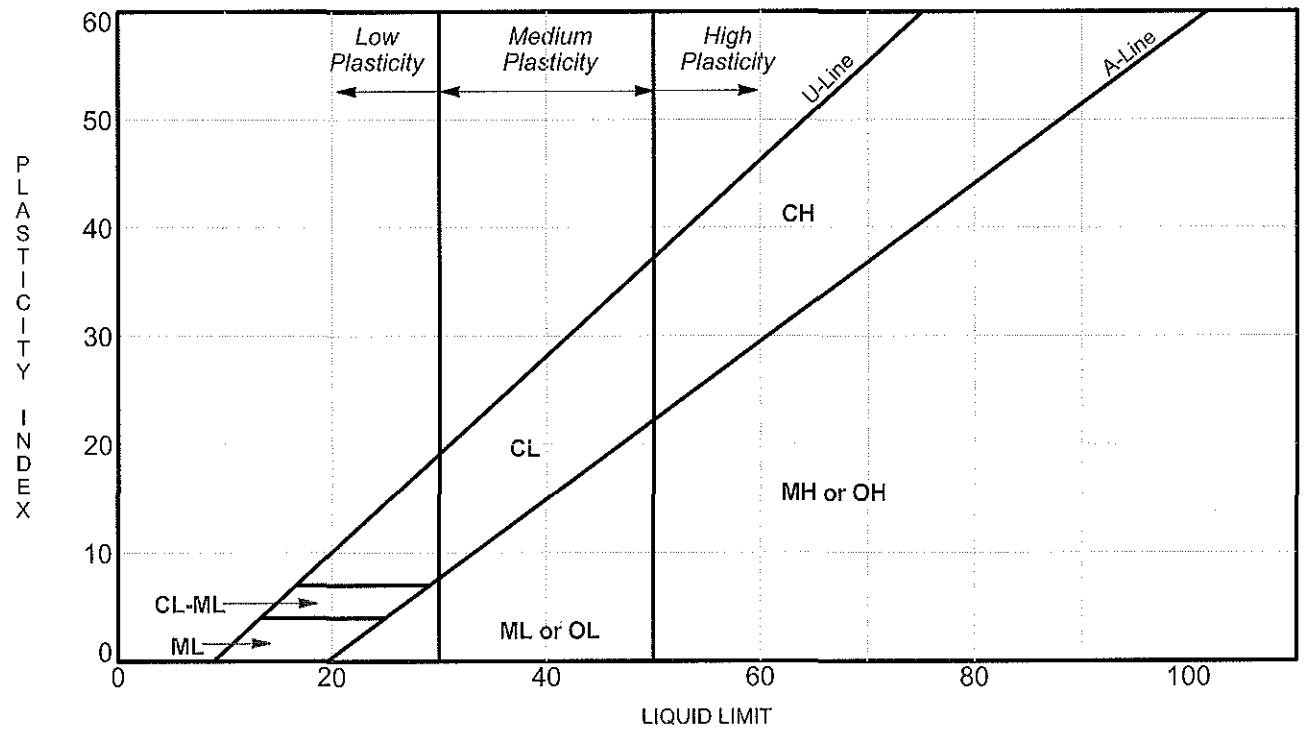
Plasticity Index	Adjective	Thread Smallest Diameter, mm
0	Nonplastic	Ball Cracks
1-10	Low Plasticity	6 - 3
>10-20	Medium Plasticity	1 - 1/2
>20-40	High Plasticity	3/4
>40	Very Plastic	1/2

Refer to A-Chart on this sheet for plasticity based on laboratory test results

DESCRIPTION OF WATER CONTENT OF SOILS
(FHWA HI-97-021)

Description	Conditions
Dry	No sign of water and soil dry to touch
Moist	Signs of water and soil is relatively dry to touch
Wet	Signs of water and soil definitely wet to touch; granular soil exhibits some free water when densified

Plasticity Chart (A-Chart)



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NCS Consultants, LLC
640 West Paseo Rio Grande
Tucson, AZ 85737
520-544-2786
520-544-3150 (Fax)

BORING LOG: B-01

SHEET 1 of 5
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

COORDINATES N: 475,305 E: 979,550
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE: Auto Hammer

COMMENTS:

SURFACE ELEV.: 2266
TOTAL DEPTH: 151.4

START DATE: 04/15/2008 **TIME:** 10:30 AM
FINISH DATE: 04/16/2008 **TIME:** 01:30 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol
04/15/08	12:30 PM	55.0	--	55.0	▽

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2265												SILTY SAND, very dense, dry, brown, fine to coarse SAND, little nonplastic fines, few fine gravel, no cementation, strong reaction with HCl. (SM)			
5	2260		S	1	X	5	6.5	18	28	33	61	16				
10	2255		S	2	X	10	11.5	9	10	12	22	17	WELL-GRADED SAND, medium dense, dry, brown, fine to coarse SAND, few fine to coarse gravel, trace nonplastic fines, no cementation, no reaction with HCl, max. particle size 1". (SW)			
15	2250		S	3	X	15	16.5	4	5	6	11	14	CLAYEY SAND, medium dense, dry, brown, fine to coarse SAND, little medium plastic fines, little fine gravel, no cementation, no reaction with HCl. (SC)			X
20	2245		S	4	X	20	21.5	10	13	18	31	18	WELL-GRADED SAND WITH SILT, dense, dry, light brown, fine to coarse SAND, few fine to coarse gravel, few nonplastic fines, no cementation, no reaction with HCl. (SW-SM)			
25													WELL-GRADED SAND WITH CLAY, dense, dry, brown, fine to coarse SAND,			

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640 West Paseo Rio Grande
Tucson, AZ 85737
520-544-2786
520-544-3150 (Fax)

BORING LOG: B-01

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2240		S	5	X	25	26.5	11	17	22	39	18	few fine to coarse gravel, few low plastic fines, no cementation, no reaction with HCl, max. particle size 0.75". (SW-SC)			
30	2235		S	6	X	30	31.5	11	16	19	35	18				
35	2230		S	7	X	35	36.5	32	36	24	60	2	Becomes very dense. 1.5" rock in sampler.			
40	2225		S	8	X	40	41.5	11	35	22	57	12				
45	2220		S	9	X	45	46.5	21	14	15	29	12	CLAYEY SAND WITH GRAVEL, medium dense, moist, brown, fine to coarse SAND, little low plastic fines, little fine to coarse gravel, no cementation, no reaction with HCl, max. particle size 1". (SC)			
50	2215		S	10	X	50	51.5	10	10	15	25	18				
55	2210		S	11	X	55	56.5	4	9	17	26	17	SILTY, CLAYEY SAND, very stiff, wet, brown, fine to medium SAND, some low plastic fines, no cementation, no reaction with HCl. (CL-ML) Groundwater encountered @ 55'.			X
60	2205		S	12	X	60	61.5	5	8	10	18	18	SANDY LEAN CLAY, very stiff, moist, brown, medium plastic CLAY, some fine to medium sand, no cementation, no reaction with HCl. (CL)			
65																

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BORING LOG: B-01

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2200		S	13	X	65	66.5	6	10	9	19	18		34.9		X
70	2195		R	14	■	70	70.8	22	50/4"			12	Becomes hard.			
75	2190		S	15	X	75	76.5	8	12	14	26	18	Becomes very stiff.			
80	2185		S	16	X	80	81.5	8	13	23	36	18	Becomes LEAN CLAY WITH SAND, hard, little fine to coarse sand.			
85	2180		S	17	X	85	86.5	3	2	5	7	12	CLAYEY SAND, loose, wet, brown, fine to coarse SAND, little low plastic fines, no cementation, no reaction with HCl. (SC)			
90	2175		S	18	X	90	91.5	5	8	14	22	18	LEAN CLAY WITH SAND, very stiff, moist, brown, low plastic CLAY, little fine to coarse sand, no cementation, no reaction with HCl. (CL)			
95	2170		S	19	X	95	96.5	10	15	28	43	18	Becomes hard.			
100	2165		R	20	■	100	101	11	20			12				
105																

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BORING LOG: B-01

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2160		S	21	X	105	106.5	12	15	17	32	18				
110	2155		S	22	X	110	111.5	16	36	44	80	16	CLAYEY SAND, very dense, moist, brown, fine to coarse SAND, some medium plastic fines, trace fine gravel, no cementation, no reaction with HCl. (SC)			
115	2150		S	23	X	115	116.5	9	15	17	32	18	LEAN CLAY WITH SAND, hard, moist, brown, medium plastic CLAY, little fine to coarse sand, trace fine gravel, no cementation, no reaction with HCl. (CL)	28.7		X
120	2145		S	24	X	120	120.8	17	50/3"		R	5	CLAYEY SAND, very dense, moist, grayish brown, fine to medium SAND, little low plastic fines, no cementation, no reaction with HCl. (SC)			
125	2140		S	25	X	125	125.3	50/4"			R	4				
130	2135		S	26	X	130	131.3	24	38	50/4"	R	10	POORLY GRADED SAND, very dense, moist, red brown, fine to medium SAND, trace nonplastic fines, no cementation, no reaction with HCl. (SP)			
135	2130		S	27	X	135	136.5	10	11	19	30	16	SANDY LEAN CLAY, hard, moist, brown, medium plastic CLAY, some fine to coarse sand, trace fine gravel, no cementation, no reaction with HCl. (CL)	22.1		X
140	2125		S	28	X	140	140.7	45	50/2"		R	4	CLAYEY SAND, very dense, moist, gray brown, fine to coarse SAND, little low plastic fines, no cementation, no reaction with HCl. (SC)			
145																

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BORING LOG: B-01

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	SOIL SAMPLE DEPTH (FT) FROM	SOIL SAMPLE DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2120		S	29		145	145.2	50/2"			R	4	Becomes brown, few fine to coarse gravel.			
150	2115		S	30		150	151.4	13	32	50/5"	R	10	Becomes some low plastic fines.			
													EOB @ 150'. Stopped sampler @ 151.4'. Groundwater was encountered @ 55'. Backfilled hole with ADWR compliant grout.			
155	2110															
160	2105															
165	2100															
170	2095															
175	2090															
180	2085															
185																

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BORING LOG: B-02

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

COORDINATES **N:** 475,132 **REF. ALIGNMENT:**
E: 979,582 **STATION:**
LOCATION: Tucson, AZ **OFFSET:**

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE: Auto Hammer

COMMENTS:

SURFACE ELEV.: 2247
TOTAL DEPTH: 151.5

START DATE: 04/21/2008 **TIME:** 07:30 AM
FINISH DATE: 04/22/2008 **TIME:** 03:30 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol
04/21/08	11:00 AM	37.0	--	37.0	▽

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2245												SILTY SAND WITH GRAVEL, dense, dry, brown, fine to coarse SAND, little fine to coarse gravel, little nonplastic fines, no cementation, strong reaction with HCl, max. particle size 1". (SM)			
5	2240		S	1		5	6.5	45	27	13	40	8				
10	2235		R	2		10	11	23	22			9	Becomes moist, some fine to coarse gravel, weak reaction with HCl.			
15	2230		S	3		15	16.5	6	10	24	34	14	Becomes wet.			
20	2225		S	4		20	21.5	9	8	8	16	15	Becomes medium dense.			X
25																

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BORING LOG: B-02

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2220		S	5	X	25	25.8	19	50/4"		R	0	No recovery.			
30	2215		S	6	X	30	31.5	29	13	24	37	14	WELL-GRADED SAND WITH CLAY AND GRAVEL, dense, moist, brown, fine to coarse SAND, little fine to coarse gravel, few low plastic fines, no cementation, no reaction with HCl, max. particle size 1". (SW-SC)			
35	2210		S	7	X	35	36.5	3	8	23	31	16	CLAYEY SAND WITH GRAVEL, dense, moist, brown, fine to coarse SAND, little low plastic fines, little fine to coarse gravel, no cementation, no reaction with HCl, max. particle size 1.25". (SC) ∇ Groundwater encountered @ 37'.			
40	2205		S	8	X	40	41.5	6	10	14	24	12	SANDY LEAN CLAY, very stiff, moist, brown, low plastic CLAY, some fine to coarse sand, few fine gravel, no cementation, no reaction with HCl. (CL)			X
45	2200		S	9	X	45	46.5	3	5	9	14	9	Becomes LEAN CLAY WITH SAND, stiff, little fine to coarse sand.			
50	2195		S	10	X	50	51.5	6	8	10	18	17	Becomes LEAN CLAY, very stiff, few fine to medium sand.			
55	2190															
60	2185		S	11	X	60	61.5	21	28	9	37	8	Becomes hard.			
65																

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BORING LOG: B-02

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
			R	13		65	66	10	24			0	No recovery.			
	2180															
70			S	14		70	71.5	7	19	15	34	8	CLAYEY SAND, dense, wet, brown, fine to coarse SAND, little low plastic fines, few fine gravel, no cementation, no reaction with HCl. (SC)			
	2175															
75			S	15		75	76.5	12	13	15	28	8	LEAN CLAY WITH SAND, very stiff, moist, brown, medium plastic CLAY, little fine to medium sand, no cementation, no reaction with HCl. (CL)			
	2170															
80			S	16		80	81.5	11	31	15	46	8	Becomes hard.			
	2165															
85			S	17		85	86.5	9	13	17	30	18				
	2160															
90			R	18		90	91	12	32			12		31.0	94.8	X
	2155															
95			S	19		95	96.5	10	28	38	66	15				
	2150															
100			S	20		100	101.5	12	11	17	28	18	Becomes very stiff.			
	2145															
105													WELL-GRADED SAND WITH GRAVEL, very dense, moist, grayish brown, fine to			

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BORING LOG: B-02

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2140		S	21		105	105.3	50/4"			R	4	coarse SAND, little fine to coarse gravel, trace nonplastic fines, no cementation, no reaction with HCl, max. particle size 1". (SW)			
110	2135		S	22		110	110.3	50/4"			R	4				
115	2130		S	23		115	115.3	50/4"			R	4				
120	2125		S	24		120	121.5	18	14	18	32	13	LEAN CLAY WITH SAND, hard, moist, brown, medium plastic CLAY, little fine to coarse sand, trace fine gravel, no cementation, no reaction with HCl. (CL)			X
125	2120		S	25		125	125.3	50/3"			R	3	WELL-GRADED SAND WITH CLAY AND GRAVEL, very dense, moist, grayish brown, fine to coarse SAND, few low plastic fines, little fine to coarse gravel, no cementation, no reaction with HCl. (SW-SC)			
130	2115		S	26		130	130.2	50/2"			R	2				
135	2110		S	27		135	135.4	50/5"			R	4				
140	2105		S	28		140	141.5	19	40	35	75	13	CLAYEY SAND WITH GRAVEL, very dense, moist, brown, fine to coarse SAND, some fine to coarse gravel, little high plastic fines, no cementation, no reaction with HCl. (SC)			
145																

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BORING LOG: B-02

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2100		S	29	X	145	146.5	19	26	42	68	18				X
150			S	30	X	150	151.5	18	36	31	67	18				
	2095												EOB @ 150'. Groundwater was encountered @ 37'. Backfilled hole with ADWR compliant grout.			
155																
	2090															
160																
	2085															
165																
	2080															
170																
	2075															
175																
	2070															
180																
	2065															
185																

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BORING LOG: B-03

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

COORDINATES N: 475,014 E: 979,581
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE: Auto Hammer

COMMENTS:

SURFACE ELEV.: 2247
TOTAL DEPTH: 151.5

START DATE: 04/23/2008 **TIME:** 07:30 AM
FINISH DATE: 04/24/2008 **TIME:** 10:00 AM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol
04/23/08	09:30 AM	36.0	--	36.0	▽

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2245												SILTY SAND WITH GRAVEL, dense, moist, brown, fine to coarse SAND, little fine to coarse gravel, little nonplastic fines, no cementation, strong reaction with HCl, max. particle size 1.75". (SM)			
5			R	1		5	6	14	37			8		8.3	107.8	X
	2240															
10			S	2		10	11.5	7	8	9	17	18	Becomes medium dense, no reaction with HCl.			
	2235															
15			S	3		15	16.5	5	6	7	13	16	Becomes wet.			
	2230															
20			S	4		20	21.5	4	6	6	12	18				
	2225															
25																

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BORING LOG: B-03

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2220		S	5		25	26.5	6	14	19	33	12	Becomes dense, some fine to coarse gravel.			
30																
	2215		S	6		30	31.5	8	15	16	31	12				
													CLAYEY SAND, dense, wet, brown, fine to coarse SAND, little fine to coarse gravel, little low plastic fines, no cementation, no reaction with HCl. (SC) Groundwater encountered @ 36'.			
35																
	2210		S	7		35	36.5	8	15	19	34	8	▽			
													SANDY LEAN CLAY, very stiff, moist, brown, medium plastic CLAY, some fine to medium sand, trace fine gravel, no cementation, no reaction with HCl. (CL)			
40																
	2205		S	8		40	41.5	2	6	9	15	15				
45																
	2200		S	9		45	46.5	1	3	5	8	16	Becomes medium.			
50																
	2195		S	10		50	51.5	6	9	11	20	16	Becomes very stiff.			
55																
	2190		R	11		55	56	7	13			12		27.3	91.3	X
60																
	2185		S	12		60	61.5	7	9	12	21	18				
65																

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BORING LOG: B-03

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2180		S	13	X	65	66.5	5	9	12	21	18				
70	2175		S	14	X	70	71.5	9	18	27	45	16	SILTY SAND, dense, moist, brown, fine to coarse SAND, little nonplastic fines, trace fine gravel, no cementation, no reaction with HCl. (SM)			X
75	2170		S	15	X	75	76.5	13	21	20	41	16				
80	2165		S	16	X	80	81.4	7	22	50/5"	R	10	CLAYEY SAND, very dense, moist, brown, fine to coarse SAND, some medium plastic fines, no cementation, no reaction with HCl. (SC)			
85	2160		S	17	X	85	86.5	10	14	16	30	17	Becomes dense.			
90	2155		S	18	X	90	91.5	11	18	23	41	14		17.1		X
95	2150		S	19	X	95	96.5	12	34	36	70	14	Becomes very dense, grayish brown, little medium plastic fines, few fine gravel.			
100	2145		S	20	X	100	101.5	6	8	13	21	16	LEAN CLAY WITH SAND, very stiff, moist, brown, medium plastic CLAY, little fine to coarse sand, no cementation, no reaction with HCl. (CL)			
105													POORLY GRADED SAND, dense, moist, grayish brown, fine to coarse SAND, few			

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BORING LOG: B-03

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2140		S	21	X	105	106.5	14	19	29	48	16	low plastic fines, trace fine gravel, no cementation, no reaction with HCl. (SP-SC)			
110	2135		S	22	X	110	111.5	10	49	45	94	12	WELL-GRADED SAND WITH GRAVEL, very dense, moist, grayish brown, fine to coarse SAND, little fine to coarse gravel, few low plastic fines, no cementation, no reaction with HCl. (SW-SC)			
115	2130		S	23	X	115	116.5	26	29	34	63	12				
120	2125		S	24	X	120	121.5	5	10	16	26	13	SANDY LEAN CLAY, very stiff, moist, brown, medium plastic CLAY, some fine to coarse sand, no cementation, no reaction with HCl. (CL)	22.6		X
125	2120		S	25	X	125	125.7	45	50/2"		R	5	WELL-GRADED SAND WITH GRAVEL, very dense, moist, grayish brown, fine to coarse SAND, little fine to coarse gravel, few low plastic fines, no cementation, no reaction with HCl. (SW-SC)			
130	2115		S	26	X	130	130.7	49	50/2"		R	6				
135	2110		S	27	X	135	136.5	15	20	27	47	16	CLAYEY SAND WITH GRAVEL, dense, moist, brown, fine to coarse SAND, some fine to coarse gravel, little high plastic fines, no cementation, no reaction with HCl. (SC)			
140	2105		S	28	X	140	141.5	27	42	48	90	14	Becomes very dense.			
145																

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BORING LOG: B-03

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	SOIL SAMPLE DEPTH (FT) FROM	SOIL SAMPLE DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
			S	29	X	145	146.5	7	9	22	31	15	Becomes dense.			
	2100															
150			S	30	X	150	151.5	17	29	30	59	14	Becomes very dense.			
	2095												EOB @ 150'. Stopped sampler @ 151.5'. Groundwater encountered @ 36'. Backfilled hole with ADWR compliant grout.			
155																
	2090															
160																
	2085															
165																
	2080															
170																
	2075															
175																
	2070															
180																
	2065															
185																

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BORING LOG: B-04

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

COORDINATES **N:** 474,813 **E:** 979,687
LOCATION: Tucson, AZ

REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE: Auto Hammer

COMMENTS:

SURFACE ELEV.: 2265
TOTAL DEPTH: 151.5

START DATE: 04/14/2008 **TIME:** 08:00 AM
FINISH DATE: 04/15/2008 **TIME:** 10:00 AM

Type/Symbol	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol
04/14/08	10:30 AM	48.0	--	48.0	▽

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
5	2260		S	1	X	5	6.5	8	13	11	24	18	WELL-GRADED SAND WITH CLAY AND GRAVEL, medium dense, dry, brown, fine to coarse SAND, little fine to coarse gravel, few low plastic fines, weak cementation, strong reaction with HCl, max. particle size 0.75". (SW-SC)			
10	2255		S	2	X	10	11.5	11	24	27	51	18	SILTY SAND, very dense, dry, brown, fine to coarse SAND, little nonplastic fines, few fine to coarse gravel, no cementation, no reaction with HCl. (SM)			
15	2250		S	3	X	15	16.5	5	6	8	14	18	WELL-GRADED GRAVEL WITH SILT AND SAND, medium dense, dry, brown, fine to coarse GRAVEL, some fine to coarse sand, few nonplastic fines, no cementation, weak reaction with HCl. (GW-GM)			
20	2245		S	4	X	20	21.5	7	7	9	16	18	Becomes moist, no reaction with HCl.			
25	2240															

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BORING LOG: B-04

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
			S	5	X	25	26.5	10	12	14	26	18				
30	2235		S	6	X	30	31.5	10	8	12	20	18				
35	2230		R	7	■	35	36	19	18			12		5.7	113.7	X
40	2225		S	8	X	40	41.5	5	7	10	17	16	WELL-GRADED SAND WITH CLAY, medium dense, moist, brown, fine to coarse SAND, few low plastic fines, few fine gravel, no cementation, no reaction with HCl. (SW-SC)			
45	2220		S	9	X	45	46.5	15	28	19	47	18	CLAYEY SAND, dense, moist, brown, fine to coarse SAND, little low plastic fines, few fine to coarse gravel, no cementation, no reaction with HCl. (SC)			
													▽ Groundwater encountered @ 48'.			
50	2215		S	10	X	50	51.5	28	33	33	66	18	Becomes very dense.			
55	2210		S	11	X	55	56.5	4	4	10	14	18	LEAN CLAY WITH SAND, stiff, moist, brown, medium plastic CLAY, little fine to coarse sand, trace fine gravel, no cementation, no reaction with HCl. (CL)	30.2		X
60	2205		S	12	X	60	61.5	5	8	10	18	17	Becomes very stiff.			
65	2200															

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BORING LOG: B-04

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
			S	13		65	66.5	2	4	8	12	18	Becomes stiff.			
70	2195		R	14		70	70.4	50/5"				12	CLAYEY SAND, very dense, moist, brown, fine to coarse SAND, some low plastic fines, few fine gravel, no cementation, no reaction with HCl. (SC)			
75	2190		S	15		75	76.5	5	6	11	17	18	LEAN CLAY WITH SAND, very stiff, moist, brown, medium plastic CLAY, little fine to coarse sand, no cementation, no reaction with HCl. (CL)			
80	2185		S	16		80	81.4	5	23	50/5"	R	18	Becomes SANDY LEAN CLAY, hard, some fine to coarse sand.			
85	2180		S	17		85	86.5	11	20	26	46	16	WELL-GRADED SAND WITH CLAY, dense, moist, brown, fine to coarse SAND, few low plastic fines, trace fine gravel, no cementation, no reaction with HCl. (SW-SC)			
90	2175		S	18		90	91.5	12	17	17	34	16	LEAN CLAY WITH SAND, hard, moist, brown, medium plastic CLAY, little fine to coarse sand, no cementation, no reaction with HCl. (CL)			
95	2170		S	19		95	96.5	7	9	18	27	18	Becomes LEAN CLAY, very stiff, few fine to medium sand.			
100	2165		S	20		100	101.3	20	27	50/4"	R	17	Becomes LEAN CLAY WITH SAND, little fine to coarse sand.			
105	2160												SILTY SAND, very dense, moist, brown, fine to coarse SAND, little nonplastic			

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BORING LOG: B-04

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
			S	21	X	105	106.5	20	40	44	84	12	fines, trace fine gravel, no cementation, no reaction with HCl. (SM)			X
110	2155		S	22	X	110	111.5	9	11	18	29	15	LEAN CLAY WITH SAND, very stiff, moist, brown, medium plastic CLAY, little fine to coarse sand, no cementation, no reaction with HCl. (CL)			
115	2150		S	23	X	115	116.5	17	26	50/5"	R	16	Becomes hard.			
120	2145		S	24	X	120	120.3	50/3"			R	3	WELL-GRADED SAND WITH GRAVEL, very dense, moist, gray, fine to coarse SAND, little fine to coarse gravel, no cementation, no reaction with HCl. (SW)			
125	2140		S	25	X	125	126.5	24	34	47	81	12	SILTY SAND, very dense, moist, light brown, fine to coarse SAND, little nonplastic fines, few fine to coarse gravel, no cementation, no reaction with HCl, max. particle size 1.5". (SM)			
130	2135		S	26	X	130	131.4	23	31	50/5"	R	14				X
135	2130		S	27	X	135	136.3	17	44	50/4"	R	12				
140	2125		S	28	X	140	140.1	50/1"			R	10	WELL-GRADED SAND, very dense, wet, brown, fine to coarse SAND, few fine gravel, trace low plastic fines, no cementation, no reaction with HCl. (SW)			
145	2120												CLAYEY SAND, very dense, moist, brown, fine to coarse SAND, little low			

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BORING LOG: B-04

NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Chuck
INSPECTOR: WUF

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	SOIL SAMPLE NUMBER	SOIL SAMPLE SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	BLOWS 0-6 INCH	BLOWS 6-12-INCH	BLOWS 12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
			S	29	X	145	145.8	43	50/4"		R	8	plastic fines, trace fine gravel, no cementation, no reaction with HCl. (SC)			
150	2115		S	30	X	150	151.5	18	15	17	32	12	Becomes dense.			
													EOB @ 150'. Groundwater encountered @ 48'. Backfilled hole with ADWR compliant grout.			
155	2110															
160	2105															
165	2100															
170	2095															
175	2090															
180	2085															
185	2080															

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BORING LOG: P-02

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES N: 474,551 E: 979,568
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2264
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 02:00 PM
FINISH DATE: 04/16/2008 **TIME:** 02:15 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2260												WELL-GRADED SAND WITH SILT, moist, brown, fine to coarse SAND, few fine gravel, few nonplastic fines, no cementation, no reaction with HCl. (SW-SM)			X
5													EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
	2255															
10																
	2250															
15																
	2245															
20																
	2240															
25																

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BORING LOG: P-04

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES N: 474,244 E: 979,569
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2260
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 02:20 PM
FINISH DATE: 04/16/2008 **TIME:** 02:35 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
													WELL-GRADED SAND WITH SILT, moist, brown, fine to coarse SAND, few fine gravel, few nonplastic fines, no cementation, no reaction with HCl. (SW-SM)			X
5	2255												EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
10	2250															
15	2245															
20	2240															
25	2235															

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BORING LOG: P-05

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES N: 473,896 E: 979,655
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2264
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 04:20 PM
FINISH DATE: 04/16/2008 **TIME:** 04:40 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2260												SILTY SAND, moist, brown, fine to coarse SAND, little nonplastic fines, few fine gravel, no cementation, weak reaction with HCl. (SM)			X
5													EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
	2255															
10																
	2250															
15																
	2245															
20																
	2240															
25																

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BORING LOG: P-06

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES N: 473,562 E: 979,575
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2264
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 02:40 PM
FINISH DATE: 04/16/2008 **TIME:** 02:55 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2260												SILTY SAND, dry, brown, fine to coarse SAND, some nonplastic fines, trace fine gravel, no cementation, strong reaction with HCl. (SM)			X
5													EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
	2255															
10																
	2250															
15																
	2245															
20																
	2240															
25																

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BORING LOG: P-07

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES N: 473,244 E: 979,666
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2266
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 04:00 PM
FINISH DATE: 04/16/2008 **TIME:** 04:15 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2265												WELL-GRADED SAND WITH SILT AND GRAVEL, moist, brown, fine to coarse SAND, little fine to coarse gravel, few nonplastic fines, no cementation, weak reaction with HCl. (SW-SM)			X
5	2260												EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
10	2255															
15	2250															
20	2245															
25																

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BORING LOG: P-08

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES **N:** 472,913 **REF. ALIGNMENT:**
E: 979,595 **STATION:**
LOCATION: Tucson, AZ **OFFSET:**

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2267
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 03:00 PM
FINISH DATE: 04/16/2008 **TIME:** 03:15 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2265												SANDY SILT, dry, brown, low plastic SILT, some fine to coarse sand, trace fine gravel, no cementation, strong reaction with HCl. (ML)			X
5	2260												EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
10	2255															
15	2250															
20	2245															
25																

REPORT:ncs boring | PROJECT:p:\la cholla - ruthrauff to river\gint\lacholla_ruthrauff_to_river.gpj [LIBRARY:ncs gint\lib v4.0.gpb] LAST MODD5/13/08 04:08 pm | PRINTED05/21/08 09:18 am

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520-544-3150 (Fax)

BORING LOG: P-09

SHEET 1 of 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES N: 472,645 E: 979,682
LOCATION: Tucson, AZ
REF. ALIGNMENT:
STATION:
OFFSET:

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2268
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 03:40 PM
FINISH DATE: 04/16/2008 **TIME:** 03:55 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2265												SILTY SAND, dry, brown, fine to coarse SAND, little nonplastic fines, few fine to coarse gravel, no cementation, strong reaction with HCl. (SM)			X
5													EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
	2260															
10																
	2255															
15																
	2250															
20																
	2245															
25																

REPORT:ncs boring | PROJECT:p:\la cholla - ruthrauff to river\grint\cholla_ruthrauff_to_river.gpj | LIBRARY:ncs gintlib v4.0.glb | LAST MODD5/13/08 04:08 pm | PRINTED05/21/08 09:18 am

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BORING LOG: P10

SHEET 1 **of** 1
NCS PROJECT #: J2007-09

PROJECT: La Cholla Blvd. - Ruthrauff to River
CLIENT: HDR (for Pima County)
CLIENT PROJECT #: 59914

CONTRACTOR: GSI
DRILLER: Drew
INSPECTOR: WUF

COORDINATES **N:** 472,183 **REF. ALIGNMENT:**
E: 979,596 **STATION:**
LOCATION: Tucson, AZ **OFFSET:**

RIG TYPE: truck mtd. CME 75
DRILLING METHOD: 8" O.D. HSA
HAMMER TYPE:

COMMENTS:

SURFACE ELEV.: 2268
TOTAL DEPTH: 5

START DATE: 04/16/2008 **TIME:** 03:20 PM
FINISH DATE: 04/16/2008 **TIME:** 03:35 PM

	Casing	Split Spoon	Ring Sampler	Split Spoon	Cuttings	Core Barrel
Type/Symbol		S	R	S2	CU	C
I.D.		1.375"	2.5"	0.87"	--	
O.D.		2"	3"	1.5"	--	
Length		18"	18"	18"	--	
Hammer WT.	140 lbs.		Drill Rod Size			
Hammer Fall	30 in.		I.D. (O.D.)			

GROUNDWATER DATA

Date	Time	Water Depth (ft)	Casing Depth (ft)	Hole Depth (ft)	Symbol

DEPTH BELOW SURFACE (FT)	ELEVATION (FT)	GRAPHIC	SOIL SAMPLE TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	TO	BLOWS 0-6 INCH	6-12-INCH	12-18 INCH	N-VALUE	RECOVERY (IN)	VISUAL SOIL IDENTIFICATION / DESCRIPTION AND REMARKS	MOISTURE, %	DRY DENSITY (PCF)	SAMPLES SENT TO LAB
	2265												SILTY, CLAYEY SAND, dry, brown, fine to coarse SAND, some low plastic fines, few fine gravel, no cementation, strong reaction with HCl. (CL-ML)			X
5													EOB @ 5'. No groundwater encountered. Backfilled hole with cuttings.			
	2260															
10																
	2255															
15																
	2250															
20																
	2245															
25																

REPORT/hcs boring | PROJECT:c:\la cholla - ruthrauff to river\gint\lacholla_ruthrauff_to_river.gpj | LIBRARY:hcs.gintlib v4.0.glb | LAST MOD05/13/08 04:08 pm | PRINTED05/21/08 09:19 am

APPENDIX B
LABORATORY TEST RESULTS

Boring	Sample	Depth	Grain Size Distribution (% Passing)[1]						LL[2]	PI[2]	USCS Class.		R-Value		In-Situ		Chemical Tests			
			3/4"	1/4"	#4	#8	#40	#200			Fines	Sample	Calc.	Lab	Moisture (%)	Dry Dens. (pcf)	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)
B-01	S3	15.0 - 16.5	--	90	86	68	31	22	32	16	CL	SC	--	--	--	--	--	--	--	--
B-01	S11	55.0 - 56.5	--	--	100	99	96	47	25	5	CL-ML	SC-SM	--	--	--	--	--	--	--	--
B-01	S13	65.0 - 66.5	--	--	--	--	94	70	49	31	CL	CL	--	--	34.9	--	--	--	--	--
B-01	S23	115.0 - 116.5	--	100	99	98	92	76	38	20	CL	CL	--	--	28.7	--	--	--	--	--
B-01	S27	135.0 - 136.5	--	100	99	98	83	61	34	15	CL	CL	--	--	22.1	--	--	--	--	--
B-02	S4	20.0 - 21.5	85	74	72	65	39	25	NP	NP	ML	SM	--	--	--	--	--	--	--	--
B-02	S8	40.0 - 41.5	100	95	94	90	81	66	31	11	CL	CL	--	--	--	--	--	--	--	--
B-02	R18	90.0 - 91.0	--	--	--	--	94	77	36	14	CL	CL	--	--	31.0	94.8	--	--	--	--
B-02	S24	120.0 - 121.5	--	99	99	99	91	74	37	20	CL	CL	--	--	--	--	--	--	--	--
B-02	S29	145.0 - 146.5	100	72	63	47	25	16	53	31	CH	SC	--	--	--	--	--	--	--	--
B-03	R1	5.0 - 6.0	100	80	76	61	32	15	NP	NP	ML	SM	--	--	8.3	107.8	--	--	--	--
B-03	R11	55.0 - 56.0	--	99	99	99	92	65	39	21	CL	CL	--	--	27.3	91.3	--	--	--	--
B-03	S14	70.0 - 71.5	--	98	98	95	64	23	NP	NP	ML	SM	--	--	--	--	--	--	--	--
B-03	S18	90.0 - 91.5	--	--	100	97	66	45	30	11	CL	SC	--	--	17.1	--	--	--	--	--
B-03	S24	120.0 - 121.5	--	--	100	99	84	64	38	18	CL	CL	--	--	22.6	--	--	--	--	--
B-04	R7	35.0 - 36.0	72	55	49	35	14	5	NP	NP	ML	GW-GM	--	--	5.7	113.7	--	--	--	--
B-04	S11	55.0 - 56.5	--	99	98	96	89	80	42	21	CL	CL	--	--	30.2	--	--	--	--	--
B-04	S21	105.0 - 106.5	--	99	98	94	52	16	--	--	--	--	--	--	--	--	--	--	--	--
B-04	S26	130.0 - 131.4	--	94	91	79	39	20	NP	NP	ML	SM	--	--	--	--	--	--	--	--
P-02	B1	0.0 - 5.0	100	94	90	75	24	8	NP	NP	ML	SW-SM	--	69.0	--	--	6.5	4,485		14
P-04	B1	0.0 - 5.0	100	94	90	77	29	8	NP	NP	ML	SW-SM	--	--	--	--	--	--	--	--
P-05	B1	0.0 - 5.0	100	90	88	78	32	13	NP	NP	ML	SM	--	--	--	--	--	--	--	--
P-06	B1	0.0 - 5.0	--	99	98	95	73	39	NP	NP	ML	SM	--	--	--	--	--	--	--	--
P-07	B1	0.0 - 5.0	93	80	75	59	17	6	NP	NP	ML	SW-SM	--	--	--	--	--	--	--	--
P-08	B1	0.0 - 5.0	--	97	97	95	88	54	21	2	ML	ML	--	--	--	--	--	--	--	--

All data shown tested by **Conformatech** of **Tucson, AZ**, **Clyde Pretti**, lab manager.

-- Not Tested

1. Only selected sieve sizes are included here. For full sieve data refer to Table B.2.
2. A liquid limit (LL) and a plasticity index (PI) of NP indicates the material is non-plastic.

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Sheet 1 of 2
05/13/2008

TABLE B.1
SUMMARY OF LAB TESTING

Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
Client: HDR (for Pima County)

REPORTtbl2_lab_summary_simple_chem | PROJECTfp:\la cholla - ruthrauff to river\geotechnical\la_ruthrauff_to_river.gpj JLIBRARYtbl2.glb v4.0.gpb | LAST MOD04/28/08 11:22 am | PRINTED05/13/08 04:09 pm

Boring	Sample	Depth	Grain Size Distribution (% Passing)[1]						LL[2]	PI[2]	USCS Class.		R-Value		In-Situ		Chemical Tests			
			3/4"	1/4"	#4	#8	#40	#200			Fines	Sample	Calc.	Lab	Moisture (%)	Dry Dens. (pcf)	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)
P-09	B1	0.0 - 5.0	97	93	92	90	77	26	NP	NP	ML	SM	--	65.0	--	--	7.3	1,154	95	54
P10	B1	0.0 - 5.0	100	95	93	89	69	47	23	6	CL-ML	SC-SM	--	--	--	--	--	--	--	--

All data shown tested by **Conformatech** of **Tucson, AZ**, **Clyde Pretti**, lab manager.

-- Not Tested

1. Only selected sieve sizes are included here. For full sieve data refer to Table B.2.
2. A liquid limit (LL) and a plasticity index (PI) of NP indicates the material is non-plastic.

NCS Consultants, LLC

Sheet 2 of 2
05/13/2008

TABLE B.1
SUMMARY OF LAB TESTING

Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
Client: HDR (for Pima County)

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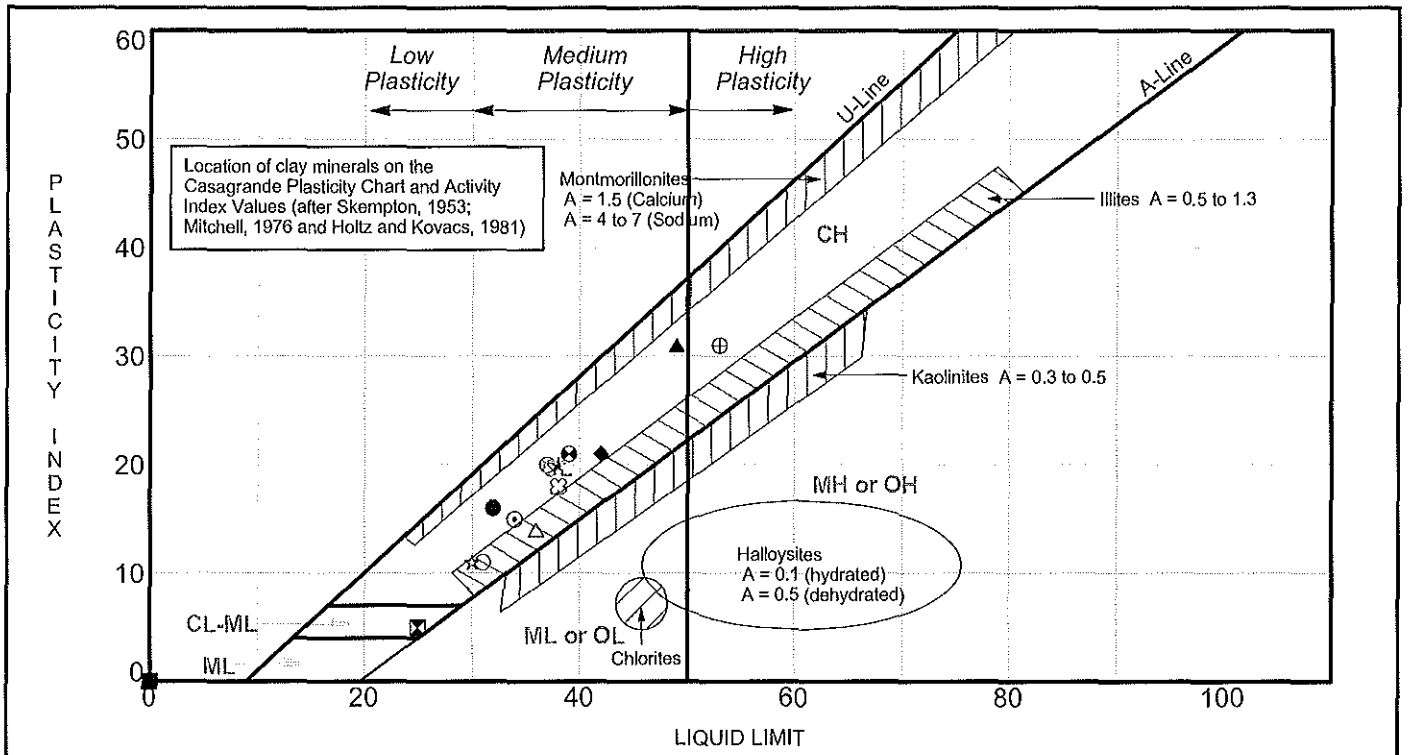

Symbol	Boring	Sample	Depth (ft.)	Natural Water Content (%)	LL[1] (%)	PL[1] (%)	PI[1] (%)	% Pass. #200	Fines USCS	USCS Classification of Entire Sample
●	B-01	S3	15.0 - 16.5	--	32	16	16	22	CL	Clayey Sand (SC)
⊠	B-01	S11	55.0 - 56.5	--	25	20	5	47	CL-ML	Silty, Clayey Sand (SC-SM)
▲	B-01	S13	65.0 - 66.5	34.9	49	18	31	70	CL	Lean Clay With Sand (CL)
★	B-01	S23	115.0 - 116.5	28.7	38	18	20	76	CL	Lean Clay With Sand (CL)
⊙	B-01	S27	135.0 - 136.5	22.1	34	19	15	61	CL	Sandy Lean Clay (CL)
✿	B-02	S4	20.0 - 21.5	--	NP	NP	NP	25	ML	Silty Sand With Gravel (SM)
○	B-02	S8	40.0 - 41.5	--	31	20	11	66	CL	Sandy Lean Clay (CL)
△	B-02	R18	90.0 - 91.0	31.0	36	22	14	77	CL	Lean Clay With Sand (CL)
⊗	B-02	S24	120.0 - 121.5	--	37	17	20	74	CL	Lean Clay With Sand (CL)
⊕	B-02	S29	145.0 - 146.5	--	53	22	31	16	CH	Clayey Sand With Gravel (SC)
□	B-03	R1	5.0 - 6.0	8.3	NP	NP	NP	15	ML	Silty Sand With Gravel (SM)
❂	B-03	R11	55.0 - 56.0	27.3	39	18	21	65	CL	Sandy Lean Clay (CL)
◕	B-03	S14	70.0 - 71.5	--	NP	NP	NP	23	ML	Silty Sand (SM)
☆	B-03	S18	90.0 - 91.5	17.1	30	19	11	45	CL	Clayey Sand (SC)
✿	B-03	S24	120.0 - 121.5	22.6	38	20	18	64	CL	Sandy Lean Clay (CL)
■	B-04	R7	35.0 - 36.0	5.7	NP	NP	NP	5	ML	Well-Graded Gravel With Silt And Sand (GW-GM)
◆	B-04	S11	55.0 - 56.5	30.2	42	21	21	80	CL	Lean Clay With Sand (CL)
◇	B-04	S26	130.0 - 131.4	--	NP	NP	NP	20	ML	Silty Sand (SM)

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Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
NCS Project Number: J2007-09

Based on Laboratory Data From:
Conformatech
Clyde Pretti, Lab Manager

ATTERBERG LIMITS RESULTS

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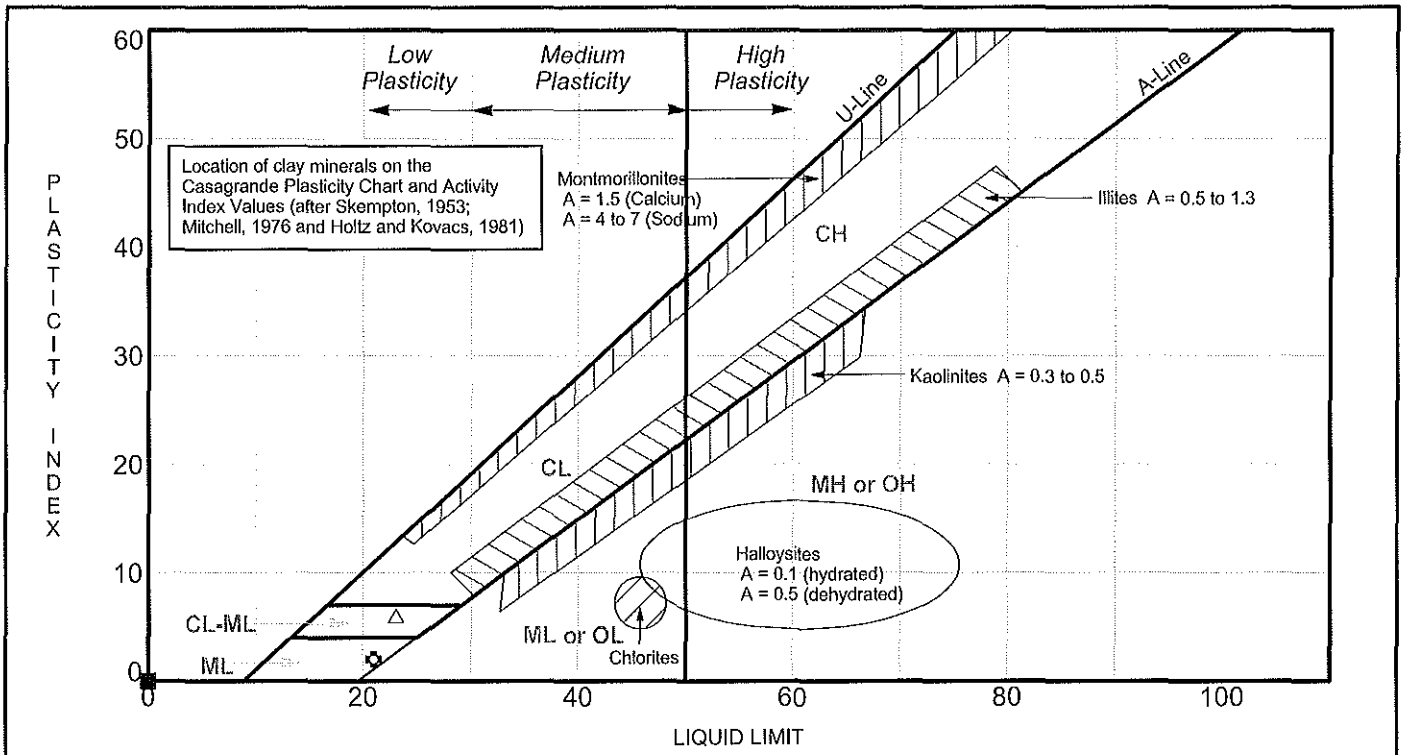

Symbol	Boring	Sample	Depth (ft.)	Natural Water Content (%)	LL[1] (%)	PL[1] (%)	PI[1] (%)	% Pass. #200	Fines USCS	USCS Classification of Entire Sample
●	P-02	B1	0.0 - 5.0	--	NP	NP	NP	8	ML	Well-Graded Sand With Silt (SW-SM)
⊠	P-04	B1	0.0 - 5.0	--	NP	NP	NP	8	ML	Well-Graded Sand With Silt (SW-SM)
▲	P-05	B1	0.0 - 5.0	--	NP	NP	NP	13	ML	Silty Sand (SM)
★	P-06	B1	0.0 - 5.0	--	NP	NP	NP	39	ML	Silty Sand (SM)
⊙	P-07	B1	0.0 - 5.0	--	NP	NP	NP	6	ML	Well-Graded Sand With Silt And Gravel (SW-SM)
✿	P-08	B1	0.0 - 5.0	--	21	19	2	54	ML	Sandy Silt (ML)
○	P-09	B1	0.0 - 5.0	--	NP	NP	NP	26	ML	Silty Sand (SM)
△	P10	B1	0.0 - 5.0	--	23	17	6	47	CL-ML	Silty, Clayey Sand (SC-SM)

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Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
NCS Project Number: J2007-09

Based on Laboratory Data From:
Conformatech
Clyde Pretti, Lab Manager

ATTERBERG LIMITS RESULTS

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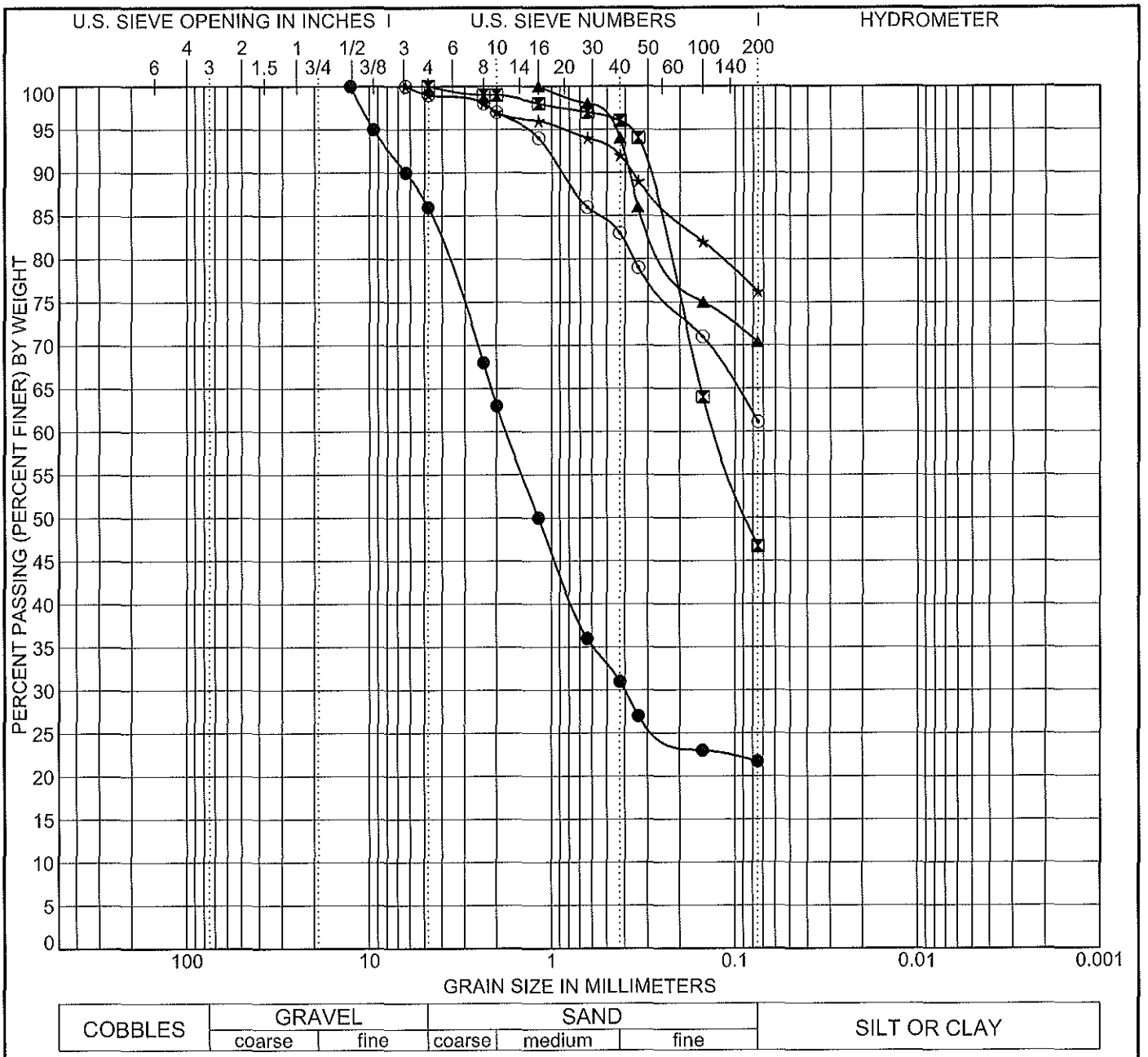

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sym.	Boring	Sample	Depth (ft.)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)	Cc	Cu	LL	PL	PI
●	B-01	S3	15.0 - 16.5	0.50	4.631	1.827	1.180	0.404					32	16	16
⊠	B-01	S11	55.0 - 56.5	0.19	0.289	0.135	0.091						25	20	5
▲	B-01	S13	65.0 - 66.5	0.05	0.322								49	18	31
★	B-01	S23	115.0 - 116.5	0.25	0.232								38	18	20
⊙	B-01	S27	135.0 - 136.5	0.25	0.568								34	19	15

Sym.	Boring	Sample	Depth (ft.)	% Cobbles & Boulders	% Gravel		% Sand			% Fines		Fines USCS	Sample USCS[1]	USCS Description [1]
					C	F	C	M	F	Silt	Clay			
●	B-01	S3	15.0 - 16.5	0.0	14.0		64.3			21.7		CL	SC	Clayey Sand
					0.0	14.0	23.0	32.0	9.3					
⊠	B-01	S11	55.0 - 56.5	0.0	0.0		53.3			46.7		CL-ML	SC-SM	Silty, Clayey Sand
					0.0	0.0	1.0	3.0	49.3					
▲	B-01	S13	65.0 - 66.5	0.0	0.0		29.6			70.4		CL	CL	Lean Clay With Sand
					0.0	0.0	0.0	6.0	23.6					
★	B-01	S23	115.0 - 116.5	0.0	1.0		22.8			76.2		CL	CL	Lean Clay With Sand
					0.0	1.0	2.0	5.0	15.8					
⊙	B-01	S27	135.0 - 136.5	0.0	1.0		37.9			61.1		CL	CL	Sandy Lean Clay
					0.0	1.0	2.0	14.0	21.9					

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Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
NCS Project Number: J2007-09

Based on Laboratory Data From:
Conformatech
Clyde Pretti, Lab Manager

GRAIN SIZE DISTRIBUTION

1. *Italicized* text indicates no plasticity tests were performed, and field classification of fines was required for USCS classification.

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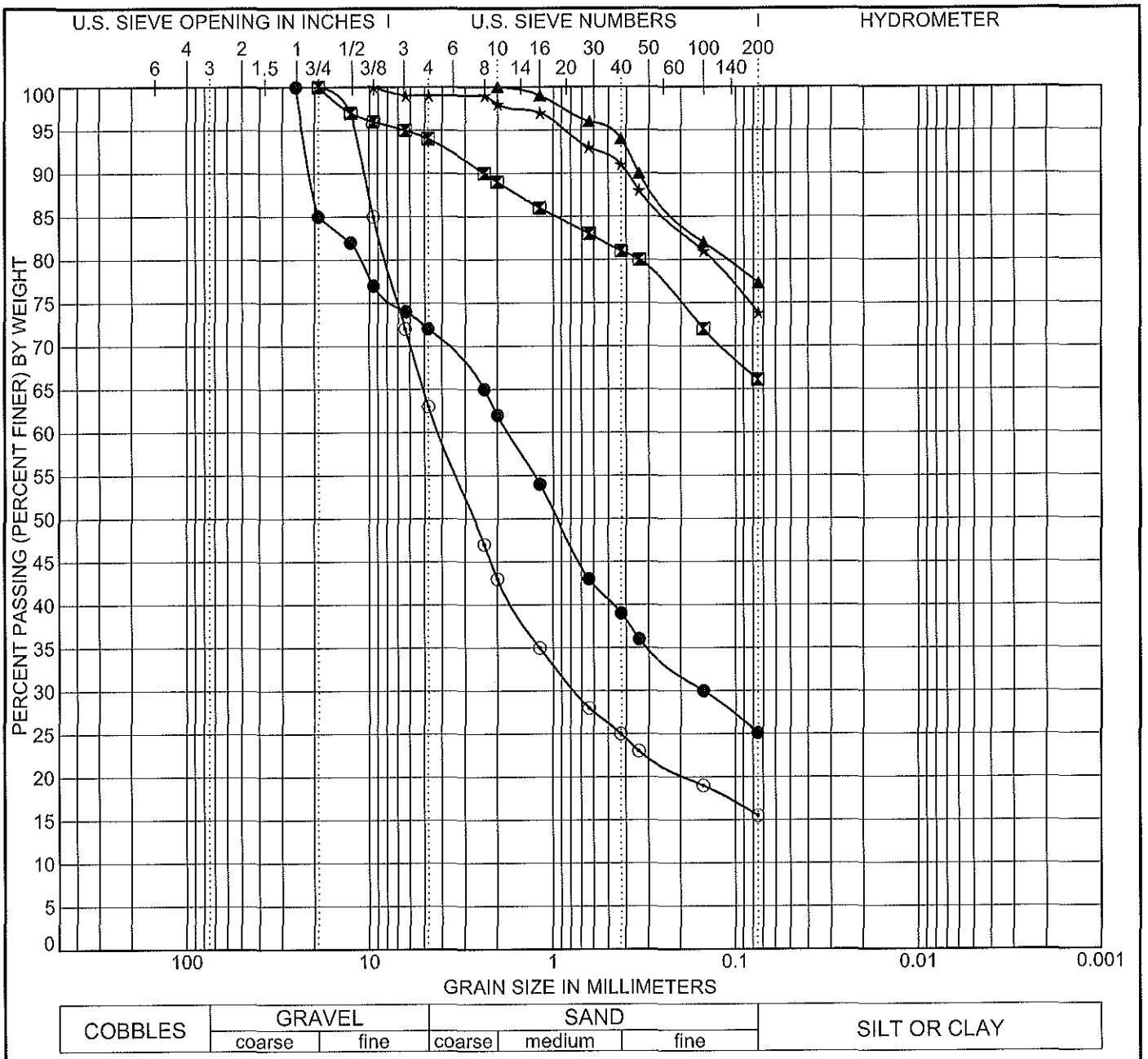

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sym.	Boring	Sample	Depth (ft.)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)	Cc	Cu	LL	PL	PI
●	B-02	S4	20.0 - 21.5	1.00	19.050	1.805	0.997	0.150					NP	NP	NP
⊠	B-02	S8	40.0 - 41.5	0.75	1.001								31	20	11
▲	B-02	R18	90.0 - 91.0	0.08	0.223								36	22	14
★	B-02	S24	120.0 - 121.5	0.38	0.259								37	17	20
⊙	B-02	S29	145.0 - 146.5	0.75	9.525	4.352	2.865	0.806					53	22	31

Sym.	Boring	Sample	Depth (ft.)	% Cobbles & Boulders	% Gravel		% Sand			% Fines		Fines USCS	Sample USCS[1]	USCS Description [1]
					C	F	C	M	F	Silt	Clay			
●	B-02	S4	20.0 - 21.5	0.0	28.0			46.9		25.1		ML	SM	Silty Sand With Gravel
					15.0	13.0	10.0	23.0	13.9					
⊠	B-02	S8	40.0 - 41.5	0.0	6.0			27.9		66.1		CL	CL	Sandy Lean Clay
					0.0	6.0	5.0	8.0	14.9					
▲	B-02	R18	90.0 - 91.0	0.0	0.0			22.7		77.3		CL	CL	Lean Clay With Sand
					0.0	0.0	0.0	6.0	16.7					
★	B-02	S24	120.0 - 121.5	0.0	1.0			25.2		73.8		CL	CL	Lean Clay With Sand
					0.0	1.0	1.0	7.0	17.2					
⊙	B-02	S29	145.0 - 146.5	0.0	37.0			47.5		15.5		CH	SC	Clayey Sand With Gravel
					0.0	37.0	20.0	18.0	9.5					

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Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
NCS Project Number: J2007-09

Based on Laboratory Data From:
Conformatech
Clyde Pretti, Lab Manager

GRAIN SIZE DISTRIBUTION

1. *Italicized* text indicates no plasticity tests were performed, and field classification of fines was required for USCS classification.

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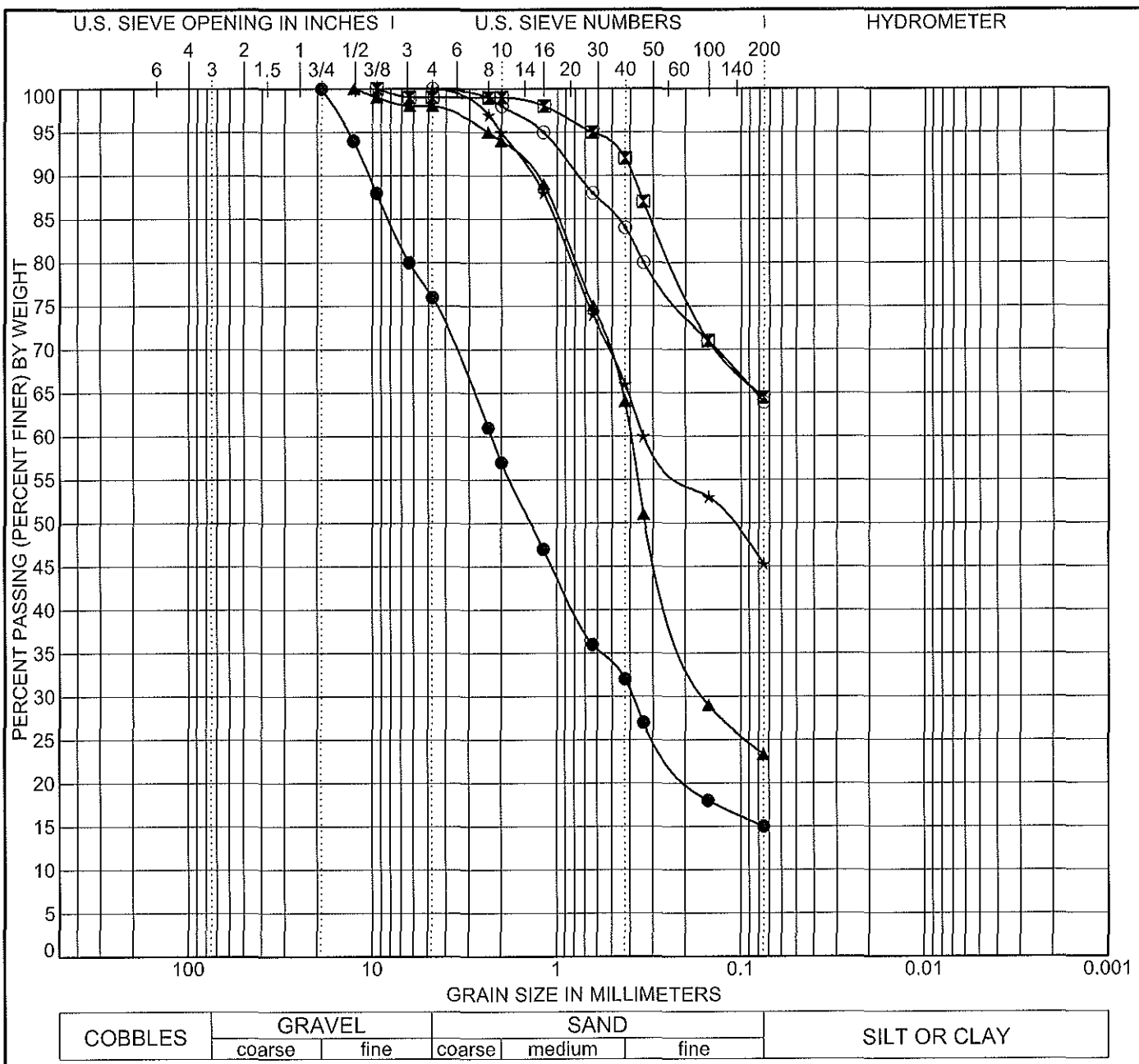

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sym.	Boring	Sample	Depth (ft.)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)	Cc	Cu	LL	PL	PI
●	B-03	R1	5.0 - 6.0	0.75	8.370	2.272	1.443	0.392	0.075				NP	NP	NP
⊠	B-03	R11	55.0 - 56.0	0.38	0.316								39	18	21
▲	B-03	S14	70.0 - 71.5	0.50	1.034	0.400	0.331	0.161					NP	NP	NP
★	B-03	S18	90.0 - 91.5	0.19	1.072	0.338	0.122						30	19	11
⊙	B-03	S24	120.0 - 121.5	0.19	0.479								38	20	18

Sym.	Boring	Sample	Depth (ft.)	% Cobbles & Boulders	% Gravel		% Sand			% Fines		Fines USCS	Sample USCS[1]	USCS Description [1]
					C	F	C	M	F	Silt	Clay			
●	B-03	R1	5.0 - 6.0	0.0	24.0		61.0			15.0		ML	SM	Silty Sand With Gravel
					0.0	24.0	19.0	25.0	17.0					
⊠	B-03	R11	55.0 - 56.0	0.0	1.0		34.5			64.5		CL	CL	Sandy Lean Clay
					0.0	1.0	0.0	7.0	27.5					
▲	B-03	S14	70.0 - 71.5	0.0	2.0		74.7			23.3		ML	SM	Silty Sand
					0.0	2.0	4.0	30.0	40.7					
★	B-03	S18	90.0 - 91.5	0.0	0.0		54.7			45.3		CL	SC	Clayey Sand
					0.0	0.0	5.0	29.0	20.7					
⊙	B-03	S24	120.0 - 121.5	0.0	0.0		36.1			63.9		CL	CL	Sandy Lean Clay
					0.0	0.0	2.0	14.0	20.1					

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Project: La Cholla Blvd. - Ruthrauff to River
Location: Tucson, AZ
NCS Project Number: J2007-09

Based on Laboratory Data From:
Conformatech
Clyde Pretti, Lab Manager

GRAIN SIZE DISTRIBUTION

1. *Italicized* text indicates no plasticity tests were performed, and field classification of fines was required for USCS classification.

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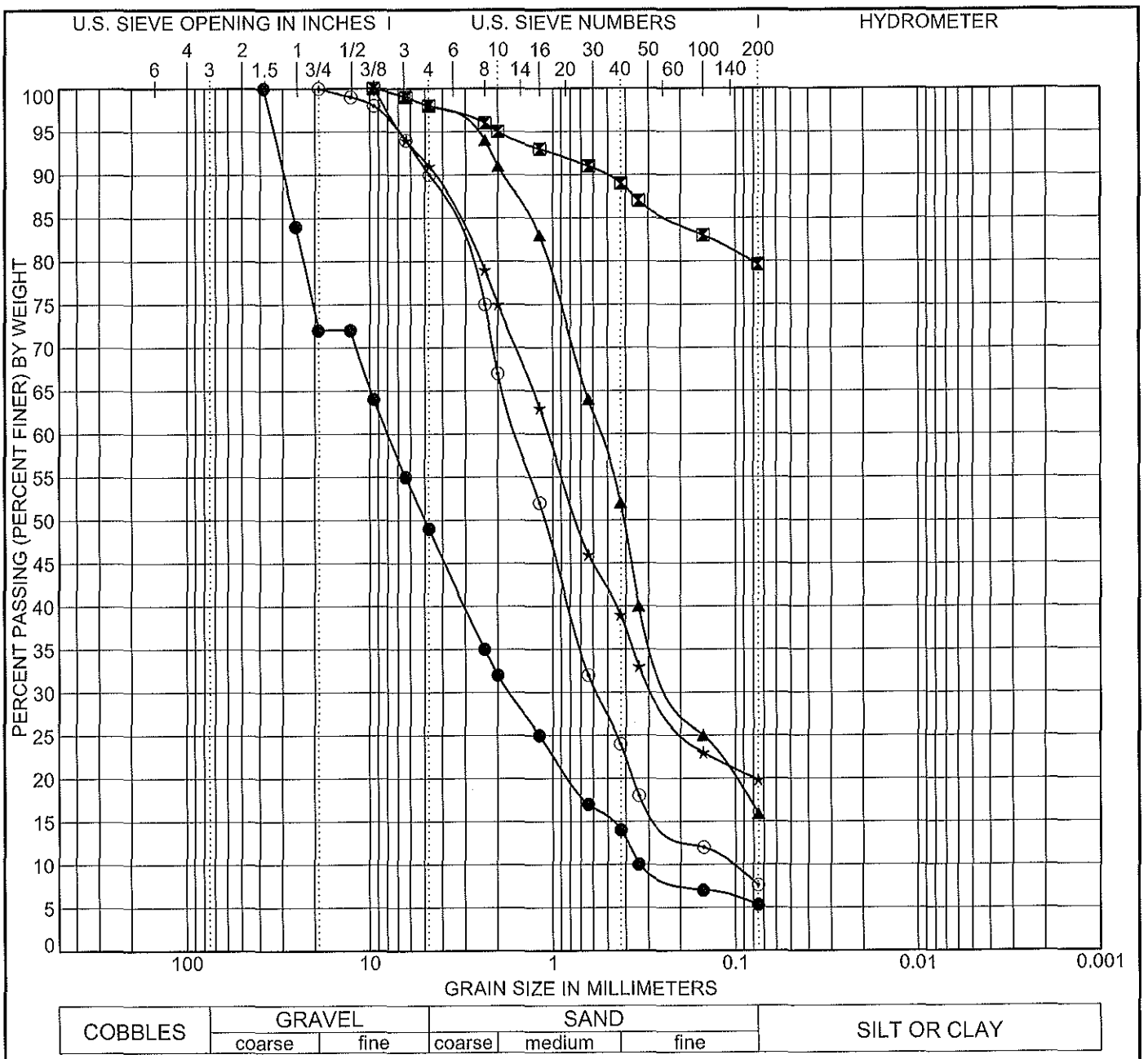

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sym.	Boring	Sample	Depth (ft.)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)	Cc	Cu	LL	PL	PI
●	B-04	R7	35.0 - 36.0	1.50	26.262	8.173	5.030	1.786	0.501	0.338	1.10	23.53	NP	NP	NP
⊠	B-04	S11	55.0 - 56.5	0.38	0.245								42	21	21
▲	B-04	S21	105.0 - 106.5	0.38	1.392	0.572	0.412	0.223							
★	B-04	S26	130.0 - 131.4	0.38	3.597	1.096	0.782	0.288					NP	NP	NP
⊙	P-02	B1	0.0 - 5.0	0.75	4.001	1.643	1.136	0.590	0.253	0.109	1.94	14.28	NP	NP	NP

Sym.	Boring	Sample	Depth (ft.)	% Cobbles & Boulders	% Gravel		% Sand			% Fines		Fines USCS	Sample USCS[1]	USCS Description [1]
					C	F	C	M	F	Silt	Clay			
●	B-04	R7	35.0 - 36.0	0.0	51.0		43.7			5.3		ML	GW-GM	Well-Graded Gravel With Silt And Sand
					28.0	23.0	17.0	18.0	8.7					
⊠	B-04	S11	55.0 - 56.5	0.0	2.0		18.4			79.6		CL	CL	Lean Clay With Sand
					0.0	2.0	3.0	6.0	9.4					
▲	B-04	S21	105.0 - 106.5	0.0	2.0		82.1			15.9		*NA*		
					0.0	2.0	7.0	39.0	36.1					
★	B-04	S26	130.0 - 131.4	0.0	9.0		71.2			19.8		ML	SM	Silty Sand
					0.0	9.0	16.0	36.0	19.2					
⊙	P-02	B1	0.0 - 5.0	0.0	10.0		82.4			7.6		ML	SW-SM	Well-Graded Sand With Silt
					0.0	10.0	23.0	43.0	16.4					

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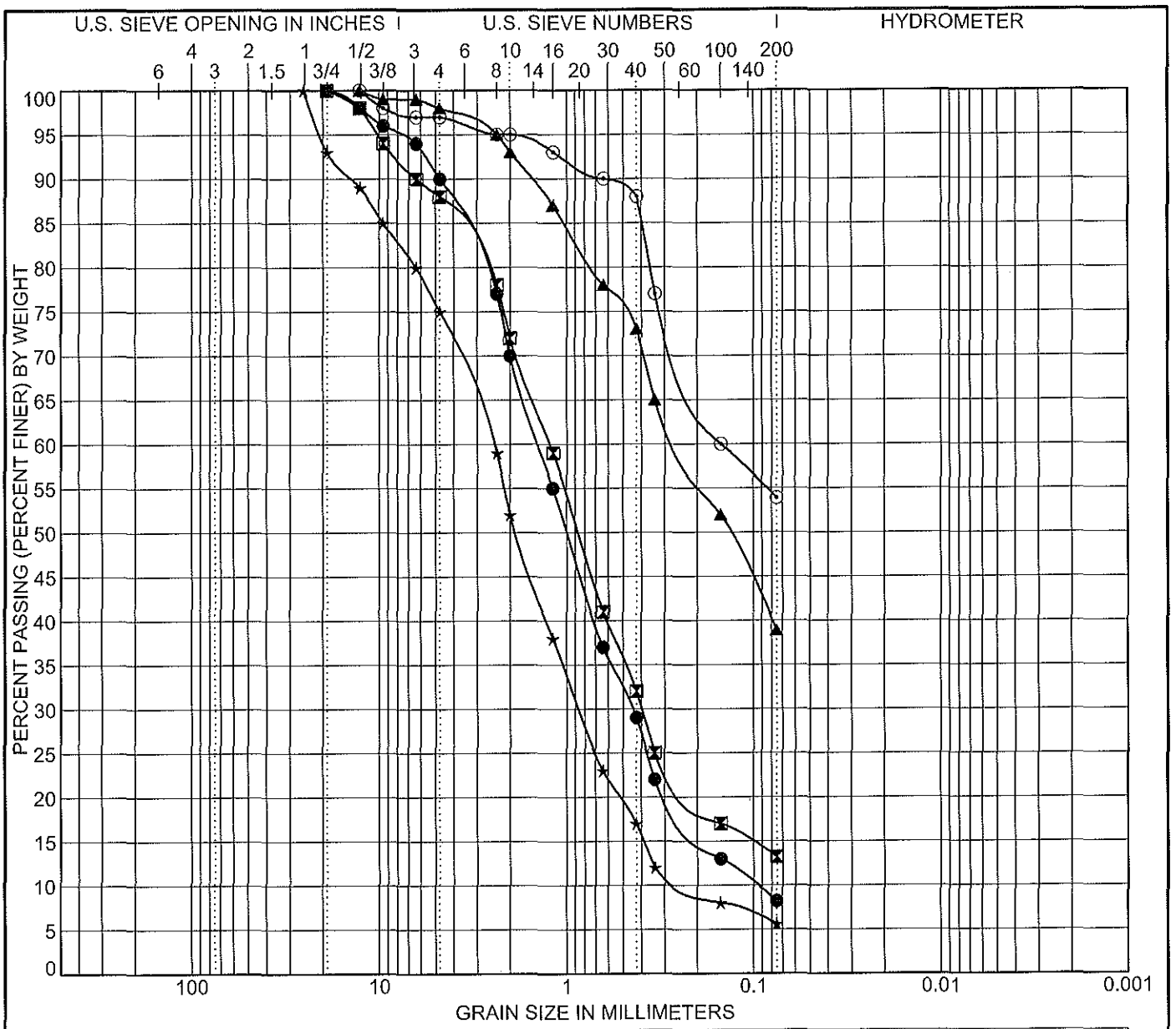

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sym.	Boring	Sample	Depth (ft.)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)	Cc	Cu	LL	PL	PI
●	P-04	B1	0.0 - 5.0	0.75	3.874	1.476	1.050	0.455	0.201	0.097	1.46	14.46	NP	NP	NP
⊠	P-05	B1	0.0 - 5.0	0.75	4.063	1.249	0.934	0.402	0.113				NP	NP	NP
▲	P-06	B1	0.0 - 5.0	0.50	1.065	0.271	0.140						NP	NP	NP
★	P-07	B1	0.0 - 5.0	1.00	9.525	2.527	1.897	0.925	0.394	0.225	1.30	10.95	NP	NP	NP
⊙	P-08	B1	0.0 - 5.0	0.50	0.402	0.150							21	19	2

Sym.	Boring	Sample	Depth (ft.)	% Cobbles & Boulders	% Gravel		% Sand			% Fines		Fines USCS	Sample USCS[1]	USCS Description [1]
					C	F	C	M	F	Silt	Clay			
●	P-04	B1	0.0 - 5.0	0.0	10.0		81.8			8.2		ML	SW-SM	Well-Graded Sand With Silt
					0.0	10.0	20.0	41.0	20.8					
⊠	P-05	B1	0.0 - 5.0	0.0	12.0		74.8			13.2		ML	SM	Silty Sand
					0.0	12.0	16.0	40.0	18.8					
▲	P-06	B1	0.0 - 5.0	0.0	2.0		59.1			38.9		ML	SM	Silty Sand
					0.0	2.0	5.0	20.0	34.1					
★	P-07	B1	0.0 - 5.0	0.0	25.0		69.4			5.6		ML	SW-SM	Well-Graded Sand With Silt And Gravel
					7.0	18.0	23.0	35.0	11.4					
⊙	P-08	B1	0.0 - 5.0	0.0	3.0		43.1			53.9		ML	ML	Sandy Silt
					0.0	3.0	2.0	7.0	34.1					

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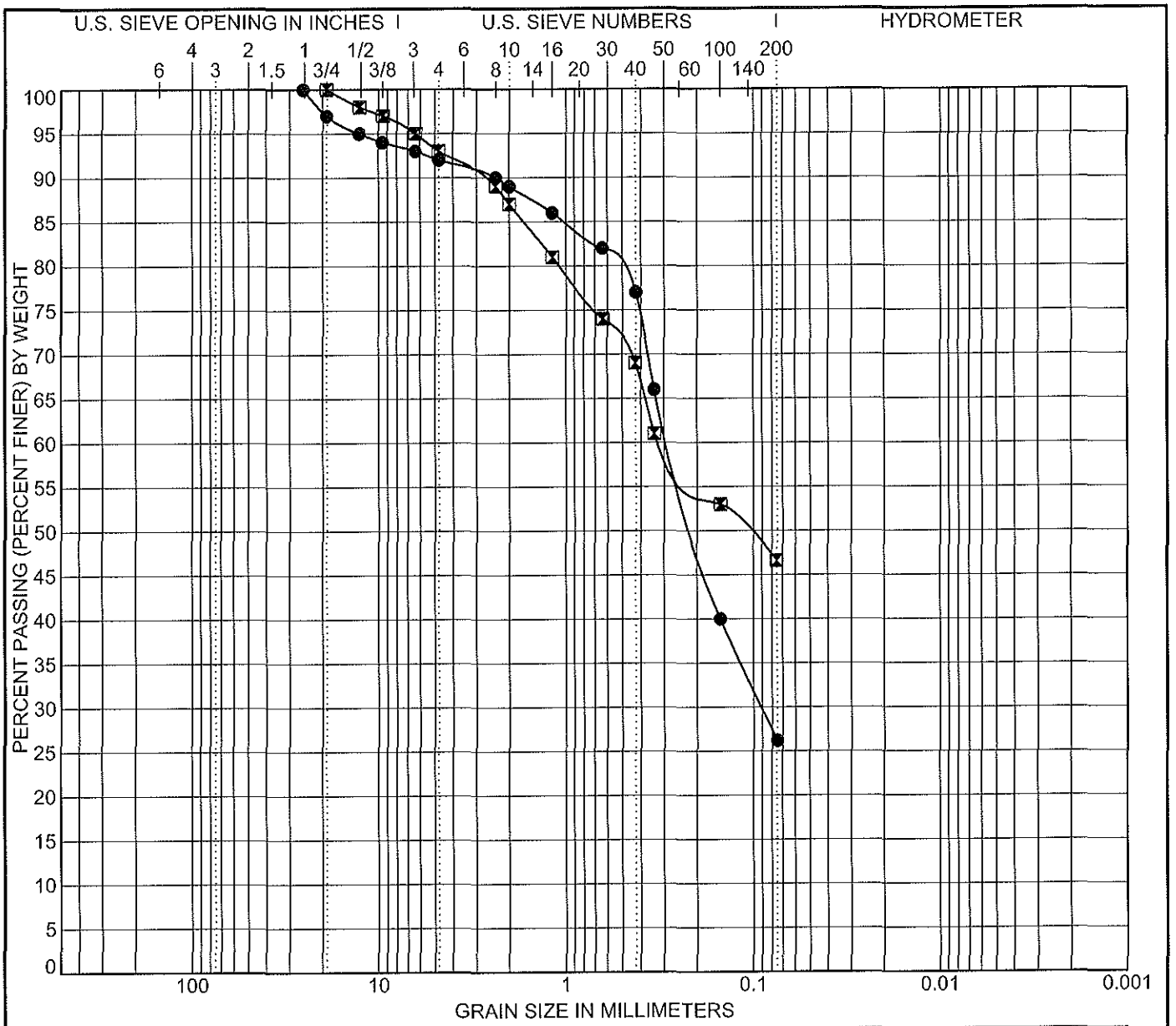

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sym.	Boring	Sample	Depth (ft.)	D100 (in)	D85 (mm)	D60 (mm)	D50 (mm)	D30 (mm)	D15 (mm)	D10 (mm)	Cc	Cu	LL	PL	PI
●	P-09	B1	0.0 - 5.0	1.00	1.047	0.302	0.234	0.099					NP	NP	NP
⊠	P10	B1	0.0 - 5.0	0.75	1.733	0.316	0.116						23	17	6

Sym.	Boring	Sample	Depth (ft.)	% Cobbles & Boulders	% Gravel		% Sand			% Fines		Fines USCS	Sample USCS[1]	USCS Description [1]
					C	F	C	M	F	Silt	Clay			
●	P-09	B1	0.0 - 5.0	0.0	8.0		65.8			26.2		ML	SM	Silty Sand
					3.0	5.0	3.0	12.0	50.8					
⊠	P10	B1	0.0 - 5.0	0.0	7.0		46.4			46.6		CL-ML	SC-SM	Silty, Clayey Sand
					0.0	7.0	6.0	18.0	22.4					

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